HE GREAT BASIN NATURALIST

e 43 No. 1 January 31, 1983 Brigham Young University

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3-83 650 64094

ISSN 017-3614

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The Great Basin Naturalist

PUBLISHED AT PROVO, UTAH, BY
BRIGHAM YOUNG UNIVERSITY

ISSN 0017-3614

VOLUME 43 | January 31, 1983 | No. 1

LIFE HISTORY OF THE LAHONTAN CUTTHROAT TROUT, *SALMO CLARKI HENSHAWI*, IN PYRAMID LAKE, NEVADA

William F. Sigler[1], William T. Helm[2], Paul A. Kucera[3], Steven Vigg[4], and Gar W. Workman[5]

ABSTRACT.— The Pyramid Lake Lahontan cutthroat trout (*Salmo clarki henshawi*) population was sampled on a monthly basis from November 1975 through December 1977. A subsample of 676 trout, stratified by fish size and lake habitat, provided biological data. The entire population is presently derived from hatchery production, stocked at lengths of approximately 75 to 300 mm. Peak annulus formation occurs in March and April, followed by the period of maximum growth. Scale patterns illustrate a variable growing season. Maximum growth in length is in the first three years of life; after that males begin to grow faster than females. Males attained a greater age in our sample; i.e., the oldest male was seven years old compared to six years for females. The Pyramid Lake Lahontan cutthroat trout exhibit nearly isometric growth.

The legal sport fishery removed <20,000 adult fish in 1977 (>380 mm); other decimating factors are poorly understood. No evidence of the following diseases or pathogens was found in the Pyramid Lake population, presuming a carrier incidence of 2 percent at the 95 percent confidence level: infectious pancreatic necrosis, infectious hematopoietic necrosis, viral hemorrhagic septicema, bacterial kidney disease, enteric redmouth, furunculosis, whirling disease, blood fluke; however, 7 of 235 (≃3 percent) adults sampled at the Marble Bluff fishway were positive for furunculosis.

Small trout feed primarily on zooplankton and benthic invertebrates; cutthroat trout >300 mm are piscivorous, feeding almost exclusively on tui chub (*Gila bicolor*). The spawning migration of Pyramid Lake cutthroat trout to the Marble Bluff egg taking facility in spring 1976 and 1977 peaked in April and May. Females mature at three or four years (352–484 mm), and males mature at two or three years (299–445 mm). Mean diameter of mature eggs is 4.51 mm; both ovum size and fecundity are a function of fish size. Fecundity ranges from 1241 to 7963 eggs, with a mean of 3815.

Lahontan cutthroat trout comprise <2 percent of the numerical relative abundance and <7 percent of the total fish biomass. Distribution patterns vary on a seasonal basis, with maximum activity during late fall and winter. Management objectives are presented and recommendations are discussed.

The Lahontan cutthroat trout (*Salmo clarki henshawi*) is unique in its ability to withstand the alkaline-saline waters of remnant Great Basin lakes. Coevolution of Pyramid Lake Lahontan cutthroat trout in a continuous lake environment for 50,000–100,000 years with an abundant prey species (tui chub, *Gila bicolor*) resulted in a unique predator—the world's largest cutthroat trout (18.6 kg).

The decline and ultimate extinction of the original strain of cutthroat trout in Pyramid Lake was caused primarily by degradation of spawning habitat associated with diversion of water out of the Truckee River-Pyramid Lake ecosystem (Trelease 1953). The Pyramid Lake trout fishery has been reestablished via hatchery propagation of Heenan, Walker, and Summit lake strains of Lahontan cut-

[1]W. F. Sigler & Associates Inc., P.O. Box 1350, Logan, Utah 84322.
[2]Utah State University, Logan, Utah 84322.
[3]Nez Perce Tribe, Lapwai, Idaho 83540.
[4]Desert Research Institute, University of Nevada System, Reno, Nevada 89507.
[5]Utah State University, Logan, Utah 84322.

Fig. 1. The largest post-1943 Lahontan cutthroat trout (12.7 kg), captured by Ralston Fillmore from Pyramid Lake, Nevada, April 1976. Photograph courtesy of Alan Ruger.

throat trout, and, in the past, of cutthroat-rainbow trout (*Salmo gairdneri*) hybrids. The subspecies S. *c. henshawi* currently has "threatened" status (Deacon et al. 1979).

Pyramid Lake presently supports a trophy sport fishery; the average trout retained by fishermen is 500 mm in length and weighs 1.2 kg. In 1976, a Paiute Indian, Ralston Fillmore, captured a 12.7 kg Lahontan cutthroat trout that represents a record for the post-1943 fishery (Fig. 1). Recent catches are evidence that the environment of Pyramid Lake is capable of supporting at least a limited valuable and unique fishery. However, human demands on limited Truckee River water and recent droughts have jeopardized the trout in Pyramid Lake. The ethics and priorities of our society, as a whole, may ultimately decide the fate of the Pyramid Lake Lahontan cutthroat trout.

Nine now discrete basins once conjoined to form vast (area 22,300 km^2; maximum depth 270 m) Lake Lahontan in the northwestern Great Basin (Hubbs and Miller 1948). Pyramid Lake is the deepest remnant of this once great lake system that experienced several cycles of water level fluctuations during the Pleistocene Epoch (Houghton 1976). Great Basin lakes have desiccated to the present state since the last pluvial period some 10–12 thousand years before present (BP). Benson (1978) concludes via sediment analyses that Pyramid Lake was greatly reduced in size 9–5 thousand years BP, but did not become dry and had subsequently been rising until the cultural impacts of the past century.

Pyramid is a graben lake approximately 40 km long and 6.5 to 16 km wide, with a north-south axis (Figure 2). At the mean 1976 elevation of 1157 m (United States Geological Survey 1977), Pyramid Lake has a surface area of 446.4 km^2, a volume of 26.4 km^3, a mean depth of 59 m and a maximum depth of 103 m (Harris 1970). Pyramid is the deepest and most voluminous saline terminal lake in the western hemisphere (Galat et al. 1981).

Pyramid Lake, located entirely within the Pyramid Lake Paiute Indian Reservation, is the terminal water body of the endorheic Truckee River system originating 193 river km upstream at oligotrophic Lake Tahoe. The evaporation loss is about 1.2 m annually. Due to transbasin diversion of the Truckee River, the lake level declined 23 m between 1905 and 1979; this amounts to a 30 percent reduction in lake volume. The lake water is highly ionic ($Na^+ > K^+ \geq Mg^{2+} > Ca^{2+}$; $Cl^- > HCO_3^- > CO_3^{2-} > SO_4^{2-}$), with a pH of 9.2. The 1976 total dissolved solids (TDS) concentration was 5235 mg/l at elevation 1157 m. On a worldwide perspective, 71 percent of some 350 saline lakes listed by McCarraher (1972) are more saline than Pyramid, but, compared to USA saline lakes, Pyramid is in the moderate range (Galat et al. 1981).

During 1976 and 1977 mean surface temperature ranged from 6.1 to 23.1 C. As winds subside and surface water temperature increases, a thermocline is formed in June and lasts through December at 16 to 22 m. The lake is monomictic (Hutchinson 1957); turnover begins in early winter and mixing extends to spring.

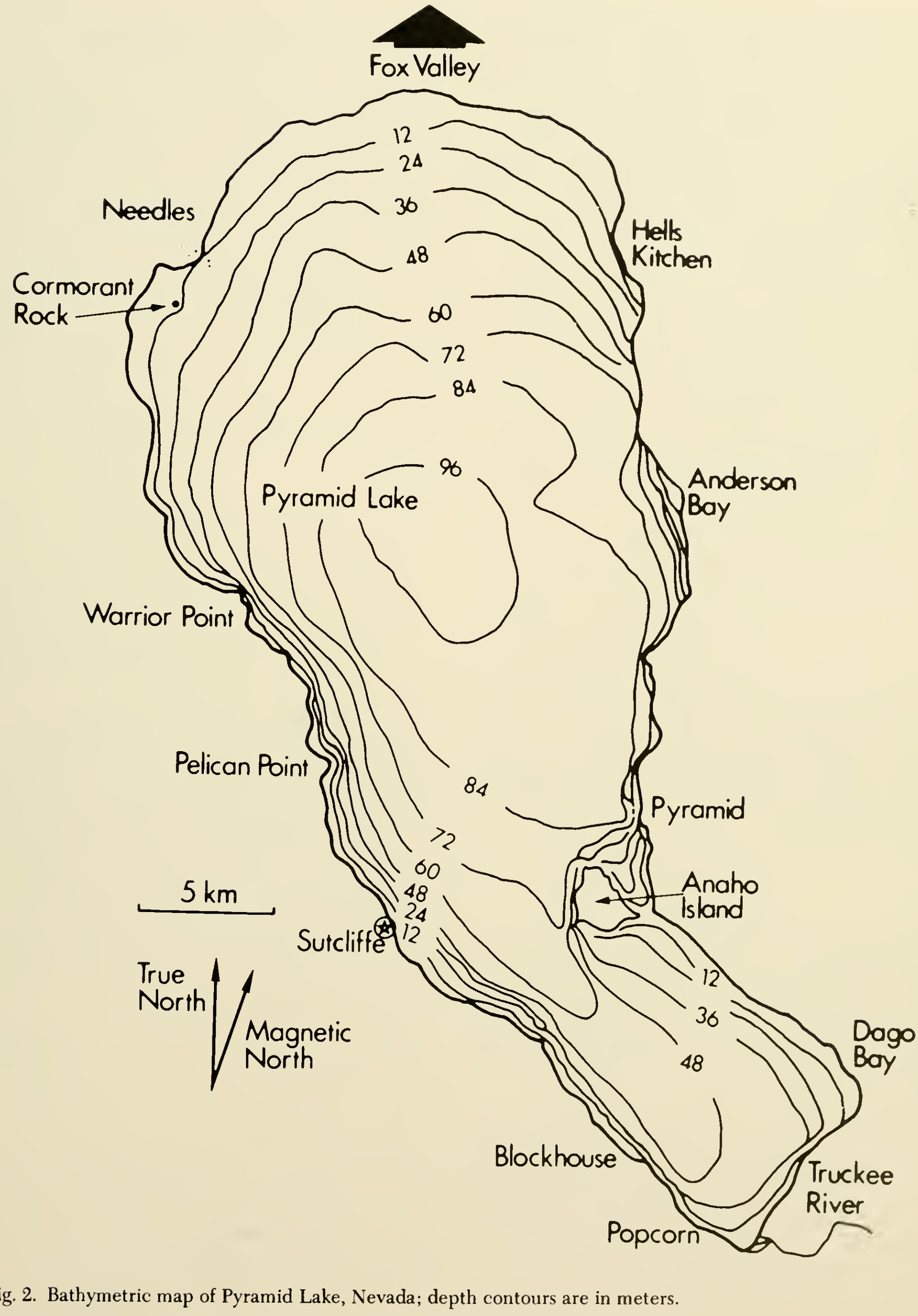

Fig. 2. Bathymetric map of Pyramid Lake, Nevada; depth contours are in meters.

Physical changes, including out-of-basin and inbasin water diversions, channelization, and destruction of riparian habitat, have adversely affected the ecology of the Truckee River-Pyramid Lake ecosystem. Historically the Lahontan cutthroat trout moved out of Pyramid and Winnemucca lakes, Nevada, and spawned in the entire Truckee River and its tributaries, a total length of 525 km. They also moved into Lake Tahoe, Nevada-California, and spawned in its tributary streams. Derby Dam, completed in 1905, 62 km above Pyramid Lake, effected a transbasin diversion of much of the lower Truckee River flow. This obstacle reduced river spawning to the area below the dam. The dam not only had the direct effect of reducing flows in the lower river, but indirectly caused the buildup of the delta at the mouth. The numbers of trout diminished steadily until 1930, which was the last successful spawning year for the original population of Pyramid Lake Lahontan cutthroat trout (Sumner 1939). The U.S. Bureau of Fisheries (now U.S. Fish and Wildlife Service) stocked limited numbers in the lake in 1931 and 1932. None was seen in Pyramid Lake after 1943 and very few after 1938. However, before that time millions of eggs had been taken from the Pyramid Lake cutthroat and stocked elsewhere (Townley 1980).

In 1976 the Marble Bluff complex, consisting of a dam and impoundment, a building, and a 5.6 km fishway ending at the lake, was completed. This facility was built so that spawning fish could migrate upriver when there was not enough water in the river delta. The fishway, operating at 0.85 to 1.27 m^3/sec, allows fish to move upstream via four step-up ladders. At the upper end of the fishway the fish may be shunted on upstream or into the building.

Importance

The Pyramid Lake Lahontan cutthroat trout is potentially of substantial economic and social importance to the Pyramid Lake Paiute Indian Tribe. Its adaptation to the highly saline waters of the lake make it a unique natural history entity.

In 1977 an estimated 27,241 people spent 276,532 hours fishing for Lahontan cutthroat trout in Pyramid Lake. They landed 43,841 fish, of which 19,930 or 46 percent were legal size (381 mm). This is at the rate of 0.16 fish per hour landed and 0.07 kept.

It has been estimated that the historic annual production of Lahontan cutthroat trout was at least 454,000 kg (Behnke 1974). The Pyramid Lake trout was the mainstay in the diet of the Pyramid Lake Paiutes and many other Indian tribes. They were also shipped to mining camps and other markets as far away as San Francisco.

Range and Distribution

An ancestoral cutthroat trout probably invaded ancient Lake Lahontan from the Columbia River Basin and developed into what is now known as the Lahontan cutthroat trout (Behnke and Zarn 1976). When the great lake desiccated, two populations of Lahontans evolved, one best adapted to lakes and the other to streams. The major lake populations of Lahontan cutthroat trout were then in Pyramid Lake, Walker Lake, Donner Lake, Independence Lake, and Lake Tahoe (Miller 1951). The trout in some of these lakes, which held an abundance of forage fish, became predatory at an early age, grew fast and large, and were moderately long lived.

Currently, the largest population of lake-dwelling Lahontan cutthroat trout is in Pyramid Lake. Walker Lake supports a small population that has no opportunity to reproduce. Summit Lake and Independence Lake may contain the most nearly pure strain of the Lahontan, but both lakes are small and have few forage fish (Behnke and Zarn 1976). A number of western lakes support reproducing populations of Lahontan cutthroat trout. Recently a small stream-dwelling population of Lahontan cutthroat trout, believed to have been transplanted from Pyramid Lake before 1930, was discovered near Pilot's Peak, north of Wendover, Utah-Nevada (Hickman and Duff 1978, Hickman and Behnke 1979). There are a number of stream-dwelling Lahontan cutthroat trout populations in the Great Basin.

In 1950, the Nevada Fish and Game Department initiated a small-scale stocking program of Lahontan cutthroat and other trout in Pyramid Lake (Trelease 1969). The program has now grown to 2.2 million 75–300 mm fish per year, supplied by two hatcheries of the Pyramid Lake Indian Tribal Enterprises (PLITE) and the Lahontan National Fish Hatchery at Gardnerville, Nevada.

Morphology and Genetics

Despite the diverse evolutionary histories of western trout (genus *Salmo*), some species are related closely enough to interbreed freely and produce fertile hybrids. It is this potential presence of all degrees of hybrids within a habitat that complicates identification and evaluation of pure stock (Behnke and Zarn 1976). The original stock of Lahontan cutthroat trout was apparently resistant to hybridization due to its long isolation in the Lahontan basin. The present subspecies does not share this characteristic. The isolation also encouraged a high degree of adaptability for lake habitat.

The following are typical meristics of the Lahontan cutthroat trout (Behnke and Zarn 1976):

Scale counts	
lateral series	
two rows above lateral line	150–180
above lateral line (origin of dorsal fin to lateral line)	33–43
Vertebrae	61–63
Gillrakers	21–28
Pyloric caecae	40–75
Basibranchial teeth	Numerous and well developed

The number of pyloric caecae is higher in the Lahontan cutthroat than in other subspecies of cutthroat. The large, round, rather dull reddish spots that appear on the head as well as on the caudal peduncle and occasionally ventrally are the best field characteristic.

The following data were collected as part of a study contracted between W. F. Sigler & Associates Inc. and the United States. This study was to provide an ecological evaluation of Pyramid Lake and its fishery resources and habitat.

Procedures

Fish life history data were taken by monthly nettings from November 1975 through December 1977. Fish were sampled by bottom set variable-mesh gill nets, vertical set gill nets, beach seines, fyke nets, and trawls. Fish were measured to the nearest millimeter in fork (FL), standard (SL), and total (TL) lengths and weighed to the nearest gram (Sigler and Kennedy 1978).

Scale samples were collected from the left side in the region above the lateral line and midway between the posterior edge of the operculum and the origin of the dorsal fin. Five scales per fish were selected and impressions made of them on plastic slides with the use of a roller press (Smith 1963).

The length-weight relationship is expressed by the formula $W = aL^b$ (Sigler 1951), where W = weight in grams, L = fork length in cm, and a and b are constants. A log transformation of W produces a linear equation. The constants a and b are calculated by the method of least squares.

Validity of the scale method was determined by criteria suggested by Van Oosten (1923, 1929, 1944) and Hile (1941). To avoid possible bias, scales were first read without knowledge of the size of the fish. The scales were read at least three times. Further checks for accuracy of age assignment included comparisons with known age and tagged fish, Peterson's method, and use of year marks on other bony parts. All scales were examined with an Eberbach microprojector at a magnification of 80X.

The body-scale relationship was calculated according to Tesch (1971). The condition factor $K = Wx10^5/L^3$ was calculated according to Carlander (1969), where W = weight in grams and L = fork length in mm. Calculations were accomplished using an age-growth computer program (Nelson 1976).

Creel census information was collected from January 1977 to April 1978. Four weekdays and six weekend days were randomly selected each month for censusing, with holidays treated as weekend days. On each selected day a check station was manned on the principal highway leading to Pyramid Lake and three aerial counts were made. Check stations were in operation from noon until dark, where all pertinent information was collected from fishermen. Aerial surveys were conducted by dividing a day into three equal time segments and an aerial count was made at the midpoint of each segment (Fig. 3). Inclement weather caused cancellation of 5 percent of the flights (Kennedy 1978). Shore fishermen and boats were counted on each flight, with the number of boat fishermen obtained by multiplying the number of boats by the average number of fishermen per boat on the day of the count (Johnson and Wroblewski 1962). When less than 10 boats were checked, the yearly mean number

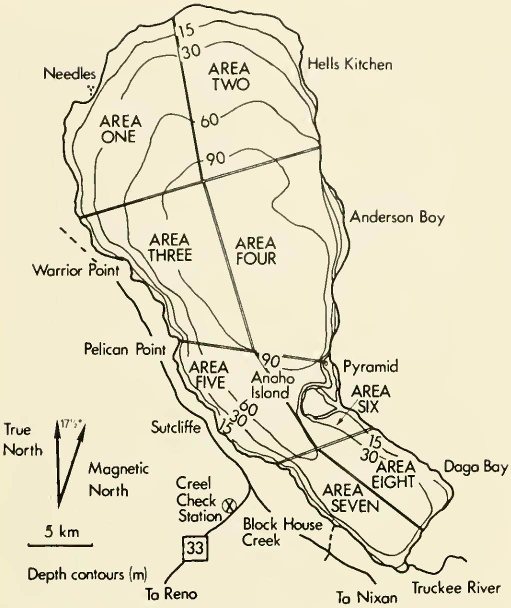

Fig. 3. Lake areas used for creel census data collection and location of creel check stations.

of fishermen per boat was used. Rate of success, effort, and harvest were calculated by computer program (David Wheaton, pers. comm. 1977). All calculations were expanded to a 30-day month. Mean lengths and weights of fish caught were also calculated.

Food habits were determined by examining the stomachs of five fish per size group from each net catch. Food habit analyses were conducted by percent of frequency of occurrence and percent of total volume.

Fecundities were determined by actual egg counts (Kucera and Kennedy 1977). Criteria described by Nikolsky (1963) were used for determining stage of maturity; only ripe females and fresh ovaries were used for fecundity studies. Linear and $\log_{10}$ $(Y+1)$ regressions between fecundity, fork length, weight, age, ovum diameter, ovary weight, and net weight (body weight minus ovary weight) were used to examine the interrelationships between these variables.

Age and Growth

Appearance of Scales and Formation of Annuli

Fork length at the time of scale formation for hatchery-reared Lahontan cutthroat planted in Pyramid Lake is 25.8 mm. Calhoun (1942) lists 40 mm (FL) as the size of Lahontan cutthroat from Blue Lake, California, at time of scale formation. Yellowstone cutthroat develop scales when they are between 40.3 mm and 42.8 mm (FL) (Brown and Bailey 1952). Laakso and Cope (1956) report 39.3 mm (FL) as the size of cutthroat trout at the time of scale formation. Cutthroat trout sampled in Montana had formed scales at 41.2 to 63.2 mm (FL) (Brown and Bailey 1952). Irving (1953) reports 23.9 mm (FL) for cutthroat trout in Henry's Lake, Idaho. Robertson (1947) found considerable variation in the size of cutthroat trout at the time of scale formation.

Nearly all scales examined from Pyramid Lake fish showed early growth patterns characteristic of hatchery rearing. Scales also showed crowded circuli beginning in late September 1975 and 1976 and in early November 1977. Nearly all scales aged showed winter bands of thin and closely spaced circuli. Summer growth bands appear as thick and widely spaced circuli. The beginning of growth, the first appearance of summer banding, is assumed to correspond with formation of the annulus. The period of annulus formation extended from about February through May, peaking in late April 1976 and late March 1977.

All annuli were readily visible. Check marks that appeared throughout all fields were prominent during the first year's growth for the majority of fish examined. These stress conditions that resulted in growth interruptions existed during the first (0 age) year for fish from the National Fish Hatchery (Lahontan National Fish Hatchery personnel, pers. comm. 1976). This situation presumably does not occur every year.

Seasonal Growth

Our analyses of age and growth for Lahontan cutthroat trout from Pyramid Lake is based on scale samples from 676 specimens taken almost exclusively with nets from November 1975 through November 1977. The general shapes of the 1976 and 1977 growth curves (Fig. 4) were the same, but during 1977 growth was more rapid and extended over a longer period of time than for comparably aged fish in 1976. Increments of growth declined with increasing age of fish in 1976, but increased in 1977. Growth increased sharply in spring, slowed in late summer, and ceased during fall and winter.

Annual Growth

Annual growth (back-calculated lengths) values were derived from the body length-scale radius relationship FL = A + B(SR); FL = fork length in mm and SR = anterior scale radius (Table 1). Body-scale regression equations, based on data collected over the entire study, were used to calculate the lengths. The results for 676 fish are: for females FL = 155.881 + 3.5364 (SR), for males FL = 79.176 + 4.2599 (SR), for indeterminates FL = 112.872 + 4.0834 (SR), and for combined FL = 132.952 + 3.8079 (SR).

Young-of-the-year Lahontan cutthroat trout sampled from Lahontan National Fish Hatchery averaged 152 mm in length at age eight months. By the end of Year 1, hatchery trout are approximately 203 mm FL (Lahontan National Fish Hatchery personnel, pers. comm. 1976). These data demonstrate that the back-calculated lengths for age I Pyramid Lake trout are accurate.

Growth in length is nearly isometric from the end of the first through the seventh years of life. Variation by sex is evident in the growth rates of certain age groups. Annual increments of growth in length for males are greater than for females from age II on. According to Irving (1953), male trout from Henry's Lake, Idaho, grow faster than females, and Bulkley (1961) reports male trout outlive females. Pyramid Lake Lahontan cutthroat trout appear to follow these patterns. Others have reported no difference between the sexes in growth rates (Drummond 1966, Snyder and Tanner 1960).

The oldest male and female aged from Pyramid Lake were in their seventh and sixth year, respectively. This longevity is somewhat less than historical data. Sumner (1939) found the oldest age groups of trout in Pyramid Lake were the seven- to nine-year-olds. Studies in smaller high altitude lakes, Upper Blue Lake (Calhoun 1944), and Topaz Lake (Johnson 1958), indicate that few trout live past their sixth year (Table 2).

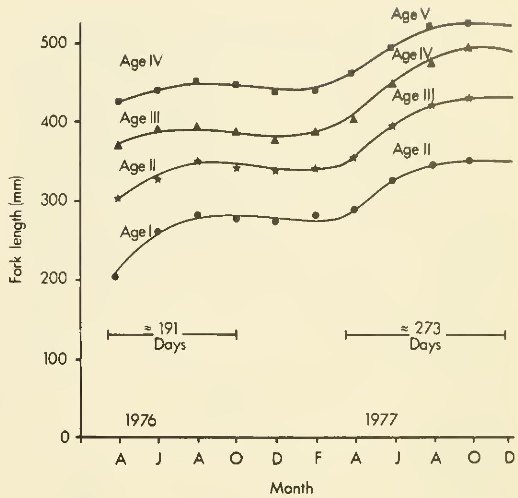

Fig. 4. Seasonal growth curves, 1976 and 1977, for Lahontan cutthroat trout age groups I through V. Fish were collected from Pyramid Lake, Nevada, from November 1975 through November 1977. The graph abscissa is divided into bimonthly intervals beginning with April.

Lahontan cutthroat trout greater than 787 mm were not sampled with our nets and thus do not appear in our age and growth studies; however, larger ones were taken by anglers. In the 1977 creel sample, which was about three times that of the net sample, 22.5 percent of the 1916 trout exceeded 600 mm in length; the longest one was 990 mm FL. The average size was 505 mm (S.D. = 107.0). Either these large fish grew faster than the average in our studies, or they were older than the maximum ages of our net-caught fish. In April 1976, an Indian angler, Ralston Fillmore, captured a 12.7 kg Lahontan cutthroat trout, the largest recorded since December 1925, when another Indian, John Skimmerhorn, caught an 18.6 kg trout, the world record cutthroat (Wheeler 1974). There are numerous unconfirmed reports of ones larger than this being marketed around the turn of the century.

LeCren (1951) states the length-weight relationship equation, in addition to providing a method of converting length to weight, also indicates taxonomic differences and events in the life history. The value of the constant "B" will equal 3.0 where growth is symmetrical or isometrical (Ricker 1971). Values less than 3.0 demonstrate linear growth is taking place faster than growth in weight. Values greater than 3.0 demonstrate the reverse; both are allometric growth.

The length-weight equations calculated for Lahontan cutthroat trout show growth slightly exceeds the cubic relationship; this represents allometric growth. We combined all years, drawing on data from 561 trout. Sizes ranged from 189 mm (36 g) to 787 mm (6163 g) (Table 3, Fig. 5). Tesch (1971) notes allometric growth in some salmonid stocks.

The length-weight curve of the Lahontan cutthroat trout shows the importance of forage fish. In Pyramid Lake cutthroat trout weight gains tend to exceed the increases in length when the diet shifts from invertebrates to fish. They are in their third year and similar to cutthroat trout from Independence Lake, California (Lea 1963). Lea states the rate of growth for the Independence Lake cutthroat trout population is only slightly

Table 1. Summary of the mean calculated fork lengths and increments of growth for Lahontan cutthroat trout collected from Pyramid Lake, Nevada, from November 1975 through November 1976.

Age group	Number of fish	Calculated fork lengths (mm) at end of each year of life						
		1	2	3	4	5	6	7
(Female)								
I	42	238						
II	68	236	306					
III	80	233	305	374				
IV	25	236	304	376	442			
V	23	236	303	374	442	500		
VI	15	233	306	374	447	508	580	
Grand average		235	305	374	443	503	580	
Increments of growth		235	70	70	68	59	72	
Number of fish		253	211	143	63	38	15	
(Male)								
I	4	178						
II	14	168	255					
III	26	169	253	341				
IV	25	171	254	344	439			
V	24	168	254	339	437	516		
VI	16	167	250	341	439	518	588	
VII	4	165	250	345	435	521	575	664
Grand average		169	253	342	438	517	585	664
Increments of growth		169	84	89	96	79	66	88
Number of fish		113	109	95	69	44	20	4
(Indeterminate)								
I	26	217						
II	51	206	286					
III	110	203	285	359				
IV	71	202	281	353	416			
V	40	200	274	343	407	475		
VI	10	197	264	334	407	471	536	
VII	2	199	274	335	384	460	538	578
Grand average		204	282	353	412	474	537	578
Increments of growth		204	79	72	64	67	68	41
Number of fish		310	284	233	123	52	12	2
(Combined)								
I	72	225						
II	133	219	294					
III	216	216	293	365				
IV	121	217	290	362	429			
V	87	215	287	358	429	494		
VI	41	213	286	360	440	506	574	
VII	6	212	286	362	433	508	565	629
Grand average		217	291	362	431	499	573	629
Increments of growth		217	75	72	70	66	66	64
Number of fish		676	605	472	256	135	48	6

curvilinear until age III, at which time the relative weight increase accelerates greatly. Lea also reports that, for Independence Lake cutthroat trout less than 225 mm, forage fish are of minor significance, but for those over 300 mm, fish become the major forage item. Hazzard and Madsen (1933) report cutthroat trout from Jackson Lake, Wyoming, also show a definite change in diet from crustacea to fish at a length of approximately 300 mm.

The condition factor ($K = W \times 10^5/L^3$) is used as an index of well-being or relative robustness. The average K of 561 Pyramid Lake Lahontan cutthroat trout, sexes and age groups combined, was 1.00. A slight sexual dimorphism is noted for condition factor, with males having a slightly higher K value than females (Table 4). This is in agreement with results from other studies. Fleener (1952) and Madsen (1940) also report higher K values for male over female cutthroat trout. However, the extent of the sexual dimorphism may vary with fish size and season; i.e., gravid females weigh significantly more just before spawning season than after. Thus the K of females is more variable than males on a seasonal basis.

A direct relationship between size and condition factor of Pyramid Lake Lahontan cutthroat trout is evident (Table 5). Lea (1963) reports a trend of increasing condition factor with increasing length for Independence Lake Lahontan cutthroat trout. Fleener (1952), however, states condition factor decreases with length for cutthroat trout from Beaver Creek, a small tributary of the Logan River, Utah. Irving (1953) says size, age, and sex are not related to condition factor for Henry's Lake cutthroat trout. It seems logical that condition factor would be directly related to fish size in lake environments where large fish have a predatory advantage. This situation occurs in Pyramid Lake since, at the critical size of about 300 mm, Lahontan cutthroat trout are able to utilize the huge forage base of tui chubs.

TABLE 2. Growth of cutthroat trout from 14 Western lakes.

		Calculated mean total length (mm) and increments at each annulus						
Location	Number	I	II	III	IV	V	VI	VII
Pyramid Lake, NV[a]	676	217	291	362	431	499	573	629
		(217)	(75)	(72)	(70)	(66)	(66)	(64)
Lower No Name Lake, WY	64	102	145	190	221	231		
(Robertson 1947)		(102)	(43)	(45)	(31)	(10)		
Priest Lake, ID	90	81	135	211	287	348	371	
(Bjornn 1957)		(81)	(54)	(76)	(76)	(61)	(23)	
Upper Priest Lake, ID	92	94	142	216	292	338	391	
(Bjornn 1957)		(94)	(48)	(74)	(76)	(46)	(53)	
White Rock and Ted's Lake, UT	22	130	185	201	221			
(Sigler and Low 1950)		(130)	(55)	(16)	(20)			
Granby Reservoir, CO		109	196	251	290			
(Finnell 1966)		(109)	(87)	(55)	(39)			
Yellowstone Lake, WY	5057	46	130	224	312	394	442	486
(Bulkley 1961)		(46)	(84)	(94)	(88)	(82)	(48)	(44)
Montana Lake, MT	2158	76	163	241	307	384		
(Peters 1964)		(76)	(87)	(78)	(66)	(77)		
Island Lake, UT	61	157	211	249	300	343		
(Sigler and Low 1950)		(157)	(54)	(38)	(54)	(43)		
Thompson Lake, MT	41	130	198	262	318			
(Echo 1955)		(130)	(68)	(64)	(56)			
Upper No Name Lake, WY	75	112	178	274	381	421	478	
(Robertson 1947)		(112)	(66)	(96)	(107)	(40)	(57)	
Blue Lake, CA	419	66	180	307	378	361		
(Calhoun 1942)		(66)	(114)	(127)	(71)			
Heenan Lake, CA	117	97	216	330	445			
(Calhoun 1942)		(97)	(119)	(114)	(115)			
Henry's Lake, ID	356	170	325	437	503	551	594	
(Irving 1953)		(170)	(155)	(112)	(66)	(48)		

[a]Fork lengths converted to total length by factors of 1.07 (189 mm – 490 mm), 1.05 (500 mm – 590 mm), and 1.03 (> 590 mm).

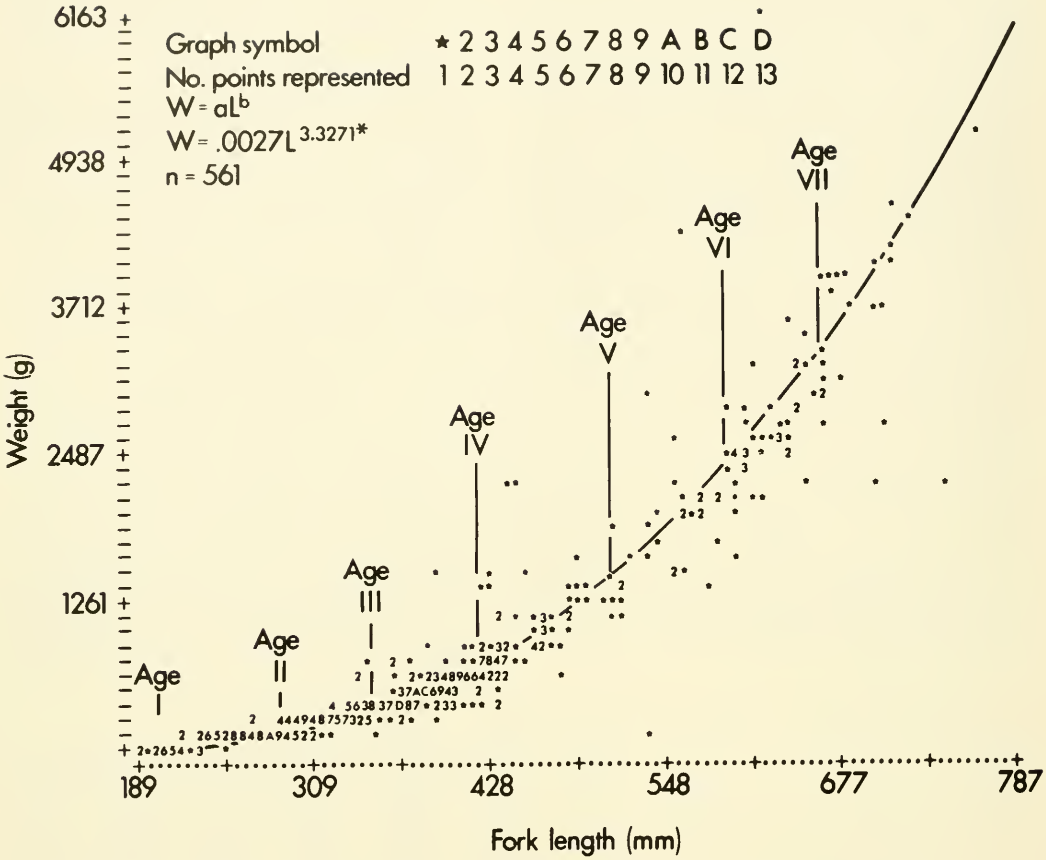

Fig. 5. Length-weight relationship of combined data for Lahontan cutthroat trout from Pyramid Lake, Nevada, November 1975 through November 1977, with mean length-weight values by age groups. FL in cm.

Conversion Factors

Factors for converting TL to FL and SL to FL for cutthroat trout from Pyramid Lake, Nevada are:

TL = 1.07 FL (189 – 490 mm)
TL = 1.05 FL (500 – 590 mm)
TL = 1.03 FL (>590 mm)
SL = .888 FL (189 – 300 mm)
SL = .893 FL (301 – 500 mm)
SL = .895 FL (>501 mm)
FL = .935 TL (202 – 524 mm)
FL = .953 TL (525 – 620 mm)
FL = .970 TL (>608 mm)
FL = 1.13 SL (168 – 266 mm)
FL = 1.12 SL (268 – 447 mm)
FL = 1.12 SL (>447 mm)

The ratios vary with size, necessitating more than one set of conversion factors. Conversion factors for cutthroat trout have been reviewed by Cope (1953).

Hatchery-reared Lahontan Cutthroat Trout, Length-weight Relationships and Condition Factors

In 1976, 612 fingerlings were taken from the Lahontan National Fish Hatchery, Gardnerville, Nevada, to determine length-weight relationships. The fingerlings represent wild Summit Lake stock ranging in fork length from 57.9 mm to 125 mm (Table 6) and Lahontan fifth-generation domestic stock, originally from Summit Lake, ranging in fork length from 40 mm to 250 mm (Table 7). The length-weight relationships are calculated as:

Summit Lake brood $W = .00001L^{2.8749}$
Lahontan brood $W = .000007L^{3.0588}$

The K-factors for domestic stock range from 1.01 to 1.21, the exponent indicating slightly faster growth in weight than length.

The K-factors for wild stock show slightly decreasing trends; the exponent is less than 3.0, indicating these fish are getting slimmer as they grow in length.

The Lahontan brood attain greater weight per length than do Summit Lake brood. The weight differences can be attributed to brood spawned from wild stock being more active (wild) and domestic stock being more passive (Lahontan National Fish Hatchery Manager, Charles R. Messier, pers. comm. 1976).

Mortality and Morbidity

Various factors may cause mortality of Pyramid Lake's trout population, including angling, death during stocking of hatchery recruits, predation on juveniles, spawning-related deaths of adults, and disease. When other decimating factors are inoperative or eliminated, senility must ultimately cause death. Among 676 Lahontan cutthroat trout sampled from Pyramid Lake during this study, no females and only four males reached age VII. Sumner's (1939) data indicates very few of the original population of Lahontan cutthroat trout lived beyond eight years, although a few may have lived to be 11.

Chemical constituents of the aquatic habitat are rarely neutral in their effects on the biota. Toxic substances often first express themselves as growth suppressants, reproductive inhibitors, increased vulnerability to disease, or destroyers of the most sensitive link in the food chain. Increased levels of TDS could be detrimental to the Pyramid Lake fishery. Walker Lake's now extinct Sacramento perch population reached its limit of "alkalinity" tolerance when it could no longer reproduce in the early 1950s. At that time, the total alkalinity was approximately 2500 mg/l as HCO_3 (Cooper 1978). In 1952, the TDS of Walker Lake was 6790 mg/l (Koch et al. 1979). Rainbow trout are stressed by and grow poorly in Pyramid Lake water; they do not survive in more concentrated alkaline waters such as Walker Lake (Knoll et al. 1979) and Omak Lake (Paul A. Kucera, pers. comm. 1982). Taylor (1972) notes that carbonate and bicarbonate salts are more toxic to Lahontan cutthroat trout at elevated TDS levels than sodium chloride alone. Elevated temperatures may have a synergistic effect on salinity toxicity and vice versa (Vigg and Koch 1980).

Mortalities range widely among fish captured and released. Hooking mortality of lure-caught cutthroat trout in Yellowstone Lake was relatively low (<6.5 percent); however, the combination of natural baits and high water temperature resulted in significantly higher mortality (Marnell 1969, Marnell and Hunsaker 1970). In Pyramid Lake, where fish <483 mm TL are illegal (as of 1 July 1982), all types of artificial lures are used. The losses from hook and release in Pyramid Lake have not been established. Legal sport fishing removed <20,000 fish in 1977, not a seriously decimating factor for the Pyramid Lake population.

Infectious disease is a potential threat to wild and cultured fish alike. Rational man-

Table 3. Length-weight relationships (linear and curvilinear) for Lahontan cutthroat trout from Pyramid Lake, Nevada, from November 1975 through November 1977.[a]

Class	Log-log transformation (linear)	Exponential (curvilinear)
(Female)	$\log_{10}W = -2.6218 + 3.3754 \log_{10}L$ ($r^2 = .95$, n = 224) F = 602.4	$W = .0023L^{3.3754}$
(Male)	$\log_{10}W = -2.8052 + 3.4778 \log_{10}L$ ($r^2 = .94$, n = 73) F = 1089.9	$W = .0016L^{3.4778}$
(Indeterminate)	$\log_{10}W = -2.3690 + 3.2023 \log_{10}L$ ($r^2 = .92$, n = 262) F = 3017.2	$W = .0042L^{3.2023}$
(Combined)	$\log_{10}W = -2.5531 + 3.3271 \log_{10}L$ ($r^2 = .94$, n = 561) F = 9293.3	$W = .0027L^{3.3271}$

[a]Equations were calculated using fork length in centimeters.

agement and utilization of any fisheries must incorporate a realistic understanding of the serious pathogens extant in the system. A fish population undergoing environmental degradation is subjected to environmental factors that may predispose the population to disease. Various interstate and international regulations have been formulated to restrict movement of serious fish pathogens.

PLITE has a program to determine the presence of pathogens in Pyramid Lake trout. Particular attention is given to those pathogens included in restrictive lists. A series of inspections begun in 1976 followed proper procedure as specified by the Fish Health Section of the American Fisheries Society and The Colorado River Wildlife Council-Fish Disease Policy (American Fisheries Society: Fish Health Section 1975). Consultation and confirmation of procedure were reviewed by Ron Goede, fish pathologist of the Utah Division of Wildlife Resources, and by Dennis E. Anderson, U.S. Fish and Wildlife Service, Fort Morgan, Colorado.

The inspections in 1977 included the following diseases and/or the pathogens inducing the diseases:

Viral:	IPN (Infectious pancreatic necrosis) (1976 & 1977)
	IHN (Infectious hematopoietic necrosis)
	VHS (Viral hemorrhagic septicemia)
Bacterial:	Bacterial kidney disease (*Renebacterium salmoninarum*)
	Enteric redmouth (*Yersinia ruckerii*)
	Furunculosis (*Aeromonas salmonicida*)
Parasitic:	Whirling disease (*Myxosoma cerebralis*)
	Blood fluke (*Sanguinicola* sp.)

Pyramid Lake and lower Truckee River fish populations were sampled by hook and line, gill net, and electrofishing. Fish were also collected from the Marble Bluff fishway and the Dunn Hatchery, Sutcliffe, Nevada.

The inspection in 1976 was conducted by Biometrics Inc., Tacoma, Washington. In 1977, the Fish Disease Control Center, U.S. Fish and Wildlife Service, Fort Morgan, Colorado, conducted inspections.

Attribute sampling for IPN in 1976 presumed a 5 percent carrier incidence and achieved 95 percent confidence limits. No evidence of any pathogen was detected in 1976 (Ferjancic 1976). Sampling in 1977 presumed a carrier incidence of 2 percent and achieved 95 percent confidence. Inspections conducted in 1977 (Ruger 1977) detected no evidence of IPN, IHN, VHS, bacterial kidney disease, enteric redmouth, furunculosis, whirling disease, or blood fluke, except 7 of 235 adults sampled at the Marble Bluff fishway were positive for furunculosis.

Sample sizes were sufficiently large to extend confidence beyond original required sampling presumption. Regulation and protocol require assumption of a 2 percent carrier incidence for 95 percent confidence in wild populations. Sample sizes in this study are sufficient at the 1 percent carrier incidence to permit 95 percent confidence in detecting IPN and at the 2 percent carrier incidence to permit 95 percent confidence in detecting all other listed diseases.

Food and Feeding Habits

Lahontan cutthroat trout in Pyramid Lake are largely piscivorous after they reach a size of approximately 300 mm. They then feed almost exclusively on tui chubs, but they may feed opportunistically on other fish and they feed to some extent on aquatic insects. Small trout feed on zooplankton and benthic invertebrates. From January through December 1976, 192 Lahontan cutthroat trout were examined for food habits; 35 had not recently fed. The highest percentage of the 35 nonfeeders occurred during the winter and early spring months when water temperatures and,

TABLE 4. Coefficient of condition for Lahontan cutthroat trout from Pyramid Lake, Nevada, fork length in mm, November 1975 through November 1977.

	Male	Female	Sexes combined[a]
N	74	225	562
Mean	1.08	1.03	1.00
Range	.634–1.416	.857–1.212	.634–1.416

[a]Includes fish in which sex was undetermined.

TABLE 5. Coefficient of condition based on increasing fork length (mm) for Lahontan cutthroat trout from Pyramid Lake, Nevada, November 1975 through November 1977.

Fork length (mm)	Number of fish	(K)
150–350	200	.831
351–550	273	.994
551–700	89	1.160

therefore, trout metabolism and feeding activity were low.

The piscivorous nature of Lahontan cutthroat trout was predictable. Fish, the most frequent food item, was eaten by 62.4 percent of the trout (Table 8). Fish also accounted for the largest volume of food (84.5 percent). Snyder (1917) found adults in lakes feed largely on minnows, with one fish from Pyramid Lake described as containing three large minnows. In Johnson's (1958) food analyses of 20 Pyramid Lake cutthroat trout, fish were dominant. Insects, zooplankton, and amphipods appear in descending order of importance. Invertebrates rather than fish are the major source of food for Lahontan cutthroat trout in two Sierra lakes, presumably because the trout occur in different areas of the lake than other species of fish (Calhoun 1942).

A diet succession from invertebrates to fish is apparent for Lahontan cutthroat trout as they increase in size (Table 9). Invertebrates make up 51.2 percent and fish 38.3 percent of the volume of food eaten by trout 198–300 mm FL. The volume of invertebrates eaten decreases with increasing trout size. Larger trout, 300–399 mm, consume 32.8 percent invertebrates and 60.8 percent fish. This is also true for Utah cutthroat trout (Sigler 1962, Sigler and Miller 1963).

Chironomids, the second most important food item, are consumed by 41.4 percent of the trout, but account for only 4.0 percent of the volume. Chironomid pupae are eaten nearly twice as frequently as larvae. This is also true for Lahontan cutthroat in Blue Lake, California (Calhoun 1944) and seasonally in Omak Lake, Washington (Paul A. Kucera, unpubl. data 1981). Platts (1959b) reports chironomidae pupae are the most important forage item for cutthroat trout in Strawberry Reservoir, Utah.

The remaining food items in the cutthroat diet were of relatively minor importance compared to consumption of fish and chironomids. Some of the items, however, can be of significant value seasonally or during certain life stages, such as zooplankton and smaller invertebrates for young-of-the-year trout. Other food items consumed in order of percent of frequency of occurrence were: terrestrial insects (10.2); amphipods, both *Hyallela* and *Gammarus* (9); algae (7.6); zooplankton (7.6); bottom substrate (4.5); Hemipterans (3.2); odonates (1.9); vascular plants (1.9); coleopterans (.6); and hydracarinads (.6).

Reproduction

The Lahontan cutthroat trout spawning migration into the Truckee River and Marble Bluff fishway peaked in April and May of 1976 and 1977 at river water temperatures varying from 8 to 16 C (Fig. 6). Although only 563 fish were captured in 1976, the run was reported to be the largest in recent years

Table 6. Expected Lahontan cutthroat trout measurements (FL) based on measurements of 200 Lahontan cutthroat trout, Summit Lake brood. Lahontan National Fish Hatchery, Gardnerville, Nevada, 1976.

Length (L) in inches	Length (L) in millimeters	Weight (W) in grams	Grams per centimeter	"K" factor	Fish per kilogram
2.16	55	1.66	.30	.99	602.94
2.36	60	2.16	.36	.99	463.37
2.55	65	2.64	.40	.96	379.11
2.75	70	3.60	.51	1.04	278.02
2.95	75	4.56	.60	1.08	219.49
3.14	80	4.88	.61	.95	205.10
3.34	85	6.21	.73	1.01	161.16
3.54	90	7.17	.79	.98	139.57
3.74	95	8.50	.89	.99	117.75
3.93	100	10.41	1.04	1.04	96.14
4.13	105	11.74	1.11	1.01	80.84
4.33	110	13.34	1.21	1.00	75.02
4.52	115	14.99	1.30	.98	66.76
4.72	120	16.91	1.40	.97	59.17
4.92	125	18.24	1.45	.93	54.87
5.11	130	20.16	1.55	.91	49.63

(U.S. Fish and Wildlife Service pers. comm. 1976). In comparison with the number of fish in the lake large enough to reproduce, this number is amazingly small. The 1977 creel census (Kennedy 1978) produced an estimated sport fishing catch of <20,000 Lahontan cutthroat trout >380 mm TL. This size is a reasonable approximation of the average length at reproductive maturity. It is obvious that the population of mature fish must be considerably greater than 563, the number that were captured. Netting did not indicate an unusual concentration of cutthroat trout in the lake near the Truckee River mouth at this time. However, large numbers of trout congregated around the Sutcliffe area where hatchery reared cutthroat are planted. As Ball (1955) postulates, since these planted fish were not imprinted on an inflowing stream, they may be milling about the area where they were originally planted.

Limited data on the maturation of female Lahontan cutthroat trout in Pyramid Lake suggest that consecutive-year spawning does

TABLE 7. Expected Lahontan cutthroat trout measurements (FL) based on measurements of 412 Lahontan cutthroat trout, Lahontan domestic brood. Lahontan National Fish Hatchery, Gardnerville, Nevada, 1976.

Length (L) in inches	Length (L) in millimeters	Weight (W) in grams	Grams per centimeter	"K" factor	Fish per kilogram
1.57	40	.65	.16	1.01	1539.84
1.77	45	.93	.20	1.02	1076.23
1.96	50	1.29	.25	1.03	775.87
2.16	55	1.73	.31	1.03	578.54
2.36	60	2.27	.37	1.05	440.92
2.55	65	2.91	.44	1.05	343.94
2.75	70	3.67	.52	1.06	272.71
2.95	75	4.54	.60	1.07	220.46
3.14	80	5.55	.69	1.08	178.57
3.34	85	6.70	.78	1.09	149.39
3.54	90	8.00	.88	1.09	125.11
3.74	95	9.46	.99	1.10	105.80
3.93	100	11.09	1.10	1.10	90.24
4.13	105	12.90	1.22	1.11	77.58
4.33	110	14.90	1.35	1.11	67.15
4.52	115	17.11	1.48	1.12	58.99
4.72	120	19.52	1.62	1.12	51.26
4.92	125	22.15	1.77	1.13	45.17
5.11	130	25.02	1.92	1.13	39.99
5.31	135	28.12	2.08	1.14	35.58
5.51	140	31.48	2.24	1.14	31.79
5.70	145	35.10	2.42	1.15	28.51
5.90	150	38.99	2.59	1.15	25.66
6.10	155	43.16	2.78	1.15	23.17
6.29	160	47.62	2.97	1.16	21.01
6.49	165	52.39	3.17	1.17	19.09
6.69	170	57.47	3.38	1.16	17.39
6.88	175	62.88	3.59	1.17	15.92
7.08	180	68.61	3.81	1.17	14.57
7.28	185	74.70	4.03	1.17	13.38
7.48	190	81.13	4.27	1.18	12.32
7.67	195	87.94	4.50	1.18	11.38
7.87	200	95.12	4.75	1.18	10.52
8.07	205	102.69	5.00	1.19	9.74
8.26	210	110.65	5.26	1.19	9.03
8.46	215	119.03	5.53	1.19	8.40
8.66	220	127.82	5.81	1.20	7.83
8.85	225	137.04	6.09	1.20	7.30
9.05	230	146.70	6.37	1.20	6.81
9.25	235	156.82	6.67	1.20	6.37
9.44	240	167.39	6.97	1.21	5.97
9.64	245	178.44	7.28	1.21	5.60
9.84	250	189.98	7.59	1.21	5.25

not occur. Judging by ovary development, several females of age groups IV and V collected prior to the spawning season were not going to reproduce the current year but would the following spring. Similar situations have been reported elsewhere. Some 1–15 percent of the cutthroat in Arnica Creek, Yellowstone National Park, spawn each year after reaching maturity, 10–26 percent are alternate-year spawners, and 46 percent skip two years (Ball and Cope 1961). Seven percent of the female Lahontan cutthroat trout in Blue Lake, California, spawned in consecutive years, and 10.5 percent of the originally marked females were in the run two years later (Calhoun 1942).

Female cutthroat trout in Pyramid Lake mature at age III or IV, when they are 352 to 484 mm FL; males mature at ages II or III, when 299 to 445 mm FL. Lahontan cutthroat trout in Independence Lake, California, mature at ages III or IV (Lea 1963). Lea attributes the presence of small numbers of mature three-year-olds to a precocial element of the population. Rankel (1976) reports spawning runs of Lahontan cutthroat trout from Summit Lake, Nevada, consist mainly of four-year-old fish. If an alternate-year spawning pattern is typical, then most female Lahontan cutthroat trout in Pyramid Lake will spawn a maximum of twice in their lifetime. If they mature at age IV, they may live to spawn only once. Some of those that mature at age III may spawn again at age V.

The sex ratio of Lahontan cutthroat trout in our net catches was 1 male:4.23 females ($n = 455$). This is not representative of the population in the lake. The ratio of males to females in the spawning runs was variable, i.e., 1.06:1 in 1976 and 1:2.35 in 1977. The ratios of Summit Lake Lahontan cutthroat trout spawning runs, from 1968 to 1975, varied from 1:1.3 to 1:2.2 and averaged 1:1.6 males to females (Rankel 1976). Angling is male-selective in Pyramid Lake. This is also true in Omak Lake (Paul A. Kucera, pers. comm. 1981).

Female Lahontan cutthroat trout spawn after attaining an average gonadal somatic index (percent gonad weight to total body weight) of 11 percent. The progression in gonadal somatic indices, observed from October through December 1977, indicates a steady increase in germinal growth through the

Table 8. Food of 157 Lahontan cutthroat trout, Pyramid Lake, Nevada, 1976.

Food item	Frequency	Percentage frequency of occurrence	Rank	Volume in ml	Percentage of total volume	Rank	Percentage of total volume excluding digested matter
Fish	98	62.42	1	1225.7	82.89	1	84.50
Chironomidae larvae	22	14.01	3	11.6	0.78	6	0.80
Chironomidae pupae	43	27.39	2	46.8	3.16	3	3.23
Odonata	3	1.91	9	2.7	0.18	9	0.19
Coleoptera	1	0.64	10	0.7	Trace[a]	13	Trace[a]
Hemiptera	5	3.18	8	1.0	Trace[a]	12	Trace[a]
Terrestrial insects	16	10.19	4	19.6	1.33	5	1.35
Amphipoda	14	8.92	5	9.2	0.62	8	0.63
Ostracoda	3	1.91	9	1.4	Trace[a]	11	0.10
Zooplankton	12	7.64	6	10.9	0.74	7	0.75
Algae	12	7.64	6	93.1	6.30	2	6.42
Vascular plants	3	1.91	9	2.0	0.14	10	0.14
Hydracarina	1	0.64	10	Trace[a]	Trace[a]	14	Trace[a]
Bottom substrate	7	4.46	7	25.8	1.74	4	1.78
Digested matter	18	11.46		28.2	1.91		–
Total				1478.7	99.98		99.89

[a]Trace = less than 0.1

winter. The largest increase involves a shift from an average value of 5.9 percent in November to 8.1 percent in December.

The diameter of mature eggs of Pyramid Lake Lahontan cutthroat trout range from 2.76 to 5.09 mm and average 4.51 mm. Monthly progression in egg sizes from October through December 1977 indicated a consistent, gradual increase in ovum size. The mean egg diameter in December was 4.11 mm, with some eggs as large as 4.60 mm. Some females may be able to spawn in

TABLE 9. Percentage of total volume and frequency of occurrence of food items consumed by Lahontan cutthroat trout from Pyramid Lake, Nevada, in relation to size. Trout were captured from January through December 1976 with bottom-set gill nets.

Food item	Volume	Percent of total volume	Frequency by occurrence	Frequency of occurrence by percent
Size group 99–198 mm (n = 1)				
Fish	1.0	100.0	1	100.0
Fork length = 184 mm	Weight = 54 g			
Size group 198–300 mm (n = 22)				
Fish	12.1	38.3	11	50.0
Benthic invertebrates	12.2	38.6	12	54.5
Terrestrial insects	4.0	12.7	2	9.5
Zooplankton	0.5	1.6	1	4.8
Digested matter	2.0	6.3	2	9.5
Vascular plants	0.8	2.5	1	
Mean fork length = 251 mm	Mean weight = 136 g			
Range = 203–297 mm	Range = 54–240 g			
Size group 300–399 mm (n = 63)				
Fish	67.1	60.8	42	66.7
Benthic invertebrates	27.6	25.0	25	39.7
Terrestrial insects	7.3	6.6	7	11.1
Zooplankton	1.3	1.2	2	3.2
Periphyton	2.6	2.4	2	3.2
Vascular plants	1.0	0.9	1	1.6
Bottom substrate	Trace[a]	Trace[a]	1	1.6
Digested matter	3.4	3.1	3	4.8
Mean fork length = 356 mm	Mean weight = 408 g			
Range = 305–398 mm	Range = 218–730 g			
Size group 399–498 mm (n = 60)				
Fish	530.7	77.8	35	58.3
Benthic invertebrates	30.0	4.4	25	41.7
Terrestrial insects	8.3	1.2	8	13.3
Zooplankton	9.1	1.3	8	13.3
Periphyton	57.5	8.4	9	15.0
Vascular plants	0.2	Trace[a]	1	1.7
Bottom substrate	23.5	3.4	6	10.0
Digested matter	22.8	3.3	9	15.0
Mean fork length = 434 mm	Mean weight = 789 g			
Range = 400–498 mm	Range = 476–1496 g			
Size group 500 + mm (n = 11)				
Fish	615.8	94.1	10	90.9
Benthic invertebrates	3.6	0.5	1	9.1
Periphyton	33.0	5.0	1	9.1
Bottom substrate	2.3	0.4	1	9.1
Mean fork length = 531 mm	Mean weight = 1741 g			
Range = 500–596 mm	Range = 1161–2753 g			

[a]Trace = less than 0.1

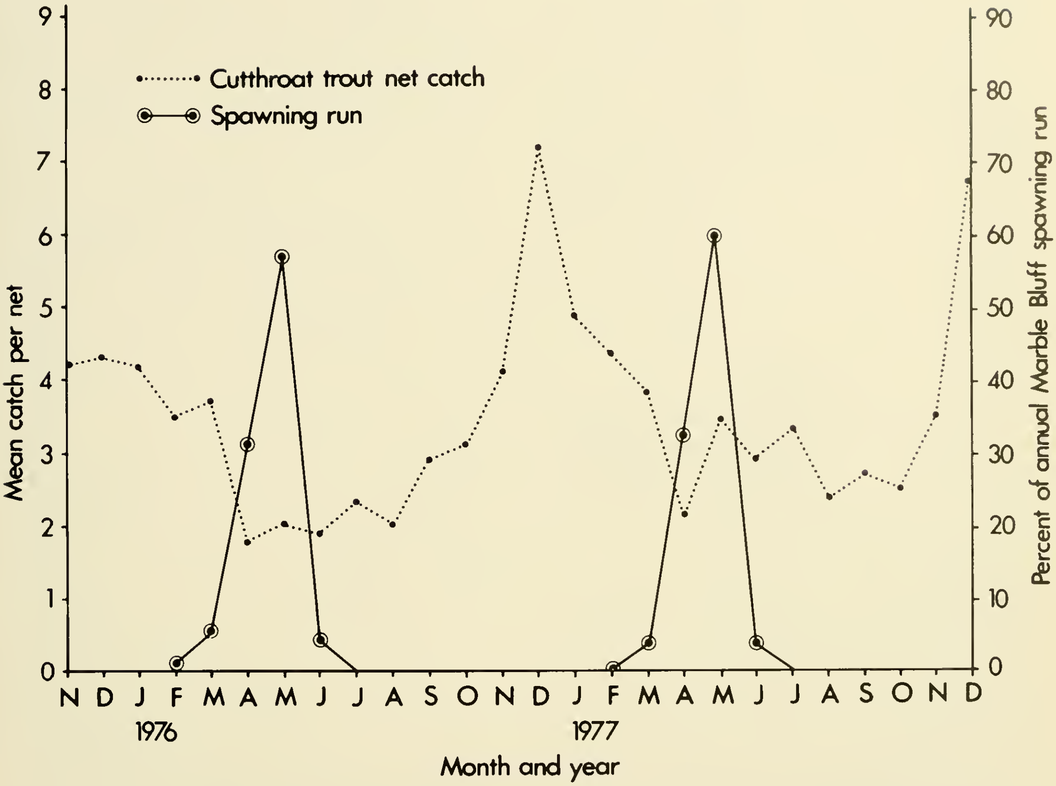

Fig. 6. Mean monthly Pyramid Lake cutthroat trout catches (15 gill net sets per month) from November 1976 through December 1977, in comparison with the spawning runs at the Marble Bluff fish passage facility.

December or January. For example, as early as January, 1981 and 1982, mature cutthroat were running up a small stream south of Sutcliffe, Nevada, artificially produced by pumping about .057 m^3/sec of lake water through rearing ponds and allowing it to run back into the lake. Egg size is positively correlated with fish length ($r = .48$; $P<0.05$) and weight ($r = .51$; $P<0.05$), indicating that egg size increases with fish size.

The number of eggs produced by a female Lahontan cutthroat trout is significantly related to age, fork length, and weight ($P<0.05$). The above relationships have significant linear fits with and without $\log_{10}$ transformation of data. Fork length provides the best predictor for fecundity, followed by weight and age. Increases in fecundity correspond to increases in length and weight. The $\log_{10}$ equation for fork length and fecundity is $\log_{10}F = 2.83 (\log_{10}FL) - 4.16$, and for weight and fecundity is $\log_{10}F = .81 (\log_{10}WT) + .92$. These fish range in fecundity from 1241 to 7963 and average 3815 eggs per female. Lea (1963) reports fecundities of Lahontan cutthroat trout in Independence Lake, California, vary from 669 to 2080 eggs and average 1191 eggs per female.

Habitat and Ecology

The most characteristic feature of the Pyramid Lake environment is the high level of salts; TDS concentration was about 5350 mg/l during 1976–1977 (Sigler and Kennedy 1978). Although sodium chloride is the dominant salt (over 70 percent), alkalinity may be the most important constituent. The mean pH is 9.2. The historic increase in TDS levels was associated with the decline in lake level (Fig. 7). Since the baseload of salts is relatively constant, TDS varies inversely with the volume of the lake. Various studies, although preliminary in nature, have demonstrated that NaCl is relatively innocuous, but alkalinity (HCO_3 + $CO_3^=$) is toxic to salmonids

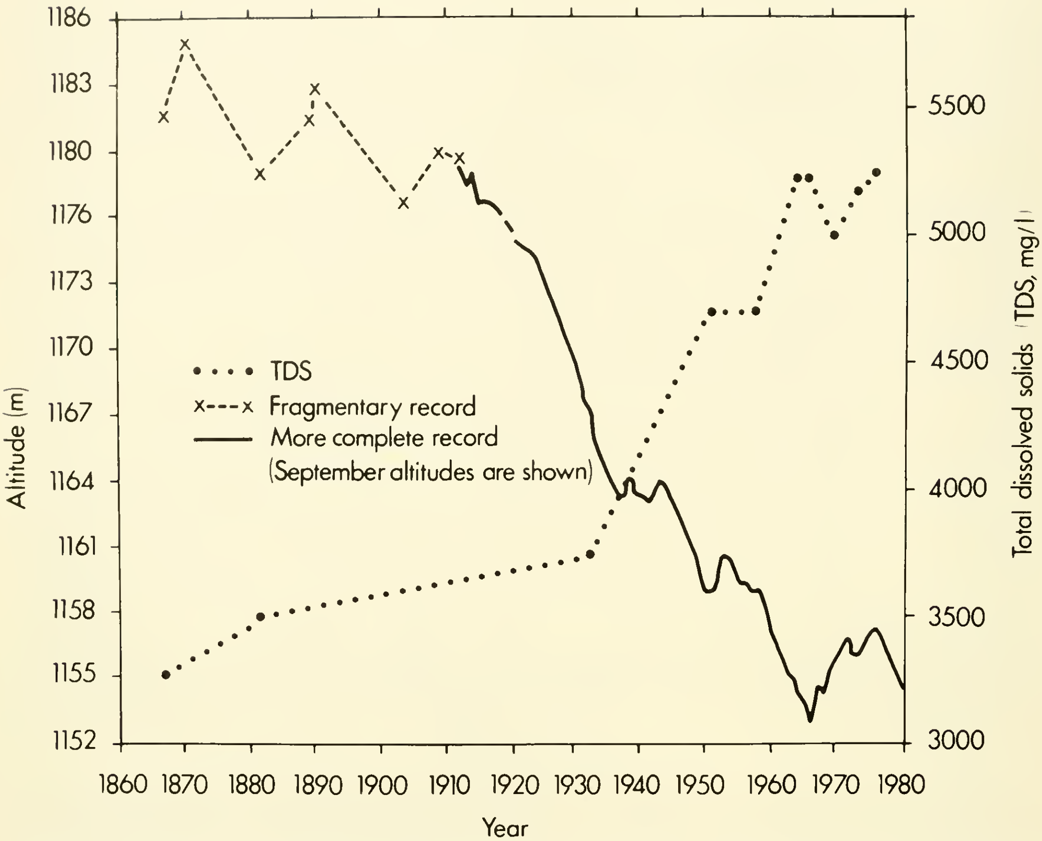

Fig. 7. Water level and total dissolved solids fluctuations in Pyramid Lake, Nevada, 1867–1979 (From Galat et al. 1981).

(Beatty 1959, Mitchum 1960, Taylor 1972, Knoll et al. 1979).

The five major species of fish in Pyramid Lake, in order of relative abundance are: tui chub, Tahoe sucker, Lahontan cutthroat trout, cui-ui (*Chasmistes cujus*), and Sacramento perch (*Archoplites interruptus*). Although numerous species have been introduced, the current species composition is almost exclusively represented by the original fish species, the only exception being the Sacramento perch (Vigg 1981). This fact is probably due to the harsh environmental conditions of Pyramid Lake, specifically the TDS levels. In contrast, exotic fish introductions have nearly extirpated the native fish fauna of oligotrophic (low TDS) Lake Tahoe at the upper end of the Truckee River (Miller 1951).

The maximum surface (0–1 m) water temperature in Pyramid Lake was 21.4 and 23.1 C in July 1976 and August 1977, respectively. The lake is thermally stratified from June through December; wind-generated mixing occurs from January through May. The thermocline forms at a depth ranging from 16 to 22 m. The euphotic depth averaged 11 m for 1976 and 1977, which resulted in a trophogenic zone of about 4.67 km^3 (Galat et al. 1981).

Surface-dissolved oxygen (DO) is above 8 mg/l, and thus not limiting to fish. Meta- and hypolimnetic DO depletion occurs beginning in July following stratification and algal decomposition; maximum DO deficits occur in the profundal zone just prior to late fall mixing. Hypolimnetic DO deficits in stratified lakes are generally associated with decomposition of organic matter, which is generated by primary production in surface water, and gradually sink to the bottom. During December, the mean DO level is <4 mg/l at depths

>61 m and <0.2 mg/l at depths >92 m (Vigg 1980). In contrast to the anoxic conditions, which are very limited on a temporal and spatial basis in Pyramid Lake, Walker Lake exhibits extensive DO depletions that severely restrict fish distribution (Cooper 1978, Koch et al. 1979).

Diatoms (*Cyclotella* sp. and *Stephanodiscus* spp.) dominate the phytoplankton community during winter; but the most abundant chlorophyte, *Crucigenia* sp., attains maximum abundance in spring (Sigler and Kennedy 1978). Blue-green algae are by far the dominant form in Pyramid Lake, comprising >74 percent. *Nodularia spumigena* is the most abundant species; blooms begin as early as July and may last as late as October. Temporal nutrient dynamics inversely relate to phytoplankton abundance. Following vernal increases of algal growth, orthophosphate and nitrate are depleted and remain at low levels during the summer period of maximum primary production. Silica, in addition to nitrate, probably limits diatom production in Pyramid Lake (Galat et al. 1981).

Benthic macroinvertebrates, periphyton, and zooplankton all are important energy sources for juvenile fish in Pyramid Lake. Diatom domination of the periphyton community is demonstrated by sampling with glass slides (<99 percent). The chlorophyte, *Cladophora glomerata*, was the dominant epilithophyton in Pyramid Lake during May and June in 1976 and 1977 (Sigler and Kennedy 1978). Chironomids are the lake's most abundant macroinvertebrates (63 percent), followed by Oligochaetes (33 percent), which are especially abundant in the profundal zone (Robertson 1978). Two euryhaline amphipods, *Gammarus lacustris* and *Hyallela azteca*, are associated with tufa and rocks. The zooplankton community is composed of five cladocerans, three copepods, and four rotifers (Lider and Langdon 1978). The cladoceran, *Diaptomus sicilis*, is a perennial species and the most abundant zooplankter throughout the year.

The Lahontan cutthroat trout is the third most numerous fish in Pyramid Lake. Compared to the more abundant tui chubs and Tahoe suckers, the trout population is numerically small, about 1.3 percent (Vigg 1981). However, the relative biomass of the Lahontan cutthroat trout population is estimated at 6.4 percent. Theoretically, the biomass of a primary piscivore such as cutthroat trout may be as much as 20 percent of the biomass of the fish forage (McConnell et al. 1978). The trout population at present is far below its theoretical maximum.

Activity of the Lahontan cutthroat trout population is at a maximum from December through March. Peak spawning migrations occurred during April and May in 1976 and 1977 (Fig. 6). In 1978 the run was from March 8 to June 13 (Wolcott 1978). The greatest trout activity observed in our study corresponds very closely to the historical spawning period of the winter race of Pyramid Lake Lahontan cutthroat trout (Snyder 1917). Snyder observed that the spawning migrations of Lahontan cutthroat occurred in two distinct periods. The larger winter run of trout out of Pyramid and Winnemucca lakes began following the rise in river flows October–December; the spawning migration extended through March. As the winter run waned, the spring run of the smaller, darker, and more heavily spotted trout commenced. This migration peaked in April and extended to May.

The sport fishing catch was highest in winter, corresponding to the high catches in the 1975–1977 net sampling program (Figure 8). The proportion of large trout was greatest during winter. The high level of winter activity of the Pyramid Lake population of Lahontan cutthroat trout is apparently a manifestation of innate spawning-related behavior. The larger and older spawners in the cutthroat trout population in Yellowstone Lake are predominant in the early part of each spawning run, with the smaller spawners comprising the latter part of the runs (Bulkley and Benson 1962).

The differences between the 1976–1977 Marble Bluff spawning runs and the activity patterns of the lake population of cutthroat trout may be explained by three factors: (1) few Pyramid Lake Lahontan cutthroat trout were apparently imprinted on the Truckee River; (2) the spawning runs were composed of a disproportionately large number of cutthroat-rainbow hybrids that were raised (thus imprinted) in the Truckee River watershed;

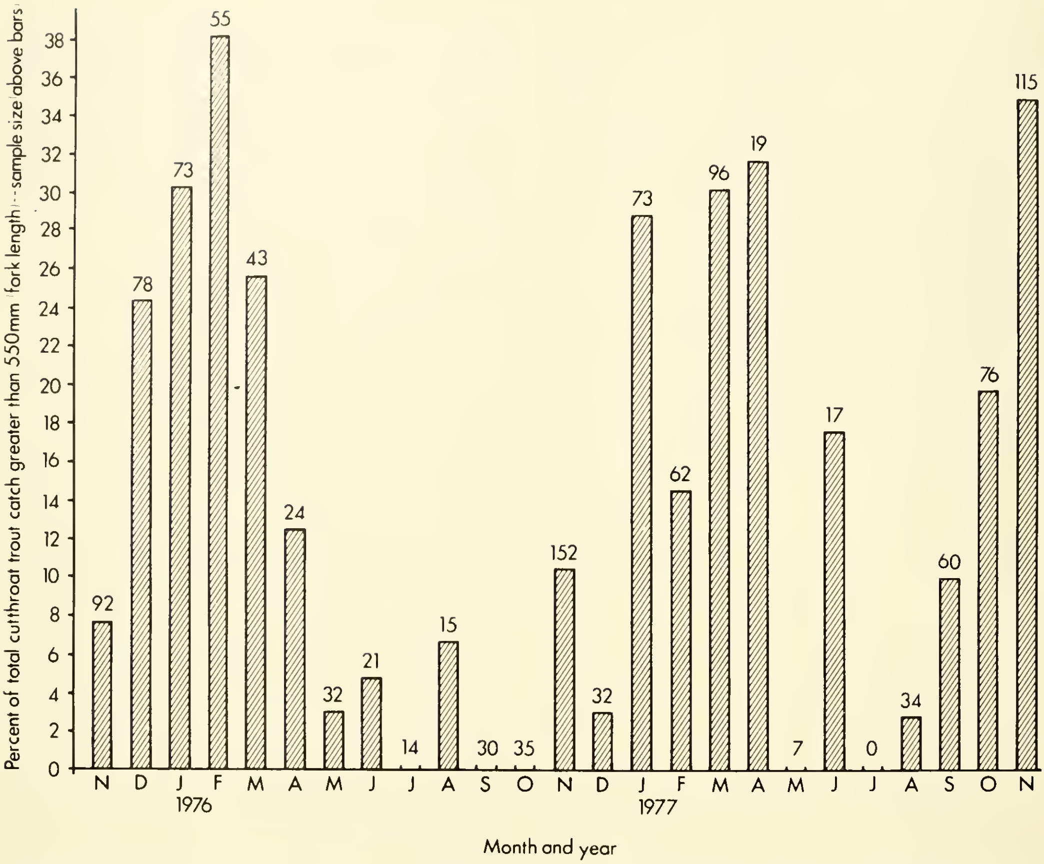

Fig. 8. The proportion of large (>550 mm) cutthroat trout taken in the monthly bottom-set gill net catches in Pyramid Lake, Nevada, November 1975 through 1977.

and (3) Lahontan cutthroat trout are probably genetically programmed for winter as well as spring spawning, but early winter peak flows are now diminished or eliminated by diversions. For example, during 1976 flows in the lower river peaked in March and steadily decreased to the lowest annual level in December (U.S. Geological Survey 1977).

Spawning cutthroat trout instinctively return to the stream in which they were born (Ball 1955, Platts 1959a, McCleave 1967, Jahn 1969). Their olfactory development patterns indicate cutthroat trout are capable of imprinting on a home stream odor at a very early age (Jahn 1972). Moreover, mature cutthroat are able to return to home streams even when deprived of their sense of vision or smell, indicating an inborn "compass" homing mechanism.

Ball (1955) says, since predetermination of spawning site is established by early life stream association, streams can be lost as nursery areas if no natural reproduction occurs, even though mature adults are present in the lake. Ball postulates that nonimprinted fish, such as gravid adults, may randomly move throughout a lake or mill about in the area where they were planted.

On an annual basis the majority of Lahontan cutthroat trout in Pyramid Lake occur at depths <61 m (Fig. 9). Compared to other species, its depth preference is intermediate, and most closely associated with that of tui chub. There is a differential seasonal depth distribution of cutthroat trout (predator) and tui chub (prey) in Pyramid Lake, i.e., inshore versus 46 m (Fig. 10). Cutthroat trout apparently prefer inshore areas during all seasons except summer, when shallow water temperatures are high. Tui chub are generally inshore during spring and summer, intermediate during autumn, and offshore during

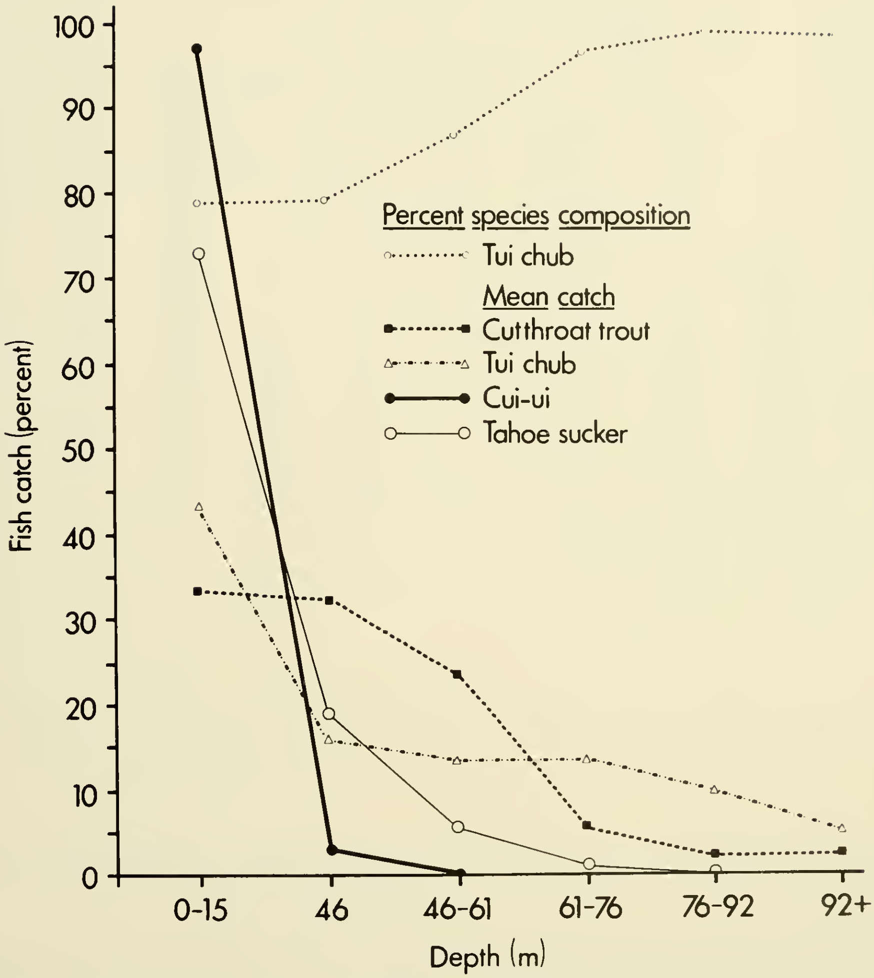

Fig. 9. Percent species composition of tui chub and percent of the mean catch of cutthroat trout, tui chub, cui-ui, and Tahoe sucker by depth in Pyramid Lake, Nevada. Data are derived from the total catch of 108 bottom gill net sets on a quarterly basis (September, December, March, and June) during 1976–1977 (Vigg 1980).

winter. Maximum overlap of the two populations occurs during spring, the period of maximum cutthroat trout growth. The two species are opposite with respect to depth distribution during winter, when trout metabolism and feeding are low.

Changes in net catch/effort and benthic depth distribution of cutthroat trout occurred on a seasonal basis in 1976–1977 (Vigg 1978). During late fall and winter, when the total catch rate of cutthroat trout was about 1.5 times that of other seasons, they inhabited predominantly inshore areas. As surface water temperatures increase from 10 to 16 C during late spring, the trout population moves into cooler, deeper waters (Fig. 11). This temperature relationship clearly illustrates the habitat preference of Lahontan cutthroat trout for cooler waters than their prey the tui chub. The lowest summer density of cutthroat trout occurs in littoral benthic and inshore surface waters, and the highest density in benthic waters in or below the thermocline. During the summer months, cutthroat are well represented at depths of 20–60 m in benthic areas, while avoiding the surface waters of the offshore limnetic zone. From June to October the majority of the limnetic trout are at depths of 15–28 m with negligible numbers at greater depths (Vigg

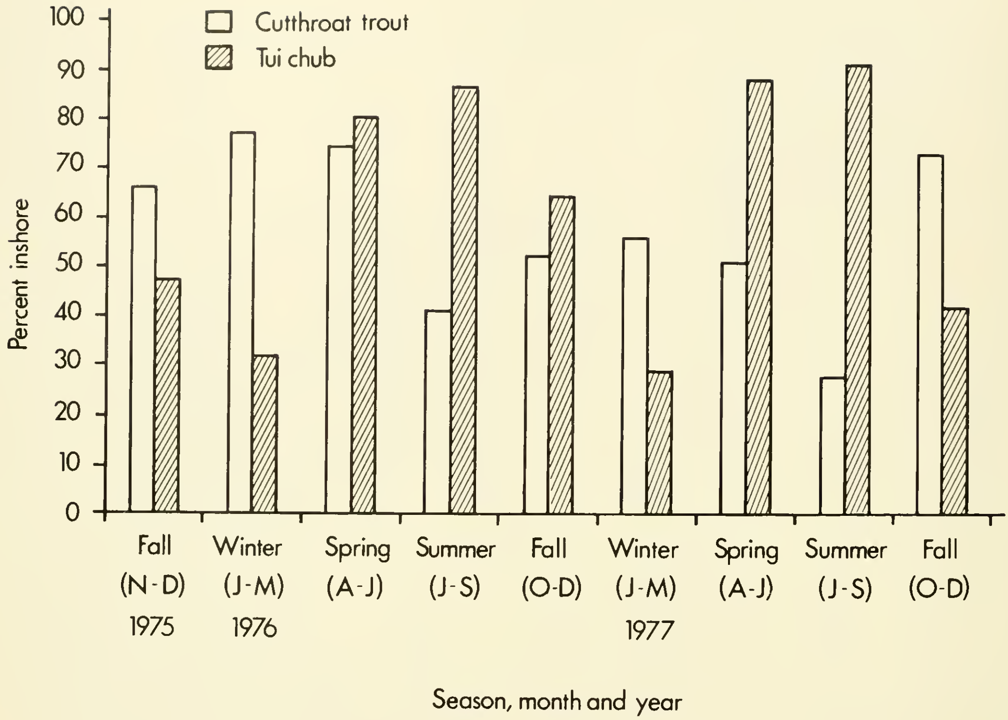

Fig. 10. Percent of the total seasonal variable mesh bottom-set gill net catches of cutthroat trout and tui chub taken at inshore (versus 46 m) sampling stations in Pyramid Lake, Nevada, from November 1975 through December 1977.

1980). As surface temperatures cool below 16 C in the fall, trout return to surface waters and inshore areas.

The profundal zone of Pyramid Lake (>61 m), which constitutes about half of the bottom area and 20 percent of the volume, is nearly devoid of cutthroat trout in summer. Temperatures at these depths are less than 7 C during all seasons, and oxygen is low during the fall and early winter. Cutthroat trout densities are slightly higher in the profundal zone during winter, but this deep area is not an important habitat for trout (Sigler and Kennedy 1978).

Management

Management of any fishery should ensure that biological, social, economic and political values are given appropriate consideration so as to produce maximum benefits to society from a given stock of fish. Although the primary beneficiary of the Pyramid Lake fishery is the Pyramid Lake Paiute Indian Tribe, society, the secondary beneficiary, must also be satisfied if the goal of the tribe is to be reached. This goal, as articulated by the U.S. Justice Department, is to produce a viable fishery in Pyramid Lake. The above statement may be assumed to be synonymous with or an extended definition of *viable fishery.*

As far as can be determined, there is virtually no natural reproduction of Lahontan cutthroat trout in the Truckee River at present. An important aspect of the management program should be to reestablish successful spawning runs in the Truckee River (Innis et al. 1981). This will require rehabilitation to stabilize stream banks and provide shade to reduce water temperatures, installation of fish ladders to permit spawning adults to migrate upriver, fish screens to keep downstream migrants from entering irrigation canals, and augmented stream flow during critical seasons. Sufficient water will be required for adults to migrate in winter and early spring; to keep temperatures below 13.3 C through the fry stage; and below

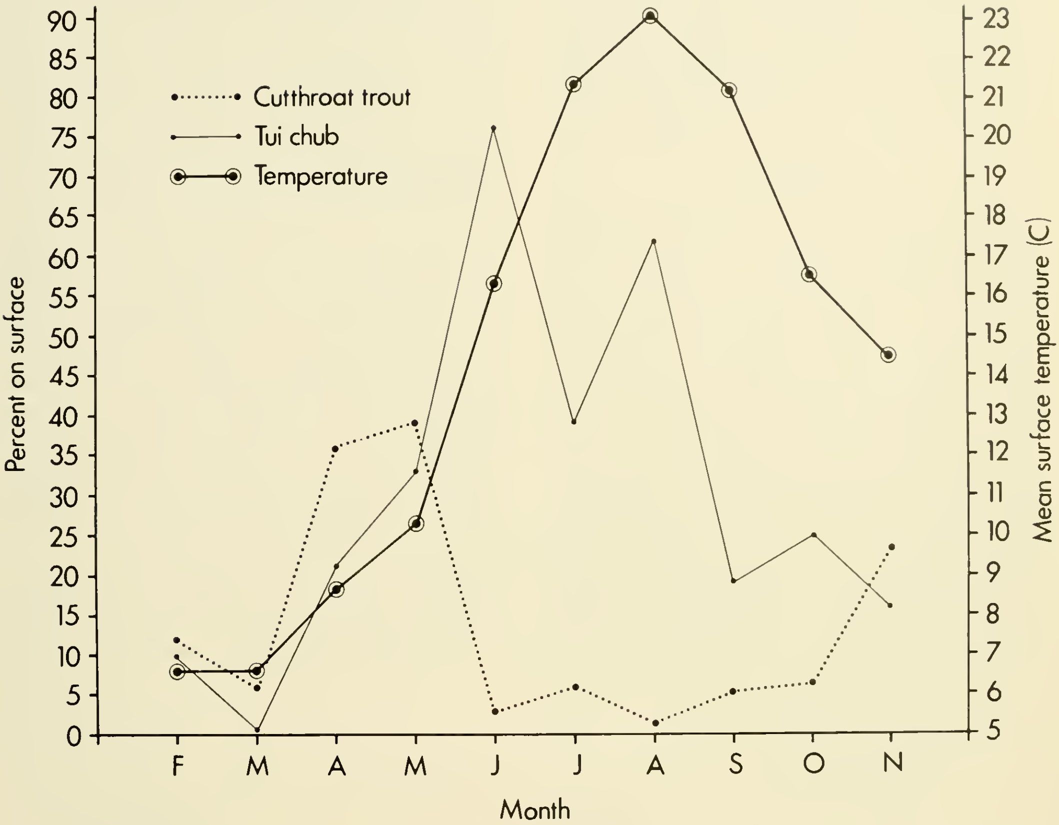

Fig. 11. Percent of the catches of cutthroat trout and tui chub taken on the surface from surface and bottom gill nets (adjusted to unit of net area) at the 23 m depth in Pyramid Lake, Nevada, from February through November 1977.

21.8 C (Vigg and Koch 1980) during juvenile residence. Since it will take years to restore river habitat, the Lahontan cutthroat trout population must be sustained by stocking.

The catch rate of legal size (>380 mm TL) Lahontan cutthroat trout in 1977 was approximately one fish per 14 hours of effort. Under the minimum legal size of 457 mm the catch rate was one fish per 18.9 hours (Alan Ruger, pers. comm. 1982). Catch rates should be increased five- to tenfold to fall within acceptable limits. This will require substantially increased recruitment rates and the reduction of incidental causes of mortality. Since mature fish appear to congregate in the vicinity of stocking sites in late fall, winter, and early spring, during the time when sport fishing is best, some of the stocking effort should be directed to the vicinity of popular fishing areas and access points (Table 10).

Unless Lahontan cutthroat trout have been imprinted on Truckee River water, they are disinclined to attempt to ascend the river to spawn. Some hatchery fish should be stocked in the lower river to initiate a spawning run. The trout reared in the PLITE Numana Hatchery may be imprinted on the Truckee River because the hatchery outfall runs into the river. The reasons for the very substantial spawning runs of Lahontan cutthroat trout up the Sutcliffe outflow (>9000 in 1982) appears to contradict some long-held beliefs and raises more questions than answers. Alan Ruger (pers. comm. 9 June 1982) thinks the fish are returning to hatchery odors, such as fish feed and juvenile fish. The modified annual temperature regime in the Truckee River, due to the regulation in flow that will be necessary to provide for all uses, must be considered in planning for the reestablishment of natural reproduction in the river. Temperatures acceptable for spawning and incubation of eggs exist during winter and early spring; thus successful natural reproduction in the river will depend in part on an early spawning migration. Behnke (1979) suggests selecting maximum-size fish at first maturity for breeding stock. He also recommends using the genetic diversity in remnant stocks to produce the best-adapted strain to Pyramid Lake conditions. As pointed out by Snyder (1917), Pyramid Lake Paiute Indians early in the century recognized two spawning runs of Lahontan cutthroat trout: one involved large fish in late November, December, and January; the other occurred in the spring when the smaller fish spawned. The spring-spawning fish always faced the hazards of high water temperatures, but not at the level that exists today. Competition for river flows is much more intense in spring than in winter. It is generally agreed that some remnant of the original gene pool of Lahontan cutthroat trout persists. Therefore, some of the present population should and apparently do tend to spawn in winter. When hatchery brood stock are to be used as a source of eggs, a program of selective breeding utilizing early-spawning fish should be initiated. Stocking in the river and lake should be limited to Lahontan cutthroat trout; hybrids should not be utilized.

Benthic invertebrates are the major food source of Lahontan cutthroat trout until they exceed 300 mm FL. Survival of smaller stocked fish may be limited by the availability of benthic invertebrates. The feasibility of stocking fish as large as 300–330 mm, and their survival and costs in comparison to the size conventionally stocked, should be evaluated. In view of the larger number of trout that must be stocked, introducing larger fish could eliminate benthic invertebrate abundance as a limiting factor and thus increase survival rates of stocked fish.

Currently all trout <483 mm TL that are landed must be released. The present catch rate of undersized fish is much greater than

TABLE 10. Comparison of gill netting catch rate, surface water temperature, and trout fishing success during 1977 at Pyramid Lake, Nevada.

	Gill net data			
	Fish per net (inshore)		Percent (inshore)	
	Monthly	Two-month $\bar{X}$	Monthly	Two-month $\bar{X}$
January	35		52	
		33.5		53
February	32		54	
		31		59
March	30		63	
		20		54
April	10		39	
		19.5		54
May	29		64	
		22.5		54
June	16		42	
		13		30
July	10		21	
		10.5		25
August	11		28	
		14		33
September	17		37	
		21.5		50
October	26		65	
		24.5		57
November	23		50	
		44.5		76
December	66		92	
January				
February				
March				

those fish longer than 483 mm. The reason for releasing a fish is the assumption that it will survive to spawn and/or be caught later. This assumption should be tested, and the size limit implemented accordingly.

The Lahontan cutthroat trout now in Pyramid Lake probably is physiologically capable of hybridizing with rainbow trout. A population of mature rainbow trout in the middle and upper Truckee River where Lahontan cutthroat trout spawn would, therefore, potentially threaten the maintenance of the lake strain. In addition, brown trout residents in the upper Truckee River will compete with and prey on young Lahontan cutthroat trout. Since a large part of the Truckee River is managed by the Fish and Game Department of California and the Nevada Wildlife Department, the decision is theirs to implement reduction in the nonnative resident populations of the river fish.

Nonfishing recreation on Pyramid Lake represents approximately 500,000 hours of use annually. This use is concentrated during the summer months, but lasts from May through November. Nonfishing recreationists currently represent a significant segment of the lake users, almost twice the use of fishing effort (Fig. 12).

Summary

The lake form of Lahontan cutthroat trout is the largest of all cutthroat. Its ancestors invaded ancient Lake Lahontan from the Columbia River drainage about 70,000 years BP. Before the coming of white men, the Lahontan cutthroat trout was a staple in the diet and an item of trade for the Paiute Indians of Pyramid Lake. Later, both white men and Indians commercialized the trout fishery in markets as far away as San Francisco. At one time the annual production may have been as much as 454,000 kg. In 1943 the last of the Lahontan cutthroat trout disappeared from Pyramid Lake. Very few had been seen after 1938. Lahontan cutthroat and other trout were stocked in the lake

Table 10 continued.

Water temperature surface	Total catch	Fish kept	Percent fish kept	Trout per hour: Total catch rate	Trout per hour: Catch rate of fish kept	$\bar{X}$ size keeper
6.81	4381	3180	73	.0837	.0608	523
6.60	4993	2495	50	.0956	.0471	538
6.60	7266	3193	44	.1558	.0685	521
8.73	1926	820	43	.0946	.0403	529
10.28	301	101	34	.0458	.0154	478
16.32	439	164	63	.0849	.0317	437
21.28	60	60		.0073	.0073	
23.12	26	26		.0130	.0130	
21.21	2234	750	34	.3471	.1165	459
16.51	5846	1992	34	.3246	.1106	455
14.50	9164	3495	38	.3452	.1317	498
11.50	7205	3654	51	.2250	.1141	488
7.80	4970	2050	41	.1211	.0499	556
7.10	2997	969	32	.0755	.0244	565
10.00	4941	1924	38	.1513	.0589	482

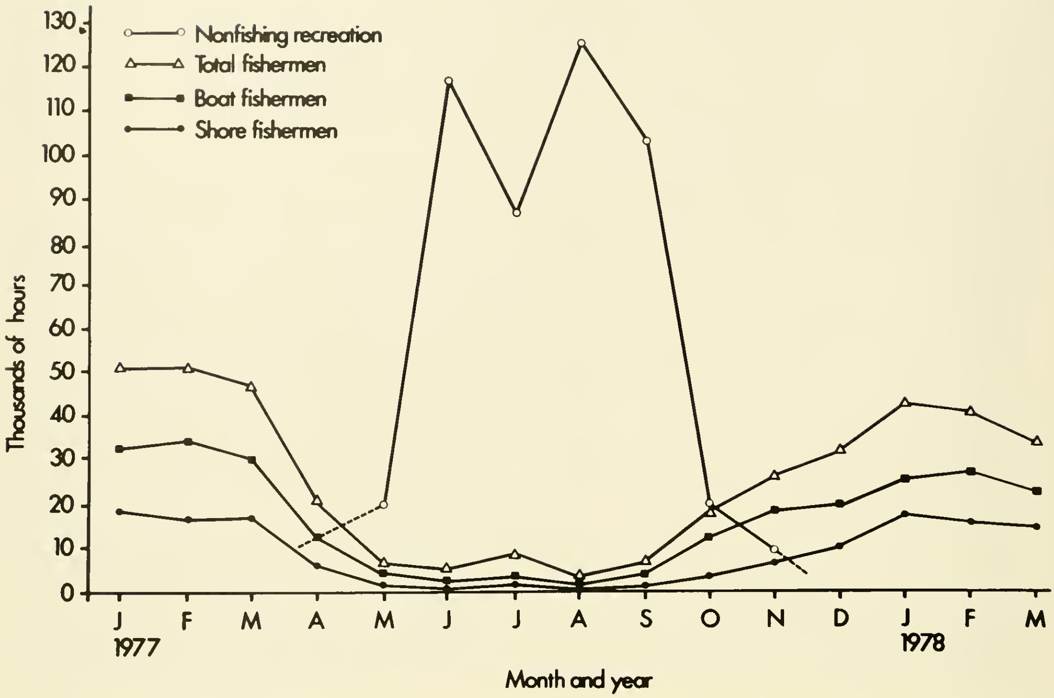

Fig. 12. Hours per month of fishing and nonfishing recreation at Pyramid Lake, Nevada, in 1977–1978.

starting in 1950. Today, there is virtually no natural reproduction.

Lahontan cutthroat trout in Pyramid Lake live six to seven years. They start maturing at age three to four, some as early as December or as late as April, May, or June. There may be what amounts to two potential spawning runs. An average-size female produces about 3815 eggs and is mature when the gonadal somatic index reaches 11 percent. None of the eight potential disease organisms explored in 1976–1977 were considered a hazard. The fish are most active in the lake from December through March, a time of most fishing effort. Cutthroat <300 mm feed primarily on invertebrates; after that size they feed heavily on fish. Five species of fish constitute >99 percent of the population. They are, in order of abundance, tui chub, Tahoe sucker, Lahontan cutthroat trout, cui-ui, and Sacramento perch.

Pyramid Lake, entirely within the Pyramid Lake Paiute Indian Reservation, is the terminus of the Truckee River, which is its only source of water except for a few desert showers. The average annual loss to evaporation is 1.2 m. The lake is 40 km long, 6.5 to 16 km wide, covers an area of 446.4 km^2, and has a mean depth of 59 m and a maximum of 103 m. Derby Dam, completed in 1905, effects a transbasin diversion of part of the Truckee River flow. The TDS of Pyramid Lake in 1977, at an altitude of 1157 m, was 5235 mg/l. The base load of TDS is reasonably stable. Pyramid Lake stratifies into three well-defined layers in June–July. It destratifies in December–January. It is a midlevel productivity lake. Pyramid Lake, a remnant of Lake Lahontan, has a pH of 9.2 and is high in carbonates and bicarbonates. Summer surface temperatures are 21–23 C. There is ample dissolved oxygen in the epilimnion and thermocline at all times. Nodularia, a blue-green alga, dominates much of the lake from late summer to early fall. Diatoms dominate the periphyton communities. Chironomids are the most abundant macroinvertebrates.

Conclusions

The Lahontan cutthroat trout fishery in Pyramid Lake is currently not a viable one. The annual catch was <20,000; the rate, one fish for >14 hours effort, when the minimum legal size was 381 mm TL. Fishing success should be increased in the magnitude of five–ten times. Any adverse changes in the lake ecology may stress the fish that will in turn make them more susceptible to disease. The 1905 diversion of the Truckee River, which in dry years may take most of the flow, reduced available stream spawning area for the cutthroat from >500 km to <62 km of substandard stream. Derby Dam, over a period of 25 years, doomed the historical cutthroat fishery. Successful reproduction in the lower river demands stable riparian habitat and water temperatures <13.3 C, until after spawning-hatching-fry emergence and <21.8 C thereafter. Brood stock or wild egg-producing fish for hatcheries should be selected for large size at first maturity and for winter or early spring maturing. Part of the maturing fish in the lake should be imprinted on the Truckee River. Since the effluent from Numana Hatchery flows into the Truckee River, it may be these trout will be imprinted. The biological implications of the large run of cutthroat into the Sutcliffe flow should be explored in depth.

Since the base load of TDS is constant in Pyramid Lake, the concentration varies inversely to lake volume. Any significant increase in TDS may prove harmful to key organisms in the food chain and to the trout. The median level of productivity that Pyramid Lake currently enjoys is considered more desirable than a higher level for Pyramid Lake Lahontan cutthroat trout.

Acknowledgments

This work was performed under Bureau of Indian Affairs contract H50C14209487. Assistance and cooperation was provided by employees of W. F. Sigler & Associates Inc. (WFSAI), members of the Pyramid Lake Paiute Indian Tribe, and the U.S. Fish and Wildlife Service, Fisheries Assistance Office, Reno, Nevada. Denise Robertson and Roy Whaley, formerly of WFSAI, were responsible for the two sections on age and growth, and food habits, respectively. The manuscript was reviewed by Alan Ruger, fisheries director, Pyramid Lake Indian Tribal Enterprises, Sutcliffe, Nevada.

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A REVIEW OF THE GENUS *SOLIPERLA* (PLECOPTERA: PELTOPERLIDAE)

Bill P. Stark[1]

Abstract.— The western Nearctic stonefly genus *Soliperla* is reviewed and six species are recognized. *Soliperla sierra* (Calif.) and *S. tillamook* (Ore.) are described as new to science and illustrations of diagnostic features are presented for all species. Males and nymphs are keyed and a phylogeny for the group is proposed.

Soliperla was proposed by Ricker (1952) as a monotypic subgenus of *Peltoperla* to contain *P. thyra* Needham & Smith. At that time the species was known only from the male holotype but Jewett (1954) described the female along with males and females of two additional species, *P. campanula* and *P. quadrispinula*; the nymph of *P. campanula* was also described at this time. Jewett (1955) described the fourth member of the group, *P. fenderi*, from a single male. These species have remained poorly known since their discovery, with only synoptic notes and regional keys (Jewett 1959, 1960) appearing until Stark and Stewart (1981) gave additional characters that supported Illies's (1966) elevation of the group to generic status.

During recent field work with colleagues in Washington, Oregon, and California, *Soli perla* nymphs were common in splash zones of small streams and springs. Through this work, nymphs were associated for the four known species, and the additional material collected along with specimens obtained from museums permits the first comprehensive treatment of *Soliperla*. Methods were given by Stark and Stewart (1981).

Soliperla Ricker

Peltoperla (*Soliperla*) Ricker 1952: 157. Type-species of subgenus: *Peltoperla thyra* Needham & Smith. Monotypic.

Soliperla Illies 1966:26.

Adults and nymphs of *Soliperla* are unusual among Nearctic Peltoperlidae in displaying distinctive pigmentation patterns. Adults are typified by a dark mesal pronotal stripe that contrasts sharply with the light yellow background (Figs. 23, 31), and nymphs have conspicuous white areas on the abdominal terga that contrast with the dark background (Figs. 4, 15). Monophyly for the group is asserted on the basis of the distinctive epiproct, with recurved crenulate apex and the membranous pair of lobes associated with the epiproct (Figs. 5, 13). The genus is currently known from the western Nearctic region from central California to Washington (Fig. 1).

Keys to *Soliperla* males

1.	Mesoventral area of aedeagus with two irregular longitudinal rows of short, thick setae (Figs. 3, 30)	2
—	Mesoventral area of aedeagus with short, thick setae, if present, not in longitudinal rows	3
2(1).	Lateral aedeagal lobes terminating in sclerotized spine with 2–4 small subapical setae (Fig. 29)	*sierra*

[1]Department of Biology, Mississippi College, Clinton, Mississippi 39058.

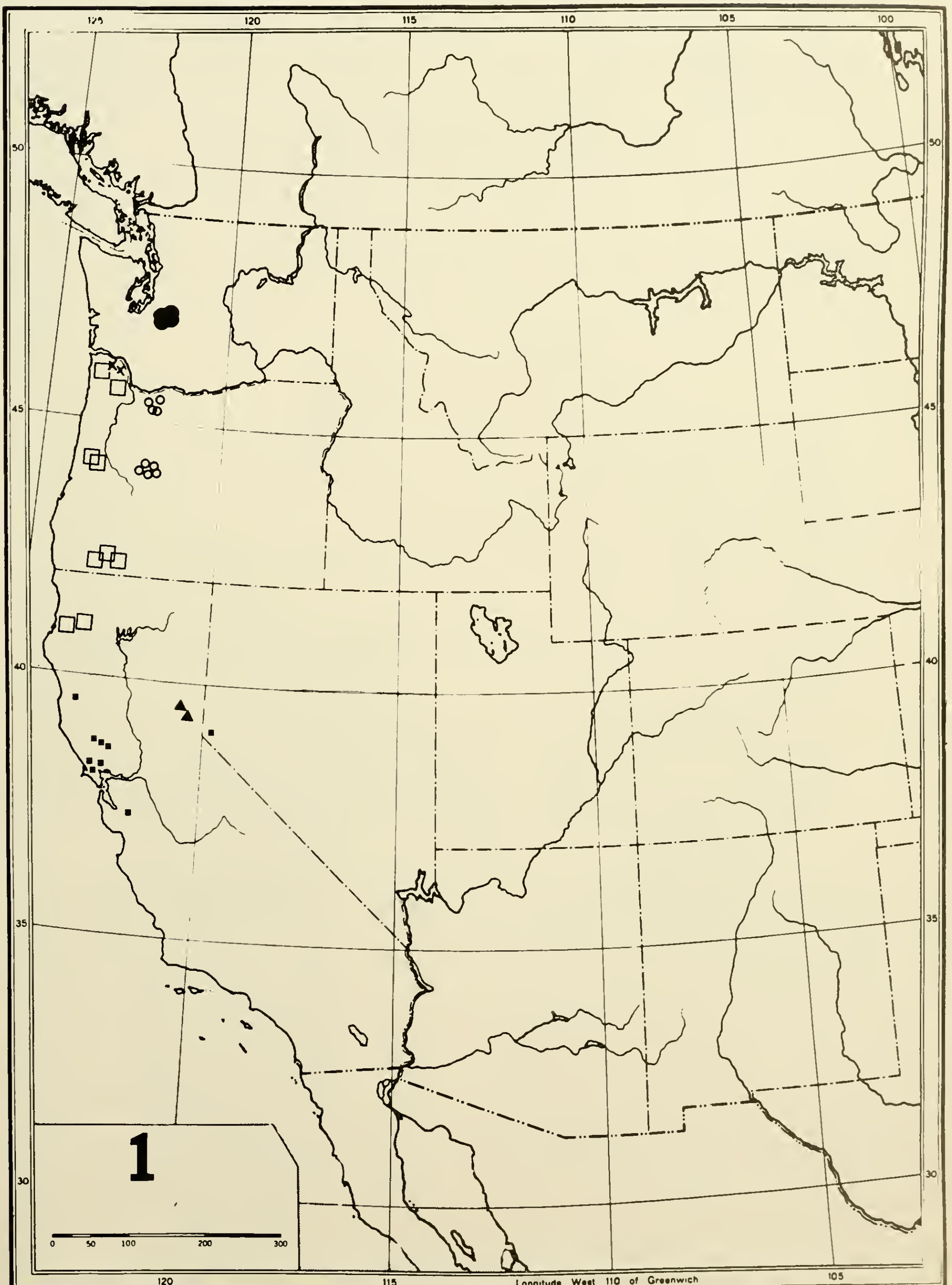

Fig. 1. Distribution of *Soliperla* species. *S. campanula* = open circles, *S. fenderi* = closed circles, *S. quadrispinula* = open squares, *S. sierra* = triangles; *S. thyra* = closed squares, *S. tillamook* = x.

— Lateral aedeagal lobes membranous apically with 2–4 small subapical setae (Fig. 2) .... *campanula*

3(1). Ventral aedeagal lobes with large sclerotized spine or a single long, thick seta (Figs. 19, 35) 4

— Ventral aedeagal lobes membranous with numerous scattered setae (Figs. 12, 45) 5

4(3). Ventral aedeagal lobes with sclerotized bilobed process (Fig. 35) .... *thyra*

— Ventral aedeagal lobes with a terminal long, thick seta (Fig. 19) .... *quadrispinula*

5(3). Ventral aedeagal lobes with irregular row of long, slender setae along apical margin (Fig. 12) .... *fenderi*

— Ventral aedeagal lobes with scattered short setae along apical margins (Fig. 45) .... *tillamook*

Preliminary key to nymphs
(*sierra* and *tillamook* unknown)

1. Some long setae in abdominal tergum 9 posterior fringe bent (Fig. 39); abdominal tergum 5 typically with lateral pale spots (Fig. 22) 2

— Long setae in abdominal tergum 9 posterior fringe straight (Fig. 6); abdominal tergum 5 typically without pale spots (Fig. 4) 3

2(1). Mesal area of abdominal tergum 8 posterior fringe with ca 20 clavate setae between long setae (Fig. 40); mesal pale spots on abdominal terga 5 and 6 rounded (Fig. 38) .... *thyra*

— Mesal area of abdominal tergum 8 posterior fringe with ca 5–7 clavate setae between long setae; mesal pale spots on abdominal terga 5 and 6 irregularly linear to triangular (Fig. 22) .... *quadrispinula*

3(1). Lateral pale spots on abdominal tergum 4 conspicuously larger than mesal spot (Fig. 15); known from Mt. Rainier, Washington .... *fenderi*

— Lateral pale spots on abdominal tergum 4 subequal to mesal spot in size (Fig. 4); widely distributed in northern Oregon .... *campanula*

Soliperla campanula (Jewett)

Peltoperla (*Soliperla*) *campanula* Jewett 1954: 167. Holotype ♂ (CAS), Oxbow Springs, Hood River Co., Oregon

Jewett (1954) detailed the major diagnostic features of this species. Males are distinguished from other *Soliperla* by the structure of the epiproct and aedeagus. The anterodorsal face of the epiproct is about twice as wide as the stalk, and the lateral margins are curved inward near the crenulate antero-ventral surface (Fig. 5). Approximately 12–14 irregular teeth are present along this surface. The ventral aspect of the aedeagus includes a large mesal lobe and two small lateral lobes. The mesal lobe has two irregular rows of about 5–10 short peglike setae, and the lateral lobes have 2–4 subapical peglike setae (Fig. 3).

Females cannot be distinguished with certainty from several related species, and the eggs (Figs. 7, 8) also seem to lack features that would distinguish them from other members of the genus. The species is currently known only from northern Oregon (Fig. 1).

MATERIAL EXAMINED.—Oregon: *Clackamas Co.*, Mt. Hood, near Timberline Lodge, 31-V-77, K. W. Stewart, S. W. Szczytko, 2 ♂ (reared) (NTSU); same location, 20-VII-67, S. G. Jewett, 1 ♀ (USNM); Mt. Hood, Still Crk. Cmp. Gnd., 12-VII-79, B. Stark, K. W. Stewart, 2 ♂ (BPS); trib. Still Crk, Mt. Hood, 17-VI-67, S. G. Jewett, 1 ♂ (USNM); Mt. Hood, 1.2 mi N Hwy 26, 20-VII-67, J. Wold (USNM); trib. Salmon Riv, Mt. Hood, 15-VII-54, S. G. Jewett 1 ♂ (USNM). *Hood River Co.*, Oxbow Springs, 26-V-40, S. G. Jewett, 1 ♂, 1 ♀ (OSU); Iron Crk, W of Bennett's Pass, 11-VII-68, E. Evans, 1 ♂, 2 ♀ (USNM). *Lane Co.*, McRea Crk, H. J. Andrews Exp. For., 6-VII-78, B. Frost, 1 ♂, 1 ♀ (OSU); Mack Crk, H. J. Andrews Exp. For., 25-VI-74, N. H. Anderson, 1 ♂ (OSU); 12.5 mi NE Blue Riv, H. J. Andrews Exp. For., 19-VII-78, B. Frost (OSU). *Linn Co.*, Ice Cap Crk, 7-VII-66, J. Bedea,

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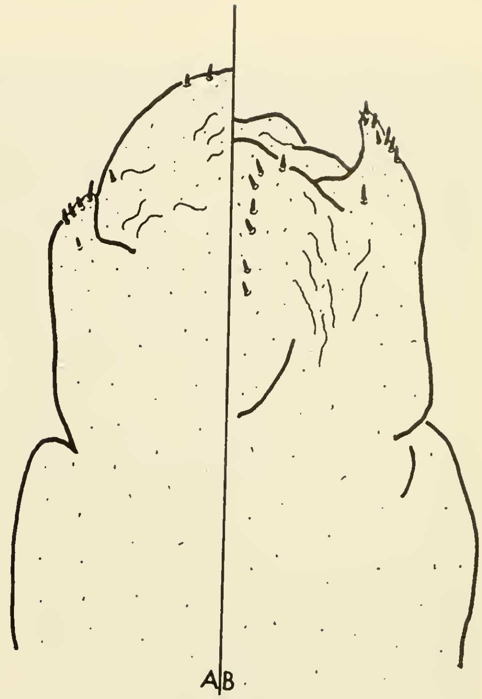

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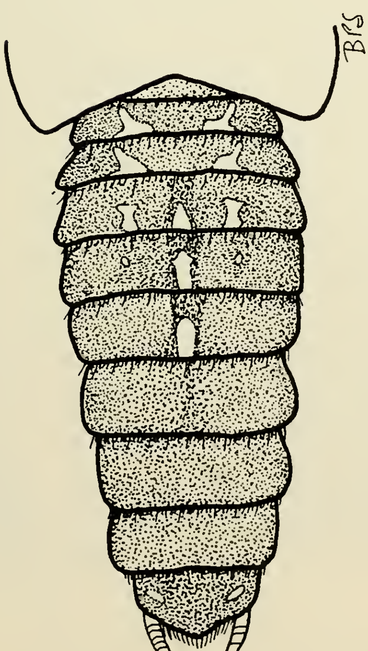

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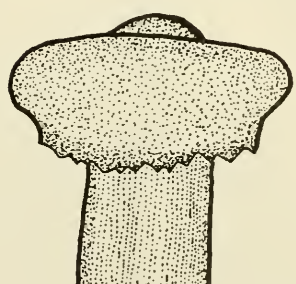

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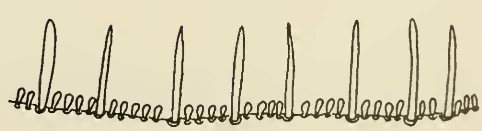

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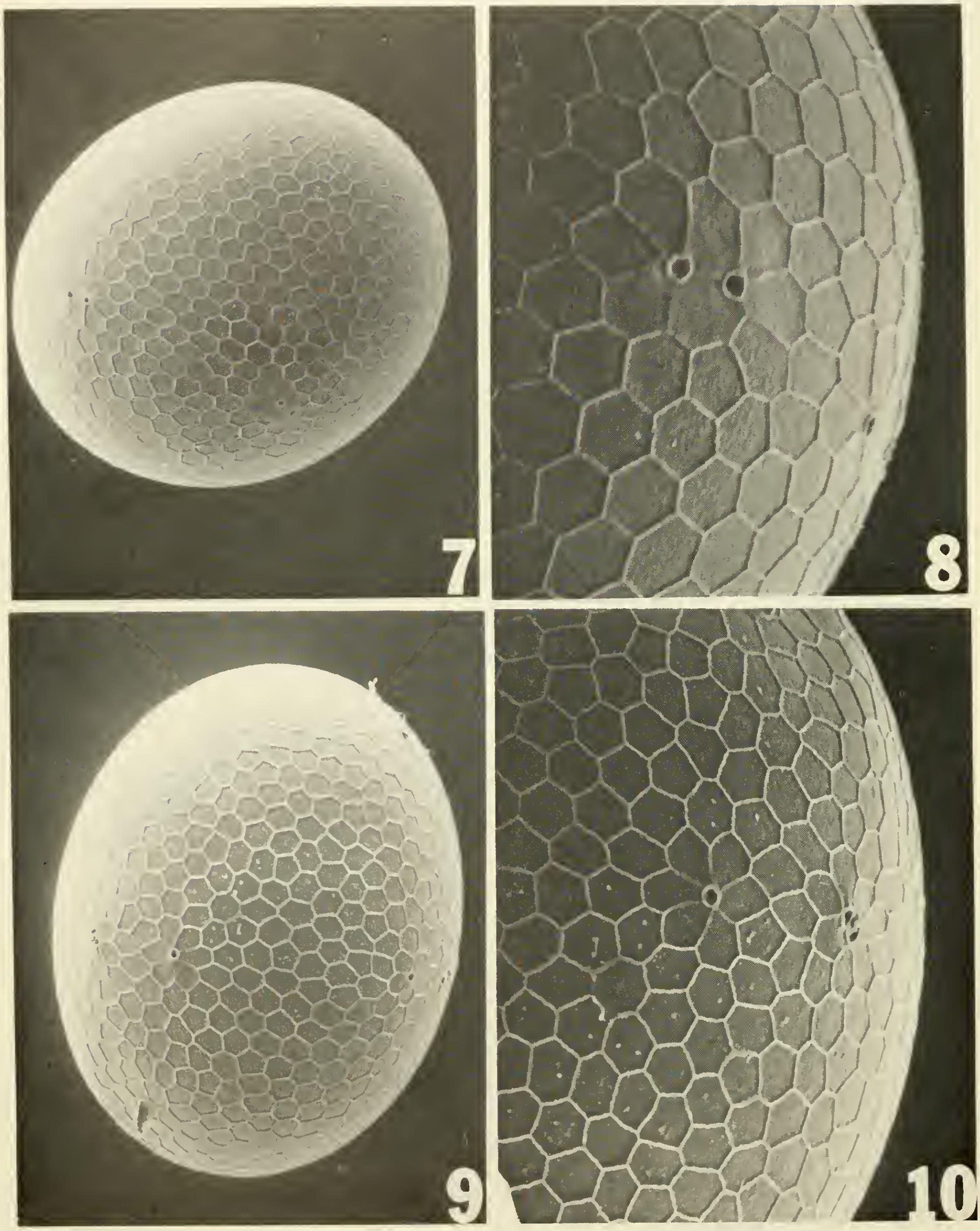
Figs. 2–6. *S. campanula*. Fig. 2. Aedeagus, lateral. Fig. 3. Aedeagus, A = dorsal, B = ventral. Fig. 4 Nymphal abdomen, dorsal. Fig. 5. Epiproct, anterodorsal. Fig. 6. Nymphal abdominal tergum 8, posterior fringe.

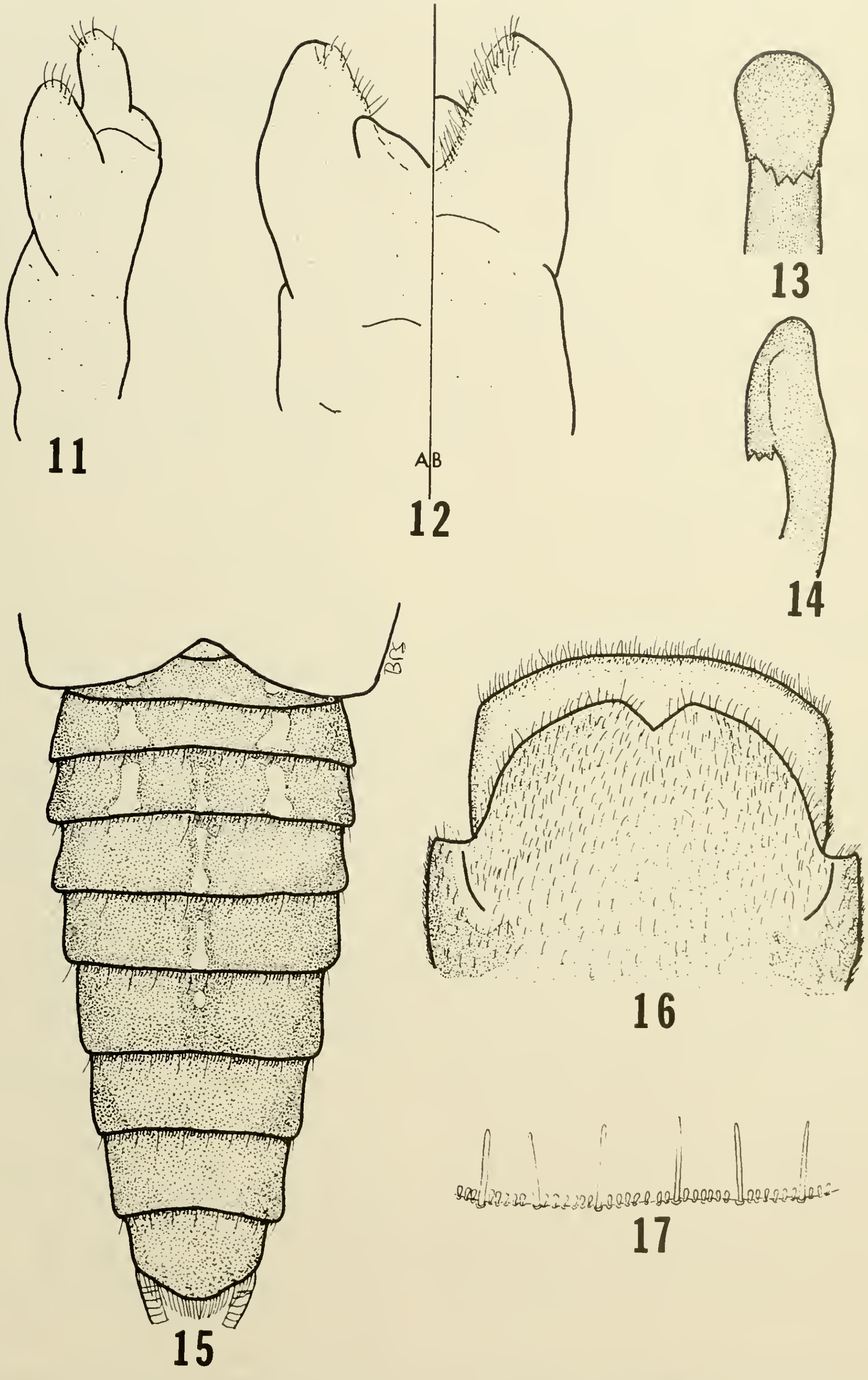


Figs. 7–10. *Soliperla* eggs. Fig. 7. *S. campanula*, 280X. Fig. 8. *S. campanula*, 1000X. Fig. 9. *S. fenderi*, 300X. Fig. 10. *S. fenderi*, 1000X.

2 ♂ (OSU); 14 mi NE Blue Riv, H. J. Andrews Expt. For., 6-VII-78, B. Frost 1 ♂ (OSU). *Multnomah Co.*, Wahkeena Falls, 3-V-47, S. G. Jewett, 2 ♂, 2 ♀ (ROM) (OSU); same location, 4-V-82, R. W. Baumann & S. G. Jewett, 1 ♂ (MLB).

Soliperla fenderi (Jewett)

Peltoperla (*Soliperla*) *fenderi* Jewett 1955: 145. Holotype ♂ (SGJ), Saint Andrews Crk, Mt. Rainier Natl. Pk., Washington



Figs. 11–17. S. *fenderi*. Fig. 11. Aedeagus, lateral. Fig. 12. Aedeagus, A = dorsal, B = ventral. Fig. 13. Epiproct, anterodorsal. Fig. 14. Epiproct; lateral. Fig. 15. Nymphal abdomen, dorsal. Fig. 16. Female sterna 8 and 9. Fig. 17. Nymphal abdominal tergum 8, posterior fringe.

Jewett's (1955) description of this species from a single male included diagnostic features of the epiproct and aedeagus. The anterodorsal face of the epiproct is about the same width as the shaft and is armed by about 5–6 teeth along the anteroventral surface (Fig. 13). The apical aedeagal section has two large membranous ventral lobes that have long slender setae in an irregular row along the distal margins (Fig. 12).

Females are distinguished on the basis of the shallow V-shaped notch on the subgenital plate (Fig. 16) and the eggs (Figs. 9, 10) are typical of the genus. This species is presently known only from Mt. Rainier National Park, but a single nymph collected by R. W. Baumann near Snoqualmie Pass could be this species (Fig. 1).

MATERIAL EXAMINED.— Washington: *Pierce Co.*, Mt. Rainier Natl. Pk. spring seeps along St. Andrews Crk, 13-VII-79, B. Stark, K. W. Stewart, 1 ♀ (reared) 7 nymphs (BPS); same location, 29-VI-81, K. W. Stewart, W. Shephard, 10 ♂, 6 ♀ (reared); small stream at Reflection Lk, 14-VII-79, B. Stark, K. W. Stewart 1 ♂ (reared) (NTSU). Seeps along Puyallap Riv, 29-VI-81, K. W. Stewart, W. Shephard, 1 ♂, 2 ♀ (reared) (NTSU). Christina Falls, 15-VI-69, R. W. Baumann, 1 ♂ (MLB).

Soliperla quadrispinula (Jewett)

Peltoperla (*Soliperla*) *quadrispinula* Jewett 1954: 169. Holotype ♂ (CAS), Wrangle Gap Camp, Jackson Co., Oregon

Jewett's (1954) description suggested that the aedeagus of this species, as the name implies, has four prominent spines. I have found considerable variation in this character even within individuals taken from the same locality. However, all males examined had a single long, thick seta on each ventral lobe (Fig. 19); the variation occurs in the number of these setae on the dorsal lobes. The range of variation seen in this character extends from no setae (found on one male from Oak Crk, Benton Co., Oregon) to 4 setae (found on several individuals from Jackson Co., Oregon). The epiproct, as Jewett (1954) indicated, is similar to that of S. *campanula*, but the dorsal carina on the anterodorsal face is not developed mesally and the lateral margins near the anteroventral surface curve outward (Fig. 20).

The female and egg (Figs. 25, 26) are indistinguishable from several others in the genus. The species has the largest known range for any member of the genus. Records are presently from northern Oregon (Clatsop Co.) to northern California (Humboldt and Trinity Cos.). Adults reared from Fieldbrook, California, mated readily in captivity but did not mate with S. *thyra* specimens from Napa Co., California.

MATERIAL EXAMINED.— California: *Humboldt Co.*, Grassy Crk, Fieldbrook, 22-V-82, B. Stark, D. Ziegler, 6 ♂, 3 ♀ (reared), 54 nymphs (BPS) (NTSU). **Oregon:** *Benton Co.*, Parker Crk, 1-VII-71, G. Steyskal, 1 ♂ (USNM); Oak Crk, 8-VI-79, P. Hammond, 3 ♀ (BK); same location, 10–13-V-69, C. Kerst, 1 ♂ (OSU); same location, 4–7-VI-68, 1 ♀ (OSU). *Clatsop Co.*, Osweg Crk, 2 mi E Elsie, 30-V-64, S. G. Jewett, 1 ♂ (ROM). *Jackson Co.*, 1.5 mi N Wrangle Cmp., 8-VII-79, B. Stark, K. W. Stewart, 19 ♂, 4 ♀, 4 nymphs (BPS) (NTSU); 15 mi S Talent, 8-VII-79, B. Stark, K. W. Stewart, 6 ♂, 3 ♀, 6 nymphs (BPS) (NTSU). *Josephine Co.*, Lake Crk, Oregon Caves Natl. Mon., 9-VII-79, B. Stark, K. W. Stewart, 1 ♀ (reared) (BPS). *Yamhill Co.*, 5 mi E Hack Crk Rd-Hwy 5 jct, 13-V-82, K. W. Stewart, D. Ziegler, 1 ♀ (reared) (NTSU).

Soliperla sierra, n. sp.

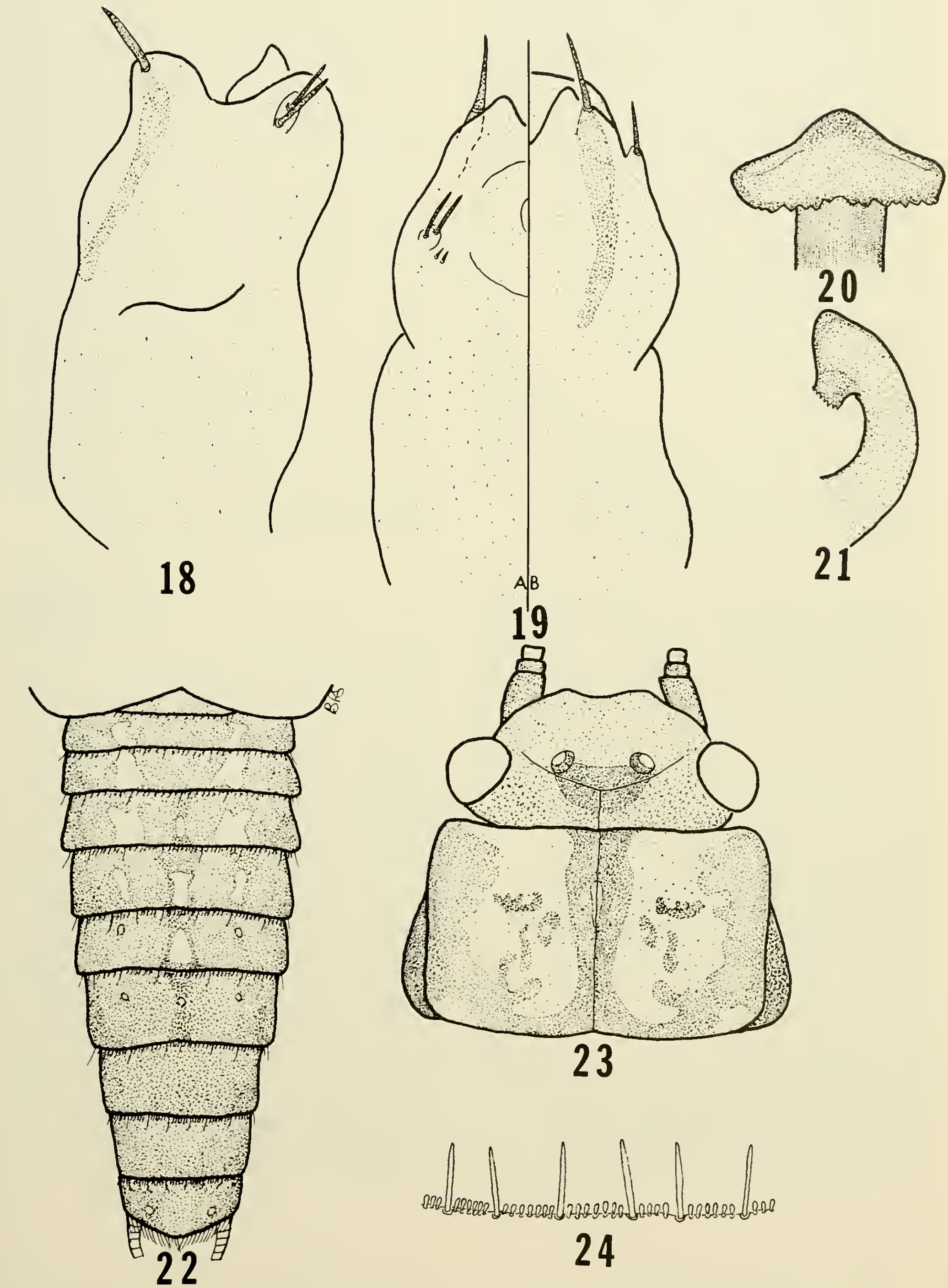
MALE.— Body length, 10 mm; forewing length, 12 mm. General color yellow patterned with light brown. Head without brown markings; pronotum with long light spot in mesal dark stripe (Fig. 31). Anterodorsal face of epiproct about 2× wide as stalk, lateral margins curved to anteroventral margin; mesal teeth widely separated (Fig. 32). Ventral lobe of aedeagus with 2 irregular mesal rows of about 5–8 short, thick setae; lateral lobes with a large conical terminal spine and about 2–4 subapical short, thick setae (Fig. 30).

FEMALE.— Body length, 12 mm; forewing length, 14 mm. General color similar to male. Subgenital plate large, parabolic, reaching posterior margin of sternum 9.

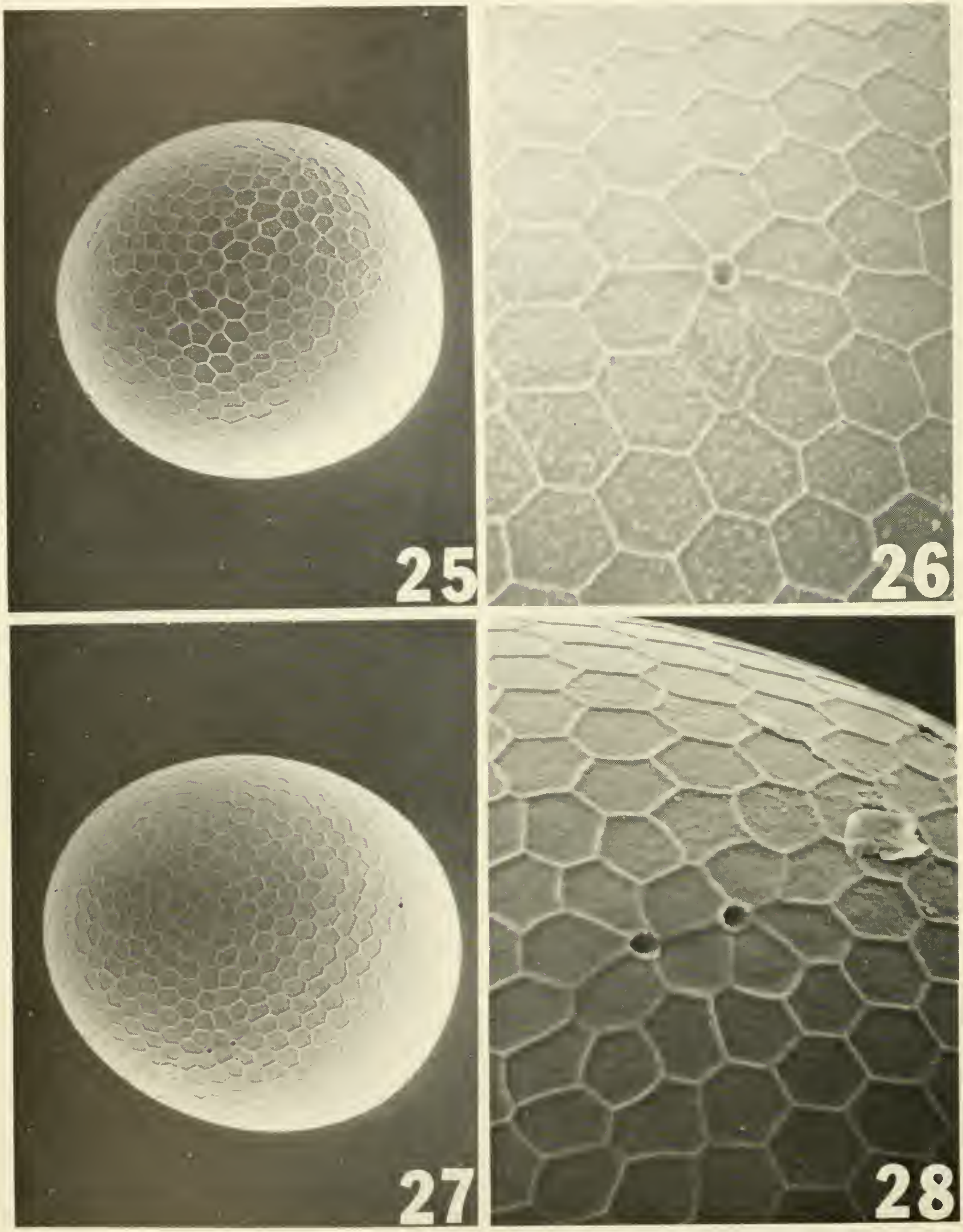
EGG.— Typical of the genus (Figs. 27, 28) but micropylar orifices are irregular rather than smooth.

TYPES.— Holotype (♂), allotype (♀), and 5 ♂ and 2 ♀ paratypes from Plumas Co., California, French Crk, 1 mi N Caribou, Butt Reservoir Rd, 25-VI-80, R. W. Baumann and J. Stanger, deposited in the U.S. National Museum (100090). Additional Paratypes: California: Sierra Co., Big Springs, Hwy 49, N Sierra City, 24-VI-80, R. W. Baumann, J. Stanger, 13 ♂, 4 ♀ (MLB).

ETYMOLOGY.— The specific name *sierra* refers to the mountain range in which it was collected.



Figs. 18–24. *S. quadrispinula*. Fig. 18. Aedeagus, lateral. Fig. 19. Aedeagus, A = dorsal, B = ventral. Fig. 20. Epiproct, anterodorsal. Fig. 21. Epiproct, lateral. Fig. 22. Nymphal abdomen, dorsal. Fig. 23. Female head and pronotum. Fig. 24. Nymphal abdominal tergum 8, posterior fringe.

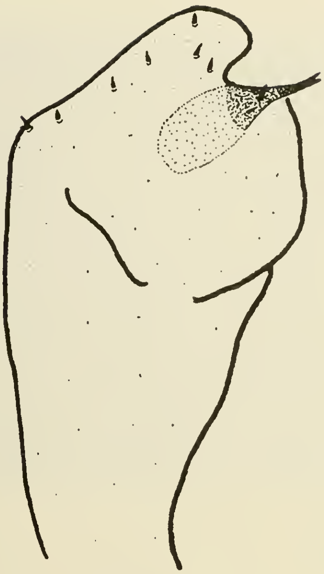


Figs. 25–28. *Soliperla* eggs. Fig. 25. *S. quadrispinula*, 240X. Fig. 26. *S. quadrispinula*, 1000X. Fig. 27. *S. sierra*, 240X. Fig. 28. *S. sierra*, 1000X.

Soliperla thyra (Needham & Smith)

Peltoperla thyra Needham & Smith 1916: 87. Holotype ♂ (Cornell Univ.), Nevada.
Peltoperla (Soliperla) thyra: Ricker 1952: 157.
Peltoperla (Soliperla) thyra: Jewett 1954: 167.

Jewett (1954) described the salient features of male and female genitalia and discussed the holotype specimen. After examining the holotype, I concur with Jewett in his usage of *thyra*. The anterodorsal face of the epiproct



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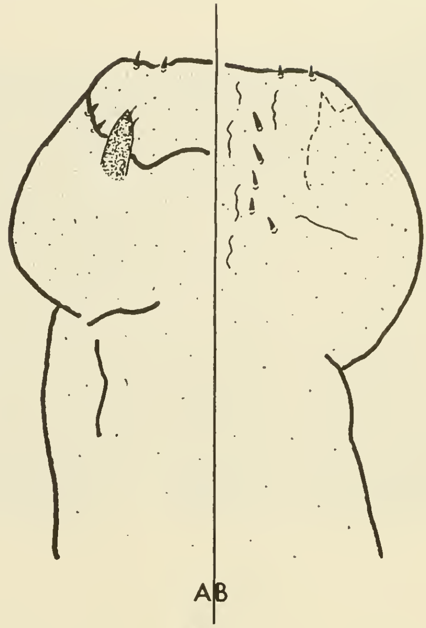

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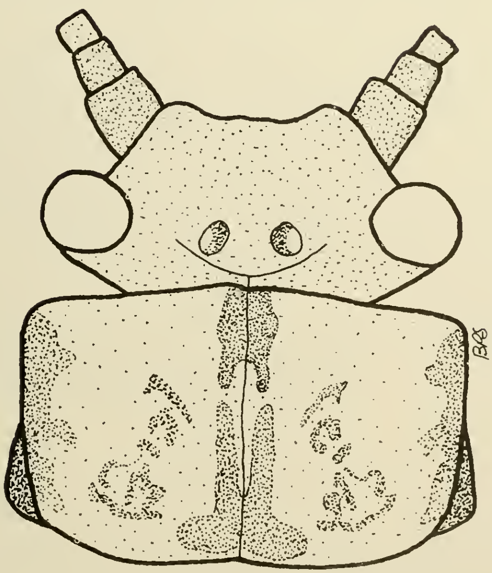

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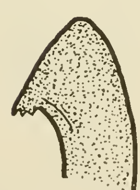

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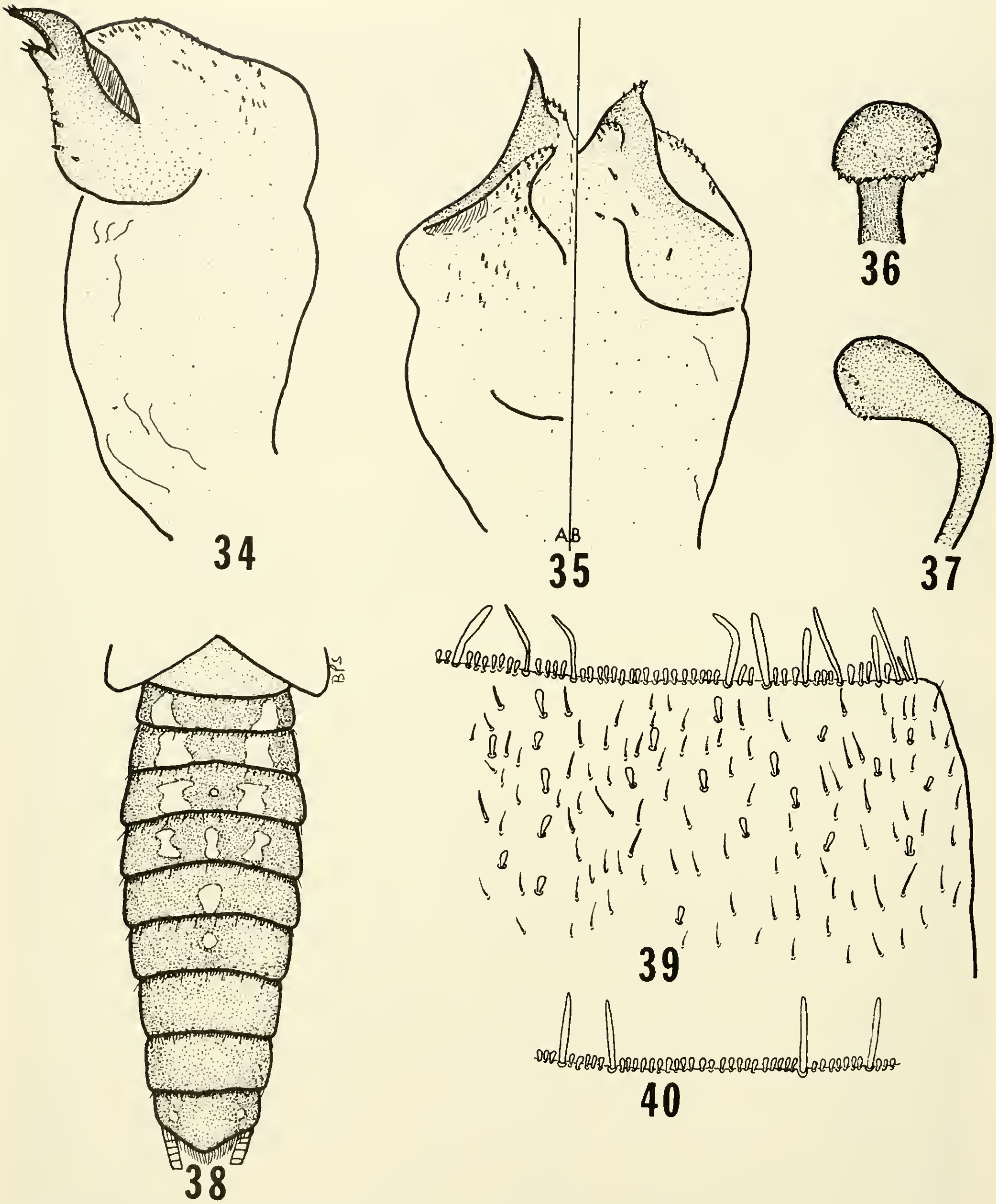
Figs. 29–33. *S. sierra*. Fig. 29. Aedeagus, lateral. Fig. 30. Aedeagus, A = dorsal, B = ventral. Fig. 31. Female head and pronotum. Fig. 32. Epiproct, anterodorsal. Fig. 33. Epiproct, lateral.

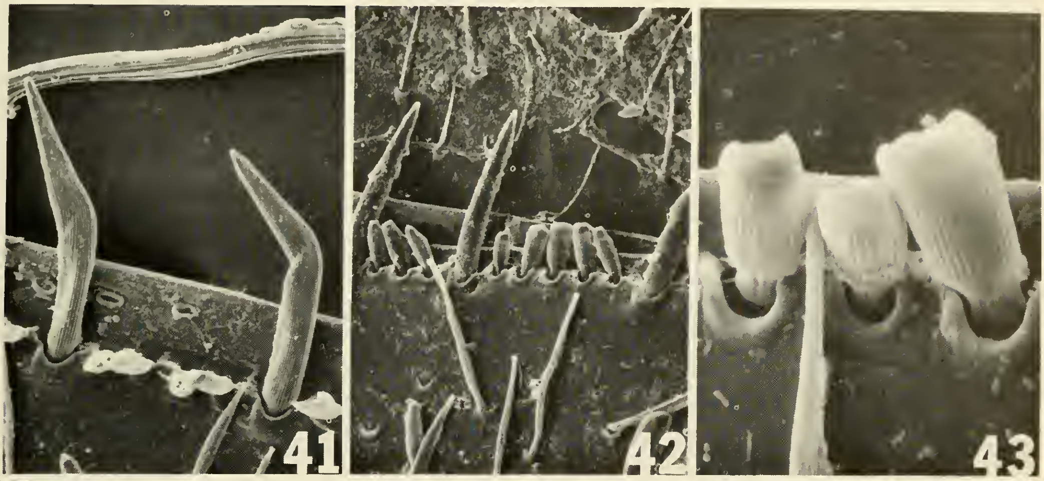
is slightly wider than the stalk and about 10 irregular teeth are located along the anteroventral surface (Fig. 36). The ventral aedeagal lobes bear a partially sclerotized spinelike bilobed process; the ventral portion of the process is less heavily sclerotized and bears about 6–8 short, thick setae, including an apical cluster (Fig. 35). The dorsal membranous lobes bear several scattered short, thick setae (Fig. 35).



Figs. 34–40. *S. thyra.* Fig. 34. Aedeagus, lateral. Fig. 35. Aedeagus, A = dorsal, B = ventral. Fig. 36. Epiproct, anterodorsal. Fig. 37. Epiproct, lateral. Fig. 38. Nymphal abdomen, dorsal. Fig. 39. Nymphal abdominal tergum 9. Fig. 40. Nymphal abdominal tergum 8, posterior fringe.

The female and egg appear indistinguishable from several other members of the genus. The species is known from scattered localities around the San Francisco area, but no specimens have been taken in Nevada or eastern California except the holotype (Fig. 1).

Material examined.— California: *Marin Co.*, Cascade Crk, Mill Valley, 25-IV-57, H. B. Leech, 1 ♂ (ROM); same location, 20-V-55, H. B. Leech, 1 ♀ (ROM); trickle nr. Alpine Lk, 1-V-55, S. W. Hitchcock, 1 ♂, 2 nymphs (OSU); Mt. Tamalpais, 25-V-74, D. G. Denning, 1 ♂ (MLB). *Mendocino Co.*, sm. stream at Leggett, 22-V-1982, B. Stark, D. Ziegler, 1 ♂, 1 ♀, 2 nymphs (NTSU). *Napa Co.*, 9 mi N Calistoga, Hwy 29, 21-V-82, B. Stark, D. Ziegler, 4 ♂, 10 ♀, 4 nymphs (2 ♂, 6 ♀ reared)



Figs. 41–43. S. *thyra* nymphal setae. Fig. 41. Bent setae, posterior fringe tergum 9, 700X. Fig. 42. Straight and clavate setae, posterior fringe tergum 8, 600X. Fig. 43. Clavate setae, posterior fringe tergum 8, 2800X.

(BPS); Angwin, IV-76, D. Ashley, 1 ♀ (BPS). *Santa Clara Co.*, Uras Canyon, 25-V-74, D. G. Denning, 1 ♀ (MLB). Nevada: no additional data (Holotype ♂) (Cornell).

Soliperla tillamook, n. sp.

MALE.— Body length, 11 mm; forewing length, 13 mm. General color yellow patterned with brown. Anterodorsal face of epiproct slightly wider than stalk; anteroventral surface with about 7–9 teeth (Fig. 46). Ventral and lateral lobes of aedeagus membranous with scattered apical short, thin setae (Fig. 45).

FEMALE.— Body length, 13 mm; forewing length, 15 mm. Subgenital plate large, parabolic, reaching to posterior margin of sternum 9.

TYPES.— Holotype (♂) and 1 ♂ paratype from Clatsop Co., Oregon, Osweg Crk, 2 mi E Elsie, 13-VI-64, S. G. Jewett. Holotype deposited in the Oregon State University museum. Allotype (♀) and 1 ♂ paratype from Clatsop Co., Oregon, trib. Big Crk, Salmon Hatchery, 28-V-49, S. G. Jewett (OSU).

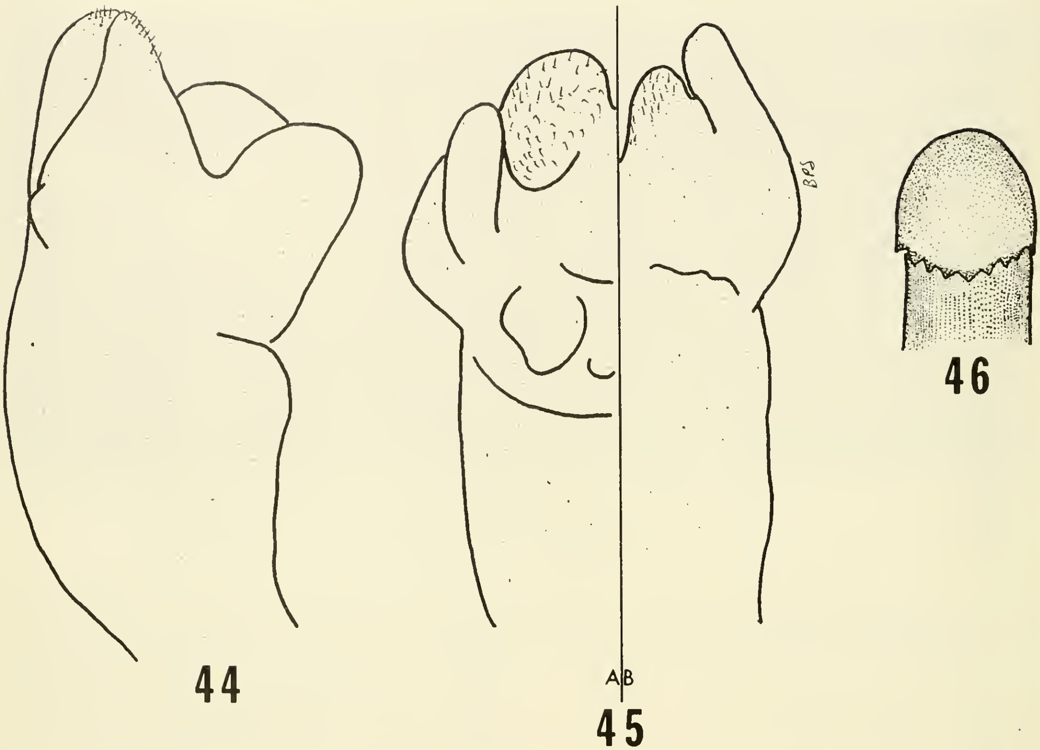
ETYMOLOGY.— The specific name honors the Tillamook Indians, who inhabited the area near the type locality.

DISCUSSION

In this study several characters suitable for making phylogenetic inferences were observed. Most of these have been selected from male genitalic structures since the egg, nymph, and female show little apparent variation. A taxonomic out group (TOG) consisting of *Yoraperla* and *Sierraperla* was formed to assist in inferring polarity of selected characters (Watrous and Wheeler 1981).

1. *Aedeagal setae.* Two variations of setae occurring on the ventral lobes were noted in the TOG and TIG (taxonomic in group). In *Yoraperla* and *Sierraperla* these setae are not appreciably thickened. Fine setae also occur in *Soliperla fenderi* and *S. tillamook* (Figs. 12, 45), but in other *Soliperla* species these setae are distinctly thickened (Figs. 3, 19). This is most conspicuous in *S. quadrispinula*, in which the setae are also longer than usual. Hence, thickened setae are regarded as apomorphic.

2. *Epiproct tip.* Within *Soliperla* several species have the epiproct tip expanded into a process that is much wider than the epiproct base (Figs. 5, 20), but in other species the epiproct tip is about as wide as the base (Fig. 13). Since *Yoraperla* and *Sierraperla* lack a developed epiproct, the TOG was expanded to include other Nearctic peltoperlid genera (*Tallaperla*, *Peltoperla*, and *Viehoperla*). In this group, both *Peltoperla* and *Viehoperla* have narrow epiproct tips, and in *Tallaperla* the epiproct is poorly developed (Stark and Stewart 1981). Hence, the expanded epiproct



Figs. 44–46. *S. tillamook*. Fig. 44. Aedeagus, lateral. Fig. 45. Aedeagus, A = dorsal, B = ventral. Fig. 46. Epiproct, anterodorsal.

tip of *S. campanula*, *S. quadrispinula*, *S. sierra*, and *S. thyra* is regarded as apomorphic.

3. *Subgenital plate margin*. The apex of the female subgenital plate is emarginate (*Sierraperla*) or notched (*Yoraperla*) in the TOG, but most *Soliperla* have a large parabolic plate that is entire along the margin. Only *S. fenderi* has a notched plate, but this notching is considered nonhomologous to that in the TOG and the notched plate is regarded as apomorphic.

4. *Outline of ventral aedeagal lobe*. In *Yoraperla*, *Sierraperla*, and several *Solipera* species, the ventral aedeagal lobe is divided longitudinally by a cleft into lateral lobes (Figs. 12, 35). In two *Soliperla* species (*S. campanula* and *S. sierra*) the apical margin of this lobe is entire; hence, this is considered to be the apomorphic feature.

5. *Arrangement of aedeagal setae*. Typically in *Yoraperla*, *Sierraperla*, and *Soliperla* species the setae on the ventral aedeagal lobe are scattered, but in two species (*S. campanula* and *S. sierra*) these setae form two irregular mesal rows (Figs. 3, 30). This latter variation is considered apomorphic.

6. *Sclerotization of ventral aedeagal lobe*. The TOG and most *Soliperla* species have entirely membranous ventral aedeagal lobes, but in *S. thyra* and *S. quadrispinula* these lobes are sclerotized (Figs. 19, 35). This latter modification is considered apomorphic.

These six characters were used to derive the cladogram shown in Fig. 47. This analysis must be regarded as tentative due to the limited number of characters utilized. The position of *S. tillamook* could not be determined since it exhibits the plesiomorphic condition for each of the six characters.

It seems probable, given the apparent high degree of endemicity in the genus, that additional species await discovery from the Olympic Peninsula, Mt. Baker, and other isolated areas of the Pacific Northwest. It is hoped material from these areas and a larger sample of *S. tillamook* will permit rigorous testing of this cladogram.

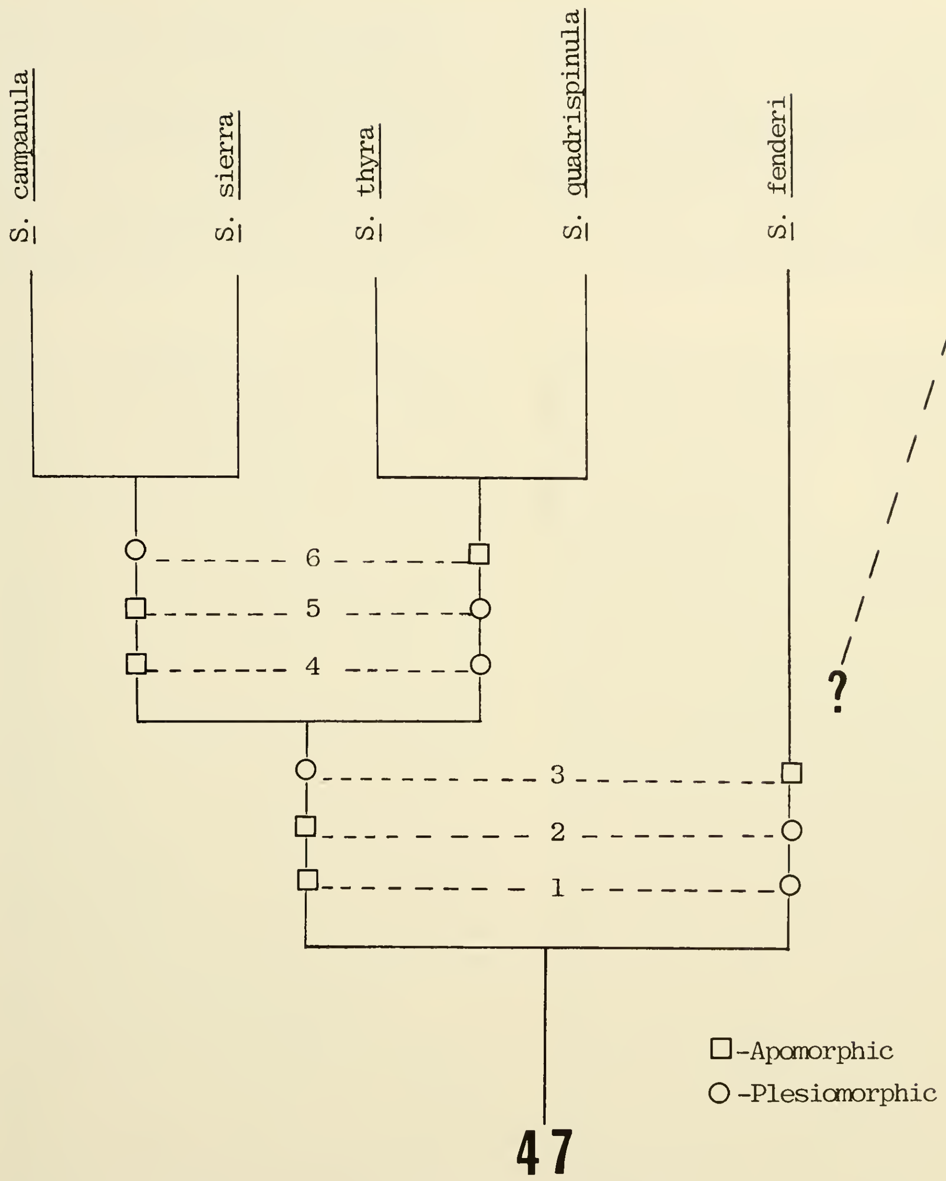


Fig. 47. Proposed phylogeny for *Soliperla* species. See text for explanation.

ACKNOWLEDGMENTS

Several individuals and museums cooperated in providing material for study. These include R. W. Baumann (Monte L. Bean Museum, Brigham Young University), O. S. Flint (United States National Museum), B. Kondratieff, J. Lattin (Oregon State University Museum), B. Mather, L. L. Pechuman (Cornell University Museum), K. W. Stewart (North Texas State University Museum) and G. Wiggins (Royal Ontario Museum). K. W. Stewart and D. Ziegler gave valuable assistance in collecting and rearing efforts. S. W. Szczytko (University of Wisconsin, Stevens Point) and S. Faison (University of Mississippi Dental School) assisted in preparing SEM micrographs. This study was supported, in part, by NSF grant DEB 78-12565.

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A BIBLIOGRAPHY OF COLORADO VEGETATION DESCRIPTION

William L. Baker[1]

Abstract.— A list of 658 references to Colorado vegetation description is presented, along with county and subject indexes to the list.

This bibliography includes published and selected unpublished references through 1981. Included are references to vegetation description, including studies that contain only qualitative description, along with more detailed quantitative studies. Also included are selected references to age/size structure, fire, succession, floristics, vegetation history (primarily palynology), phenology, plant geography, vegetation zonation, and the timberline. An index is included to subjects other than vegetation description. Coverage of these tangential subjects may not be comprehensive. Autecological and environmental studies are generally excluded, as are studies pertaining only to nonvascular vegetation.

References are included here if at least part of the study area is in Colorado. Excluded are the many works from adjoining states that may have relevance, particularly to the margins of Colorado, but have no part of their study areas inside Colorado. Researchers should consult bibliographies from adjoining states for these references.

Included below is an index to the bibliography by county. A single reference may pertain to more than one county. Also included are a list of studies pertaining to the whole state, and a list of "regional studies" that pertain to an undefined, or poorly demarcated part of the state. Researchers seeking complete coverage of a particular county should also check references in these lists.

Subject Index

County Index

[1]Colorado Natural Heritage Inventory, 1550 Lincoln Street, Suite 110, Denver, Colorado 80203.

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Acknowledgments

I am grateful to the numerous people who provided access to unpublished reports, and to J. Scott Peterson, who provided support and criticism. The author would appreciate being informed if there are omissions.

EVALUATION OF A PROGRAM TO CONTROL HYDATID DISEASE IN CENTRAL UTAH[1]

Ferron L. Andersen[2], John R. Crellin[2,3], Craig R. Nichols[4], and Peter M. Schantz[5]

Abstract.— A program to control hydatid disease in central Utah was evaluated by: (1) surveillance of infection in dogs and sheep, (2) questioning adult residents of two Sanpete County communities (Fountain Green and Spring City) about their knowledge of hydatid disease and their attitudes toward preventive measures, (3) interviewing local officials to evaluate the proposed implementation of proper community-wide measures, (4) analyzing records of prophylactic treatment of dogs with praziquantel, and (5) comparing scores of tests given to third and fourth grade students before and after they colored an educational pamphlet about hydatid disease.

Infection rates of *Echinococcus granulosus* in dogs brought to volunteer diagnostic clinics dropped from 28.3 percent in 1972 to 1.0 percent in 1979, but increased to 9.8 percent in 1981. This last rise was due mainly to the fact that some dogs were examined that belonged to range sheepmen who had either not attended a field clinic recently or had never attended at all. Prevalence of the parasite in slaughtered sheep decreased steadily from 13.2 percent in 1972 to 2.8 percent in 1981. With regard to the questionnaire phase of the project, 87.3 percent and 84.3 percent of the respondents understood the role of dogs in the life cycle of *E. granulosus* in Fountain Green and Spring City, respectively. Over 50 percent of the respondents of these two communities had worked directly with sheep sometime in their life. In general, residents were more willing to practice preventive measures involving sheep than they were to implement measures involving dogs alone. However, many of the recommended community-wide preventive measures were not implemented. With the coloring book, students answered an average of 62.5 percent of the questions correctly before they colored the pamphlet and 83.3 percent afterward. Overall, our results suggest that residents of Sanpete County are knowledgeable about hydatid disease and its mode of transmission, and that, in general, progress has been made in control of hydatid disease in central Utah.

Utah has had the most autochthonous cases of hydatidosis (39) in man reported from the contiguous United States (Crellin et al., 1982), with the first reported case diagnosed in 1944 (Carlquist and Dowell 1951). Studies on dogs, foxes, and coyotes were undertaken in the early 1950s to identify the definitive host, but these were unsuccessful (Butler and Grundmann 1951, Grundmann et al. 1953, Butler and Grundmann 1954). The normal hosts of *Echinococcus granulosus* in Utah (dogs and sheep) were revealed in 1969 as part of an investigation into the death of a nine-year old boy in the community of Herriman (Kahn et al. 1972), near Salt Lake City. Concurrently, parasitologists at Brigham Young University began surveillance of the parasite in dogs and sheep in central Utah (Fox et al. 1970, Andersen et al. 1973, Loveless et al. 1978). As more work was done, it became apparent that the main foci of infection were in that area of Utah, especially Sanpete County. As a result, a cooperative program to study and control hydatid disease in central Utah was begun in 1971 by personnel from Brigham Young University (Provo, Utah), the Utah Department of Health (Salt Lake City, Utah), and the Centers for Disease Control (Atlanta, Georgia) (Andersen et al. 1974).

Materials and Methods

Description of Study Area

Sanpete County is in the center of Utah and has a total area of 4,136 sq km. A valley (1700 m elevation) bordered by mountains (3400 m elevation) runs the length of the county. There are 14,615 people in the county (U.S. Bureau of the Census 1980a), 90 percent of which are Mormons (The Church of Jesus Christ of Latter-day Saints) (Stinner et al. 1978). Unlike most farming regions in the

[1]This project was supported in part by U.S. Public Health Service Grant AI-10588.
[2]Department of Zoology, Brigham Young University, Provo, Utah 84602.
[3]Present address: Trinity College, Deerfield, Illinois 60015.
[4]Bureau of Communicable Disease Control, Utah Department of Health, Salt Lake City, Utah 84103.
[5]Division of Parasitic Diseases, Center for Infectious Diseases, Centers for Disease Control, Atlanta, Georgia 30333.

United States, nearly all residents of Sanpete County, regardless of occupation, live in one of 13 communities which vary in population from 153 to 2807 (U.S. Bureau of the Census 1980a). In 1978 there were approximately 1950 dogs (Loveless et al. 1978) and 90,400 sheep in the county (U.S. Bureau of the Census 1980b). Agriculture is the principal industry, with an emphasis on turkeys and sheep. Range sheep herds are grazed in the mountains during summer, on the valley floor during spring and fall, and on the desert (100–200 km to the west) during winter. In addition to the range herds, there are also semirange herds that are confined during winter but grazed in the mountains during summer. There are also many small flocks confined on a year-round basis, which are usually made up of ewes obtained from range sheepmen (Crellin et al., 1982).

Description of Hydatid Disease Control Program

The main goals of the program have been reported previously (Andersen et al. 1974) and are summarized on Table 1. The educational portion of the program was accomplished through press releases, an article in the *National Woolgrower* (Andersen and Wallentine 1976), pamphlets distributed countywide, talks to civic and church groups, and displays and personal counseling done during community screening clinics. A filmstrip and coloring book were developed as tools to educate children. Copies of the filmstrip were given to the audiovisual departments of the two school districts in Sanpete County, and in 1980 coloring books were distributed to all third and fourth grade students in eight elementary schools in the county. The overall goal of this portion of the program was to educate the residents about the life cycle of *E. granulosus*, and the proper measures that could be taken to prevent the disease.

Local governments were advised as to proper community-wide control measures, and it was their choice whether or not such measures were implemented. Included within this phase of the program was prophylactic treatment by a local veterinarian (Dr. M. John Ramsay) of dogs in the northern half of Sanpete County with bunamidine hydrochloride (1974–1978) and praziquantel (1979–1981).

Surveillance of dogs, sheep, and human beings was conducted in several areas of central Utah. Starting in 1971, clinics to examine dogs were held in communities in Sanpete County, and, in 1980 and 1981, on nearby mountain range lands (Table 2). In other areas (Summit and Utah counties), clinics were usually held at the sheep camp location. Dogs were dosed with arecoline hydrobromide, and the resulting purge was examined on site. Sheep were checked at slaughter for the presence of cysts by state meat inspectors, and the identification of cysts suspected was confirmed at the parasitology laboratory at Brigham Young University. Forty-nine coyotes (Andersen et al. 1973, Conder and Loveless 1978) and 74 deer (Jensen et al., 1982b) were also examined to assess their possible role as sylvatic reservoirs of infection. Immunodiagnostic clinics for human beings were conducted usually in conjunction with clinics for dogs (Klock et al. 1973, Barbour et al. 1978). Clinics were advertised in local newspapers, by posters placed in communities, and by letters and phone calls to sheepmen by individuals from the Utah Department of Health, BYU, and a local veterinarian's office.

TABLE 1. Main goals of a program to control hydatid disease in Sanpete County, Utah.

COMMUNITY OBJECTIVES
1. Covering or fencing animal disposal pits at waste disposal sites
2. Eliminating stray or roving dogs
3. Conducting educational programs in local schools

INDIVIDUAL OBJECTIVES
1. Fostering a widespread understanding of the parasite's life cycle
2. Advocating proper preventive measures such as not feeding sheep viscera to dogs, burning or burying sheep that die on the range, and not allowing dogs to roam
3. Encouraging individuals to have themselves and their dogs checked for *E. granulosus* at yearly screening clinics

Evaluation of Control Program

The effectiveness of the control measures was evaluated by monitoring trends in infection rates in dogs and sheep and the numbers of new cases diagnosed in human beings.

The success of holding screening clinics was evaluated partially by comparing the list of all those who brought dogs for examination with a complete list of all sheepmen in the region (Crellin et al., 1982). Further evaluation was obtained by questioning adult residents of two Sanpete County communities (Fountain Green and Spring City) concerning their knowledge of hydatid disease and attitudes towards proper preventive measures. The procedures employed in devising, distributing, and analyzing these questionnaires were described earlier (Condie et al., 1981). Implementation of community-wide measures was evaluated through interviews with city officials and visits to the various community waste disposal sites.

The effectiveness of the coloring books in increasing knowledge about hydatid disease and proper preventive measures was analyzed by testing the students before they received the coloring book and again two weeks afterward. Pre- and posttest scores were compared using a paired *t*-test.

Results

Of 15,775 sheep slaughtered in five central Utah abattoirs since 1971, 1116 (7.1 percent) were infected with *E. granulosus*. The range in yearly prevalence was 13.2 percent in 1972 to 2.8 percent in 1980 and 1981 (Fig. 1). During the study period, 83 screening clinics for dogs were held; 109 of 1120 (9.7 percent) dogs purged were infected with the adult cestode. Infection rates of the parasite in dogs declined from 28.3 percent in 1972 (Loveless et al. 1978) to 1.0 percent in 1979, but rose to 8.9 percent in 1980 and to 9.8 percent in 1981 (Fig. 1) (Jensen et al. 1982a). This rise, however, was probably due to the fact that in 1980 7 of the 8 dogs found infected were owned by sheepmen who had never attended a clinic, and that in 1981 4 of the 5 dogs infected were owned by sheepmen who had not attended a clinic in several years. Sixty of 593 (10.1 percent) owners who attended a clinic had at least one infected dog (Fig. 2 and Table 3). Generally, the proportion of owners with at least one infected dog was higher in communities from the northern half of the county (Table 3). Twenty-seven of the 28 (96.4 percent) range sheepmen presently in the county have taken some of their dogs to at least one clinic, but no more than 19 (67.8 percent) have attended in any one year. Seven clinics were held in Summit County where 6 of 69 (8.7 percent) dogs harbored *E. granulosus*, and one clinic was held in Utah County where 1 of 21 (4.8 percent) dogs was infected. No echinococcosis infections were found among 49 coyotes (Andersen et al. 1973, Conder and Loveless 1978) and 74 deer examined (Jensen et al. 1982b).

TABLE 2. Dogs infected with *Echinococcus granulosus* in Sanpete County, 1971–1981.

	Use of dog			
	Tending sheep		House pet	
Community	Dogs purged	Dogs infected (%)	Dogs purged	Dogs infected (%)
North Sanpete				
Fairview	70	14(20.0)	91	4(4.4)
Fountain Green	153	32(21.7)	67	3(4.5)
Mt. Pleasant	92	5(5.4)	31	2(6.5)
Spring City	81	16(19.8)	161	12(7.5)
Other communities	55	4(7.3)	33	0(0.0)
Area total	451	72(16.0)	383	21(5.5)
South Sanpete				
Ephraim	56	8(14.3)	21	0(0.0)
Manti	43	4(9.3)	96	1(1.0)
Mayfield	2	0(0.0)	37	0(0.0)
Gunnison	11	3(27.3)	20	0(0.0)
Area total	112	15(13.4)	174	1(0.6)
County total	563	87(15.4)	557	22(3.9)

TABLE 3. Dog owners in Sanpete County who have had dogs infected with *Echinococcus granulosus*, 1971–1981.

	Range sheepmen		Semirange sheepmen		Not sheepmen	
Region	No. of owners	No. with infected dogs (%)	No. of owners	No. with infected dogs (%)	No. of owners	No. with infected dogs (%)
North	25	16(64.0)	67	15(22.4)	285	21(7.4)
South	19	7(36.8)	12	1(8.3)	180	1(0.6)
Total	44	23(52.3)	79	16(20.3)	465	22(4.7)

Fourteen autochthonous cases of hydatid disease in man have been diagnosed in Sanpete County—an average annual incidence of 3.7 per 100,000 (Table 4). Twelve of these 14 cases were from the northern half of the county. The 7 cases in Fountain Green since 1952 translate to a prevalence of 50 per 100,000. Six of 2747 individuals in Sanpete County tested serologically for the presence of hydatid cysts were diagnosed to be asymptomatic carriers, and subsequently 4 of these 6 have had surgery (Barbour et al. 1978).

In the door-to-door surveys, responses were obtained from 140 of 156 (89.7 percent) and 147 of 176 (83.5 percent) households in Fountain Green and Spring City, respectively. In Fountain Green 256 individuals (1980 population of 578), and in Spring City 228 (1980 population of 675) returned completed questionnaires. Twenty-nine percent of the respondents from Fountain Green indicated that they were aware of hydatid disease before 1971, but only 9.0 percent from Spring City were aware of this disease prior to that year. In Fountain Green, 87.3 percent of the respondents currently understood the role of dogs in the life cycle of *E. granulosus*, and 70.0 percent knew the role of sheep. In Spring City 84.3 percent understood the role of dogs and 69.0 percent knew the role of sheep. There were 62.0 percent and 54.0 percent of the adult residents of Fountain Green and Spring City, respectively, who had worked with sheep some time in their life. In Fountain Green 83.0 percent of the adult residents and in Spring City 77.5 percent were willing to pay to have a proper animal disposal pit built and maintained. Spring City residents were asked the reasons why they did or did not bring their dogs to clinics. The

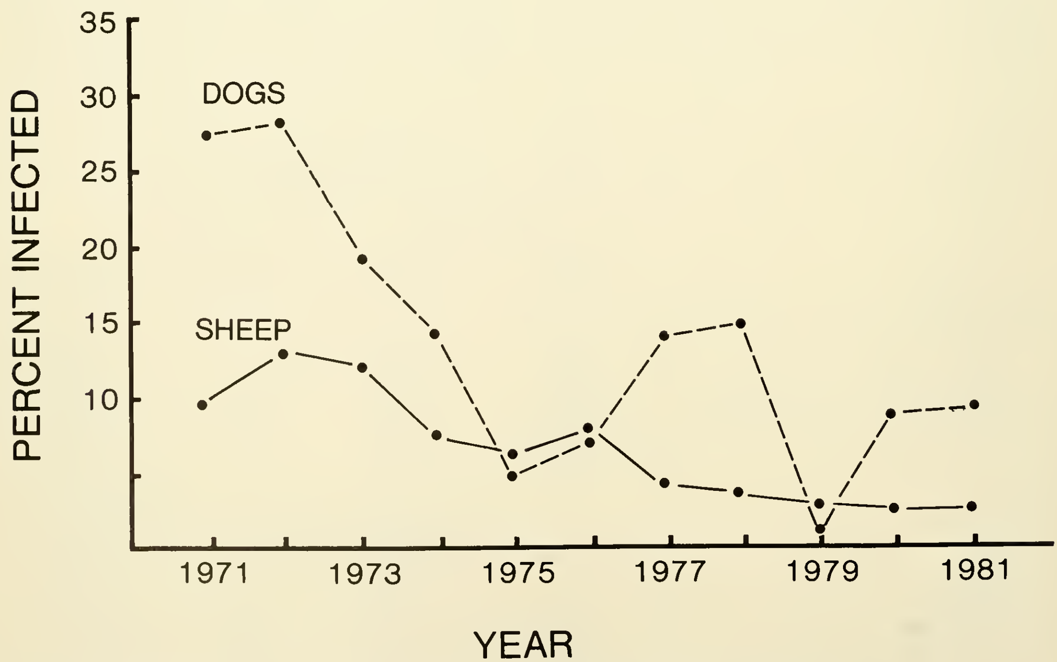

Fig. 1. Prevalence of *Echinococcus granulosus* in dogs and sheep from central Utah, 1971–1981.

TABLE 4. Fourteen autochthonous cases of hydatid disease in human beings from Sanpete County, Utah.

Name	Sex	Year of birth	City of residence	Connection with sheep raising	Year of surgery	Location of cyst
N.P.	F	1944	Fountain Green	Direct[a]	1952	Lung
J.B.	M	1916	Fountain Green	Direct	1964	Lung & Liver
P.A.	M	1946	Fountain Green	Direct	1967	Liver
P.J.	M	1931	Fountain Green	Direct	1971	Liver
L.C.	M	1949	Fountain Green	Direct	1971	Liver
M.C.	M	1908	Mt. Pleasant	Direct	1972	Lung
R.L.	M	1908	Mt. Pleasant	Direct	1973	Lung
D.J.	M	1960	Fountain Green	Indirect[b]	1974	Liver
R.C.	M	1913	Spring City	Direct	1975	Liver
D.A.	M	1921	Fountain Green	Direct	1975	Liver
B.S.	F	1967	Manti	Indirect	1976	Lung
D.D.	F	1955	Gunnison	Direct	None[c]	Liver
C.W.	F	1926	Spring City	Direct	None[c]	Liver
E.C.	M	1951	Fairview	Indirect	1979	Lung

[a]Patient or family members are sheepmen.
[b]Patient lives near sheepmen.
[c]Case diagnosed in 1976.

desire to know if their dog was infected (93.9 percent) and their desire to eliminate hydatid disease (90.3 percent) were the reasons most commonly given for attending. Being unaware of the clinic (55.9 percent) and a lack of personal time (35.2 percent) were the reasons most frequently listed for not attending. Data on sources of information (Table 5), attitudes and practices of dog and sheep owners (Table 6), and dog and sheep populations (Table 7) are also presented herein.

Implementation of community-wide preventive measures and participation in the praziquantel treatment program were gener-

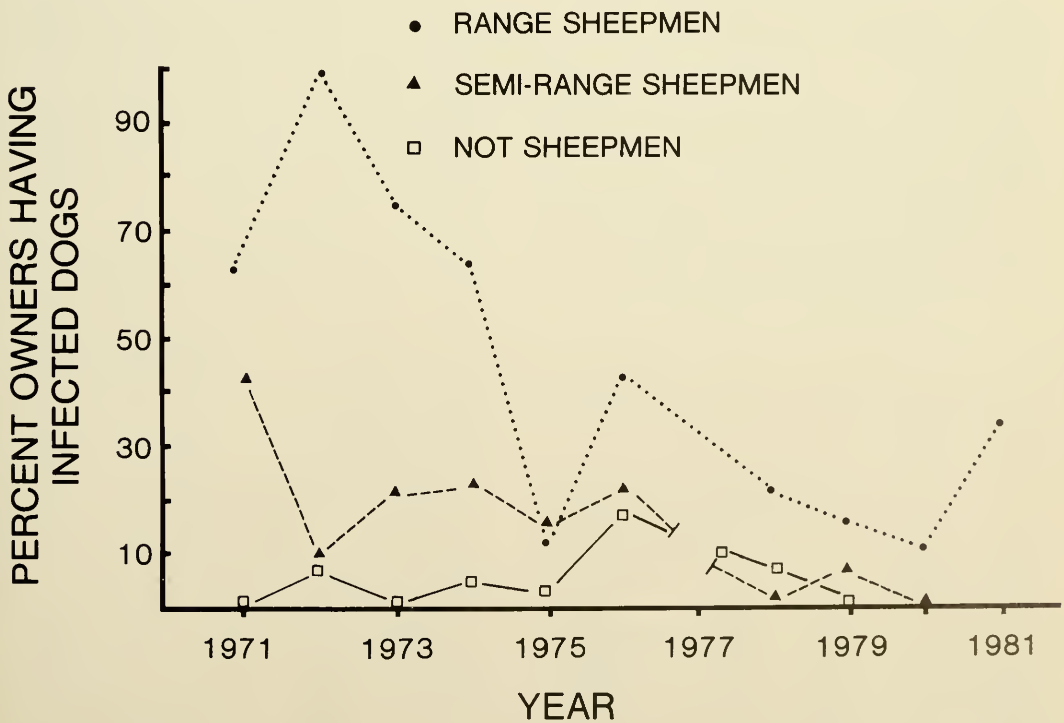

Fig. 2. Percent of individuals in Sanpete County, Utah, having dogs infected with *Echinococcus granulosus*, 1971–1981.

ally poor. Only one community (Spring City) of the six that had an animal disposal pit, had a pit cover. Two communities (Moroni and Manti) did not allow dead animals to be left at their waste disposal sites. Laws making it illegal to leave dead animals on the range were passed recently in Sanpete and five adjoining counties, but, at this time, enforcement is nonexistent. All communities have leash laws, but only one (Manti) has made an effort to eliminate stray dogs. Fairview, Fountain Green, Moroni, and Mt. Pleasant have enacted laws requiring treatment of dogs with praziquantel as a stipulation for obtaining or renewing a dog license; however, few sheepdogs in Sanpete County are licensed and compliance is largely voluntary. In the praziquantel treatment program, only 7 of 63 (11.1 percent) owners participating had ever had dogs known to be infected. Only 22 of the 63 (34.9 percent) owners had ever brought their dogs to a screening clinic.

Discussion

Among the human population at risk in Sanpete County, cystic hydatid disease has been diagnosed at a rate (3.7 cases per 100,000 population per year) comparable to those in other regions regarded as highly endemic for this infection. Data for comparison include rates from the Australian state of Tasmania prior to the initiation of a statewide control program (15 per 100,000 per year; McConnell and Green 1979); from Cyprus (12.9 per 100,000 per year; Anonymous 1981); from Chile (7.8 per 100,000 per year; Anonymous 1981); and from Yugoslavia (3.7 per 100,000 per year; Anonymous 1981). Also, infection rates in dogs and sheep at the beginning of the study period herein reviewed were similar to those in other endemic regions (Anonymous 1981).

Most successful programs to control *E. granulosus* have had both a formal organizational structure and a mandatory involvement of the local population (Gemmell 1979). In contrast, the control effort in central Utah has been a cooperative project involving university, state, and federal agencies, and participation of the community has been completely voluntary. The voluntary aspect of the program has imposed certain limitations on the rate of progress of suggested preventive and control measures. Although the majority of dog owners and sheep ranchers have responded positively to recommended measures, and also availed themselves of the diagnostic services provided, our questionnaire survey indicated that some individuals have not. The data indicate that the health educational aspects of the program have succeeded in making most adult residents of the two communities thoroughly aware of hydatid disease, but this may not be adequate to sustain interest and to motivate necessary changes. We had previously observed that most dog owners in Sanpete County were able to respond correctly to questions about the life cycle of

TABLE 5. Helpfulness of various sources of information about hydatid disease in Fountain Green and Spring City, Utah.

Source of information	Percentage of respondents who perceived source as helpful[a] Fountain Green (%)	Spring City (%)
Screening clinics	70.8	56.3
Friends	60.2	47.8
Pamphlets	56.5	50.7
Veterinarian	51.6	32.7
Newspapers	23.5	36.7
Filmstrip	16.0	14.4
Physician	12.9	13.5

[a]Individuals who marked a "4" or "5" on a 1 (no help) to 5 (very helpful) scale.

TABLE 6. Attitudes and practices of dog and/or sheep owners in Fountain Green and Spring City, Utah.

Attitude or practice	Percentage of respondents Fountain Green (%)	Spring City (%)
Attitude—willing to:		
take dog to clinic[a]	83.5	78.2
pay for prophylactic treatment of dog[a]	86.7	95.7
control dog[a]	48.8	65.0
use animal pit	88.0	87.8
Practice:		
allow dog to have access to area where sheep are killed[b]	21.6	11.0
butcher sheep at home or on range[b]	63.3	90.6

[a]Dog owners: Fountain Green, 64, and Spring City, 66.
[b]Sheep owners: Fountain Green, 34, and Spring City, 27.

hydatid disease and how to prevent it; however, many continue to manage their dogs in ways that permit them ready access to sources of infection (Schantz and Andersen 1980).

Another problem associated with the voluntary nature of our program involves the interpretation of data collected at diagnostic field clinics for dogs. Generally, rates of infection measured annually suggested a downward trend, although rates in most recent years have increased somewhat (Fig. 1). This apparent increase most likely reflects differences in the yearly samples of the canine population, rather than actual increases in rates of transmission. Some effort was made in the later years to encourage dog owners who had not previously attended to bring their animals to the voluntary clinics. Also, more diagnostic clinics were held in the summer sheep range land, rather than in local communities as was done previously. Thus, higher rates of infection were found in dogs not previously examined and in those sheep dogs that were from high-risk canine populations associated with herds of sheep.

In contrast to these fluctuating changes noted in the infection rates of dogs, a more steady decline was noted for the slaughtered sheep, and yet no changes in sheep marketing practices were known to occur during the study period.

It now seems likely to conclude that, after 10 years, *E. granulosus* has largely been eliminated from "house" dogs (those dogs not working with sheep), but is still found in small numbers in dogs owned by the county's sheepmen. This partial control has probably been achieved through educational efforts that resulted in a reduction in availability of sheep viscera to dogs. However, recommended preventive measures such as control of dogs and proper disposal of dead animals have not been effectively implemented. The number of sheep in Sanpete County has dropped 38.5 percent since 1969 (U.S. Bureau of Census 1980b), and this could be a factor in the reduction in prevalence of *E. granulosus*. A drop in total sheep numbers was considered a factor in the elimination of hydatid disease from Iceland (Beard 1973).

In spite of the progress noted in our control program to date, there is still a continued potential for transmission of *E. granulosus* between dogs and human beings in Sanpete County. Basically, this is due to: (1) the lack of a county-wide control program for dogs, (2) the lack of adequately maintained animal disposal pits and covers in most of the communities, (3) the persistence of home-slaughtering of sheep, and (4) concentration of most county residents within communities. Our results, and those of an earlier study (Condie et al. 1981), suggest that individuals in central Utah are generally unwilling to control their dogs, but would be supportive of community efforts to build and maintain proper disposal pits for dead sheep.

In the future we plan to continue the distribution of all educational aids available, and also to encourage the community officials in those areas where hydatid disease has occurred to build and maintain proper animal disposal pits and covers. In addition, most clinics will be held closer to summer grazing areas, and sheepmen with a poor attendance record at clinics will be encouraged to have their dogs checked on a regular basis.

Table 7. Dog and sheep populations in Fountain Green and Spring City, Utah.

	Fountain Green	Spring City
Households with dogs	64/140	66/147
Number of dogs	109	101
Dogs per dog-owning household	1.7	1.5
Households with sheep	34/140	27/147
Number of sheep	24,317	3,655
Sheep per sheep-owning household	714	135

Table 8. Efficacy of coloring books as educational aids for third and fourth grade students in Sanpete County, Utah.

School	No. students	Average pretest score (%)	Average posttest score (%)
Fairview	47	57.3	79.6*
Fountain Green	6	51.7	83.3*
Moroni	50	66.6	80.8*
Mt. Pleasant/ Spring City	107	60.7	78.4*
Ephraim	63	64.4	88.1*
Gunnison	84	66.8	87.5*
Manti	56	59.5	86.6*
Total	413	62.5	83.3*

*Posttest score significantly greater than pretest score at $\alpha = 0.05$ using paired *t*-test.

Finally, since praziquantel (Droncit®) is now an approved drug in the United States, and since dog owners within the two communities surveyed indicated that they are willing to pay for treatment, we will encourage continued prophylactic treatment of dogs with this drug. Finally, surveillance of hydatid disease will be maintained by monitoring infection rates in slaughtered sheep and by registering diagnosed human cases.

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INFLUENCE OF CRYPTOGAMIC CRUSTS ON MOISTURE RELATIONSHIPS OF SOILS IN NAVAJO NATIONAL MONUMENT, ARIZONA

Jack D. Brotherson[1] and Samuel R. Rushforth[1]

Abstract.— Cryptogamic soil crusts of Betatakin Canyon in Navajo National Monument were investigated to understand the influence of such crusts on soil moisture relationships and potential sediment production. Crusts sampled were part of the pinyon-juniper community and were studied in paired units. The presence of crusts on soils significantly increased the depth of water penetration and decreased runoff. Soils showed reduced infiltration of water where lichen and algal crusts were present and enhanced infiltration rates where mosses were present. Crusts appear to cause surface sealing and therefore likely reduce surface evaporation rates as well.

Cryptogamic crusts are nonvascular plant communities that grow on or immediately beneath the soil surface. Such communities are components of most desert ecosystems. They have been described in several ecosystems in western North America (Anderson and Rushforth 1976, Anderson et al. 1982a) as well as in the deserts of the Middle East (Evenari et al. 1971). Until recently scant attention had been given them and little was known concerning their role in native ecosystems. Studies of the past decade indicate that they exert a significant impact on reducing soil erosion (Evenari et al. 1971, Loope and Gifford 1972, Kleiner and Harper 1972, Kleiner and Harper 1977, Anderson et al. 1982a, Anderson et al. 1982b). Fletcher and Martin (1948) found that fungal and algal crusts increase the tensile strength of soil. The algae appear to be the most effective in binding the surface soil particles (Durrell and Shields 1961) because of the thick gelatinous sheaths that enclose the trichomes of several algal species (Anderson and Rushforth 1976). Such gelatinous sheaths add strength and aggregating qualities to the 1 or 2 mm of surface soil upon which they grow (Anantani and Marathe 1974).

Research on the biology of cryptogamic crusts has also been done in several other areas. These studies include taxonomy (Ali and Sandhu 1972, Anderson and Rushforth 1976); nitrogen fixation (MacGregor and Johnson 1971, Reddy and Gibbons 1975); land reclamation (Singh 1950); soil fertility (Shields and Durrell 1964); reproduction, growth and habitat relations (Evenari et al. 1971, Anderson et al. 1982b); and moisture (Booth 1941, Loope and Gifford 1972).

The objective of this study was to investigate the influence of cryptogamic crusts in the pinyon-juniper woodlands of northeastern Arizona on depth of water penetration, infiltration, runoff, and potential sediment production.

Study Area

Navajo National Monument is located in northeastern Arizona (Fig. 1) and is the site of three large Anasazi Indian cliff dwellings. Betatakin Canyon, the site of the present study, is a side canyon of the larger Tsegi Canyon complex and has been described by Hack (1945). The major geological formation comprising the canyon is Navajo Sandstone, which forms sheer towering cliffs 200 m or more in height. The canyon floor consists of deep alluvial deposits of sandy Quaternary fill. Kayenta sandstone outcrops in the lower reaches of the canyon.

The annual temperatures recorded at the park headquarters weather station at Betatakin canyon ranges from –23 to 38 C with a mean of 10 C. The number of frost-free days in the area varies from 107 to 213, with an average of 155 days. Total annual precipitation ranges from 17 to 48 cm with a yearly mean of 29 cm. There is a single wet season lasting from late summer through fall.

[1]Department of Botany and Range Science, Brigham Young University, Provo, Utah 84602.

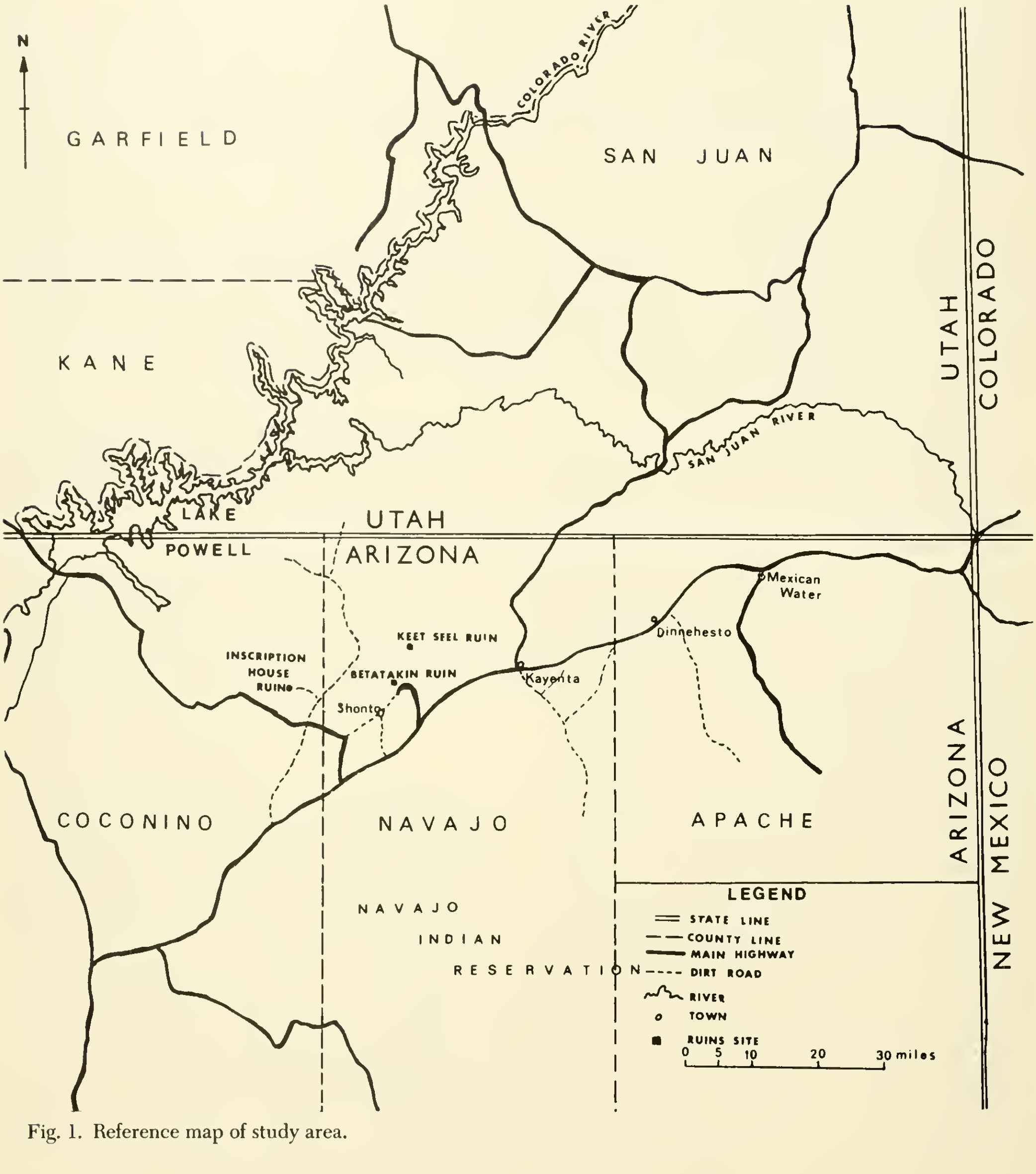


Fig. 1. Reference map of study area.

Methods

Cryptogamic crusts were sampled in the pinyon-juniper (*Pinus edulis-Juniperus osteosperma*) community that borders Betatakin Canyon in Navajo National Monument, Arizona. Cryptogam crusts were studied in paired units so that varying conditions in habitat (slope, exposure, soil texture, etc.) could be kept to a minimum. Pairs consisted of five sites where crusts were intact and undisturbed and five adjacent sites where the crusts had been heavily disturbed or destroyed. A total of 10 sites were considered for each measurement. Pairs were always located within 2 m of each other.

Water infiltration rates were measured by using a thin-walled aluminum cylinder 12 cm tall and 65 mm in diameter. The cylinder was gently turned into the crust or soil to a depth of 2 cm and then 50 ml of water was ponded above the core inside of the cylinder. Infiltration into the core was measured as the number of seconds needed for the ponded water to disappear into the core.

Depth of water penetration and runoff were assessed by raining 1.5 liters of water onto the crust or adjacent soil surface through a perforated 80 mm diameter disk. The perforations were evenly spaced on a 0.5 cm grid. The disk was placed at a distance of 1.2 m above the ground surface. Total delivery time for the water to be dispensed onto the crust or soil surface was 60 seconds. These rates were designed to approximate or exceed precipitation at cloudburst proportions (i.e., 10 cm/hr). High intensities of precipitation, such as those exceeding infiltration capacities of the soil, are significant because of their effects on runoff and erosion. Once the water had disappeared into the crust or soil surface, depth of penetration was measured immediately. Five depth measurements were taken for each watering at each of the 10 areas and then averaged to give a single value for each site.

Runoff was measured by recording the across slope and downslope spread of water rained onto study sites. The area of spread was computed from these measurements using the formula for the area of an ellipse.

Soil movement was assessed by estimating the amount of soil moved during a measured rain. The following index was used: 1 = no appreciable movement; 2 = moderate movement—up to 10 percent of soil being displaced; and 3 = heavy movement—between 10 and 20 percent of soil being displaced.

All runoff and soil movement measurements were taken during the third week of August 1980. Sampling intensity was determined following the estimation procedures described by Avery 1975. Significant differences in the paired measurements were assessed through the use of Students-t statistic.

Results and Discussion

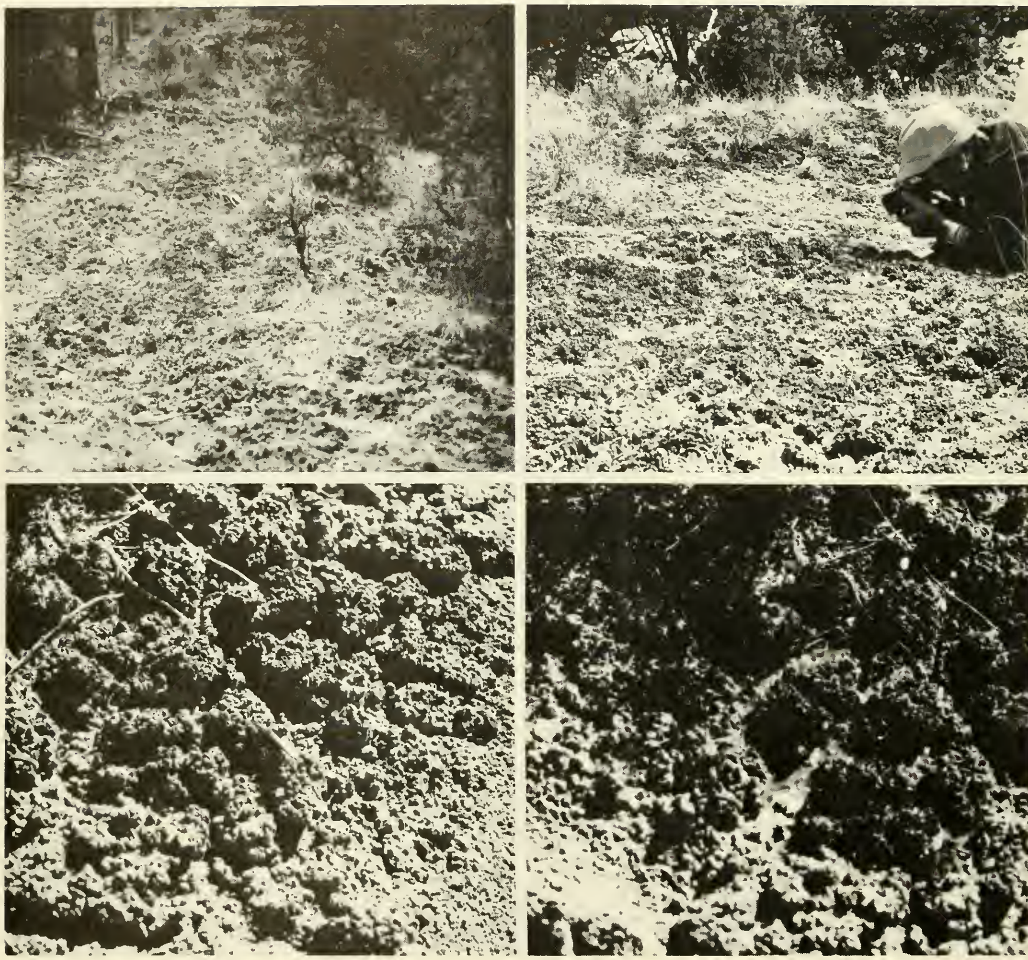
The influence of cryptogamic crusts on six soil moisture characteristics was assessed. Average values for all measurements taken during this study are given in Table I. All but one of the measured characteristics showed significant differences between crusted and uncrusted soils.

Infiltration measurements on the paired study sites indicated that well-developed cryptogamic crusts (Fig. 2) significantly increased the depth of water penetration. This was also found by Loope and Gifford (1972). Downslope movement of water was significantly greater on the sites that exhibited no crust development. Likewise, the differences in total area of surface spread was significantly greater on uncrusted soils. These differences are probably best explained by the micro-topographic changes that develop at the soil surface under the influence of cryptogamic crust growth. Well-developed crusts form pedestals so that the ground surface looks something like a convoluted brain coral (Fig. 2-4). Hills and valleys a few centimeters in relief develop across broad crusted areas. The small valleys run in all directions and cause pooling of the water as it hits the soil surface (Fig. 5). This pooling holds the water in place for extended periods, thus increasing the time for infiltration to occur and simultaneously decreasing runoff and movement across the soil surface. With reduced surface movement, deeper penetration of water occurs. The net effect is to slow the movement of surface-flowing water, providing longer periods for infiltration, less opportunity for

Table 1. Relationships of cryptogamic crusts growing on the soil in Navajo National Monument to measured moisture parameters. Figures represent means and standard deviations (sd).

Characteristic measured	Crust		Noncrust		Significance level
	Mean	sd	Mean	sd	
Water penetration depth (cm)	5.46	1.35	3.23	0.69	.05
Downslope spread (cm)	67.62	13.74	95.50	4.24	.001
Across slope spread (cm)	47.24	10.87	45.72	6.48	NS
Area of spread (sq cm)	10434.11	3041.18	13738.50	2185.26	.001
Soil movement*	1.00	0.00	2.60	0.89	.01
Infiltration (seconds)					
Moss cover	15.40	3.90	238.00	87.90	.001
Lichen and algae cover	48.00	14.50	31.00	8.10	.001

*Soil movement was assessed as follows: 1 = no movement, 2 = moderate movement—up to 10 percent of soil being displaced, 3 = heavy movement—between 10–20 percent of soil being displaced.



Figs. 2–5. Cryptogamic crusts. Left top, moving clockwise: 2. Crusts beneath Utah juniper trees. 3. Well-developed cryptogamic soil crusts. 4. Close-up of cryptogamic crusts showing typical pinnacle development. 5. Close-up of cryptogamic crust after experimental rain showing water ponding.

concentration in rills, and decreased power to cause erosion. In other words, cryptogam crusting fosters more infiltration and less runoff of surface water.

Well-developed crust areas also showed significantly less soil movement (Table 1). These data support the findings of several other studies (Fletcher and Martin 1948, Loope and Gifford 1972, Kleiner and Harper 1977, Anderson et al. 1982b). Cryptogamic crusts appear to have a protective influence on the soil in four major ways. First, they bind the soil surface particles with the intertwining growth of algal and fungal filaments (Durrell and Shields 1961). Second, the moss and lichen constituents of cryptogam crusts aid in stabilizing the soil by covering the surface with thalli and penetrating the soil surface with rhizoids (Anderson et al. 1982b). Third, the irregularities of a well-developed cryptogamic crust surface tend to break up microwind patterns and thus reduce windborn soil movement (Brady 1974). And fourth, with less water movement there is also significantly less soil movement.

Well-developed crusts also influenced water movement into the soil. Where moss cover was high, infiltration rates were greatly enhanced over areas where moss cover had been removed. The enhancement of infiltration appeared to be due to the moss thalli acting as a sponge. On the other hand, where they had been removed, a .05 to 1 cm thick layer of silt beneath them acted to retard infiltration. Infiltration rates were significantly reduced or impeded by lichen and algal crust cover. The highest infiltration rates (most rapid penetration by water) occurred on soils with no cryptogamic cover (Table 1). In general, where cryptogamic cover was high, increased resistance to infiltration occurred. Loope and Gifford (1972) noted this pattern and also found that, when crusts were wetted previous to infiltration trials, infiltration rates on crusted soils were retarded by a factor of two. Fritsch (1922) first suggested that the highly mucilaginous sheaths of blue-green algae, which are the major components of cryptogamic crusts in arid environments, might form a layer at the soil surface that would both impede water infiltration into the soil and impede evaporation of soil moisture caught beneath the algal layer. This would provide more water to the plants growing in such areas. Booth (1941) later tested this hypothesis and showed that more moisture was to be found in the upper layers of soil (i.e., the upper 2.5 cm) where cryptogamic crusts were prominent than in adjacent soils with no crusts (i.e., 8.9 percent vs. 1.3 percent, respectively).

Data from several studies indicate that high cryptogamic crust cover is associated with high silt in the soil surface (Evenari et al. 1971, Loope and Gifford 1972, Kleiner and Harper 1977, Anderson et al. 1982b). Textural observations on our sites showed similar patterns. Kleiner and Harper (1977) also argue that once established the crusts tend to trap silt at the soil surface. Evenari et al. (1971) and Blackburn and Skou (1974) present data that indicate that soils high in silt often have low permeability rates and high runoff. They suggested that soils with high levels of silt in the upper layers often show high initial infiltration rates, but, as more wetting occurs, the percolation rates decrease rapidly and eventually an almost impenetrable layer can be formed. Beneath such a sealed surface, air caught in the voids of the lower layers may have a difficult time escaping and may therefore further retard infiltration (Evenari et al. 1971).

It appears then that at least three factors tend to reduce water infiltration rates in soils with cryptogam crusts: (1) the effect of high levels of silt in the soil and its resultant swelling and sealing action when mixed with water (Evenari et al. 1971); (2) the wetting action of the water on the gelatinous sheaths of the algal filaments, causing the filament to swell and tightly bind the surface soil particles (Anantani and Marathe 1974, Durrell and Shields 1961, Fritsch 1922); and (3) air trapped beneath the sealed surface to further impede water penetration.

Evenari et al. (1971) also indicated from their research on micro-watershed irrigation projects that, as the farm areas receive runoff water ladened with silt from the watersheds and as the silt is deposited on the soil surface, evaporation from the irrigated fields was reduced to as little as 7.4 mm over a seven month period. This kind of reduction in evaporation in a desert with annual evaporation values from 1700 to 2700 mm would be highly important relative to moisture retention in the subsurface layers of the soil.

Since cryptogamic crusts tend to seal the soil surface and since crusts also increase the depth of water penetration, the effects they have on reducing moisture stress in desert ecosystems could prove to be extremely valuable. Furthermore, since crust communities tend to grow in association with high silt levels at the soil surface, these elevated silt levels undoubtedly further reduce water losses by evaporation. This being the case, cryptogamic crusts may be as important in their role in water conservation in desert systems as they are in preventing soil erosion.

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A VASCULAR FLORA OF THE SAN RAFAEL SWELL, UTAH[1]

James G. Harris[2]

Abstract.— The vegetation of the San Rafael Swell in southeastern Utah is examined based on personal field collections and previously collected herbarium specimens in the Brigham Young University Herbarium (BRY). An annotated checklist includes information on frequency of occurrence and habitat preference for each entity. Treated are 491 vascular plant taxa from 59 families.

The San Rafael Swell is the eroded remnant of a massive domal anticline, oval in shape, stretching along a northeasterly axis from Capitol Reef National Park in northern Wayne County to the foot of the Tavaputs Plateau in Carbon County. Folding of the earth's crust, which formed the domal anticline, and the subsequent erosion of the central dome left a huge area of concentric stone rings, each progressively younger from the innermost to the outermost. One of these rings, the Ferron Sandstone Member of the Mancos Shale Formation, encloses approximately 1.4 million acres of land and forms the boundary of this study. In some cases, where the Ferron Sandstone has been completely eroded from the structural confines of the swell, artificial boundaries have been followed (Fig. 1).

Throughout the field seasons of 1979 and 1980, I attempted to collect representatives of all vascular plant species growing in the San Rafael Swell. A voucher specimen from each collection has been placed in the Brigham Young University Herbarium (BRY). Included in the checklist are species not found by me, but collected by others and vouched for by specimens in the Brigham Young University Herbarium. The checklist is not definitive; additional taxa will undoubtedly be discovered in the swell.

The following sources were used for identification and nomenclature: lower vascular plants and gymnosperms, Cronquist et al. (1972); dicotyledons, Neese and Welsh (1981), Welsh (1978, 1980a, 1980b), Welsh and Atwood (1981), Welsh and Moore (1973), Welsh and Reveal (1977), Welsh et al. (1981); monocotyledons, Cronquist et al. (1977).

The checklist includes 478 vascular plant taxa found in the study area and an additional 13 taxa known to occur on lands immediately adjacent to the study area and to be expected in the San Rafael Swell. These 13 taxa are listed below:

Allionia incarnata L.
Cordylanthus wrightii Gray
Descurainia pinnata (Walter) Britt. var. *filipes* (Gray) Peck
Eriogonum smithii Reveal
Euphorbia micromera Boiss.
Haplopappus drummondii (T. & G.) Blake
Helianthus petiolaris Nutt.
Hymenopappus filifolius Hook. var. *lugens* (Greene) Jeps.
Lupinus pusillus Pursh var. *rubens* (Rydb.) Welsh
Phacelia demissa Gray var. *heterotricha* Howell
Physocarpus alternans (Jones) Howell
Sphaeralcea munroana (Dougl.) Spach
Sporobolus giganteus Nash

The flora of the San Rafael Swell is not particularly rich in numbers of species. This is due, at least in part, to the relatively narrow elevational range in the area. Although not rich in numbers of species, the flora is rather rich in numbers of unique and geographically restricted species. The following eight species are strictly endemic to the San Rafael Swell:

Astragalus rafaelensis Jones
Cryptantha johnstonii Higgins
Cryptantha jonesiana (Payson) Payson
Erigeron maguirei Cronquist

[1]Part of a master's thesis, originally submitted to the Department of Botany and Range Science, Brigham Young University, Provo, Utah 84602.

[2]Department of Botany and Range Science, Brigham Young University, Provo, Utah 84602. Present address: Department of Botany, University of Alberta, Edmonton, Alberta T6G 2E9.

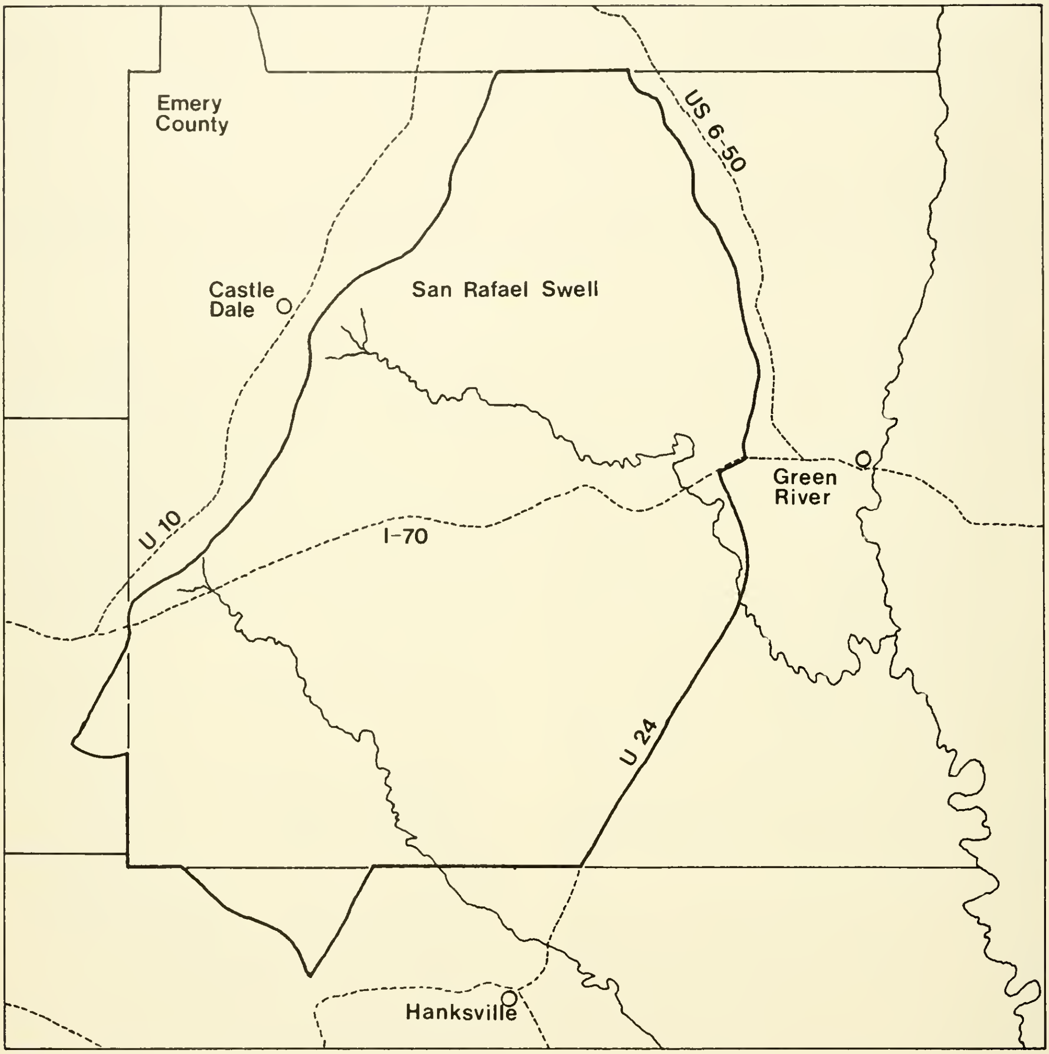

Fig. 1. Map of the San Rafael Swell study area.

Pediocactus despainii Welsh & Goodrich
Sclerocactus wrightii Benson
Sphaeralcea psoraloides Welsh
Thelypodiopsis barnebyi Welsh & Atwood

An additional seven species are endemic to the San Rafael Swell and the adjacent lands in close proximity to the swell. They are listed as follows:

Astragalus pardalinus (Rydb.) Barneby
Astragalus woodruffii Jones
Hoffmanseggia repens (Eastw.) Cockerell
Hymenoxys depressa (T. & G.) Welsh & Reveal
Lomatium junceum Barneby & Holmgren
Psorothamnus polyadenius (Torr.) Rydb. var. *jonesii* Barneby
Townsendia aprica Welsh & Reveal

Vegetative Zones

The vegetation of the San Rafael Swell can be divided into five major zones: the Sand Desert Shrub Zone, the Salt Desert Shrub Zone, the Mixed Desert Shrub Zone, the Pinyon-Juniper Zone, and the Ponderosa Pine-Mountain Brush Zone. These zones are controlled principally by elevation, precipitation, and local edaphic factors. Although in some areas the zones are clear and well defined, in most areas they interfuse considerably and it becomes difficult to draw a sharp boundary line between them.

SAND DESERT SHRUB ZONE.— The San Rafael Desert, in the southeastern region of the San Rafael Swell, ranges from an elevation of about 4200 ft (1280 m) at the lowest point to about 5000 ft (1524 m) at the highest point. It is a sandy desert with moving dunes in some areas. Common shrubs in this zone include: *Artemisia filifolia, Ephedra torreyana, Yucca harrimaniae, Poliomintha incana, Tiquilia latior,* and *Coleogyne ramosissima. Abronia elliptica, Oenothera pallida, Hoffmanseggia repens,* and *Oryzopsis hymenoides* are characteristic herbaceous plants of this zone.

SALT DESERT SHRUB ZONE.— In the San Rafael Swell the Salt Desert Shrub Zone is widespread, occurring mainly on alkaline clay soils between 4500 and 5800 ft (1372–1766 m) in elevation. Communities in this zone are characteristically dominated by *Atriplex confertifolia* interspersed with any of the following subdominant species: *Hilaria jamesii, Oryzopsis hymenoides, Enceliopsis nudicaulis, Aristida purpurea, Eriogonum inflatum, Salsola iberica* or *Ceratoides lanata.*

Highly alkaline flood plains in this zone are often covered by nearly pure stands of *Sarcobatus vermiculatus,* which may at times be accompanied by thick clumps of *Tamarix ramosissima.*

Heavy clay soils of the Mancos Shale Formation are often dominated by *Atriplex cuneata* and *Atriplex corrugata.* During wet springs these areas may be blanketed by annual species such as *Cleome lutea, Lupinus pusillus, Malcolmia africana, Camissonia scapoidea,* and *Camissonia eastwoodiae.*

MIXED DESERT SHRUB ZONE.— Deep, well-drained soils between 4500 and 5800 ft (1372–1766 m) in elevation are often dominated by one or several of the following shrubby species: *Artemisia tridentata, Artemisia bigelovii, Artemisia spinescens, Xanthocephalum sarothrae* or *Chrysothamnus viscidiflorus.* These may be intermingled with an understory of herbaceous plants including: *Hilaria jamesii, Stipa comata, Bouteloua gracilis, Astragalus* spp., *Sphaeralcea* spp., and *Leucelene ericoides.*

PINYON-JUNIPER ZONE.— *Pinus edulis* and *Juniperus osteosperma* are conspicuously dominant at elevations between 5800 and 7800 ft (1766–2377 m). Within this altitudinal range *Juniperus osteosperma* is dominant at the lower elevations and *Pinus edulis* is dominant at the higher elevations. Intermediate elevations yield a heterogeneous mixture of both species.

Dense stands have almost no understory, but more open or scattered stands will include almost all the species found in the Mixed Desert Shrub Zone.

PONDEROSA PINE-MOUNTAIN BRUSH ZONE.— The highest point in the San Rafael Swell is the San Rafael Knob at 7921 ft (2414 m) in elevation. The area surrounding the knob and the summit of Cedar Mountain represent the highest vegetative zone in the swell. *Pinus edulis* continues to remain dominant even at the highest elevations, but above 7500 ft (2286 m) plants characteristic of the Ponderosa Pine-Mountain Brush Zone become increasingly common. Some common species in this zone are: *Pinus ponderosa, Artemisia nova, Cowania mexicana, Mahonia fremontii, Populus tremuloides, Amelanchier utahensis, Cercocarpus montanus, Ribes leptanthum, Juniperus scopulorum, Hymenoxys richardsonii, Symphoricarpos longiflorus* and *Philadelphus microphyllus.*

In addition to these five major vegetative zones, smaller communities dependent on unique local habitats are scattered throughout the area. These include plants distributed along seeps and streams, along washes and roadsides where runoff collects, in hanging gardens, on rocky outcrops, and on disturbed sites.

ANNOTATED CHECKLIST

Following each species entry in the checklist (with the exception of the 13 taxa from lands adjacent to the study area) a designation is given concerning the frequency of occurrence and habitat preference of the taxon. Plants of broad distribution that are not limited to a specific zone or community type are listed as widespread. The following abbreviations are used:

C—common
O—occasional
U—uncommon
R—rare
SnD—Sand Desert Shrub Zone
SlD—Salt Desert Shrub Zone
MD—Mixed Desert Shrub Zone
PJ—Pinyon-Juniper Zone

PM—Ponderosa Pine-Mountain Brush Zone
SS—Seeps and streams
WR—Washes and roadsides
HG—Hanging gardens
RO—Rocky outcrops
DS—Disturbed sites
W—Widespread

ACERACEAE
Acer glabrum Torr. (R;PM)

ANACARDIACEAE
Rhus trilobata Nutt. var. *simplicifolia* (Greene) Barkl. (C;WR)
Rhus trilobata Nutt. var. *trilobata* (C;WR)
Toxicodendron rydbergii (Small) Greene (C;SS,HG)

APIACEAE
Cymopteris acaulis (Pursh) Raf. (O;SnD,SlD)
Cymopteris bulbosus Nels. (C;W)
Cymopteris fendleri Gray (C;W)
Cymopteris purpurascens (Gray) Jones (O;SlD)
Cymopteris purpureus Wats. (O;W)
Lomatium junceum Barneby & Holmgren (R;SlD,MD,PJ)
Sium suave Walt. (R;WR)

APOCYNACEAE
Amsonia eastwoodiana Rydb. (C;SnD)
Amsonia jonesii Woodson (O;MD,PJ)
Apocynum cannabinum L. (C;SS,HG)
Cycladenia humilis Benth. var. *jonesii* (Eastw.) Welsh & Atwood (R;MD)

ASCLEPIADACEAE
Asclepias cryptoceras Wats. (C;W)
Asclepias labriformis Jones (C;WR,SD,MD)
Asclepias macrosperma Eastw. (C;SnD,MD)
Asclepias ruthiae Maguire & Woodson (O;W)
Asclepias speciosa Torr. (C;WR)

ASTERACEAE
Ambrosia acanthicarpa Hook. (O;SlD,MD,PJ)
Ambrosia artemisiifolia L. (C;SlD,MD,PJ)
Artemisia biennis Willd. (U;WR)
Artemisia bigelovii Gray (C;MD,PJ)
Artemisia campestris L. (U;SnD,MD)
Artemisia dracunculus L. (C;WR)
Artemisia filifolia Torr. (C;SnD)
Artemisia frigida Willd. (R;WR)
Artemisia ludoviciana Nutt. (O;WR)
Artemisia nova Nels. (C;PJ,PM)
Artemisia pygmaea Gray (O;SlD,MD,PJ)
Artemisia spinescens Eaton (O;SlD, MD)
Artemisia tridentata Nutt. (C;MD,PJ,WR)
Aster glaucodes Blake (U;PM)
Baccharis emoryi Gray (U;WR)
Brickellia longifolia Wats. (U;WR)
Brickellia microphylla (Nutt.) Gray (U;WR)
Brickellia oblongifolia var. *linifolia* (Eaton) Robins (O;PJ,WR)
Brickellia scabra (Gray) Nels. (R;HG,WR)
Chaenactis stevioides Hook. & Arn. (C;SlD,MD)
Chamaechaenactis scaposa (Eastw.) Rydb. (O;PJ)
Chrysothamnus greenei (Gray) Greene (O;SlD)
Chrysothamnus linifolius Greene (O;WR)
Chrysothamnus nauseosus (Pall.) Britt. var. *consimilis* (Greene) Hall (C;WR)
Chrysothamnus nauseosus (Pall.) Britt. var. *gnaphaloides* (Greene) Hall (U;WR)
Chrysothamnus nauseosus (Pall.) Britt. var. *junceus* (Greene) Hall (U;WR)
Chrysothamnus nauseosus (Pall.) Britt. var. *leiospermus* (Gray) Hall (R;WR)
Chrysothamnus pulchellus (Gray) Greene (U;WR)
Chrysothamnus viscidiflorus (Hook.) Nutt. var. *stenophyllus* (Gray) Hall (U;WR)
Chrysothamnus viscidiflorus (Hook.) Nutt. var. *viscidiflorus* (C;WR)
Cirsium pulchellum (Greene) Woot. & Standl. (U;WR)
Cirsium undulatum (Nutt.) Spreng. (C;WR)
Dicoria canescens Gray (U;SnD)
Encelia frutescens Gray (U;WR)
Enceliopsis nudicaulis (Gray) Nels. (C;SlD, MD)
Enceliopsis nutans (Eastw.) Nels. (C;SlD,MD)
Erigeron argentatus Greene (O;SlD,MD,PJ)
Erigeron compactus Blake var. *consimilis* Cronquist (O;MD,PJ)
Erigeron divergens T. & G. (U;PJ)
Erigeron eatonii Gray (U;PJ,PM)
Erigeron maguirei Cronquist (R;WR)
Erigeron pulcherrimus Heller var. *pulcherrimus* (C;SlD,MD,PJ)
Erigeron pumilus Nutt. ssp. *concinnoides* Cronq. var. *condensatus* (Eaton) Cronq. (C;SlD,MD,PJ)
Erigeron utahensis Gray (C;WR,RO)
Gaillardia pinnatifida Torr. (C;SlD,MD)
Gaillardia spathulata Gray (C;SlD,MD,PJ)
Grindelia squarrosa (Pursh) Dunal. (O;WR)
Haplopappus armerioides (Nutt.) Gray (C;MD,PJ,RO)
Haplopappus drummondii (T. & G.) Blake
Helianthella microcephala (Gray) Gray (C;PJ,PM)
Helianthus annuus L. (C;WR)
Helianthus anomalus Blake (C;SnD)
Helianthus petiolaris Nutt.
Heterotheca villosa (Pursh) Shinners (C;SlD,MD,PJ)
Hymenopappus filifolius Hook. var. *lugens* (Greene) Jeps.
Hymenopappus filifolius Hook. var. *megacephalus* Turner (C;SlD,MD)
Hymenopappus filifolius Hook. var. *pauciflorus* (Johnst.) Turner (O;SlD)
Hymenoxys acaulis (Pursh) Parker var. *arizonica* (Greene) Parker (C;MD,PJ)
Hymenoxys depressa (T. & G.) Welsh & Reveal (O;RO)
Hymenoxys richardsonii (Hook.) Cockerell (C;PJ,PM)
Iva axillaris Pursh (O;SS,WR)
Iva xanthifolia Nutt. (O;WR)
Leucelene ericoides (Torr.) Greene (C;W)
Lygodesmia arizonica Tomb (C;SlD,MD,WR)
Lygodesmia grandiflora (Nutt.) T. & G. (C;SlD)
Lygodesmia juncea (Pursh) D. Don (R;SnD)
Machaeranthera canescens (Pursh) Gray (R;SnD)
Machaeranthera grindelioides (Nutt.) Shinners (C;W)
Machaeranthera linearis Greene (U;WR)
Machaeranthera tanacetifolia (H.B.K.) Nees (C;WR)
Malacothrix sonchoides (Nutt.) T. & G. (C;SlD,MD)
Oxytena acerosa Nutt. (C;SS,WR)
Parthenium ligulatum (Jones) Barneby (U;SlD,MD,PJ)
Petradoria pumila (Nutt.) Greene (C;PJ,WR,RO)
Platyschkuhria integrifolia (Gray) Rydb. var. *oblongifolia* (Gray) Ellison (C;WR)
Prenanthella exigua (Gray) Rydb. (C;WR,RO)
Senecio multicapitatus Greenm. (U;PJ,PM,WR)

Senecio multilobatus T. & G. (O;PJ,WR)
Stephanomeria exigua Nutt. (O;WR)
Stephanomeria runcinata Nutt. (R;WR)
Stephanomeria spinosa (Nutt.) Tomb (U;WR)
Stephanomeria tenuifolia (Torr.) Hall (C;WR,RO)
Taraxacum officinale Weber (C;SS)
Tetradymia canescens DC. (O;PJ,PM)
Tetradymia glabrata Gray (C;MD,PJ)
Tetradymia spinosa Hook. & Arn. (O;WR)
Thelesperma subnudum Gray (C;W)
Townsendia annua Beaman (U;MD)
Townsendia aprica Welsh & Reveal (U;SlD,MD,PJ)
Townsendia incana Nutt. (C;SlD,MD,PJ)
Tragopogon dubius Scop. (C;W)
Vanclevea stylosa (Eastw.) Greene (C;SnD)
Wyethia scabra Hook. (C;WR)
Xanthium strumarium L. (O;SS)
Xanthocephalum microcephalum (DC.) Shinners (R;PJ)
Xanthocephalum sarothrae (Pursh) Shinners (C;SlD,MD,PJ)
Xylorhiza venusta (Jones) Heller (C;RO)

BERBERIDACEAE
Mahonia fremontii (Torr.) Fedde (C;MD,PJ)

BETULACEAE
Betula occidentalis Hook. (R;SS)

BORAGINACEAE
Cryptantha cinerea Greene (R;PJ,PM)
Cryptantha confertifolia (Greene) Payson (R;SnD)
Cryptantha crassisepala (T. & G.) Greene var. *elachantha* Johnst. (C;W)
Cryptantha flava (Nels.) Payson (C;W)
Cryptantha flavoculata (Nels.) Payson (C;PJ)
Cryptantha fulvocanescens (Wats.) Payson var. *echinoides* (Jones) Higgins (O;SlD)
Cryptantha fulvocanescens (Wats.) Payson var. *fulvocanescens* (C;MD,PJ)
Cryptantha gracilis Osterh. (U;PJ)
Cryptantha humilis (Gray) Payson var. *nana* (Eastw.) Higgins (O;PJ)
Cryptantha jamesii (Torr.) Payson var. *disticha* (Eastw.) Payson (U;MD,WR)
Cryptantha jamesii (Torr.) Payson var. *setosa* (Jones) Johnst. (C;PJ)
Cryptantha johnstonii Higgins (U;SlD)
Cryptantha jonesiana (Payson) Payson (U;SlD)
Cryptantha mensana (Jones) Payson (O;SlD)
Cryptantha paradoxa (Nels.) Payson (O;PJ)
Cryptantha recurvata Coville (O;MD,PJ,WR)
Cryptantha rollinsii Johnst. (O;MD,PJ,WR)
Cryptantha tenuis (Eastw.) Payson (O;WR)
Cryptantha wetherillii (Eastw.) Payson (O;SlD)
Heliotropium convulvulaceum (Nutt.) Gray (U;SnD)
Lappula occidentalis (Wats.) Greene var. *cupulata* (Gray) Higgins (R;MD,PJ)
Lappula occidentalis (Wats.) Greene var. *occidentalis* (C;W)
Lithospermum incisum Lehm. (C;PJ)
Tiquilia latior (Johnst.) Richardson (O;SlD,MD)

BRASSICACEAE
Arabis demissa Greene var. *lanugida* Rollins (R;PJ,PM)
Arabis perennans Wats. (O;PJ)
Arabis pulchra Jones var. *pallens* Jones (O;PJ)
Arabis selbyi Rydb. (C;PJ)
Caulanthus crassicaulis (Torr.) Wats. (C;PJ)
Chorispora tenella (Pall.) DC. (U;DS)
Descurainia pinnata (Walt.) Britt. var. *filipes* (Gray) Peck
Descurainia pinnata (Walt.) Britt. var. *intermedia* (Rydb.) Hitchc. (U;MD)
Descurainia pinnata (Walt.) Britt. var. *osmarium* (Cockerell) Shinners (C;W)
Descurainia sophia (L.) Webb. (O;WR)
Dithyrea wislizenii Engelm. in Wisliz. (O;SnD)
Lepidium densiflorum Schrad. var. *pubicarpum* (Nels.) Thell. (R;PJ)
Lepidium densiflorum Schrad. var. *ramosum* (Nels.) Thell. (O;MD,PJ)
Lepidium montanum Nutt. var. *jonesii* (Rydb.) Hitchc. (C;W)
Lesquerella alpina (Nutt.) Wats. var. *alpina* (O;PJ,PM)
Lesquerella intermedia (Wats.) Heller (O;PJ,PM)
Lesquerella kingii Wats. (R;PJ)
Lesquerella rectipes Woot. & Standl. (C;W)
Lesquerella subumbellata Rollins (U;PJ,PM)
Malcolmia africana (L.) R. Br. in Ait. (C;SlD,DS)
Physaria acutifolia Rydb. (C;PJ)
Physaria chambersii Rollins (U;PJ)
Schoencrambe linifolia (Nutt.) Greene (O;PJ,PM)
Sisymbrium altissimum L. (C;PJ,PM)
Stanleya pinnata (Pursh) Britt. (C;SlD)
Stanleya viridiflora Nutt. in T. & G. (U;MD,PJ)
Streptanthella longirostris (Wats.) Rydb. (C;W)
Streptanthus cordatus Nutt. ex T. & G. (C;PJ)
Thelypodiopsis barnebyi Welsh & Atwood (R;MD)
Thelypodiopsis divaricata (Rollins) Welsh & Reveal (C;SlD,MD,PJ)

CACTACEAE
Coryphantha vivipara (Nutt.) Britt. & Rose (O;PJ)
Echinocereus triglochidiatus Engelm. var. *melanacanthus* (Engelm.) Benson (C;SlD,MD,PJ)
Opuntia basilaris Engelm. & Bigel. (O;SnD,MD,PJ)
Opuntia erinacea Engelm. (O;SnD)
Opuntia polyacantha Haw. (C;W)
Pediocactus despainii Welsh & Goodrich (R;PJ)
Pediocactus simpsonii (Engelm.) Britt. & Rose (R;PJ)
Sclerocactus parviflorus Clover & Jotter var. *intermedius* (Peebles) Woodruff & Benson (C;W)
Sclerocactus wrightiae Benson (U;SlD,MD,PJ)

CAPPARIDACEAE
Cleome lutea Hook. (C;SlD)
Cleome serrulata Pursh (O;PJ)
Cleomella palmerana Jones (O;PJ)

CAPRIFOLIACEAE
Sambucus coerulea Raf. (U;PJ,PM)
Symphoricarpos longiflorus Gray (O;PJ,PM)

CARYOPHYLLACEAE
Arenaria eastwoodiae Rydb. (C;PJ)
Arenaria fendleri Gray (C;SlD)
Arenaria hookeri Nutt. var. *desertorum* Maguire (R;PJ)
Paronychia sessiliflora Nutt. (O;PJ,WR)

CELASTRACEAE
Forsellesia meionandra (Koehne) Heller (O;PJ,RO)

CHENOPODIACEAE
Allenrolfea occidentalis (Wats.) Kuntze (O;SlD)
Atriplex argentea Nutt. (U;SlD)
Atriplex canescens (Pursh) Nutt. (C;SlD,MD)
Atriplex confertifolia (Torr. & Frem.) Wats. (C;SlD)
Atriplex corrugata Wats. (C;SlD)

Atriplex cuneata Nels. (C;SlD)
Atriplex graciliflora Jones (U;SlD)
Atriplex powellii Wats. (C;SlD)
Atriplex saccaria Wats. (U;MD)
Bassia hysopifolia Pallas (U;WR)
Ceratoides lanata (Pursh) Howell (C;SlD)
Chenopodium fremontii Wats. (C;W)
Chenopodium glaucum L. (O;SlD)
Chenopodium pratericola Rydb. (C;SS)
Grayia brandegei Gray (U;MD)
Halogeton glomeratus (Bieb.) Meyer (C;DS)
Kochia iranica Bornm. (C;WR)
Kochia americana Wats. (R;SlD,WR)
Monolepis nuttalliana (Schult.) Greene (O;WR)
Salsola iberica Sennen & Pau (C;W)
Sarcobatus vermiculatus (Hook.) Torr. (C;SlD,SS,WR)
Suaeda torreyana Wats. (C;SS,WR)

CONVOLVULACEAE
Convolvulus arvensis L. (C;WR)
Cuscuta cuspidata Engelm. (C;MD)

CUPRESSACEAE
Juniperus osteosperma (Torr.) Little (C;PJ,PM)
Juniperus scopulorum Sarg. (U;PM)

CYPERACEAE
Carex filifolia Nutt. (C;SS)
Carex parryana Dewey (R;SS)
Eleocharis palustris (L.) Roemer & Schult. (O;SS)
Eleocharis rostellata (Torr.) Torr. (U;SS)
Scirpus maritimus L. (O;SS)
Scirpus pungens Vahl. (C;SS)
Scirpus validus Vahl. (O;SS)

ELAEAGNACEAE
Shepherdia rotundifolia Parry (U;PJ)
Shepherdia argentea (Pursh) Nutt. (U;WR)

EPHEDRACEAE
Ephedra torreyana Wats. (C;W)
Ephedra viridis Coville (C;W)

EQUISETACEAE
Equisetum laevigatum A. Br. (C;SS)

EUPHORBIACEAE
Euphorbia albomarginata T. & G. (U;PJ)
Euphorbia fendleri T. & G. (C;SlD,MD,PJ)
Euphorbia micromera Boiss.
Euphorbia nephradenia Barneby (R;SlD,WR)
Euphorbia palmeri Engelm. (R;SlD)
Euphorbia parryi Engelm. (C;SnD)
Euphorbia robusta (Engelm.) Small (O;PJ,PM)
Euphorbia serphyllifolia Pers. (C;PJ,PM)

FABACEAE
Astragalus amphioxys Gray var. *amphioxys* (C;SlD,MD,PJ)
Astragalus amphioxys Gray var. *vespertinus* (Sheld.) Jones (C;W)
Astragalus argophyllus Nutt. var. *martinii* Jones (U;PJ,PM)
Astragalus asclepiadoides Jones (C;SlD)
Astragalus brandegei Porter (U;SlD,MD,PJ)
Astragalus calycosus Torr. (O;SlD,MD,PJ)
Astragalus ceramicus Sheldon (U;WR)
Astragalus coltonii Jones var. *coltonii* (C;SlD,MD,PJ)
Astragalus convallarius Greene var. *convallarius* (U;PJ,PM)
Astragalus cymboides Jones (C;SlD,MD,PJ)
Astragalus desperatus Jones var. *desperatus* (C;SnD,MD,PJ)
Astragalus desperatus Jones var. *petrophilus* Jones (C;MD,SnD,PJ)
Astragalus episcopus Wats. (C;MD,PJ)
Astragalus flavus Nutt. var. *argillosus* (Jones) Barneby (C;SlD)
Astragalus flavus Nutt. var. *flavus* (C;SlD,MD,PJ)
Astragalus flexuosus (Hook.) Don. var. *diehlii* (Jones) Barneby (O;SlD,MD,PJ)
Astragalus geyeri Gray (O;MD)
Astragalus kentrophyta Gray var. *coloradoensis* Jones (U;WR,RO)
Astragalus kentrophyta Gray var. *elatus* Wats. (R;SlD)
Astragalus lentiginosus Dougl. var. *araneosus* (Sheld.) Barneby (C;MD,PJ)
Astragalus lentiginosus Dougl. var. *palans* (Jones) Jones (C;MD,PJ)
Astragalus lonchocarpus Torr. (C;SlD,MD,PJ)
Astragalus moencoppensis Jones (C;SlD,MD,PJ)
Astragalus mollissimus Torr. var. *thompsonae* (Wats.) Barneby (C;W)
Astragalus musiniensis Jones (C;SlD,MD,PJ)
Astragalus pardalinus (Rydb.) Barneby (O;SnD,MD,PJ)
Astragalus praelongus Sheld. var. *ellisiae* (Rydb.) Barneby (C;SlD)
Astragalus praelongus Sheld. var. *praelongus* (U;SlD)
Astragalus preussii Gray var. *preussii* (C;SlD,MD,PJ)
Astragalus rafaelensis Jones (O;SlD)
Astragalus sabulonum Gray (O;PJ,PM)
Astragalus spatulatus Sheld. (O;PJ,PM)
Astragalus subcinereus Gray var. *basalticus* Welsh (R;PJ)
Astragalus tenellus Pursh (O;MD,PJ)
Astragalus wingatanus Wats. (R;SlD,MD,PJ)
Astragalus woodruffii Jones (U;SnD,MD)
Dalea flavescens (Wats.) Welsh (O;SnD,MD,PJ)
Dalea oligophylla (Torr.) Shinners (O;WR,RO)
Glycyrrhiza lepidota Pursh (C;WR,SS)
Hedysarum boreale Nutt. (C;MD,PJ,PM)
Hoffmanseggia repens (Eastw.) Cockerell (C;SnD)
Lathyrus brachycalyx Rydb. var. *eucosmus* (Butters & St. John) Welsh (U;WR)
Lupinus argenteus Pursh var. *argenteus* (R;WR)
Lupinus argenteus Pursh var. *tenellus* Dougl. (U;MD)
Lupinus brevicaulis Wats. (U;SlD,MD)
Lupinus pusillus Pursh var. *pusillus* (C;SlD,MD,PJ)
Lupinus pusillus Pursh var. *rubens* (Rydb.) Welsh
Medicago sativa L. (C;WR)
Melilotus alba Medicus (O;SS,WR)
Melilotus officinalis (L.) Lam. (O;SS,WR)
Oxytropis lambertii Pursh var. *bigelovii* Gray (R;PJ,PM)
Oxytropis sericea Nutt. (O;MD,PJ)
Psoralea lanceolata Pursh var. *lanceolata* (U;MD,PJ)
Psoralea lanceolata Pursh var. *stenophylla* (Rydb.) Toft & Welsh (O;WR)
Psorothamnus polyadenius (Torr.) Rydb. var. *jonesii* Barneby (R;SlD,MD)
Psorothamnus thompsonae (Vail) Welsh & Atwood (R;MD)
Robinia pseudoacacia L. (R;WR)
Sophora stenophylla Gray (O;MD)

FUMARIACEAE
Corydalis aurea Willd. (R;PJ)

GENTIANACEAE
Swertia albomarginata (Wats.) Kuntze (R;PM)
Swertia utahensis (Jones) St. John (C;SnD,MD)
HYDROPHYLLACEAE
Phacelia constancei Atwood (R;SlD)
Phacelia corrugata Nels. (C;W)
Phacelia demissa Gray var. *demissa* (O;SlD,PJ)
Phacelia demissa Gray var. *heterotricha* Howell
Phacelia indecora Howell (R;SlD)
Phacelia ivesiana Torr. (C;SlD,MD,PJ)
Phacelia rafaelensis Atwood (C;MD,PJ)
JUNCACEAE
Juncus arcticus Willd. (C;SS)
Juncus balticus Willd. (C;SS)
Juncus nodosus L. (U;SS)
Juncus torreyi Coville (O;SS)
JUNCAGINACEAE
Triglochin maritima L. (U;SS)
LAMIACEAE
Poliomintha incana (Torr.) Gray (C;SnD)
LILIACEAE
Allium geyeri Wats. (C;PJ,PM)
Allium macropetalum Rydb. (U;SlD)
Allium textile Nels. & Macbr. (C;SnD)
Androstephium breviflorum Wats. (C;SlD,MD,PJ)
Asparagus officinalis L. (O;WR,SS)
Calochortus nuttallii T. & G. (C;SlD,MD)
Eremocrinum albomarginatum (Jones) Jones (C;SnD)
Smilacina stellata (L.) Desf. (C;HG)
Yucca harrimaniae Trel. (C;SnD,MD,PJ)
LINACEAE
Linum aristatum Engelm. (U;WR)
Linum perenne L. (C;WR)
Linum puberulum (Engelm.) Heller (O;SlD)
Linum subteres Winkler (O;WR,PJ)
LOASACEAE
Mentzelia albicaulis Dougl. (C;SlD,MD,PJ)
Mentzelia humilis (Gray) Darl. (U;WR)
Mentzelia multiflora (Nutt.) Gray (C;SnD)
Mentzelia pterosperma Eastw. (U;WR)
Mentzelia pumila (Nutt.) T. & G. (O;WR)
MALVACEAE
Sphaeralcea coccinea (Nutt.) Rydb. (C;W)
Sphaeralcea grossulariifolia (Hook. & Arn.) Rydb. (O;SnD,MD)
Sphaeralcea leptophylla (Gray) Rydb. (R;WR)
Sphaeralcea munroana (Dougl.) Spach
Sphaeralcea parvifolia Nels. (C;W)
Sphaeralcea psoraloides Welsh (R;SlD,MD)
NYCTAGINACEAE
Abronia elliptica Nels. (C;SnD,MD,WR)
Abronia nana Wats. (U;SlD,PJ)
Allionia incarnata L.
Oxybaphus linearis (Pursh) Robins. (C;W)
Tripterocalyx micranthus (Torr.) Hook. (O;SnD)
OLEACEAE
Fraxinus anomala Torr. in Wats. (C;WR)
ONAGRACEAE
Calylophus lavandulaefolia (T. & G.) Raven (O;PJ,RO)
Camissonia eastwoodiae (Munz) Raven (C;SnD,SlD)
Camissonia scapoidea (T. & G.) Raven (C;SnD,SlD)
Camissonia walkeri (Nels.) Raven (U;SlD,MD)
Oenothera brachycarpa (Gray) Britt. (U;MD,PJ,WR)
Oenothera caespitosa Nutt. (C;SnD,MD,WR)
Oenothera pallida Lindl. ssp. *pallida* (C;SnD,MD,WR)
Oenothera pallida Lindl. ssp. *trichocalyx* (Nutt.) Munz & Klein (C;SlD,MD)
ORCHIDACEAE
Epipactis gigantea Dougl. ex Hook. (C;HG,SS)
OROBANCHACEAE
Orobanche fasciculata Nutt. (O;W)
PAPAVERACEAE
Argemone corymbosa Greene (C;SnD)
Argemone munita Dur. & Hilg. (C;SnD)
PINACEAE
Pinus edulis Engelm. (C;PJ,PM)
Pinus ponderosa Lawson (C;PM)
Pseudotsuga menziesii (Mirb.) Franc. (C;PM)
PLANTAGINACEAE
Plantago patagonica Jacq. (C;SlD,MD)
POACEAE
Agropyron caninum (L.) Beauv. (U;MD,RO)
Agropyron cristatum (L.) Gaertn. (C;MD,PJ)
Agropyron spicatum (Pursh) Scribn. & Smith (U;PJ)
Agropyron trachycaulum (Link) Malte (U;WR)
Andropogon hallii Hackel (R;WR)
Aristida purpurea Nutt. (C;W)
Bouteloua curtipendula (Michx.) Gray (R;MD)
Bouteloua gracilis (H.B.K.) Lag. ex Steud. (C;SlD,MD,PJ)
Bromus japonicus Thunb. (R;PJ)
Bromus tectorum L. (C;WR,DS)
Calamagrostis scopulorum Jones (U;WR)
Dichanthelium lanuginosum (Elliott) Gould (U;SS)
Distichlis spicata (L.) Greene var. *stricta* (Torr.) Scribn. (C;SlD,WR)
Elymus canadensis L. (U;WR)
Elymus cinereus Scribn. & Merr. (O;MD,PJ)
Elymus junceus Fischer (R;SlD,MD)
Elymus salina Jones (C;PJ)
Erioneuron pilosum (Buckley) Nash (C;MD,RO,WR)
Erioneuron pulchellum (H.B.K.) Tateoka (R;PJ)
Festuca pratensis Huds. (U;SS)
Hilaria jamesii (Torr.) Benth. (C;W)
Hordeum jubatum L. (C;WR)
Muhlenbergia asperifolia (Nees & Mey.) Parodi (O;WR)
Muhlenbergia pungens Thurber (C;SnD)
Munroa squarrosa (Nutt.) Torr. (O;PJ)
Oryzopsis hymenoides (Roem. & Schult.) Ricker (C;W)
Oryzopsis micrantha (Trin. & Rupr.) Thurber (U;PJ)
Panicum virgatum L. (O;SS,WR)
Phragmites australis (Car.) Trin. ex Steud. (C;SS)
Poa fendleriana (Steud.) Vasey (O;PJ,PM)
Poa pratensis L. (U;SS,WR)
Poa sandbergii Vasey (U;PJ)
Polypogon monspeliensis (L.) Desf. (U;SS,WR)
Schedonnardus paniculatus (Nutt.) Trel. (R;SlD)
Schizachyrium scoparium (Michx.) Nash (O;PJ,WR)
Sitanion hystrix (Nutt.) Smith (C;W)
Spartina gracilis Trin. (U;SS)
Sporobolus airoides (Torr.) Torr. (C;SlD,MD)
Sporobolus contractus Hitchc. (O;MD,PJ,WR)
Sporobolus cryptandrus (Torr.) Gray (C;SlD,MD,PJ)
Sporobolus flexuosus (Thurb.) Rydb. (U;SnD,WR)
Sporobolus giganteus Nash
Stipa arida Jones (U;WR)
Stipa comata Trin. & Rupr. (C;MD,PJ)
Stipa columbiana Macoun. (U;PJ)

Stipa speciosa Trin. & Rupr. (U;PJ)
Vulpia octoflora (Walt.) Rydb. (O;PJ,WR)

POLEMONIACEAE
Gilia aggregata (Pursh) Spreng. (C;W)
Gilia congesta Hook. (O;SlD)
Gilia gunnisonii T. & G. (C;MD,WR)
Gilia inconspicua (Smith) Sweet (C;PJ)
Gilia latifolia Wats. (R;RO,WR)
Gilia leptomeria Gray (C;SnD,MD,PJ)
Gilia polycladon Torr. in Emory (O;SlD)
Gilia pumila Nutt. (O;SlD)
Gilia roseata Rydb. (C;WR,RO)
Gilia stenothyrsa Gray (O;PJ)
Leptodactylon caespitosum Nutt. (U;WR)
Leptodactylon pungens (Torr.) Nutt. (O;MD,WR,RO)
Leptodactylon watsonii (Gray) Rydb. (U;WR,RO)
Phlox austromontana Cov. (O;PJ)
Phlox hoodii Rich. (C;MD,PJ)
Phlox longifolia Nutt. (O;SlD,MD)

POLYGALACEAE
Polygala acanthoclada Gray (R;MD)
Polygala subspinosa Wats. (C;SlD,PJ,RO)

POLYGONACEAE
Eriogonum alatum Torr. in Sitgr. (C;PJ)
Eriogonum batemanii Jones (C;PJ)
Eriogonum bicolor Jones (C;MD,PJ)
Eriogonum cernuum Nutt. (C;SlD)
Eriogonum corymbosum Benth. var. *corymbosum* (C;SlD,MD)
Eriogonum fasciculatum Benth. var. *polifolium* (Benth. in DC.) T. & G. (R;MD)
Eriogonum flexum Jones (R;SlD)
Eriogonum gordonii Benth. (U;SlD,MD)
Eriogonum hookeri Wats. (O;MD,PJ)
Eriogonum inflatum Torr. & Frem. var. *fusiforme* (Small) Reveal (O;SlD,MD,PJ)
Eriogonum inflatum Torr. & Frem. var. *inflatum* (C;SlD,MD)
Eriogonum jamesii Benth. var. *flavescens* Wats. (C;MD,PJ,WR)
Eriogonum leptocladon T. & G. var. *leptocladon* (C;SlD)
Eriogonum microthecum Nutt. var. *foliosum* (T. & G.) Reveal (O;SlD)
Eriogonum ovalifolium Nutt. var. *ovalifolium* (C;W,RO)
Eriogonum salsuginosum (Nutt.) Hook. (O;MD,PJ)
Eriogonum shockleyi Wats. var. *longilobum* (Jones) Reveal (C;SlD,MD)
Eriogonum smithii Reveal
Eriogonum tumulosum (Barneby) Reveal (U;PJ)
Eriogonum wetherillii Eastw. (O;W)
Polygonum aviculare L. (O;WR,DS)

POLYPODIACEAE
Adiantum capillus-veneris L. (U;HG)
Cheilanthes feei Moore (O;HG)
Pellaea glabella Mett. ex Kuhn (R;HG)

PORTULACEAE
Portulaca oleracea L. (R;PJ,PM)
Talinum validulum Greene (O;PJ)

RANUNCULACEAE
Aquilegia micrantha Eastw. (C;HG)
Clematis ligusticifolia Nutt. (C;WR)
Delphinium nuttallianum Pritz. ex Walp. (O;W)
Delphinium scaposum Greene (O;PJ)
Ranunculus cymbalaria Pursh (U;SS)
Ranunculus testiculatus Crantz (O;DS)

ROSACEAE
Amelanchier utahensis Koehne (C;WR,SS)
Cercocarpus intricatus Wats. (C;PJ,RO)
Cercocarpus montanus Raf. (C;PJ,PM,WR)
Coleogyne ramosissima Torr. (C;SnD)
Cowania mexicana D. Don (C;PJ)
Fallugia paradoxa (D. Don) Endl. (O;WR)
Physocarpus alternans (Jones) Howell
Physocarpus monogynus (Torr.) Cou. (U;PJ)
Purshia tridentata (Pursh) DC. (O;WR)
Rosa woodsii Lindl. (R;PM)

RUBIACEAE
Galium multiflorum Kellogg (O;WR)

SALICACEAE
Populus x acuminata Rydb. (U;WR,SS)
Populus angustifolia James ex Torr. (O;WR)
Populus fremontii Wats. (C;WR,SS)
Populus tremuloides Michx. (O;PM)
Salix exigua Nutt. (C;SS)

SANTALACEAE
Comandra umbellata (L.) Nutt. var. *pallida* (DC.) Jones (C;W,WR)

SAXIFRAGACEAE
Philadelphus microphyllus Gray (C;PJ,PM)
Ribes cereum Dougl. (R;PJ,PM)
Ribes leptanthum Gray (O;PM)

SCROPHULARIACEAE
Castilleja chromosa Nels. (O;W)
Castilleja linariaefolia Benth. (O;SS)
Castilleja scabrida Eastw. (C;W)
Cordylanthus kingii Wats. (O;PJ)
Cordylanthus wrightii Gray
Mimulus rubellus Gray (R;PM)
Penstemon carnosus Pennell (C;PJ)
Penstemon cyanocaulis Payson (U;WR)
Penstemon eatonii Gray (O;PJ,PM)
Penstemon lentus Pennell (U;WR)
Penstemon utahensis Eastw. (C;PJ)

SELAGINELLACEAE
Selaginella mutica Eaton ex Underw. (U;HG)

TAMARICACEAE
Tamarix ramosissima Ledeb. (C;SS,WR)

TYPHACEAE
Typha latifolia L. (C;SS)

ULMACEAE
Celtis reticulata Torr. (U;WR)
Ulmus pumila L. (R;WR)

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PRONGHORN RESPONSES TO HUNTING COYOTES

Timothy D. Reynolds[1]

ABSTRACT.— Six accounts of pronghorn antelope (*Antilocapra americana*) chasing or attacking coyotes (*Canis latrans*) are described: three chases by individual pronghorn does, two by herds of antelope, and one joint effort by a pronghorn doe and a Short-eared Owl (*Asio flammeus*). Modifications of Berger's (1979) ungulate antipredatory defense model are proposed.

Coyotes (*Canis latrans*) in the western United States feed on pronghorn antelope (*Antilocapra americana*). Published accounts indicate that coyote predation on pronghorn is not a particularly rare event (Thompson 1949, Arrington and Edwards 1951, Udy 1953, Beale and Smith 1973). In fact, Springer and Smith (1981) recorded pronghorn remains in more than 50 percent of the summer coyote scats they examined. Contrariwise, until recently, published accounts of responses of pronghorn to predators were uncommon, and records of pronghorn chasing or attacking coyotes were lacking. Berger (1979) described a "previously unknown defense strategy in pronghorn" in which a group of antelope chased a coyote. From this observation he developed a schematic representation of antipredatory defenses in ungulates, and concluded that predator harassment is beneficial to the prey by (1) giving naive individuals the opportunity to recognize predators in a low risk situation, (2) allowing the prey to safely monitor the predator's position, and (3) making the predator reluctant to attack in the future. Lipetz and Bekoff (1980) analyzed 25 antelope-coyote chases and concluded only that such encounters appear to have direct survival value for pronghorn fawns.

Described here are six observations of pronghorn, either singly or in groups, chasing coyotes. One event, detailed below, included a joint effort between a Short-eared Owl (*Asio flammeus*) and a pronghorn doe. A refinement of Berger's (1979) antipredatory defense model is proposed for pronghorn. All observations were recorded in the sagebrush (*Artemisia tridentata*) dominated habitat at the National Environmental Research Park on the U.S. Department of Energy's Idaho National Engineering Laboratory (INEL) Site in southeastern Idaho.

Observations

Group Response

On 14 July 1978 and 18 November 1979, I witnessed groups of pronghorn chase coyotes. The first occasion was similar to Berger's (1979) report. A coyote was observed stalking a small band of antelope (4 does, 1 fawn) that was loafing and feeding about 300 m from a larger group (5 does, 2 bucks, 2 fawns). One feeding doe from the smaller band apparently sighted the coyote at a distance of nearly 100 m, stared toward the coyote for a few seconds, and sounded an alarm call. The remaining antelope of both groups were then alert and directed their attention toward the vicinity of the coyote. When the stalking coyote approached within 40 m, the group of 5 quickly joined the larger group. The coyote followed, maintaining a distance of 40–50 m from the antelope, and sat down as the groups merged. One doe (thought to be a yearling) took a few steps toward the coyote, then returned to the main group. She repeated this investigative sequence twice. On the fourth foray she was accompanied by the 13 other pronghorn. All antelope stopped momentarily about 30 m from the coyote, then burst into a full run toward the coyote.

[1]Department of Biology, Idaho State University, Pocatello, Idaho 83209; and U.S. Department of Energy, Radiological and Environmental Science Laboratory, 550 2nd Street, Idaho Falls, Idaho 83401. Present address: Biology Department, Boise State University, Boise, Idaho 83725.

The coyote fled and was pursued for 300–400 m before disappearing from view.

The November 1979 encounter differed from the previous one in that 2 coyotes were observed moving near a large group of about 120 pronghorn. The pronghorn sighted the coyotes at a distance of about 200 m. A large buck left the group and walked directly toward the coyotes. He was followed by about 20 animals (both does and bucks). This group began running toward the coyotes when the distance had closed to less than 100 m. The remaining 100 or so pronghorn simply observed the chase. The coyotes immediately took flight. The pronghorn stopped chasing after running about 150 m. The coyotes continued their retreat, but at a slow run or trot, while repeatedly looking back at the pronghorn. The coyotes vanished from view at about 600 m.

My first example above, and Berger's (1979) report, suggest that pronghorn groups must contain sufficient numbers of animals before a chase will be initiated. This lower limit or threshold concept may be valid under certain conditions, but as evidenced by the following accounts it is by no means a universal trend in antelope antipredatory behavior.

Doe with Fawns

On 20 June 1978, a female pronghorn was observed nursing two fawns, seemingly unaware of a coyote furtively approaching her from the rear. While licking one fawn, the doe apparently noticed the coyote 30 m away and gave an alarm call. The fawns promptly dropped into the immobility response (Autenrieth and Fichter 1975) and the doe stared intently at the advancing coyote. The coyote approached to within 20 m, and then made a dash toward the antelope. The doe responded by charging the coyote, causing it to veer away from the fawns. The doe pursued the coyote for nearly 50 m, and then returned to a position about halfway between the fawns and the predator. Twice more the coyote ran toward the fawns, and each time was thwarted by the charging doe, who again positioned herself between her young and the coyote. The coyote slowly moved away from the antelope while the doe intently watched its progress. When the coyote had withdrawn to a distance of 80 m, it abruptly changed its direction, putting itself on a course that would bring it within 20–30 m of the fawns. The doe again charged the coyote and pursued it for nearly 400 m before both disappeared from view. The doe returned to the area 85 minutes later, called her fawns from seclusion, and resumed nursing them.

Another postparturient doe and coyote interaction was observed on 30 June 1978. Other than the fact that this doe had only one fawn, this encounter closely followed the sequence described above: the coyote approached to within 30 m before charging, only to be charged by the doe. Second and third attacks followed; each time the coyote was chased a short distance away by the doe. On the fourth attempt, as the coyote veered from its course, the doe actually butted it in the side, rolling it over. The coyote regained its footing without losing momentum, and was vigorously pursued by the doe for about 150 m. The doe stopped, watched the coyote run away, then intermittently fed, or sham-fed (Autenrieth and Fichter 1975), for nearly 30 minutes before returning to the vicinity of the fawn.

A third antelope doe was observed defending two neonates, approximately two weeks old, from a pair of coyotes on 8 June 1979. When observations began (0925 hours MST) the doe was feeding and the fawns were cavorting nearby. At 0932 hours the doe spotted coyote No. 1 about 50 m to the north and gave an alarm call. The fawns immediately lay down, separated from each other by a distance of 8–10 m. As the doe focused her attention on the now stationary coyote, coyote No. 2 appeared behind coyote No. 1 and began moving in an arc toward the east. Coyote No. 2 had approached to within 20 m of the fawns when the doe charged it, causing it to move further eastward from the fawns. Almost simultaneously, coyote No. 1 dashed toward the fawns and was within 10 m of them before the doe whirled and charged, forcing it to the west of the secluded young. Coyote No. 2 then advanced and was driven off, again to the east. Coyote No. 1 again attacked, this time advancing within 1–2 m of one of the fawns before being repulsed by the doe. Bleating, the fawn burst from its bed, and ran in a southerly direction accompanied by the doe. At the sound of the bleat, the second fawn immediately took flight, but was quickly brought down from behind by coyote No. 2. The doe and the surviving fawn ran at full speed for nearly 200 m and abruptly stopped. The fawn lay down and the doe moved in a seemingly leisure manner, roughly in a southwestward direction, frequently looking back toward the feeding coyotes.

Joint Interspecific Response

At 0545 hours on 13 May 1977, an extraordinary predator-prey encounter was observed and recorded. A single pronghorn doe was observed feeding about 400 m west of my position and about 80 m west of a Short-eared Owl nest known to contain two young. A Short-eared Owl was noticed flying oddly about 100 m north of the doe. The owl was flying in a southerly direction and repeatedly "dive bombing" from a height of 10–15 m to the top of the sage. The owl continued this undulating flight toward the now alert pronghorn. As the owl closely approached, the doe ran through the sagebrush in the same direction as the owl's flight, alternating a head up and head down posture. The latter was coordinated with short bursts of speed. The animals continued this pattern for about 100 m. As they emerged from the sagebrush into a crested wheatgrass (*Agropyron cristatum*) planting, a coyote was seen running ahead of the antelope and below the owl. Together, they pursued the coyote for nearly 300 m before the coyote reentered the sagebrush. Both the pronghorn and the owl then abandoned the chase. The doe looked in the direction of the coyote for nearly five minutes, then resumed feeding. The owl circled to a height of about 50 m and began hunting activities. Carrying a prey item, it visited the nest 15 minutes later. Further investigation indicated that the owl's mate had been on or near the nest throughout the joint antipredatory defense. It is doubtful that the antelope participating in the chase was protecting a fawn. The earliest record of pronghorns fawning on the Idaho National Engineering Laboratory Site is 23 May (1980), with the peak of fawning normally occurring the last week of May and the first week of June each year.

Conclusions

Figure 1 is an adaptation of Berger's (1979) antipredatory defense model for ungulates, and represents my proposed spectrum of pronghorn responses to hunting coyotes. The wide solid arrows indicate the responses most likely to occur in pronghorn coyote encounters. Narrow solid lines represent documented responses that occur less often, and the wavy arrows account for the rare observation of concurrent, interspecific chasing. The dashed arrows indicate some possible reactions of pronghorn to hunting coyotes that were not recorded in my observations.

The actions taken by pronghorn when confronted by coyotes appear to be generally related to the size and composition of the pronghorn group. Individuals unaccompanied by fawns, or small groups of pronghorn, tend to retreat from coyote predators, often joining other bands of pronghorn. Larger groups of pronghorn exhibit a continuum of responses ranging from mild interest, or curiosity, to actual attack that in the broadest context represents mobbing behavior (Harvey and Greenwood 1978). My observations indicate the postparturient does, with fawns nearby, invariably attack or chase coyotes advancing toward them. The intensity of these attacks, and the context in which they occur, closely resembles the antipredatory response of "snarling" described by Curio (1975). The constancy of this behavior supports the thesis that, in certain situations (i.e., does with fawns nearby), predator harassment has direct survival value for pronghorn fawns (Lipetz and Bekoff 1980). The significance of the joint (cooperative?) chase by a pronghorn doe and a Short-eared Owl is unknown.

There are two plausible interpretations of this event. First, as several instances of pronghorn chasing Short-eared Owls in an antipredatory context have been observed (Fichter, pers. comm., Copeland, in litt.), it is possible that the doe was responding to both the coyote and the owl as potential predators. However, if the doe was not protecting a fawn (the date of this encounter suggests she was not), the adaptive advantage, or evo

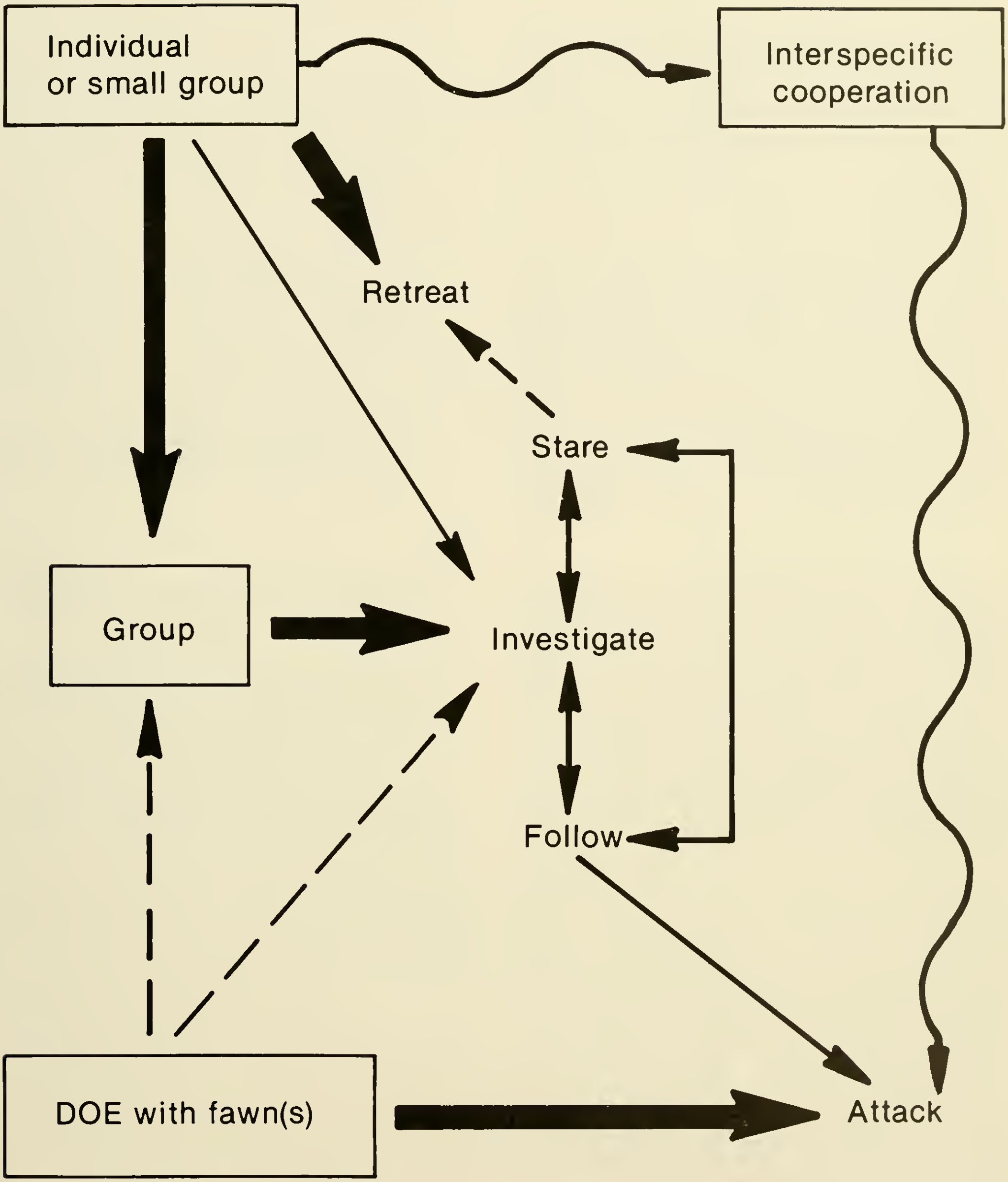

Fig. 1. A proposed model of the responses of pronghorn antelope to coyotes. See text for the explanation of arrows.

lutionary significance of her actions is not obvious. On the other hand, as this paper and that by Lipetz and Bekoff (1980) suggests, pronghorn chasing coyotes is not an exceptionally rare event. Although published records are few, Short-eared Owls have not infrequently been observed mobbing predatory species, including coyotes (pers. obs., Trost, pers. comm., Clark 1975). It is likely that the antelope-owl-coyote interaction described here represents a mutual, albeit fortuitous, effort by the antelope and owl to hustle the coyote. The proximity of the chase to the owl nest makes the reasons behind the owl's involvement obvious. The factors precipitating the antelope's behavior are less certain. Fichter (unpublished data) witnessed a buck band of over a dozen pronghorn chase a coyote in mid-June 1965. These animals pursued the predator for 1–1.5 km, passing in front of and circling the running coyote at least twice, a sequence frequently associated with moving vehicles in pronghorn country. It is possible that in certain low-risk situations, such as when a coyote is already fleeing from harassment, antelope may participate in the chase as a playlike exercise. This might represent a learning experience for the prey and/or predator, lending support to any or all of Berger's (1979) explanations for ungulates attacking predators. However, the rarity of birds and mammals jointly mobbing a potential predator precludes a convenient analysis of the role of this interspecific behavior in the relationship of predators and prey. More data are required before the evolutionary significance of this and similar observations can be properly assessed.

Acknowledgments

This is a contribution from the INEL Site Ecological Studies Program, supported by the Office of Health and Environmental Research, U.S. Department of Energy. I thank R. E. Autenrieth for his suggestions and M. W. Barrett, P. T. Bromley, E. Fichter, O. D. Markham, J. M. Peek, F. L. Rose, and G. E. Svendsen for improving the drafts of this manuscript.

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FLORISTICS OF THE UPPER WALKER RIVER, CALIFORNIA AND NEVADA

Matt Lavin[1]

Abstract.— A checklist of the vascular flora of the upper Walker River is presented. Listed are 1078 taxa from this 4000 km^2 area. The upper Walker River encompasses a portion of the boundary between the Intermountain and Sierra Nevada floristic regions, and hence displays much floristic diversity within a relatively small area. Due to its location along the east slope of the Sierra Nevada, the Walker River drainage is unique in that it contains much elevational variation eastward into the Intermountain Region. This elevational extension is due to the presence of large mountain ranges including the Sweetwater Mountains, the Bodie Hills, and the Wassuk Range. As a result of this elevational variation, there is much overlapping of the two floristic regions. Additionally, the easternmost exposures of the Sierran granodiorites occur within the Walker River basin and may enhance the eastward migration of Sierran plants. The 90 percent floristic similarity (Sorenson's) between the Sweetwater Mountains, lying to the east of the Sierra, and the east slope of the Sierra Nevada (within the Walker River drainage) indicates the Sweetwaters to be more affiliated with the Sierran flora instead of the Intermountain flora.

The upper Walker River drainage includes an area of approximately 4000 km^2, located at the north end of Mono County, California, the southern ends of Douglas and Lyon counties, Nevada, and the western edge of Mineral County, Nevada. The western boundary of this drainage generally follows the crest of the Sierra Nevada from the Conway Summit-Virginia Lakes area, northward to the Topaz Lake-Monitor Pass area. The eastern boundary is delimited by the Bodie, Masonic, and Pine Grove hills and the southwest slopes of the Pine Nut Range. The Sweetwater Mountains and the Wellington hills lie between these hills and the Sierra Nevada.

East slope Sierran vegetation present here has been generally described by Billings (1951) and Rundel et al. (1977). The area is dominated by mixed conifer forests composed of *Pinus jeffreyi* and *Abies concolor* at the low elevations, and *Abies magnifica, Tsuga mertensiana, Pinus monticola,* and *P. albicaulis* at the higher elevations. The alpine vegetation of the Sierra is uniquely adapted for extreme summer drought (Chabot and Billings 1972).

To the east of the Sierra, Intermountain vegetation (high elevation sagebrush steppe situated above woodlands composed of *Pinus monophylla* and *Juniperus osteosperma*) predominates. This vegetation has also been briefly described by Billings (1951). The Sweetwater Mountains, situated between the Intermountain and Sierran floristic regions, display characteristics of both.

The vascular flora of the upper Walker River is modestly represented in literature. Works such as Hinton (1975), Reveal (1968), Cox (1972), Reveal and Ertter (1980), Hardham and True (1972), Strother (1974), Munz (1968), Barneby (1964), Dempster and Ehrendorfer (1965), Halse (1981), and others cite specific collections made within this area. Davis (1979) compiled a plant list and keys to the plants occurring on the east central Sierra (Owens Lake to Lake Tahoe) and associated desert ranges. This work was based solely on distributions given in existing floras.

Sharsmith (1940) includes the Walker River portion of the Sierra Nevada as the northernmost boundary of the Sierra alpine floristic region. This area includes Leavitt Peak south to Dunderberg Peak. Thorne (1982) defines the upper Walker River basin as the northern boundary of the transmontane Californian floristic region.

Major and Taylor (1977) conducted a vegetation study of the alpine zone of the Sweetwater Mountains. They list 43 species from the area. Taylor (1977) indicates a 40–50

[1]Department of Biology, University of Nevada, Reno, Nevada 89557. Present address: P.O. Box 13494, Reno, Nevada 89507.

percent floristic similarity (Sorenson's) between the Carson Pass area of the Sierra Nevada and the Sweetwater Mountains. Since a 50 percent turnover rate in plant species occurs every 650 km along the Cascade-Sierran axis (Taylor 1977), the Walker River portion of the Sierra must have a very high degree of similarity with Carson Pass, 60 km to the north. An interpretation of this would mean the Walker River portion of the Sierra has approximately a 50 percent floristic similarity to the Sweetwaters.

Bell (1980) described the alpine flora of the Wassuk Range, located in the lower Walker River drainage just west of Walker Lake (50 km east of the Sweetwater Mountains). She lists 70 vascular plants from the alpine flora of this region. Bell has also recently completed a study of the alpine flora of the Sweetwater Mountains, but this information is unavailable.

Messick (1982) completed a flora of the Bodie Hills, and the results of this work are incorporated in Table 1.

The upper Walker River drainage is the region of several type collections. The Sweetwater Mountains are the type locale for *Cordylanthus ramosus* ssp. *setosus*, *Senecio pattersonensis* and *Draba lemmonii* var. *incrassata*. In the Bodie Hills, we have the type locale for *Draba quadricostata*, *Pinus monophylla*, *Arabis bodiensis* (see Rollins 1982), *Streptanthus oliganthus*, and *Phacelia monoensis*. *A. bodiensis*, *S. pattersonensis*, *D. lemmonii* var. *incrassata*, and *D. quadricostata* are endemic to the Walker River drainage.

The Wellington Hills are the type locale for *Astragalus oophorus* var. *lavinii*, and Sonora Pass for *Raillardella argentea*, *Cymopterus cinerarius*, and *Wyethia mollis*. "A dry rocky mountain near Sonora Pass" is the type location for *Astragalus platytropis*, *A. lentiginosus* var. *ineptus*, and *A. whitneyi*. Barneby suggests that the type locale for these three Astragali may be the Sweetwater Mountains. However, during the course of this investigation, all three, including *A. platytropis*, were found on Leavitt and Emma Peak of the Sierra Nevada. Therefore, the type locale given by Gray could have possibly referred to the Sierra instead of the Sweetwaters.

Methods

The checklist (Table 1) was developed from collections made during the course of this study: July 1979 to August 1982. Additional collections were recorded from the herbaria at the University of Nevada, Reno (RENO), The New York Botanical Garden (NY), and the California Academy of Sciences (CAS). Collections from the upper Walker River made by Arnold Tiehm and Margaret Williams, Reno, Nevada; Steve Wharff, Tonopah, Nevada; Frank Smith, Smithfield, Utah; Dennis Breedlove, CAS; Joe Robertson, E. F. Kleiner, Tom Lugaski, Pat and Ham Vreeland, H. N. Mozingo, and Fred Ryser, all from the University of Nevada, Reno, were also recorded in this checklist. Approximately 3850 numbers were recorded. Distributional information contained within the checklist was continually refined while in the field. Various documentary works, mentioned in the introduction, were used to determine those plants that have a probable distribution within the upper Walker River drainage, but were not observed during this study.

Almost all of the taxa listed can be found on deposit at the University of Nevada, Reno, herbarium and the Toiyabe National Forest Supervisor's Office, Reno, Nevada.

The purposes of the checklist (Table 1) are to both document the flora present in the upper Walker River and to document the geographical and altitudinal distribution of each taxon within this area. Nomenclature generally follows Kartesz and Kartesz (1980).

Results and Discussion

Table 1 lists 1078 taxa of vascular plants from the upper Walker River. The upper Walker River drainage is unique in that it extends much elevational variation of the east slope of the Sierra Nevada eastward into the Intermountain Region, due to the presence and close proximity of such large mountain ranges as the Sweetwater Mountains, the Bodie Hills, and the Wassuk Range. Along any floristic boundary there is bound to be some overlap of unique plant species or characteristic vegetation of one flora into another. However, many plants having their center of distribution in the Intermountain Region also have outlying populations in the montane environments of the Sierra Nevada. This phenomenon is discussed by Taylor (1976) for the Carson Pass area of the Sierra. He attributes the occurrence of many Intermountain plants on the east slope of the Sierra to Xerothermic invasion. A list of these plants at the headwaters of the Walker River follow:

Agoseris glauca var. *monticola*
Allium biceptrum
Allium parvum
Arabis bodiensis
A. pulchra var. *pulchra*
Artemisia arbuscula
Aster ascendens
Astragalus platytropis
A. iodanthus
Amelanchier utahensis
Antennaria dimorpha
Balsamorhiza sagittata
Calyptridium roseum
Cercocarpus ledifolius
Cirsium utahense
Cheilanthes gracillima
Chenopodium overi
Chorizanthe brevicornu var. *spathulata*
Chrysothamnus nauseosus ssp. *albicaulis*
C. viscidiflorus
Crepis acuminata
C. modocensis ssp. *subacaulis*
Castilleja linariifolia
Cordylanthus ramosus ssp. *setosus*
Cryptantha circumscissa
Cryptantha echinella
Erigeron aphanactis
E. nevadincola
E. breweri var. *porphyreticus*
E. eatonii ssp. *plantagineus*
Eriogonum elatum
E. microthecum var. *ambiguum*
E. ovalifolium var. *nevadense*
E. wrightii var. *subscaposum*
Galium multiflorum
Gilia leptantha ssp. *salticola*
Grayia spinosa
Haplopappus acaulis
Heuchera duranii
Hydrophyllum capitatum var. *alpinum*
Leptodactylon pungens
Linanthus nuttallii
Lupinus caudatus ssp. *caudatus*
L. nevadensis
Lomatium nevadense var. *nevadense*
Lomatium nevadense var. *parishii*
Melica stricta
Mentzelia congesta
Mimulus densus
M. rubellus
Navarretia breweri
Opuntia polyacantha var. *rufispina*
Poa nevadensis var. *juncifolia*
P. nevadensis var. *nevadensis*
Paeonia brownii
Penstemon bridgesii
Phoenicaulis cheiranthoides
Phacelia humilis
Phlox covillei
Plagiobothrys hispidus
P. kingii var. *harknessii*
Prunus andersonii
Purshia tridentata
Pinus monophylla
Ribes velutinum
Rosa woodsii var. *ultramontana*
Scrophularia desertorum
Senecio canus
S. pattersonensis
S. spartioides
Sisyrinchium halophilum
Sphaeromeria cana
Stephanomeria spinosa
Streptanthus oliganthus
Tetradymia canescens
Thelypodium crispum
Zigadenus paniculatus

These 77 plant taxa represent approximately 10 percent of the flora present on the east slope of the Sierra within the Walker River drainage. This is below Taylor's (1976) estimate of 20 percent for the east slope within the Carson River drainage just to the north. However, when distribution records become more complete, it would not be surprising to find 20 percent of the Sierran flora within the Walker River basin being composed of Intermountain elements.

The Xerothermic climate may also have been responsible for the northern migration of *Amelancheir pallida* var. *covillei*, *Ceanothus greggii* var. *vestitus*, *Cercocarpus ledifolius* var. *intricatus*, *Ivesia purpurascens* ssp. *congdonis*, *Cryptantha confertiflora*, *Phacelia peirsoniana*, and *Plagiobothrys jonesii*. The Walker River drainage may be the northernmost location for these plants. (*Cryptantha confertiflora* has been found just to the north in the Carson River drainage.)

It is documented that the eastward migration of Sierran plant species into the Intermountain Region is small relative to the westward migration of Rocky Mountain plants into this region (Harper et al. 1978). However, the Walker River drainage has many Sierra or Pacific cordilleran plant species occurring well into the Intermountain Region, some of which occur as far east as Masonic Mountain or the Wassuk Range. A list of these plants follows:

Agropyron pringlei
Allium campanulatum

Allophyllum gilioides
A. violaceum
Amelanchier pallida
Anelsonia eurycarpa
Angelica lineariloba
Arabis inyoensis
A. platysperma var. *howellii*
Arnica nevadensis
Astragalus kentrophyta var. *danaus*
A. lentiginosus var. *ineptus*
A. purshii var. *lectulus*
Calochortus leichtlinii
Carex tahoensis
Chaenactis nevadensis
Chrysothamnus parryi ssp. *monocephalus*
Claytonia nevadensis
Cryptantha glomeriflora
Cryptantha nubigena
Cymopteris cinerarius
Draba lemmonii (var. *incrassata*)
D. oligosperma var. *subsessilis*
D. stenoloba var. *ramosa*
Erigeron petiolaris
E. pygmaeus
Eriogonum rosense
Gentianopsis holopetala
Gentiana newberryi
Geum canescens
Galium hypotrichium ssp. *hypotrichium*
Haplopappus apargioides
Hieracium horridum
Ivesia lycopodioides
I. purpurascens ssp. *congdonis*
Juniperus occidentalis ssp. *australis*
Kalmia microphylla
Ledum glandulosum var. *californica*
Leucophysalis nana
Lupinus andersonii
L. caudatus ssp. *montigenus*
L. confertus
L. hypolasius
L. meionanthus
L. caudatus ssp. *montigenus*
L. sellulus var. *lobbii*
L. tegeticulatus (*breweri bryoides*)
Luzula divaricata
Mimulus coccineus
Penstemon davidsonii var. *davidsonii*
Pinus jeffreyi
P. monticola
Polygonum douglasii var. *latifolia*
Raillardella argentea
Rhamnus rubra ssp. *rubra*
Scirpus clementis
Senecio fremontii var. *occidentalis*
S. scorzonella
Sisyrinchium idahoense var. *occidentale*
Symphoricarpos parishii
Trifolium andersonii ssp. *andersonii*

Additionally, work done by Goodrich (1981) in central Nevada has shown that several other Pacific cordilleran plants extend their ranges far into the Intermountain Region. These plants, also found extending eastward within the Walker River basin, include *Artemisia rothrockii, Carex helleri, Silene sargentii, Astragalus whitneyi* (see Reveal 1979) and *Astragalus purshii* var. *tinctus* (see Barneby 1964). *Silene sargentii* has been listed as endemic to the Sierra Nevada. However, the type collection, as given by Hitchcock and Maguire (1947), is from Table Mountain of the Monitor Range in central Nevada.

The eastward distribution of these Sierran plants may be enhanced by the very eastern exposures of the Sierran granodiorites. These granites can be found as far east as the Wassuk Range (Bateman 1967). However, the most likely factor enhancing the migration of these Sierran plants is the abundance of montane and alpine habitats found eastward into the Intermountain Region. The floristic components of the Sweetwater Mountains point to this eastward migration.

The Sweetwaters, situated between the Sierra and Intermountain floristic regions, are regarded as belonging to the Intermountain flora (Cronquist et al. 1972). Sierra conifer forests are extensive on the Sweetwaters, especially toward the southern end. The timberline vegetation is dominated solely by *Pinus albicaulis*, a Sierran characteristic.

Using the information provided in Table 1, Sorenson's index of similarity (Billings 1978) between the Sierra and Sweetwaters can be determined with regard to floristic elements in both the alpine and the montane conifer forests. These are calculated to be 90 and 93 percent, respectively. This indicates the Sweetwater Mountains to be more affiliated, floristically, with the Sierra than previously thought.

However, it might be considered that the east slope of the Sierra, within the Walker River drainage, being influenced by Intermountain vegetation, is bound to yield a high index of similarity to the Sweetwaters. In other words, the whole of the upper Walker could be considered "Intermountain" with regard to vegetational composition. This is reinforced by the fact that the Walker River portion of the Sierra does lack typical "understory" brush vegetation that is found just to the north in the Carson River drainage. *Arctostaphylos patula, Ceanothus cordulatus* and *C. prostratus* have not been found here (or are at least not abundant) and *A. nevadensis* was found only twice in very small populations. Instead, the dominant brush cover consists of *Purshia tridentata*, *Ceanothus velutinus*, *Artemisia tridentata* ssp. *vaseyana*, and *Symphoricarpos oreophilus*.

In comparing all the upper Walker River flora with the flora of central Nevada (Goodrich 1981), both floras being just about equal in number of taxa, approximately a 50 percent similarity can be determined. The Sweetwaters could, therefore, be easily considered as part of the east slope Sierran flora. Aside from the high indices of similarity, the Sweetwaters are dominated by many Sierra or Pacific cordillera plant species; *Lupinus hypolasius*, *Chrysothamnus parryi* ssp. *monocephalus*, and *Draba oligosperma* var. *subsessilis* at the highest elevations, and *Pinus jeffreyi* and *P. contorta* var. *murrayana* at the lower elevations.

Acknowledgments

This study was funded by the U.S. Forest Service, Toiyabe National Forest. I am very grateful to them for this and for their cooperation. Thanks to Sue Sullivan, U.S. Forest Service, the checklist (Table 1) and its transfer to Brigham Young University Press was made possible. For their help with identification of plant specimens, I am indebted to Warren Wagner (*Botrychium*), Lincoln Constance (Apiaceae), Ted Barkley (*Senecio*), Almut Jones (*Aster*), Guy Nesom (*Erigeron*), Gerald Ownbey (*Cirsium* and *Argemone*), Reed Rollins (*Brassicaceae*), Arthur Cronquist (miscellaneous), Alfred Schuyler (aquatic plants), Gary Wallace (*Pyrola*), Rupert Barneby (Fabaceae), Richard Halse (*Phacelia*), Duane Atwood (*Phacelia*), Douglass Henderson (*Sisyrinchium*), Paul Fryxell (Malvaceae), David Boufford (*Circaea*), Alva Day (Polemoniaceae), Lauramae Dempster (*Galium*), Harlan Lewis (*Gayophytum*), Lawrence Heckard (*Castilleja*, *Cordylanthus*, *Orthocarpus*), Fredrick Meyer (*Valeriana*), John T. Howell (*Carex* and miscellaneous), Margaret Williams (miscellaneous), Arnold Tiehm (miscellaneous), and Ken Genz (miscellaneous). I am especially grateful to John Thomas Howell, Margaret Williams and Arnold Tiehm for sharing with me their intimate knowledge of the Intermountain and Sierran floras, and to the curators at NY and CAS for allowing access to their herbaria.

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TABLE 1. Checklist of the vascular flora of the upper Walker River. For the columns under the heading of "AREA":N = Sierra Nevada; S = Sweetwater Mountains; W = Wellington Hills; M = Masonic Hills, Bodie Hills, Pine Grove Hills, and the southwest slopes of the Pine Nut Range. For the columns under the heading of "HABITAT": 1 = riparian; 2 = low elevation sagebrush-grass zone; 3 = pinyon-juniper woodland; 4 = high elevation sagebrush-grass zone; 5 = Jeffrey pine-white fir forests; 6 = red fir forests; 7 = lodgepole pine forests; 8 = whitebark pine forests; 9 = alpine zone (see Billings 1951, Lavin 1981, for a general description of these). An X indicates the plant has been observed in the field or by herbarium specimen; an O indicates the plant has a probable distribution within the area due to information obtained in the literature.

	AREAS				HABITATS								
	N	S	W	M	1	2	3	4	5	6	7	8	9
ADIANTACEAE - PTERIDOPHYTA													
Aspidotis													
densa (Brack.) Lellinger	X								X		X		
Cheilanthes													
gracillima D.C. Eat.	X	X					X		X		X		
Cryptogramma													
crispa (L.) R. Br. ex Hook.													
ssp. *acrostichoides* (R. Br.) Hulten	X										O	X	X
Pellaea													
breweri D.C. Eat.	X	X		O					O		O	X	X
bridgesii Hook.	X	X							X		X	X	X
ASPLENIACEAE													
Athyrium													
distentifolium Tausch ex Opiz													
var. *americanum* (Butters) Boivin	X										X		
Cystopteris													
fragilis (L.) Bernh.	X	X		X			X		X	X	X	X	X
Woodsia													
oregana D.C. Eat.		X					X						
scopulina D.C. Eat.	X	X							X		X	X	X
DENNSTAEDTIACEAE													
Pteridium													
aquilinum (L.) Kuhn													
var. *pubescens* Underwood	X								X		X	X	
EQUISETACEAE													
Equisetum													
arvense L.	X	X			X		X		X		X	X	O
hyemale L.													
var. *affine* (Engelm.) A.A. Eat.	X				X				X				
laevigatum A. Braun	X	X	X	X	X		X	X	X				

Table 1 continued.

	AREAS				HABITATS								
	N	S	W	M	1	2	3	4	5	6	7	8	9
ISOETACEAE													
Isoetes													
bolanderi Engelm.													
var. *bolanderi*	X				X						X	X	X
MARSILEACEAE													
Marsilea													
vestita Hook. & Grev.	X				X				X				
OPHIOGLOSSACEAE													
Botrychium													
lunaria (L.) Sw.													
var. *minganese* (Victorin) Dole	O										O		
simplex E. Hitchcock	X											X	
SELAGINELLACEAE													
Selaginella													
watsonii Underwood	X	X									X	X	X
CUPRESSACEAE - PINOPHYTA													
Juniperus													
communis L.	X										X	X	
occidentalis Hook.													
ssp. *australis* Vasek	X	X		X			X	X	X	X	X		
osteosperma (Torr.) Little		X	X	X		X	X	X					
EPHEDRACEAE													
Ephedra													
nevadensis S. Wats.		X	X	X		X	X						
viridis Coville	X	X	X	X		X	X	X	X				
PINACEAE													
Abies													
concolor (Gord. & Glend.) Hildebr.	X	X			X		X		X	X	X		
magnifica A. Murr.	X								X	X	X		
Pinus													
albicaulis Engelm.	X	X									X	X	X
contorta Dougl. ex Loud.													
var. *murrayana* (Grev. & Balf.) Engelm.	X	X		O			X	O	X	X	X	X	X
flexilis James	X	X		O				O			X	X	
jeffreyi Grev. & Balf.	X	X	X	X			X	X	X				
monophylla Torr. & Frem.	X	X	X	X			X	X	X				
monticola Dougl. ex D. Don	X			X				X		X	X		
Tsuga													
mertensiana (Bong.) Carr.	X									X	X	X	
ACERACEAE - ANTHOPHYTA													
Acer													
glabrum Torr.													
var. *torreyi* (Greene) Smiley	X								X	X	X		
ALISMATACEAE													
Sagittaria													
cuneata Sheldon				O	O		O						
AMARANTHACEAE													
Amaranthus													
albus L.		*X*	*X*			*X*							
blitoides S. Wats.	X	X	X	X		X	X	X	X				
retroflexus L.			X	X		X							
APIACEAE													
Angelica													
breweri Gray	X								X		O		
lineariloba Gray	X	X		X				X	X		X	X	

Table 1 continued.

	AREAS				HABITATS								
	N	S	W	M	1	2	3	4	5	6	7	8	9
Berula													
erecta (Huds.) Coville			X		X		X						
Cicuta													
douglasii (DC.) Coult. & Rose			X	X	X		X						
Conium													
maculatum L.	X	X			X		X						
Cymopterus													
cinerarius Gray	X	X										X	X
globosus (S. Wats.) S. Wats.		X		X		X	X						
panamintensis Coult. & Rose													
var. *panamintensis*		O					?						
Heracleum													
lanatum Michx.	X	X			X				X		X		
Ligusticum													
grayii Coult. & Rose	X								X	X	X	X	X
Lomatium													
dissectum (Nutt.) M. & C.													
var. *multifidum* (Nutt.) M. & C.	X	X	X	X		X	X	X	X		X		
foeniculaceum (Nutt.) Coult. & Rose													
ssp. *macdougalii* (Coult. & Rose) Theobald				X		X	X						
nevadense (S. Wats.) Coult. & Rose													
var. *nevadense*	X	X	X	X		X	X	X	X		X	X	
var. *parishii* (Coult. & Rose) Jepson	X	X	X	X		X	X	X	X				
plummerae (Coult. & Rose) Coult. & Rose													
var. *sonnei* (Coult. & Rose) Jepson			X				X						
Osmorhiza													
chilensis Hook. & Arn.	X	X			X				X		X		
occidentalis (Torr. & Gray) Torr.	X	X		X	X		X	X	X		X	X	
Perideridia													
bolanderi (Gray) A. Nels. & J.F. Macbride													
ssp. *bolanderi*	X	X	X	X			X		X		X	X	X
lemmonii (Coult. & Rose) Chuang & Const.	X	X		O				X	X				
parishii (Coult. & Rose) A. Nels.													
ssp. *latifolia* (Gray) Chuang & Const.	X								O	O	X	X	
Podistera													
nevadensis (Gray) S. Wats.	O												O
Pteryxia													
terebinthina (Hook.) Coult. & Rose													
var. *californica* (Coult. & Rose) Mathias	X	X	X	X			X	X	X		X		
Sphenosciadium													
capitellatum Gray	X	X	X	X	X		X	X	X	X	X	X	
APOCYNACEAE													
Apocynum													
androsaemifolium L.													
ssp. *pumilum* (Gray) Boivin	X	X							X	X	X		
X *medium* Greene	X			O				O	X				
ASCLEPIADACEAE													
Asclepias													
cryptoceras S. Wats.													
ssp. *cryptoceras*				O				O					
ssp. *davisii* (Woods.) Woods.		X	X	X			X	X					
fascicularis Dcne.	X	X					X	X					
speciosa Torr.	X	X	X	X		X	X	X					
ASTERACEAE													
Achillea													
millefolium L.													
var. *alpicola* (Rydb.) Garrett	X	X		X				X	X		X	X	X
var. *lanulosa* (Nutt.) Piper	X	X	X	X	X		X		X				

Table I continued.

	AREAS				HABITATS								
	N	S	W	M	1	2	3	4	5	6	7	8	9
Agoseris													
aurantiaca (Hook.) Greene	X	X			X				X		X		
elata (Nutt.) Greene	X	X		X	X				X	X	X	X	X
glauca (Pursh) Raf.													
var. *monticola* (Greene) Cronquist	X	X									X	X	X
var. *laciniata* (D.C. Eat.) Smiley	X	X	X	X		X	X	X	X				
Ambrosia													
acanthicarpa Hook.	X	X	X	X		X	X						
Anisocoma													
acaulis Torr. & Gray		X					X						
Antennaria													
alpina (L.) Gaertn.													
var. *media* (Greene) Jepson	X	X										X	X
dimorpha (Nutt.) Torr. & Gray	X	X	X	X		X	X		X		O		
microphylla Rydb.	X	X	X				X		X		X	X	X
umbrinella Rydb.	X	X										X	X
Arnica													
chamissonis Less.													
ssp. *foliosa* (Nutt.) Maguire													
var. *andina* (Nutt.) Ediger & Barkley	X	X	X		X		X		X	X	X	X	
ssp. *foliosa* (Nutt.) Maguire													
var. *incana* (Gray) Hulten	X	X			X		X		X		X	X	
cordifolia Hook.													
var. *cordifolia*	X	X									X		
diversifolia Greene	X	X							X				
longifolia D.C. Eat.	X	X							X		X	X	X
mollis Hook.	X	X								X	X	X	
nevadensis Gray	X	X										X	X
parryi Gray													
var. *sonnei* (Greene) Cronquist	O										O	O	
sororia Greene	X	X		O			X	X	X				
Artemisia													
arbuscula Nutt.	X	X	X	X			X	X	X		X	X	X
cana Pursh	X	X			X		X		X		X	X	X
douglasiana Bess.	X	X	X	X			X		X				
dracunculus L.	X	X	X	X		X	X	X	X				X
ludoviciana Nutt.													
ssp. *incompta* (Nutt.) Keck	X	X		X	X		X		X		X	X	X
ssp. *ludoviciana*	X	X					X		X				
norvegica Fries													
var. *saxitalis* (Bess.) Hook.	X									X	X	X	X
nova A. Nels.		X	X	X		X	X						
rothrockii Gray	X	X										X	X
spinescens D.C. Eat.			X	O			X						
tridentata Nutt.													
ssp. *vaseyana* (Rydb.) Beetle	X	X	X	X			X		X		X	X	
ssp. *wyomingensis* Beetle & Young		X	X	X		X	X						
ssp. *tridentata*	X	X	X	X		X	X	X	X		X	X	
Aster													
ascendens Lindl. in Hook.	X	X		O	X		X						
alpigenus (Torr. & Gray) Gray													
ssp. *andersonii* (Gray) Onno	X	X			X						X	X	X
campestris Nutt.													
var. *bloomeri* Gray	X	X		O				O	X				
eatonii (Gray) T.J. Howell	X	X			X		X		X				
integrifolius Nutt.	X				X					X	X	X	
occidentalis (Nutt.) Torr. & Gray													
var. *occidentalis*	X	X	X	X	X		X		X	X	X	X	
scopulorum Gray		X	X	X		X	X	X					

Table 1 continued.

	AREAS				HABITATS								
	N	S	W	M	1	2	3	4	5	6	7	8	9
Balsamorhiza													
hookeri (Hook.) Nutt.		X	X	X		X	X		X				
sagittata (Pursh) Nutt.	X	X	X	X		X	X		X		X		
Bidens													
cernua L.			X		X		X						
Brickellia													
grandiflora (Hook.) Nutt.													
var. *petiolaris* Gray	X										X		
microphylla (Nutt.) Gray			X	X		X							
oblongifolia Nutt.													
var. *linifolia* (D.C. Eat.) B.L. Robins.		X	X	X		X	X						
Chaenactis													
alpigena C.W. Sharsmith	X											X	X
douglasii (Hook.) Hook. & Arn.													
var. *rubricaulis* (Rydb.) Ferris	X	X	X	X		X	X	X	X		X	X	
nevadensis (Kellogg) Gray	X	X										X	X
xantiana Gray				X		X							
Chrysothamnus													
nauseosus (Pall.) Britton													
ssp. *consimilis* (Greene) Hall & Clem.	X	X	X	X		X	X	X					
ssp. *albicaulis* (Nutt.) Hall & Clem.	X	X		X			X		X		X		
ssp. *hololeucus* (Gray) Hall & Clem.				O			O	O					
parryi (Gray) Greene													
ssp. *monocephalus* (Nels. & Kenn.) Hall & Clem.	X	X										X	X
ssp. *nevadensis* (Gray) Hall & Clem.		X		O			X						
viscidiflorus (Hook.) Nutt.													
ssp. *puberulus* (D.C. Eat.) Hall & Clem.	X	X	X	X		X	X	X	X		X	X	X
ssp. *viscidiflorus*	X	X	X	X		X	X		X				
Cichorium													
intybus L.	X	X			X	X	X						
Cirsium													
andersonii (Gray) Petrak	X	X			X				X		X	X	X
congdonii Moore & Frankton	X	X							X				
eatonii (Gray) B.L. Robins.	X											X	X
pastoris J.T. Howell	X	X	X	X			X		X				
tioganum (Congd.) Petrak	X	X	X	X	X		X		X		X	X	X
utahense Petrak	X	X		O			X		X			X	
vulgare (Savi) Tenore	X	X	X	X			X		X				
Conyza													
canadensis (L.) Cronquist													
var. *glabrata* (Gray) Cronquist	X	X	X	X	X		X		X				
Crepis													
acuminata Nutt.													
ssp. *acuminata*	X	X		O			X	X	X		X		
intermedia Gray	X	X	X	X			X		X		X		
modocensis Greene													
ssp. *subacaulis* (Kell.) Babcock & Stebbins	X	X		O				O			X	X	
nana Richards.													
ssp. *ramosa* Babcock & Stebbins	X											X	X
ssp. *nana*	X	X										X	X
occidentalis Nutt.													
ssp. *pumila* (Rydb.) Babcock & Stebbins	X	X	X	X		X	X		X		X		
ssp. *occidentalis*	X	X	X	X		X	X	X	X				
ssp. *conjuncta* (Jepson) Babcock & Stebbins	X	X	X	X		X	X	X	X		X		
runcinata (James) Torr. & Gray													
ssp. *hallii* Babcock & Stebbins				X	X		X						
Dugaldia													
hoopesii (Gray) Rydb.	X	X		O	X			X	X	X	X	X	X

Table 1 continued.

	AREAS				HABITATS								
	N	S	W	M	1	2	3	4	5	6	7	8	9
Eatonella													
nivea (D.C. Eat.) Gray	X	X		X			X	X					
Erigeron													
aphanactis (Gray) Greene													
var. *aphanactis*	X	X	X	X		X	X	X					
barbellulatus Greene	X									O	X	X	X
bloomeri Gray													
var. *bloomeri*		X	X	X		X	X						
breweri Gray													
var. *breweri*	X								X		X		
var. *porphyreticus* (M.E. Jones) Cronquist	X	X	X	X			X	X	X			X	
clokeyi Cronquist	X	X		X			X	X	X		X	X	X
compositus Pursh													
var. *glabratus* Macoun	X	X		X				X	X		X	X	X
coulteri Porter	X	X		O	X				X		X	X	
divergens Torr. & Gray	X	X							X		X	X	
eatonii Gray													
ssp. *plantagineus* (Greene) Cronquist	X	X	X	X		X	X	X	X		X		
lonchophyllus Hook.	X	X	X	O	X		X		X		O	O	
nevadincola Blake	X	X	X	X			X				X		
peregrinus (Pursh) Greene													
ssp. *callianthemus* (Greene) Cronquist													
var. *angustifolius* (Gray) Cronquist	X	X		O	X						X	X	X
ssp. *callianthemus* (Greene) Cronquist													
var. *hirsutus* Cronquist	X				X						X	X	
petiolaris Greene	X	X										X	X
pygmaeus (Gray) Greene	X	X										X	X
tener (Gray) Gray				X					X				
vagus Payson	X											X	X
Eriophyllum													
lanatum (Pursh) Forbes													
var. *integrifolium* (Hook.) Smiley	X	X	X	X			X	X	X		X	X	X
Eupatorium													
occidentale Hook.	X	X	X	X			X	X	X	X	X	X	
Glyptopleura													
marginata D.C. Eat.				X		X	X						
Gnaphalium													
palustre Nutt.	X	X			X				X		X		X
microcephalum Nutt.													
var. *thermale* (E. Nels.) Cronquist				X		X							
Grindelia													
squarrosa (Pursh) Dunal													
var. *squarrosa*		X	X	X		X	X						
Gutierrezia													
sarothrae (Pursh) Britt. & Rusby			X				X						
Haplopappus													
acaulis (Nutt.) Gray	X	X	X	X		X	X	X	X		X	X	
apargioides Gray	X	X		O				O			X	X	X
bloomeri (Hook.) Gray	X	X									X		
lanceolatus (Hook.) Torr. & Gray													
var. *lanceolatus*	X	X			X			X	X				
macronema Gray	X	X										X	X
racemosus (Nutt.) Torr.													
ssp. *glomeratus* (Nutt.) Hall				O			O						
suffruticosus (Nutt.) Gray	X	X		O				O			X	X	X
uniflorus (Hook.) Torr. & Gray													
ssp. *uniflorus*	X	X			X		X		X				

Table 1 continued.

	AREAS				HABITATS								
	N	S	W	M	1	2	3	4	5	6	7	8	9
Helianthus													
annuus L.	X	X					X		X				
Heterotheca													
breweri AGray) Shinners	X								X		X	X	
Hieracium													
albiflorum Hook.	X				X				X	O	X		
gracile Hook.													
var. *gracile*	X										X	X	
horridum Fries	X	X							X		X	X	
Hulsea													
algida Gray	X	X		O								X	X
heterochroma Gray	O								O				
Hymenopappus													
filifolius Hook.													
var. *nanus* (Rydb.) B.L. Turner		X	X	X		X	X						
Hymenoxys													
cooperi (Gray) Cockerell													
var. *canescens* (D.C. Eat.) Parker	X	X										X	X
Iva													
axillaris Pursh	X	X	X	X		X	X	X					
Lactuca													
serriola L.	X	X	X	X	X		X		X				
tartarica (L.) C.A. May													
ssp. *pulchella* (Pursh) Stebbins				X			X						
Layia													
glandulosa (Hook.) Hook. & Arn.													
ssp. *glandulosa*		X	X	X		X	X						
Leucanthemum													
vulgare Lam.	X	X			X		X		X				
Machaeranthera													
canescens (Pursh) Gray			X	X			X						
shastensis Gray													
var. *montana* (Greene) Cronquist & Keck	X	X									X	X	X
var. *gossophylla* (Piper) Cronquist & Keck	X	X		X			X	O	X		X		
Madia													
glomerata Hook.	X	X							X				
gracilis (Sm.) Keck				X			X						
Malacothrix													
sonchoides (Nutt.) Torr. & Gray													
var. *torreyi* (Gray) E. Williams				X		X							
Microseris													
lindleyi (DC.) Gray		X	X				X	X					
Nothocalais													
alpestris (Gray) Chambers	O										O	O	O
Psilocarphus													
brevissimus Nutt.													
var. *brevissimus*			X				X						
Raillardella													
argentea (Gray) Gray	X	X									X	X	X
scaposa (Gray) Gray	X											X	
Senecio													
canus Hook.	X	X	X	X			X	X	X		X	X	X
cymbalarioides Beuk	X											X	X
fremontii Torr. & Gray													
var. *occidentalis* Gray	X	X									X	X	X
hydrophilus Nutt.	X		X	O	X		X				X		
integerrimus Nutt.													
var. *exaltatus* (Nutt.) Cronquist	X	X	X	X		X	X	X	X		X	X	
multilobatus Torr. & Gray ex Gray	X	X	X	X	X		X	X	X		X	X	X

Table 1 continued.

	AREAS				HABITATS								
	N	S	W	M	1	2	3	4	5	6	7	8	9
pattersonensis Hoover	X	X										X	X
scorzonella Greene	X	X									X	X	X
serra Hook.													
var. *serra*	X	X	X	O	X		X		X		X	X	
spartioides Torr. & Gray	X	X							X		X	X	
streptanthifolius Greene	X								X		X	X	X
triangularis Hook.	X	X		X	X				X	X	X	X	X
werneriifolius (Gray) Gray	X	X										X	X
Solidago													
canadensis L.													
var. *salebrosa* (Piper) M.E. Jones	X								X				
multiradiata Ait.	X	X									X	X	X
occidentalis (Nutt.) Torr. & Gray			X	X	X	X							
spectabilis (D.C. Eat.) Gray			X	O	X		X						
Sonchus													
asper (L.) Hill	X	X	X	X	X		X		X				
Sphaeromeria													
cana (D.C. Eat.) Heller	X	X									X	X	X
potentilloides (Gray) Heller													
var. *potentilloides*				X				X					
Stephanomeria													
exigua Nutt.													
ssp. *coronaria* (Greene) Gottlieb	X	X		O							X	X	
ssp. *exigua*	X	X	X	X		X	X	X					
spinosa (Nutt.) S. Tomb	X	X	X	X		X	X	X	X				
Taraxacum													
officinale Weber	X	X	X	X	X	X	X	X	X		X	X	X
Tetradymia													
axillaris A. Nels.													
var. *longispina* (M.E. Jones) Strother				X		X							
canescens DC.	X	X	X	O		X	X	X	X		X	X	X
glabrata Torr. & Gray	X	X	X	X		X	X	X					
spinosa Hook. & Arn.			X	X		X	X						
tetrameres (Blake) Strother				O		O							
Townsendia													
condensata Parry ex Gray		X											X
scapigera D.C. Eat.		X		O				X			X	X	X
Tragopogon													
dubius Scop.	X	X	X	X	X		X	X	X				
Wyethia													
mollis Gray	X	X	X	X			X	X	X	X	X	X	
BETULACEAE													
Alnus													
incana (L.) Moench													
ssp. *tenuifolia* (Nutt.) Breittung	X						X		X				
BORAGINACEAE													
Amsinckia													
tessellata Gray		X	X	X		X	X						
Cryptantha													
affinis (Gray) Greene	X	X					X		X	O	O		
circumscissa (Hook. & Arn.) Johnston													
var. *hispida* (J.F. Macbr.) Johnston	X	X	X	X		X	X		X		X		
var. *circumscissa*	X	X	X	X		X	X		X		X		
confertiflora (Greene) Payson		X	X	X		X	X						
echinella Greene	X	X	X	X			X	X	X		X		
flavoculata (A. Nels.) Payson	X	X	X	X		X	X	X	X		X		
glomeriflora Greene	X	X	X			X	X		X		X		X
humilis (Gray) Payson													
var. *humilis*	X	X		X			X						

Table 1 continued.

	AREAS				HABITATS								
	N	S	W	M	1	2	3	4	5	6	7	8	9
jamesii (Torr.) Payson													
var. *abortiva* (Greene) Payson				X				X					
nubigena (Greene) Payson	X	X										X	X
pterocarya (Torr.) Greene													
var. *pterocarya*	X	X	X	X		X	X	X	X				
torreyana (Gray) Greene													
var. *torreyana*	X	X		O				X	X				
var. *pumila* (Heller) Johnston			X	X			X						
watsonii (Gray) Greene	X	X	X	X		X	X	X	X		X	X	
sp. nov.	X	X		X								X	
Hackelia													
floribunda (Lehm.) Johnston				O		O							
micrantha (Eastw.) J.L. Gentry	X	X		O	X		X	X	X		X	X	
Lappula													
redowskii (Hornem.) Greene													
var. *redowskii*	X	X	X	X			X	X	X		X	X	
Mertensia													
oblongifolia (Nutt.) G. Don													
var. *nevadensis* (A. Nels.) L.O. Williams	X	X	X	X			X	X	X		X	X	X
Pectocarya													
setosa Gray		X	X	X		X	X						
Plagiobothrys													
hispidus Gray	X	X	X	X			X	X	X		X	X	
jonesii Gray		X	X	X		X	X						
kingii (S. Wats.) Gray													
var. *harknessii* (Greene) Jepson	X	X	X	X			X					X	
var. *kingii*		X	X	X		X	X						
scouleri (Hook. & Arn.) Johnston													
var. *scouleri*	X	X	X	X	X		X	X	X		X		
Tiquilia													
nuttallii (Benth. ex Hook.) Richards.				X		X							
BRASSICACEAE													
Anelsonia													
eurycarpa (Gray) Macbr. & Payson	X	X											X
Arabis													
bodiensis Rollins	X	X		X			X	X			X	X	
cobrensis M.E. Jones		X	X	X			X	X	X				
davidsonii Greene	X				X				X		X		
divaricarpa A. Nels.	X	X	X				X		X		X	X	X
drummondii Gray	X	X		O				O	X		X		
fernaldiana Rollins													
var. *stylosa* (S. Wats.) Rollins				X				X					
glabra (L.) Bernh.	X	X			X				X		X		
hirsuta (L.) Scop.													
var. *glabrata* Torr. & Gray	X	X							X	X	X		
holboellii Hornem.													
var. *pendulocarpa* (A. Nels.) Rollins	X	X									X	X	X
var. *pinetorum* (Tidestrom) Rollins	X	X	X	X			X	X	X		X		
var. *retrofracta* (Grahm.) Rydb.	X	X	X	X			X	X	X			X	
var. *holboellii*				X			X						
inyoensis Rollins	X	X										X	X
lemmonii S. Wats.													
var. *lemmonii*	X	X										X	X
var. *depauperata* (A. Nels. & Kenn.) Rollins	O												O
lyallii S. Wats.													
var. *lyallii*	X	X		O								X	
platysperma Gray													
var. *platysperma*	X	X		X				X	X		X	X	X
var. *howellii* (S. Wats.) Jepson	X	X									X	X	X

Table 1 continued.

	AREAS				HABITATS								
	N	S	W	M	1	2	3	4	5	6	7	8	9
puberula Nutt.	X	X	X	X		X	X	X	X		X		
pulchra M.E. Jones ex S. Wats.													
var. *pulchra*	X	X	X	X			X		X				
var. *gracilis* M.E. Jones			X	X		X	X						
sparsiflora Nutt.													
var. *subvillosa* (S. Wats.) Rollins	X	X	X	X			X	X	X		X		
var. *sparsiflora*	X	X	X	X			X	X	X		X		
Barbarea													
orthoceras Ledeb.													
var. *dolichocarpa* Fern.	X	X	X	X	X		X		X		X		
var. *orthoceras*	X	X	X	X	X		X		X		X	X	X
Capsella													
bursa-pastoris (L.) Medic.	X	X	X	X			X	X	X				
Cardamine													
breweri S. Wats.													
var. *breweri*	X	X	X	X	X		X	X	X	X	X	X	X
Cardaria													
pubescens (C.A. Mey) Jarmolenko				O			O						
Caulanthus													
pilosus S. Wats.				X		X							
Descurainia													
californica (Gray) O.E. Schulz	X	X	X	X			X		X	X	X	X	
pinnata (Walt.) Britt.													
ssp. *filipes* (Gray) Detling	X	X	X	X		X	X		X		X		
ssp. *halictorum* (Cockerell) Detling				X		X							
ssp. *menziesii* (DC.) Detling	X	X	X	X			X		X				
richardsonii (Sweet) O.E. Schulz													
ssp. *incisa* (Engelm.) Detling				O				O					
ssp. *viscosa* (Rydb.) Detling	X	X							O	O	O	X	X
sophia (L.) Webb ex Prantl	X	X	X	X	X	X	X	X	X	X	X	X	
Draba													
albertina Greene	X	X		O	X						X	X	X
breweri S. Wats.	X	X		O								X	X
densifolia Nutt.	X	X	X	X			X	X	X		X	X	X
douglasii Gray													
var. *crockeri* (Lemmon) C.L. Hitchc.				X			X	X					
lemmonii S. Wats.													
var. *lemmonii*	X											X	X
var. *incrassata* Rollins		X									X	X	X
oligosperma Hook.													
var. *subsessilis* (S. Wats.) O.E. Schulz	X	X											X
var. *oligosperma*	X	X										X	X
paysonii J.F. Macbride	O										O	O	O
quadricostata Rollins		X	X	X			X	X					
stenoloba Ledeb.													
var. *ramosa* C.L. Hitchcock	X	X			X						X	X	X
Erysimum													
argillosum (Greene) Rydb.				O			O						
capitatum (Dougl.) Greene	X	X	X	X			X	X	X		X		
perenne (S.Wats. ex Coville) Abrams	X	X		X				X			X	X	X
repandum L.			X	X		X	X						
Hymenolobus													
procumbens (L.) Nutt. ex Torr. & Gray				X			X						
Lepidium													
lasiocarpum Nutt.				X		X	X						
perfoliatum L.	X	X	X	X		X	X	X	X				
virginicum L.													
var. *pubescens* (Greene) C.L. Hitchc.	X	X	X	X		X	X	X	X				

Table 1 continued.

	AREAS				HABITATS								
	N	S	W	M	1	2	3	4	5	6	7	8	9
Lesquerella													
kingii S. Wats.													
var. *kingii*	X	X	X	X		X	X	X	X		X	X	X
Nasturtium													
officinale R. Br.	X	X	X	X	X		X		X				
Phoenicaulis													
cheiranthoides Nutt.	X	X	X	X			X	X	X		X	X	X
Polyctenium													
fremontii (S. Wats.) Greene				X			X						
Rorippa													
curvisiliqua (Hook.) Bess. ex Britton	X	X			X						X	X	
teres (Michx.) R. Stuckey	X	X	X	X	X			X	X		X		
Sisymbrium													
altissimum L.	X	X	X	X		X	X		X				
Stanleya													
pinnata (Pursh) Britton													
var. *pinnata*		X	X	X		X	X						
Streptanthus													
cordatus Nutt. ex Torr. & Gray	O						O		O				
oliganthus Rollins	X	X		X			X	X	X				
tortuosus Kellogg													
var. *orbiculatus* (Greene) Hall	X										X	X	X
Thelypodium													
crispum Greene ex Payson	X	X	X	X	X	X	X	X				X	
integrifolium (Nutt.) Endl.													
ssp. *complanatum* Al-Shehbaz			X	X	X	X	X						
laciniatum (Hook.) Endl.				X		X							
CACTACEAE													
Opuntia													
polyacantha Haw.													
var. *rufispina* (Engelm. & Bigelow) Benson	X	X	X	X		X	X	X	X		X	X	
pulchella Engelm.			X	X		X							
CALLITRICHACEAE													
Callitriche													
heterophylla Pursh emend. Darby													
var. *bolanderi* (Hegelm.) Fassett.				O				O					
verna L. emend. Kuetz.	X	X		X		X	X	X	X				
CAMPANULACEAE													
Nemacladus													
rigidus Curran			X	X		X	X						
Porterella													
carnosula (Hook. & Arn.) Torr.	X				X				X	O	O	O	
CAPPARIDACEAE													
Cleomella													
hillmanii A. Nels.				X		X							
parviflora Gray				X			X						
CAPRIFOLIACEAE													
Lonicera													
involucrata (Rich.) Banks ex Spreng.	X				X				X	X	X	X	
Sambucus													
caerulea Raf.	X	X	X	X			X	X	X		X	X	
racemosa L.													
ssp. *pubens* (Michx.) House													
var. *microbotrys* (Rydb.) Kearney & Peebles	X	X								O	X	X	X
Symphoricarpos													
longiflorus Gray		X	X	X		X	X						

Table 1 continued.

	AREAS				HABITATS								
	N	S	W	M	1	2	3	4	5	6	7	8	9
oreophilus Gray													
var. *oreophilus*	X	X	X	X			X	X	X		X	X	X
parishii Rydb.				O				O					
CARYOPHYLLACEAE													
Arenaria													
aculeata S. Wats.	X	X	X	X			X	X	X		X	X	X
Cerastium													
alpinum L.	X	X			X							X	X
vulgatum L.	X	X			X		X		X		X		
Minuartia													
nuttallii (Pax) Briq.													
ssp. *fragilis* (Maguire & Holmgren) McNeill				X			X		X				
ssp. *gracilis* (B.L. Robins.) McNeill	X	X									X	X	X
obtusiloba (Rydb.) House	O												O
rossii (R. Br.) Graebn.	O	X											X
rubella (Wahlenb.) Hiern	X	X											X
Pseudostellaria													
jamesiana (Torr.) Weber & Hartman	X	X			X				X		X		
Sagina													
saginoides (L.) Karst.	X	X		O	X			O	X			X	
Saponaria													
officinalis L.	X	X				X	X						
Silene													
bernardina S. Wats.													
ssp. *maguirei* Bocquet													
var. *maguirei*	O						O						
ssp. *bernardina*	X	X		O				O				X	X
menziesii Hook.													
ssp. *dorrii* (Kellogg) C.L. Hitchc.& Maguire	X			O				O	X		X		
nuda (S. Wats.) C.L. Hitchc. & Maguire													
ssp. *insectivora* (Henders.) C.L. Hitchc. & Maguire	O						O		O				
sargentii S. Wats.	X	X		X								X	X
Stellaria													
crispa Cham. & Schlecht.	X	X			X				X		X	X	X
longipes Goldie	X	X	X	X	X		X		X		X	X	
umbellata Turcz. ex Kar. & Kir.	X				X					X	X	X	
CHENOPODIACEAE													
Atriplex													
argentea Nutt.													
ssp. *argentea*			X			X							
canescens (Pursh) Nutt.													
ssp. *canescens*			X	X		X	X						
confertifolia (Torr. & Frem.) S. Wats.				X		X							
heterosperma Bunge			X		X		X						
patula L.													
ssp. *hastata* (L.) H. & S.		X	X	X			X						
rosea L.			X	X		X	X						
Bassia													
hyssopifolia (Pallas) Kuntze				X		X	X						
Ceratoides													
lanata (Pursh) J.T. Howell													
var. *lanata*	X	X	X	X		X	X						
Chenopodium													
album L.	X	X	X	X			X		X		X		X
atrovirens Rydb.	X	X		O			X	O	X	X			
botrys L.		X	X	X		X	X						
dessiccatum A. Nels.													
var. *leptophylloides* (J. Murr) H.A. Wahl.	X	X							X		X		
var. *dessiccatum*	X	X					X		O	O	O		

Table 1 continued.

	AREAS				HABITATS								
	N	S	W	M	1	2	3	4	5	6	7	8	9
fremontii S. Wats.				X			X						
leptophyllum (Moq.) Nutt. ex S. Wats.	O			O		O	O	O	O				
overi Aellen	X	X									X	X	
Grayia													
spinosa (Hook.) Moq.	X	X	X	X		X	X	X	X		X		
Halogeton													
glomeratus (Stephan ex Bieb) C.A. Mey.				X		X							
Kochia													
scoparia (L.) Schrad.			X	X		X	X						
Monolepis													
nuttalliana (Roem. & Schult.) Greene	X	X	X	X			X	X	X		X	X	
spathulata Gray	O			O			O		O	O			
Salsola													
iberica Sennen & Pau	X	X	X	X		X	X						
Sarcobatus													
vermiculatus (Hook.) Torr.													
var. *vermiculatus*		X	X	X	X	X	X						
Sueda													
occidentalis S. Wats.				X			X						
CLUSIACEAE													
Hypericum													
formosum H.B.K.													
ssp. *scouleri* (Hook.) C.L. Hitchc.	X	X			X		X		X				
CONVOLVULACEAE													
Calystegia													
polymorpha (Greene) Munz	X	X							X				
Convolvulus													
arvensis L.		X	X	X			X						
CORNACEAE													
Cornus													
sericea L.													
ssp. *sericea*	X	X		O	X		X		X		X		
CRASSULACEAE													
Sedum													
integrifolium Coult. & A. Nels.	X											X	X
lanceolatum (Nutt.) Britton & Rose	X	X								O	X	X	
obtusatum Gray	X								X		X	X	X
CROSSOSOMATACEAE													
Forsellesia													
nevadensis (Gray) Greene		X					X						
CUSCUTACEAE													
Cuscuta													
suksdorfii Yunker													
var. *subpedicellata* Yunker				O			O						
CYPERACEAE													
Carex													
abrupta Mackenzie	X	X							X		X		
aquatilis Wahlenb.	X	X			X				X			X	O
athrostachya Olney	X	X		X	X			X	X	O	X	O	
aurea Nutt.	X	X			X		X		X		X	X	
brevipes W. Boott.	O			O	O			O	O				
canescens L.	O				O					O	O	O	
capitata L.	X	X								O	O	X	X
congdonii Bailey	X	X			X						X		X
disperma Dewey	X	X		X				X	X		X		
douglasii Boott	X	X	X	X			X	X	X		X	X	X

Table 1 continued.

	AREAS				HABITATS								
	N	S	W	M	1	2	3	4	5	6	7	8	9
exserta Mackenzie	X	X		X				X	X		X	X	X
festivella Mackenzie	X	X					X		X	X	X	X	
fissuricola Mackenzie	O									O			
haydeniana Olney	O											O	O
helleri Mackenzie	X	X		O								X	X
heteroneura W. Boott													
var. *epapillosa* (Mackenzie) F.J. Herm.	O	O								O	O	O	O
var. *heteroneura*	X	X			X				X		X	X	
hoodii Boott	X	X			X				X		X	X	
jepsonii J.T. Howell	X				X				X				
jonesii Bailey	X	X			X				X	O	O	O	
lanuginosa Michx.	X	X	X		X		X		X		X	X	
leporinella Mackenzie	X	X								O	O	X	X
luzulifolia W. Boott	X	X			X						X	X	
microptera Mackenzie	O	O		O						O	O	O	
nebraskensis Dewey	X	X	X	X	X		X	X	X		X	X	X
nervina Bailey	O								O	O	O	O	
nigricans C.A. Mey.	X	X			X						X	X	
pachystachya Cham. ex Steudel.				O	O		O						
phaeocephala Piper	X	X										X	X
praegracilis W. Boott		X	X	X		O	X	X	X	O			
rossii Boott ex Hook.	O			O					O	O	O	O	
rostrata Stokes ex With.	X	X		O	X				X		X		
scopulorum T. H. Holm.													
var. *bracteosa* (Bailey) F.J. Herm.	X	X								X	X	X	
var. *scopulorum*	X	X			X				X	O	X	X	X
simulata Mackenzie				O	O		O						
specifica Bailey	O								O	O	O	O	
spectabilis Dewey	O									O	O	O	
straminiformis Bailey	X	X		O				X	X	X	X	X	X
subnigricans Stacey	X	X								O	X	X	X
tahoensis Smiley	X	X										X	X
vallicola Dewey	X	X		X				X	X		X	X	
vernacula Bailey	X	X			X					O	X	X	X
vesicaria L.	X	X			X				X	X	X	X	
Eleocharis													
engelmannii Steud.		X	X		X		X						
palustris (L.) Roemer & Schultes	X	X	X	X	X		X		X				
pauciflora (Lightf.) Link	X	X		X	X		X		X		X	X	
Eriophorum													
crinigerum (Gray) Beetle	X				X					O	X	X	
Scirpus													
acutus Muhl. ex Bigelow			X		X		X						
americanus Pers.			X		X		X						
clementis M.E. Jones	O			O	O						O	O	
microcarpus Presl.	X	X		O	X				X		X		
nevadensis S. Wats.				O	O		O						
pungens Vahl.				X	X		X						
ELAEAGNACEAE													
Elaeagnus													
angustifolia L.				O			O						
Shepherdia													
argentea (Pursh) Nutt.		X	X	X	X		X						
ELATINACEAE													
Elatine													
rubella Rydb.				O				O					

Table 1 continued.

	AREAS				HABITATS								
	N	S	W	M	1	2	3	4	5	6	7	8	9
ERICACEAE													
Arctostaphylos													
nevadensis Gray	X										X		
Cassiope													
mertensiana (Bong.) D. Don	X											X	X
Kalmia													
microphylla (Hook.) Heller													
var. *microphylla*	X			O	X			O		O	X	X	X
Ledum													
glandulosum Nutt.													
var. *californicum* (Kellogg) C.L. Hitchc.	X	X		O						X	X	X	X
Orthilia													
secunda (L.) House													
ssp. *secunda*	X				X					X	X		
Phyllodoce													
breweri (Gray) Heller	X									X	X	X	X
Pterospora													
andromedea Nutt.	X								X	X	X		
Pyrola													
californica Krisa	X				X				X	X			
dentata Sm.													
var. *dentata*	X	X			X					X	X	X	
minor L.	X				X						X		
Sarcodes													
sanguinea Torr.	X								X				
Vaccinium													
caespitosum Michx.													
var. *paludicola* (Camp) Hulten	X				X							X	X
uliginosum L.													
ssp. *occidentale* (Gray) Hulten	X										X	X	X
EUPHORBIACEAE													
Chamaesyce													
serpyllifolia (Pers.) Small	X	X	X	X		X	O					X	
FABACEAE													
Astragalus													
andersonii Gray		X	X				X						
bolanderi Gray				O				O					
calycosus Torr. ex S. Wats.													
var. *calycosus*				X		X	X	X					
canadensis L.													
var. *brevidens* (Gand.) Barneby	X				X				X				
casei Gray				X		X							
curvicarpus (Heller) J.F. Macbr.													
var. *curvicarpus*	O			X		X			O				
gibbsii Kellogg				O		O							
iodanthus S. Wats.													
var. *iodanthus*		X	X	X		X	X		X				
johnnis-howellii Barneby				X		X		O					
kentrophyta Gray													
var. *danaus* Barneby	X	X										X	X
lentiginosus Dougl. ex Hook.													
var. *ineptus* (Gray) M.E. Jones	X	X		X			X	X	X	X	X	X	X
malacus Gray		X	X	X		X	X						
obscurus S. Wats.			X				X						
oophorus S. Wats.													
var. *lavinii* Barneby in ed.			X	X		X	X						
platytropis Gray	X	X										X	X

Table 1 continued.

	AREAS				HABITATS								
	N	S	W	M	1	2	3	4	5	6	7	8	9
purshii Dougl. ex Hook.													
var. *lectulus* (S. Wats.) M.E. Jones	X	X		X			X	X	X		X	X	X
var. *tinctus* M.E. Jones	X	X	X	X			X	X	X				
whitneyi Gray													
var. *whitneyi*	X	X		X			X	X	X		X	X	X
Dalea													
ornata (Dougl. ex Hook.) Eat. & Wright				X		X							
Lupinus													
andersonii S. Wats.	X	X		X				X	X	X	X	X	X
arbustus Dougl. ex Lindl.													
ssp. *calcaratus* (Kellogg) Dunn	X	X		X				X	X		X	X	
brevicaulis S. Wats.		X	X	X		X	X						
caudatus Kellogg													
ssp. *caudatus*	X	X	X	X			X	X	X				
ssp. *montigenus* (Heller) Hess & Dunn	X	X										X	X
confertus Kellogg	X	X		X		X			X				
hypolasius Greene	X	X									X	X	X
lyallii Gray													
var. *danaus* (Gray) S. Wats.	X											X	X
var. *lyallii*	X											X	
meionanthus Gray	X	X							X	X	X	X	X
nevadensis Heller	X	X	X	X			X	X	X				
polyphyllus Lindl.													
ssp. *superbus* (Heller) Munz	X	X			X					X	X	X	
sellulus Kellogg													
var. *lobbii* (S. Wats.) Cox	X	X									X	X	X
var. *sellulus*	X								X		X	X	
tegeticulatus Eastw	X	X		X				X	X		X	X	X
X *inyoensis* Heller	X	X		X				X				X	
Medicago													
lupulina L.	X	X	X	X	X	X	X	X	X				
sativa L.	X	X	X	X	X	X	X		X				
Melilotus													
albus Medic.	X	X	X	X	X		X		X				
officinalis (L.) Pallas	X	X	X	X	X		X		X		X		
Oxytropis													
parryi Gray	X	X											X
Robinia													
pseudoacacia L.	X						X						
Trifolium													
andersonii Gray													
ssp. *beatleyae* Gillett			X	X			X	X					
ssp. *andersonii*		X	X				X	X	X				
cyathiferum Lindl.	X	X		O	X			O	X	X			
hybridum L.	X				X				X				
longipes Nutt.													
ssp. *longipes*	X	X		O	X			O	X	O	X	X	X
monanthum Gray													
var. *monanthum*	X	X		O	X			X	X	X	X	X	X
pratense L.	X	X			X				X				
productum Greene	X								O	O	X	X	
repens L.	X	X	X		X		X		X				
wormskjoldii Lehm.	X	X			X		X		X				
Vicia													
americana Muhl. ex Willd.													
ssp. *americana*	X	X	X	X	X		X		X				
FAGACEAE													
Castanopsis													
sempervirens (Kellogg) Dudley	X								X	X	X	X	

Table 1 continued.

	AREAS				HABITATS								
	N	S	W	M	1	2	3	4	5	6	7	8	9
GENTIANACEAE													
Frasera													
speciosa Dougl. ex Griseb.	X	X							X	X	X	X	
Gentiana													
calycosa Griseb.	O									O	O	O	
newberryi Gray	X	X			X							X	X
Gentianopsis													
holopetala (Gray) Iltis	X	X		O	X		X		X	O	X	X	
GERANIACEAE													
Erodium													
cicutarium (L.) L'Her.	X	X	X	X		X	X	X	X				
Geranium													
richardsonii Fisch. & Trautv.	X	X	X		X		X		X	O	X	X	
HALORAGIDACEAE													
Hippuris													
vulgaris L.	X	X		X	X	X	X		X		X		
HYDROCHARITACEAE													
Elodea													
canadensis Michx.	X				X				X			X	
HYDROPHYLLACEAE													
Hesperochiron													
californicus (Benth.) S. Wats.	X	X	X	X	X	X	X	X	X				
Hydrophyllum													
capitatum Dougl. ex Benth.													
var. *alpinum* S. Wats.	X	X			X						X	X	
Nama													
aretioides (Hook. & Arn.) Brand		X	X	X		X	X	X					
densum Lemmon	X	X		O				O	X				
rothrockii Gray				O				O					
Nemophila													
spatulata Coville	X	X		X				X	X		X		X
Phacelia													
bicolor Torr. ex S. Wats.				O				O					
curvipes Torr. ex S. Wats.	X	X	X	X			X	X	X				
frigida Greene	X	X									X	X	X
hastata Dougl. ex Lehm.													
ssp. *compacta* (Brand) Heckard	X	X		X				X	X		X	X	X
heterophylla Pursh													
ssp. *virgata* (Greene) Heckard	X	X	X	X		X	X	X	X				
humilis Torr. & Gray													
var. *humilis*	X	X	X	X			X	X	X				
hydrophylloides Torr. ex Gray	O								O		O		
linearis (Pursh) Holz.				X				X					
monoensis Halse				X		X	X						
peirsoniana J.T. Howell			X				X						
ramosissima Dougl. ex Lehm.													
var. *ramosissima*	X	X	X	X			X	X	X		X		
tetramera J.T. Howell				X		X	X						
Tricardia													
watsonii Torr. ex S. Wats.				X		X	X						
IRIDACEAE													
Iris													
missouriensis Nutt.	X	X	X	X	X	X	X	X	X		X	X	
Sisyrinchium													
halophilum Greene	X	X	X	X	X		X		X				
idahoense Bickn.													
var. *occidentale* (Bickn.) Henderson	X	X	X	X	X		X		X		X	X	

Table 1 continued.

	AREAS				HABITATS								
	N	S	W	M	1	2	3	4	5	6	7	8	9
JUNCACEAE													
Juncus													
balticus Willd.	X	X	X	X	X		X	X	X				
bryoides F.J. Herm.	X	X			X			X	X		X	X	
bufonius L.													
var. *occidentalis* F.J. Herm.	X	X			X				X				
var. *bufonius*	X	X		O	X			O	X			X	X
capillaris F.J. Herm.	X	X			X						X		
chlorocephalus Engelm.	O								O	O	O	O	
drummondii E. Mey.	O								O	O	O	O	
ensifolius Wikstr.													
var. *montanus* (Engelm.) C.L. Hitchcock				O	O			O					
hemiendytus F.J. Herm.	X	X			X				X		O	O	
kelloggii Engelm.	O			O	O			O	O				
longistylis Torr.	X	X			X						X	X	
macrandrus Coville				X			X						
megaspermus F.J. Herm.	O				O				O				
mertensianus Bong.	X	X			X			X	X		X	X	
mexicanus Willd.	X	X	X	X	X		X	X	X		X	X	
nevadensis S. Wats.	X	X		O	X		X		X		O	O	
orthophyllus Coville	X	X	X	X	X		X	X	X		X	X	
parryi Engelm.	X	X		O							X	X	X
saximontanus A. Nels.	X	X			X						X		
Luzula													
divaricata S. Wats.	X	X									X	X	
multiflora (Retz.) Lej.													
ssp. *comosa* (E. Mey.) Hulten	X	X							X		X	X	X
spicata (L.) DC.	X	X									X		
subcongesta (S. Wats.) Jepson	X								X		X	X	X
JUNCAGINACEAE													
Triglochin													
concinna Burtt-Davy													
var. *debilis* (M.E. Jones) J.T. Howell				O	O		O						
maritima L.			X	O	X		X						
LAMIACEAE													
Agastache													
urticifolia (Benth.) Kuntze	X	X	X	X			X		X		X	X	
Marrubium													
vulgare L.	X	X	X	X		X	X	X	X				
Mentha													
arvensis L.													
ssp. *haplocalyx* Briq.	O	X	X	X	X		X						
Monardella													
odoratissima Benth.													
ssp. *glauca* (Greene) Epling	X	X		X				X	X		X	X	X
Salvia													
dorrii (Kellogg) Abrams													
var. *dorrii*		X	X	X		X	X						
Trichostema													
austromontana Lewis	O	O		O				O	O	O			
LEMNACEAE													
Lemna													
gibba L.	X	X	X	X	X		X	X	X				
minuta H.B.K.				O	O			O					
trisulca L.	X			X	X				X				
LENTIBULARIACEAE													
Utricularia													
vulgaris L.	X				X				X				

Table 1 continued.

	AREAS				HABITATS								
	N	S	W	M	1	2	3	4	5	6	7	8	9
LILIACEAE													
Allium													
amplectens Torr.				O			O						
anceps Kellogg		X	X	X		X	X	X					
atrorubens S. Wats.													
var. *atrorubens*		X	X	X		X	X						
bisceptrum S. Wats.	X	X		X				X	X		X	X	
campanulatum S. Wats.	X	X	X	X	X	X	X		X		X	X	
lemmonii S. Wats.	X	X			X				X				
parvum Kellogg		X	X	X		X	X						
validum S. Wats.	X				X				X		X		
Calochortus													
bruneaunis A. Nels. & J.F. Macbride	X	X	X	X			X						
leichtlinii Hook. f.	X	X	X	X			X	X	X		X	X	
Camassia													
leichtlinii (Baker) S. Wats.	O								O				
Fritillaria													
atropurpurea Nutt.	O			O				O			O	O	
pinetorum A. Davids.	X								X				
Lilium													
parvum Kellogg	X				X				X	X	X	X	
Muilla													
transmontana Greene	X	X	X	X			X	X					
Smilacina													
stellata (L.) Desf.													
var. *stellata*	X	X	X	X	X		X		X	X	X		
Triteleia													
gracilis (S. Wats.) Greene	O								O	O	O		
ixioides (Ait. f.) Greene													
ssp. *analina* (Greene) Lenz	X										X	X	
Veratrum													
californicum Durand													
var. *californicum*	X	X		O	X		X	X	X		X	X	
Zigadenus													
paniculatus (Nutt.) S. Wats.	X	X	X	X		X	X	X	X		X	X	
venenosus S. Wats.													
var. *venenosus*	X	X		X	X		X	X			X		
LIMNANTHACEAE													
Floerkea													
proserpinacoides Willd.	X	X			X			O	X	O	X		
LINACEAE													
Linum													
lewisii Pursh													
var. *lewisii*	X	X		X				X	X	O	X	X	X
LOASACEAE													
Mentzelia													
albicaulis (Hook.) Torr. & Gray	X	X	X	X		X	X	X	X			X	
congesta (Nutt.) Torr. & Gray	X	X	X	X			X	X	X		X		
dispersa S. Wats.	X	X							X		X		
laevicaulis (Hook.) Torr. & Gray	X	X	X	X		X	X		X		X	X	
montana (A. Davids.) A. Davids.	X	X					X						
torreyi Gray													
var. *torreyi*				O			O						
veatchiana Kellogg			X				X						
LORANTHACEAE													
Arceuthobium													
divaricatum Engelm.		X	X	X			X						
Phoradendron													
juniperinum Engelm. ex Gray													
ssp. *juniperinum*	X	X	X	X			X		X				

Table 1 continued.

	AREAS				HABITATS								
	N	S	W	M	1	2	3	4	5	6	7	8	9
MALVACEAE													
Malva													
neglecta Wallr.	X	X	X	X					X		X		
Sidalcea													
glaucescens Greene	O								O	O	O	O	
multifida Greene	X	X							X		X		
oregana (Torr. & Gray) Gray													
ssp. *spicata* (Regel) C.L. Hitchc.	X	X		X	X			X	X		X	X	
Sphaeralcea													
ambigua Gray													
ssp. *monticola* Kearney			X	X		X	X						
grossulariifolia (Hook. & Arn.) Rydb.		X	X			X	X						
MORACEAE													
Humulus													
lupulus L.													
var. *lupuloides* E. Small				O			O						
NYCTAGINACEAE													
Abronia													
turbinata Torr. ex S. Wats.				O		O							
Mirabilis													
bigelovii Gray													
var. *retrorsa* (Heller) Munz			X	X		X	X						
NYMPHAEACEAE													
Nuphar													
luteum (L.) Sibthorp. & Sm.													
ssp. *polysepalum* (Engelm.) E.O. Beal	X				X						X		
OLEACEAE													
Menodora													
spinescens Gray				X		X							
ONAGRACEAE													
Boisduvalia													
densiflora (Lindl.) S. Wats.	X										X		
Camissonia													
claviformis (Torr. & Frem.) Raven													
ssp. *integrior* (Raven) Raven		X	X	X		X	X						
nevadensis (Kellogg) Raven		X		X		X	X						
pubens (S. Wats.) Raven	X	X	X	X				X	X				
pusilla Raven		X	X	X		X	X						
subacaulis (Pursh) Raven	X	X	X	X	X		X		X		X		
tanacetifolia (Torr. & Gray) Raven													
ssp. *tanacetifolia*		X	X	X	X		X	X					
Circaea													
alpina L.													
ssp. *pacifica* (Aschers. & Magnus) Raven	X				X				X	O	O		
Epilobium													
anagallidifolium Lam.	X	X			X				X			X	X
angustifolium L.	X	X	X	X	X		X	X	X	X	X	X	X
brachycarpum Presl.	X	X		X			X	X	X				
ciliatum Raf.													
ssp. *ciliatum*	X	X	X	X	X		X	X	X	X	X	X	
glaberrimum Barbey	X	X							O	O	X	X	
lactiflorum Hausskn.	X	X			X				X		X	X	
latifolium L.	X	X			X						X	X	
obcordatum Gray													
ssp. *obcordatum*	X	X										X	X
oregonese Hausskn.	X	X		O				O	X				

Table 1 continued.

	AREAS				HABITATS								
	N	S	W	M	1	2	3	4	5	6	7	8	9
Gayophytum													
decipiens Lewis & Szweykowski	X	X	X	X	X		X	X	X		X	X	
diffusum Torr. & Gray													
ssp. *parviflorum* Lewis & Szweykowski	X	X		O	X			X	X		X		X
heterozygum Lewis & Szweykowski	X	X			X				X		X		
ramosissimum Torr. & Gray	X	X	X	X	X		X	X	X		X		X
Oenothera													
caespitosa Nutt.													
ssp. *marginata* (Nutt.) Munz		X	X	X		X	X	X	X		X		
hookeri Torr. & Gray													
ssp. *angustifolia* (R.R. Gates) Munz	X	X	X	X	X	X	X	X	X				
ORCHIDACEAE													
Corallorhiza													
maculata Raf.	X								X	O	O		
Epipactis													
gigantea Dougl. ex Hook.	O				O				O				
Listera													
convallarioides (Sw.) Nutt.	X				X				X				
Platanthera													
dilatata (Pursh) Lindl. ex Beck													
var. *leucostachys* (Lindl.) Luer	X	X			X				X	X	X	X	
sparsiflora (S. Wats.) Schlechter	X	X			X		X		X				
Spiranthes													
romanzoffiana Cham.	O				O				O	O	O	O	
OROBANCHACEAE													
Orobanche													
corymbosa (Rydb.) Ferris													
var. *corymbosa*			X	X		X	X						
fasciculata Nutt.													
var. *lutea* (Parry) Ashey				O		O	O						
var. *fasciculata*	X	X	X	X		X	X		X		X	X	
PAEONIACEAE													
Paeonia													
brownii Dougl. ex Hook.	X	X						X	X		X		
PAPAVERACEAE													
Argemone													
munita Dur. & Hilg.													
ssp. *rotundata* (Rydb.) G. Ownbey	X	X	X	X			X	X	X				
Corydalis													
aurea Willd.	X	X						X	X		X		
Dicentra													
uniflora Kellogg	X	X								O	X	X	
Eschscholzia													
californica Cham.	X	X					X		X				
PLANTAGINACEAE													
Plantago													
lanceolata L.	X	X			X		X		X				
POACEAE													
Agropyron													
dasystachum (Hook.) Scribn. & Sm.													
var. *dasystachum*				O				O					
desertorum (Link.) Schultes	X	X	X			X	X	X	X		X		
pringlei (Scribn. & Sm.) A.S. Hitchc.	X	X										X	X
scribneri Vasey		X										X	X
trachycaulum (Link.) Malte ex H. Lewis													
var. *latiglume* (Scribn. & Sm.) Beetle	O								O				
var. *trachycaulum*	X	X		X					X		X		

Table 1 continued.

	AREAS				HABITATS								
	N	S	W	M	1	2	3	4	5	6	7	8	9
Agrostis													
capillaris L.	X	X	X					X		X		X	
exarata Trin.	X	X	X	O	X		X		X				X
filiculmis M.E. Jones	X	X							X		X		
lepida A.S. Hitchc.	X	X									X	X	
scabra Willd.	X	X		O	X		X	X	X		X		
Alopecurus													
aequalis Sobol.	X	X		X	X		X		X				
geniculatus L.	X	X			X							X	X
Beckmannia													
syzigachne (Stendl.) Fearn.		X			X	X							
Bromus													
anomalus Rupr. ex Fourn.				O				O					
carinatus Hook. & Arn.	X	X	X	X	X		X	X	X		X		
catharticus Vahl	X	X							X				
commutatus Schrad.	X	X			X		X		X				
inermis Leyes.	X	X		X	X				X				
rubens L.			X	X			X						
suksdorfii Vasey	O								O	O	O	O	
tectorum L.	X	X	X	X		X	X	X					
Calamagrostis													
breweri Thurb.	X												X
canadensis (Michx.) Beauv.	X	X		O	X			X				X	
purpurascens R. Br.	X	X										X	X
Dactylis													
glomerata L.	X								X		X		
Danthonia													
intermedia Vasey	X											X	
Deschampsia													
cespitosa (L.) Beauv.													
ssp. *cespitosa*	X	X		O	X		X		X		X	X	X
danthonioides (Trin.) Munro ex Benth.	X	X			X		X						
elongata (Hook.) Munro ex Benth.	X	X		O	X			O	X		X	X	
Distichlis													
spicata (L.) Greene													
var. *stricta* (Torr.) Beetle			X	X		X	X						
Echinochloa													
crusgalli (L.) Beauv.	X	X			X	X							
Elymus													
cinereus Scribn. & Merr.	X	X	X	X		X	X	X	X		X		
glaucus Buckl.													
ssp. *glaucus*	X	X							X		X		
ssp. *virescens* (Piper) Gould		X					X						
triticoides Buckl.													
var. *triticoides*			X	X		X	X						
var. *pubescens* A.S. Hitchc.		X	X	X		X	X						
Elysitanion													
X *hansenii* (Scribn.) Bowden	X	X										X	X
Eragrostis													
orcuttiana Vasey				X			X						
Festuca													
brachyphylla Schultes	X	X		O								X	X
pratensis Huds.		X			X	X	X						
rubra L.	X	X					X		X		X	X	X
Glyceria													
elata (Nash) M.E. Jones	X	X			X				X		X		
Hilaria													
jamesii (Torr.) Benth.				X		X	X						
Hordeum													
brachyantherum Nevski	X	X		X			X	X	X		X		
jubatum L.	X	X	X	X			X		X		X		

Table 1 continued.

	AREAS				HABITATS								
	N	S	W	M	1	2	3	4	5	6	7	8	9
Koeleria													
nitida Nutt.	X	X	X	X			X	X	X		X		X
Leucopoa													
kingii (S. Wats.) W.A. Weber	X	X	X	X			X	X	X		X	X	X
Melica													
bulbosa Geyer ex Porter & Coult.	X	X						X	X		X	X	
stricta Boland.	X	X		X			X	X	X		X	X	
Muhlenbergia													
asperifolia (Nees & Meyem) Parodi	X	X	X	X			X		X				
filiformis (Thurb.) Rydb.	X	X									X		X
richardsonis (Trin.) Rydb.	X	X	X	X		X	X		X		X	X	X
Oryzopsis													
hymenoides (Roemer & Schultes) Ricker	X	X	X	X		X	X	X	X		X		
Panicum capillare L.				X	X		X						
Phleum													
alpinum L.	X	X		X	X			X	X		X	X	X
pratense L.	X	X	X	X	X		X		X				
Phragmites													
australis (Cav.) Trin. ex Steud.			X	O	X		X						
Poa													
ampla Merr.	X	X		X			X	X					
annua L.	X	X			X				X				
bolanderi Vasey	X	X							X				
bulbosa L.	X	X			X		X		X				
compressa L.	X	X			X	X	X		X				
cusickii Vasey	X	X		X				X	X		X		X
epilis Scribn.	X	X							X		X	X	X
fendleriana (Steud.) Vasey	X	X	X	X			X	X	X				
gracillima Vasey	X	X										X	
incurva Scribn. & Williams	X	X										X	
interior Rydb.	X	X					X		X				
leibergii Scribn.	X	X										X	X
leptocoma Trin.			X	O			X						
nervosa (Hook.) Vasey	X	X		X			X		X		X	X	X
nevadensis Vasey ex Scribn.													
var. *juncifolia* (Scribn.) Beetle	X	X							X				
var. *nevadensis*	X	X	X	X	X		X	X	X		X	X	
palustris L.	X	X	X	O	X	X	X	O	X		X		
pratensis L.	X	X	X	X	X		X	X	X	X	X	X	X
rupicola Nash. ex Rydb.	X	X										X	X
scabrella (Thurb.) Benth. ex Vasey	X	X		X			X	X					
secunda Presl.	X	X	X	X		X	X	X	X				
suksdorfii (Beal) Vasey ex Piper	O			O									O
Polypogon													
monspeliensis (L.) Desf.	X	X	X	X	X		X		X				
Puccinellia													
distans (Jacq.) Parl.	O				O		O						
lemmonii (Vasey) Scribn.	X	X					X		X		X		
nuttalliana (Schultes) A.S. Hitchc.	O				O		O						
Secale													
cereale L.	X	X							X				
Sitanion													
hystrix (Nutt.) J.G. Smith													
var. *brevifolium* (J.G. Smith) C.L. Hitchc.	X	X	X	X		X	X		X		X	X	X
jubatum J.G. Smith	X	X									X		
Sphenopholis													
obtusata (Michx.) Scribn													
var. *obtusata*				O	O		O						
Sporobolus													
cryptandrus (Torr.) Gray				X			X						

Table 1 continued.

	AREAS				HABITATS								
	N	S	W	M	1	2	3	4	5	6	7	8	9
Stipa													
californica Merr. & Burtt-Davy	X	X							X	X	X		
columbiana Macoun.	X	X									X	X	
comata Trin. & Rupr.													
var. *comata*	X	X	X	X			X	X	X		X		
nevadensis B.L. Johnson	X	X	X	X			X		X		X	X	
occidentalis Thurb. ex S. Wats.	X	X		X			X		X		X		
pinetorum M.E. Jones				O				O					
speciosa Trin. & Rupr.		X	X	X			X						
thurberiana Piper				X		X	X	X					
webberi (Thurb.) B.L. Johnson				X			X		X				
Trisetum													
spicatum (L.) Richt.													
ssp. *spicatum*	X	X		X					X		X	X	X
triflorum (Bigelow) Love & Love													
ssp. *molle* (Michx.) Love & Love	X	X											X
Vulpia													
megalura (Nutt.) Rydb.	X	X					X						
octoflora (Walt.) Rydb.													
var. *hirtella* (Piper) Henr.	X	X	X	X			X		X				
var. *octoflora*		X	X	X			X						
POLEMONIACEAE													
Allophyllum													
gilioides (Benth.) A. & V. Grant	X	X		X	X		X		X		X		
integrifolium (Brand) A. & V. Grant	O								O		O		
violaceum (Heller) A. & V. Grant	X	X	X	X		X		X		X			
Collomia													
grandiflora Dougl. ex Lindl.	X	X		X			X		X		X		
linearis Nutt.	X	X	X	X	X		X		X		X	X	X
tinctoria Kellogg	X	X	X				X		X				
Eriastrum													
sparsiflorum (Eastw.) Mason		X	X	X		X	X						
wilcoxii (A. Nels.) Mason	X	X		O			X	X	X				
Gilia													
brecciarum M.E. Jones													
ssp. *brecciarum*	X	X	X	X			X	X	X				
capillaris Kellogg	X	X			X				X	O	O	O	
inconspicua (Sm.) Sweet				O		O							
interior (Mason & A. Grant) A. Grant	O								O				
leptalea (Gray) Greene													
ssp. *leptalea*	X	X									X		
leptantha Parish													
ssp. *salticola* (Eastw.) A. & V. Grant	X	X							X				
leptomeria Gray			X	X		X	X						
malior Day & V. Grant			X	X			X						
modocensis Eastw.	X	X	X	X		X	X	X	X		X		
ophthalmoides Brand	X	X	X	X			X		X		X		
sinuata Dougl. ex Benth.				O		O		O					
Gymnosteris													
parvula (Rydb.) Heller	X	X	X	X		X	X	X	X		X	X	
Ipomopsis													
aggregata (Pursh) V. Grant													
ssp. *aggregata*	X	X							X				
ssp. *attenuata* (Gray) V. & A. Grant	X	X		X				X	X		X	X	
congesta (Hook.) V. Grant													
ssp. *montana* (A. Nels. & Kennedy) V. Grant	X										X	X	X
ssp. *palmifrons* (Brand) Day	X	X		X				X				X	X

Table 1 continued.

	AREAS				HABITATS								
	N	S	W	M	1	2	3	4	5	6	7	8	9
Leptodactylon													
pungens (Torr.) Nutt. ex Rydb.													
ssp. *pulchriflorum* (Brand) Mason	X	X	X	X		X	X	X	X		X	X	X
Linanthus													
ciliatus (Benth.) Greene													
var. *neglectus* (Greene) Jepson	X								X		X		X
nuttallii (Gray) Greene ex Milliken													
ssp. *nuttallii*	X	X		O			X	X	X		X	X	
septentrionalis Mason	X	X	X	X			X	X	X		X		
Microsteris													
gracilis (Hook.) Greene													
ssp. *gracilis*	X	X							X		O	O	O
ssp. *humilis* (Greene) V. Grant		X	X	X		X	X	X	X				
Navarretia													
breweri (Gray) Greene	X	X	X	X			X	X	X		X	X	X
divaricata (Torr. ex Gray) Greene													
var. *divaricata*	O								O				
Phlox													
caespitosa Nutt.													
ssp. *pulvinata* Wherry	X	X										X	X
covillei E. Nels.	X	X		X				X	X	O	O	X	X
diffusa Benth.													
ssp. *subcarinata* Wherry	O											O	O
ssp. *diffusa*	X	X		X				X	X		X	X	X
hoodii Richards													
ssp. *canescens* (Torr. & Gray) Wherry		X	X	O		X	X	X	X				
longifolia Nutt.	X	X	X	X		X	X	X	X				
Polemonium													
caeruleum L.													
ssp. *amygdalinum* (Wherry) Munz	X	X			X				X		X		
californicum Eastw.	O									O	O	O	
chartaceum Mason		X											X
eximium Greene	X												X
pulcherrimum Hook.	X	X										X	X
Polygalaceae													
Polygala													
intermontana Wendt				X		X	X						
subspinosa S. Wats.			X	X		X	X						
Polygonaceae													
Chorizanthe													
brevicornu Torr.													
var. *spathulata* (Rydb.) C.L. Hitchc.	X			O			X						
watsonii Torr. & Gray		X	X	X			X						
Eriogonum													
baileyi S. Wats.													
var. *baileyi*	X	X	X	X			X	X	X				
beatlleyae Reveal				O			O						
brachyantherum Coville		X				X							
caespitosum Nutt.	X	X	X	X		X	X	X	X		X		
var. *cernuum*				X		X							
elatum Dougl. ex Benth.													
var. *elatum*	X	X	X	X			X		X		X	X	
esmeraldense S. Wats.		X		O			X	O					
heermannii Dur. & Hilg.													
var. *humilius* (Stokes) Reveal		X	X	X		X	X						
hookeri S. Wats.				O			O						
incanum Torr. & Gray	X											X	X

Table 1 continued.

	AREAS				HABITATS								
	N	S	W	M	1	2	3	4	5	6	7	8	9
lobbii Torr. & Gray													
var. *lobbii*	X	X									X	X	X
maculatum Heller		X				X	X						
marifolium Torr. & Gray	X	X									X	X	X
microthecum Nutt.													
var. *laxiflorum* Hook.	X	X		X			X	X	X		X	X	X
var. *ambiguum* (M.E. Jones) Reveal	X	X	X	X		X	X		X				
nidularium Coville		X	X	X		X	X						
nudum Dougl. ex Benth.													
var. *deductum* (Greene) Jepson	X	X							X		X	X	X
nutans Torr. & Gray													
var. *nutans*				X		X		O					
ochrocephalum S. Wats.													
var. *alexandrae* Reveal in ed			X	X		X	X		X				
ovalifolium Nutt.													
var. *ovalifolium*	X	X	X	X		X	X		X		X	X	
var. *nivale* (Canby) M.E. Jones	X	X		X			X	X				X	X
var. *nevadense* Gandoger	X	X	X	X		X	X		X				
pusillum Torr. & Gray			X	X		X							
rosense A. Nels. & Kennedy	X	X		X				X			X	X	X
spergulinum Gray													
var. *reddingianum* (M.E. Jones) J.T. Howell	X	X	X	X			X	X	X		X	X	X
strictum Benth.													
ssp. *proliferum* (Torr. & Gray) Stokes				X		X		O					
umbellatum Torr.													
var. *nevadense* Gandoger	X	X										X	X
var. *umbellatum*	X	X	X	X		X	X	X	X		X	X	X
vimineum Dougl. ex Benth.		X	X	X		X		X					
wrightii Torr. ex Benth.													
var. *subscaposum* S. Wats.	X	X	X	X			X	X	X				
Oxyria													
digyna (L.) Hill	X	X		O								X	X
Oxytheca													
dendroidea Nutt.													
ssp. *dendroidea*				X		X							
Polygonum													
amphibium L.													
var. *stipulaceum* Coleman		X			X	X	X						
aviculare L.	X	X	X	X			X						
bistortoides Pursh	X	X			X				X		X	X	
douglasii Greene													
var. *douglasii*	X	X	X	X			X		X		X		
var. *johnstonii* Munz	O			O				O		O	O	O	
var. *latifolium* (Engelm.) Greene	X	X		X				X				X	X
kelloggii Greene	X	X	X	X			X	X	X		X	X	X
minimum S. Wats.	X										X	X	X
persicaria L.			X		X		X						
shastense Brewer ex Gray	X										X	X	
Rumex													
acetosella L.	X	X							X		X		
californicus Rech. f.	X	X		O			X	O	O	O	O	O	
crispus L.	X	X	X	X		X	X		X				
lacustris Greene				O	O	O	O						
occidentalis S. Wats.	O					O							
paucifolius Nutt. ex S. Wats.													
ssp. *paucifolius*	X	X		X	X			X	X		X		X
ssp. *gracilescens* (Rech. f.) Rech. f.	X	X											X
salicifolius Weinm.			X				X						
triangulivalvis (Danser) Rech. f.	X	X		X			X	X	X		X		

Table 1 continued.

	AREAS				HABITATS								
	N	S	W	M	1	2	3	4	5	6	7	8	9
PORTULACACEAE													
Calyptridium													
roseum S. Wats.	X	X	X	X		X	X						
umbellatum (Torr.) Greene	X	X		X		X	X	X	X		X	X	X
Claytonia													
nevadense S. Wats.	X	X			X							X	X
rubra (T.J. Howell) Tidestrom	X	X	X	X		X	X		X				
umbellata S. Wats.	X	X											X
Lewisia													
nevadensis (Gray) B.L. Robins.	X	X	X	X	X			X	X		X	X	X
pygmaea (Gray) B.L. Robins.													
ssp. *pygmaea*	X	X									X	X	X
rediviva Pursh													
ssp. *rediviva*		X	X	X			X	X					
ssp. *minor* (Rydb.) A. Holmgren		X	X	X			X	X					
sierrae Ferris	X			O							X	X	
triphylla (S. Wats.) B.L. Robins.	X									O	X	O	
Montia													
chamissoi (Ledeb. ex Spreng.) Greene	X	X	X	X	X		X	X	X		X		
POTAMOGETONACEAE													
Potamogeton													
gramineus L.	X	X		X	X		X	X	X				
richardsonii (Benn.) Rydb.	X				X							X	
PRIMULACEAE													
Androsace													
septentrionalis L.													
var. *subumbellata* A. Nels.	X	X										X	X
Dodecatheon													
alpinum (Gray) Greene													
ssp. *alpinum*	X	X			X						X	X	X
ssp. *majus* H.J. Thompson	X	X	X	X	X		X	X	X	X	X		
jeffreyi Van Houtte	O				O				O	O	O	O	
Primula													
suffrutescens Gray	O											O	O
RANUNCULACEAE													
Aconitum													
columbianum Nutt.	X	X		O	X			O	X		X		
Actaea													
rubra (Ait.) Willd.													
ssp. *arguta* (Nutt.) Hulten	X				X				X	X	X		
Anemone													
drummondii S. Wats.	X								O	O	X	X	X
Aquilegia													
formosa Fisch.													
var. *pauciflora* (Greene) Boothman	X	X			X		X		X		X	X	
var. *formosa*	X	X	X	X	X		X	X	X	X	X	X	
pubescens Coville	X											X	X
Caltha													
leptosepala DC.													
ssp. *howellii* (Huth) P.G. Smith	X											X	
Clematis													
ligusticifolius Nutt.													
var. *brevifolia* Nutt.	O				O				O				
Delphinium													
andersonii Gray													
ssp. *andersonii*	X	X	X	X		X	X	X	X		X		
glaucum S. Wats.	X	X			X				X	O	X	X	

Table 1 continued.

	AREAS				HABITATS								
	N	S	W	M	1	2	3	4	5	6	7	8	9
parishii Gray													
ssp. *parishii*			X	X		X	X						
polycladon Eastw.	X									X	X	X	
Myosurus													
aristatus Benth. ex Hook.	X	X	X	X	X		X	X	X				
minimus L.													
ssp. *montanus* Campbell	X	X	X	X	X		X	X					
Ranunculus													
alismifolius Geyer ex Benth.													
var. *alismellus* Gray	X	X			X			X	X	O	X	X	
andersonii Gray	O			O			O	O	O				
aquatilis L.													
var. *capillaceus* (Thuill.) DC.	X	X	X	O	X		X	O	X	O	X	X	
cymbalaria Pursh													
var. *saximontanus* Fern.	X	X	X	X	X		X	X	X	X	X		
eschscholtzii Schlecht.													
var. *eschscholtzii*	X	X			X						X	X	
var. *oxynotis* (Gray) Jepson	X	X		O							X	X	X
glaberrimus Hook.													
var. *ellipticus* Hook.		X			X			X	O	O	O		
occidentalis Torr. & Gray													
var. *ultramontanus* Greene	X	X			X				X				
testiculatus Crantz	X	X			X		X		X				
Thalictrum													
fendleri Gray													
var. *fendleri*	X	X							X	X	X	X	
sparsiflorum Turcz. ex Fisch. & Mey.													
var. *saximontanum* Boivin	X	X								X	X	X	
RHAMNACEAE													
Ceanothus													
greggii Gray													
var. *vestitus* (Greene) McMinn	X	X					X						
velutinus Dougl. ex Hook.	X	X		X			X	X	X	X	X		
Rhamnus													
rubra Greene													
ssp. *rubra*	X			O					X				
ROSACEAE													
Amelanchier													
pallida Greene	X	X	X	X			X	X	X		X		
pumila Torr. & Gray	X								X	X	X		
utahensis Koehne													
var. *covillei* (Standl.) Clokey		X					X						
var. *utahensis*	X	X	X	X		X	X	X	X				
Cercocarpus													
ledifolius Nutt. ex Torr. & Gray													
var. *ledifolius*	X	X	X	X			X	X	X		X	X	
var. *intricatus* (S. Wats.) M.E. Jones		X	X				X						
Chamaebatiaria													
millefolium (Torr.) Maxim.				X		X	X						
Fragaria													
virginiana Duchesne													
ssp. *platypetala* (Rydb.) Staudt	O				O				O	O	O	O	
Geum													
canescens (Greene) Munz	X	X			X						X	X	X
macrophyllum Willd.	X	X	X	X	X		X	X	X		X	X	

Table 1 continued.

	AREAS				HABITATS								
	N	S	W	M	1	2	3	4	5	6	7	8	9
Holodiscus													
dumosa (Nutt.) Heller													
var. *glabrescens* (Greenm.) C.L. Hitchc.	X	X	X	X			X	X	X		X	X	
Horkelia													
fusca Lindl.													
ssp. *pseudocapitata* (Rydb.) Keck	X	X		O				X	X		X		
Ivesia													
gordonii (Hook.) Torr. & Gray	X	X										X	X
lycopodioides (Hook.) Torr. & Gray													
ssp. *lycopodioides*	X	X			X							X	
ssp. *megalopetala* (Rydb.) Keck	X				X							X	
muirii Gray	O											O	O
purpurascens (S. Wats.) Keck													
ssp. *congdonis* (Rydb.) Keck	O	X							O		X		
shockleyi S. Wats.	X											X	X
Potentilla													
anserina L.													
ssp. *anserina*	X			X	X		X		X				
biennis Greene	X	X	X	X	X	X	X	X		X	X	X	
breweri S. Wats.	X	X								O	O	X	X
diversifolia Lehm.	X	X			X						O	X	X
drummondii Lehm.													
ssp. *bruceae* (Rydb.) Keck	X	X			X							X	X
ssp. *drummondii*	O				O					O	O	O	
flabellifolia Hook. ex Torr. & Gray													
var. *flabellifolia*	X	X			X					O	X	X	X
fruticosa L.													
ssp. *floribunda* (Pursh) Elkington	X			O							X	X	X
glandulosa Lindl.													
ssp. *nevadensis* (S. Wats.) Keck	X	X		X	X			X	X	X	X	X	X
gracilis Dougl. ex Hook.													
var. *glabrata* (Lehm.) C.L. Hitchc.	X	X		O	X		X	X	X		X	X	X
var. *flabelliformis* (Lehm.) Torr. & Gray		X	X		X		X						
newberryi Gray				O	O	O	O						
pectinisecta Rydb.		X	X	X	X		X						
pseudosericea Rydb.	X	X			X							X	X
Prunus													
andersonii Gray	X	X	X	X		X	X	X	X	X			
emarginata (Dougl. ex Hook.) Walp.	X	X						X	X	X	X		
virginiana L.													
var. *demissa* (Nutt.) Sarg.	X	X					X		X				
var. *melanocarpa* (A. Nels.) Sarg.				O			O						
Purshia													
tridentata (Pursh) DC.	X	X	X	X		X	X	X	X		X	X	
Rosa													
woodsii Lindl.													
var. *ultramontana* (S. Wats.) Jepson	X	X	X	X	X		X	X	X	X	X	X	
Rubus													
parviflorus Nutt.													
var. *bifarius* Fern.	X								X	X			
Sibbaldia													
procumbens L.	X	X		O	X							X	X
Sorbus													
californica Greene	X								O	O	X	X	
Spiraea													
densiflora Nutt. ex Torr. & Gray													
ssp. *densiflora*	X										X	X	X

Table 1 continued.

	AREAS				HABITATS								
	N	S	W	M	1	2	3	4	5	6	7	8	9
RUBIACEAE													
Galium													
aparine L.	X	X	X				X		X				
bifolium S. Wats.	X	X	X	X	X		X		X	X	X	X	X
hypotrichium Gray													
ssp. *ebbettsense* Dempster & Ehrend.	X											X	
ssp. *hypotrichium*	X	X		O								X	X
multiflorum Kellogg	X	X	X	X		X	X	X	X				
trifidum L.													
ssp. *pacificum* Wieg.				O			O						
ssp. *subbiflorum* (Wieg.) Puff	X				X			X					
triflorum Michx.	X				X				X				
Kelloggia													
galioides Torr.	X	X							X	X	X	X	
SALICACEAE													
Populus													
balsamifera L.													
ssp. *trichocarpa* (Torr. & Gray) Brayshaw	X	X	X		X		X		X				
fremontii S. Wats.	X	X		O	X	X	X						
tremuloides Michx.	X	X	X	X	X	X	X	X	X	X	X	X	
Salix													
arctica Pallas	X	X			X							X	X
drummondiana Barratt ex Hook.	X	X			X							X	
eastwoodiae Heller	O				O					O	O	O	
exigua Nutt.	X	X	X	X	X		X	X	X				
geyeriana Anderss.													
var. *geyeriana*		X			X								X
var. *argentea* (Bebb) Schneid.	X	X		X	X			X	X	X	X	X	
lasiandra Benth.													
var. *lasiandra*	X	X	X		X		X		X		X		
var. *caudata* (Nutt.) Sudworth	X	X			X		X		X				
lasiolepis Benth.	X	X		O	X	X	X						
lemmonii Bebb	X	X			X				X	O	X	X	
ligulifolia (Ball) Ball ex Schneid.	O				O				O		O		
lutea Nutt.	X	X		X	X		X		X	O	O		
melanopsis Nutt.	X	X	X	X	X		X		X				
myrtillifolia Anderss.													
var. *myrtillifolia*	O			X	X			X	O	O	O	O	
orestera Schneid.	X	X		O	X						X	X	X
planifolia Pursh													
var. *monica* (Bebb) Schneid.	X	X							X		X	X	X
reticulata L.													
ssp. *nivalis* (Hook.) Love, Love & Kapoor	X											X	X
scouleriana Barratt ex Hook.	X	X							X		O	O	
SAXIFRAGACEAE													
Heuchera													
duranii Bacig.	X	X	X	X			X	X	X		X	X	X
rubescens Torr.													
var. *alpicola* Jepson	X	X	X	X			X	X	X		X	X	X
Lithophragma													
glabrum Nutt.	X	X	X	X		X	X	X	X		X	X	
Mitella													
breweri Gray	X									X	X	X	
pentandra Hook.	X									X	X	X	
Parnassia													
palustris L.													
var. *californica* Gray	X	X			X		X		X		X	X	X

Table 1 continued.

	AREAS				HABITATS								
	N	S	W	M	1	2	3	4	5	6	7	8	9
Ribes													
aureum Pursh													
var. *aureum*	X	X	X	X	X			X	X	O	O		
cereum Dougl.	X	X	X	X			X	X	X		X	X	X
inebrians Lindl.	X	X	X	X			X		X		X	X	X
inerme Rydb.													
var. *inerme*	X	X	X	X	X		X	X	X	O	X		
montigenum McClatchie	X	X							X	X	X	X	X
velutinum Greene													
var. *velutinum*	X	X	X	X		X	X	X	X		X		
var. *glanduliferum* (Heller) Jepson		X	X				X	X					
viscosissimum Pursh													
var. *viscosissimum*	O						O	O	O				
Saxifraga													
aprica Greene	X				X							X	X
bryophora Gray	X				X					O	X	X	X
nidifica Greene	X				X				X	O	X	O	
odontoloma Piper	X	X			X				X		X	X	
oregana T.J. Howell													
var. *sierrae* Coville	X	X			X				X	O	X	O	
tolmiei Torr. & Gray													
var. *ledifolia* (Greene) Engl. & Irmsch.	X											X	X
SCROPHULARIACEAE													
Antirrhinum													
kingii S. Wats.				X		X							
Castilleja													
applegatei Fern.													
var. *fragilis* (Zeile) N. Homgren	X	X	X	X			X	X	X		X		
var. *pallida* (Eastwood) N. Holmgren	X										X	X	
chromosa A. Nels.	X	X	X	X		X	X	X	X				
exilis A. Nels.			X	O	X		X						
lemmonii Gray	X											X	X
linariifolia Benth. ex DC.	X	X	X	X			X	X	X		X	X	X
miniata Dougl. ex Benth.	X	X	X		X				X		X	X	
nana Eastwood	X												X
peirsonii Eastwood	X											X	
pilosa (S. Wats.) Rydb.	X	X		X				X	X		X	X	X
Collinsia													
parviflora Dougl. ex Lindl.	X	X	X	X		X	X	X	X		X		X
Cordylanthus													
helleri (Ferris) J.F. Macbride			X	X		X	X						
ramosus Nutt. ex Benth.													
ssp. *setosus* Pennell	O	X	X	X			X						
Keckiella													
breviflora (Lindl.) Straw													
ssp. *glabrisepala* (Keck) Straw	X	X					X		X				
Limosella													
aquatica L.				O	O		O						
Mimetanthe													
pilosa (Benth.) Greene			X	O	X		X						
Mimulus													
breweri (Greene) Coville	X				X				X		X	X	X
coccineus Congd.	X	X										X	X
densus A.L. Grant		X	X	X		X	X	X					
floribundus Dougl. ex Lindl.	X	X			X				X				
guttatus Fisch. ex DC.	X	X	X	X	X			X	X		X		
lewisii Pursh	O				O				O	O	O	O	
mephiticus Greene	X	X	X	X			X	X	X		X	X	X

Table 1 continued.

	AREAS				HABITATS								
	N	S	W	M	1	2	3	4	5	6	7	8	9
moschatus Dougl.	X	X			X				X				
primuloides Benth.													
var. *primuloides*	X	X		O	X		X		X		X		
rubellus Gray	X	X			X		X		X		X		
suksdorfii Gray	X	X	X	X		X	X	X	X		X	X	X
tilingii Regel	X	X	X	X	X		X		X		X	X	X
Orthocarpus													
copelandii Eastwood													
var. *cryptanthus* (Piper) Keck	X	X		X				X	X		X		
hispidus Benth.	X	X		O			X	O	X		X		
luteus Nutt.	O						O	O	O				
Pedicularis													
attollens Gray													
ssp. *attollens*	X	X			X						X	X	X
groenlandica Retz.													
ssp. *groenlandica*	X				X							X	X
semibarbata Gray													
var. *semibarbata*	X										X		
Penstemon													
bridgesii Gray	X	X	X	X			X	X	X		X	X	X
davidsonii Greene													
var. *davidsonii*	X	X										X	X
deustus Dougl. ex Lindl.													
ssp. *deustus*		X	X	X			X						
heterodoxus Gray													
var. *heterodoxus*	X	X									X	X	X
humilis Nutt. ex Gray		X	X	X			X	X					
newberryi Gray													
ssp. *newberryi*	X	X							X		X	X	X
procerus Dougl. ex Grahm.													
ssp. *formosus* (A. Nels.) Keck	X	X			X						X		X
rubicundis Keck				X			X						
rydbergii A. Nels.													
var. *varians* (A. Nels.) Cronq.	X	X		X	X		X	X	X		X		
speciosus Dougl. ex Lindl.	X	X	X	X			X	X	X		X	X	X
Scrophularia													
desertorum (Munz) R.J. Shaw	X	X	X	X			X		X		X		
Verbascum													
thapsus L.	X	X	X	X	X	X	X	X	X		X		
Veronica													
americana (Raf.) Schwein. ex Benth.	X	X		X	X		X		X				
anagallis-aquatica L.			X		O	O							
beccabunga L.	O				O	O							
peregrina L.													
ssp. *xalapensis* (H.B.K.) Pennell	X	X		O	X			O	X		X		
serpyllifolia L.													
ssp. *humifusa* (Dickson) Syme	X	X		X	X			X	X		X	X	
ssp. *serpyllifolia*		X	X	X	X		X		X				
wormskjoldii Roemer & Schultes													
ssp. *alterniflora* (Fern.) Pennell	X				X							X	X
SOLANACEAE													
Leucophysalis													
nana (Gray) Averett	X	X					X	X	X		X		
Nicotiana													
attenuata Torr. ex S. Wats.	X	X	X	X		X	X		X				
Solanum													
triflorum Nutt.				O		O	O						

Table 1 continued.

	AREAS				HABITATS								
	N	S	W	M	1	2	3	4	5	6	7	8	9
TYPHACEAE													
Typha													
latifolia L.	X	X			X		X						
URTICACEAE													
Urtica													
dioica L.													
var. *holosericea* (Nutt.) C.L. Hitchc.	X	X	X	X	X		X		X				
VALERIANACEAE													
Plectritis													
macrocera Torr. & Gray													
ssp. *grayii* (Suksdorf) Morey	X	X					X						
Valeriana													
californica Heller	X	X		O				O	X		X	X	X
VERBENACEAE													
Verbena													
bracteata Lag. & Rodr.			X			X	X						
VIOLACEAE													
Viola													
adunca Sm.													
var. *adunca*	O				O				O				
bakeri Greene													
ssp. *bakeri*	X	X						X	O	O			
beckwithii Torr. & Gray													
ssp. *beckwithii*	O					O	O						
macloskeyi Lloyd													
ssp. *macloskeyi*	X				X				X		X	X	X
nephrophylla Greene													
var. *nephrophylla*	X	X	X	X	X		X	X	X		X		
purpurea Kellogg													
ssp. *atriplicifolia* (Greene) Baker & Clausen	X	X		X			X	X	X		X		X
ssp. *aurea* (Kellogg) Clausen		X	X	X			X	X					
ZYGOPHYLLACEAE													
Tribulus													
terrestris L.		X	X				X						

AGROPYRON ARIZONICUM (GRAMINEAE: TRITICEAE) AND A NATURAL HYBRID FROM ARIZONA

Grant L. Pyrah[1]

ABSTRACT.— The new hybrid X *Agrositanion pinalenoensis* (Gramineae: Tribe Triticeae) is found in disturbed, forested areas of higher elevations in southern Arizona. In the Pinaleno Mountains where logging has been heavy, numerous disturbed habitats have permitted frequent hybrid populations to persist. Intermediate phenotype, chromosome behavior, lack of seed set, and pollen sterility were used to interpret the status of this hybrid derivative. Introgression and/or segregation are not apparent.

Of the many natural and experimental intergeneric hybrids reported in the Triticeae, none have been reported between *Agropyron arizonicum* Scribner & Smith and *Sitanion hystrix* var. *brevifolium* (J. G. Smith) C. L. Hitchcock. The present paper describes extensive hybridizations between these two taxa.

Agropyron arizonicum has flat leaves, distinct flexuous spikes, one spikelet per node, and more or less ascending awns (although they are somewhat divergent at maturity). *Sitanion hystrix* has long been recognized as an extremely variable species; however, erect spikes, very long awns on the glumes and lemmas, and 2 spikelets per rachis node are typical. The variation in Arizona has been treated by Wilson (1963) as *S. longifolium.*

Although *Sitanion hystrix* has very extensive distribution in western North America, it is limited to higher elevations of isolated mountain ranges in the southwestern United States and northern Mexico. On these isolated mountain ranges, the range of this species frequently overlaps that of *Agropyron arizonicum*, a species of high elevations restricted to west Texas, southwestern New Mexico, and southeastern Arizona (Fig. 1). In the Pinaleno Mountains, Graham Co., Arizona, and the Santa Catalina Mountains, Pima Co., Arizona (Fig. 2), where extensive areas have been disturbed by logging (Fig. 3), recreation, summer home development, and road building, numerous hybrids between *Agropyron arizonicum* and *Sitanion hystrix* var. *brevifolium* are formed. Eleven hybrid

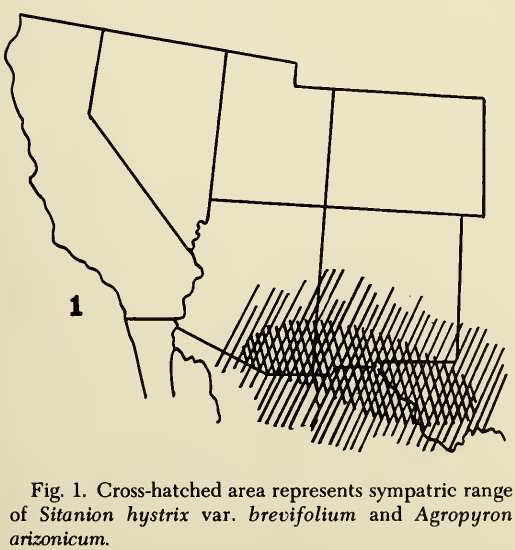


Fig. 1. Cross-hatched area represents sympatric range of *Sitanion hystrix* var. *brevifolium* and *Agropyron arizonicum.*

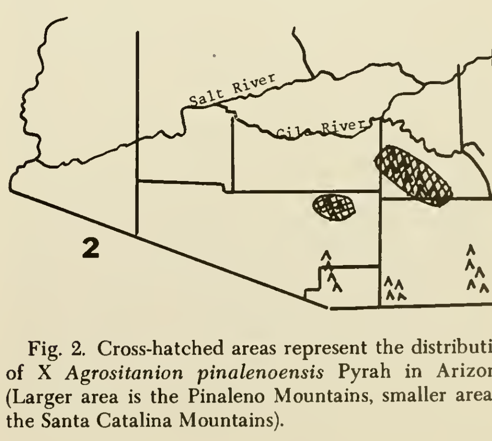


Fig. 2. Cross-hatched areas represent the distribution of X *Agrositanion pinalenoensis* Pyrah in Arizona. (Larger area is the Pinaleno Mountains, smaller area is the Santa Catalina Mountains).

[1]Southwest Missouri State University, Springfield, Missouri 65802.

Fig. 3. Typical disturbed forest with dense stands of *Agropyron arizonicum* and *Sitanion hystrix* var. *brevifolium*.

populations were found and studied in the Pinaleno Mountains at elevations generally between 7000 and 10,000 ft.

Materials and Methods

Eleven hybrid populations in the Pinaleno Mountains and two hybrid populations from the Santa Catalina Mountains were studied. Prepared herbarium specimens from each are deposited in the Southwest Missouri State University herbarium. Five additional mature inflorescences were obtained from each hybrid and four parent specimens from the High Peak population. These were put in envelopes and used for comparative measurements of length of glume, lemma, awn, and rachis joint, and also determination of the number of spikelets per rachis node.

A few late-flowering inflorescences were fixed in a solution of one part glacial acetic acid to three parts absolute ethyl alcohol. These were stored in 70 percent ethyl alcohol and used for cytological studies.

Pollen grains were obtained from mature spikes and viewed with the scanning electron microscope to determine viability. Soil pH was determined by sampling five sites each for parental species and the hybrid. The soil sample was carefully obtained by taking soil from the entire soil profile of 0 to 5 inches and mixed. A soil-water slurry was prepared and the pH determined by a standard pH meter.

In an attempt to assess the pollen parent and the seed parent and hybrid success, a large population near High Peak was studied in the following way. A circular area 6 m in diameter was marked around each of 25 hybrids. The number of specimens of each parental species as well as other hybrids within this circle were recorded.

Results and Discussion

Pure stands of *Sitanion* typically grow in rather open, unshaded, shallow soil, with topsoil and litter depths from 1 to 3 inches and clay with scattered rock constituting the remaining root zone. Soil pH range is 5.4 to 5.8. *Agropyron arizonicum* grows in richer soils, with the topsoil and litter occupying the upper 10 inches and only a limited amount of clay and rock toward the bottom of the root zone. Soil pH range is 5.9 to 6.4. Characteristically, this species is more vigorous in partially shaded areas, but it also grows in open sun. Nearly all combinations of the above soil conditions and other habitat requirements have been created by logging and road building, resulting in numerous disturbed habitats, as well as habitats for each parental species in very close proximity. In many of these situations, plants of both species either touch each other or are within only a few inches. Since flowering occurs over the same time period, this allows for showers of pollen to accomplish hybridization. In nearly all these situations hybrids are found.

The frequency of hybridization between these species is difficult to assess, since a mature hybrid plant is the only indication that hybrid pollination occurred. A circular area (6 m in diameter) around each of 25 hybrids near High Peak was examined and the number of associated parental and hybrid plants was counted (Table 1). It is suggestive from the columns opposite hybrids 8, 9, 10, 11, and 13 that hybrid success is dependent upon the density and proximity of both parents. Although this may appear to be obvious, there are situations in some dicots in which hybridization is abundant but one parent is rare (Stutz 1964, Pyrah 1965). A series of artificial hybridizations would be necessary to determine whether or not *Agropyron* or *Sitanion* is more important as the seed or pollen parent of the natural hybrids.

Hybrid plants are readily recognized because of their robust size and slightly nodding spikes (Fig. 4), and most are growing in disturbed habitats (Fig. 3). Soil pH ranges from 5.7 to 6.5. Of the 11 populations studied, nearly every hybrid specimen fell within an intermediate range in morphological features and fragility of the rachis. A diagramatic illustration (Fig. 5) of *Sitanion hystrix* var. *brevifolium* and *Agropyron arizonicum* with their putative hybrids shows average lengths of the glume, lemma, awn, and rachis joint

Table 1. Comparison of the number of parental and hybrid plants within an area (6 meters in diameter) around 25 hybrids in a population near High Peak (see text).

Hybrid No.	*Sitanion*	*Agropyron*	Hybrids
1	8	0	0
2	15	0	0
3	14	0	2
4	15	0	2
5	10	7	0
6	20	4	1
7	20	1	1
8	8	8	5
9	8	8	5
10	8	8	5
11	7	9	5
12	5	2	1
13	6	6	5
14	15	1	0
16	15	0	1
17	15	0	1
18	20	0	0
19	9	1	1
20	15	0	1
21	13	0	0
22	1	2	0
23	5	0	1
24	5	0	1
25	8	3	0

Fig. 4. Spikes of *Sitanion hystrix* var. *brevifolium* (left), hybrid (center), and *Agropyron arizonicum* (right).

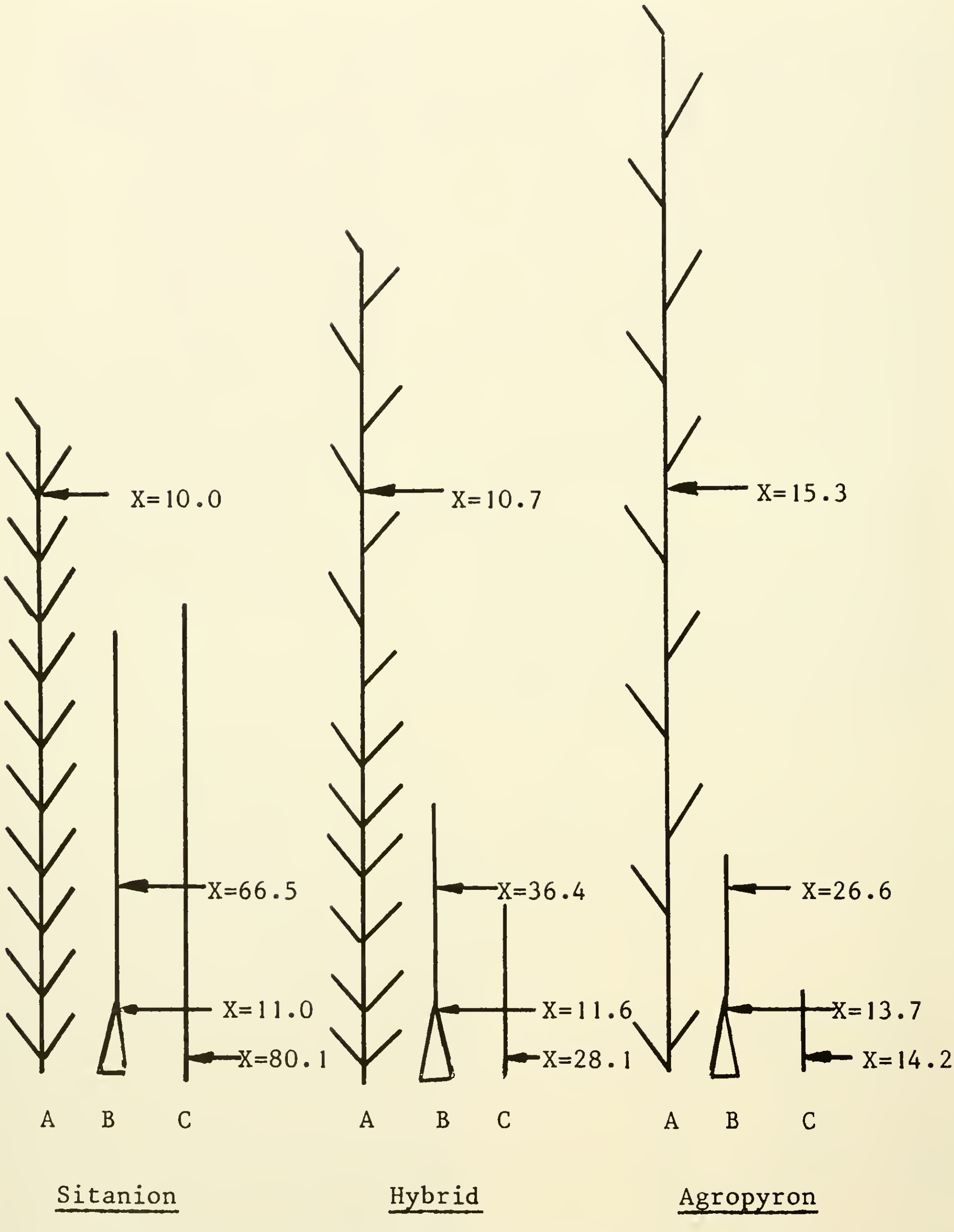


Fig. 5. Schematic representation of some spike and spikelet characters of S. *hystrix* var. *brevifolium*, *A. arizonicum*, and their natural hybrid. Measurements used in this figure are means ($\bar{X}$) from one population. A = Spike; center line between oblique lines (spikelets) represent the rachis joint. B = Lemma (triangle) with attached awn. C = Glume.

and the number of spikelet pairs per spike. Measurements were derived from a population near High Peak consisting of 25 hybrids and 4 parental specimens (Table 2). Field observation and examination of numerous herbarium specimens reveal clearly that the 2 parents are rather uniform with regard to the characters used and that where variation exists the range does not overlap that of the hybrid.

TABLE 2. Summary of measurements of spike characters used from one population to distinguish *Agropyron arizonicum*, *Sitanion hystrix* var. *brevifolium*, and their natural hybrid.

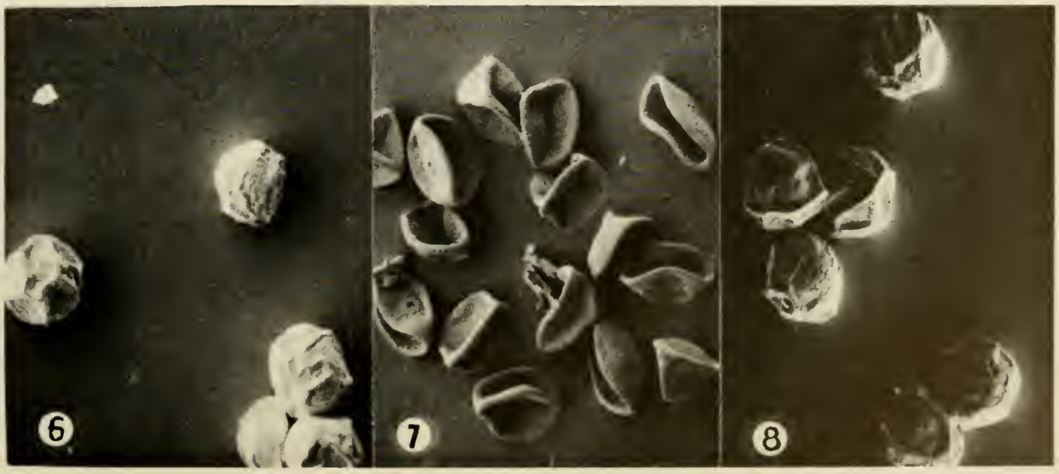
		No. nodes per spike	No. single spikelets	No. double spikelets	Glume length	Lemma awn length	Lemma length	Rachis joint length
Agropyron	X̄	11.900	11.600	0.300	14.156	26.588	13.739	15.349
	N	40.000	40.000	40.000	109.000	119.000	119.000	109.000
	S^2	2.329	2.318	0.648	2.290	4.758	9.122	3.059
	X̄SE	0.368	0.367	0.103	0.219	0.436	0.836	0.293
Sitanion	X̄	10.900	1.900	9.000	80.091	66.505	11.037	10.020
	N	40.000	40.000	40.000	99.000	109.000	109.000	99.000
	S^2	1.236	0.709	1.013	11.639	8.759	0.849	2.162
	X̄SE	0.195	0.112	0.160	1.170	0.839	0.081	0.217
Hybrid	X̄	13.360	8.730	4.630	28.071	36.372	11.609	10.737
	N	400.000	400.000	400.000	1236.000	1336.000	1336.000	1236.000
	S^2	2.380	2.888	2.733	4.741	7.441	1.220	1.969
	X̄SE	0.119	0.144	0.137	0.135	0.204	0.033	0.056

The hybrid did not set seed and no viable pollen was produced because the pollen grains were collapsed and empty (compare Figs. 6, 7, and 8). Preliminary cytological examination of one hybrid showed 14 bivalents at metaphase; however, some bivalents show irregular pairing of chromosome segments that could cause cryptic structural hybridity (Fig. 9; arrows indicate conspicuous asynaptic and synaptic pairing within two bivalents). Morphology of spike characters was generally intermediate. These evidences strongly suggest that the plants studied are first generation hybrids and that little or no introgression occurs. These hybrid plants conform to the generic description of X *Agrositanion* as reported by Bowden (1967).

DESCRIPTIONS OF THE HYBRIDS

X *Agrositanion pinalenoensis* Pyrah, Hyb. nov. (*Agropyron arizonicum* Scribner & Smith X *Sitanion hystrix* var. *brevifolium* (J. G. Smith) C. L. Hitchcock).

Hybrida sterilis, inter *Sitanion hystrix* var. *brevifolium* et *Agropyron arizonicum* probabiliter sed differt ab utroque spica moderate nutanti et inferioribus sex nodis spicae cum binatis vel binatis singulisque spiculis et superioribus nodis spicae cum singulus spiculus; differt a prima articulis rhachis et lemmatibus longioribus et glumis et aristis lemmatum brevioribus; differt a secunda articulis rhachis et lemmatibus brevioribus et glumis et aristis lemmatum longioribus.



Figs. 6, 7, and 8. Electron micrographs (SEM) of pollen from *Sitanion hystrix* var. *brevifolium* (Fig. 6), hybrid (Fig. 7), and *Agropyron arizonicum* (Fig. 8). ca 600X.

Fig. 9. Meiotic metaphase I of hybrid. Arrows indicate two pairs of chromosomes with synaptic and asynaptic regions.

Sterile hybrids differing from both parents by having moderately nodding spikes and usually having the lower 6 to 8 spike nodes with paired spikelets or a combination of paired and single spikelets and only single spikelets at the upper nodes; differing from *Sitanion* by having longer rachis joints and lemmas but shorter glumes and lemma awns; differing from *Agropyron* by having shorter rachis joints and lemmas but longer glumes and lemma awns.

TYPE.— Open grassy meadows of disturbed forests along State Rt. 366 near mile marker 141 on Mt. Graham, Pinaleno Mountains, Graham Co., Arizona, 13 Aug. 1975, Grant L. Pyrah 3051 (SMS).

DISCUSSION

The classification of genera, species, and hybrids in the Triticeae is still open to question. Many taxonomists question the validity of recognizing all the genera now published, although Gould (1947) and Church (1967) are two of only a few who have initiated some consolidation. Widespread hybridization, similar chromosome behavior, and several variable spike characteristics were the primary bases for consolidating *Sitanion, Agropyron,* and *Hystrix* with *Elymus.* Hitchcock et al. (1969) defend the retention of established separate generic names for this agronomically important tribe, primarily on the basis of practicality. *Agropyron arizonicum* is probably closely allied to *A. spicatum* and there are still conflicts about the variation found in *Sitanion hystrix.* Wilson (1963) treats the plants of this region as *Sitanion longifolium,* but Hitchcock et al. (1969) prefer *S. hystrix* var. *brevifolium.*

Confusion is now arising in the literature for numerous named hybrids because of the lack of agreement as to the generic status of each of the parents involved. If a consolidation of genera were accepted, hybrids would bear the appropriate specific designation within the genus *Elymus.* However, Bowden (1967) recognized the classical treatment of this tribe and made appropriate nomenclatural designations for intergeneric hybrids in conformity with the International Code of Botanical Nomenclature. Hybrid naming in this case had resulted in such generic combinations as *Agroelymus, Agrohordeum, Agrositanion, Elyhordeum,* and *Sitordeum.* I have chosen to use the classification of Bowden and to create the binomial X *Agrositanion pinalenoensis* Pyrah.

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SPECIES COMPOSITION, DISTRIBUTION, AND PHYTOSOCIOLOGY OF KALSOW PRAIRIE, A MESIC TALL-GRASS PRAIRIE IN IOWA

Jack D. Brotherson[1]

Abstract.— Species composition, distribution, and phytosociology of an 8 hectare area of tall grass prairie was intensively studied. Elevation and soils data were correlated with species distribution patterns. All species showed a response. Nine general patterns of distribution were observed in relation to elevation and soil types. Ordination and interspecific association analyses were used to identify clusters or groups of species having similar ecological amplitudes. *Sporobolis heterolepis* is the dominant plant of the upland prairie. The vegetation of the prairie is best described and represented by the continuum concepts of phytosociology.

A government survey started in March 1832, when Iowa was still a territory, and completed in August 1859 first documented the original extent of Iowa's prairie. The survey indicated that in the 1850s grassland covered about 85 percent of Iowa (U.S. Government 1868, Hayden 1945, Hewes 1950, and Dick-Peddie 1955). Today there are only a few tracts of this once vast Iowa prairie remaining.

Provision for state-owned prairies was made in 1933 when the Iowa State Conservation Commission prepared a report known as the Iowa Twenty-five Year Conservation Plan. This plan led to the purchase of several prairies that are now owned by state agencies. The prairies were purchased and set aside as natural areas with the intent that the various typical landscapes, wild flowers, and wild life of the native tall-grass prairie region be preserved for posterity. It was also intended that these areas would be useful as game and wild life sanctuaries; as examples of the native prairie soil types, where comparisons could be made with cultivated soils of the same soil association; and as reserves of prairie where scientific investigations could be made on problems concerning the native vegetations, floras, and faunas of the various topographic, climatic, and prairie districts throughout Iowa. Therefore, they were meant to serve as a reference point by which future generations could compare the influences of man on Iowa since settlement (Hayden 1946, Moyer 1953, Aiiman 1959, Landers 1966).

Kalsow Prairie, 64.8 ha (160 acres) of unplowed grassland in Pocahontas County, Iowa, is one such area. Criteria for its purchase dictated that this area satisfy the requirements of a game preserve, contain one or more soil types of an association, and include several regional vegetation types (Hayden 1946). Since its purchase in 1949 it has been the object of several studies on the nature and description of its vegetation, soils, management, insects, response to fire, mammals, and nematodes (Moyer 1953, Ehrenreich 1957, Esau 1968, Richards 1969, Brennan 1969, Norton and Ponchillia 1968, Schmitt 1969).

The characteristics of Iowa prairie in terms of vegetation types, structure, and general ecology of the dominant species was the subject of several papers during the 1930s and 1940s (Steiger 1930, Rydberg 1931, Weaver and Fitzpatrick 1934, Hayden 1943). These authors recognized the existence of six major types of grassland or vegetative communities and generally concluded that water relations, as affected by climate, soil, and topography, are responsible for local variations in the structure and distribution of Iowa prairie vegetation. Weaver and Fitzpatrick (1934) state:

> In varying the water relations of soil and air they merely bring about changes in the groupings of the dominant grasses and accompanying segregations and rearrangements of the forbs.

[1]Department of Botany and Range Science, Brigham Young University, Provo, Utah 84602.

The major grassland types, as alluded to in the above studies, were labeled "Consociations" after Weaver and Clements (1938) and were designated as follows:

1. Big Bluestem type (*Andropogon gerardi*)—found on the lower moist slopes and well-aerated lowlands.
2. Slough Grass type (*Spartina pectinata*)—found on poorly aerated and wet soils of sloughs and natural drainage systems.
3. Tall Panic Grass-Wildrye type (*Panicum virgatum* and *Elymus canadensis*)—found to occur on soils intermediate between Slough Grass and Big Bluestem types.
4. Little Bluestem type (*Schizachyrium scoparius*)—most important upland type (well-drained soils).
5. Needle Grass type (*Stipa spartea*)—found on the uplands, often occurring as a narrow zone following the shoulders of the ridges.
6. Prairie Dropseed type (*Sporobolus heterolepis*)—found locally on the dryest upland sites.

Moyer (1953), Aikman and Thorne (1956), Ehrenreich (1957), and Kennedy (1969) in recent studies present ecological and taxonomic descriptions of four state-owned native prairie tracts. All accounts contain extensive reviews of prairie literature. The vegetation complex as treated in these studies is limited basically to upland prairie. The studies also include information on soils, microclimate, topography, and management. Aikman (1959) reviewed in some detail the state of prairie research in Iowa.

Investigations involving the distribution of individual species within the prairie association began with the work of Shimek (1911, 1915, 1925). Weaver (1930) and Weaver and Fitzpatrick (1932) discuss the role of the major grasses and forbs within the community. Steiger (1930) and Cain and Evans (1952) mapped the spatial distributions of several species. They conclude that the principal factors affecting the local distribution patterns of prairie species are as follows: (1) microclimatic conditions, (2) edaphic variations, (3) the biology of the species concerned, particularly methods of reproduction and dispersal, (4) the relations of the species and other organisms, animal as well as plant, occurring in the community, and (5) the element of chance in the dispersal and establishment of new individuals. Local distribution patterns of species have been of interest to many ecologists (Curtie 1955, Kenshaw 1964, Sanders 1969).

Species in general show varying degrees of aggregation or association due to exhibited preferences for or tolerances of certain environmental conditions. The distributional patterns and interactions of the component species of a community express its phytosociological structure. Studies of grassland phytosociology have been concerned with either classification or ordination of basic species groups (Crawford and Wishart 1968).

This investigation was undertaken to provide information on the phytosociology of an 8 ha tract of Kalsow prairie in relation to edaphic and topographic variation. It includes information on species composition and distribution, factors affecting the distributional patterns of these species, community types, and interrelationships within and between these communities.

Materials and Methods

Study Site

Kalsow Prairie is one of several state-owned Iowa prairies. It is 5 miles northwest of Manson, Iowa, and comprises the NE ¼ of Section 36, Belleville Township, T 90N, R 32W, Pocahontas County. It occurs in a part of northcentral Iowa that was glaciated during the most recent advances of the Wisconsin Glacier and within the Clarion-Nicollet-Webster soil association area (Ruhe 1969). The area was chosen for study on the basis of its vegetational composition (i.e., floristic richness and the presence of several plant community types).

The Vegetation

Taxonomy

Voucher specimens from the prairie were collected in duplicate throughout the growing seasons. All specimens were identified, and identical sets have been deposited in the herbaria of Iowa State University, Ames, Iowa, and Brigham Young University, Provo, Utah. Nomenclature follows Pohl (1966) for the grasses, Gilly (1946) for the sedges, and Gleason (1952) for the forbs.

Community Types

The 8 ha tract within Kalsow Prairie is adjacent to the south boundary of Kalsow Prairie and contains within its borders two vegetation types or subcommunities. These vegetation units were identified and delimited as follows (Fig. 1):

1. Upland prairie—includes a major portion of the study area on the ridges and adjacent lower slopes.
2. Potholes and drainage—found in the swales and lowlands of the study site.

The vegetation of these community types was analyzed using two separate approaches. The first involved the identification and listing of all species found within their boundaries. The second utilized random plots to determine percent cover, composition, and

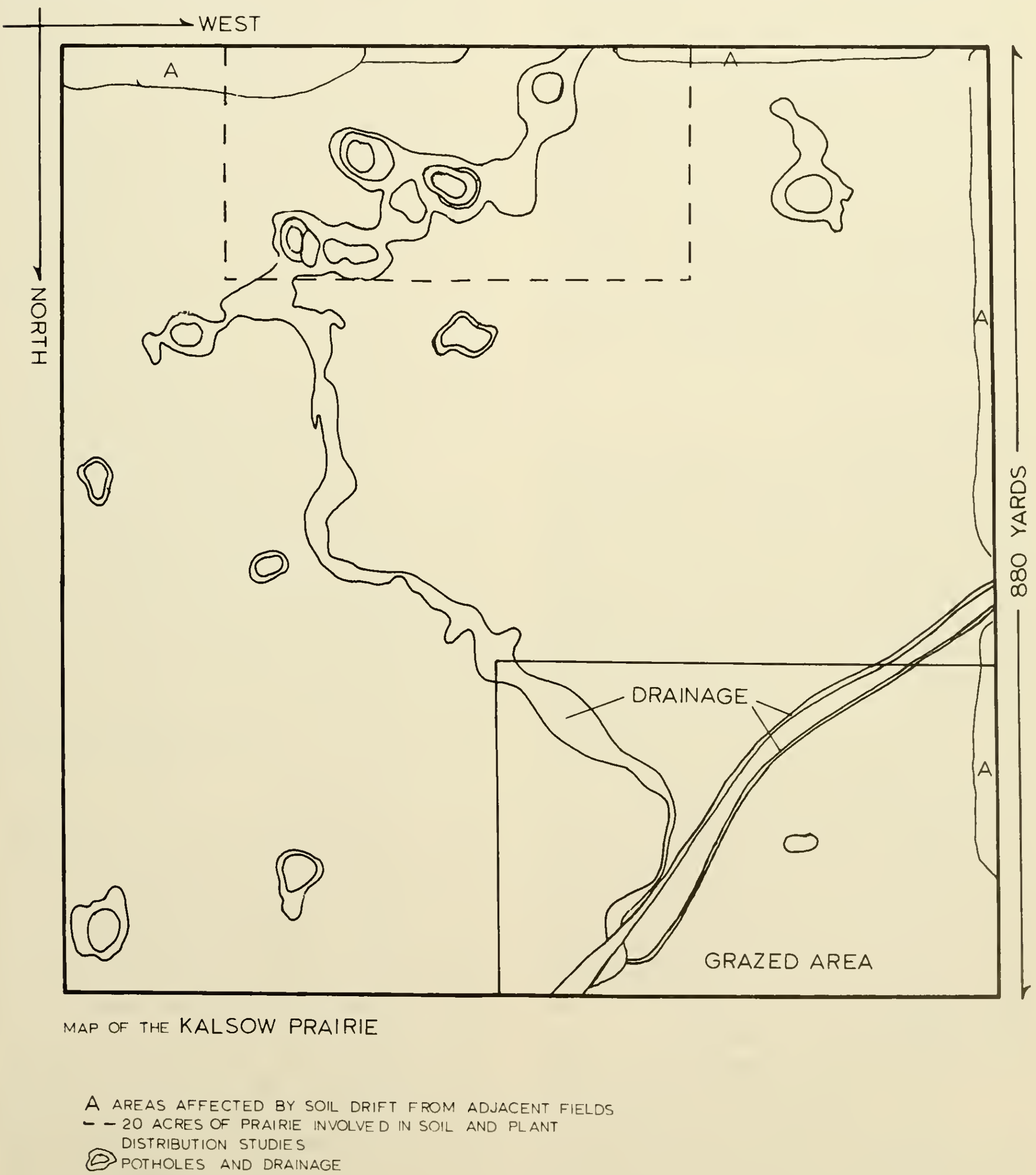

Fig. 1. Map of Kalsow Prairie.

interspecific relationships of species within these subcommunities.

Quadrat Analysis

The vegetation of each area was sampled by using 20 × 50 cm (1000 cm^2) quadrats. The quadrats were located on a restricted basis to reduce bias and to keep adjacent quadrats equal distances apart. Sampling was done between August 1 and September 15, when most species had reached their maximum growth. Cover estimates were made for each quadrat through use of Daubenmire's (1959) method.

Coverage was determined separately for all species overlapping the plot regardless of where the individuals were rooted. Coverage was projected to include the perimeter of overlap of each species regardless of superimposed canopies of other species. The canopies of different species are commonly interlaced or superimposed over the same area; therefore coverage percents often total greater than 100 percent.

Community Analysis

Plant distribution and topographic studies. An 8 ha (20 acres) plot of prairie (Figure 1) containing a large segment of potholes and drainage was selected and staked off in a 9 × 9 m grid. Each 27 square-meter block was then surveyed and a presence list compiled for all plant species found within the area. A total of 968 blocks was thus surveyed, and distribution data were tabulated for 160 species. Topographic readings were taken at 968 points and recorded in tenths of feet on the same 8 ha grid. Points were located at the corners of the 27 square meter plots.

Soil mapping. Soils were mapped on the 8 ha intensive study area. Mapping was done in cooperation with the Iowa State University Soils Survey under the supervision of Dr. Thomas E. Fenton, with Mr. J. Herbert Huddleston doing the actual mapping in the field. The mapping criteria for decisions on soil series delineation were as follows:

A Clarion—typical well-drained soil on convex ridges. Surface color 10YR 2/2–3/2; subsoil color 10YR 4'3–5'4.

A⁻ Clarion-Nicollet—an intergrade with respect to drainage as interpreted from the color profile. Surface is still 10YR 2/2–3/3, but the subsoil colors are duller, not exceeding /3 chroma. Profile is not mottled as in Nicollet.

N Nicollet—typical Nicollet, 10YR 2⅛–2/2 surface color, /2 chromas in the subsoil, which is mottled. Depth to carbonates generally greater than 30 inches.

Na Calcareous Nicollet—as above, but calcareous at some depth less than 30 inches.

W Webster—typical Webster with black (N2/–10YR 2/1) surface colors and gray (10YR 4/1–4/2–5/2) subsoil colors. Depth to gray subsoil ranges from 23/41 inches, but is commonly 30–35 inches. Carbonates occur at some depth below 22 inches, but the usual range in depth to carbonates is 22–36 inches. Some soils identified as Webster are noncalcareous in the entire probe depth (42 inches).

Wh Heavy Webster—typical colors of Webster but heavier textures, stronger development in the B and a lack of carbonates in 42 inches. In many places spots of Wh are included in the regular Webster mapping unit. On the other hand, some areas identified as regular Webster but noncalcareous to 36 inches or more might better have been called heavy Webster. The Webster soils, as mapped, include a rather broad range of texture and depths to carbonates, which could be more precisely subdivided only with further investigations.

N⁻ Webster-Nicollet—an intergrade whose surface color and friability is like Nicollet but whose subsoil is darker or grayer than true Nicollet. The soil is drier than Webster.

Na⁻ Calcareous Webster-Nicollet—as above but calcareous somewhere above 22 inches.

H Harps—typical Harps, a loamy, weakly developed soil that effervesces strongly to violently from the surface downward. Calcium carbonate equivalent probably in the range 20–40 percent.

C Canisteo—this is essentially calcareous Webster. As mapped, it may be noncalcareous in the surface, but carbonates must be detected somewhere in the 0–15 inch layer. It has lower calcium carbonate equivalent, heavier textures, and stronger development than Harps.

H⁻ Harps-Canisteo—an intergrade that has either Harps-like characteristics in the surface and becomes more Canisteo-like with depth or Canisteo-like surface characteristics and a Harps-like subsoil.

Wa Webster-Canisteo—an intergrade in which carbonates are first detected in the 15–22 inch layer. All other characteristics of Wa, W, and C are essentially the same.

C⁻ Inverted Canisteo-Heavy Webster—this represents a rather peculiar condition that tends to occur as a narrow band around the potholes. The surface is moderately to strongly calcareous, but carbonates decrease with depth to a noncalcareous, heavy, well-developed subsoil like that of heavy Webster.

G Glenco—a poorly drained soil that occupies small potholes, the outer portions of large potholes, or connecting drainage-ways. It has a black, highly organic surface but a gray, mineral, heavy, well-developed subsoil. In many respects it is similar to heavy Webster except for the organic surface and lack of grit and pebbles. Depth to carbonate is generally greater than 42 inches, but may be up to 36 inches.

Ga Calcareous Glenco—Glenco that becomes calcareous above 36 inches. It usually lacks the heavy textures and good development of regular Glenco as well.

O Okoboji—a black, mucky silt loam, very weakly developed soil occurring in the deepest areas of the potholes.

GO Glenco-Okoboji—an intergrade that may have the heavy textures of Glenco, but is darker, more organic, less well developed, and wetter than Glenco.

Seventeen soil series were recognized and mapped in the field, utilizing soil samples obtained with a 42-inch hand probe.

Data Analysis

General descriptive data. Data collected from quadrat studies, mapping studies, soil studies, and topographic studies were used to describe generally the vegetation. Frequency values and average cover values were determined for all species in every stand.

Ordination analysis. An ordination technique proposed by Orloci (1966) was employed to ordinate vegetation units within the different subcommunities listed above. Through this technique the entities to be ordinated (i.e., plant species or stands of vegetation) are projected as points into n-dimensional space. Such points are positioned by attribute scores through the application of the R and Q techniques of factor analysis. Once established, this multidimensional array of points is then reduced to a three dimensional system. This is accomplished by selecting the two most different stands or species and placing one at zero and the other at some distance along the abscissa. All other stands or species under consideration are then positioned linearly in relationship to these two extremes. This action thus establishes the X-axis. The above process is repeated until all points have been established in three dimensional space (i.e., Y and Z axes have been added). Coordinate values for the X, Y, and Z axes are given as output from the computer.

Interspecific association analysis. Expressions of interspecific association were attempted utilizing Cole's Index (1949). Step one in the computation of the index involves the accumulation of 2 × 2 contingency tables. Actual calculation of the index involves the following three sets of formulas:

when ad ≧ bc:

$$C_7 \pm {}_c = \frac{ad - bc}{(a + b)(b + d)} \quad \frac{(a + c)(c + d)}{n(a + b)(b + c)}$$

when bc > ad and d ≧ a:

$$C_7 \pm {}_c = \frac{ad - bc}{(a + b)(a + c)} \quad \frac{(b + d)(c + d)}{n(a + b)(a + c)}$$

when bc > ad and a > d:

$$C_7 \pm \sigma_c = \frac{ad - bc}{(b + d)(c + d)} \frac{(a + b)(a + c)}{n(b + d)(c + d)}$$

where C_7 = Cole's Index of Interspecific Association

σ_c = standard deviation Cole's Index

n = total number of samples

and a, b, c, and d represent the four cells of the 2 × 2 contingency table.

Tests of statistical significance were performed by means of the Chi-square test. The chi-squares were computed by the formula:

$$X^2 = \frac{(ad - bc)^2 n}{(a + b)(a + c)(c + d)(b + d)}$$

where X^2 = Chi-square value

n = number of samples

and a, b, c, and d represent the different cells of the 2 × 2 contingency table.

In all cases a single degree of freedom was used. Chi-square values greater than 3.84 were considered to be significant at the 5 percent level, and values greater than 6.63 were considered to be significant at the 1 percent level.

Data representation. Graphic representation of data obtained from topographic studies and from ordination analysis was drawn by the computer. Such representation was accomplished through the use of a plotting technique developed and programmed by Mr. Howard Jesperson, Agricultural Experimental Station, Iowa State University.

Results and Discussion

Species composition

Information on species sampled in the upland regions of Kalsow Prairie is presented in Table 1. Cover, composition (i.e., based on cover), and frequency values of *Sporobolus heterolepis, Andropogon gerardi, Poa pratensis,* and *Panicum leibergii* indicate these are the dominant grasses of the upland sites. Important or subdominant forbs include *Solidago canadensis, Solidago rigida, Helianthus grosseserratus, Amorpha canescens, Aster ericoides, Desmodium canadense, Zizia aurea, Helianthus laetiflorus, Aster laevis, Ratibida pinnata, Ceanothus americanus,* and *Rosa suffulta.*

Average cover values (Table 1) ranged from a high of 25.4 for *Sporobolus heterolepis* to a low of 0.01 for several species. Percentage frequency values, on the other hand, ranged from 73.1 for *Andropogon gerardi* to 0.1 for many species. No tests of correlation were made between average cover values and percentage frequency, but those species showing the highest cover values generally showed correspondingly higher percentage frequency values.

Since *Sporobolus heterolepis* is the dominant plant of the upland sites, Kalsow Prairie is placed within the "Consociation" designated by Weaver and Fitzpatrick (1934) as the Prairie Dropseed type (*Sporobolus heterolepis*). Weaver and Fitzpatrick (1934) described this particular consociation as being the least extensive and least important tall-grass subcommunity. It was found to occupy drier upland sites and included the two subcominants *Stipa spartea* and *Schizachyrium scoparius.* Although these two species were present (Table 1), they were not found in sufficient quantity to be labeled subdominants. The important grass species found with *Sporobolus heterolepis* in this study (i.e., *Andropogon gerardi, Poa pratensis,* and *Panicum leibergii*) suggest that the present-day upland regions of Kalsow Prairie are vegetatively distinct from the Prairie Dropseed Consociation of similar areas described earlier by Weaver. Both the species and their characteristics suggest that this difference is due either to change in the original vegetation, to differences in community characteristics, or to variations in the more recently glaciated land. *Poa pratensis,* for example, is an introduced species whose characteristics are such that it is able to compete well within the environment of prairie protected from fire and, under conditions of grazing, mowing, and other disturbance, is known to increase in importance (Weaver 1954). *Andropogon gerardi,* on the other hand, is a native grass described by Weaver and Fitzpatrick (1934) as the dominant of the most extensive tall-grass consociation that occupied the lowlands and lower moist slopes of the tall-grass prairie region.

Historical information, as well as evidence obtained in this study, indicates that much of the Kalsow Prairie has been subjected to

TABLE 1. Cover, composition, and frequency percentages for species sampled on upland prairie sites.

Species	Cover (%)	Composition (%)	Frequency (%)	Frequency[a] (%)
Sporobolus heterolepis	25.42	27.81	66.7	85.0
Andropogon gerardi	15.93	17.43	73.1	87.5
Poa pratensis	12.36	13.52	54.5	90.0
Solidago canadensis	4.12	4.51	38.9	15.0
Solidago rigida	2.57	2.81	19.4	5.0
Panicum leibergii	2.56	2.80	34.0	12.5
Helianthus grosseserratus	2.30	2.52	31.6	10.0
Amorpha canescens	2.08	2.28	15.0	27.5
Aster ericoides	1.99	2.19	40.7	37.5
Desmodium canadense	1.66	1.82	23.0	5.0
Zizia aurea	1.62	1.77	36.1	67.5
Helianthus laetiflorus	1.49	1.63	11.4	7.5
Aster laevis	1.30	1.42	16.9	7.5
Ratibida pinnata	1.26	1.39	20.6	10.0
Ceanothus americanus	1.15	1.26	.9	2.5
Rosa suffulta	1.07	1.17	18.4	45.0
Lysimachia hybrida	.84	.92	.7	5.0
Convolvulus sepium	.76	.83	1.2	2.5
Silphium laciniatum	.72	.79	12.4	15.0
Achillea lanulosa	.68	.74	11.7	45.0
Galium obtusum	.65	.71	29.1	5.0
Spartina pectinata	.60	.66	10.3	17.5
Artemisia ludoviciana	.59	.65	4.4	2.5
Comandra umbellata	.59	.65	9.1	45.0
Schizachyrium scoparius	.52	.57	1.7	85.0
Fragaria virginiana	.52	.57	20.7	7.5
Physalis heterophylla	.47	.51	2.1	
Elymus canadensis	.45	.49	19.4	12.5
Stipa spartea	.45	.49	6.6	20.0
Aster simplex	.43	.47	13.1	
Muhlenbergia racemosa	.37	.40	11.2	
Panicum virgatum	.36	.39	12.1	75.0
Senecio pauperculus	.36	.39	9.3	
Lithospermum canescens	.35	.38	13.0	17.5
Heliopsis helianthoides	.31	.34	5.8	17.5
Psoralea argophylla	.29	.32	3.8	5.0
Solidago missouriensis	.28	.31	2.7	5.0
Apocynum sibiric...	.27	.30	3.3	
Asclepias tuberosa	.26	.28	3.5	2.5
Setaria viridis	.23	.25	.7	
Cirsium altissimum	.23	.25	4.6	17.5
Sorghastrum nutans	.21	.23	5.4	42.5
Liatris pycnostachya	.21	.23	9.8	27.5
Petalostemum purpureum	.20	.22	29.5	32.5
Pycnanthemum virginianum	.20	.22	7.0	5.0
Lythrum alatum	.20	.22	.6	
Phlox pilosa	.16	.18	6.3	10.0
Physalis virginiana	.16	.18	3.1	7.5
Viola pedatifida	.14	.15	5.5	5.0
Setaria lutescens	.13	.14	.5	
Viscia americana	.12	.13	4.7	7.5
Lathyrus venosus	.12	.13	2.5	5.0
Equisetum kansanum	.11	.12	4.7	42.5
Eryngium yuccifolium	.11	.12	1.0	2.5
Petalostemum candidum	.11	.12	3.9	7.5

[a]Figures taken from Moyer (1953) for comparison purposes.

Table 1 continued.

Species	Cover (%)	Composition (%)	Frequency (%)	Frequency[a] (%)
Baptisia leucophaea	.09	.10	.7	15.0
Asclepias syriaca	.07	.08	1.4	
Ambrosia artemisifolia	.06	.07	1.4	
Baptisia leucantha	.06	.07	.7	
Carex gravida	.06	.07	2.0	
Oxalis stricta	.06	.07	.9	
Teucrium canadense	.06	.07	1.7	
Viola sp.	.06	.07	3.2	
Gentiana andrewsii	.05	.06	1.1	2.5
Potentilla arguta	.05	.06	.5	
Scutellaria leonardii	.05	.06	2.2	
Thalictrum dasycarpum	.05	.06	1.6	7.5
Lespedeza capitata	.04	.04	1.0	2.5
Solidago riddellii	.04	.04	2.4	
Anemone cylindrica	.03	.03	.5	35.0
Helenium autumnale	.03	.03	.8	
Pedicularis canadensis	.03	.03	1.2	22.5
Bouteloua curtipendula	.03	.03	.9	7.5
Chenopodium album	.02	.02	.2	
Lathyrus palustris	.02	.02	1.1	
Liatris aspera	.02	.02	.8	25.0
Lycopus americanus	.02	.02	.7	
Lysimachia chiliata	.02	.02	.6	
Mentha arvensis	.02	.02	.4	
Solidago gymnospermoides	.02	.02	1.4	5.0
Vernonia fasciculata	.02	.02	.3	
Taraxacum officinale	.02	.02	.9	
Echinacea pallida	.02	.02	.4	10.0
Agropyron repens	.01	.01	.5	
Agropyron smithii	.01	.01	1.2	2.5
Anemone canadensis	.01	.01	1.7	
Arabis hirsuta	.01	.01	.1	
Asclepias sullivantii	.01	.01	.2	5.0
Asclepias verticillata	.01	.01	.4	2.5
Astragalus canadensis	.01	.01	.3	
Cicuta maculata	.01	.01	.3	10.0
Helianthus maximiliani	.01	.01	.6	
Juncus tenuis	.01	.01	.1	
Lactuca scariola	.01	.01	.4	
Lysimachia quadriflora	.01	.01	.8	
Panicum capillare	.01	.01	.1	
Phleum pratense	.01	.01	.6	85.0
Rudbeckia hirta	.01	.01	.3	
Veronicastrum virginicum	.01	.01	.1	
Allium sp.	.01	.01	.1	
Aster novae-angliae	.01	.01	.4	
Cacalia tuberosa	.01	.01	.1	
Prenanthes racemosa	.01	.01	.7	
Solidago nemoralis	.01	.01	2.6	2.5
Trifolium pratense	.01	.01	.1	12.5

[a]Figures taken from Moyer (1953) for comparison purposes.

mowing, grazing to some extent, and abundant pocket gopher activity. Both Mima mounds and pocket gopher (*Geomys bursanins*) activity are widely scattered across the prairie. The Mima mounds are poorly understood areas of disturbance. Other disturbance areas are along the south and west boundaries of the prairie, where dust from adjacent plowed fields has been deposited in depths up to two or three feet.

The distribution of soil types in the 8 ha intensive study site is here of interest. Our survey showed that much of the 8 ha is of lowland soil types. In fact, a large part of the upland prairie may occupy lowland soil types. The disturbance will give possible explanation to the high incidence of *Poa pratensis* found with *Sporobolus heterolepis*, and the large tracts of lowland soil types might well explain the abundance of *Andropogon* *gerardi.* Why *Sporobolus heterolepis* is found growing in such abundance on the lowland areas is difficult to explain, but it might be due to the high amount of calcareous soil types found within Kalsow Prairie.

Early studies (Weaver and Fitzpatrick 1934, Shimek 1925) suggest the distribution of *Sporobolus heterolepis* as restricted to driest uplands. Because these areas often show a lack of soil profile development or outcroppings of parent material often high in carbonates (Oschwald et al., 1965), it is feasible that *Sporobolus heterolepis* is adapted to grow on soils of high carbonate content and that it might easily be extended to lowland soils high in carbonate content.

Moyer (1953), in a study of the Kalsow Prairie vegetation, gave percentage frequency values for many of the species included in Table 1 of this paper. His figures are reported in column four of Table 1 for comparison. These figures suggest that there have been some changes in the species composition of the upland prairie since 1953. Some of the species that show increases in percentage frequency in the past are *Solidago canadensis, Solidago rigida, Panicum leibergii, Helianthus grosseserratus, Desmodium canadense, Galium obtusum,* and *Fragaria virginiana.* Species that show decreases in percentage frequency over this same period are *Phleum pratense, Poa pratensis, Zizia aurea, Rosa suffulta, Schizachyrium scoparius, Panicum virgatum, Sorghastrum nutans, Equisetum kansanum, Anemone cylindrica, Liatris aspera,* and *Sporobolus heterolepis.* Such changes are not easily explained but might be related to general fluctuations of the vegetation over a period of years, to fluctuations in climatic conditions (i.e., time and duration of rainfall, drought, etc.), to interspecific competition, to differences in the technique and intensity of sampling, and to the possible influence of slight disturbance upon the prairie due to increased populations of pocket gophers, dust accumulation from adjacent fields, public visitors, and management practices.

To describe in greater detail the interrelationships of species in the upland prairie a three-dimensional stand and species ordination treatment was attempted using Orloci's (1966) method. The results are shown in Figures 2, 3, and 4. Data used in the ordination

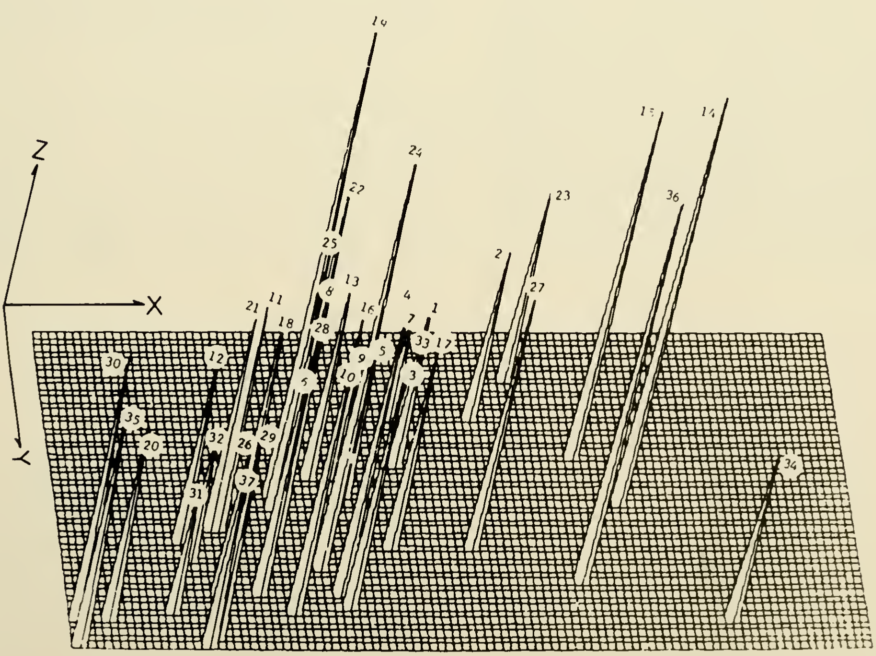

Fig. 2. Three-dimensional ordination of 37 upland prairie sites.

were from 444 samples taken from 37 sites in the upland prairie community. These 37 sites are shown as points in three-dimensional space in Figure 2 and as dots in two-dimensional space in Figure 3. Initially, attempts were made to place the individual sites into specific groups. Groups were designated on the basis of where the stands fell when plotted in three-dimensional space (i.e., those sites which fell close together were considered to be the most similar and were placed within the same group). Attempts to understand the meaning of such groupings were unsuccessful. Further attempts to understand the ordering pattern led to the conclusion that discrete grouping within these upland prairie regions is not feasible. It appears that the ordering of the stands into three-dimensional space was controlled by the response of several of the major species to environmental gradients. Of these species, *Andropogon gerardi* (Fig. 5) and *Sporobolus heterolepis* (Fig. 6) were plotted against the X and Y coordinates of the ordination. As can be seen, both species show continuous distribution in relationship to the axes. Stands plotted near the origin and adjacent to the Y-axis were found to be from drier sites, and those found away from the origin were found on wetter, more moist sites. These facts tend to support the hypothesis that the vegetation of the upland prairie is a continuum as earlier described by Curtis (1955) and Dix and Butler (1960). Kennedy (1969), in studying an upland prairie in Guthrie County, Iowa, also concluded that prairie vegetation there is best described through the use of the continuum-index concept.

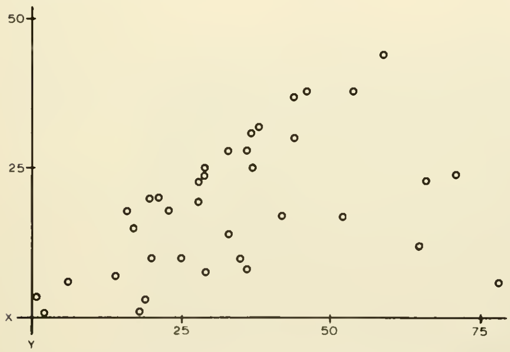

Fig. 3. Two-dimensional ordination of 37 upland prairie sites. Factors responsible for pattern are unknown.

Attempts at environmental factor correlation with the ordination axes were not made since only general information on environmental gradients was available. It seems, however, that these axes represent environmental gradients and that the ordering of stands or species along these axes is accomplished through the response of the different stands or species to certain factors such as moisture, texture, soil carbonates, or other soil factors.

The species ordination is shown in Figure 4. *Spartina pectinata* and *Ceanothus americanus* are the most different entities on the X-axis, and *Andropogon gerardi* is the most distinct entity on the Y-axis. Other species having distinct distribution patterns are *Physalis virginiana, Silphium laciniatum, Oxalis stricta, Amorpha canescens, Solidago missouriensis, Desmodium canadense, Helianthus grosseserratus, Aster ericoides, Vicia americana, Pycnanthemum virginianum, Ratibida pinnata, Aster laevis,* and *Helianthus laetiflorus.* All other species either showed no definite distribution patterns or were too rare to establish a meaningful pattern. The circles A, B, and C in Figure 4 represent the points where 76 of the 92 species fell. This ordering of species has not delineated associated groups but has pointed out

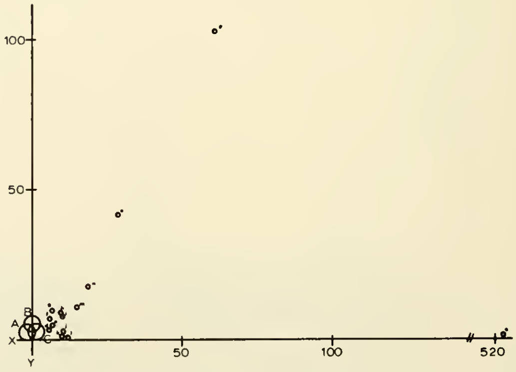

Fig. 4. Two-dimensional ordination of species found in upland prairie study sites, factors responsible for patterns unknown: A, B, and C. = Clusters of species not showing distinct distribution patterns. d. = *Helianthus laetiflorus.* e. = *Aster laevis.* f. = *Ratibida pinnata.* g. = *Pycnanthemum virginianum.* h. = *Aster ericoides.* i. = *Vicia americana.* j. = *Helianthus grosseserratus.* k. = *Desmodium canadense.* l. = *Amorpha canescens.* m. = *Oxalis stricta.* n. = *Silphium laciniatum.* o. = *Physalis virginiana.* p. = *Andropogon gerardi.* q. = *Spartina pectinata.*

those species that exhibit peculiar distribution patterns or that show a definite response to one or several environmental stimuli. Sanders (1969) found that the R-analysis of Orloci (1966) did give him some fairly distinct groups of associated species as well as groups of species that could not be considered associated. Collins (1968) used the technique to identify taxa that were distinct and different and used them as indicator species in his interpretation of the ecological relationships of fossil diatom populations. It is evident from Figure 4 that the method has not provided information on groups of associated species but rather has indicated taxa that are distinct and therefore may have some usefulness as indicator species.

Attempts to discover groups of positively associated species within the upland regions of Kalsow Prairie were made using Cole's Index (1949). Those species showing positive association with other taxa are shown in Table 2. A total of 298 significant associations were found. Some species, such as *Achillea lanulosa, Agropyron smithii, Amorpha canescens, Andropogon gerardi, Asclepias tuberosa, Carex gravida, Comandra umbellata, Helenium autumnale, Lespedeza capitata, Phleum pratense,* and *Solidago gymnospermoides*, exhibit positive association with only a limited number of species. Other species, however, show positive association with a large number of species. Some of these species are *Aster ericoides, Desmodium canadense, Fragaria virginiana, Galium obtusum, Helianthus grosseserratus, Poa pratensis, Solidago canadensis, Solid-go rigida, Sporobolus heterolepis,* and *Zizia aurea*. Many species showed no significant association or expressed values of high negative association. Positive values of Cole's Index indicate that species occur together more often than would otherwise be expected due to chance (Hale 1955, Hurlbert 1969). Therefore, through the use of such an index one can deduce groups of species that consistently show positive values of association with one another. Figures 7, 8, and 9 were constructed from values taken from Table 2 to illustrate the existence of such groups within the upland prairie. In all three cases one species was picked and the corresponding figure was then built up around this species.

Species Distribution Patterns

Eight hectares of the prairie adjacent to its southern boundary (Figure 1) were selected for intensive study of the distribution of plant species in relation to soils and topography. The area was chosen because it included within its boundaries a representation of all vegetation types occurring on Kalsow Prairie. The area was staked on a 9 × 9 m grid that placed 968 points within the 8 ha. From these points all factors included in this study were examined.

The presence of all plant species found in the area was recorded in relation to each 27 square-meter section of the grid. From these present figures, distribution maps for 160 species were constructed. Examples of these maps are shown in Figures 10A through 10HH. These figures illustrate examples of distribution patterns often shared by several species. *Andropogon gerardi* (Fig. 10D) illustrates a type of pattern typical of many species commonly found in the upland prairie.

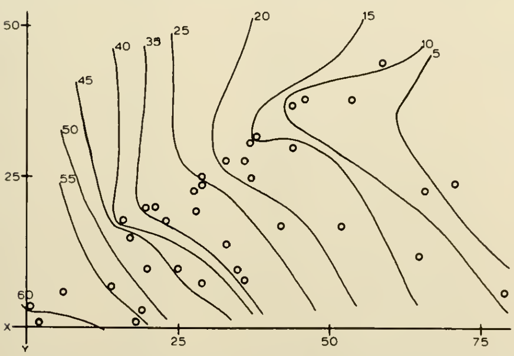

Fig. 5. Two-dimensional ordination of upland prairie with percentage cover values of *Sporobolus heterolepis* for each site shown relating directly to the Y-axis.

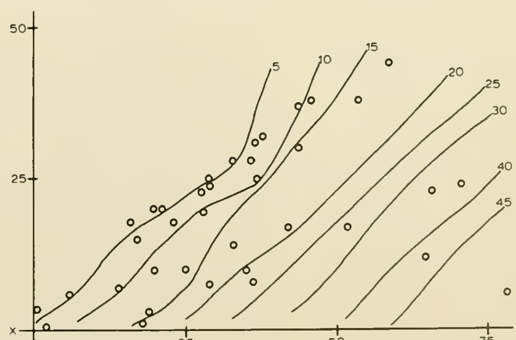

Fig. 6. Two-dimensional ordination of upland prairie with percentage cover values of *Andropogon gerardi* for each site shown relating directly to the X-axis.

TABLE 2. Cole's Index values expressing positive interspecific association on upland prairie.

Species	Species	X^{2a}	$C_7{}^b$	$\sigma_7{}^c$
Achillea lanulosa	*Andropogon gerardi*	18.77	.73	.17
	Aster ericoides	6.84	.22	.08
	Poa pratensis	5.03	.27	.11
	Solidago rigida	13.41	.21	.05
	Sporobolus heterolepis	11.06	.51	.15
Agropyron repens	*Carex gravida*	4.91	.22	.09
	Convolvulus sepium	7.04	.44	.16
	Physalis heterophylla	5.31	.22	.09
Agropyron smithii	*Andropogon gerardi*	5.96	.73	.29
	Aster ericoides	8.97	.45	.15
	Galium obtusum	4.33	.34	.16
	Helianthus grosseserratus	5.43	.43	.18
	Muhlenbergia racemosa	24.25	.27	.05
	Petalostemum purpureum	8.26	.20	.06
	Pycnanthemum virginianum	5.65	.18	.07
	Solidago canadensis	13.22	.53	.14
	Solidago riddellii	25.22	.24	.04
Ambrosia artemisifolia	*Asclepias syriaca*	83.22	.43	.04
	Helianthus grosseserratus	5.12	.23	.10
	Senecio pauperculus	155.77	.77	.06
	Setaria lutescens	58.48	.28	.03
	Setaria viridis	165.69	.57	.04
	Stipa spartea	4.00	.24	.12
	Taraxacum officinale	172.49	.55	.04
Amorpha canescens	*Andropogon gerardi*	15.62	.51	.13
	Panicum leibergii	28.29	.24	.04
	Solidago rigida	19.00	.20	.04
	Sporobolus heterolepis	41.54	.77	.11
Andropogon gerardi	*Aster ericoides*	126.73	.18	.01
	Poa pratensis	176.68	.30	.02
	Solidago canadensis	85.47	.15	.01
	Sporobolus heterolepis	238.41	.46	.02
Schizachyrium scoparius	*Comandra umbellata*	10.40	.21	.06
	Lithospermum canescens	19.30	.35	.08
	Panicum leibergii	5.62	.41	.17
	Petalostemum purpureum	7.53	.18	.06
	Phlox pilosa	11.12	.19	.05
	Solidago rigida	6.01	.25	.10
	Sporobolus heterolepis	8.23	.77	.26
	Zizia aurea	5.23	.31	.13
Anemone canadensis	*Artemisia ludoviciana*	5.53	.19	.08
	Petalostemum candidum	6.16	.19	.07
	Poa pratensis	5.57	.80	.33
	Solidago missouriensis	25.23	.16	.03
Apocynum sibiricum	*Aster simplex*	14.68	.26	.06
	Calamagrostis canadensis	102.95	.70	.06
	Carex aquatilis	44.71	.35	.05
	Carex retrorsa	70.51	.55	.06
	Carex lasiocarpa	66.57	.39	.04
	Fragaria virginiana	3.83	.38	.19
	Heliopsis helianthoides	4.39	.27	.12
	Polygonum coccimeum	15.26	.18	.04
	Spartina pectinata	13.73	.18	.05
Artemisia ludoviciana	*Aster ericoides*	4.53	.42	.19
	Convolvulus sepium	51.32	.22	.03
	Helianthus laetiflorus	14.98	.28	.07
	Poa pratensis	15.37	.78	.19
Asclepias sullivantii	*Elymus canadensis*	5.94	.67	.27

[a]Chi-square
[b]Cole's Index
[c]Standard deviation Cole's Index

Table 2 continued.

Species	Species	X^{2a}	$C_7{}^b$	$\sigma_7{}^c$
Asclepias syriaca	*Aster simplex*	4.71	.38	.17
	Cirsium altissimum	5.77	.21	.08
	Desmodium canadense	9.84	.66	.21
	Equisetum kansanum	6.87	.21	.08
	Lithospermum canescens	8.15	.31	.10
	Rosa suffulta	9.99	.32	.10
	Senecio pauperculus	47.45	.43	.06
	Taraxacum officinale	25.23	.20	.04
	Thalictrum dasycarpum	12.88	.23	.06
Asclepias tuberosa	*Aster ericoides*	4.80	.27	.12
	Desmodium canadense	17.17	.42	.10
	Elymus canadensis	9.21	.29	.09
	Sporobolus heterolepis	17.15	.92	.22
	Zizia aurea	7.13	.30	.11
Asclepias verticillata	*Lithospermum canescens*	14.39	1.00	.26
Aster ericoides	*Helianthus grosseserratus*	17.76	.17	.03
	Poa pratensis	105.26	.46	.04
	Solidago canadensis	49.17	.22	.03
	Sporobolus heterolepis	70.97	.49	.05
	Zizia aurea	40.95	.19	.02
Aster laevis	*Desmodium canadense*	23.69	.30	.06
	Panicum leibergii	53.78	.36	.04
	Poa pratensis	27.26	.54	.10
	Sporobolus heterolepis	9.76	.41	.13
Aster simplex	*Calamagrostis canadensis*	42.41	.21	.03
	Carex gravida	34.75	.21	.03
	Carex retrorsa	30.80	.17	.03
	Fragaria virginiana	4.89	.19	.08
	Galium obtusum	54.31	.37	.05
	Helianthus grosseserratus	95.05	.56	.05
	Poa pratensis	7.48	.58	.21
	Senecio pauperculus	61.08	.19	.02
	Silphium laciniatum	32.99	.29	.05
	Spartina pectinata	34.20	.32	.05
Bouteloua curtipendula	*Comandra umbellata*	5.23	.29	.12
	Helianthus laetiflorus	7.18	.41	.15
	Phlox pilosa	7.47	.31	.11
Calamagrostis canadensis	*Carex aquatilis*	427.86	.50	.02
	Carex retrorsa	580.80	.74	.03
	Carex lasiocarpa	404.31	.45	.02
	Phalaris arundinacea	171.76	.20	.01
	Polygonum coccineum	64.45	.18	.02
	Spartina pectinata	154.17	.30	.02
Carex atherodes	*Carex retrorsa*	18.21	.27	.06
	Polygonum coccineum	370.61	.87	.04
	Scirpus fluviatilis	145.67	.34	.02
Carex aquatilis	*Carex retrorsa*	469.33	.88	.04
	Carex lasiocarpa	406.70	.59	.02
	Phalaris arundinacea	57.45	.16	.01
	Polygonum coccineum	33.93	.17	.02
	Spartina pectinata	66.04	.26	.03
Carex gravida	*Desmodium canadense*	17.26	.49	.11
	Fragaria virginiana	30.76	.64	.11
	Galium obtusum	21.59	.56	.11
	Helianthus grosseserratus	36.90	.71	.11
	Liatris pycnostrachya	8.21	.22	.07
	Muhlenbergia racemosa	4.90	.23	.10
	Petalostemum purpureum	9.82	.23	.07

[a]Chi-square
[b]Cole's Index
[c]Standard deviation Cole's Index

Table 2 continued.

Species	Species	X^{2a}	C_7^b	σ_7^c
	Silphium laciniatum	19.94	.30	.06
	Solidago canadensis	6.94	.57	.21
Carex lasiocarpa	*Lathyrus palustris*	110.24	1.00	.09
	Lysimachia hybrida	147.33	1.00	.08
	Phalaris arundinacea	92.24	.21	.02
	Polygonum coccineum	27.12	.17	.03
	Spartina pectinata	72.67	.30	.03
Carex retrorsa	*Carex lasiocarpa*	465.71	.50	.02
	Phalaris arundinacea	158.23	.20	.01
	Polygonum coccineum	79.04	.20	.02
	Spartina pectinata	117.52	.27	.02
Cirsium altissimum	*Fragaria virginiana*	8.78	.21	.07
	Galium obtusum	7.65	.29	.10
	Helianthus grosseserratus	8.53	.34	.11
	Petalostemum candidum	8.80	.15	.05
	Physalis virginiana	24.36	.28	.05
	Solidago canadensis	5.09	.21	.09
Comandra umbellata	*Desmodium canadense*	47.92	.50	.07
	Elymus canadensis	11.91	.23	.06
	Fragaria virginiana	15.97	.26	.06
	Panicum leibergii	16.18	.24	.05
	Petalostemum purpureum	19.78	.18	.03
	Poa pratensis	10.28	.39	.12
	Ratibida columnifera	26.47	.26	.05
	Solidago rigida	15.47	.23	.05
	Sporobolus heterolepis	15.25	.62	.15
	Zizia aurea	28.32	.43	.08
	Solidago nemoralis	32.92	.17	.02
Convolvulus sepium	*Poa pratensis*	5.30	.66	.28
Desmodium canadense	*Elymus canadensis*	80.81	.27	.02
	Fragaria virginiana	75.91	.40	.04
	Galium obtusum	81.55	.43	.04
	Helianthus grosseserratus	26.91	.24	.04
	Muhlenbergia racemosa	31.07	.23	.04
	Poa pratensis	38.84	.34	.05
	Solidago rigida	20.28	.21	.04
	Sporobolus heterolepis	99.46	.70	.06
	Zizia aurea	66.09	.29	.03
Elymus canadensis	*Fragaria virginiana*	72.47	.27	.03
	Galium obtusum	21.27	.26	.05
	Poa pratensis	44.15	.39	.05
	Sporobolus heterolepis	42.70	.49	.07
Equisetum kansanum	*Heliopsis helianthoides*	7.25	.19	.07
	Lithospermum canescens	20.66	.20	.04
	Petalostemum candidum	11.42	.21	.06
	Phlox pilosa	6.58	.19	.07
	Sporobolus heterolepis	20.81	.83	.18
	Zizia aurea	11.12	.31	.09
Eryngium yuccifolium	*Panicum leibergii*	7.80	.31	.11
	Rosa suffulta	10.29	.22	.06
	Solidago rigida	4.57	.24	.11
	Sporobolus heterolepis	7.90	.85	.30
Fragaria virginiana	*Galium obtusum*	69.59	.39	.04
	Helianthus grosseserratus	40.39	.31	.04
	Muhlenbergia racemosa	37.67	.26	.04
	Poa pratensis	29.55	.33	.05
	Solidago canadensis	13.28	.33	.08
	Sporobolus heterolepis	39.10	.48	.07
	Zizia aurea	4.89	.18	.08

[a]Chi-square
[b]Cole's Index
[c]Standard deviation Cole's Index

Table 2 continued.

Species	Species	X^{2a}	$C_7{}^b$	$\sigma_7{}^c$
Galium obtusum	*Helianthus grosseserratus*	91.71	.35	.03
	Muhlenbergia racemosa	25.27	.21	.04
	Silphium laciniatum	41.48	.17	.02
	Solidago canadensis	13.09	.31	.08
	Zizia aurea	5.17	.18	.07
Gentiana andrewsii	*Heliopsis helianthoides*	12.46	.45	.12
	Liatris pycnostachya	4.04	.26	.13
	Lithospermum canescens	4.52	.40	.18
	Zizia aurea	4.34	.71	.34
Helenium autumnale	*Helianthus grosseserratus*	15.18	.88	.22
	Lythrum alatum	48.25	.19	.02
	Muhlenbergia racemosa	10.43	.22	.06
	Poa pratensis	11.28	.86	.25
	Pycnanthemum virginianum	7.30	.25	.09
	Senecio pauperculus	40.42	.62	.09
	Solidago canadensis	5.32	.41	.17
Helianthus grosseserratus	*Solidago canadensis*	73.49	.21	.02
Helianthus laetiflorus	*Panicum leibergii*	42.24	.37	.05
	Phlox pilosa	25.63	.18	.03
	Sporobolus heterolepis	5.53	.36	.15
Helianthus maximiliana	*Scutellaria leonardii*	11.06	.19	.05
	Taraxacum officinale	11.06	.19	.05
Heliopsis helianthoides	*Poa pratensis*	6.77	.52	.19
	Pycnanthemum virginianum	20.89	.32	.07
	Ratibida pinnata	6.37	.21	.08
	Solidago canadensis	8.97	.41	.13
Lactuca scariola	*Pedicularis canadensis*	12.13	.19	.05
	Rosa suffulta	7.31	.35	.12
Lathyrus palustris	*Lysimachia hybrida*	35.58	.24	.04
	Senecio pauperculus	3.94	.21	.10
	Silphium laciniatum	10.63	.46	.14
	Spartina pectinata	14.78	.39	.10
	Viola sp.	6.30	.23	.08
Lespedeza capitata	*Lithospermum canescens*	12.60	.45	.12
	Panicum leibergii	3.80	.38	.19
	Rosa suffulta	5.52	.28	.11
	Silphium laciniatum	5.93	.28	.11
Liatris aspera	*Physalis virginiana*	21.69	.40	.08
Liatris pycnostachya	*Poa pratensis*	6.21	.24	.09
	Silphium laciniatum	17.79	.19	.04
	Solidago canadensis	17.40	.28	.06
	Sporobolus heterolepis	39.56	.78	.12
	Zizia aurea	26.25	.32	.06
Lithospermum canescens	*Panicum leibergii*	26.20	.25	.04
	Sporobolus heterolepis	37.09	.81	.13
	Zizia aurea	23.59	.33	.06
Lycopus americanus	*Lythrum alatum*	52.06	.21	.02
	Senecio pauperculus	18.03	.43	.10
	Spartina pectinata	19.71	.43	.09
Lysimachia hybrida	*Muhlenbergia racemosa*	5.77	.60	.25
	Polygonum coccineum	53.59	1.00	.13
	Scirpus fluviatilis	95.59	.83	.08
	Spartina pectinata	13.03	.64	.17
	Viola sp.	9.00	.31	.10
Lysimachia quadriflora	*Muhlenbergia racemosa*	8.08	.22	.07
	Pedicularis canadensis	54.24	.50	.06
	Petalostemum purpureum	4.08	.20	.09
	Poa pratensis	4.41	.63	.30
	Senecio pauperculus	17.76	.48	.11

[a]Chi-square
[b]Cole's Index
[c]Standard deviation Cole's Index

Table 2 continued.

Species	Species	X^{2a}	C_7^b	σ_7^c
Lythrum alatum	*Senecio pauperculus*	5.70	.27	.11
	Spartina pectinata	6.37	.28	.11
Mentha arvensis	*Phalaris arundinacea*	6.67	.21	.08
	Polygonum coccineum	6.64	.30	.11
Muhlenbergia racemosa	*Zizia aurea*	7.48	.25	.09
Panicum capillare	*Pycnanthemum virginianum*	20.53	.20	.04
	Senecio pauperculus	27.20	.24	.04
	Silphium laciniatum	12.59	.20	.05
	Solidago canadensis	6.31	.21	.08
	Zizia aurea	11.91	.28	.08
Panicum leibergii	*Poa pratensis*	12.96	.24	.06
	Sporobolus heterolepis	56.41	.65	.08
Panicum virgatum	*Poa pratensis*	12.96	.24	.06
	Sporobolus heterolepis	56.41	.65	.08
Pedicularis canadensis	*Pycnanthemum virginianum*	37.72	.49	.07
	Senecio pauperculus	5.78	.22	.09
	Solidago rigida	5.11	.29	.12
	Zizia aurea	20.45	.79	.17
Petalostemum candidum	*Ratibida pinnata*	4.02	.21	.10
	Rosa suffulta	4.27	.23	.10
Petalostemum purpureum	*Poa pratensis*	11.86	.34	.09
	Solidago canadensis	16.33	.28	.06
	Solidago rigida	20.61	.22	.04
	Sporobolus heterolepis	30.35	.71	.12
	Zizia aurea	24.91	.33	.06
Phalaris arundinacea	*Polygonum coccineum*	78.87	.41	.04
	Spartina pectinata	25.65	.26	.05
Phleum pratense	*Phlox pilosa*	5.50	.34	.14
	Ratibida pinnata	7.39	.73	.26
Phlox pilosa	*Ratibida pinnata*	8.27	.25	.08
	Sporobolus heterolepis	7.60	.64	.23
Physalis virginiana	*Rosa suffulta*	5.93	.21	.08
	Solidago rigida	4.93	.32	.14
Poa pratensis	*Sporobolus heterolepis*	54.66	.31	.04
Polygonum coccineum	*Scirpus fluviatilis*	350.08	.37	.01
Potentilla arguta	*Solidago missouriensis*	5.48	.30	.12
Psoralea argophylla	*Stipa spartea*	6.50	.18	.07
Pycnanthemum virginianum	*Senecio pauperculus*	30.62	.19	.03
	Silphium laciniatum	25.56	.21	.04
	Solidago canadensis	25.73	.31	.06
	Sporobolus heterolepis	11.25	.39	.11
	Zizia aurea	7.48	.69	.25
Ratibida pinnata	*Sporobolus heterolepis*	22.69	.48	.10
	Zizia aurea	19.66	.23	.05
Rosa suffulta	*Sporobolus heterolepis*	13.85	.54	.14
Rudbeckia hirta	*Solidago rigida*	7.17	.75	.28
Senecio pauperculus	*Solidago canadensis*	51.17	.42	.05
	Taraxacum officinale	100.89	.32	.03
Setaria lutescens	*Setaria viridis*	525.50	.89	.03
Silphium laciniatum	*Solidago canadensis*	4.85	.34	.15
	Spartina pectinata	15.95	.21	.05
	Sporobolus heterolepis	32.83	.52	.09
	Viola sp.	38.07	.19	.03
	Zizia aurea	43.57	.31	.04
Solidago canadensis	*Sporobolus heterolepis*	21.62	.28	.06
Solidago gymnospermoides	*Solidago rigida*	3.87	.22	.11
	Sporobolus heterolepis	8.50	.86	.29
	Zizia aurea	9.77	.47	.15

[a]Chi-square
[b]Cole's Index
[c]Standard deviation Cole's Index

Table 2 continued.

Species	Species	X^{2a}	C_7^b	σ_7^c
Solidago rigida	*Sporobolus heterolepis*	96.94	.84	.08
Sorghastrum nutans	*Sporobolus heterolepis*	17.68	.81	.19
	Zizia aurea	5.46	.23	.09
Sporobolus heterolepis	*Zizia aurea*	130.17	.19	.01
Viola sp.	*Zizia aurea*	8.97	.35	.11
Panicum implicatum	*Solidago nemoralis*	8.63	.19	.06

[a]Chi-square
[b]Cole's Index
[c]Standard deviation Cole's Index

This pattern indicates that these species have wide ecological amplitudes and are limited basically by conditions peculiar to the drainage areas of the prairie. Other species that showed similar distribution patterns were *Aster ericoides, Elymus canadensis, Equisetum kansanum, Lithospermum canescens, Petalostemum purpureum, Poa pratensis, Ratibida pinnata, Rosa suffulta, Solidago canadensis, Solidago rigida, Sporobolus heterolepis,* and *Zizia aurea.*

A pattern closely resembling that of *Andropogon gerardi* but also showing limited distribution on the higher and drier ridges of the area is that exemplified by *Silphium laciniatum* (Fig. 10J). Species included under this type of pattern were *Desmodium canadense, Fragaria virginiana, Galium obtusum, Helianthus grosseserratus, Heliopsis helianthoides, Liatris pycnostachya, Panicum virgatum,* and *Spartina pectinata.*

The pattern showed by *Ambrosia artemisifolia* (Fig. 10B) is limited to the border weed communities. Other species found limited to these areas were *Amaranthus tamariscinus, Ambrosia trifida, Brassica nigra, Chenopodium album, Helianthus annuus, Polygonum pennsylvanicum, Polygonum persicaria, Setaria lutescens,* and *Setaria viridis.*

Figure 10C (*Amorpha canescens*) illustrates a pattern common to species limited to growth on the ridges and lower slopes of the area. This would correspond to areas composed mainly of Clarion, Nicollet, and Webster soil types (Fig. 11). When compared with the pattern exhibited by *Andropogon gerardi,* this type shows a narrowing ecological amplitude and decrease in the ability of species exhibiting this type of pattern to compete in lowland areas. Other species showing this type of pattern were *Achillea lanulosa, Arabis hirsuta, Asclepias syriaca, Asclepias tuberosa, Aster laevis,* and *Panicum leibergii.*

Several species found limited in distribution to the mid- and upland slopes of the prairie exemplify the pattern shown by *Solidago nemoralis* (Fig. 10E). These species were *Eryngium yuccifolium, Solidago gymnospermoides, Solidago riddellii,* and *Viola pedatifida.* Such species show rather narrow ecological amplitudes when compared with the groups discussed earlier.

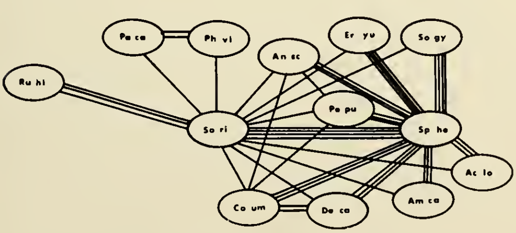

Fig. 7. *Solidago rigida* and associated species of upland prairie as determined by Cole's (1949) Index, the more lines between species, the greater the association. So ri = *Solidago rigida,* Ru hi = *Rudbeckia hirta,* Pe ca = *Pedicularis canadensis,* Ph vi = *Physalis virginiana,* An Sc = *Schizachyrium scoparius,* Er yu = *Eryngium yuccifolium,* Pe pu = *Petalostemum purpureum,* So gy = *Solidago gymnospermoides,* Sp he = *Sporobolus heterolepis,* Ac la = *Achillea lanulosa,* Am ca = *Amorpha canescens,* De ca = *Desmodium canadense,* Co um = *Comandra umbellata.*

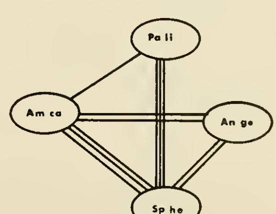

Fig. 8. *Amorpha canescens* and associated species of upland prairie as determined by Cole's (1949) Index, the more lines between the species, the greater the association. Am ca = *Amorpha canescens,* Pa li = *Panicum leibergii,* An ge = *Andropogon gerardi,* Sp he = *Sporobolus heterolepis.*

Another group exhibiting rather narrow ranges in distribution are characterized by the patterns shown in Figures 10N and 10O. These species, *Artemisia ludoviciana*, *Ceanothus americanus*, *Echinacea pallida*, *Helianthus laetiflorus*, *Lathyrus venosus*, *Lespedeza capitata*, *Liatris aspera*, *Petalostemum candidum*, *Potentilla arguta*, *Psoralea argophylla*, *Solidago missouriensis*, and *Stipa spartea*, are found occupying the ridges and drier sites of the prairie. This would correspond to the Clarion, Clarion-Nicollet, and Nicollet areas of Figure 11.

A final group of species limited from growth in the drainage areas of the prairie show a pattern characteristic of those found in Figure 10A (*Agropyron smithii*) and Figure 10F (*Helenium autumnale*). Here again the ecological amplitudes of these species are narrow when compared with Andropogon *gerardi* or *Sporobolus heterolepis*. As can be seen, the distribution of these species corresponds closely to the borders of the pothole and drainage complex; thus these species mainly occupy soils that are characterized by being highly calcareous to the surface. Other species exhibiting this type of distribution are *Agrostis alba*, *Aster simplex*, *Lycopus americanus*, *Lysimachia quadriflora*, *Lythrum alatum*, *Senecio pauperculus* and *Viola* sp.

Species restricted in occurrence to the potholes and drainage ways of the area were found to exhibit two types of distributional patterns. The first, shown by *Calamagrostis*

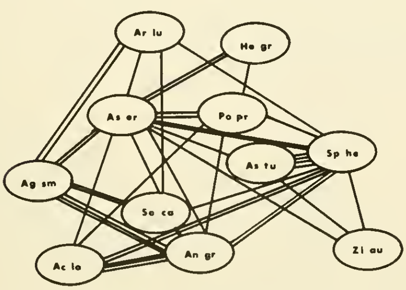

Fig. 9. *Aster ericoides* and associated species of upland prairie as determined by Cole's (1949) Index, the more lines between the species, the greater the association. As er = *Aster ericoides*, Ar lu = *Artemisia ludoviciana*, He gr = *Helianthus grosseserratus*, Po pr = *Poa pratensis*, As tu = *Asclepias tuberosa*, Sp he = *Sporobolus heterolepis*, Zi au = *Zizia aurea*, An gr = *Andropogon gerardi*, So ca = *Solidago canadensis*, Ac la = *Achillea lanulosa*, Ag sm = *Agropyron smithii*.

canadensis in Figure 10F, corresponds generally to the shallower areas of the drainage system. The pattern shown by Figure 10F also includes the species *Apocynum sibiricum*, *Asclepias incarnata*, *Carex aquatilis*, *Carex lasiocarpa*, *Carex retrorsa*, *Phalaris arundinacea*, *Teucrium canadense*, and *Vernonia fasiculata*. The areas covered by these species correspond generally to the Glenco soils as shown in Figure 11. The second, illustrated by *Carex atherodes* and *Scirpus fluviatilis* in Figure 10G and 10H, is more restricted in extent than the above and corresponds to the deeper areas within the drainage system. Species occupying areas equivalent to those shown in Figures 10G and 10H were *Lysimachia hybrida*, *Polygonum coccineum*, and *Mentha arvensis*. These areas correspond to Glenco-Okoboji and Okoboji soil locations as shown in Figure 11.

In several cases it was noted that two species belonging to the same genus showed opposing patterns of distribution. Examples of this phenomenon are illustrated by the species *Aster laevis* and *Aster simplex*, Figures 10K and 10L; *Helianthus grosseserratus* and *Helianthus laetiflorus*, Figures 10S and 10T; and *Liatris aspera* and *Liatris pycnostachya*, Figures 10U and 10V.

Other species were shown to have patterns corresponding to the distribution of Mima mounds found within the area. Such patterns are shown by *Convolvulus sepium* (Fig. 10F) and by *Oxalis stricta* (Fig. 10Y).

Many factors affect the distribution of a species within the community. It has been shown that individuals of different taxa seldom have identical spatial arrangements within an area (Greig-Smith 1964), yet, as shown above, the distribution patterns of some species may be similar and often show overlapping boundaries. Such species may be closely associated due to preferences for similar microenvironments or, as in the case of *Andropogon gerardi*, because of wide ecological amplitude. Generally these differences in the local distribution of species have been attributed to local microenvironments (i.e., Mima mounds, animal burrows, ridge tops, and drainage ways), interspecific competition (i.e., allelopathy, shade tolerance, etc.), species biology (i.e., modes of reproduction, seed dispersal, immigration rates, etc.), or one to

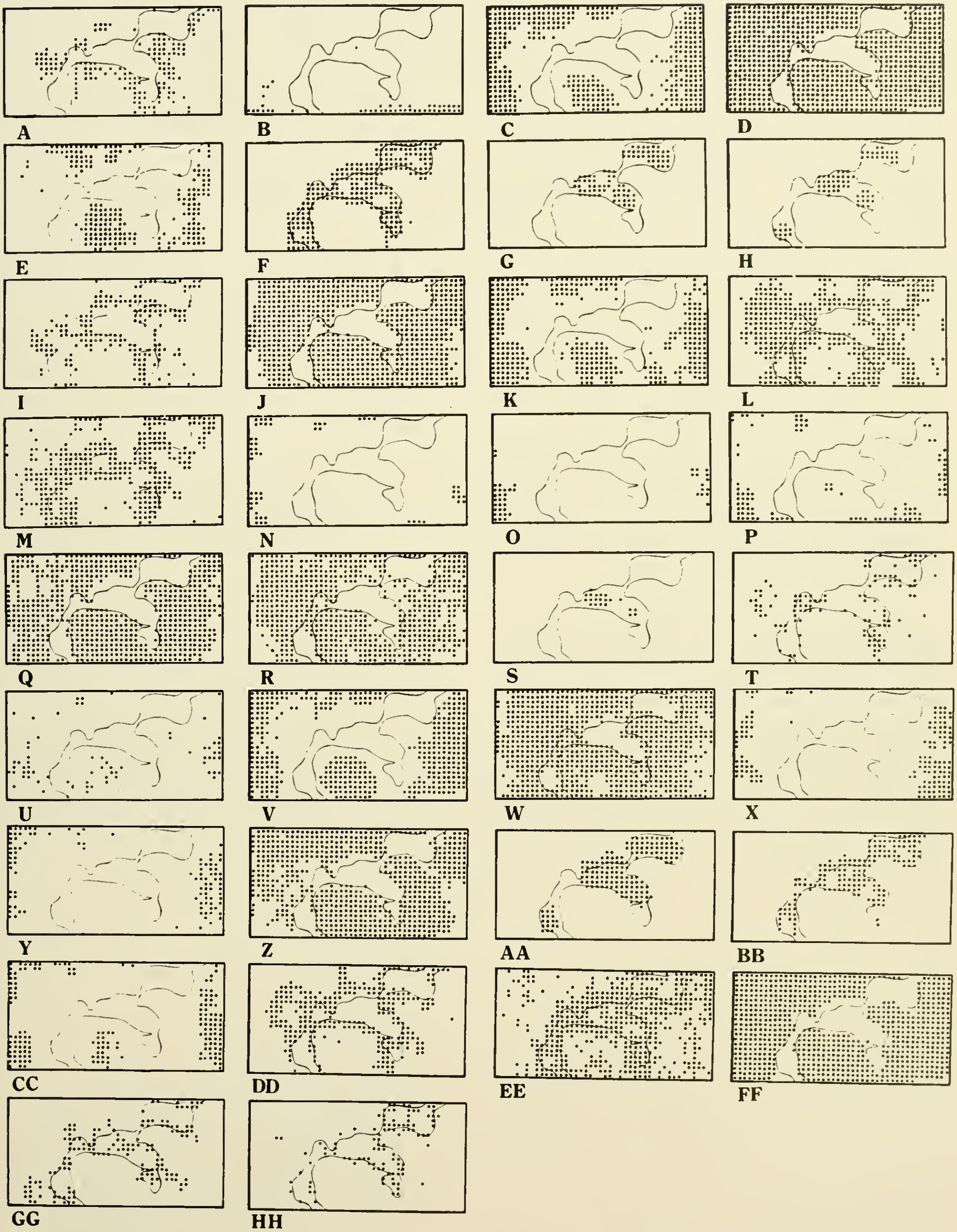

Fig. 10. Distribution patterns in 8 hectare study area of: A. *Agropyron smithii.* B. *Ambrosia artemisifolia.* C. *Amorpha canescens.* D. *Andropogon gerardi.* E. *Solidago nemoralis.* F. *Calamagrostis canadensis.* G. *Carex atherodes.* H. *Scirpus fluviatilis.* I. *Helenium autumnali.* J. *Silphium laciniatum.* K. *Aster laevis.* L. *Aster simplex.* M. *Apocynum sibericum.* N. *Artemisia ludoviciana.* O. *Ceanothus americanus.* P. *Convolvulus sepium.* Q. *Desmodium canadense.* R. *Fragaria virginiana.* S. *Helianthus grosseserratus.* T. *Helianthus laetiflorus.* U. *Liatris aspera.* V. *Liatris pyonostachya.* W. *Lisimachia hybrida.* X. *Lycopus americanus.* Y. *Oxalis stricta.* Z. *Panicum leibergii.* AA. *Polygonum coccineum.* BB. *Phalris arundinacea.* CC. *Psoralea aryophylla.* DD. *Senecio aurens.* EE. *Spartina pectinata.* FF. *Sporobolus heterolepis.* GG. *Teucrium canadense.* HH. *Vernonia fasciculata.*

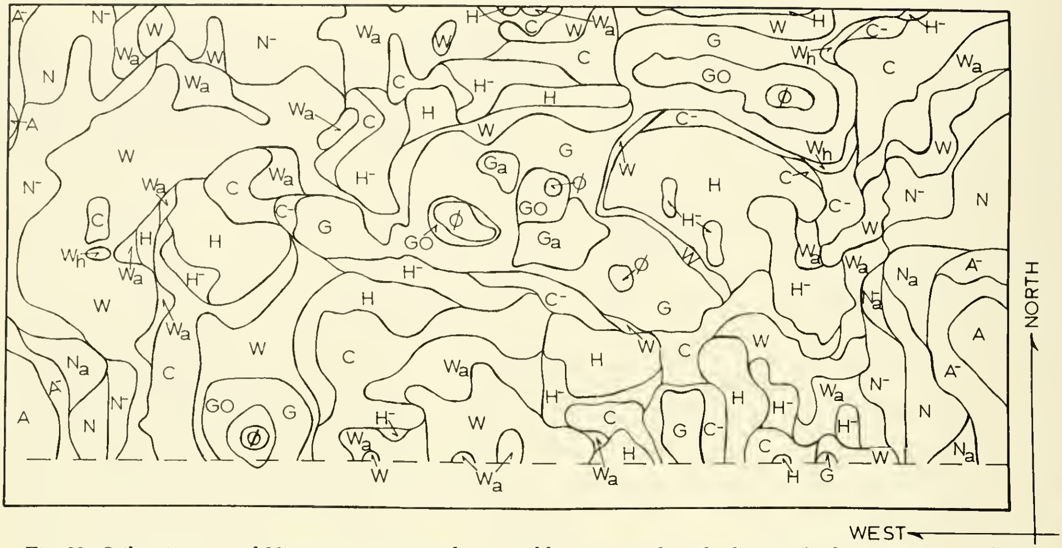

Fig. 11. Soil series map of 20-acre intensive study area, abbreviations described in Methods section. A = Clarion, A⁻ = Clarion-Nicollet, N = Nicollet, Na = calcareous Nicollet, N⁻ = Nicollet-Webster, Na⁻ = calcareous Nicollet-Webster, W = Webster, Wh = heavy Webster, Wa = calcareous Webster, C = Canisteo, H = Harps, H⁻ = Harps-Canisteo, C⁻ = inverted Canisteo-heavy Webster, G = Glenco, Ga = calcareous Glenco, GO = Glenco-Okoboji, O = Okoboji.

several edaphic factors (soil and water regimes, macronutrients, micronutrients, texture, organic matter, etc.) (Curtis 1959, Greig-Smith 1964, Kershaw 1964). From this we can conclude that species showing similar patterns of distribution may be equally well adapted in their response to one or more environmental stimuli and yet differ greatly in their basic ecological amplitudes. The response of individuals to the environmental complex is measured in a species distribution pattern as well as in its importance within the community.

Attempts were made to access the response of the species included in this study to the factors of soil and topography. Soil and elevation readings were recorded at all 968 points of the grid. From these readings a soils map (Figure 11) and contour and elevation maps (Figs. 12, 13) were constructed for the

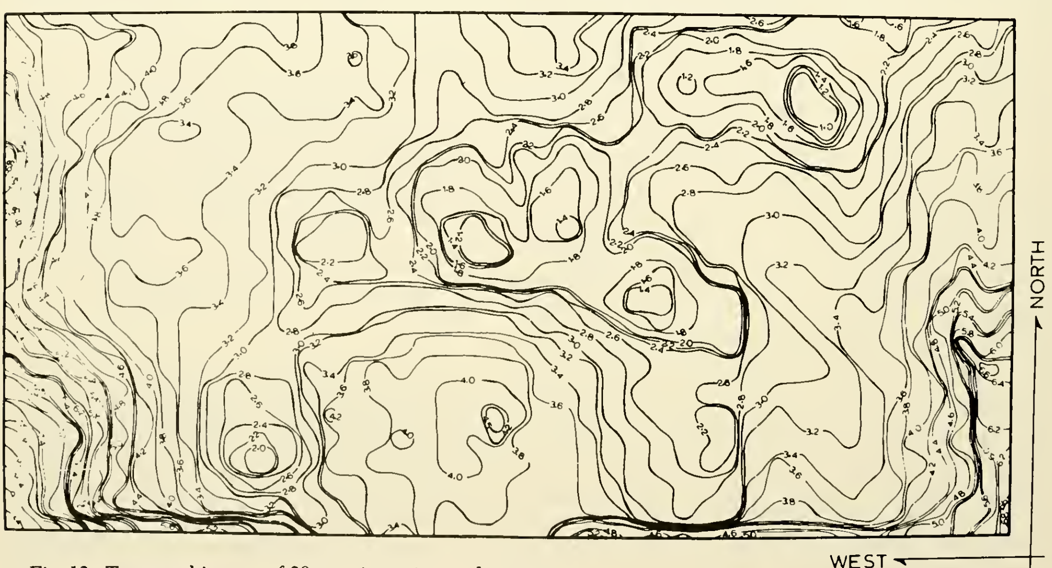

Fig. 12. Topographic map of 20-acre intensive study area.

8 ha plot. This made it possible to group all plant samples according to 0.5 ft changes in elevation or according to soil series. Once grouped, average cover values were computed for all participating species and recorded in Tables 3 (elevation data) and 4 (soils data). As can be seen from these tables, all species showed response to these factors. Several species, *Andropogon gerardi, Amorpha canescens, Aster ericoides, Elymus canadensis, Panicum leibergii, Poa pratensis, Solidago canadensis, Sporobolus heterolepis,* and *Zizia aurea,* showed wide tolerance in relation to both soil and elevation, but all exhibited peaks or plateaus of occurrence. These peaks or plateaus are interpreted to represent the optimum conditions under which a particular species can reach its highest importance within the community in relation to the entire species complex.

Other species showed rather narrow ranges of tolerance. Some of these were *Schizachyrium scoparius, Apocynum sibiricum, Asclepias sullivantii, Calamagrostis canadensis, Carex atherodes, Eryngium yuccifolium, Lysimachia hybrida, Physalis heterophylla, Viola pedatifida* and *Ceanothus americanus.* Those exhibiting narrow ranges also showed peaks of occurrence. For species exhibiting narrow tolerances, four basic types of distribution patterns as related to elevation (Table 3) are recognizable: (1) pothole and drainage, (2) lower slopes, (3) mid- and upper slopes, and (4) ridges.

For species showing response to the soil factor (Table 4) three basic classes are recognizable: (1) Glenco, Glenco-Okoboji, and Okoboji, (2) calcareous, and (3) noncalcareous and ridge. Species indicating preference for class 1 were *Calamagrostis canadensis, Carex atherodes, Carex aquatilis, Carex lasiocarpa, Carex retrorsa, Lysimachia hybrida, Polygonum coccineum,* and *Scirpus fluviatilis.* Species showing preference for the calcareous soils (class 2) were *Agropyron smithii, Desmodium canadense, Galium obtusum, Helenium autumnale, Petalostemum purpureum, Senecio pauperculus, Silphium laciniatum, Solidago canadensis, Solidago nemoralis* and *Solidago riddellii.* Examples of species preferring class 3 were *Amorpha canescens, Artemisia ludoviciana, Asclepias tuberosa, Baptisia leucophaea, Eryngium yuccifolium, Lathyrus palustris, Panicum leibergii, Poa pratensis, Solidago missouriensis, Vicia americana,* and *Ceanothus americanus.*

These groups of recognizable patterns, each involving several species, suggest the existence of subcommunities within the prairie area. To ascertain the existence of such communities, the data from Tables 3 and 4 were treated using Orloci's (1966) method of ordination. When the results from the soils analysis were plotted (Fig. 14), four basic groups

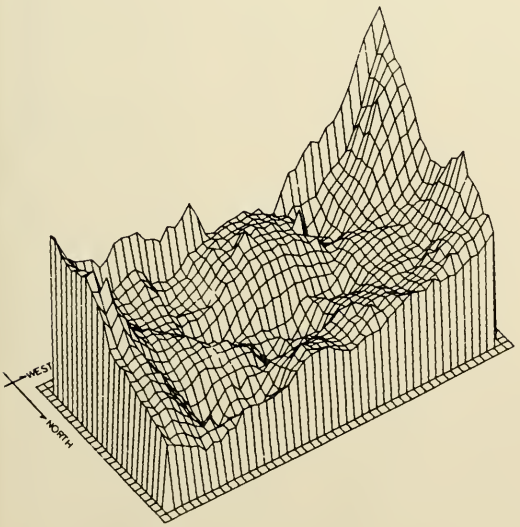

Fig. 13. Topographic map of 20-acre intensive study area plotted by computer.

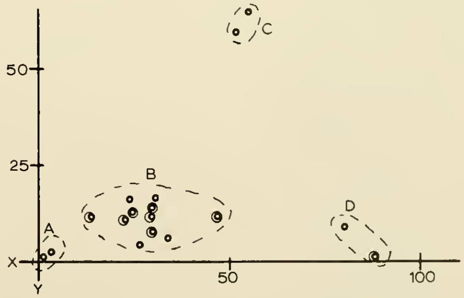

Fig. 14. Two-dimensional ordination of vegetation found on the different soil types in the 20-acre study area; cluster A indicates vegetation on Nicollet and Nicollet-Webster soil types; B indicates vegetation on Clarion, Clarion-Nicollet, Webster, heavy Webster, calcareous Nicollet, calcareous Nicollet-Webster, calcareous Webster, Canisteo, Harps, Harps-Canisteo, and inverted Canisteo-heavy Webster soil types; C indicates vegetation on Glenco-Okoboji and Okoboji soil types; D indicates vegetation on Glenco and calcareous Glenco.

TABLE 3. Average cover values for species in relation to elevation in 20-acre intensive study area.

Species	1 .7–1.2	2 1.3–1.8	3 1.9–2.4	4 2.5–3.0	5 3.1–3.6	6 3.7–4.2
Achillea lanulosa				.23	.23	.28
Agropyron smithii			.02	.12	.09	
Ambrosia artemisifolia				.01	.01	.55
Amorpha canescens				.20	1.49	4.27
Andropogon gerardi		.52	5.57	9.06	9.49	10.10
Schizachyrium scoparius			.25	.92	.75	.55
Anemone canadensis					.02	.03
Anemone cylindrica						
Apocynum sibiricum	1.36	1.98	1.15	.65	.04	.19
Arabis hirsuta					.01	
Artemisia ludoviciana					.06	.02
Asclepias incarnata		.52				
Asclepias sullivantii				.08	.02	
Asclepias syriaca			.13		.07	.28
Asclepias tuberosa			.02	.02	.44	.71
Aster ericoides			.41	1.87	2.09	1.72
Aster laevis				.10	.77	1.84
Aster simplex		.56	2.72	2.55	1.66	.82
Baptisia leucantha						
Baptisia leucophaea					.13	
Calamagrostis canadensis	1.59	33.65	36.13	9.52	1.09	
Carex atherodes	34.55	16.35	4.28	.23		
Carex aquatilis		2.05	3.22	1.33	.19	.02
Carex gravida					.01	
Carex lasiocarpa		1.63	1.91	.53	.08	
Carex retrorsa		4.51	7.24	2.67	.57	.02
Chenopodium album			.02		.14	
Cicuta maculata						
Cirsium altissimum			.54	.55	.67	.44
Comandra umbellata		.03	.02	.14	.38	.32
Convolvulus sepium					.09	.03
Desmodium canadense			.72	2.37	3.49	2.96
Elymus canadensis			.11	.49	1.05	.85
Equisetum kansanum			.04	.14	.21	.24
Eryngium yuccifolium					.05	.91
Fragaria virginiana			.89	.92	1.91	1.11
Galium obtusum		.90	1.91	1.69	1.84	.93
Gentiana andrewsii		.21		.01	.06	.13
Helenium autumnale		.03	.28	.19	.18	.02
Helianthus grosseserratus		2.95	8.89	8.88	7.46	4.59
Helianthus laetiflorus				.01	.43	1.39
Helianthus maximiliani					.01	
Heliopsis helianthoides				.28	.22	.24
Lactuca scariola				.02	.06	.03
Lathyrus palustris		.03	.02	.08	.06	
Lathyrus venosus						.06
Lespedeza capitata				.01	.01	.11
Liatris pycnostachya			.20	.80	.63	.65
Lithospermum canescens			.07	.26	.34	.33
Lycopus americanus			.24	.13		.03
Lysimachia chiliata					.01	
Lysimachia hybrida		21.50	1.42			
Lysimachia quadriflora			.07	.04	.03	.03
Lythrum alatum		.24	.20	.12		
Mentha arvensis		.28		.08		
Muhlenbergia racemosa			.52	.78	.25	.22
Oxalis stricta				.18		
Panicum capillare					.01	

Table 3 continued.

7 4.3–4.8	8 4.9–5.4	9 5.5–6.0	10 6.1–6.6	11 6.7–7.2	12 7.3–7.8	13 7.9–8.4	14 8.5–9.0	15 9.1–9.6
.71	1.00	1.07	.13			8.00		
.05		.71						
2.03	4.50	1.79	1.71	7.86	.83	7.50	1.25	
11.70	14.67	10.95	26.21	14.29	57.92	40.00	20.00	
1.42								
.33	.08	.71	2.50	4.29		3.00		
		.71						
1.46	.25	.71						
3.35	3.08	2.02	7.89	2.50		3.50	1.25	
1.37	2.42	4.76	7.37	2.50	5.83	1.00		
.09								
.28								
.33	1.08							
		.12						
.33				2.14				
.24		.12						
			.79	2.14	2.92	3.00	7.50	
2.36	2.08	2.50	.26	2.14				
.71	.25	.48	.26	.71	.42		1.25	
.09	.08			.36		.50		
.09	.08	.71						
.99	.08		.13					
.52	.25	.12	.13	.71				
3.82	.83	.24						
3.16	2.67	2.50	8.16	5.71				
.14			.79					
.33	.17	.12	.39					
.28	.08							
.24	.08							
.47	.25	.24	.53		.42			
	.50	.71						
.05		.71						
.05								

Table 3 continued.

Species	1 .7–1.2	2 1.3–1.8	3 1.9–2.4	4 2.5–3.0	5 3.1–3.6	6 3.7–4.2
Panicum leibergii			.02	.51	1.19	2.31
Panicum virgatum			.26	.66	.86	.60
Pedicularis canadensis				.47	.09	.13
Petalostemum candidum			.02		.02	.02
Petalostemum purpureum		.03	.13	.59	.40	.35
Phalaris arundinacea	7.05	5.49	3.98	.49		
Phlox pilosa			.04	.05	.13	.13
Physalis heterophylla						
Physalis virginiana				.01	.04	.03
Poa pratensis			1.24	2.82	3.57	4.24
Polygonum coccineum	27.27	16.81	4.02	1.52	.01	
Potentilla arguta						.02
Psoralea argophylla					.02	.09
Pycnanthemum virginianum			.37	1.83	.77	.35
Ratibida pinnata		.21	.30	1.65	1.93	1.50
Rosa suffulta				.24	.46	.91
Rudbeckia hirta			.10		.01	.03
Scirpus atrovirens		.52				
Scirpus fluviatilis	2.05	6.22	1.41	.08		
Scutellaria leonardii			.07	.04	.13	.08
Senecio pauperculus		.42	3.15	3.92	.59	.35
Setaria lutescens			.13		.01	.09
Setaria viridis				.01	.03	.24
Silphium laciniatum			2.09	4.84	2.75	2.10
Solidago canadensis		.66	3.98	6.02	5.68	2.12
Solidago gymnospermoides				.01	.31	.11
Solidago missouriensis				.01		.09
Solidago rigida				1.81	3.20	5.44
Sorghastrum nutans			.09	.17	.42	.08
Spartina pectinata	1.36	4.27	3.74	1.79	.84	.30
Sporobolus heterolepis		.52	7.76	23.83	40.98	49.78
Stipa spartea						.05
Teucrium canadense		.03	1.07	.31	.01	
Thalictrum dasycarpum				.04	.44	.33
Vernonia fasiculata			.59			
Veronicastrum virginicum						.02
Viola pedatifida					.04	.08
Viola sp.			.07	.12	.12	.08
Vicia americana					.05	.05
Zizia aurea		.21	1.43	3.28	4.18	2.74
Allium sp.					.02	
Aster novae-angliae				.23	.02	
Cacalia tuberosa						.02
Ceanothus americana					.01	
Panicum implicatum					.06	.09
Prenanthes racemosa				.08		
Solidago nemoralis			.02	.13	.45	1.69
Solidago riddellii		.03	.13	.69	.18	.03
Taraxacum officinale						.09
Echinacea pallida						.02

were recognizable. These groups are labeled A, B, C, and D, with group A corresponding to the noncalcareous and ridge entity described previously and made up of plants showing preference for Nicollet and Nicollet-Webster soils. Group B includes all but one of the calcareous soil types plus four noncalcareous types. The noncalcareous types are found at the periphery of the group and include Clarion, Clarion-Nicollet, Webster, and heavy Webster soil types. Group C includes the Glenco-Okoboji and Okoboji soils, and group D includes Glenco and calcareous-Glenco soils. These last two groups correspond to class 1 for species showing response to the soil factor described above.

Table 3 continued.

7 4.3–4.8	8 4.9–5.4	9 5.5–6.0	10 6.1–6.6	11 6.7–7.2	12 7.3–7.8	13 7.9–8.4	14 8.5–9.0	15 9.1–9.6
2.64	2.16	2.62	9.74	2.50	2.92	.50		
.24	.67		.13					
	.17		.13					
.09	.58							
		.12						
			4.87	2.14	5.00			
.09		.12	.13		2.50			
7.36	9.25	26.55	22.50	27.86	26.67	38.50	61.25	
		.71	.13					
.05	1.00	.83	.13	.71	2.92	.50		
.24	.17							
1.46	2.75		2.11					
2.03	1.50	2.62	1.18				1.25	
.09				.36				
.57								
		2.50	.79					
2.41		4.88	.13					
.61								
2.22	3.50	2.38	4.34	11.43	2.92		7.50	
			1.58		2.50			
5.66	3.17	2.74	.79					
.09			.26					
.05								
42.74	43.08	26.90	17.63	33.21	8.75	8.00		
.09	.08	.95	.26			.50	1.25	
			.13					
.42								
.09	.08							
.05								
.09			.26		.42			
2.36	.25	1.31	.13		.42			
	.50		1.97	2.14	2.50	24.50		
.05								
.05								

Ordination of elevation data (Fig. 15) showed no recognizable groupings. Instead it separated the different elevation classes (Table 3) along a curve, point 14 representing the ridge tops and point 1 representing the bottom of the potholes. This would tend to support statements made earlier that the vegetation of Kalsow Prairie is best represented by the continuum concept of Curtis and McIntosh (1951).

The definable subcommunities or groups (Fig. 14) as based on soils data represent the response of the different taxa in the vegetation to an environmental stimulus (i.e., carbonate soils) that is not distributed along gradients (i.e., at 9 × 9 m sampling levels)

TABLE 4. Average cover values for species in relation to soil series in 20-acre intensive study area.

Species	A	A^-	N	Na	N^-	Na^-	W
Achillea lanulosa	.14	.19	.57		.44	.21	.37
Agropyron smithii							.01
Ambrosia artemisifolia		.56					
Amorpha canescens	3.47	2.87	4.16	4.06	6.57		2.56
Andropogon gerardi	39.72	19.25	12.26	21.56	10.04	10.63	6.70
Schizachyrium scoparius					.08		.80
Anemone canadensis							.03
Apocynum sibiricum							.09
Arabis hirsuta							
Artemisia ludoviciana	3.19	.56	.38	1.88	.12		
Asclepias incarnata							
Asclepias sullivantii							
Asclepias syriaca			.28				.01
Asclepias tuberosa		.65	.61	1.88	.73		.19
Aster ericoides	3.89	1.94	3.58	2.19		.42	1.50
Aster laevis	3.47	4.44	1.56	9.68	1.29	2.50	.46
Aster simplex					.08		2.12
Baptisia leucophaea	.14		.85	1.88	.24		.03
Calamagrostis canadensis							10.48
Carex atherodes							.75
Carex aquatilis							1.11
Carex gravida							.01
Carex lasiocarpa							.28
Carex retrorsa							2.07
Chenopodium album							.01
Cirsium altissimum			.33		.48		.60
Comandra umbellata	.14	.19	.19		.08	.21	.05
Convolvulus sepium	.97		.28		.04		
Desmodium canadense		.65	1.88	2.19		2.71	1.64
Elymus canadensis	.28	.19	.24	2.19	.44	1.04	.60
Equisetum kansanum	.14		.05	.31	.44	.42	.12
Eryngium yuccifolium			.61		.65		.38
Fragaria virginiana	.14	.19	.24		.16		2.15
Galium obtusum			.14		.65	.42	1.83
Gentiana andrewsii							.01
Helenium autumnale							.03
Helianthus grosseserratus			1.65	.31	2.58	1.25	9.26
Helianthus laetiflorus	3.19	6.20	3.87	6.87	2.18	4.79	.18
Helianthus maximiliani							
Heliopsis helianthoides			.28				.03
Lactuca scariola					.24		.01
Lathyrus palustris							.08
Lathyrus venosus	.56	.09	.24	1.88			
Lespedeza capitata		.65				.21	
Liatris pycnostachya			.14	.31	1.21		.40
Lithospermum canescens	.28	.56	.52	.31	.56	1.04	.17
Lycopus americanus					.04		.11
Lysimachia chiliata							
Lysimachia hybrida							
Lysimachia quadriflora							.03
Lythrum alatum							.01
Mentha arvensis							.12
Muhlenbergia racemosa						.21	.23
Oxalis stricta		.09		1.88			
Panicum capillare						.21	.01
Panicum leibergii	6.67	7.50	2.64	4.06	.77	3.33	1.20
Panicum virgatum		1.20	.14		.44	2.71	.49
Pedicularis canadensis					.04		
Petalostemum candidum		.19	.09				
Petalostemum purpureum		.65			.12		.21

Table 4 continued.

Wh	Wa	C	H	H⁻	C⁻	G	Ga	GO	O
.42	.40	.07	.02	.09	.65				
.10		.09	.22	.17					
					.09				
.73	1.93	.33	.33	.04		.02			
12.19	9.09	10.87	14.42	11.57	14.25	.05	.13		
.63	.77	.46	1.74	1.31		.02			
			.02						
.73		.09	.25		.74	2.06	3.50	2.63	
			.02						
	.17								
								1.88	
	.03	.02	.16						
		.18							
	.71	.64	.07	.81					
2.81	1.22	2.81	2.59	2.42	1.76				
	1.70	1.18	.31	.55					
3.54	1.02	1.36	1.63	1.18	3.98	1.80	2.38		
	.17								
11.15		2.46	1.41	.81	13.61	45.26	56.88	1.50	
.63				.25		7.73	8.25	32.38	21.50
1.88		.20	.11	.64	1.48	3.90	3.00		
1.04		.04	.16	.25	.39	2.48	3.88	.25	
6.88		.37	.58	1.23	1.38	8.27	10.63	6.00	
.10	.77	.50	.67	.68	.19	.35			
	.45	.64	.16	.30	.09				
.10	.48					.14			
1.35	4.66	3.53	2.79	4.15	2.69	.14			
.31	1.08	1.10	.56	1.10	.37	.07			
.10	.31	.15	.11	.17					
	.26	.02							
.52	2.24	1.62	.96	.98	1.57	.07	.13		
2.08	1.42	2.43	1.52	2.16	1.85		.13		
		.18				.14			
		.31	.58	.30	.09				
13.85	5.17	9.96	7.86	6.31	12.41	3.36	4.63		
.10	.20			.04					
			.02						
	.34	.31	.18	.34	.65				
	.06		.02						
.10	.06		.05	.09		.02			
.10									
	.23								
.63	1.02	.72	.67	.42	.28				
.10	.48	.33	.22	.21	.09				
.10	.03	.02	.18	.04	.09	.05	.13		
		.02							
						.28			17.25
	.03	.02	.11	.04	.09				
						.19	.25		
						.02	1.31		
.10	.20	.42	1.47		.93	.05	.75		
	.43								
	2.70	1.57	.05	.68					
.31	.80	1.03	.51	.30	.83				
	.20	.46	.45	.25					
	.06		.02						
.31	.60	.50	.87	.42	.28				

TABLE 4. Average cover values for species in relation to soil series in 20-acre intensive study area.

Species	A	A⁻	N	Na	N⁻	Na⁻	W
Phalaris arundinacea							1.09
Phlox pilosa		.19			.16		.03
Physalis heterophylla		2.31	.28	1.88			
Physalis virginiana	.14	.09	.28		.08		.03
Poa pratensis	16.53	31.09	5.99	32.81		5.21	3.22
Polygonum coccineum							.44
Potentilla arguta	.14	.56	.05				
Psoralea argophylla	1.81	1.30	.15	.31	.08	.21	
Pycnanthemum virginianum		.28					.43
Ratibida pinnata	2.92	3.24	.05		.32	1.46	1.29
Rosa suffulta	.14	3.06	1.56	2.19		1.67	.29
Rudbeckia hirta					.04		
Scirpus atrovirens							
Scirpus fluviatilis							.01
Scutellaria leonardii		.09	.05		.08		.14
Senecio pauperculus							1.24
Setaria lutescens		.56					
Setaria viridis		.56		.31			
Silphium laciniatum			.38			1.25	2.15
Solidago canadensis	.14	2.41	3.21	.31	2.86	1.25	3.16
Solidago gymnospermoides			.09		.69	1.88	
Solidago missouriensis	1.67	.56	.28				
Solidago rigida		.56	3.25	.31	4.27	2.50	3.79
Sorghastrum nutans				.31	.20		.11
Spartina pectinata					.04		.83
Sporobolus heterolepis	12.08	21.76	62.69	37.19	58.95	27.92	37.41
Stipa spartea	.97	.09	.14		.08	.21	.05
Teucrium canadense			.05			.21	.23
Tahlictrum dasycarpum							.05
Vernonia fasciculata							.09
Veronicastrum virginicum							.01
Viola pedatifida			.09		.12		.05
Viola sp.							.03
Vicia americana	.28	.09	.05	.31	.04		.03
Zizia aurea	.14	.93	4.58	4.06	1.73	3.33	1.52
Allium sp.							
Aster novae-angliae							.09
Cacalia tuberosa							.01
Ceanothus americana	10.56	.56			.04		
Panicum implicatum					.04		.15
Prenanthes racemosa							.09
Solidago nemoralis			.28		.93		.75
Solidago riddellii							.01
Taraxacum officinale							

but in mappable units with fairly discrete boundaries. This would tend to cause vegetation sensitive to carbonate influence to group accordingly.

An ordination of species, utilizing the data from Tables 3 and 4, isolated taxa having distinct distribution patterns. These species are *Amorpha canescens, Andropogon gerardi, Aster ericoides, Aster laevis, Calamagrostis canadensis, Carex athorodes, Carex aquatilis, Desmodium canadense, Helianthus grosseserratus, Helianthus laetiflorus, Panicum leibergii, Phalaris arundinacea, Poa pratensis, Polygonum coccineum, Ratibida pinnata, Scirpus fluviatilis, Silphium laciniatum, Solidago canadensis, Solidago rigida, Spartina pectinata, Sporobolus heterolepis, Zizia aurea,* and *Ceanothus americanus*, all of which show distinct distribution patterns and in many cases high preference for certain soil groups or elevations.

The relationships between elevation and soil series are shown in Figure 16. The soil types are positioned along the base line as

Table 4 continued.

Wh	Wa	C	H	H^-	C^-	G	Ga	GO	O
1.56						6.24	6.63	.75	
.63	.20	.09	.07	.17	.09				
	.06	.02	.05						
1.35	2.81	3.86	3.15	3.18	5.74	.05			
				.25		8.74	2.88	40.50	36.75
.10	.06								
.10	.45	.99	2.17	1.99	.83				
.10	1.73	3.05	1.94	1.91	.09				
	.68	.42	.20	.25					
		.09	.16						
						.35			
						1.87		13.63	17.50
.21	.11	.04	.09	.09	.09				
3.65	.48	2.45	3.59	2.84	9.17		.13		
						.14			
				.25					
7.40	2.95	3.84	4.69	4.79	3.61	.28	.75		
2.50	4.12	7.30	7.39	5.30	13.43	.05			
	.26			.09					
			.05						
.63	5.34	3.77	1.36		1.20				
.10	.17	.35	.63	.34	.09				
1.88	.28	.15	.54	.85	.56	7.22	6.88	3.38	
29.38	44.40	25.42	24.08	32.80	9.44	.79	.13		
.73	.28	.15	.38	.25	.09	.30		.13	
		.20	.38	.17	.09				
						.49			
.21				.04					
	.09	.31	.09	.25	.09				
	.09	.02	.02						
.31	3.41	5.31	4.64	5.13	3.52				
.10			.02						
		.13	.05	.04	.56				
		.04							
.73	1.02	.31	.47	.17					
2.92	.09	.50	.45	.03	.19				

they appeared in the field. In all cases where the noncalcareous soils had adjacent calcareous variants the calcareous variants showed higher average elevations.

Summary and Conclusions

1. *Sporobolus heterolepis* is the dominant plant of the upland prairie that places Kalsow Prairie within the "Consociation" designated by Weaver and Fitzpatrick (1934) as the Prairie-Dropseed type.

2. The vegetation of the upland prairie communities is best described and represented by the continuum concept as described by Curtis (1955).

3. The vegetation of the upland prairie has changed since Moyer's 1953 study. Species showing increased importance in my study are *Solidago canadensis, Solidago rigida, Panicum leibergii, Helianthus grosseserratus,* and *Fragaria virginiana.* Species decreasing in importance were *Phleum pratense, Poa pratensis, Zizia aurea, Schizachyrium scoparius,*

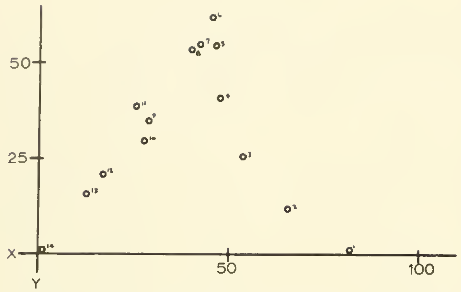

Fig. 15. Two-dimensional ordination of vegetation found at different elevations in the 20-acre study area; 1 = .7–1.2 feet elevation, 2 = 1.3–1.8 feet elevation, 3 = 1.9–2.4 feet elevation, 4 = 2.5–3.0 feet elevation, 5 = 3.1–3.6 feet elevation, 6 = 3.7–4.2 feet elevation, 7 = 4.3–4.8 feet elevation, 8 = 4.9–5.4 feet elevation, 9 = 5.5–6.0 feet elevation, 10 = 6.1–6.6 feet elevation, 11 = 6.7–7.2 feet elevation, 12 = 7.3–7.8 feet elevation, 13 = 7.9–8.4 feet elevation, 14 = 8.5–9.0 feet elevation.

Panicum virgatum, Sorghastrum nutans, and *Sporobolus heterolepis.*

4. Soil series, elevations, and species distribution patterns were mapped on an 8 ha intensive study plot. Elevation and soils data are correlated with species distribution patterns. All species show a response. Nine general patterns of distribution are described, with the following species as examples:

a. *Andropogon gerardi*—species of wide distribution, limited only by conditions peculiar to the drainage areas of the prairie.
b. *Silphium laciniatum*—a pattern closely resembling that of *Andropogon gerardi* but showing limited distribution on the higher and drier ridges.
c. *Ambrosia artemisifolia*—species limited to the border weed communities.
d. *Amorpha canescens*—a pattern common to species limited to the ridges and lower slopes.
e. *Solidago nemoralis*—species limited to mid- and upland slopes of the prairie.
f. *Ceanothus americanus*—a pattern limited to the ridges and drier sites of the prairie.
g. *Helenium autumnale*—limited to growth on soils that are highly calcareous to the surface.
h. *Calamagrostis canadensis*—limited to growth along the shallower areas of the pothole and drainage system.
i. *Scirpus fluviatilis*—growth corresponds to deeper areas within the drainage system.

5. Species occurring in the intensive study were ordinated using Orloci's (1966) method. The technique did not delineate associated groups of species, yet it pointed out species exhibiting peculiar distribution patterns. Such species are useful as indicator species.

6. Indices of interspecific association were computed for all participating species (Cole 1949) and found to be extremely useful in identifying clusters or groups of species having similar ecological amplitudes.

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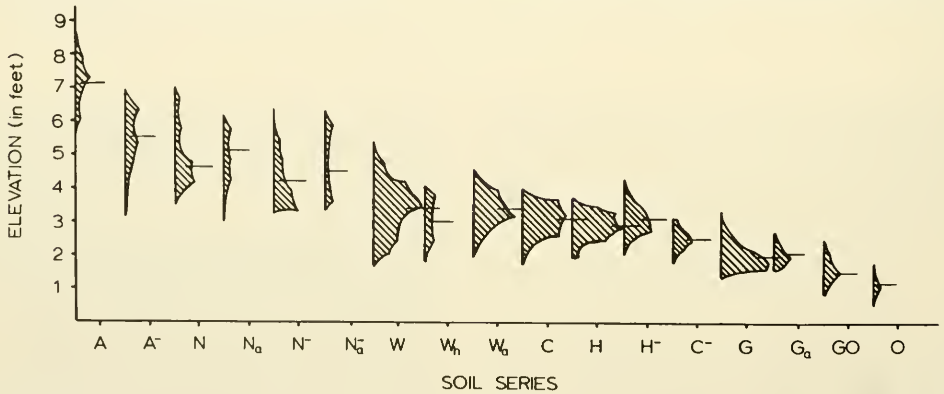

Fig. 16. Relationships between elevation and soil series as found in 20-acre intensive study area; mean value indicated for each soil by short horizontal line.

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DEER MOUSE, *PEROMYSCUS MANICULATUS*, AND ASSOCIATED RODENT FLEAS (SIPHONAPTERA) IN THE ARCTIC-ALPINE LIFE ZONE OF ROCKY MOUNTAIN NATIONAL PARK, COLORADO

R. B. Eads[1] and E. G. Campos[1]

Abstract.— *Peromyscus maniculatus* and related small rodents have been examined for ectoparasites in the tundra region of the Rocky Mountain National Park 1974–1979. One hundred and ninety-four *P. maniculatus* were examined from two tundra sites. Flea infestation rates were 1.9 fleas per mouse examined and 4.1 fleas per infested mouse. Species taken in significant numbers were *Monopsyllus thambus* (51 percent), *Peromyscopsylla hesperomys* (34 percent), *Malaraeus euphorbi* (9 percent), and *Catallagia calisheri* (4 percent). *Peromyscus maniculatus* host/flea relationships in the tundra are compared with those in other life zones in the park.

Personnel of the Vector-Borne Diseases Division have studied ectoparasite/host relationships in the Rocky Mountain National Park (RMNP) for a number of years. Of principal interest have been vectors and reservoirs of *Yersinia pestis* and Colorado tick fever virus. All life zones in the Park have been investigated. Because of a dearth of published information concerning fleas and other ectoparasites of rodents in the arctic-alpine life zone of the Rocky Mountains, data obtained during the period 1974–1979 in the zone are presented here. Emphasis has been placed on the deer mouse, *Peromyscus maniculatus*, as it is by far the most abundant rodent in the zone. *Peromyscus maniculatus* fleas in the tundra are compared with those in other life zones.

Study Area

The RMNP is located in Larimer and Boulder counties in north central Colorado. It covers 1046 km² of mountainous terrain, with elevations ranging from 2400 to over 4300 m.

Regional ecosystems of north central Colorado, with approximate elevations as defined by Marr (1961), include the grassland-lower montane ecotone region (1707–1829 m), lower montane forest climax region (1829–2347 m), lower montane-upper montane ecotone region (2347–2438 m), upper montane forest climax region (2438–2743 m), upper montane-subalpine ecotone region (2743–2835 m), subalpine forest climax region (2835–3353 m), subalpine-alpine ecotone region (3353–3475 m), and alpine tundra climax region (3475 m-mountain tops).

Collections in the tundra were concentrated at sites 1 and 2, located as shown in Figure 1. Site 1 is 2.5 km west of Rainbow Curve on Trail Ridge Road at an elevation of around 3475 m. Site 2 is on Fall River Road, some 1.5 km below the Alpine Visitors Center at an elevation of approximately 3523 m. Sites 1 and 2 are in areas with limited human activity. Trapping was confined to an area of 5 or 6 ha in both locations. In the tundra (Fig. 2) short grasses, sedges, and forbes predominate in the exposed meadows. Somewhat taller grasses and dwarf shrubs are found in low-lying areas partially protected from the violent winds that sweep the tundra.

Methods

Mammals were captured in the tundra, primarily in Sherman live traps (7.62 × 7.62

[1]Vector-Borne Diseases Division, Center for Infectious Diseases, Centers for Disease Control, Public Health Service, U.S. Department of Health and Human Services, Post Office Box 2087, Fort Collins, Colorado 80522-2087.

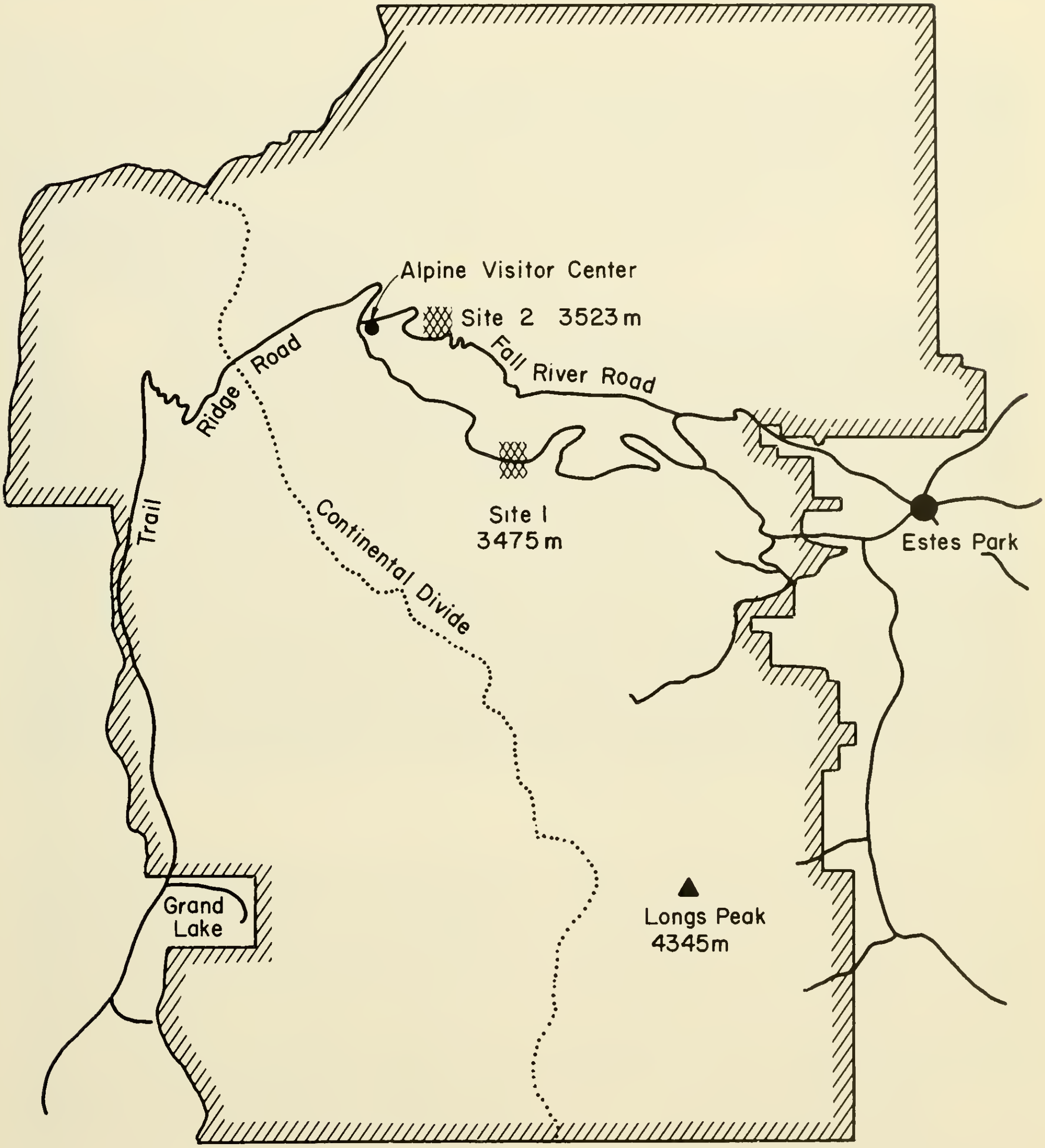

Fig. 1. Flea collection sites in the Rocky Mountain National Park, Larimer County, Colorado.

× 22.86 cm), with National live traps (12.7 × 12.7 × 40.64 cm) also used on occasion. No attempts were made to collect larger mammals. Traps baited with rolled oats were set in parallel lines of 20 stations at approximately 20 m intervals. Traps were placed adjacent to rocky outcroppings, when available, to provide trapped rodents some protection from the elements. The number of lines varied, but there were usually 4 or 5, 25 m apart. Traps were set in the morning and inspected the following day.

Trapping in the tundra was limited to the summer months. Trail Ridge and Fall River roads were only open to vehicular traffic June–September, with some closures at irregular intervals during this period due to hazardous driving conditions.

As the Sherman traps were picked up, those containing rodents were placed in plastic bags to prevent loss of fleas during transport to a field laboratory. Each mammal was lightly anesthetized with ether and brushed in a white enamel pan to remove ectopara-

Fig. 2. Tundra region, Rocky Mountain National Park.

sites. Certain animals were bled, ear tagged, and released, and serological tests for plague and Colorado tick fever were performed. Others were held for more extensive ectoparasite recovery efforts, including examination of the mice under a dissecting microscope. Fleas collected were held in 2 percent saline solution for plague testing or in 70 percent alcohol for definitive taxonomic studies.

Results and Discussion

Trapping over a six-year period (1974–79) has provided considerable information on deer mouse host/flea relationships in the Colorado tundra region. As shown in Table 1, 156 *P. maniculatus* were captured in this period during the summer months at Site 1. An average of 8 *P. maniculatus* were taken per 100 trap nights. About 47 percent were infested with fleas, with a mean number of 2.1 fleas per animal examined and 4.4 per infested animal. Site 2 was trapped less frequently than Site 1. As shown in Table 2, the flea burden was 1.1 fleas per mouse and 2.9 fleas per infested mouse.

Ectoparasites other than fleas were infrequently encountered on deer mice in the tundra. Fewer than 10 percent were infested, usually lightly, with the sucking louse, *Hoplopleura hesperomydis.* Larval chigger mites were somewhat more prevalent. *Neotrombicula harperi*, *N. microti*, and *Euschoengastia guntheri* were taken. A single larval argasid tick was recovered from a *P. maniculatus* above the tree line, probably an *Argas* sp.

The second most prevalent rodent taken in the tundra was the heather vole, *Phenacomys intermedius.* Twenty-three were examined, and 65 percent were infested with three species of fleas at the rate of 2.4 fleas per animal and 3.6 per infested animal. Species included *Peromyscopsylla selenis* (67 percent), *Megabothris abantis* (19 percent), and *Monopsyllus thambus* (15 percent). Two species of chigger mites, *N. harperi* and *E. guntheri*, were recovered from heather voles. One vole was heavily infested and several lightly infested with the dermanyssid mite *Hirstionyssus isabellinus.*

TABLE 1. *Peromyscus maniculatus* examined for fleas in the tundra region of the Rocky Mountain National Park (Site 1).

Date	Percent traps with *P. manic.*	Number *P. manic.*	Number with fleas	Total fleas	Mean number fleas/animal	Mean number fleas/ infested animal
7-16-74	9	11	6	19	1.73	3.17
7-24-74	8	6	3	31	5.17	10.33
8-14-74	10	10	4	11	1.1	2.75
8-15-74	8	6	3	16	2.67	5.33
9-26-74	15	18	4	6	.33	1.5
8-22-75	14	17	11	19	1.12	1.73
8-18-76	6	7	3	7	1.0	2.33
6-29-77	7	2	2	10	5.0	5.0
8-17-77	5	10	4	22	2.2	5.5
9-02-77	5	4	3	6	1.5	2.0
9-09-77	10	4	1	4	1.0	4.0
6-27-78	5	6	4	26	4.33	6.5
7-07-78	3	3	1	2	.67	2.0
7-25-78	5	4	2	12	3.0	6.0
8-03-78	3	4	4	6	1.5	1.5
9-07-78	16	17	7	22	1.29	3.14
7-10-79	7	7	3	16	2.29	5.33
7-18-79	6	6	3	54	9.0	18.0
8-24-79	12	14	6	36	2.57	6.0
	8.11	156	74	325	2.08	4.39

Lesser numbers of the least chipmunk, *Eutamias minimus* (7); golden-mantled ground squirrel, *Spermophilus lateralis* (3); yellow-bellied marmot, *Marmota flaviventris* (2); and pika, *Ochotona princeps* (3) were captured and examined.

Eleven fleas, 10 *Monopsyllus eumolpi*, and one *M. thambus* were removed from 4 of the 7 chipmunks. The 2 marmots were infested with 7 *Thrassis stanfordi* and 2 *Oropsylla rupestris*. Three *Oropsylla idahoensis* were recovered from 2 of the 3 golden-mantled ground squirrels. The 3 pikas examined were infested with the following fleas: 46 *Amphalius necopinus*, 46 *Ctenophyllus terribilis*, and 1 *M. thambus*. The chigger mite, *N. microti*, was also taken from all 3 pikas.

Peromyscus maniculatus host/flea relationships in the tundra have proven to be distinctive relative to the other life zones in the

TABLE 2. *Peromyscus maniculatus* examined for fleas in the tundra region of the Rocky Mountain National Park (Site 2).

Date	Number of mice trapped	Number with fleas	Number and species of fleas
7-17-74	3	1	2 *Monopsyllus thambus*
7-24-74	4	2	3 *M. thambus* 1 *Malaraeus euphorbi*
8-17-77	10	4	9 *M. thambus* 7 *M. euphorbi* 4 *Peromyscopsylla hesperomys* 1 *Megabothris abantis* 1 *Catallagia calisheri*
9-02-77	4	3	5 *P. hesperomys* 2 *M. thambus* 1 *C. calisheri*
9-09-77	15	4	3 *M. thambus* 2 *P. hesperomys* 1 *M. euphorbi*
9-24-77	2	1	1 *Peromyscopsylla selenis*
TOTALS	38	15	43

RMNP. As shown in Table 3, 21 species were recovered in 1974 and 20 in 1975 in all life zones. This is well over twice the number of species found to be parasitizing deer mice in the tundra. The 2 × ratio remains virtually unchanged when the recoveries are limited to normal or true parasites of deer mice, excluding species that have strayed from environmental associates.

Monopsyllus wagneri was the principal flea below the treeline (68 percent); over 60 percent of the deer mice were infested in 1974–1975. The only other prevalent species were *Malaraeus telchinum* (10 percent of total fleas) and *Opisodasys keeni* (8 percent of total fleas). Each of the other 11 species normally parasitic on deer mice made up 1–5 percent of the total fleas. As shown in Table 4, mean infestation rates for the 2,090 *P. maniculatus* examined in all life zones in the RMNP in 1974–76 were 1.2 fleas per mouse and 2.5 fleas per infested mouse.

Higher flea infestation rates per deer mouse were obtained in the tundra than in the other life zones. This may be a reflection of more intensive examination of the mice in the tundra. Also, tundra mice were usually held for several examinations, and in the other life zones normal procedure was to inspect them once, tag and release them. A total of 194 deer mice were examined from the two tundra sites, and 368 fleas were recovered from 89 of them. This is a rate of 1.9 fleas per mouse examined and 4.1 fleas per infested mouse.

In the tundra, fewer species were involved in parasitizing deer mice than in the other life zones. Only four were taken in significant numbers. *Monopsyllus wagneri* disappears completely from the mice in the tundra and is replaced by *M. thambus* (51 percent of total fleas at Site 1 and 44 percent at Site 2). Overlapping of the two species occurred at Rainbow Curve, elevation approximately 3290 m. This scenic overlook consists of an exposed rocky slope with large boulders bordered by subalpine forest.

TABLE 3. Species of fleas from *Peromyscus maniculatus* in all life zones in Rocky Mountain National Park in 1974–1975.

Species	1974 Number of fleas—1,018		1975 Number of fleas—1,357	
	Percent of total fleas	Percent of animals with species	Percent of total fleas	Percent of animals with species
CERATOPHYLLIDAE				
Malaraeus euphorbi	1	1.3	1.5	1.3
M. telchinum	5.9	7.3	14.5	17.5
Megabothris abantis	< 1	< 1	< 1	< 1
Monopsyllus eumolpi	< 1	< 1	< 1	< 1
M. thambus	4.1	3.6	< 1	< 1
M. wagneri	64.8	60.8	70.3	60
M. vison	< 1	< 1	< 1	< 1
Opisocrostis labis	< 1	< 1	< 1	< 1
Opisodasys keeni	9.9	9.5	5.8	7.3
Orchopeas leucopus	< 1	< 1	–	–
Oropsylla idahoensis	1	1.7	< 1	1.6
HYSTRICHOPSYLLIDAE				
Callistopsyllus deuterus	–	–	< 1	< 1
Catallagia calisheri	< 1	< 1	< 1	< 1
C. decipiens	4.4	3.9	1.8	3
C. neweyi	< 1	< 1	< 1	< 1
Epitedia wenmanni	2.4	4.1	2	3.6
Hystrichopsylla occidentalis	< 1	< 1	< 1	< 1
Megarthroglossus sp.	< 1	< 1	–	–
M. divisus	–	–	< 1	< 1
Rhadinopsylla sectilis	< 1	< 1	< 1	< 1
LEPTOPSYLLIDAE				
Amphipsylla sibirica	< 1	< 1	< 1	< 1
Peromyscopsylla hesperomys	4.2	4.5	< 1	1.9
P. selenis	< 1	< 1	–	–

TABLE 4. Summary of flea collections from *Peromyscus maniculatus* from all life zones in Rocky Mountain National Park, 1974–1976.

Year	Number of mice examined for fleas	Number of mice with fleas	Percent of mice infested	Total number of fleas	Number of fleas/ mouse	Number of fleas/ infested mouse
1974	955	431	45.1	1,018	1.1	2.4
1975	957	507	53.0	1,357	1.4	2.7
1976	178	80	44.9	183	1.0	2.3
TOTALS	2,090	1,018	48.7	2,558	1.2	2.5

Peromyscopsylla hesperomys was the second most prevalent *P. maniculatus* flea in the tundra (35 percent of the total fleas at Site 1 and 26 percent at Site 2). This flea is found on deer mice in all life zones of the RMNP but in much smaller numbers at the lower elevations, making up <5 percent of the total fleas collected in the park.

The third most common species on deer mice in the tundra, *Malaeraeus euphorbi* (7 percent of the total fleas at Site 1 and 21 percent at Site 2) was also more prevalent than at lower altitudes. Less than 2 percent of total fleas collected in the park were this species.

A nest flea, *Catallagia calisheri*, was a poor fourth on tundra deer mice. However, the fact that 4 percent of the fleas at Site 1 and 5 percent at Site 2 were this species is indicative of much greater numbers in the nests. *Catallagia calisheri* was not taken below the tree line. At lower elevations in RMNP, the common deer mouse nest *Catallagia* was *decipiens*. Single specimens of the nest fleas, *Callistopsyllus deuterus* and *Megarthroglossus* sp. (female) were taken from deer mice in the tundra. Both genera were also rarely encountered in other RMNP life zones. *Orchopeas leucopus*, a common *Peromyscus* parasite at lower elevations, was rare in the park. It was taken but once in the tundra and once in other RMNP life zones. The only other fleas taken from deer mice in the tundra were a few *Megabothris abantis* and *Peromyscopsylla selenis*, strays from heather voles.

CONCLUSIONS

Our data concerning the fleas of *P. maniculatus* support the conclusions of Wenzel and Tipton (1966) that the altitudinal ranges of many ectoparasites do not necessarily coincide with those of the hosts. *Peromyscus maniculatus* is prevalent in the RMNP at all elevations. However, vertical stratification is evident in the species of fleas parasitizing them, especially at the upper levels. In the tundra, around 3475 m, the number of flea species on *P. maniculatus* was greatly reduced from the lower elevations, but the mean number per animal was somewhat higher. Only four species were encountered in significant numbers on *P. maniculatus* in the tundra. *Monopsyllus thambus* and *Catallagia calisheri*, found only on the tundra, replaced *M. wagneri* and *C. decipiens* of lower elevations, respectively. *Peromyscopsylla hesperomys* and *Malaraeus euphorbia*, found at all elevations studied in RMNP, were significantly more prevalent on *P. maniculatus* in the tundra than at lower elevations.

ACKNOWLEDGMENTS

Excellent cooperation has been received from naturalists of the National Park Service, U.S. Department of Interior, during these studies. Ray Bailey, Vector-Borne Diseases Division statistician, was most helpful in supplying computerized data. Gary Maupin took the tundra photograph. Numerous persons, presently and formerly with VBDD, contributed to the field investigations. Included were Dr. R. G. McLean, Dr. A. M. Barnes, Ronald Shriner, Karen Pokorny, Gary Maupin, Leon Carter, Edwin Heidig, William Archibald, and David Pegg.

Taxonomic assistance was kindly provided by the following authorities: Dr. J. E. Keirans (ticks), Dr. R. B. Loomis (chigger mites), and Dr. K. C. Emerson (sucking lice).

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FOOD OF LARVAL TUI CHUBS, *GILA BICOLOR*, IN PYRAMID LAKE, NEVADA[1]

David L. Galat[2] and Nancy Vucinich[3]

Abstract.— Four near-surface locations in Pyramid Lake, Nevada, were sampled for larval tui chubs (*Gila bicolor*) during summer and early fall 1979. Numbers of larvae collected were highest in mid-July. Zooplankton was the only food eaten throughout the survey; the cladoceran *Moina hutchinsoni* was the major species eaten at all locations. Another cladoceran, *Diaphanosoma leuchtenbergianum*, was also important to the diet of pelagic larvae, and the copepod *Cyclops vernalis* was eaten in significant quantities by nearshore fish. Changes in diet composition of larval tui chubs during summer corresponded to seasonal succession of zooplankton species in Pyramid Lake.

The tui chub, *Gila bicolor*, is a polytypic cyprinid native to drainage systems in Oregon, California, and Nevada (Moyle 1976). It is the most abundant fish in Pyramid Lake, Nevada, where adults constitute over 90 percent of gill net catches (Vigg 1978, 1981). A major role of this species in the economy of Pyramid Lake is as forage for the primary sport fish, the Lahontan cutthroat trout (*Salmo clarki henshawi*), which commonly attains trophy weights of over 3 kg (Snyder 1917, Kucera 1978, Galat et al. 1981).

LaRivers (1962), Langdon (1979), and Vucinich et al. (1981) provided information on food of adult and juvenile tui chubs in Pyramid Lake; Miller (1951), Kimsey (1954), and Cooper (1978) presented similar information for this species in other waters; and Williams and Williams (1980) described the food of related *Gila* species. We present data on abundance, distribution, and food of the previously uninvestigated larval phase of the tui chub in Pyramid Lake.

Methods

Two shallow littoral stations in Pyramid Lake (40° 00′ N, 119° 35′ W), one northeast and the other southeast of Sutcliffe, Nevada, were quantitatively sampled for larval tui chubs between 18 June and 9 August 1979. A metered 1 mm-mesh net, 0.5 m in diameter, was hand-towed along the surface at about the 1 m depth contour and parallel to shore. However, only 2 of 10 attempts at collecting larval tui chubs in the shallow littoral region were successful and only three larvae were captured. Because so few fish were recovered from these locations they are not discussed further.

Two deeper littoral locations were also quantitatively sampled for larval fishes: a surface pelagic station, northeast of Sutcliffe, Nevada, at the 72 m depth contour, and a surface nearshore station, southeast of Sutcliffe at the 5–10 m depth contour, were sampled every two weeks from 26 June through 26 October 1979. Larvae were collected with the 0.5 m net described above, towed 1–3 m below the surface behind a boat. Fish collected were immediately killed in MS-222 to minimize regurgitation and preserved in 10 percent formalin.

After identifying larvae as tui chubs and measuring their fork lengths (FL), the entire digestive tract was removed. Contents from a maximum of 10 nonempty larval tracts were pooled for each date and station where more than two fish were collected. All zooplankters recovered from larval fish were identified to species and enumerated under a compound microscope at 40–200X. Algae and unidentifiable matter (e.g., detritus and digested material) were never observed in substantial amounts and were not quantified.

Numbers of organisms recovered from guts were converted to carbon equivalents based on the average carbon content of whole

[1]The Colorado Cooperative Fishery Research Unit is supported by the U.S. Fish and Wildlife Service, Colorado Division of Wildlife, and Colorado State University.
[2]Cooperative Fishery Research Unit, Colorado State University, Fort Collins, Colorado 80523.
[3]Pyramid Lake Indian Tribal Enterprises, Star Route, Sutcliffe, Nevada 89510.

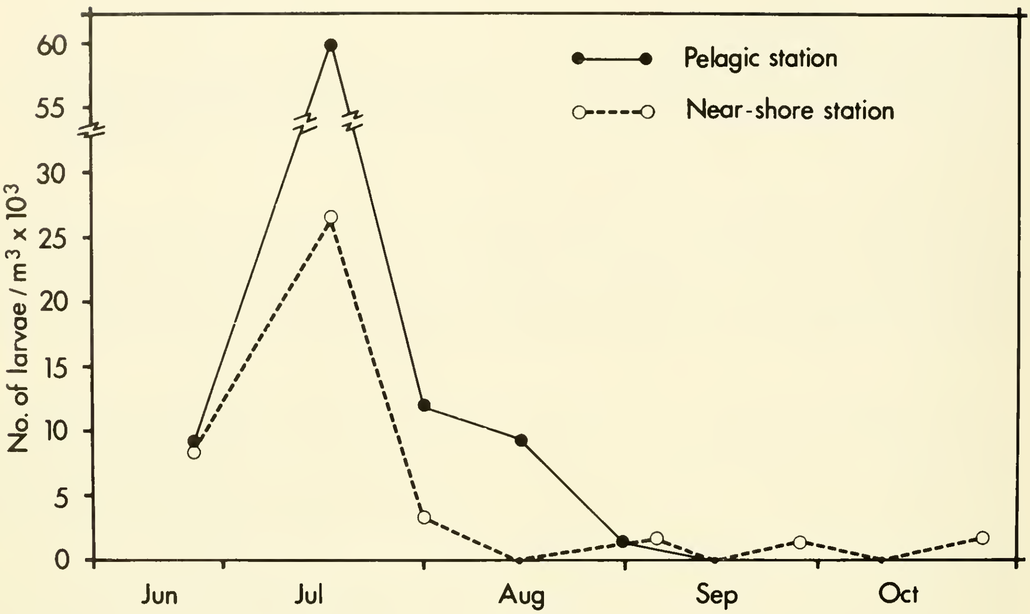

Fig. 1. Numbers of tui chub larvae collected near the surface at two locations in Pyramid Lake, Nevada, 1979.

organisms as measured with a Hewlett-Packard model 185B CHN analyzer, following Sharp's (1974) procedures. Because carbon values were not obtained for *Daphnia schodleri* or copepod nauplii, these organisms were assigned approximate carbon equivalents relative to their intact size. We selected this approach over volumetric or weight techniques because it more accurately reflected the bioenergetic significance of a food item to the fish's diet.

Results and Discussion

The length range of larval tui chubs captured was 6–15 mm. Following Snyder's (1976) terminology, only mesolarvae (<12 mm FL) and metalarvae (≥ 12 mm) were identified from our collections. Yolk sacs were not apparent in any larvae. The alimentary tract was straight and tubelike in larvae up to 13 mm long; in progressively larger fish it began to loop and swell anteriorly. The transition of fish from metalarva to juvenile occurred at a length of about 15 mm.

Estimated larval abundance at the pelagic and nearshore stations peaked in mid-July at 0.06 and 0.03 larvae/m^3, respectively (Fig. 1), when water temperature from the surface to a depth of 5 m was 21 C. This period coincides with the reported time of peak tui chub spawning in Pyramid Lake (Kucera 1978). By September few larvae were collected at the surface nearshore station, and none at the surface pelagic site.

Digestive tracts from tui chubs taken on four pelagic and three nearshore sampling dates, totaling 25 and 14 larvae, respectively, were examined. Guts were usually one-half to three-quarters full and contained only zooplankton (Tables 1 and 2).

Moina hutchinsoni was the dominant zooplankter recovered from all pelagic larvae sampled and was also of greatest significance to larvae in two of three nearshore collections. *Diaphanosoma leuchtenbergianum* ranked second in importance among food items for pelagic larvae but was of minor importance among nearshore larvae. In contrast, *Cyclops vernalis* appeared in all three nearshore samples but was insignificant in pelagic larval stomachs. *Alona costata* was observed in larvae from two nearshore samples but was not recovered from pelagic larvae. Food items eaten in small amounts were *Eucypris* sp., *Branchionus* spp., *Daphnia schodleri,* and copepod nauplii.

We anticipated finding more rotifers and copepod nauplii in larval tui chub stomachs, particularly since these groups were abundant in littoral zooplankton samples (Vucinich et al. 1981). Kimsey (1954) reported that

TABLE 1. Pooled stomach contents of pelagic larval tui chubs from Pyramid Lake, Nevada. Carbon values are approximate and represent reconstructed organisms. Numbers in parentheses are subtotals for the various categories.

	June 26			July 17			July 31			August 15		
Food item	No.	Total C (μg)	Percent Total C	No.	Total C (μg)	Percent Total C	No.	Total C (μg)	Percent Total C	No.	Total C (μg)	Percent Total C
Cladocera	(8)	(22)	(98.7)	(32)	(88)	(99.7)	(55)	(150)	(98.4)	(50)	(139)	(96.8)
Moina	8	22	98.7	24	67	75.7	34	95	62.5	45	126	87.7
Diaphanosoma				7	18	20.5	21	55	35.9	5	13	9.1
Alona												
Daphnia				1	2.8	3.2						
Copepoda							(2)	(1.0)	(0.7)	(4)	(4.5)	(3.2)
Cyclops										1	3.0	2.1
Nauplii							2	1.0	0.7	3	5	1.1
Rotatoria												
Brachionus	1	0.3	1.3	2	0.5	0.6	5	1.4	0.9			
Ostracoda												
Eucypris												
Grand total	9	22		34	88		62	152		54	144	
No. tracts examined	3			14			7			6		
No. tracts with food	2			10			7			6		
Mean fish length (mm)	10.2			10.2			10.9			11.9		

newly hatched tui chubs in Eagle Lake, California, fed on rotifers, diatoms, desmids, and other microscopic material. Perhaps tui chub larvae smaller than those captured in the present study fed on these organisms.

Digestive tracts from larvae captured at the surface nearshore station contained more *C. vernalis*, *A. costata*, and *Eucypris* sp. than were recovered from larvae collected at the surface pelagic station. Conversely, *D. leuchtenbergianum* was more abundant in guts from pelagic tui chubs. A probable explanation for these differences is that the first three zooplankton taxa named prefer a benthic habitat and hence would be more available than *D. leuchtenbergianum*, a limnetic species, to nearshore tui chubs (Pennak 1978). Shifts in larval tui chub diet composition

TABLE 2. Pooled stomach contents of near-shore larval tui chubs from Pyramid Lake, Nevada. Carbon values are approximate and represent reconstructed organisms. Numbers in parentheses are subtotals for the various categories.

	June 26			July 17			July 31		
Food item	No.	Total C (μg)	Percent Total C	No.	Total C (μg)	Percent Total C	No.	Total C (μg)	Percent Total C
Cladocera	(7)	(18)	(33.2)	(66)	(183)	(80.2)	(31)	(87)	(96.7)
Moina	2	5.6	10.9	60	168	73.6	31	87	96.7
Diaphanosoma				4	10	4.6			
Alona	5	12	22.3	2	4.6	2.0			
Daphnia									
Copepoda	(23)	(35)	(66.8)	(8)	(19)	(8.3)	(1)	(3.0)	(3.3)
Cyclops	23	35	66.8	6	18	7.9	1	3.0	3.3
Nauplii				2	1.0	0.4			
Rotatoria									
Brachionus				21	5.7	2.5			
Ostracoda									
Eucypris				3	21	9.0			
Grand total	30	53		98	228		32	90	
No. tracts examined	3			10			2		
No. tracts with food	2			10			2		
Mean fish length (mm)	10.3			12.8			12.8		

from *C. vernalis* to *D. leuchtenbergianum* and *M. hutchinsoni* as the summer progressed paralleled seasonal changes in the relative abundance of these zooplankton species in Pyramid Lake (Galat et al. 1981), suggesting that larval tui chubs, like adults (Langdon 1979), are opportunistic feeders.

ACKNOWLEDGMENTS

We thank the Pyramid Lake Paiute Indian Tribe for granting us permission to conduct this study. We also thank E. P. Bergersen, K. Hamilton-Galat, E. P. Eschmeyer, and D. Snyder for their critical review of the manuscript. Mark Coleman assisted with field collections and zooplankton identification. Study funding was provided by the Bureau of Indian Affairs under Contract 14-16-0008-974 to the U.S. Fish and Wildlife Service and Colorado State University.

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Volume 43 No. 2 April 30, 1983 Brigham Young University

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6-83 650 66305

ISSN 017-3614

The Great Basin Naturalist

PUBLISHED AT PROVO, UTAH, BY
BRIGHAM YOUNG UNIVERSITY

ISSN 0017-3614

VOLUME 43 | April 30, 1983 | No. 2

UTAH FLORA: COMPOSITAE (ASTERACEAE)

Stanley L. Welsh[1]

ABSTRACT.— A revision of the sunflower family, Compositae (Asteraceae), is presented for the state of Utah. Included are 613 taxa in 100 genera. Keys to genera, species, and infraspecific taxa are provided, along with detailed descriptions, distributional data, and pertinent discussion. Many nomenclatural changes have been necessary to bring Utah composites into line with contemporary interpretations of the family. They include: *Artemisia tridentata* Nutt. var. *wyomingensis* (Beetle & Young) Welsh; *Aster kingii* D.C. Eaton var. *barnebyana* (Welsh & Goodrich) Welsh; *Brickellia microphylla* (Nutt.) Gray var. *watsonii* (Robins.) Welsh; *Chrysothamnus nauseosus* (Pallas) Britt. — var. *abbreviatus* (Jones) Welsh, var. *arenarius* (L.C. Anderson) Welsh, var. *glareosus* (Jones) Welsh, var. *iridis* (L.C. Anderson) Welsh, and var. *nitidus* (L.C. Anderson) Welsh; *Cirsium arizonicum* (Gray) Petrak var. *nidulum* (Jones) Welsh; *Cirsium calcareum* (Jones) Woot. & Standl. — var. *bipinnatum* (Eastw.) Welsh and var. *pulchellum* (Greene) Welsh; *Cirsium neomexicanum* Gray var. *utahense* (Petrak) Welsh; *Cirsium undulatum* (Nutt.) Spreng. var. *tracyi* (Rydb.) Welsh; *Crepis runcinata* (James) T. & G. var. *glauca* (Nutt.) Welsh; *Erigeron speciosus* (Lindl.) DC. — var. *mollis* (Gray) Welsh and var. *uintahensis* (Cronq.) Welsh; *Gutierrezia petradoria* (Welsh & Goodrich) Welsh; *Gutierrezia pomariensis* (Welsh) Welsh; *Haplopappus racemosus* (Nutt.) Torr. — var. *sessiliflorus* (Greene) Welsh and var. *prionophyllus* (Greene) Welsh; *Haplopappus watsonii* Gray var. *rydbergii* (Blake) Welsh; *Lygodesmia grandiflora* (Nutt.) T. & G. — var. *arizonica* (Tomb) Welsh and var. *dianthopsis* (D.C. Eaton) Welsh; *Machaeranthera canescens* (Pursh) Gray — var. *commixta* (Greene) Welsh, var. *leucanthemifolia* (Greene) Welsh, and var. *vacans* (A. Nels.) Welsh; *Petradoria pumila* (Nutt.) Greene var. *graminea* (Woot. & Standl.) Welsh; and *Senecio spartioides* T. & G. var. *multicapitatus* (Greenm. in Rydb.) Welsh.

This paper is one of a series of works leading to a definitive treatment of the flora of Utah. Previous papers have dealt with the Brassicaceae, Fabaceae, Rosaceae, and miscellaneous smaller families.

The sunflower family has long been recognized for its great size and complexity both in Utah and elsewhere; it is probably the largest flowering plant family on earth. In Utah it consists of 100 genera and 613 taxa, of which some 40, or about 7 percent, are introduced. The 573 indigenous taxa comprise about 20 percent of the flora native to the state. This large family is apparently unique in total numbers, but is also unique in having such a small proportion of adventive taxa. The figures are misleading, to an extent, because of the omission of numerous cultivated ornamentals. Few actual crop or food plants are derived from members of this family. Only lettuce and sunflower are grown as crops or as garden plants from the vast array of species in this great family. Despite the paucity of food plants, there are many ornamental species. These have been included in the present treatment only when they have escaped, or when they have been planted routinely for many years, and when specimens have been preserved in the herbarium. The cultivated flora requires a separate intensive effort not herein attempted.

The importance of members of this family to wildlife, both as cover and as food, is well known by range managers. Despite the presence of chemical substances produced by the plants, which impart unpleasant flavors or

[1]Life Science Museum and Department of Botany and Range Science, Brigham Young University, Provo, Utah 84602.

even poisonous substances, many of them are eaten by both wildlife and by livestock. Sagebrush and rabbitbrush species are well known for their value in reclamation of sites requiring rehabilitation.

Negative values are reflected in the weedy species that occupy cultivated lands, in the mechanically injurious species (such as thistles and their relatives), and in the numerous poisonous kinds. Livestock losses have been reported in literature from utilization of species of the family, i.e., *Baileya*, *Hymenoxys* (especially *richardsonii*), *Oxytenia acerosa*, *Psilostrophe*, *Senecio*, and *Tetradymia*. Other plants are rendered unpalatable by their complex biochemical compounds, and they tend to increase on range lands where other more palatable plants are eaten selectively. *Gutierrezia* and *Chrysothamnus* species fit this latter category, although selected phases of the same *Chrysothamnus* species might be palatable or differentially palatable. Certainly there is much room for investigation of members of this huge assemblage.

The largest genus, and one of the most complex taxonomically, is *Erigeron*, with more than 60 taxa. Without the able monograph by Cronquist, and lacking his cooperative help, the species of *Erigeron* would have been much more difficult to interpret. Because of his knowledge, his dedication, and his helpful cooperation, this treatment is dedicated to him. The same kinds of problems, made even more complicated by extensive hybridization, is true for *Senecio*, which Barkley has treated so competently. Fortunately, monographs or revisions are available for most of the larger genera. However, no modern work is definitive for *Aster*, which requires interpretation on a cosmopolitan, rather than provincial, basis. Also, *Artemisia* has not been treated in its entirety for several decades. Much research on the nature of the biochemical constituents of *Artemisia* has shed light on the taxonomy of the group.

Difficulties in the composite genera and species, aside from those involving the great number of taxa, include those due to hybridization, ploidy level, and apomixis. Blending of morphological forms due to hybridization, subtle changes due to variations in chromosome sets, and the problems of interpretation of apomictic races each lead to problems not easily soluble. And the end results are subject to a variety of preliminary conclusions, each subject to change as additional information becomes available. Further, generic lines in the family are not definitive, with aggregations of species sometimes representing convenience rather than actual affinities. Recent workers have tended to segregate traditional genera into finer subunits or additional genera. This seems to represent a continuing trend, and it seems probable that some of the genera treated herein will be broken up in the future. The weight of evidence for doing so lies with the future workers. Those who find it modern to give "new" generic interpretations are often merely opting previous workers, whose interpretations were flawed. Another later generation will opt for a different set of names based on what they consider to be "modern."

Some of the species are edaphic specialists, occurring on definite substrates of restricted aerial or elevational distribution. The woody asters (*Xylorhiza*) are selenophytes and are restricted to shales and silt- and mudstones of fine-textured geological formations in eastern to southwestern Utah.

The present work should be considered tentative at best. Despite the large number of specimens available for study (13,700), many of the taxa are imperfectly known and distributions are yet to be understood. Monographic work is required for practically all groups, whether completed in the recent past or not. It is hoped that this work will provide a useful summary for those who work with Utah composites.

To the extent possible the work presented below contains the most modern names for the entities involved, based on application of contemporary International Rules of Botanical Nomenclature. Following the name of the entities are the synonyms that apply to Utah plants specifically. No attempt has been made to list synonymy exhaustively. The basionym has been included more or less uniformly, and an attempt has been made to cite all synonyms based on Utah plants, including a brief notation of type locality.

The discussion following the description of each species, or the name of the infraspecific taxon, includes the plant communities in which the taxon occurs. They are arranged in ascending order from dry low elevation communities to mesic high elevation communities. Community data is followed by elevational range (given in meters), counties of known occurrence (in alphabetical order), and the distribution outside Utah. At the end of the discussion are two numbers, the first, in Arabic numerals, indicates the number of Utah specimens examined for the taxon and the second, in Roman numerals, is the number collected in Utah by the author. The numbers are given to provide the reader with the basis of understanding of the taxon by the writer and his familiarity with the plants in the field. The plants are not equally well known by this writer, and the user should be able to make judgements when the taxonomy presented herein does not adequately approach the conditions as noted in the field. The approach to reality is always an approximation, and much improvement will take place in the future, as more information is derived from specimens not now available for the present study.

COMPOSITAE (ASTERACEAE)

Sunflower Family

Annual, biennial, or perennial herbs, or shrubs; leaves alternate, opposite, or whorled, simple, pinnatifid, or compound; inflorescence of involucrate heads, these solitary or several in corymbose, racemose, paniculate, or cymose clusters; flowers few to numerous on a common receptacle, surrounded by green bracts forming a cup-shaped, cylindrical, or urn-shaped involucre enclosing the flowers in bud; heads entirely of tubular (disk) corollas, entirely of ligulate (ray) corollas, or with tubular corollas forming a central disk and an outer radiating row of ligulate corollas; receptacle flat, convex, conic, or cylindric, naked or bearing chaffy bracts, scales, or hairs; calyx lacking, or crowning the summit of the ovary and modified as a pappus of capillary bristles, scales, or awns; stamens alternate with corolla lobes; filaments free (rarely connate); the anthers united and forming a tube (rarely separate); ovary inferior, of 2 carpels, 1-loculed and with a single ovule; styles 1, 2-cleft, exserted through the anther tube; fruit an achene. **Note:** All involucral measurements are from dried pressed herbarium specimens. The width measurements are sometimes broader than in fresh material.

ARNOW, L., B. ALBEE, AND A. WYCKOFF. 1980. Flora of the central Wasatch Front, Utah. Univ. of Utah Printing Service, Salt Lake City. 663 pp.

MEYER, S. E. 1976. Annotated checklist of the vascular plants of Washington County, Utah. Unpublished thesis, Univ. of Nevada, Las Vegas. 276 pp.

1. Corollas all raylike; plants usually with milky juice .... KEY 1
— Corollas not all raylike, some or all of them tubular; juice seldom if ever milky 2
2(1). Corollas all tubular; no ray flowers present, or the rays vestigial and minute .... KEY II
— Corollas not all tubular; ray flowers present 3
3(2). Pappus of capillary bristles, at least in part .... KEY III
— Pappus of awns or scales, or lacking 4
4(3). Pappus lacking .... KEY IV
— Pappus present, of awns or scales .... KEY V

KEY I.

Corollas all raylike; plants usually with milky juice.

1. Pappus lacking 2
— Pappus present 3

2(1). Rays 10–20 mm long; plants glabrous, with leaves in basal rosette .... *Atrichoseris*
— Rays 5–7 mm long; plants pubescent, with well-developed cauline leaves .... *Lapsana*

3(1). Pappus, at least in part, of plumose bristles 4
— Pappus of simple bristles, of awns, or of scales 7

4(3). Plants acaulescent, with merely bracteate stems .... *Hypochaeris*
— Plants caulescent 5

5(3). Achenes not beaked, truncate at apex; involucres usually less than 15 mm long .... *Stephanomeria*
— Achenes tapering or beaked at apex; involucres usually more than 15 mm long 6

6(5). Leaves pinnatifid; corollas white or pinkish; involucre with an outer series of short bractlets; southern Utah .... *Rafinesquia*
— Leaves not pinnatifid, entire; corollas yellow or purplish; involucre lacking short outer bractlets; widespread .... *Tragopogon*

7(3). Pappus of 1–3 series of unawned or awned scales 8
— Pappus of capillary bristles 9

8(7). Pappus of 2 or 3 series of unawned scales; corollas blue, closing by mid-morning .... *Cichorium*
— Pappus scales in a single series, awned; corollas yellow, not closing by mid-morning .... *Microseris*

9(7). Achenes more or less flattened; stems leafy; heads in panicles or in umbellate clusters 10
— Achenes not flattened; stems leafy or scapose; heads solitary or variously disposed 11

10(9). Involucres cylindric or ovoid-cylindric; achenes beaked; flowers yellow or blue .... *Lactuca*
— Involucres broadly campanulate to hemispheric; achenes not beaked; flowers yellow .... *Sonchus*

11(9). Corollas pink or purplish 12
— Corollas yellow or yellowish, or white or cream colored 14

12(11). Plants annual; heads mainly 5–7 mm long (from base of involucre to tip of pappus) .... *Prenanthella*
— Plants perennial; heads mainly 8–20 mm long or more 13

13(12). Plants with rigid spine-tipped branches .... *Stephanomeria*
— Plants unarmed, the branches soft .... *Lygodesmia*

14(11). Leaves all basal; heads solitary on scapose peduncles 15
— Leaves not all basal, the stems leafy; heads not on scapose peduncles 17

15(14). Achenes not beaked, truncate; pappus bristles barbellate .... *Microseris*
— Achenes beaked or tapering to apex; pappus not of barbellate bristles 16

16(15). Achenes 10-ribbed or 10-nerved, not spinulose; involucral bracts usually imbricated in several series .... *Agoseris*
— Achenes 4- to 5-ribbed, spinulose, especially near apex; principal bracts in a single series, the outer much shorter .... *Taraxacum*

17(14). Achenes ridged or tuberculate between the angles; leaves either crustaceous margined or peduncles stipitate-glandular; southwestern Utah 18
— Achenes striate between the angles; leaves and peduncles otherwise (rarely glandular setose in some *Crepis* species); widely distributed 19

18(17). Plants depressed annuals with crustaceous-margined leaves, not stipitate-glandular; achenes abruptly beaked, transversely ridged between the ribs .... *Glyptopleura*
— Plants erect, lacking crustaceous-margined leaves, conspicuously stipitate-glandular above; achenes tapering to a beak, not transversely ridged .... *Calycoseris*

19(17). Pappus bristles early deciduous, more or less united below and falling together, only a few of the stout outer ones may be persistent .... *Malacothrix*
— Pappus bristles persistent or tardily deciduous, and then falling separately 20

20(19). Pappus tan to brown; involucral bracts not thickened .... *Hieracium*
— Pappus white or whitish; involucral bracts somewhat thickened at base or on midrib .... *Crepis*

KEY II.

Corollas all tubular; no ray flowers present.

1. Heads unisexual, the pistillate heads with 1–4 flowers enclosed in involucre; involucre burlike or nutlike, only style tips exserted 2
— Heads perfect or unisexual; involucre not burlike or nutlike 4

2(1). Involucral bracts of the staminate heads separate; fruiting involucres burlike, covered with hooked appendages .... *Xanthium*
— Involucral bracts of the staminate heads united; fruiting involucres various but, if burlike, lacking hooked appendages 3

3(2). Shrubs; fruiting involucre with several transverse, scarious wings; leaves or their lobes linear-filiform .... *Hymenoclea*
— Shrubs or herbs; fruiting involucre lacking transverse wings; leaves and their lobes not linear-filiform .... *Ambrosia*

4(1). Stamens not united by their anthers; flowers always unisexual, the pistillate corollas none or much reduced 5
— Stamens with united anthers or rarely not united in some species with perfect flowers, at least some flowers usually perfect 7

5(4). Achenes long-villous; leaves or their lobes linear-filiform .... *Oxytenia*
— Achenes not long-villous; leaves or their lobes not linear-filiform 6

6(5). Pistillate flowers subtended by large, chaffy scales simulating inner involucral bracts; achenes with pectinate or winged margins .... *Dicoria*
— Pistillate flowers subtended by chaffy scales or these lacking; achenes without pectinate or toothed wings .... *Iva*

7(4). Involucral bracts with translucent, usually yellow or orange dots .... *Porophyllum*
— Involucral bracts without distinct dots; pappus various, but not as above 8

8(7). Pappus of capillary bristles, at least in part, these smooth, scabrous, barbellate, or plumose 9
— Pappus lacking or, if present, not of capillary bristles 41

9(8). Leaves opposite or whorled, some or all cauline 10
— Leaves alternate, at least basally, or basal and actually alternate 13

10(9). Corollas yellow; involucral bracts in 1 series or in 2 series, but all equal in length .... *Arnica*
— Corollas white, ochroleucous, flesh colored, blue, or purple; involucral bracts in 2 to several series 11

11(10). Pappus double—the outer series of short scales, the inner series of capillary bristles; shrubs with white bark .... *Hofmeistera*
— Pappus single, or else plants herbaceous; shrubs or herbs 12

12(11). Achenes 5-angled or 5-ribbed; involucral bracts subequal or in 2 series ... *Eupatorium*
— Achenes 10-angled or 10-ribbed; involucral bracts imbricated in several series of different lengths .... *Brickellia*

13(9). Leaves spinescent, usually with spiny teeth or lobes, rarely entire but then with spine-tipped apex, thistlelike 14
— Leaves entire, denticulate or lobed, lacking spines, not thistlelike 18

14(13). Corollas of some or all flowers bilabiate; basal leaf axils woolly; leaves spinulose-dentate; flowers pink; arid sites in Kane and Washington counties .... *Perezia*
— Corollas not bilabiate; leaves not or seldom spinulose-dentate; basal leaf axils woolly; flowers pink-white or cream; various distribution 15

15(14). Pappus of 2 series of awns, the outer long and naked, the inner short and hispidulous; flowers yellow .... *Cnicus*
— Pappus of plumose or barbellate capillary bristles; flowers not yellow 16

16(15). Pappus bristles plumose (rarely some otherwise); receptacle densely bristly .. *Cirsium*
— Pappus bristles merely barbellate 17

17(16). Receptacle densely bristly, not fleshy or honeycombed; heads nodding .... *Carduus*
— Receptacle not bristly or scarcely so, fleshy and honeycombed; heads not nodding .... *Onopardum*

18(13). Receptacle with dense bristles or narrow, chaffy scales between disk flowers 19
— Receptacle naked or at most short-hairy, never with dense bristles or scales 21

19(18). Involucral bracts with hooked spines; lower leaves large (resembling rhubarb), cordate at base .... *Arctium*
— Involucral bracts without spines, or spines not hooked; lower leaves not large and cordate at base 20

20(19). Receptacle chaffy except in center; plants small, woolly .... *Filago*
— Receptacle chaffy throughout; plants not small and woolly .... *Centaurea*

21(20). Heads unisexual; plants dioecious (staminate flowers may have styles but ovary does not develop) 22
— Heads with at least central flowers perfect 24

22(21). Plants shrubs or else woody at base, not tomentose; leaves sometimes toothed or lobed; involucral bracts not strongly scarious margined .... *Baccharis*
— Plants herbaceous, more or less tomentose; leaves entire; involucral bracts strongly scarious, at least along margins 23

23(22). Pappus bristles of pistillate flowers united at base and falling together; pappus bristles of staminate flowers usually club shaped at apex; plants usually less than 30 cm tall; basal leaves commonly in a rosette; cauline leaves reduced and different in shape; leaves usually tomentose on both sides .... *Antennaria*

— Pappus of pistillate flowers separate at base and falling separately; pappus bristles of staminate flowers not club shaped at apex; plants mostly over 30 cm tall; leaves all alike, usually green and glabrate above .... *Anaphalis*

24(21). Stems longitudinally brown-striate; involucral bracts imbricate, chartaceous, the inner with scarious margins and broadly rounded apices; shrubs with yellow flowers, of western Millard County .... *Lepidospartum*

— Stems striate or not; involucral bracts scarious, hyaline, or herbaceous but not as above; herbs, or shrubs with flowers and distribution various 25

25(24). Involucral bracts scarious or hyaline (only partly so in *Pluchea*) 26

— Involucral bracts herbaceous, at least in the center 28

26(25). Involucral bracts subscarious; corollas purplish; plants not tomentose, slender woody shrubs .... *Pluchea*

— Involucral bracts scarious; corollas rarely purplish; plants tomentose, prostrate to erect herbs 27

27(26). Plants perennial, subdioecious pistillate heads usually with a few central, perfect flowers .... *Anaphalis*

— Plants annual or perennial, not dioecious; heads all alike, the marginal flowers pistillate and central ones perfect .... *Gnaphalium*

28(25). Involucral bracts in a single series, a few very short ones may be present at the very base 29

— Involucral bracts of 2 or more series, these often of different lengths 32

29(28). Plants woody, shrubs; involucral bracts 4–6 per head .... *Tedradymia*

— Plants herbaceous; bracts more than 6 per head 30

30(29). Plants annual; heads with inner flowers perfect, the outer pistillate .... *Conyza*

— Plants perennial; heads with all flowers perfect 31

31(30). Style branches with a tuft of hairs near the truncate apex; involucral bracts in 1 series only (a few short bracts may be present) .... *Senecio*

— Style branches without a tuft of hairs near the truncate apex; involucral bracts actually in 2 or more series .... *Erigeron*

32(28). Pappus double, the outer series of short scales, the inner ones of capillary bristles; shrubs with white bark .... *Hofmeistera*

— Pappus simple or else the plants herbaceous 33

33(32). Plants annual 34

— Plants perennial 36

34(33). Plants low, depressed, scurfy pubescent herbs; leaves broadly ovate or roundish, entire or toothed .... *Psathyrotes*

— Plants not as above 35

35(34). Leaves all entire .... *Aster*

— Leaves toothed or lobed, at least the lower .... *Conyza*

36(33). Involucral bracts in more or less distinct vertical rows .... *Chrysothamnus*

— Involucral bracts not in vertical rows 37

37(36). Involucral bracts usually in 1 subequal series .... *Erigeron*

— Involucral bracts imbricate, in 2 or more series 38

38(37). Involucral bracts not longitudinally striate; flowers commonly yellow .. *Haplopappus*
— Involucral bracts longitudinally striate; flowers commonly cream to off-white, or pink to purplish 39

39(38). Flowers pink to purplish; plants of northwestern Utah .... *Eupatorium*
— Flowers cream to white; plants of various distribution 40

40(39). Pappus plumose; plants perennial herbs .... *Kuhnia*
— Pappus scabrous or hispidulose; plants shrubs or herbs .... *Brickellia*

41(9). Receptacle with bristles or chaffy scales among the flowers 42
— Receptacle naked or merely short-hairy 50

42(41). Receptacle densely bristly .... *Centaurea*
— Receptacle with chaffy scales 43

43(42). Plants low woolly annuals; outer bracts boat shaped and enclosing the achenes 44
— Plants various, but not low and woolly; outer bracts various but not usually enclosing the achenes 45

44(43). Stem leaves opposite; style lateral .... *Psilocarpus*
— Stem leaves alternate; style terminal .... *Stylocline*

45(43). Involucral bracts in 2 distinct sets — the outer herbaceous, the inner differing in shape and texture; leaves opposite, at least below, or alternate 46
— Involucral bracts not in 2 unlike sets; leaves alternate or basal 47

46(45). Leaves alternate throughout; outer involucral bracts about 5, spreading, herbaceous, the inner (1–3 subtending pistillate flowers) larger and broader, becoming strongly accrescent and hooded in fruit .... *Dicoria*
— Leaves opposite, at least below; outer involucral bracts various, but not as above, not accrescent and hooded in fruit .... *Thelesperma*

47(45). Involucral bracts in 1 series, boat shaped, each bract enclosing a marginal flower; rays short, yellow .... *Madia*
— Involucral bracts in 1 or more series, not boat shaped and enclosing marginal flowers; rays lacking 48

48(47). Plants woody shrubs; mostly along the canyons of the Colorado and Green rivers .... *Encelia*
— Plants herbaceous; widely distributed 49

49(48). Receptacles high-conical, mostly over 3 cm long; stems leafy .... *Rudbeckia*
— Receptacles merely convex, much less than 3 cm long; leaves all basal ..... *Enceliopsis*

50(41). Pappus none 51
— Pappus present 54

51(50). Leaves opposite, some cauline, somewhat connate at base; plants of Grand, San Juan, and Tooele counties .... *Flaveria*
— Leaves alternate or basal 52

52(51). Heads numerous, in spikes, racemes, or panicles; anthers with acute tips; receptacles flat; plants woody or herbaceous .... *Artemisia*
— Heads solitary on ends of stems, or sometimes corymbose or capitate; anthers with rounded tips; receptacles convex or conic; plants herbaceous, or woody only at base 53

53(52). Plants annual; heads solitary or paniculately arranged; leaves green and glabrous .... *Chamomilla*
— Plants perennial; heads corymbose or capitate; leaves usually silvery-canescent .... *Chrysanthemum*

54(50). Plants dioecious shrubs .... *Baccharis*
— Plants not dioecious herbs or shrubs 55

55(54). Pappus of 2–8 caducous awns; plants usually strongly glutinous .... *Grindelia*
— Pappus various, but not of 2–8 caducous awns 56

56(55). Leaves and involucre conspicuously punctate with translucent oil glands .... *Dyssodia*
— Leaves and involucre sometimes impressed-punctate, but without translucent oil glands 57

57(56). Pappus of 12 or more scale or bristlelike segments, these nearly or quite as long as achene 58
— Pappus of fewer than 12 scalelike segments or else much shorter than achene 59

58(57). Pappus of 12–16 linear, acuminate awns; involucres glutinous; leaves 3- to 5-nerved .... *Vanclevea*
— Pappus of ca 35 flattened, silvery scales and bristles of different widths; involucres not glutinous; leaves 1-nerved .... *Acamptopappus*

59(57). Achenes strongly compressed; pappus of 1 or 2 slender awns .... *Laphamia*
— Achenes not compressed or, if so, then pappus not of 1 or 2 slender awns 60

60(59). Pappus a crown with margins entire or of short scales united into a crown 61
— Pappus not as above 63

61(60). Plants annual; heads solitary or paniculately arranged; flowers all perfect; leaves green and glabrous .... *Chamomilla*
— Plants perennial; heads corymbose or capitate, rarely solitary; some marginal flowers pistillate only; leaves mostly silvery-canescent 62

62(61). Plants 0.5–1 m tall; leaves doubly pinnately dissected, mainly 10–20 cm long .... *Tanacetum*
— Plants mainly less than 0.3 m tall; leaves entire, once pinnately dissected, ternate, merely toothed apically, or entire, mainly less than 10 cm long ... *Sphaeromeria*

63(60). Involucral bracts with a thin, scarious, white, yellow, or purplish margin and tip .... *Hymenopappus*
— Involucral bracts without a scarious, colored margin and tip 64

64(63). Plants scapose; leaves roundish, entire, or crenate .... *Chamaechaenactis*
— Plants leafy stemmed; leaves not roundish and entire or subentire 65

65(64). Pappus scales with a strong midrib; leaves lanceolate or linear, entire; southern Utah .... *Palafoxia*
— Pappus scales nerveless or essentially so; leaves, at least in part, toothed to pinnatifid; widely distributed .... *Chaenactis*

KEY III.

Corollas not all tubular; ray flowers present pappus of capillary bristles.

1. Rays white, pink, violet, or purple, not yellow 2
— Rays yellow or orange-yellow 9

2(1). Pappus of numerous unequal bristles, alternating with shorter, lacerate scales; involucral bracts subequal; low winter annuals .... *Monoptilon*

— Pappus of numerous bristles; involucral bracts imbricate or subequal; plants various, but seldom low winter annuals 3

3(2). Pappus, at least of disk flowers, of several to many rigid bristles; achenes pubescent with 2-forked hairs or the hairs barbed at apex .... *Townsendia*

— Pappus, at least of disk flowers, of many capillary bristles, at least in part; achenes glabrous or pubescent with simple hairs 4

4(3). Rays very inconspicuous, shorter than the tube and scarcely if at all exceeding their pappus; central perfect flowers few; plants annual .... *Conyza*

— Rays usually conspicuous, longer than the tube and pappus; central perfect flowers several to many; plants annual, biennial, or perennial 5

5(4). Involucres subequal, rarely somewhat graduated; rays usually narrow; style tips very short, triangular, rounded, or obtuse .... *Erigeron*

— Involucres usually strongly graduated; rays comparatively broad; style tips ovate and acute to subulate, usually lanceolate 6

6(5). Plants perennial, rhizomatous, or annual, or, if from a caudex, ordinarily less than 10 cm tall (see also *Aster kingii*) 7

— Plants from a caudex or taproot 8

7(6). Low, white-rayed perennial herbs from spreading cordlike rootstocks, in arid sites; flowering in springtime .... *Leucelene*

— Low to tall, white- to pink- or purple-rayed annual or perennial herbs from rhizomes or fibrous roots (a caudex in *A. kingii*); mainly flowering in summer and autumn .... *Aster*

8(6). Plants herbaceous, from a taproot, biennial or perennial; heads usually several to numerous .... *Machaeranthera*

— Plants more or less woody, from a ligneous caudex; heads usually solitary and large (primary selenophytes) .... *Xylorhiza*

9(1). Leaves opposite, at least below 10

— Leaves alternate throughout 12

10(9). Plants subshrubs .... *Laphamia*

— Plants herbaceous 11

11(10). Leaves with stiff marginal bristles; involucre and leaves with conspicuous oil glands; plants annual .... *Pectis*

— Leaves without stiff marginal bristles; involucre and leaves without oil glands; plants perennial .... *Arnica*

12(11). Plants 1–1.5 m tall, herbaceous; heads 3–5 cm wide; rays 1–2 cm long .... *Inula*

— Plants various, usually less than 1 m tall, or, if taller, woody; heads much smaller; rays seldom to 1 cm long 13

13(12). Pappus of 2–8 stiff, caducous bristles; plants usually glutinous .... *Grindelia*

— Pappus of numerous, usually soft, persistent bristles 14

14(13). Pappus of about 20 twisted, flattish bristles .... *Amphipappus*

— Pappus of numerous, straight, capillary bristles 15

15(16). Pappus double, the inner of numerous bristles, the outer sometimes scalelike 16

— Pappus not double, of subequal capillary bristles only 17

16(15). Leaves essentially filiform .... *Conyza*
— Leaves not filiform, linear-oblong or broader .... *Heterotheca*

17(15). Involucral bracts in distinct vertical ranks 18
— Involucral bracts not in distinct vertical ranks 19

18(19). Outer involucral bracts with loose herbaceous tips; erect stems perennial; plants shrubs; leaves deciduous .... *Chrysothamnus*
— Outer involucral bracts without loose herbaceous tips; erect stems annual; plants herbaceous; leaves persistent .... *Petradoria*

19(17). Involucral bracts in 1 series, frequently with some smaller bracts at base; style branches truncate apically .... *Senecio*
— Involucral bracts neither in 1 series nor with smaller bracts at base; style branches without truncate tips 20

20(19). Heads small, the involucres usually less than 6 mm high, usually very numerous and densely paniculate, rarely racemose or corymbose; plants rhizomatous, fibrous rooted .... *Solidago*
— Heads medium to large, the involucres usually more than 6 mm high, neither very numerous nor densely paniculate; plants with taproots, occasionally also rhizomatous .... *Haplopappus*

Key IV.

Corollas not all tubular; ray flowers present; pappus lacking.

1. Rays white, pink, or pink-purple, sometimes yellow at base 2
— Rays yellow, sometimes partly purplish or maroon 6

2(1). Receptacle naked 3
— Receptacle with chaffy scales 5

3(2). Leaves all basal; plants scapose .... *Bellis*
— Leaves not all basal, at least some cauline; plants caulescent 4

4(3). Receptacle broad and flattish; involucral bracts with a dark brown submarginal line .... *Chrysanthemum*
— Receptacle convex, conic, or hemispheric; involucral bracts without a dark brown submarginal line .... *Chamomilla*

5(3). Heads small, numerous, in dense, flattish or rounded cymose panicles; plants perennial .... *Achillea*
— Heads comparatively large, solitary or few; plants annual or perennial .... *Anthemis*

6(1). Receptacles not chaffy 7
— Receptacles chaffy, at least toward the margin 12

7(6). Heads 1- or 2-flowered, in dense glomerate clusters, sessile in the forks of the stem, or terminal and leafy involucrate .... *Flaveria*
— Heads several- to many-flowered, solitary on terminal peduncles 8

8(7). Plants woolly 9
— Plants not woolly 10

9(8). Rays persistent, becoming papery .... *Baileya*
— Rays not persistent .... *Eriophyllum*

10(8). Involucre and leaves with translucent oil glands .... *Pectis*
— Involucre and leaves without translucent oil glands 11

11(10). Rays conspicuous; involucral bracts acuminate, without scarious margins .... *Bahia*
— Rays minute; involucral bracts obtuse, with scarious margins .... *Tanacetum*

12(6). Ray achenes partly or wholly enfolded by their involucral bracts; plants annual, glandular-viscid above .... *Madia*
— Ray achenes not conspicuously enfolded by their involucral bracts or, if so, then plants perennial; plants perennial or, if annual, not glandular above 13

13(12). Involucre distinctly double, the outer bracts herbaceous, the inner ones broader and united to about the middle .... *Thelesperma*
— Involucre not double, the bracts distinct to the base 14

14(13). Plants scapose perennials; leaves broad, silvery-pubescent, entire; heads very broad .... *Enceliopsis*
— Plants leafy stemmed or subscapose; leaves various but not broad and silvery-pubescent, or if so, then sagittate; heads broad or narrow 15

15(14). Plants subscapose; leaves variously dissected or sagittate; heads broad .. *Balsamorhiza*
— Plants with stems definitely leafy; leaves usually not dissected or sagittate 16

16(15). Plants shrubby; achenes conspicuously ciliate on the margins, notched at the apex, very flat .... *Encelia*
— Plants herbaceous; achenes not conspicuously ciliate on the margins 17

17(16). Leaves doubly pinnately dissected; heads numerous in corymbose cymes ...... *Achillea*
— Leaves simple, entire or toothed to lobed; heads few to several 18

18(17). Achenes 2-winged; disks 15–25 mm wide; leaves white-strigose beneath, green above .... *Verbesina*
— Achenes not 2-winged; disks 6–15 mm wide; leaves green on both sides .... *Heliomeris*

Key V.

Corollas not all tubular; ray flowers present; pappus of awns or scales.

1. Receptacle chaffy 2
— Receptacle not chaffy, either naked or bristly 17

2(1). Pappus scales fimbriate; ray flowers 4 or 5, white, only slightly surpassing the disk; introduced weedy plants, to be expected in Utah .... *Galinsoga parviflora* Cav.
— Pappus scales or awns not fimbriate; ray flowers various in size and color; indigenous or introduced 3

3(2). Receptacle bearing a row of chaffy scales between the ray flowers and the outer disk flowers, otherwise naked; pappus of 10–20 slender setiform scales .... *Layia*
— Receptacle chaffy throughout; pappus not of 10–20 slender scales 4

4(3). Ray achenes dorsiventrally compressed, the thickened margins attached to a contiguous pair of infertile disk flowers and the subtending bract, and falling as a unit; pulvinate herbs of eastern Utah and shrubs of southwestern Utah .... *Parthenium*
— Ray achenes various, but not as above; herbs or shrubs 5

5(4). Pappus of awns only, without scales 6
— Pappus, at least in part, of scales 10

6(5). Achenes flat and obcompressed; awns retrorsely hispid .... *Bidens*
— Achenes not obcompressed; awns not retrorsely hispid 7

7(6). Achenes plump; pappus of 2 to several caducous awns .... *Helianthus*
— Achenes flat, very strongly compressed; pappus various 8

8(7). Plants scapose; heads large, solitary .... *Enceliopsis*
— Plants leafy stemmed; heads medium sized, usually several 9

9(8). Plants shrubby; achenes narrowly white margined, the margin not continuous between weak awns .... *Encelia*
— Plants herbaceous annuals; achenes strongly white margined, the margin continuous between stout awns .... *Geraea*

10(5). Achenes very flat, strongly compressed 11
— Achenes not very flat, usually much thickened 13

11(10). Leaves once to twice pinnatifid .... *Anthemis*
— Leaves not pinnatifid, entire or nearly so 12

12(11). Plants scapose .... *Enceliopsis*
— Plants leafy stemmed .... *Helianthella*

13(10). Pappus caducous (of 2 awns and rarely some scales) .... *Helianthus*
— Pappus persistent 14

14(13). Inner involucral bracts united to middle into a cup .... *Thelesperma*
— Inner involucral bracts not united into a cup 15

15(14). Receptacle merely convex; rays pistillate .... *Wyethia*
— Receptacle conic or cylindric; rays neuter 16

16(15). Involucral bracts subequal, in 2 or 3 series .... *Rudbeckia*
— Involucral bracts unequal, in 2 series, the inner ones shorter .... *Ratibida*

17(1). Rays white or purple 18
— Rays yellow, sometimes marked with purple 24

18(17). Pappus a short crown 19
— Pappus of awns or scales 21

19(18). Leaves entire or pinnately divided .... *Chrysanthemum*
— Leaves irregularly 2–3 times pinnately dissected 20

20(19). Plants annual; heads 1–2.5 cm wide; receptacle conic, hollow .... *Chamomilla*
— Plants biennial or perennial; heads 3–5 cm wide; receptacle hemispheric . *Matricaria*

21(18). Pappus of 1 plumose awn and a denticulate crown .... *Monoptilon*
— Pappus of 2 to several awns or scales 22

22(21). Plants dwarf woolly annuals .... *Eriophyllum*
— Plants annual or perennial, not woolly 23

23(22). Pappus of numerous awns or scales; involucral bracts conspicuously scarious-margined .... *Townsendia*
— Pappus of 4 or 5 stiff awns; involucral bracts obscurely scarious-margined .... *Rigiopappus*

24(17). Receptacle densely bristly or hairy 25
— Receptacle naked 26

25(24). Heads very small; involucres less than 10 mm wide .... *Gutierrezia*
— Heads medium sized; involucres more than 10 mm wide .... *Gaillardia*

26(24). Pappus of 4 hyaline scales united at the base; rays reddish purple to yellow ... *Hulsea*
— Pappus a crown, or of cauducous or persistent awns or scales; rays mostly yellow 27

27(26). Pappus a mere crown or of caducous awns 28
— Pappus persistent, of awns or scales 30

28(27). Pappus of 2–8 caducous awns; plants glutinous .... *Grindelia*
— Pappus a short crown; plants seldom if ever glutinous 29

29(28). Leaves entire, bristly margined basally .... *Pectis*
— Leaves 2- or 3-pinnate .... *Tanacetum*

30(27). Pappus of 1 or 2 awns or scales (rarely more) with or without a crown .... *Perityle*
— Pappus of 4 to many awns or scales 31

31(30). Pappus of about 20 slender, twisted awns; rays 1 or 2 small .... *Amphipappus*
— Pappus of 4–16 twisted or plane awns or scales; rays usually several 32

32(31). Pappus of 4 or 5 stiff, narrowly lanceolate awns; achenes linear, transversely rugulose .... *Rigiopappus*
— Pappus of scales, awn-tipped scales, or setose-dissected awns 33

33(32). Pappus of several scales dissected nearly to base; dwarf woolly annuals .... *Syntrichopappus*
— Pappus awns or scales not dissected or else plants perennial or woody 34

34(33). Pappus of several more or less united scales; rays broad, papery, and persistent .... *Psilostrophe*
— Pappus not of united scales; rays not papery and persistent (occasionally so in *Hymenoxys*) 35

35(34). Leaves and involucre with conspicuous oil glands .... *Dyssodia*
— Leaves and involucre without conspicuous oil glands 36

36(35). Achenes slender, elongate-clavate 37
— Achenes stouter, oblong or obovoid 38

37(36). Plants woolly .... *Eriophyllum*
— Plants merely strigose .... *Platyschkuhria*

38(36). Involucral bracts spreading or reflexed; receptacle convex to subglobose; leaves decurrent .... *Helenium*
— Involucral bracts appressed; receptacle almost flat; leaves not decurrent 39

39(38). Pappus of numerous scales; stems leafy; leaves linear or linear-spatulate, entire, 2.5 mm wide or less .... *Gutierrezia*
— Pappus of about 5 scales; leaves lobed or, if entire, broader and mostly or entirely basal .... *Hymenoxys*

ACAMPTOPAPPUS Gray

Shrubs with white bark; leaves alternate, entire, 1-nerved; heads yellow, discoid, subglobose, cymose at tips of branches; flowers all fertile; involucral bracts ca 4-seriate, strongly imbricate, the bracts broad, rounded, the tip greenish, the margin scarious, erose; receptacle convex, fimbrillate; style branches linear; achenes subturbinate, densely villous; pappus persistent, of ca 35 flattened silvery scales and bristles of different widths.

Acamptopappus sphaerocephalus **(Harv. & Gray) Gray** Goldenhead. [*Haplopappus sphaerocephalus* Harv. & Gray]. Low rounded shrubs to 1 m tall, much branched, glabrous throughout or scabrous along some leaf margins; leaves spatulate to almost linear, 4–28 mm long, 1–5 mm wide, obtuse to acute, mucronulate, thick, sessile; heads subglobose, 6–10 mm high; involucre 4–6 mm high. Blackbrush, indigobush, and creosote bush communities at 850 to 1375 m in Kane, San Juan, and Washington counties; Arizona, Nevada, and California; 22 (iv).

ACHILLEA L.

Perennial, rhizomatous, aromatic herbs, with watery juice; stems erect or ascending; leaves alternate, 1- to 3-pinnately dissected; leaves several to many, borne in compact to open corymbose cymes; involucral bracts imbricate in several series, chaffy, the margins scarious and hyaline; receptacle chaffy; ray flowers present, usually 3–12, pistillate, fertile, yellow, white, pink, or pink-purple; disk flowers mostly 10 or more, perfect, fertile; pappus none; style branches flattened; achenes compressed, callus margined, glabrous, beakless.

1. Flowers yellow; leaves coarsely twice pinnately dissected; plants cultivated .... *A. filipendulina*
— Flowers white, pink, or pink-purple; leaves finely 2–3 times dissected; plants indigenous or cultivated .... *A. millefolium*

Achillea filipendulina **Lam.** Fernleaf Yarrow. Herbs, the stems erect, 8–12 dm tall or more, longitudinally furrowed and minutely glandular; leaves 4–35 cm long, doubly pinnatifid, the lateral lobes with one large lobe on the upper side; heads numerous, borne in hemispheric or flat-topped corymbose cymes; involucre 3–4 mm high, the bracts with pale scarous margins, villous; rays about 5, to 1 mm long, yellow; disk flowers 30–40, yellow; achenes 1–2 mm long. Cultivated ornamental, Salt Lake and Utah counties, and to be expected elsewhere; introduced from Asia; 2 (0).

Achillea millefolium **L.** Milfoil Yarrow. Herbs, the rhizomes horizontal; stems ascending to erect, 0.5–10 dm tall, villous-tomentose, simple or branched above; leaves 2–26 cm long, reduced upwards, pinnately once to thrice dissected, the segments very slender; heads numerous, borne in hemispheric or flat-topped, corymbose cymes; involucres 4–6 mm high, the bracts dark to pale margined, villous to glabrate; rays usually about 5, 2–3.5 mm long, white to pink or pink-purple; disk flowers 10–20; achenes 1–2 mm long. Gravelly, sandy, and clayey soils in sagebrush, pinyon-juniper, cottonwood, juniper, rabbitbrush, ponderosa pine, mountain brush, aspen, Douglas fir, spruce-fir, and alpine tundra communities at 1070 to 3750 m in all Utah counties; widely distributed in North America; circumboreal. Two very similar taxa are present in Utah; the common, indigenous ssp. ***lanulosum*** (Nutt.) Piper (n = 18), and the introduced, cultivated, ssp. *millefolium* (n = 27). A trend is recognizable within ssp. *lanulosum;* the high elevation specimens tend to have dark involucral bracts, fewer heads, and lower stature. These alpine plants have been treated as var. *alpi cola* (Rydb.) Garrett, but they intergrade completely with specimens attributable to var. *lanulosa*. Indeed, the two extremes can be found mounted on the same herbarium sheet, taken from the same locality; 133 (xv).

AGOSERIS Raf.

Perennial scapose herbs with milky juice, from taproots; leaves all basal, entire to pinnately lobed or merely toothed; heads solitary on a naked scape; involucral bracts in 2 to several series, herbaceous, or the inner ones hyaline or nearly so; receptacle usually naked; corollas all raylike, perfect, yellow to orange, often drying pinkish or purplish; pappus of capillary bristles; style branches semicylindric; achenes angular or terete, prominently nerved, usually beaked.

1. Plants annual; achene beak 2–3 times as long as the body; rare in Utah .... *A. heterophylla*

— Plants perennial; achene beak less than half to 2 or more times as long as the body 2

2(1). Achene beak striate, mostly less than half as long as the body (longer in some var. *laciniata*); flowers yellow, often drying bluish to pinkish .... *A. glauca*

— Achene beaks scarcely striate, more than half to 2 or more times as long as the body 3

3(2). Flowers brownish orange to yellow-orange, often drying purplish; achene beak less than twice as long as the body .... *A. aurantiaca*

— Flowers yellow, often drying bluish or pinkish; achene beak more than twice as long as the body .... *A. grandiflora*

Agoseris aurantiaca **(Hook.) Greene** Orange Agoseris. Plants 0.6–6.6 dm tall, from a simple or branched caudex; leaves 3.5–36 cm long, 0.5–3 cm broad, narrowly oblanceolate, entire to toothed or lobed, villous to glabrate; scapes villous-tomentose to nearly glabrous; involucres 10–27 mm long, 10–42 mm wide, the outer bracts villous to glabrate and ciliate, often purple spotted; corollas brownish orange to yellow-orange, often drying purplish; achene body 4–8 mm long, the slender beak not striate, from more than half as long to longer than the body. Two rather weak and intergrading phases are recognized at varietal rank.

1. Involucres with bracts subequal or nearly so, slender, tapering, some often over 20 mm long .... *A. aurantiaca* var. *aurantiaca*

— Involucres with bracts definitely imbricate, broad, and rounded apically or abruptly tapering .... *A. aurantiaca* var. *purpurea*

Var. *aurantiaca* [*Troximon aurantiacum* Hook.; *A. arizonica* Greene; *A. gracilens* (Gray) Kuntze; *A. longirostris* Greene, type from Fish Lake]. Sagebrush, mountain brush, juniper, pinyon-juniper, and alpine meadow communities at 1375 to 3355 m in Beaver, Box Elder, Carbon, Duchesne, Juab, Salt Lake, San Juan, Sevier, Tooele, Uintah, Utah, and Wasatch counties; Alberta to British Columbia, south to California and New Mexico; 33 (v).

Var. *purpurea* **(Gray) Cronq.** [*Troximon aurantiacum* var. *purpureum* Gray; *A. purpurea* (Gray) Greene; *A. confinis* Greene, type from near Marysvale]. Mountain brush, aspen, aspen-fir, and spruce-fir communities at 1700 to 3425 m in Carbon, Emery, Grand, Juab, Iron, Piute, Sanpete, Sevier, and Wasatch counties; Montana to Arizona and New Mexico; 20 (vi).

Agoseris glauca **(Pursh) Raf.** Pale Agoseris; Mountain Dandelion. Plants perennial, 0.2–6.4 dm tall, from a simple or branched caudex; leaves 2–26 cm long, 0.2–3 cm broad, narrowly oblanceolate to linear or spatulate to elliptic, entire or toothed to lobed, villous to glabrate; involucres 12–28 mm high, 0.8–4 cm wide, the outer bracts villous to glabrous, ciliate or not, sometimes purple spotted; corollas yellow, often drying bluish to pinkish; achene body 4–10 mm long, the striate beak stout, to half as long as the body (slender and to as long as the body in some var. *laciniata*). Three intergrading and partially sympatric varieties are present in Utah.

1. Leaves laciniately toothed or lobed; plants of broad distribution, common .... *A. glauca* var. *laciniata*

— Leaves entire, rarely with a few teeth or lobes; plants variously distributed, locally common 2

2(1). Plants pubescent, at least below the heads; mainly of spruce-fir and alpine communities, sometimes lower .... *A. glauca* var. *dasycephala*

— Plants glabrous throughout, mainly of lower elevation wet meadows, but sometimes of high elevation meadows .... *A. glauca* var. *glauca*

Var. *dasycephala* (T. & G.) Jeps. [*Ammogeton scorzoneraefolius* Shrad.; *A. scorzoneraefolia* (Shrad.) Greene; *Troximon pumilum* Nutt.; *A. pumila* (Nutt.) Rydb.; *A. glauca* var. *pumila* (Nutt.) Garrett; *T. glaucum* var. *dasycephalum* T. & G.; *A. villosa* Rydb.]. Sagebrush, mountain brush, aspen, spruce-fir, and alpine tundra communities at 1830 to 3385 m in Duchesne, Garfield, Iron, Kane, Piute, Salt Lake, San Juan, Sanpete, Sevier, Tooele, Uintah, and Utah counties; Alaska to Manitoba and south to Colorado. Plants of this variety pass by degree into each of the following; 29 (v).

Var. *glauca* [*Troximon glaucum* Pursh; *A. isomeris* Greene, type from the Uinta Mountains]. Meadows at 2325 to 3660 m in Box Elder, Duchesne, Iron, Juab, Sanpete, Sevier, Summit, Uintah, and Wasatch counties; British Columbia to Manitoba and south to California and Arizona; 22 (iv).

Var. *laciniata* (D.C. Eaton) Smiley [*Troximon parviflorum* Nutt.; *A. parviflora* (Nutt.) D. Dietr.; *A. glauca* var. *parviflora* (Nutt.) Rydb.; *T. taracifolium* Nutt.; *A. taracifolia* (Nutt.) D. Dietr.; *Macorhynchus glaucus* var. *laciniatus* D.C. Eaton; *A. taraxacoides* Greene, type from near Marysvale; *A. caudata* Greene, type from Salina Canyon; *A. agrestis* Osterh.; *A. glauca* var. *agrestis* (Osterh.) Q. Jones]. Sagebrush, mountain brush, juniper, pinyon-juniper, Douglas fir, aspen, and spruce-fir communities at 1300 to 3050 m in Beaver, Box Elder, Carbon, Daggett, Duchesne, Emery, Garfield, Grand, Juab, Kane, Millard, Piute, San Juan, Salt Lake, Sanpete, Sevier, Summit, Tooele, Uintah, Utah, Washington, Wayne, and Weber counties; Washington to Montana and south to Arizona. The phase designated as var. *agrestis* blends completely in our area with that treated herein as var. *laciniata;* 84 (xii).

***Agoseris grandiflora* (Nutt.) Greene** [*Stylopappus grandiflorus* Nutt.]. Plants perennial, 1.5–4.5 (7) dm tall, from a simple or branching caudex; leaves 8–25 cm long, 1–3 cm broad, narrowly oblanceolate, pinnatifid to subentire, villous to glabrate; involucres 15–38 mm long, 20–43 mm wide, the outer bracts villous-tomentose to glabrate, ciliate, often suffused with purple; corolla yellow, drying bluish to pinkish; achene body 4–7 mm long, the nerveless beak more than twice as long as the body. Specimens tentatively assigned to this species are from Cache, Iron, Tooele, and Washington counties, where they occur in sagebrush and mountain brush communities at 1830 to 2135 m; British Columbia to California and Nevada; 4 (i).

***Agoseris heterophylla* (Nutt.) Greene** Annual Agoseris. [*Macrorhynchus heterophyllus* Nutt.]. Plants annual, 0.3–2.5 (4) dm tall, with 1 to several scapes from the base; leaves 1–20 (15) cm long, 0.3–1.5 cm wide, narrowly oblanceolate, toothed or pinnatifid to entire, all basal, or with some not strictly basal; involucres 5–20 mm long, 4–10 mm wide, sparingly villous with multicellular hairs, the cross-walls purplish; corolla yellow, sometimes turning pinkish on drying; achene body 2–5 mm long, prominently ribbed or winged, the beak 2–3 times as long as the body. Our one collection (Diehl D29, 1899 BRY) is from Salt Lake County at low elevation; British Columbia to California and Arizona; 1 (0).

AMBROSIA L

Annual or perennial herbs or shrubs; leaves alternate or opposite, pinnately or palmately lobed, toothed, or dissected; heads unisexual, discoid; staminate heads in slender spicate, bractless racemes; involucre 5- to 12-lobed;

receptacle flat, bearing flattened filiform-setose bracts; staminal filaments monadelphous, the anthers scarcely united; pistillate heads borne below the fertile ones, mostly axillary, their involucres closed, nutlike, armed with prickles arranged in one or more series; pistil naked, the corolla lacking; pappus lacking.

PAYNE, W. W. 1964. A reevaluation of the genus *Ambrosia*. J. Arnold Arboretum 45:401–438.

1. Plants woody shrubs of southwestern Utah 2
— Plants annual or perennial herbs, of various distribution 3

2(1). Leaves mainly less than 15 mm long, pinnately lobed, the lobes again toothed or lobed, silvery-strigose overall .... *A. dumosa*
— Leaves mainly more than 20 mm long, merely toothed or lobed, the lobes not again toothed or lobed, bicolored, the upper surface green, the lower surface white-tomentose .... *A. eriocentra*

3(1). Leaves palmately lobed, the lobes serrate; plants tall coarse herbs .... *A. trifida*
— Leaves pinnatifid or pinnately lobed; plants slender herbs usually less than 5 dm tall 4

4(3). Leaves bicolored, the lower surface obscured by appressed white hairs; plants low rhizomatous perennials .... *A. tomentosa*
— Leaves various, but not definitely bicolored; plants from taproots or rhizomes, but, if the latter, not as above 5

5(4). Plants perennial, rhizomatous; leaves opposite .... *A. psilostachya*
— Plants annual; leaves mainly alternate 6

6(5). Lower stems and leaves with pustular-based, stiff, multicellular hairs; plants often with lower lateral branches decumbent-ascending; burs with spines in more than one series .... *A. acanthicarpa*
— Lower stems lacking pustular-based hairs, all stems slender and curved ascending-appressed; burs with spines in one series .... *A. artemisiifolia*

Ambrosia acanthicarpa **Hook.** Bur Ragweed. [*Franseria acanthicarpa* (Hook.) Coville]. Plants annual, 0.9–7.5 dm tall, often branching from the base, the lower branches commonly decumbent-ascending; pubescence of stiff multicellular hairs, the bases pustular; leaves mostly alternate, petiolate, the blades 0.9–4.5 cm long, 0.6–3.5 cm wide, bipinnatifid to pinnatifid; heads numerous in terminal or axillary racemes; staminate above, pistillate below; staminate heads short-pedunculate, not bracteate; pistillate solitary or clustered in upper axils, with 2–3 series of flattened, curved spines. Blackbrush, salt desert shrub, desert shrub, pinion-juniper, and riparian communities, often in sandy substrates, at 850 to 2000 m, in Beaver, Carbon, Daggett, Duchesne, Emery, Garfield, Grand, Iron, Juab, Kane, Millard, San Juan, Tooele, Uintah, Utah, Washington, and Wayne counties; Washington to Saskatchewan, south to California, Arizona, and Texas; 60 (xi).

Ambrosia artemisiifolia **L.** Common Ragweed. [*A. elatior* L.]. Plants annual, mostly 3–9 dm tall, branching from above the middle; pubescence of lax multicellular hairs, the bases not pustular; leaves alternate, or the lower usually opposite, petiolate, the blades 2.5–8.5 cm long, 1.9–7.5 cm wide, 1- to 2-pinnatifid; heads numerous in terminal or axillary racemes, the staminate above, pistillate below, clustered or solitary, with 1 series of tuberculate spines. Moist disturbed sites at 1375 to 1500 m in Juab and Utah counties; widespread in North America; 11 (i).

Ambrosia dumosa **(Gray) Payne** Bur-sage. [*Franseria dumosa* Gray]. Shrubs, 2–6 dm tall, rounded, much branched; branchlets white, subspinescent; pubescence dense, strigose; leaves alternate, petiolate, the blades 9–30 mm long, 5–15 mm wide, mostly 2-pinnatifid, uniformly hairy on both sides; staminate heads spicate, rather few; pistillate heads often scattered among the staminate; pistillate involucre maturing 20–35 lance-subulate spines. Creosote bush, blackbrush, and Joshua tree communities at 670 to 1000 m in Washington County; Arizona, California, and Mexico; 28 (i).

Ambrosia eriocentra **(Gray) Payne** [*Franseria eriocentra* Gray]. Shrubs, 3–10 (12) dm tall, aromatic, branchlets white, subspinescent, pubescence of white tomentum and coarse multicellular hairs; leaves alternate, subsessile, sinuately toothed to lobed or 1-pinnatifid, 8–40 (50) mm long, 2–20 mm wide; staminate heads more or less clustered; pistillate heads 1-flowered; pistillate involucre with 12–20 flattened, subulate spines. Creosote bush, blackbrush, and Joshua tree communities at 670 to 1000 m in Washington County; Arizona, Nevada, and California; 12 (ii).

Ambrosia psilostachya **DC.** Western Ragweed. [*A. coronopifolia* T. & G.]. Perennial herbs, mostly 3–6 dm tall, simple or branching above the middle; pubescence of harsh, spreading, multicellular, pustular-based hairs (at least in part); leaves opposite, at least below, petiolate to subsessile, the blades 4–10 cm long, 2.5–4.5 cm wide, mostly once pinnatifid; staminate heads in terminal or axillary spicate racemes; pistillate involucres merely tuberculate or quite unarmed. Meadows, stream banks, and roadsides in sagebrush and other communities at 1300 to 2100 m in Davis, Juab, Millard, Salt Lake, Utah, and Weber counties; Washington to Illinois, south to Arizona and Mexico; 20 (ii).

Ambrosia tomentosa **Nutt.** [*Franseria discolor* Nutt.; *F. tomentosa* (Nutt.) A. Nels., not *A. tomentosa* Gray]. Perennial rhizomatous herbs, mostly 1–3.5 dm tall, branching from above the base; pubescence of short, stiff, appressed hairs; leaves alternate, petiolate, the blades 2–15 cm long, 0.4–3.5 cm wide, 1- to 3-pinnatifid; staminate heads racemose; pistillate heads armed with 2 or 3 series of coarse spines. Meadows and stream banks at 1300 to 1525 m in Davis, Duchesne, and Grand counties (likely elsewhere); Wyoming and Colorado; 5 (iii).

Ambrosia trifida **L.** Giant Ragweed. Annual, robust herbs, 10–15 dm tall or more; pubescence spreading-hirsute to hispid, at least above; leaves opposite, petiolate, the blades palmately 3- to 5-lobed, or unlobed, mainly 5–20 cm long, 4–15 cm wide, scabrous on both surfaces, serrate; staminate involucres 3-nerved; pistillate involucres 5–10 mm long, bearing short spines at the tip. Uncommon (introduced?) weedy plants of disturbed sites in Salt Lake County (likely elsewhere); widely distributed in North America; 1 (0).

Amphipappus T. & G.

Low shrubs; branches white-barked, divaricate; leaves alternate, entire, short-petiolate; heads small, radiate, few flowered, clustered at tips of branches; involucre in ca 3 series, strongly imbricate, straw colored to greenish, the bracts broad, rounded; receptacle fimbrillate; ray flowers yellow, 1 or 2, small; disk flowers 3–6, perfect; ray achenes hairy, broadly oblanceolate, compressed, their pappus of more or less united bristles, awns, or scales; disk achenes undeveloped, glabrous or sparingly pilose, their pappus of twisted, hispidulous bristles or scales.

Porter, C. L. 1943. The genus *Amphipappus* Torr. & Gray. Amer. J. Bot. 30: 481–483.

Amphipappus fremontii **T. & G.** Chaffbush. Shrubs 3–8 dm tall, the herbage scabrous-puberulent; leaves 5–12 mm long, 2–5 mm wide, oblanceolate to elliptic, cuneate basally, acute to obtuse and apiculate, green; heads 4–6 mm high, the bracts greenish medially near the apex, the margins hyaline and more or less erose. Joshua tree and creosote bush communities at 700 to 900 m in Washington County; Nevada, Arizona, and California. Our material belongs to var. ***spinosus*** (A. Nels.) C. L. Porter [ssp. *spinosus* (A. Nels.) Keck]; 4 (i).

Anaphalis DC.

Perennial, dioecious or polygamodioecious, rhizomatous herbs, with watery juice; stems ascending to erect, simple or branched above; leaves simple, alternate, entire; heads several to many, in hemispheric or flat-topped corymbose cymes; involucral bracts imbricate in several rows, chaffy, scarious, white, or with a dark triangular basal spot; receptacle naked; corollas of disk flowers only, imperfect, whitish, the pistillate heads sometimes bearing some central staminate flowers, the pistillate corollas tubular-filiform, the staminate corollas tubular-funnelform; pappus of capillary bristles; style branches somewhat flattened; achenes small, roughened, glabrous to sparingly hairy.

Anaphalis margaritacea (L.) Benth. & Hook. Pearly Everlasting. [*Gnaphalium margaritaceum* L.]. Plants 1.5–8 dm tall, the stems white villous-tomentose; leaves only gradually reduced upwards, 2.5–12 cm long, 0.5–2 cm wide, narrowly lanceolate to oblong, elliptic, or oblanceolate, sessile, entire, flat to slightly revolute, white-tomentose below, commonly less pubescent and greenish above; heads showy, the involucres 4–7 mm high, 5–10 mm broad, the bracts pearly-white, with a dark triangular base, glabrous; achenes about 1 mm long. Meadows, streambanks, and openings in ponderosa pine, lodgepole pine, box elder, and aspen communities at 1150 to 2700 m in Box Elder, Duchesne, Iron, Juab, Salt Lake, Summit, Wasatch, and Washington counties; widely distributed in North America; Asia; 33 (vi).

ANTENNARIA Gaertn.

Perennial, dioecious herbs with stolons, caudices, or rhizomes, the juice watery; stems ascending to erect, usually simple; leaves simple, alternate and basal, the cauline generally reduced upward; heads solitary to many, borne in corymbose cymes; involucral bracts imbricate in several rows, scarious (at least marginally), often colored; receptacle naked; corollas of disk flowers only, imperfect, whitish or tawny; pistillate corollas tubular-filiform, the pappus of numerous capillary bristles; staminate corollas tubular-funnelform, the pappus of few clavate to barbellate, usually flattened bristles; style branches slightly flattened; achenes terete to slightly compressed, glabrous or papillose.

1. Heads solitary; flowering stems usually less than 5 cm tall .... *A. dimorpha*
— Heads (1) 2 to many (see *A. rosulata*); flowering stems often more than 5 cm tall 2
2(1). Upper leaf surface green; leaf blades broadly spatulate, rounded to obtuse .... *A. neglecta*
— Upper leaf surface not notably different from the lower; blades seldom both spatulate and rounded to obtuse 3
3(2). Plants not forming mats, lacking leafy stolons, some caespitose from caudex or rhizomes 4
— Plants mat forming, with leafy stolons 6
4(3). Involucral bracts glabrous or nearly so, scarious near the base, white-opaque apically .... *A. luzuloides*
— Involucral bracts densely tomentose in the lower half, opaque to dark with pale scarious apices 5
5(4). Involucral bracts blackish in aspect, the tips pale and scarious .... *A. pulcherrima*
— Involucral bracts opaque white, somewhat darkened at the middle .. *A. anaphaloides*
6(3). Terminal scarious portion of involucral bracts dirty brownish to blackish green on at least the middle and outer ones 7
— Terminal scarious portion of involucral bracts white to pink, with a dark basal spot on some only 8
7(6). Terminal scarious portion of involucral bracts blackish green; plants usually alpine in Uinta, Wasatch, and Tushar Mountains, and on the Markagunt Plateau .... *A. alpina*
— Terminal scarious portion of bracts merely discolored and pale brown, or the inner bracts whitish at the tips; plants usually of lower elevations .... *A. umbrinella*
8(6). Flowering stems less than 5 cm tall; heads 1 or 2; plants of Garfield, Kane, and Wayne counties .... *A. rosulata*

— Flowering stems commonly more than 5 cm tall; heads usually 3 or more; plants of broad, or other, distribution 9

9(8). Involucral bracts with a black spot between the tomentose greenish base and the opaque white-scarious apex .... *A. corymbosa*

— Involucral bracts lacking a conspicuous black spot 10

10(9). Involucres mostly 4–7 mm high, often bright pink; pistillate corollas mostly 2–4.5 mm long .... *A. microphylla*

— Involucres mostly 7–11 mm high, seldom pink; pistillate corollas mostly 5–8 mm long .... *A. parvifolia*

Antennaria alpina **(L.) Gaertn.** Alpine Pussytoes. Plants caespitose from a caudex, mat forming and stoloniferous, 2–13 cm tall; basal leaves 0.6–2.2 cm long, 2–6 mm wide, cuneate-oblanceolate to spatulate, acute to obtuse or rounded apically, grayish tomentose on both surfaces or greenish and subglabrous above on some leaves; heads 3–5, borne in subcapitate cymes; pistillate involucres 5–7 mm high, villous-tomentose below, the scarious tips of bracts uniformly blackish or brownish green, all rather blunt apically, often erose; staminate involucres mostly 4–5 mm high, the scarious tips of bracts often pale apically; achenes glabrous. Lodgepole pine, spruce-fir, and alpine tundra communities at 3050 to 3550 m in Daggett, Duchesne, Piute, Salt Lake, Uintah, and Utah counties; north to Alaska and east to Labrador; circumboreal. Our material belongs to var. ***media*** (Greene) Jeps. [*A. media* Greene; *A. austromontana* E. Nels., type from Tushar Mountains]. There is a tendency for some specimens to approach *A. parvifolia* in the Uinta Mountains and *A. umbrinella* elsewhere; 27 (vii).

Antennaria anaphaloides **Rydb.** Pearly Pussytoes. Plants from a caudex, not mat forming or stoloniferous, 1.5–3.5 (5) dm tall; basal leaves 2.5–19 cm long, 4–18 mm wide, narrowly oblanceolate to elliptic, tomentose on both surfaces; heads several to many in branching or compact cymes; pistillate involucres 5–8 mm high, villous-tomentose below, the scarious tips opaque-white, all rounded or obtuse, often erose; staminate involucres 5–8 mm high, similar to the pistillate; achenes glabrous. Aspen, spruce-fir, sagebrush, and mountain brush communities at 2440 to 3325 m in Daggett, Summit, and Uintah counties; British Columbia to Montana and south to Nevada and Colorado; 7 (i).

Antennaria corymbosa **E. Nels.** Plains Pussytoes. [*A. nardina* Greene]. Plants caespitose, mat forming and stoloniferous, 5–26 cm tall; basal leaves 0.6–3.7 cm long, 2–6 mm wide, narrowly oblanceolate to spatulate, acute to obtuse apically, gray to greenish and tomentose on both surfaces; heads commonly 3–8, in compact to branching cymes; pistillate and staminate involucres 4.5–6 mm high, the bracts green and tomentose basally, with a dark spot at the base of the white or sordid terminal portion; achenes puberulent. Alpine tundra, krumholz, spruce-fir, lodgepole pine, and willow-alder communities, often along stream banks and in wet meadows or bogs, at 2240 to 3355 m in Beaver, Duchesne, Garfield, Summit, and Uintah counties; Montana and Idaho to Colorado and California(?). The main body of the species in Utah lies in the Uinta Mountains, with outliers in the Stansbury and Tushar mountains, and in the Markagunt Plateau; 22 (iii).

Antennaria dimorpha **(Nutt.) T. & G.** Low Pussytoes. [*Gnaphalium dimorphum* Nutt.; *A. dimorpha* var. *macrocephala* D.C. Eaton, type from Salt Lake City]. Plants caespitose, mat forming, rooting from short caudex branches, not truly stoloniferous, 1–5 (7) cm tall; basal leaves narrowly oblanceolate, 0.6–4 cm long, 1–14 mm wide, acute apically, grayish tomentose on both sides; heads solitary, terminal on short leafy stems; pistillate involucres (7) 10–18 mm long, the bracts strongly imbricated, slender, attenuate, green at base, suffused with brown above the base, the apical portions yellowish to brownish scarious; staminate involucres 6–9 mm long, tomentose at the base, brown above the base, the broad apical portion hyaline to scarious; achenes puberulent. Mat-saltbush, sagebrush, juniper, oak-serviceberry, ponderosa pine, and spruce-fir-lodgepole pine communities at

1430 to 3050 m in Beaver, Daggett, Duchesne, Iron, Juab, Millard, Salt Lake, Sanpete, Sevier, Summit, Tooele, Utah, and Washington counties (and certainly elsewhere); British Columbia to Montana, south to California, Nevada, Colorado, and Nebraska; 37 (viii).

Antennaria luzuloides **T. & G.** Rush Pussytoes. [*A. oblanceolata* Rydb.]. Caespitose from a caudex, 1.1–5 (7) dm tall; basal leaves 2–5 (8) cm long, 2–8 mm wide, greenish, tomentose on both surfaces; heads numerous in a compact or more often branched corymbose inflorescence; pistillate and staminate involucres similar, 4–5 mm high, glabrous to the base, the bracts brownish scarious and more or less hyaline below, opaque whitish above; achenes puberulent. Openings in aspen-conifer and lodgepole pine-spruce communities at 2950 to 3050 m in Duchesne and Summit counties; British Columbia to Montana, south to California, Nevada, and Colorado; 7 (i).

Antennaria microphylla **Rydb.** Rosy Pussytoes. [*A. rosea* Rydb.; *A. concinna* E. Nels.; *A. arida* A. Nels.]. Plants caespitose, stoloniferous and mat forming, 0.4–3 (4) dm tall; basal leaves 0.5–3 cm long, 2–8 mm wide, oblanceolate to spatulate; heads 2–13 (or more), in congested to open cymes; pistillate involucres 4–7 mm high, the bracts tomentose below, greenish or scarious below the middle, often somewhat brownish below the scarious, whitish or pinkish, terminal portion; mainly known from pistillate individuals; achenes glabrous or sparingly hispidulous. Sagebrush, juniper, ponderosa pine, Douglas fir, lodgepole pine, spruce-fir, and alpine meadow communities at 1830 to 3450 m in Beaver, Box Elder, Carbon, Daggett, Duchesne, Emery, Garfield, Iron, Juab, Kane, Millard, Piute, Rich, Salt Lake, Sanpete, Sevier, Summit, Tooele, Uintah, Utah, Wasatch, Wayne, and Weber counties; Alaska to Ontario, south to California and New Mexico; 105 (xxiii).

Antennaria neglecta **Greene** Field Pussytoes. [*A. marginata* Greene]. Plants caespitose, stoloniferous and mat forming, 5–15 (25) cm tall; basal leaves 1.8–3.5 cm long, 3–15 mm wide, spatulate, thinly tomentose to glabrous and green above, white-tomentose beneath; heads mainly 3–5, in compact cymes; pistillate involucres 6–11 mm high, the bracts tomentose on the greenish base, the apical scarious portion white or suffused with pink; staminate plants rare; achenes glabrous or minutely pubescent. Pinyon-juniper and shrub communities at 1525 to 1900 m in San Juan, Utah, and Washington counties; Alaska to Newfoundland, south to California, Arizona, and Virginia; 3 (i). Our few specimens are hardly adequate to represent this species clearly in Utah.

Antennaria parvifolia **Nutt.** [*A. aprica* Greene; *A. obtusita* Greene]. Plants caespitose, stoloniferous and mat forming, 3–15 cm tall; basal leaves 0.8–3.5 cm long, 3–8 mm wide, spatulate, obtuse to acute apically, tomentose on both sides; heads 2–6 or more; pistillate involucres 7–11 mm high, the bracts more or less tomentose on the greenish base, the scarious portion white, sordid, or pink; staminate plants rarely collected; achenes glabrous. Mountain brush, pinyon-juniper, sagebrush, ponderosa pine, aspen, lodgepole, and spruce-fir communities at 1650 to 3250 m in Beaver, Carbon, Daggett, Duchesne, Emery, Garfield, Juab, Kane, Piute, San Juan, Summit, Tooele, Uintah, Utah, and Wayne counties; British Columbia to Manitoba, south to Arizona and New Mexico; 46 (iv).

Antennaria pulcherrima **(Hook.) Greene** Showy Pussytoes. [*A. carpathica* var. *pulcherrima* Hook.]. Plants from a caudex, not mat forming or stoloniferous, 23–40 cm tall; basal leaves 4–19 cm long, 5–23 mm wide, narrowly to broadly oblanceolate to elliptic, tomentose on both surfaces; heads several to many in branching or compact cymes; pistillate and staminate involucres both 6.5–8 mm long, the bracts tomentose at the greenish base, the terminal scarious portion blackish to brownish or the apex whitish; achenes glabrous. Sedge-rush meadows, streamsides, and bogs at 2440 to 2800 m in Duchesne, Garfield, and Summit counties; Alaska to Newfoundland, south to Colorado; 5 (i).

Antennaria rosulata **Rydb.** Plants caespitose, stoloniferous and mat forming, 1–3 cm tall; basal leaves 0.5–1.1 cm long, 2–5 mm broad, spatulate, obtuse to rounded apically, tomentose on both surfaces; heads 1 or 2, terminating short erect branches; pistillate involucres 5–9 mm high, the outer bracts greenish and tomentose to the apex, the inner ones green at base, with scarious slender white tips; staminate involucres 4–5 mm high, the bracts densely tomentose at base, the broad scarious tips white-opaque; achenes puberulent. Ponderosa pine, aspen, Douglas fir, limber pine, sagebrush, and spruce communities, and in alpine meadows, at 2600 to 3350 m in Garfield, Kane, and Wayne counties; Colorado, New Mexico, and Arizona; 14 (i).

Antennaria umbrinella **Rydb.** [*A. dioica* authors, not (L.) Gaertn.]. Plants caespitose, mat forming and stoloniferous, 2–14 mm tall; basal leaves 0.7–2 cm long, 0.2–1.5 cm wide, cuneate-oblanceolate to spatulate, acute to obtuse apically, tomentose on both sides; heads 2–6, borne in subcapitate cymes; pistillate involucres 5–8 mm long, the bracts greenish and tomentose at the base, the scarious tips dirty brownish to pale tan, or the innermost almost white, acute to rounded, usually erose; staminate plants unknown in our region; achenes glabrous. Aspen communities and alpine meadows at 2745 to 3500 m in Duchesne, Juab, and Summit counties; Alaska to Hudson Bay, south to California, Arizona, and Colorado; 4 (0). Specimens assigned here are more or less intermediate between *A. alpina* and *A. microphylla*. Many more specimens are required to provide definitive information on this entity in Utah.

ANTHEMIS L.

Annual or short-lived perennial, aromatic herbs from taproots, the juice watery; stems erect, commonly branched; leaves alternate, 1–3 pinnately dissected; heads solitary on the uppermost branches; involucral bracts imbricated in several series, chaffy, the margins scarious or hyaline; receptacle hemispheric, chaffy at least near the middle; ray flowers present, white or yellow, usually 10 or more, sterile; disk flowers numerous, perfect, fertile; pappus none or a short crown; style branches flattened; achenes subterete or compressed, not callous-margined, glabrous, beakless.

1. Rays white; pappus lacking; disk commonly less than 10 mm broad .... *A. cotula*
— Rays yellow; pappus a short crown; disk commonly more than 12 mm broad .... *A. tinctoria*

Anthemis cotula **L.** Mayweed. Plants annual, 1–7.5 dm tall; stems simple or branched, ill scented; leaves 1–6 cm long, twice pinnatifid, the ultimate segments lance-oblong, sparsely villous and glandular-dotted; heads borne solitary at the upper ends of the uppermost branches; ray flowers commonly 10–20, white, sterile, 5–10 mm long; disk flowers numerous; disk 4–10 (12) mm wide; receptacle chaffy only in the middle, the bracts narrowly subulate; achenes slightly flattened, glandular, the pappus lacking. Introduced Old World weeds of fields, roadsides, revegetated woodlands, and other disturbed sites at 1280 to 1400 m in Duchesne, Morgan, Salt Lake, Utah, and Weber counties (likely elsewhere); widespread in North America; 7 (0).

Anthemis tinctoria **L.** Yellow Camomile. Plants short-lived perennials, 2.5–6 dm tall; stems simple or branched; leaves 1.5–7 cm long, 1- to 2-pinnatifid, the segments oblong in outline, merely toothed or lobed, villous-tomentose below, glabrous or glabrate above, sparsely glandular-dotted; heads borne solitary at ends of the uppermost branches; ray flowers 20–35, yellow, fertile, 7–14 mm long; disk flowers numerous; disk 12–15 mm wide or more; receptacle chaffy throughout, the bracts narrow and with yellow awn-tips; achenes compressed; pappus a short crown. Old World cultivated ornamentals; widely planted and occasionally escaping (Salt Lake County, Garrett 8865 BRY); widespread in North America; 1 (0).

ARCTIUM L.

Biennial, coarse herbs with watery juice, from a taproot; leaves rhubarblike, basal and alternate, entire or toothed; heads few to numerous in axillary or terminal corymbose or racemose inflorescences; flowers all tubular, perfect, the corollas pink to purplish; involucres urn shaped, the bracts imbricate in many series, the tips slender and inwardly hooked; receptacle flat, densely bristly; achenes slightly compressed, more or less 3-angled, many nerved, truncate apically; pappus of numerous, scaly, deciduous bristles.

1. Heads mainly 1.5–2.5 cm thick, arranged in racemelike axillary clusters, the terminal also racemelike .... *A. minus*
— Heads commonly over 2.5 cm thick, arranged in corymbose clusters, especially the terminal .... *A. lappa*

Arctium lappa L. Great Burdock. Plants 8–15 dm tall; basal leaves long-petiolate, the blades commonly 2–5 dm long, 1–3 dm broad, cordate-ovate, obtuse, thinly tomentose beneath, glabrous or nearly so above; inflorescence corymbosely disposed, the peduncles glandular or glandular-hairy; heads 2.5–4 cm broad, the involucre greenish stramineus, glabrous or glandular, often sparingly arachnoid-tomentose. Cultivated for its edible roots, and persisting; introduced from Eurasia; 1 (0).

Arctium minus **(Hill) Bernh.** Burdock. Plants 5–15 dm tall; basal leaves long-petiolate, the blades commonly 1–3.5 (4) dm long, 1–3 dm wide, cordate-ovate, obtuse, thinly tomentose to glabrous beneath, glabrous above or nearly so; inflorescence racemosely disposed, the peduncles short or lacking; heads 1–2.5 cm thick (rarely more), the bracts glabrous or glandular to definitely arachnoid. Introduced Old World weed of consequence in Cache, Juab, Millard, Piute, Sevier, Summit, Tooele, Uintah, Utah, Wasatch, Wayne, and Weber counties, and probably cosmopolitan; widespread in North America; Eurasia; 23 (i).

ARNICA L.

Perennial herbs from rhizomes or caudices, the juice watery; stems erect, simple or branched above; leaves opposite or the uppermost alternate, simple, entire or toothed; heads solitary, or 3–9 (11) in corymbose clusters; involucral bracts subequal or evidently biseriate, herbaceous; receptacle naked, convex; ray flowers present, yellow or orange, several to many, fertile, or lacking (in *A. parryi*); disk flowers numerous, perfect, fertile; pappus of barbellate or subplumose capillary bristles; style branches flattened; achenes cylindrical, 5- to 10-nerved, pubescent to glabrate or glabrous, often glandular.

MAGUIRE, B. 1943. A monograph of the genus *Arnica*. Brittonia 4:386–510.

1. Heads discoid (rarely some with rays), the lateral (lower) ones spreading or reflexed, the uppermost one erect .... *A. parryi*
— Heads radiate, the lateral ones (if any) erect like the uppermost 2

2(1). Cauline leaves (4) 5–9 pairs; pappus brownish; heads often 5 or more per main stem 3
— Cauline leaves 1–4 (5) pairs; pappus white or brownish; heads mainly 1–4 per stem 4

3(2). Involucral bracts merely acute to abruptly rounded (rarely acuminate), bearing an apical or subapical tuft of hairs .... *A. chamissonis*
— Involucral bracts acuminate to attenuate, not especially more hairy at the apex .... *A. longifolia*

4(2). Leaves (at least the lower) cordate, ovate, or broadly ovate-lanceolate, often cordate, truncate, or obtuse basally, seldom cuneate 5
— Leaves narrowly lanceolate to lance-oblong or lanceolate, usually cuneate basally 7

5(4). Pappus brownish, subplumose; main cauline leaves obtuse to subcuneate basally .... *A. diversifolia*

—	Pappus white, merely barbellate; main cauline leaves usually cordate, truncate, or obtuse basally	6
6(5).	Blades of main cauline leaves much longer than the petiole, or sessile; achenes glabrous throughout, or at least near the base	*A. latifolia*
—	Blades of main cauline leaves subequal to or shorter than the petioles; achenes uniformly, though sometimes sparingly, hairy	*A. cordifolia*
7(4).	Pappus brownish, subplumose	*A. mollis*
—	Pappus usually white or tawny, merely barbellate	8
8(7).	Heads turbinate-campanulate, commonly with 7–10 rays; lower cauline leaves sessile or nearly so	*A. rydbergii*
—	Heads hemispheric, commonly with 10–20 rays; lower cauline leaves often petiolate	9
9(8).	Old leaf bases bearing dense brown wool in the axils; disk corollas both spreading hairy and stipitate-glandular	*A. fulgens*
—	Old leaf bases lacking axillary tufts of hair, or with white hair only; disk corollas merely stipitate-glandular	*A. sororia*

Arnica chamissonis **Less.** [*A. foliosa* Nutt.; *A. chamissonis* ssp. *foliosa* (Nutt.) Maguire; *A. foliosa* var. *incana* Gray]. Plants 1–6 (8) dm tall, the stems erect or ascending, simple or more commonly branched in the inflorescence, sparsely to densely villous with multicellular hairs and often glandular as well; basal leaves 3–11 (15) cm long, 3–16 (20) mm wide, lanceolate to oblong or oblanceolate, with 3–5 main veins, pilose to villous or tomentose, tapering to a slender petiole, entire to distinctly toothed, smaller than the cauline ones and often withered by flowering time; cauline leaves (4) 5–8 (9) pairs, lanceolate to lance-elliptic, the largest near the middle of stem or slightly below, the lower ones petiolate and with membranous connate-sheathing bases, the upper sessile, entire to distinctly toothed; heads (1) 3–9, the peduncle apex sparingly to densely villous with whitish hairs often intermixed with glands; involucres 9–15 mm high, the bracts lanceolate, obtuse, acute, or less commonly acuminate, sparsely to densely pilose, ciliate, the tips with a conspicuous tuft of whitish hairs; rays usually 10–16, yellow; achenes 4–6 mm long, hairy to glandular or glabrate; pappus brownish to straw colored, barbellate. Stream banks, gravel bars, and lake shores in aspen, willow, and spruce-fir communities at 2300 to 3350 m in Duchesne, Emery, Garfield, Iron, Kane, Salt Lake, Sanpete, Sevier, Summit, Tooele, Wasatch, Washington, and Wayne counties; Alaska to Hudson Bay, south to California and New Mexico; 29 (v). Maguire (1943) treated all Utah material as ssp. *foliosa* (Nutt.) Maguire. Cronquist (Univ. Washington Publ. Biol. 17(5): 45-54. 1955) cited var. *incana* (Gray) Hulten [ssp. *incana* (Gray) Maguire] from Utah. Our specimens are only arbitrarily separable into two phases, differing mainly in degree of pubescence. The correct name at varietal level for our gray hairy plants appears to be *A. chamissonis* var. *andina* (Nutt.) Ediger & Barkley.

Arnica cordifolia **Hook.** Plants 1.5–4 dm tall, the stems erect or ascending, simple or branched above, sparsely villous with multicellular hairs and often glandular as well; basal leaves smaller than the cauline, often withered at anthesis; petioles of main leaves (at least) often longer than the blades; cauline leaves 2–4 (5) pairs, the blades 2–9 cm long (from sinus to apex), 1–9 cm wide, cordate-ovate to orbicular or reniform, or the uppermost lanceolate, the largest below the middle of the stem, the lower leaves petiolate, the upper ones sessile or subsessile, serrate-dentate to subentire; heads 1 (3), rarely more, the peduncle apex villous with whitish hairs often intermixed with glands; involucres 14–20 mm high, the bracts lanceolate to oblong, acuminate to acute, sparsely to densely pilose and often glandular-ciliate, the tip with a moderate tuft of hair; rays usually 10–15, yellow; achenes 4–5.5 mm long, uniformly hairy and often glandular; pappus white, barbellate. Sagebrush, Douglas fir, white fir, lodgepole pine, ponderosa pine, aspen, and spruce-fir communities at 1525 to 3355 m in Beaver, Box Elder, Cache, Carbon, Daggett, Duchesne, Garfield, Iron, Juab, Piute, Salt Lake, San Juan, Sanpete, Sevier, Summit, Uintah, Utah, Wasatch, Washington, Wayne, and Weber counties (likely universal); Alaska to Michigan, south to California, Arizona, New Mexico, and Nebraska; 102 (xii). The white pappus and cordate long-petiolate leaves are diagnostic for this species.

Arnica diversifolia **Greene** Plants 1.5–4.2 dm tall, the stems erect or ascending, simple or branched above, sparsely villous with multicellular hairs and often glandular, or almost glabrous; basal leaves smaller than the cauline and often withered by flowering time, borne on slender to broadly winged petioles shorter than or subequal to the blades; cauline leaves 2–4 (5) pairs, blades 2–8 cm long, 0.8–4 (6) cm wide, ovate or the uppermost lanceolate, the largest at the middle or below, becoming sessile to subsessile above, subentire or irregularly serrate; heads 1–3 or more, the peduncle apex sparsely to moderately villous with whitish hairs and often with glands; involucre 10–16 mm high; bracts lanceolate, acuminate to acute, sparsely to densely pilose and often glandular, ciliate, the tip lacking a tuft of hairs; rays usually 10–15, yellow; achenes 5–7 mm long, glabrous or sparsely and uniformly hairy; pappus brownish, subplumose. Stream sides, meadows, and scree slopes in spruce-fir and alpine tundra communities at 2560 to 3400 m in Duchesne, Grand, Piute, San Juan, Sanpete, Summit, Uintah, and Utah counties; Alaska and Yukon, south to Oregon and Colorado; 19 (ii). This taxon is not well collected in Utah. The broad leaves and brownish subplumose pappus are diagnostic for these plants that might be regarded as consisting of a series of hybrid derivatives between *A. mollis* and *A. cordifolia*, *A. latifolia*, or *A. rydbergii.* More work is necessary.

Arnica fulgens **Pursh** [*A. pedunculata* Rydb.]. Plants 1.5–6 (7) dm tall, the stems erect, the basal leaf axils with tufts of long brown woolly hair, otherwise stipitate-glandular and often hairy as well; basal leaves smaller than the cauline, often withered at anthesis, with broadly winged petioles or subsessile; cauline leaves 2–4 pair, the blades oblanceolate to elliptic (often narrowly so), mostly 3–12 cm long, 0.6–4 cm wide, the largest ones near the base, becoming sessile upward, subentire to entire; heads 1–3, the peduncle apex yellowish villous; involucre 10–15 (18) mm high, the bracts narrowly elliptic to lance-elliptic, attenuate to an obtuse or acute apex, villous, the tips pubescent within; rays mostly 10–20, yellow to yellow-orange; achenes 4–5.5 mm long, densely hairy; pappus whitish to cream colored, barbellate. Dry sagebrush community at 2000 m in Daggett County; British Columbia to Saskatchewan, south to California, Nevada, and Colorado; 1 (0).

Arnica latifolia **Bong.** [*A. gracilis* Rydb.; *A. jonesii* Rydb.]. Plants 1–4 (6) dm tall, the stems erect or ascending, simple or branched above, sparsely villous with multicellular hairs and often glandular; basal leaves smaller than the cauline, usually withered by flowering time, the petioles (if any) usually shorter than the blades; cauline leaves 2–5 pairs, the blades 2–4.5 (7) cm broad, cordate-ovate to lanceolate, the largest ones at the middle or below, the lower ones with petioles shorter than the blades, the upper ones sessile or subsessile, serrate-dentate, less commonly entire or nearly so; heads 1–5 or rarely more, the peduncle apex sparsely to moderately villous with whitish or yellowish hairs and often glandular; involucres 9–17 mm high, the bracts lanceolate, acuminate to acute, sparsely pilose and often glandular, ciliate, lacking an apical tuft of hair; rays usually 8–12, yellow; achenes 5–8 mm long, glabrous or sparsely hairy, or glabrous in the lower por tion; pappus white, barbellate. Lodgepole pine, spruce-fir, and alpine tundra communities at 2240 to 3400 m in Duchesne, Salt Lake, Summit, and Utah counties; Alaska and Yukon to California and Colorado; 24 (v). Specimens available for study are variable. They occur in the Uinta and Wasatch mountains and on the Tavaputs Plateau. The var. *gracilis* (Rydb.) Cronq. was reported from Utah by Maguire (l.c., as *A. gracilis* Rydb.), but has not been seen by me. It differs from the bulk of our material in its small size (1–3 dm), more numerous heads (3–9), and narrow small involucre 9–13 mm high. The single collection cited by Maguire is from Salt Lake or Utah County. More material is necessary.

Arnica longifolia D.C. Eaton in Wats. [*A. caudata* Rydb., type from Big Cottonwood Canyon]. Plants 3–10.5 dm tall; stems erect or sprawling, tufted from caudexlike shortened rhizomes, simple or branched above, shortly villous to puberulent and often somewhat glandular-viscid; basal leaves lacking or soon withering, the cauline ones 5.5–20 cm long, 0.6–3 cm wide, lanceolate to elliptic, with 3–5 main veins, puberulent, all sessile, 5–7 pairs, the largest near the middle of the stem, the lower ones connate-sheathing, entire or nearly so; heads 1–9, the peduncle apex sparingly yellowish villous; involucres 6–13 mm high, the bracts lanceolate to lance-oblong, acute to acuminate, sparingly pilose and glandular, ciliate, the tips sparingly white-hairy; rays mainly 8–13, yellow; achenes 4.5–5.5 mm long, glabrate, or uniformly stipitate-glandular; pappus brownish to straw colored, barbellate. Snow flushes, talus, and stream banks in lodgepole pine, aspen, ponderosa pine, Douglas fir, white fir, and spruce-fir communities at 1890 to 3325 m in Box Elder, Cache, Garfield, Grand, Juab, Rich, Salt Lake, Sanpete, Summit, Tooele, and Washington counties; Washington to Alberta, south to California, Nevada, and Colorado; 15 (i). Our material belongs to var. *longifolia.*

Arnica mollis Hook. [*A. arachnoidea* Rydb., type form Big Cottonwood Canyon; *A. chamissonis* var. *longinodosa* A. Nels., type from near Marysvale; *A. ovata* Greene, type from Alta]. Plants 1.5–6.5 dm tall, the stems erect or ascending, loosely to compactly clump-forming, simple, or branched in inflorescence, puberulent to villous and glandular; basal leaves smaller than the cauline ones, often withered at anthesis, the cauline ones 4.5–18 cm long, 0.8–4 cm wide, oblanceolate to obovate, lanceolate or elliptic, the lower slenderly to broadly petiolate, becoming sessile upwards, 3–4 pairs, the largest below the middle, the lower connate-sheathing, entire to irregularly denticulate; heads 1–5 (7), the peduncle apex sparingly yellowish villous; involucres 10–17 mm high, the bracts lanceolate to lance-elliptic, acute to attenuate, sparingly to densely villous-pilose and more or less glandular, lacking a subapical tuft of hair; rays mainly 12–18, yellow; pappus brownish, subplumose; achenes pubescent to stipitate-glandular. Meadows, bogs, stream banks, seeps, talus slopes, and rock stripes in sagebrush, ponderosa pine, lodgepole pine, Douglas fir, white fir, aspen, spruce-fir, and alpine tundra communities at 1950 to 3550 m in Box Elder, Cache, Daggett, Duchesne, Garfield, Juab, Kane, Piute, Rich, Salt Lake, Sanpete, Summit, Tooele, Uintah, and Utah counties; British Columbia to California, Nevada, and Colorado; 50 (xii).

Arnica parryi Gray. Plants 1.5–5 (6) dm tall, erect or ascending, from elongate rhizomes, simple or branched in inflorescence, villous and more or less glandular; basal leaves smaller than the cauline ones, often withered at anthesis, the cauline ones long petioled below, becoming sessile upwards, the blades 2–9.5 cm long, 0.4–4 cm wide, lanceolate to ovate, the base obtuse to truncate or cuneate, 2–4 (5) pairs, the largest near the stem base, the lower connate-sheathing, entire to denticulate; heads 3–12, nodding in bud, the peduncle apex glandular-villous; involucres 10–16 mm high, the bracts narrowly lanceolate, acute to attenuate, glandular-villous, lacking a subapical tuft of hairs; rays lacking, or rarely present, yellow; pappus brownish, barbellate to subplumose; achenes glabrous to glandular or hairy. Aspen and spruce-fir communities at 2415 to 3175 m in Carbon, Daggett (?), Garfield, Iron, Salt Lake, Sanpete, and Summit counties; British Columbia and Alberta to California and Colorado; 9 (ii). A specimen from Piute County (Welsh et al. 14018 BRY) has ray flowers well developed.

Arnica rydbergii Greene. Plants 1–2.6 dm tall, erect or ascending, from elongate rhizomes, sparingly villous and shortly stipitate-glandular; basal leaves smaller than the cauline, sometimes bladeless, often withered at anthesis, the cauline ones short to long petioled below, becoming sessile upwards, the blades 2–5 cm long, 0.4–1.5 cm wide, lanceolate to elliptic, ovate, or obovate, the base obtuse to cuneate, 2 or 3 (4) pair, the largest at or near the middle of the stem, the lower connate-sheathing, entire or denticulate; heads 1–5, the peduncle apex yellowish villous, glandular; involucres 9–13 mm high, the bracts narrowly lanceolate, acute to attenuate, stipitate-glandular, ciliate, lacking a subapical tuft of hair; rays mainly 7–10, yellow; pappus white, barbellate; achenes shortly pilose. Spruce-fir and lodgepole pine forests in Duchesne, Summit, and Utah counties; British Columbia and Alberta to Oregon and Colorado; 12 (iii).

Arnica sororia **Greene** Plants 1.5–6 dm tall, the stems erect, the basal axils lacking tufts of hair, otherwise more or less villous and glandular; basal leaves smaller than the cauline, often withered at anthesis, with winged to narrow petioles or subsessile; cauline leaves 2–4 pair, the blades lanceolate to elliptic, mostly 3–10 cm long, 0.5–2 cm wide, the largest ones near the base, becoming sessile upward, mainly entire; heads 1–3, the peduncle apex sparingly villous; involucres 10–15 mm high, the bracts narrowly oblong-lanceolate, attenuate, villous, the tips more or less hairy within; rays mainly 9–15, yellow; achenes 4–6 mm long, densely short-hairy; pappus white, barbellate. Meadows and foothills in sagebrush and aspen communities at 1675 to 2100 m in Cache and Rich counties; Alberta and British Columbia to Wyoming, Nevada, and California; 2 (0).

ARTEMISIA L.

Annual, biennial, or perennial herbs, subshrubs, or shrubs from taproots, caudices, or rhizomes, the juice watery; stems decumbent to ascending or erect, simple or branched; leaves alternate or basal, entire or toothed, lobed, or divided; heads several to numerous, borne in spicate, racemose, or paniculate clusters; involucral bracts imbricate in several series, dry, at least the inner with scarious margins; receptacle naked or beset with long hairs, often glandular; corollas of disk flowers only (rarely with minute bilabiate ray flowers in *A. bigelovii*), perfect, or sometimes the central ones sterile, the marginal merely pistillate; marginal corollas tubular (or bilabiate), the central ones tubular-funnelform; pappus lacking, or a short crown; style branches flattened; achenes subterete or angular, glabrous.

BEETLE, A. A. 1960. A study of sagebrush — The section Tridentate of *Artemisia*. Univ. Wyoming Agr. Expt. Sta. Bull. 368. 83 pp.

KECK, D. D. 1946. A revision of the *Artemisia vulgaris* complex in North America. Proc. Calif. Acad. 25:421–468.

1. Plants shrubs or subshrubs 2
— Plants herbs 13
2(1). Heads with both ray and disk flowers, the ray flowers 2-lipped; branchlets of inflorescence spreading to reflexed; plants of rimrock areas in Colorado drainage, rarely in southern Great Basin .... *A. bigelovii*
— Heads discoid; branchlets of inflorescence variously disposed; plants seldom of rimrock, the distribution various 3
3(2). Leaves 1 to 3-pinnately or ternately dissected, the segments linear 4
— Leaves entire or toothed, or if lobed, the lobes oblong or broader, or if linear (see *A. filifolia*), tall shrubs of sandy areas at low elevations 6
4(3). Plants silvery-canescent; receptacle hairy; growing commonly on windswept ridges, but not always so restricted .... *A. frigida*
— Plants green to gray-green; receptacle glabrous, or, if hairy, plants of low elevations 5
5(4). Shrubs with spreading branches, spinescent, flowering in springtime .... *A. spinescens*
— Shrubs with erect or ascending branches, not spinescent, flowering in late summer and autumn .... *A. pygmaea*
6(3). Leaves linear-filiform, less than 1 mm wide, entire, or 3-parted; tall plants of sandy low elevation sites .... *A. filifolia*
— Leaves broader, entire, or the segments broader than 1 mm wide; plants of various habitats and elevations 7

7(6). Leaves entire or with 1 or 2 teeth; heads borne in slender panicles; plants of high elevations .... *A. cana*

— Leaves toothed or lobed at the apex; heads borne in slender spicate to broad panicles 8

8(7). Plants usually less than 3 dm tall; leaves usually less than 1 cm long; foliage dull yellow- to lead-gray or rarely silvery .... *A. nova*

— Plants mainly more than 3 dm tall; leaves usually more than 1 cm long (at least some); foliage silvery-canescent 9

9(8). Leaves all, or many of them, deeply cleft into narrowly oblong lobes which may be further divided; flowers commonly 5–8 per head .... *A. tripartita*

— Leaves mainly merely toothed apically; flowers various 10

10(9). Leaves coarsely and deeply 3-lobed, the lobes broad and rounded apically; inflorescence narrow, seldom over 1.5 cm wide; plants of Rich and Summit counties .... *A. longiloba*

— Leaves variously 3- to 5-toothed, seldom lobed; inflorescence various; plants variously distributed 11

11(10). Inflorescence open, paniculate, commonly more than 2 cm wide; plants of broad distribution, our common sagebrush species .... *A. tridentata*

— Inflorescence narrow, spicate, commonly less than 1.5 cm wide; plants less broadly distributed 12

12(11). Plants often less than 4 dm tall; leaves mainly less than 1.5 cm long; heads small; plants usually of middle elevations .... *A. arbuscula*

— Plants often over 4 dm tall; leaves mostly over 2 cm long; heads large; plants of high elevations .... *A. spiciformis*

13(1). Leaves all entire, or the lower ones toothed or lobed, glabrous and green above and beneath, or white-hairy on both surfaces (see also *A. carruthii* and *A. michauxiana*), usually much longer than broad 14

— Leaves deeply incised, pinnatifid, or ternately divided, variously pubescent, various in length-width proportions 15

14(13) Leaves green above and beneath; central flowers of heads with normal ovaries .... *A. dracunculus*

— Leaves white-hairy above and beneath or green above; central flowers of head with abortive ovaries .... *A. ludoviciana*

15(14). Plants annual or biennial from a taproot; leaves green, essentially glabrous; adventive 16

— Plants perennial from a rhizome or caudex; leaves tomentose, strigose, or pilose ... 17

16(15). Inflorescence paniculate, loose and open; heads borne on short peduncles; involucres 1–2 mm high .... *A. annua*

— Inflorescence a spicate panicle, the branches appressed-ascending; heads sessile or nearly so; involucres more than 2 mm high .... *A. biennis*

17(15). Cauline leaves reduced upwards, the largest leaves in a basal rosette, silvery-villous to strigulose, scarcely tomentose and uniformly colored above and beneath; plants from caudices, only occasionally rhizomatous 18

— Cauline leaves not especially reduced upwards, seldom with a basal rosette, variously tomentose and often bicolored; plants often rhizomatous (except in *A. absinthium*) 20

18(17). Pubescence of leaves loosely villous to glabrous; corollas hairy, the receptacle glabrous; plants of high elevations in the Uinta and La Sal mountains 19

— Pubescence of leaves appressed strigose or villosulose; corollas glabrous or hairy, but, if hairy, the receptacle long-villous; plants variously distributed 20

19(18). Involucres 3–4 mm high; plants of the La Sal Mountains .... *A. parryi*

— Involucres 4–5.3 mm high; plants of the Uinta Mountains .... *A. norvegica*

20(19). Inflorescence a spicate raceme; receptacle and corolla long-villous; plants of high elevations .... *A. scopulorum*

— Inflorescence a slender panicle; receptacle and corollas glabrous; plants of low elevations, seldom of high elevations .... *A. campestris*

21(17). Receptacle beset with numerous long hairs between the flowers; leaves about equally hairy above as below; plants introduced, weedy, of low elevations .... *A. absinthium*

— Receptacle naked; leaves more or less tomentose below, usually green or greenish above, or equally tomentose on both sides; plants indigenous, not weedy, of mid-to-high elevations 22

22(21). Leaves entire or with entire lobes; plants of moderate elevations in central and southern Utah .... *A. carruthii*

— Leaves bipinnatifid, the lobes again toothed; plants of high elevations in the Uinta, Wasatch, and La Sal mountains .... *A. michauxiana*

Artemisia absinthium **L.** Absinthe. Perennial fragrant herbs from a rhizomatous caudex, 5–10 (12) dm tall, appressed sericeus; leaves bi- or tripinnatifid, the main lobes again lobed or toothed, silvery-sericeus on both surfaces, with very short tangled hairs, hardly tomentose, 1.5–5.5 cm long on flowering stems (2–10 cm long on sterile stems) the main ultimate segments mostly 2–4 mm wide, petiolate below, shortly petiolate and less commonly divided above; involucres 2–3 mm high, the bracts scarious over the greenish center, the margins brownish hyaline; flowers all fertile, the marginal ones pistillate; receptacles with numerous long slender hairs; achenes glabrous. Roadsides, streambanks, and abandoned fields in Garfield, Rich, and Utah counties; widely established in North America; adventive from Europe; 6 (ii).

Artemisia annua **L.** Sweet Wormwood. Annual fragrant herbs, mainly 0.3–1.5 (3) m tall; stems sparingly glandular; leaves 2- or 3-pinnatifid, the main lobes again lobed, green and minutely glandular on both surfaces, 1.5–8 (10) cm long, the main ultimate segments 0.5–3 mm wide, petiolate below, subsessile or shortly petiolate above; involucres 1.3–2 mm high; involucral bracts with green centers minutely glandular, the margins hyaline; receptacles naked; achenes glabrous. Introduced weedy species of disturbed sites in Washington County; adventive from Eurasia, now widely naturalized in North America; 1 (0).

Artemisia arbuscula **Nutt.** Low Sagebrush. [*A. tridentata* ssp. *arbuscula* (Nutt.) H. & C.; *A. tridentata* var. *arbuscula* (Nutt.) McMinn]. Shrubs, commonly 2–4 (5) dm tall, the vegetative stems 1.5–10 cm long, the flowering stems erect, 8–30 cm long; leaves 0.4–1.6 cm long, shallowly 3- to 5-dentate to deeply lobed, cuneate basally, appressed canescent; inflorescence spicate, mostly less than 2 cm wide; involucres 4–6 mm long, campanulate; involucral bracts 4–8, canescent, the margins brownish-scarious; flowers 4–9, all perfect; receptacle naked; achenes glabrous. Pinyon-juniper, mountain brush, sagebrush, white fir, aspen, and spruce-fir communities at 1375 to 2550 m in Box Elder, Cache, Millard, Rich, Salt Lake, Summit, and Tooele counties; Washington to Montana, south to California and Nevada; 14 (0). *A. arbuscula*, or low sagebrush, has been confused with both *A. tridentata* and *A. nova*. It can be distinguished from the former by its narrow inflorescence, and from the latter by its canescent involucres. Beetle (l.c.) reports intermediates with A. *longiloba*, a taxon with broadly campanulate heads and bluntly lobed leaves.

Artemisia biennis **Willd.** Biennial Wormwood. Plants annual or biennial, with taproots, the stems 0.3–9 (10) dm tall or more, glabrous; basal leaves often withered by anthesis; cauline leaves well developed, 1.5–10 (15) cm long, once pinnately divided, the segments oblong to oblanceolate, again toothed, essentially glabrous, green; inflorescence spicate or in spicate panicles; heads numerous, crowded, sessile or subsessile, erect or nearly so; involucres 2–3 mm high, 2–4 mm broad, the bracts glabrous, greenish to yellowish, the margins hyaline; marginal flowers perfect, fertile, the corollas glabrous; receptacle and achenes glabrous. Floodplains, lake beds and shores, mud flats, and pond margins at 1375 to 2900 m in Cache, Duchesne, Garfield, Grand, Iron, Millard, Salt Lake, Sanpete, Tooele, Uintah, and Utah counties; widespread in North America, where presumably indigenous in the western portion; Europe; 20 (v).

Artemisia bigelovii **Gray** Bigelow Sagebrush. Shrubs, commonly 2–7 (10) dm tall or more, the vegetative stems 1–3 dm long, the flowering stems erect, 3–4.5 dm tall; leaves 0.3–2.3 cm long, 1–7 mm wide, entire or shallowly 3-toothed, basally cuneate, appressed to loosely canescent-tomentose; inflorescence narrowly paniculate, mostly less than 4 cm wide, the branches often lax and with heads tending to be pendulous; involucres mainly 2.5–3.5 mm high, subcylindric to narrowly campanulate, the bracts 5–10, silvery canescent, with narrow scarious margins; flowers 3 or 4, imperfect or some perfect, the marginal pistillate (ray) flowers bilaterally symmetrical; receptacle naked; achenes glabrous. Rimrock areas in pinyon-juniper and mixed desert shrub communities at 975 to 2135 m in Duchesne, Emery, Garfield, Grand, Kane, Millard, San Juan, Sevier, Uintah, and Wayne counties; California and Nevada east to Colorado, New Mexico, and Texas; 45 (xvii).

Artemisia campestris **L.** Field Wormwood. Perennial herbs from a caudex and taproot, the stems (1.5) 2.5–7 dm tall (rarely taller), tomentose or glabrous; basal leaves well-developed (often withered at anthesis), 2–12 cm long, 2- to 3-pinnatifid or ternate, the segments linear to narrowly oblong or spatulate, villous or pilose to glabrous on both sides; cauline leaves reduced upwards, once pinnatifid, ternate, or entire; inflorescence of narrow to lax panicles; heads numerous, shortly pedunculate on contracted to lax branchlets, finally pendulous; involucres 2.5–3.8 mm high, 2–2.3 mm wide, the bracts glabrous, greenish to yellowish, the margin hyaline; marginal flowers pistillate, fertile, the corollas glabrous; disk flowers sterile, the ovaries abortive; receptacle and achenes glabrous. Saltbush, greasewood, sagebrush, mountain brush, and pinyon-juniper communities, mainly in dunes and other sandy sites at 1250 to 2075 m in Emery, Garfield, Grand, Kane, San Juan, Sevier, Washington, and Wayne counties; Arizona, New Mexico, Colorado, Wyoming, and west to the Pacific; 24 (vii). Our material is assignable to ssp. ***borealis*** (Pallas) H. & C., in a broad sense, and belongs to var. ***scouleriana*** (Benth.) Cronq. [*A. pacifica* Nutt.; *A. campestris* ssp. *pacifica* (Nutt.) H. & C.; *A. forwoodii* authors, not Wats.; *A. caudata* authors, not Michx.] in a more narrow sense.

Artemisia cana **Pursh** Silver Sagebrush. Shrubs, commonly 2.5–12 (15) dm tall, the vegetative branches 1–3 (5) dm long; flowering stems erect, 1–3 dm tall; leaves 0.8–5.3 (7) cm long, linear to narrowly elliptic or oblong, entire, or some of them toothed or deeply lobed, usually acute basally, acute to obtuse apically, appressed tomentose; inflorescence narrowly spicate or glomerate-paniculate, mostly less than 5 cm wide, often conspicuously bracteate, the branches, when present, erect, the heads erect; involucres 3.3–6.1 mm high, 3.5–6 mm wide, campanulate; bracts numerous, the outer silvery-canescent, with greenish median, the margins brownish scarious, rounded-erose; flowers 10–20, perfect; receptacle naked; achenes glabrous. Meadows and stream terraces, less commonly on moist slopes away from meadows and streams at 2270 to 3050 m in Cache, Carbon, Daggett, Duchesne, Emery, Garfield, Iron, Juab, Kane, Piute, Rich, Sanpete, Sevier, Summit, Utah, Wasatch, and Washington counties; British Columbia to Saskatchewan, south to California, Nevada, and New Mexico. Our materials are assigned to var. ***viscidula*** Osterh. [*A. cana* ssp. *viscidula* (Osterh.) Beetle], which differs from typical var. *cana* in its smaller, narrower leaves and less canescent herbage. Silver sagebrush forms intermediates with both *A. tridentata* var. *vaseyana* and *A. spiciformis*, within whose altitudinal range it occurs, but whose habitats are ordinarily separate; 42 (viii).

Artemisia carruthii **Wood ex Carruth** Carruth Wormwood. [*A. wrightii* Gray; *A. vulgaris* ssp. *wrightii* (Gray) H. & C.]. Plants perennial herbs, with well-developed rhizomes, the stems 2–7 dm tall, sparingly to densely tomentose; basal leaves not well developed; cauline leaves various but usually pinnatifid with linear lobes, those of innovations and sometimes the primary ones at base of flowering stems entire or merely lobed, 0.6–3 cm long, the lobes 0.5–1.5 (2) mm wide, linear or narrowly oblong, tomentose on both sides, or less so above; inflorescence paniculate (narrowly so) or spicate; heads numerous, shortly pedunculate to sessile, erect; involucres 2.3–3 mm high, 2–2.5 mm wide, the bracts sparingly tomentose, pale greenish with hyaline margins; marginal flowers pistillate, fertile; central flowers perfect, fertile, the corollas glabrous; receptacle and achenes glabrous. Canyon bottoms, slopes, and rock outcrops in sagebrush, mountain brush, aspen, and spruce-fir communities at 1890 to 3050 m in Emery, Iron, Piute, San Juan, Utah, and Washington counties, and likely elsewhere; east to Kansas and south to Arizona, New Mexico, and Texas. This taxon is allied to *A. ludoviciana*, and some specimens appear to be intermediate between them. There is justification for inclusion of *A. carruthii* within an expanded *A. ludoviciana*, but no formal proposal is intended or implied herein. The deeply pinnatisect main foliage leaves are thought to be diagnostic. The species has not been collected in sufficient numbers as to understand its distribution in any definitive manner; 16 (ii).

Artemisia dracunculus **L.** Terragon. [*A. glauca* Pallas; *A. dracunculus* ssp. *glauca* (Pallas) H. & C.; *A. aromatica* A. Nels.; *A. dracunculoides* Pursh]. Plants shortly rhizomatous, perennial herbs, the stems (2) 5–12 (15) dm tall, glabrous (rarely tomentose?); leaves primarily cauline, entire or rarely a few of them cleft, 1.2–7.5 cm long, 1–6 mm wide, glabrous, green on both surfaces; inflorescence paniculate; heads numerous, short-pedunculate to subsessile, more or less pendulous; involucres 2–2.8 mm high, 2.2–3 mm wide, the bracts glabrous, greenish, with broad hyaline margins; marginal flowers pistillate, fertile; central flowers sterile, the ovaries abortive, the corolla glabrous (often glandular); receptacle and achenes glabrous. Rabbitbrush, sagebrush, skunkbush, wildrye, salt desert shrub, pinyon-juniper, ponderosa pine, aspen, spruce-fir, and hanging garden communities at 1220 to 3200 m in Duchesne, Emery, Garfield, Grand, Iron, Juab, Kane, Millard, Piute, San Juan, Sanpete, Sevier, Tooele, Uintah, Utah, Wasatch, Washington, and Wayne counties; Yukon southeast to Illinois and south to Mexico. Our material fits within the concept of var. ***glauca*** (Pallas) Bess. in Hook., which is probably not separable from var. *dracunculus* of the Old World; 63 (xvii).

Artemisia filifolia **Torr.** Sand Sagebrush; Old-man Sagebrush. Shrubs commonly 5–15 dm tall, the vegetative branches 1–3 dm long; flowering branches erect, 1.5–6 dm long; leaves 0.6–8 cm long, 0.3–1.5 mm wide, revolute (appearing terete) or somewhat flattened (and still revolute), entire or the lower ternate, appressed villous-tomentose; inflorescence paniculate, mostly more than 3 cm wide, conspicuously bracteate, the branches erect, the heads pendulous; involucres 1.6–2.2 mm long 1.5–2.2 mm wide, campanulate to subglobose; bracts 5–9, densely silvery canescent; flowers 3–9, the marginal ones pistillate, fertile, the central ones sterile; receptacle naked; achenes glabrous. Sandy sites in blackbrush, creosote bush, ephedra, *Poliomintha, Eriogonum*, rabbitbrush, and pinyon-juniper communities at 825 to 2290 m in Emery, Garfield, Grand, Iron, Kane, San Juan, Washington, and Wayne counties; Colorado and South Dakota, south to Arizona, Texas, and Mexico; 43 (vi).

Artemisia frigida **Willd.** Fringed Sagebrush; Prairie Sagewort. Shrubs 0.5–4.5 dm tall, white-tomentose to strigulose; flowering stems arising from short prostrate or ascending woody offsets; leaves of basal offsets much like the stem leaves, 0.5–1.5 (2.5) cm long, 2- to 3-ternately (or subpinnately) divided into linear segments mainly 0.3–0.8 mm wide, often with stipulelike divisions near the base, whitish pilose-tomentose throughout (fading brownish); inflorescence paniculate or less commonly borne sessile or on very short peduncles; involucres 2–3.5 mm high, 4–6 mm broad, the bracts pilose-tomentose, with brownish scarious margins; marginal flowers pistillate, fertile; central flowers perfect, fertile, the corolla glabrous (often glandular), yellow or tinged reddish; receptacle long-hairy; achenes glabrous. Shadscale, sagebrush, pinyon-juniper, ponderosa pine, mountain brush, aspen, spruce, and alpine (often on windswept ridge crests) communities at 900 to 3480 m in Box Elder, Carbon, Duchesne, Emery, Garfield, Grand, Juab, Kane, Millard, Piute, San Juan, Sanpete, Sevier, Summit, Uintah, Utah, Wasatch, and Wayne counties (likely elsewhere); Alaska to Quebec, south to Arizona and Kansas; Asia; 78 (x).

***Artemisia longiloba* (Osterh.) Beetle** Longleaf Sagebrush. [*A. spiciformis* (?) *longiloba* Osterh.]. Shrubs, mainly 2–5 dm tall, appressed villous-tomentose; flowering stems 1–2 dm long; leaves 0.4–2 cm long, broadly cuneate, deeply 3-lobed, the lobes obtuse, appressed villous-tomentose; inflorescence spicate, the heads several, shortly pedunculate to sessile, erect; involucres 4–6 mm high, 3–5 mm wide, the 4–12 bracts villous-tomentose, green, with brownish scarious margins; marginal flowers perfect, fertile, central flowers perfect, fertile, the corolla glabrous (glandular), cream colored; receptacle and achenes glabrous. Sagebrush and grass communities at 1675 to 2440 m in Rich and Summit counties; Oregon to Montana, south to Nevada and Colorado. This entity is reported to grow in tight to heavy soils (Beetle 1960) and matures seed in July and August. The plants have large heads similar to those of *A. cana* and the low habit of *A. nova*. Possibly they would best be treated within an expanded *A. tridentata*, but no combination is proposed herein; 4 (0).

***Artemisia ludoviciana* Nutt.** Perennial rhizomatous herbs, the stems 2–10 dm tall (or more), white-tomentose or glabrate to glabrous; leaves mainly cauline, entire, lobed, or pinnately incised, white-tomentose below, green and glabrous or tomentose above (rarely glabrous throughout), 0.8–9 cm long, 0.1–1 (2) cm wide; inflorescence spicate to paniculate; heads numerous, shortly pedunculate to sessile, more or less pendulous; involucres 2.5–4.5 mm high, 3–7 mm wide (or more), the bracts tomentose to glabrous, with broad scarious margins; marginal flowers pistillate, fertile; central flowers perfect, fertile, the corolla glabrous, yellow; receptacle and achenes glabrous. This is a wide spread species of many phases and habitats. In Utah there are five more or less distinctive varieties. Two of the varieties, *ludoviciana* and *incompta* are especially abundant, the remaining three less so. Not all specimens are readily separable into the named varieties, and the following key is arbitrary.

1. Inflorescence an open panicle, often more than 8 cm wide; plants of southern and southeastern Utah 2

— Inflorescence a spicate panicle, usually less than 6 cm wide; plants of various distribution 3

2(1). Leaves mainly less than 2.5 cm long, the margin often narrowly revolute .... *A. ludoviciana* var. *albula*

— Leaves mainly over 2 cm long, the margins not revolute .... *A. ludoviciana* var. *mexicana*

3(1). Leaves entire or less commonly some of them toothed or lobed .... *A. ludoviciana* var. *ludoviciana*

— Leaves more or less deeply parted or divided 4

4(3). Involucres 3.5–4.2 mm high, 4–7 mm wide .... *A. ludoviciana* var. *latiloba*

— Involucres 2.5–3.5 (3.8) mm high, 2.5–5 mm wide .... *A. ludoviciana* var. *incompta*

Var. *albula* (Wooton) Shinners [*A. albula* Wooton, nomen novum pro *A. microcephala* Wooton]. This distinctive short-leaved variety has open inflorescences; it occurs in riparian areas with rabbitbrush, cottonwood, and copperweed at 880 to 1680 m in Emery, Garfield, Kane, San Juan, and Washington counties; Nevada and Colorado south to Mexico; 4 (ii).

Var. *incompta* (Nutt.) Cronq. [*A. incompta* Nutt.; *A. ludoviciana* ssp. incompta (Nutt.) Keck]. The deeply lobed or cleft leaves and compactly spicate inflorescence are diagnostic. The plants occur at moderate to high elevations (2135 to 3500 m) in aspen, spruce-fir, willow-wet meadow, and riparian communities in Cache, Carbon, Duchesne, Juab, Millard, Piute, Salt Lake, San Juan, Sanpete, Sevier, Summit, Tooele, Utah, and Wasatch counties; Oregon to Montana, south to California, Nevada, and Colorado; 65 (vi). This variety passes by degree into *A. michauxiana* at high elevations.

Var. *latiloba* Nutt. [*A. candicans* Rydb.; *A. ludoviciana* ssp. *candicans* (Rydb.) Keck]. This variety is similar to var. *incompta*, differing in larger (higher and wider) heads. It is poorly understood in Utah, where it was reported by Keck (1946) from Cache County. Our one specimen is from Utah County, without locality data; 1 (0).

Var. *ludoviciana* [*A. gnaphaloides* Nutt.; *A. ludoviciana* var. gnaphaloides (Nutt.) T. & G.; *A. purshianus* Bess. in Hook.]. The typical variety is a plant with entire or cleft (rarely deeply cleft or parted) leaves and loose, but not open, inflorescences. Rabbitbrush, sagebrush-grass, mountain brush, pinyon-juniper, ponderosa pine, and hanging garden communities at 880 to 2750 m in all Utah counties, except for Morgan, Piute, and Summit (and likely there also); British Columbia to Ontario, south to California, Arizona, New Mexico, Texas, and Indiana; 86 (xvi).

Var. *mexicana* (Willd.) Fern. [*A. mexicana* Willd.; *A. ludoviciana* ssp. mexicana (Willd.) Keck]. This is the long-leaved plant with open inflorescences; it forms the counterpart of var. *albula*. It is a component of riparian, pinyon-juniper, ponderosa pine, and aspen communities at 750 to 2600 m in Garfield, Grand, Kane, San Juan, Washington, and Wayne counties; Colorado to Missouri, south to Mexico; 17 (viii).

***Artemisia michauxiana* Bess.** Michaux Wormwood. [*A. discolor* Dougl. ex Bess.]. Perennial herbs, the stems 0.8–4 dm tall (rarely more), white tomentose to glabrate or glabrous; leaves mainly cauline, 0.5–4 (5) cm long and about as broad, bipinnately dissected, the secondary segments again toothed or lobed, acute, the uppermost seldom entire, commonly green above and tomentose beneath, but often green beneath also; inflorescence spicate; heads several to numerous, commonly pedicellate, erect or nodding; involucres 3.4–4.4 mm high, 3–6 mm wide, the bracts glabrous or sparingly tomentose, green, the broad margins brownish scarious and erose-ciliate; marginal flowers pistillate, fertile; central flowers perfect, fertile, the corolla glabrous (glandular), yellow; receptacle and achenes glabrous. Spruce-lodgepole pine and alpine tundra communities, often in boulder stripes and talus, at 2950 to 3500 m in Duchesne, San Juan, Summit, and Utah counties (Uinta, La Sal, and Wasatch mountains); British Columbia and Alberta south to Nevada and Wyoming; 11 (ii). Keck (1946) notes that *A. michauxiana* is connected through a series of intermediates with *A. ludoviciana* var. *incompta* in Nevada specimens. This is true for ours also. There appears to be some justification for treating *A. michauxiana* within an enlarged *A. ludoviciana*, but such a combination is not implied herein.

Artemisia norvegica* Fries** Spruce Wormwood. Perennial herbs, 2–4.1 dm tall, from a simple or branched caudex and stout taproot, the caudex branches short, clothed with persistent leaf bases, the flowering stems arising directly from the caudex, villous, often reddish; leaves of basal rosettes 2–19 cm long, bi- or tripinnatifid, the segments lance-attenuate to acute, villous on both surfaces; cauline leaves becoming smaller upwards, often with stipulelike divisions near the base; inflorescence racemose; heads several to numerous, finally nodding, the peduncles to 4.5 cm long; involucres 4–5.3 mm high, 6–11 mm wide, the bracts sparingly to densely villous-pilose, more or less green, the margins broadly dark brownish scarious; marginal flowers pistillate, fertile; central flowers perfect, fertile, the corollas long-hairy from near the base, cream colored; receptacle and achenes glabrous. Spruce-fir, lodgepole pine, and alpine tundra communities in Duchesne and Summit counties; Alaska east to Mackenzie, and south to California and Colorado. Our material belongs to var. ***piceetorum Welsh & Goodrich in Welsh; 4 (iii).

Artemisia nova **A. Nels.** Black Sagebrush. [*A. tridentata* ssp. *nova* (A. Nels.) H. & C.; *A. tridentata* var. *nova* (A. Nels.) McMinn; *A. arbuscula* ssp. *nova* (A. Nels.) Ward]. Shrubs, 1–3 (5) dm tall, the main branches spreading, the vegetative stems 1–3 dm long (rarely more); flowering stems mainly 1.5–3 (4) dm long; leaves 0.3–2.1 cm long, shallowly to deeply 3- to 5-lobed or -toothed, the lobes or teeth rounded, often lead-gray or gray green, cuneate basally, appressed canescent and often minutely punctate; inflorescence narrowly paniculate, seldom more than 3 cm wide; involucres 3.1–5.8 mm long, 1.4–3.4 mm wide, cylindric to narrowly campanulate; bracts 8–12, canescent to glabrous, green to yellowish, the margin hyaline; flowers 3–8, all perfect; receptacle glabrous; achenes glabrous. Horsebrush, greasewood, shadscale, ephedra, juniper, sagebrush, rabbitbrush, winterfat, pinyon-juniper, and mountain brush communities at 1400 to 2600 m in Beaver, Box Elder, Cache, Carbon, Daggett, Duchesne, Emery, Garfield, Grand, Iron, Juab, Kane, Millard, Piute, Rich, San Juan, Sanpete, Sevier, Summit, Tooele, Uintah, and Weber counties; Oregon to Montana, south to California, Arizona, and New Mexico; 57 (x). Black sagebrush forms intermediates with all other members of the section Tridentatae that it contacts. The intermediates form narrow bands along lines of contact, but generally the habitats are mutually exclusive. There is little justification for considering black sagebrush in an expanded *A. tridentata* unless one is willing to accept most of the remainder of the section as portions of that species also.

Artemisia parryi Gray Parry Wormwood. Perennial herbs, 0.8–2 (4) dm tall, from a simple or branched caudex and stout taproot, the caudex branches short, clothed with persistent leaf bases, the flowering stems arising directly from the caudex, sparingly and loosely villous to glabrous, often reddish; leaves of basal rosettes 2–4 (8) cm long, twice pinnatifid, the segments oblong to lance-oblong, sparingly and loosely villous (to glabrous?); cauline leaves becoming smaller upwards; inflorescence racemose to subspicate; heads several to numerous, commonly nodding, the peduncles 1–5 mm long; involucres 3–4 mm long, 3–5 mm wide, the bracts sparingly villous to glabrate, with green to brownish middle and brownish scarious margins; marginal flowers pistillate, fertile; central flowers perfect, fertile, the corollas long-hairy (to glabrous?); receptacle and achenes glabrous. Alpine sites in the La Sal Mountains (Grand and San Juan counties); Colorado; 0 (0). The species is reported for Utah by Hall and Clements (l.c.), but no specimens have been seen from the state by me. Possibly it is only a phase of *A. norvegica*.

Artemisia pygmaea Gray Pygmy Sagebrush. Shrubs 0.5–2 dm tall, from superficial woody caudexlike branches and stout taproots, the vegetative stems to 0.5 dm long; flowering stems erect to 2 dm tall; leaves 0.3–1 cm long, pinnately (or subbipinnately) 3- to 10-lobed, the lobes acute, yellow- to gray-green, sparingly villous to glabrous; inflorescence spicate or narrowly paniculate, less than 2 cm wide; involucres 5.2–6.3 mm high, 3–4.5 mm wide, cylindric or becoming campanulate upon drying; involucral bracts oblong, 15 or more, sparingly villous to glabrous, green, the margins stramineous-hyaline; marginal flowers lacking; central flowers 3–5, perfect, fertile, the corollas cream colored, glandular; receptacle and achenes glabrous. Black sagebrush, rabbitbrush, shadscale, greasebush, juniper, pinyon-juniper, and ponderosa pine communities at 1600 to 2300 m in Beaver, Duchesne, Emery, Garfield, Iron, Millard, Piute, Sevier, and Uintah counties (likely elsewhere); Arizona and Nevada; 27 (viii). This dwarf sagebrush occurs in peculiar edaphic situations on Green River Shale, in clay soils forming the matrix in igneous gravels, on calcareous gravels, and on dolomitic outcrops and gravels. It is often a component of communities that support rare plant species.

Artemisia scopulorum Gray Dwarf Sagewort. Perennial herbs, 0.5–3.7 dm tall, from a simple or branched caudex and stout taproot, the caudex branches short, clothed with persistent leaf bases, the flowering stems arising directly from the caudex, appressed pilose to loosely and sparingly villous, often reddish or purplish; leaves of basal rosettes 1.5–9 cm long, twice pinnatifid, the segments oblong to elliptic, pubescent like the stems; inflorescence spicate to racemose; heads several to numerous, erect or nodding, the peduncles lacking, or to 2.3 cm long; involucres 3–5.2 mm high, 3–8 mm wide, the bracts villous, green to brownish in the middle, the margins brown-scarious; marginal flowers pistillate, fertile; central flowers perfect, fertile, the corollas cream colored, long-hairy; receptacle copiously long-villous; achenes glabrous. Talus slopes, moraines, and outwash plains and terraces in alpine tundra and meadows in spruce, lodgepole pine, and Douglas fir communities at 3050 to 4000 m in Boulder, Tushar, La Sal, and Uinta mountains; Beaver, Duchesne, Garfield, Grand, Piute, Summit, and Uintah counties; Montana, Wyoming, Colorado, and New Mexico; 30 (xi). The hairy corollas and long-villous receptacles are diagnostic for this distinctive species.

Artemisia spiciformis **Osterh.** Osterhout Sagebrush. Shrubs, mainly 5–8 dm tall, the vegetative stems 0.4–1 dm long, the flowering stems erect, 1.5–3.4 dm long; leaves 1.7–5.7 cm long, shallowly to deeply 3- to 5-lobed or -toothed, often widest below the teeth, the lobes acute to obtuse (or rounded) or lacking, gray-green, long-cuneate basally, appressed villous-canescent; inflorescences narrowly paniculate, usually less than 4 cm wide; involucres 5–6.3 mm long, 3.5–7 mm wide, cylindric to campanulate; involucral bracts 8–12 or more, canescent to glabrate, green, with broad yellowish brown scarious margins; flowers 6–10 or more, all perfect; receptacle and achenes glabrous. Ridge margins and snow-flushes in sagebrush-grass, snowberry, aspen, spruce-fir, and Douglas fir communities at 2680 to 3050 m in Cache (?), Duchesne, Emery, Juab, Sanpete, Summit, Tooele, and Wasatch counties (likely elsewhere); Colorado and Wyoming; 16 (ii). This is the material which has long passed under the name of *A. rothrockii* Gray in Utah. Resemblance to that species appears to be superficial, with relationships running to both *A. cana* and *A. tridentata* var. *vaseyana*. Its habitat is intermediate between the high elevation, moderately xeric conditions of var. *vaseyana*, and the more mesic stream terrace and valley bottoms of *A. cana*.

Artemisia spinescens **D.C. Eaton in Wats.** Budsage. Shrubs, flowering in springtime, the branches spreading and often prostrate, 0.5–3 dm long or more, the vegetative stems mainly 0.3–0.8 dm long, commonly surpassing the flowering stems; leaves 0.4–2 cm long, petiolate, the blade palmately 3- to 5-cleft, the main divisions again cleft, suborbicular in outline, villous; inflorescence of short leafy-bracted racemose or spicate branches, or of solitary heads, the rachis persistent as a thorn; involucres 2–3.5 mm high, 3.5–5 mm wide; involucral bracts 4–8, villous, green, with narrow hyaline margins; flowers 6–20 or more, the marginal ones pistillate, fertile, the central ones sterile; corollas copiously long-hairy; receptacle naked; achenes long-hairy. Silty, clayey, or gravelly, often saline, substrates in black sagebrush, shadscale, tetradymia, greasewood, blackbrush, juniper, and winterfat communities at 1200 to 1925 m in Carbon, Duchesne, Emery, Garfield, Juab, Kane, Millard, Piute, San Juan, Sevier, Tooele, Uintah, and Utah counties; Oregon to Montana, south to California and New Mexico; 92 (vii). This low shrub is a principal browse plant for domestic livestock on the spring ranges of western and southern Utah.

Artemisia tridentata **Nutt.** Big or Common Sagebrush. Shrubs 4–20 (30) dm tall; branches spreading to erect, the vegetative branchlets 0.5–2 dm long; flowering stems mostly 1.5–4 dm long, usually much surpassing the vegetative ones; leaves 0.5–5 cm long, 3- to 5-toothed apically, or the upper ones entire, long-cuneate; inflorescence paniculate, 3–20 (15) cm wide; involucres 3–5 mm long, 2–4 mm wide, the bracts 10–20, green, canescent, the margins scarious; flowers 3–8, all perfect, the corollas cream colored, glandular; receptacle and achenes glabrous. Three more or less completely intergrading varieties are known from Utah; they tend to occupy distinctive habitats, but intermediates form wherever they meet. Further, this taxon is known to hybridize with most if not all other members of the section Tridentatae. The help of Durrant MacArthur and Sherel Goodrich of the U.S. Forest Service is here gratefully acknowledged. They sorted our materials into their respective varieties following my initial attempt and general failure. While it is not possible to segregate all specimens, the following key will prove useful to those who must manage the sagebrush lands of Utah and the west.

1. Vegetative stems short, standing at about the same height, the inflorescence rather uniformly overtopping them; plants of middle and higher elevations .... *A. tridentata* var. *vaseyana*

— Vegetative stems short to long, the inflorescence not uniformly overtopping them; plants of low to moderate elevations 2

2(1). Leaves mainly to 2 cm long or more, narrowly cuneate; plants of low to moderate elevations .... *A. tridentata* var. *tridentata*

— Leaves mainly less than 1.2 cm long, cuneate to cuneate-flabellate; plants mainly of moderate elevations, in drier sites .... *A. tridentata* var. *wyomingensis*

Var. *tridentata* Big Sagebrush. Sagebrush, juniper, pinyon-juniper, and rabbitbrush communities at 1220 to 2410 m in most, if not all, Utah counties; Washington to Montana, south to California, Arizona, and New Mexico; 57 (xviii).

Var. *vaseyana* (Rydb.) B. Boi. Vasey Sagebrush. [*A. tridentata* ssp. *vaseyana* (Rydb.) Beetle]. Sagebrush, rabbitbrush, mountain brush, pinyon-juniper, aspen, Douglas fir, ponderosa pine, and spruce-fir communities at 1830 to 3050 m in all, or nearly all, Utah counties; Idaho to the Dakotas, south to Colorado; 55 (viii).

Var. *wyomingensis* (Beetle & Young) Welsh stat. nov. [based on *Artemisia tridentata* ssp. *wyomingensis* Beetle & Young Rhodora 67: 405. 1965]. Wyoming Sagebrush. Shadscale, rabbitbrush, sagebrush, juniper, bitterbrush, and mountain mahogany communities at 1525 to 1980 m in Box Elder, Garfield, Emery, Rich, Tooele, and Uintah counties; Wyoming and Idaho to Colorado. This is the sagebrush of drier sites at middle elevations. Its distribution is poorly understood; likely it is widespread. Its recognition allows management considerations by professionals in the various state and federal agencies; 9 (0).

***Artemisia tripartita* Rydb.** Threetip Sagebrush. Shrubs 2–20 dm tall, the branches erect, the vegetative ones 0.3–1.5 dm long, the flowering stems 0.6–3.5 dm long; leaves 1–4 cm long, deeply 3-cleft, the linear lobes 0.5–0.8 mm wide, canescent, the lobes sometimes again divided, or the upper ones entire; inflorescence paniculate, commonly 2–5 cm wide; involucres campanulate, 3–4 mm long, 1.5–4 mm wide; bracts many, imbricate, canescent and more or less green, the inner with broad brownish scarious margins; flowers 4–8, all perfect, the corollas stramineus to cream-colored, more or less glandular; ach enes and receptacle glabrous. Sagebrush and mountain brush communities at ca 1525 to 1830 m in Box Elder and Cache counties; British Columbia to Montana, south to California and Colorado; 1 (0).

ASTER L.

Annual or perennial herbs from rhizomes (suffrutescent in *A. spinosus*), with watery juice; stems decumbent to ascending or erect, simple or branched; leaves alternate, simple, entire or toothed; heads solitary or few to several in corymbose clusters; involucral bracts strongly imbricate to subequal (or the outer surpassing the inner), herbaceous throughout, or with scarious margins near the base; receptacle flat or merely convex, naked; rays blue, purple, pink, or white, few to numerous, pistillate; disk flowers numerous, perfect, fertile, yellow or tinged reddish or purplish; pappus of capillary bristles; style branches flattened, oblong to lanceolate, mostly more than 0.5 mm long; achenes mostly several nerved.

1. Plants suffrutescent, rushlike, armed with axillary or subaxillary thorns, from a deep-seated rhizome; known from Garfield County (possibly Washington also) .... *A. spinosus*

— Plants herbaceous, annual or perennial, unarmed, from a taproot or rhizome; distribution various 2

2(1). Plants annual, from taproots 3

— Plants perennial, from rhizomes or subrhizomatous caudices, or from branching caudices 4

3(2). Involucral bracts definitely acute; rays wanting or nearly so, the pistillate corollas tubular, shorter than the style .... *A. brachyactis*

— Involucral bracts obtuse to obtusish; rays to 2 mm long, longer than the style ... . *A. frondosus*

4(2). Plants with a well developed caudex; involucral bracts reflexed, at least the outer; plants of rock crevices in the Wasatch and Canyon mountains .... *A. kingii*

— Plants with caudex lacking or poorly developed, rhizomatous; involucral bracts not reflexed; plants of various habitats and localities 5

5(4). Leaves all erect-ascending, thickened, to about 4 mm wide; pappus double, the outer series of very short bristles; heads solitary; plants known from Box Elder County .... *A. scopulorum*

— Leaves various, seldom as above; pappus in one series, or rarely double; heads solitary to numerous; distribution various 6

6(5). Involucral bracts dry, chartaceous, with scarious tips (at least the innermost), with a distinctive midvein, not herbaceous (the outer sometimes so) 7

— Involucral bracts herbaceous at the tips or throughout, lacking a distinctive midvein 9

7(6). Involucral bracts (at least the outer) bluntly obtuse apically; herbage strongly glaucous; plants often of open calcareous sites .... *A. glaucodes*

— Involucral bracts acute; herbage green, not glaucous; plants of various habitats 8

8(7). Rays white (drying pinkish); main leaves often over 20 mm wide; plants 6–15 dm tall, of montane areas in central northern Utah .... *A. engelmannii*

— Rays purple or violet; leaves mainly less than 15 mm wide; plants 2–6 dm tall, of central northern and western Utah .... *A. perelegans*

9(5). Involucres and peduncles glandular 10

— Involucres and peduncles lacking glands or apparently so 13

10(9). Stems glabrous; leaves linear to linear-oblanceolate, 2–5 mm wide, 1.5–7 cm long; plants of saline or hot water seeps and springs .... *A. pauciflorus*

— Stems puberulent to villous with multicellular hairs, or glabrous, but, if so, differing in other respects 11

11(10). Rays white; leaves glaucous; plants of central to south central Utah ... *A. wasatchensis*

— Rays blue to purple, lavender, or violet 12

12(11). Cauline leaves clasping the stem, mainly 15–40 mm wide; involucres 8–15 mm high; plants of central northern Utah .... *A. integrifolius*

— Cauline leaves not or only slightly clasping, 2–10 mm wide; involucres 5–8 mm high .... *A. campestris*

13(9). Pubescence occurring in decurrent lines below leaf bases, commonly not uniform below the heads, or only in the inflorescence; inflorescence often conic, mostly large and leafy .... *A. hesperius*

— Pubescence of stem uniform, or, if in decurrent lines, uniform below the heads and confined to the inflorescence; inflorescence few to many flowered and not usually leafy to large and leafy (see also *A. eatonii*) 14

14(13). Rays white; involucral bracts strigulose dorsally (rarely glabrous), with spreading to squarrose minutely spinulose tips; heads numerous 15

— Rays pink to purple, or less commonly white; involucral bracts mucronate at the tip; heads few to numerous 16

15(14). Rhizomes well developed, creeping; involucres 4.6–6.5 mm high, 7–9.5 mm wide (when pressed); plants of western Utah .... *A. falcatus*

— Rhizomes mainly poorly developed, or reduced and caudexlike; involucres 3.8–4.9 mm high, 4.5–6 mm wide; plants of eastern Utah .... *A. pansus*

16(14). Achenes glabrous or nearly so; herbage glabrous except for lines of puberulence in the inflorescence, tending to be glaucous; rare plants in southeastern Utah .... *A. laevis*

— Achenes pubescent, except in some *A. foliaceus*; herbage pubescent to almost glabrous, scarcely glaucous 17

17(16). Involucral bracts strongly imbricate, the outer ones at least obtuse or obtusish (sometimes acute), not foliaceous; pubescence below the heads harsh .... *A. chilensis*

— Involucral bracts not strongly imbricate, or, if so, the bracts sharply acute, the outer ones acute, or, if obtuse, foliaceous; pubescence below heads soft or minute........18

18(17). Inflorescence a long slender leafy panicle; heads numerous; stem pubescence short, uniform; leaves mostly more than 7 times longer than wide; rays usually pink to white .... *A. eatonii*

— Inflorescence an open or congested panicle; heads solitary to several; pubescence various; rays usually blue to violet 19

19(18). Involucral bracts slender, never foliaceous; leaves at midstem mostly less than 1 cm wide, mostly over 7 times longer than broad .... *A. occidentalis*

— Involucral bracts various, but some of them usually enlarged and foliaceous; leaves at midstem mostly less than 7 times longer than broad .... *A. foliaceus*

Aster brachyactis **Blake in Tidestr.** [*Tripolium angustum* Lindl. in Hook.; *A. angustus* (Lindl.) T. & G., not Nees; *Brachyactis angustus* (Lindl.) Britt. in Britt. & Brown]. Annual herbs, with taproots, glabrous throughout, except for leaf margins and involucral bracts; stems 0.9–5.3 (7) dm tall; leaves 1.3–8 (12) cm long, 1–7 (9) mm wide, linear to narrowly oblong, entire, the lower ones soon deciduous; heads few to numerous, in paniculate to spicate inflorescences; involucres 5.5–9.4 (11) mm high, 7–15 (17) mm wide, the bracts linear-oblong, acute to attenuate, herbaceous, subequal to somewhat imbricate, or some outer ones often surpassing the inner; marginal flowers pistillate, the corollas tubular filiform, lacking rays, much shorter than the styles; pappus abundant, white, longer than the corollas. Sandbars, terraces, stream banks, marshes and pond margins, often where saline, in tamarix, rush, rabbitbrush, and cottonwood communities at 1220 to 1525 m in Box Elder, Carbon, Duchesne, Emery, Grand, Garfield, Salt Lake, Uintah, and Utah counties; British Columbia to Minnesota, south to Washington and Colorado; 14 (i).

Aster campestris **Nutt.** Meadow Aster. Perennial rhizomatous herbs, glandular, at least in inflorescence; stems puberulent to glabrous, mainly 1–5 dm tall; leaves 2–8 cm long, 2–8 mm wide, linear to oblong, entire, sessile, sometimes clasping, the lower ones larger and more or less petiolate, or smaller, soon deciduous; heads solitary or several to many; involucres 5–8 mm high, glandular, the bracts subequal to definitely imbricate, acute or attenuate, with long herbaceous tips; rays 15–20, violet to purple, 6–12 mm long. Meadows at 1525 to 2475 m, reported for Utah (Univ. Washington Publ. Biol. 17(5): 77. 1955), but I have seen no specimens from the state.

Aster chilensis Nees Pacific Aster. Perennial rhizomatous to subrhizomatous herbs, uniformly harshly strigose to strigulose, at least above; stems (0.8) 1.2–10.5 dm tall; leaves 0.6–16.5 cm long, 2–16 (20) mm wide, entire or nearly so, pubescent to glabrous, ciliate, the lower ones more or less petiolate, often deciduous at anthesis in taller plants, becoming smaller and sessile upwards, sometimes markedly reduced-bracteate in inflorescence; inflorescence of 1 to many heads, narrow, corymbose, or open paniculate; involucres 5–8 mm high, 6–15 mm broad, the bracts imbricate, green tipped (machaerantheroid), the chartaceous bases white to straw colored, the outer ones abruptly pointed but mucronate; rays commonly 15–40, purplish to violet (rarely white) or pink, 5–15 mm long; achenes pubescent. Alluvial fans, terraces, and slopes along stream and canal banks, in hanging gardens, rabbitbrush, sagebrush, grass-sedge, cottonwood-willow, ponderosa pine, juniper-pinyon, mountain brush, aspen, and spruce-fir communities at 850 to 3200 m in all Utah counties; Washington to Saskatchewan, south to California and New Mexico; 189 (xxviii). The Pacific aster is a generalized taxon with no clearly diagnostic features. It is separated from its near congeners by a group of intangible characteristics. Involucral bracts are definitely imbricate, with the greenish portion usually glabrous, and margins ciliate. The tips of outer bracts are often but not always obtuse, and the tip, even when abruptly contracted is mucronate. These features, which I designate as "machaerantheroid," are shared to a greater or lesser extent with *A. eatonii*, *A. occidentalis*, and *A. foliaceus*. The harsh pubescence below the heads appears to be diagnostic, but is difficult to distinguish from the soft or merely puberulent vesture of closely related species. Not all specimens can be assigned with certainty to any of the taxa. There are two intergrading morphological phases of the Pacific aster, which are striking in their extremes, but which probably represent nothing more than developmental gradients. There are plants with few flowers that lack distinctive reduced bracteate leaves in the inflorescence, and taller plants with more numerous heads and distinctively bracteate inflorescences. The inflorescences of the taller plants are mainly corymbiform, and not cylindroid as in *A. eatonii*. More work is indicated. Our material belongs to ssp. ***adscendens*** (Lindl.) Cronq.

Aster eatonii **(Gray) Howell** Eaton Aster. [*A. foliaceus* var. *eatonii* Gray; *A. oregonus* authors, not (Nutt.) T. & G.]. Perennial rhizomatous to subrhizomatous herbs, uniformly puberulent, at least above (below the heads and sometimes on upper leaves), the stems (2.7) 6–10.5 dm tall, often reddish; leaves 0.8–15 cm long, 2–25 mm wide, entire or serrate, puberulent to glabrous, ciliate, the lowermost shortly petiolate, often deciduous in anthesis, becoming smaller and sessile upwards, linear to narrowly elliptic or lanceolate to oblanceolate; inflorescence of few to numerous heads, commonly open-cylindric to conic in form; involucres 4.5–8 (10) mm high, 6–10 mm wide, the bracts more or less subequal to indistinctly imbricate, green tipped (but not especially machaerantheroid), the chartaceous bases white to straw colored, all or most of them mucronate; rays 20–40, commonly pink (sometimes white), 5–12 mm long; achenes pubescent. Gravel bars, stream terraces, meadows, canal banks, hanging gardens, and marshes at 1370 to 2325 m in Cache, Garfield, Grand, Iron, Juab, Kane, Salt Lake, Summit, Uintah, Utah, Wasatch, and Washington counties; British Columbia to Saskatchewan, south to California, Arizona, and New Mexico; 48 (ix). The pink or white rays, uniform upper stem puberulence and leaves many times longer than broad are diagnostic for most specimens. Reports of *A. junciformis* Rydb. for Utah appear to be based on slender phases of the Eaton aster with linear leaves and slender rhizomes.

Aster engelmannii **(D.C. Eaton) Gray** Engelmann Aster. [*A. elegans* var. *engelmannii* D.C. Eaton]. Perennial rhizomatous or subrhizomatous herbs, puberulent to sparingly villous with multicellular hairs, or somewhat glandular, the stems 2–15.2 dm tall, reddish at the base; leaves 2–13.5 cm long, 3–46 mm wide, elliptic to lanceolate, entire (or nearly so), sparingly puberulent to glabrous or sparsely villous, sessile, largest near midstem, the lowermost reduced to scales; inflorescence of 1 to numerous large heads, corymbose or conic; involucres 8–13 mm high, 11–25 mm wide, the bracts mainly strongly imbricate, with a definite midvein, commonly purplish (at least the inner), the outer sometimes green and more or less foliaceous, sometimes all greenish or straw colored to the tip, glabrous dorsally, ciliate; rays 8–23, white (drying pinkish), 12–25 mm long; achenes pubescent. Mountain brush, juniper, Douglas fir, aspen, white fir, lodgepole pine, and spruce-fir communities at 1950 to 3200 m in Cache, Carbon, Davis, Duchesne, Juab, Salt Lake, Sanpete, Summit, Utah, and Wasatch counties; British Columbia and Alberta, south to Nevada and Colorado; 57 (vi).

Aster falcatus **Lindl.** [*A. multiflorus* var. *commutatus* T. & G.; *A. commutatus* (T. & G.) Gray]. Perennial rhizomatous herbs, villous or villous-hirsute with multicellular hairs, the stems 2.8–7.5 dm tall; leaves 1.2–6 (8) cm long, 2–8 mm wide, entire, antrorsely scaberulous on both surfaces (or glabrous), sessile, linear to narrowly oblong, often spinulose-mucronate, the lowermost often lacking at anthesis; inflorescences several- to many-headed, cylindroid; involucres 4.6–6.5 mm high, 7–9.5 mm wide, the bracts strongly to only somewhat imbricate, with a green tip, scaberulous to glabrous dorsally and ciliate; rays mainly 17–25, white (drying pale lavender in some), 6–8 mm long; achenes pubescent. Oak, sagebrush, and ponderosa pine communities at 1525 to 2135 m in Box Elder, Kane, Utah, and Washington counties; Alaska to Minnesota, south to California, New Mexico, and Kansas; 7 (i). The species is closely allied to *A. pansus* (q.v.), which has smaller heads.

Aster foliaceus **Lindl. in DC.** Leafybract Aster. Perennial rhizomatous or subrhizomatous herbs, uniformly and shortly soft-villous below the heads, uniformly villous to glabrous below, or in lines below leaf bases, the stems 1.3–7 dm tall; leaves 1.8–16 cm long, 3–34 mm wide, entire or nearly so, strigose to glabrous, ciliate, the lower ones petiolate (often lacking at anthesis), becoming smaller and sessile (and more or less clasping) upwards; inflorescence of 1–19 (50) corymbosely arranged large and showy heads; involucres 6–12 mm high, 10–20 mm wide, the bracts imbricate to slightly so, foliaceous or slender, green with pale white to yellowish or brownish chartaceous bases (at least the inner), acute to obtuse or rounded, mucronate; rays mainly 15–50, pink to purple, blue, or violet, 9–16 (20) mm long; achenes hairy. The leafybract aster is a portion of an assemblage that includes the concept of *A. subspicatus* Nees. Both *A. foliaceus* and *A. subspicatus* were described from coastal Alaska (Unalaska and Yakutat Bay, respectively). Brownish bases of involucral bracts, commonly serrate leaves, and reddish pappus are supposedly diagnostic for *A. subspicatus*, which is not known from Utah, but some specimens of *A. foliaceus* have one or more of these features. In the Alaska Flora (Welsh 1974), I treated both species under the older name of *A. subspicatus*. Now, I follow tradition so as to avoid creation of synonyms should further study indicate a better course of action. Three more or less distinctive infraspecific taxa are present in Utah.

1. Involucral bracts foliaceous, 2–6 mm broad; plants uncommon .... *A. foliaceus* var. *canbyi*
— Involucral bracts not especially foliaceous, mainly less than 2 (2.5) mm wide; plants common to uncommon 2

2(1). Plants mainly 0.5–2.5 dm tall, decumbent or ascending; bracts often purple margined or tipped; known from high elevations, rare .... *A. foliaceus* var. *apricus*
— Plants often more than 2 dm tall, erect; bracts seldom as above; known from low to high elevations, common .... *A. foliaceus* var. *parryi*

Var. *apricus* Gray Meadows in spruce-fir forest at 3050 to 3660 m in Summit County; British Columbia to Montana, south to California and Colorado; 1 (0).

Var. *canbyi* Gray Mountain brush, aspen, and spruce-fir communities at 1950 to 2900 m in Iron, Juab and Salt Lake counties; Washington to Wyoming, south to California and New Mexico; 5 (0).

Var. *parryi* (D.C. Eaton) Gray [*A. adscendens* var. *parryi* D.C. Eaton; *A. foliaceus* var. *frondeus* Gray]. Meadows and openings in aspen, spruce, lodgepole pine, and Douglas fir communities at 1890 to 3265 m in Cache, Duchesne, Garfield, Iron, Juab, Piute, Salt Lake, Sanpete, Summit, Tooele, Uintah, and Utah counties; Washington to Wyoming, south to California and New Mexico; 36 (viii). This is the phase of the leafybract aster that simulates *A. occidentalis* (q.v.), but which seldom has long peduncles, dark blue-purple ray corollas, and much reduced upper stem leaves of that species.

Aster frondosus **(Nutt.) T. & G.** Leafy Aster. [*Tripolium frondosum* Nutt.]. Annual herbs from taproots; stems 0.2–3.6 cm tall; leaves 1–6 cm long, 2–12 mm wide, linear to oblong or oblanceolate, entire, the lower ones sometimes deciduous; heads few to numerous, in a narrow paniculate to spicate inflorescence; involucres 5–9 mm high, 6–13 mm wide, the bracts oblong to narrowly oblanceolate, obtuse or obtusish, herbaceous, subequal to moderately imbricate; marginal flowers pistillate, the rays developed, pink, to 2 mm long; pappus abundant, white, longer than the disk corollas. Lake shores, seep margins, wet meadows, and stream banks in saltgrass, tamarix, Russian olive, rabbitbrush, and greasewood communities at 1250 to 2270 m in Beaver, Duchesne, Garfield, Grand, Juab, Kane, Salt Lake, San Juan, Utah, and Wayne counties; Washington to Wyoming, south to California and New Mexico; 18 (ii).

Aster glaucodes **Blake** Blueleaf Aster. Perennial rhizomatous herbs, glabrous and glaucous, or puberulent to glandular in the inflorescence; stems 1.1–7 dm tall; leaves 1.4–12.5 cm long, 4–25 mm wide, entire, lance-oblong to oblong or elliptic, glaucous, glabrous, sessile and clasping, the lower often lacking at anthesis, reduced upwards; heads few to numerous in corymbose inflorescences; involucres 6–9 mm tall, 7–9 mm wide, the bracts imbricate, dry, chartaceous throughout or sometimes some of them greenish, the midvein prominent, commonly suffused with pink or purple, mainly obtuse to less commonly acute apically; rays 10–20, white or pink, 11–17 mm long. There are two varieties within our specimens.

1. Peduncles and/or involucres glandular-pubescent; plants of Washington and adjacent western Kane counties .... *A. glaucodes* var. *pulcher*
— Peduncles and involucres lacking glandular pubescence; plants widespread .... *A. glaucodes* var. *glaucodes*

Var. *glaucodes* This is the common phase of the species, often on calcareous substrates at higher elevations and in saline seeps at moderate to lower elevations in sagebrush, pinyon-juniper, mountain brush, ponderosa pine, ryegrass, spruce-fir, Douglas fir, lodgepole pine, and hanging garden communities at 1220 to 3050 m in Cache, Carbon, Duchesne, Emery, Garfield, Grand, Kane, San Juan, Sanpete, Sevier, Summit, Tooele, Uintah, Utah, Washington, and Wayne counties; Idaho and Wyoming, south to Arizona and Colorado; 56 (ix).

Var. *pulcher* (Blake) Kearney & Peebles Note: This taxon was published at subspecific rank by Blake, and was inadvertantly accepted at varietal rank by Kearney and Peebles (Arizona Flora 872. 1951), without citation of the basionym, *A. glaucodes* ssp. *pulcher* Blake, Proc. Biol. Soc. Washington 35: 174. 1922. Salt desert shrub, sagebrush, pinyon-juniper, and ponderosa pine communities at 825 to 2136 m in Washington and adjacent western Kane counties; Arizona; 6 (0).

Aster hesperius **Gray** Siskiyou Aster. [*A. laetivirens* Greene]. Perennial rhizomatous herbs, villous with multicellular hairs in decurrent lines from leaf bases, or less commonly almost glabrous and with decurrent lines below the heads; stems 3.6–9.5 (15) dm tall; leaves 3–17 (21) cm long, 5–27 mm wide, entire or serrate, glabrous or scabrous, ciliate, the lower ones commonly petiolate, often deciduous at anthesis, becoming smaller, sessile and more or less clasping upwards, sometimes much reduced in inflorescence; heads few to numerous in open to narrow subcorymbose inflorescences; involucres 4.5–7 (8) mm high, 7–12 mm wide, the bracts imbricate to subequal, green tipped, the chartaceous base white to straw colored, all acute and mucronate; rays commonly 20–50, pink to blue or white, 6–14 mm long; achenes hairy. Wet meadows, canal banks, and stream sides with sedges, rabbitbrush, willow, and other riparian communities at 850 to 2135 m in Box Elder, Cache, Duchesne, Garfield, Grand, Kane, Millard, Summit, Utah, Wasatch, and Washington counties; Alberta to Saskatchewan, south to California, Arizona, New Mexico, and Missouri; 32 (vii). This plant occurs at lower elevations in Utah and has been confused with *A. foliaceus*, with which some plants share the subequal bracts. It has also been mistaken for *A. chilensis*, with which it is partially sympatric. The lack of uniformly disposed hair in the inflorescence appears to be diagnostic.

Aster integrifolius **Nutt.** Thickstem Aster. Perennial subrhizomatous herbs, glandular villous with multicellular hairs, at least above; stems 2.3–6.4 (7) dm tall; leaves 2.5–19 cm long, 8–50 mm wide, entire, oblanceolate to elliptic or lanceolate, glandular-villous, ciliate, the lower ones petiolate, becoming smaller, sessile and clasping upward; heads few to several (numerous), large and showy, in elongate to subcorymbose clusters; involucres 8–13 (14) mm high, 12–23 mm wide, the bracts mainly subequal, green or suffused with purple, glandular dorsally, foliaceous or not; rays commonly 10–25, dark purple, 10–15 mm long. Meadows and moist woods in sedge-willow, sagebrush, Douglas fir, and spruce communities at 2275 to 3125 m in Rich, Salt Lake, Summit, and Wasatch counties; Washington and Montana, south to California and Colorado; 8 (0).

Aster kingii **D.C. Eaton** [*Machaeranthera kingii* (D.C. Eaton) Cronq. & Keck]. Perennial herbs from a caudex and taproot, the caudex branches clothed with blackish or dark brown marcescent leaf bases, these scarious and ashy when young; stems 3–12 (15) cm long, more or less villous below, stipitate-glandular above; basal leaves 0.8–12 cm long, 3–22 mm wide, petiolate, the petiole bases expanded and scarious, the blades oblanceolate or spatulate, glabrous or glandular, or less commonly hispidulous or merely puberulent on one or both sides; heads 1–5, racemosely or corymbosely arranged; involucres 8–11 mm high, 10–16 mm wide; bracts glandular to shortly stipitate-glandular, herbaceous above the middle, scarious below, often suffused purplish, especially the inner, the tips of at least the outer reflexed; rays 15–27, white (often fading pale pink), 8–17 mm long, 1.5–2.8 mm wide; achenes ca 3.5 mm long. Douglas fir-white fir, mountain brush, and cottonwood communities at 1839 to 3050 m in Juab, Millard, Salt Lake, and Utah counties; endemic; 21 (i). The southern populations have at least some toothed leaves and stems with longer stipitate-glandular hairs; they belong to var. ***barnebyana*** (Welsh & Goodrich) Welsh comb. nov. [based on: *Machaeranthera kingii* var. *barnebyana* Welsh & Goodrich Brittonia 33: 299. 1981]; 6 (0). Attempts to segregate genera within the Astereae are often fraught with difficulties. This is especially true of that core of genera involving *Haplopappus, Machaeranthera, Xylorhiza,* and *Aster.* Cronquist and Keck (1957. Brittonia 9: 231-329) reconstituted the genus *Machaeranthera*, and included within that expanded generic definition those species treated elsewhere herein as *Machaeranthera* and *Xylorhiza*. Included within the series Integrifoliae of section Xylorhiza was *Aster kingii*. Watson (1978. Madrono 25: 205–210) has shown the chromosome number to be 2n = 18 for *Aster kingii*, and he notes that its placement within *Machaeranthera* section Xylorhiza "is phenologically, ecologically, morphologically, and chromosomally anomalous. . . ." The chromosome numbers reported for *Xylorhiza* are 2n = 12 or 24; that of *Machaeranthera*, in a restricted sense, is 2n = 8, 10, or 16; that of *Aster* is mainly 2n = 18. The taproots and squarrose involucral bracts suggest an alliance with *Machaeranthera*, shorn of *Xylorhiza*, but the similarity seems superficial, especially in light of different chromosome numbers. Some asters in a strict sense, i.e., *A. alpigenus* Rydb., have a caudex, with the rhizome attenuated. The logical conclusion of such an attenuation is the caudex of *A. kingii*, and the squarrose bracts seem to have been secondarily derived, being present to a greater or lesser degree in other *Aster* species as well as in *Machaeranthera*. Hence, it seems best to treat this taxon within *Aster*.

Aster laevis **L.** Smooth Aster. Subrhizomatous perennial herbs, glabrous or nearly so; stems mainly 5–12 dm tall; leaves 0.8–14 cm long, 2–30 mm wide, entire or serrate, linear-subulate to lanceolate or elliptic, the lower ones petiolate, often lacking at anthesis, becoming smaller, sessile, and more or less clasping upwards; heads numerous, in corymbose inflorescences; involucres 5–8 mm high, 7–12 mm broad (when pressed), the bracts slender, green tipped, the chartaceous bases straw colored to brownish or white, acute and mucronate; rays 15–30, blue or purple, 6–9 mm long; achenes glabrous. Riparian communities at ca 1400 m in Grand (and San Juan?) County; Yukon to Maine, south to Oregon, New Mexico, and Georgia; 1 (i). This plant is rare in collections from Utah, due presumably to the paucity of late season collections from southeastern Utah.

Aster occidentalis **(Nutt.) T. & G.** Western Aster. [*Tripolium occidentale* Nutt.]. Rhizomatous or subrhizomatous perennial herbs, uniformly, softly, and often loosely villous (at least above); stems 0.9–8.5 dm tall; leaves 1–15 cm long, 1–20 mm wide, entire or toothed, glabrous or nearly so, ciliate, the lower ones petiolate, sometimes lacking at anthesis, rather abruptly smaller and finally sessile upwards; inflorescence mainly of 1–7 (rarely to 15), corymbosely arranged large and showy heads; involucres 5–12 mm high, 7–20 mm wide, the bracts imbricate to subequal, slender, green, with pale yellowish to white or brownish chartaceous bases (at least the inner), mainly acute, mucronate; rays 20–50, blue to purple, 6–15 mm long; achenes hairy. Meadows and stream sides in lodgepole pine, cottonwood, willow, aspen, and spruce-fir communities at 2175 to 3175 m in Carbon, Daggett, Duchesne, Emery, Garfield, Grand, Piute, Sanpete, Sevier, Summit, and Wasatch counties; Mackenzie to Colorado and California; 43 (ix). This species shares the features of soft loose pubescence and general aspect with the partially sympatric *A. foliaceus*. The very slender and abruptly reduced cauline leaves are diagnostic in most instances.

Aster pansus **(Blake) Cronq.** Elongate Aster. Subrhizomatous herbs, villous or villous-hirsute with multicellular hairs, the stems 3–12 (or more) dm tall; leaves 1–6 cm long, 2–8 mm wide, entire, antrorsely scaberulous on both surfaces, sessile, linear to narrowly oblong, often spinulose-mucronate, the lowermost commonly lacking at anthesis; inflorescence paniculate to secund-paniculate, narrow; involucres 3.8–4.9 mm high, 4.5–6 mm wide, the bracts strongly imbricate, green tipped, scaberulous dorsally and ciliate; rays mainly 15–25, white, 3–8 mm long; achenes hairy. Drainages, meadows, seeps, and hanging gardens at 1220 to 1890 m in Daggett, Grand, San Juan, and Uintah counties; British Columbia to Montana, south to Colorado and Nebraska; 6 (iv). This species forms the basis for inclusion in previous botanical works of the name *A. ericoides* L. in the Utah flora. It is closely allied to *A. falcatus*, but differs in the smaller heads, taller stature, and eastern distribution.

Aster pauciflorus **Nutt.** Alkali Aster. [*A. thermalis* Jones, type from Monroe Hot Springs]. Subrhizomatous perennial herbs, glabrous below, stipitate-glandular above and in inflorescence; stems 2–7.5 dm tall; leaves 1.1–12.5 cm long, 1–4 mm wide, entire, acicular to lance-linear or linear, glaucous, glabrous, all sessile or the lowermost petiolate, reduced upwards; heads few to several in corymbose inflorescences; involucres 4.3–7 mm long, 7–10 mm wide, the bracts imbricate to subequal, glandular dorsally, green throughout, narrow and acute; rays mainly 20–35, blue to purple, 5–12 mm long; achenes hairy. Hot springs, stream terraces, and salt grass meadows, often in saline or alkaline substrates at 1300 to 2135 m in Box Elder, Duchesne, Emery, Juab, Kane, Millard, Sanpete, Sevier, Salt Lake, and Utah counties; Saskatchewan to Nevada, Arizona, and Mexico. This distinctive glandular aster has been collected in full anthesis on 27 April growing in hot water at Monroe Hot Springs in Sevier County. It continues to flower into October; 21 (vi).

Aster perelegans **Nels. & Macbr.** Nuttall Aster. [*Eucephalus elegans* Nutt.; *A. elegans* (Nutt.) T. & G., not Willd.]. Subrhizomatous perennial herb, puberulent to glabrate (sometimes glandular); stems 3–7 dm tall; leaves 1.3–6.5 cm long, 3–14 mm wide, entire, oblong to oblong-lanceolate or elliptic, scabrous, firm, sessile, the lowermost reduced in size; heads 3–16, in corymbose inflorescences; involucres 7–10 mm high, 7–12 mm wide, the bracts chartaceous, imbricate, with prominent midvein, and acute to obtuse apex, the margins hyaline and ciliate, more or less puberulent dorsally; rays 5–16, dark purple, 7–13 mm long; achenes hairy. Sagebrush, mountain brush, Douglas fir, aspen, and limber pine communities at 1725 to 3050 m in Carbon, Duchesne, Juab, Millard, Salt Lake, Wasatch, and Weber counties; Oregon to Montana, south to Nevada; 21 (iv).

Aster scopulorum **Gray** Crag Aster. [*Chrysopsis alpina* Nutt., not *A. alpinus* L.]. Perennial subrhizomatous herbs with a woody caudex, villous on stems and peduncles; stems 4–12 cm tall; leaves 5–12 (15) mm long, 1–3 mm wide, overlapping, elliptic to oblong or linear, firm, scabrous or puberulent, often with some villous hairs above, spinulose-mucronate; heads solitary, pedunculate; involucre 7–11 mm high, 8–12 mm wide, the bracts imbricate, sparingly villous-hirsute and glandular, with a prominent midvein in the lower half, greenish, with chartaceous border and hyaline margins, acute; rays mainly 8–15, blue or purplish, 6–15 mm long; achenes hairy. Sagebrush community at 2440 to 2745 m in Box Elder County; Oregon to Montana, south to California and Nevada; 8 (0).

Aster spinosus **Benth.** Mexican Devilweed. Suffrutescent, rushlike plants from a deeply placed rhizome, glabrous; stems 6–12 (or more) dm tall, with axillary or supraxillary thorns to 1.5 cm long; leaves 2–4 cm long, 2–5 mm wide, firm, entire to toothed, reduced above to scales; heads solitary at ends of branches, or some axillary; involucres 4–6 mm high, 6–8 mm wide, the bracts imbricate, slender, acute to acuminate, green, with prominent scarious margin; rays 15–30, white, very short; achenes glabrous. Riparian communities at below 1130 m in Garfield and probably Washington counties; California to Texas, south to Central America; 1 (0). The plant was collected at the mouth of Ticaboo Canyon, along the Colorado River in Glen Canyon (Lindsay 20, 1958 UT), at a site now inundated by Lake Powell. This is one of a series of extirpations related to construction of Glen Canyon Dam. The plant should be sought in the St. George vicinity.

Aster wasatchensis **(Jones) Blake** Markagunt Aster. Subrhizomatous perennial, glandular-puberulent; stems 3.5–6.5 dm tall; leaves 1.8–8.5 cm long, 6–24 mm wide, entire, lanceolate to oblong, or oblanceolate, glandular-puberulent to glabrous, firm, more or less glaucous, the lowermost often smaller and commonly lacking at anthesis; heads several to numerous, more or less corymbosely arranged; involucres 8–11.5 mm long, 10–20 mm wide, the bracts herbaceous throughout or the inner with scarious bases, glandular dorsally, abruptly acute to attenuate, apically; rays 15–25, white or pink, 10–20 mm long; achenes hairy. Pinyon-juniper, aspen, limber pine, and spruce-fir communities at 1890 to 3050 m in Garfield, Iron, Millard, and Piute counties; endemic. This remarkable aster is unique in Utah in having foliaceous or subfoliaceous glandular involucral bracts and glaucous leaves; 14 (vi).

ATRICHOSERIS Gray

Annual scapose herbs, with milky juice, from taproots; leaves all basal, sinuate-dentate, often spotted; heads on slender peduncles, few to numerous, corymbosely arranged; involucre of about 12–15 subequal but biseriate, lance-linear scarious-margined bracts and some shorter outer bracts; receptacle naked; corollas all raylike, perfect, white; pappus lacking; achenes oblong, with corky-thickened ribs.

Atrichoseris platyphylla **Gray** Tobaccoweed; Gravel Ghost. Plants 3–10 dm tall (or more), from slender taproots; leaves 1.2–10.5 cm long, 0.5–6 cm wide, obovate to broadly spatulate, tapering abruptly to a broad petiole, sinuate-dentate, the teeth mucronate-cuspidate, glabrous, often mottled, more or less glaucous; involucres 6–8 mm high, 12–16 mm wide, the outer bracts ovate-lanceolate, hyaline, more or less scurfy, the inner ones lance-acuminate, with broad hyaline margins;

corollas white, 8–20 mm long; achenes white, with corky ridges. Joshua tree, ambrosia, yucca, cholla communities at 670 to 750 m in Washington County; California and Arizona; 4 (i).

BACCHARIS L.

Dioecious shrubs; leaves alternate, entire or toothed; heads discoid, many flowered, the corollas white, turbinate, borne in corymbose or paniculate clusters; involucres imbricate, the bracts chartaceous, whitish; pistillate heads with tubular-filiform obscurely toothed or truncate corollas, the pappus of copious capillary bristles; staminate heads of tubular 5-toothed corollas, the pappus (often scanty) of usually twisted clavellate scales; receptacle naked; style branches flattened; achenes subcylindric, 5- to 10-ribbed.

1. Branches fastigiate, deeply sulcate and more or less ridged, the leaves commonly deciduous at anthesis; achenes 10-ridged 2
— Branches not especially fastigiate, commonly spreading to ascending; leaves commonly persistent at flowering time; achenes 5- or 10-ribbed 3

2(1). Main leaves linear; pistillate pappus to 10 mm long or more in fruit ... *B. sarothroides*
— Main leaves obovate-spatulate; pistillate pappus to 3 mm long in fruit...*B. sergilloides*

3(1). Leaves long-cuneate basally, thickened, entire or few toothed toward apex; branches often subfastigiate; achenes 10-nerved; plants of Virgin and Colorado drainages 4
— Leaves not especially long-cuneate basally, commonly thin, entire, or toothed from below the middle; achenes 5-nerved 5

4(3). Staminate involucres 3.5–5.3 mm long, 3.7–4.8 mm wide; pistillate involucres 7.3–8.5 mm long; pappus 11–13 mm long; plants of Washington and Kane counties .... *B. emoryi*
— Staminate involucres 5.3–6 mm long, 5–10 mm wide; pistillate involucres 6–6.5 mm long; pappus 8–9.5 mm long; plants of Emery, Grand, Garfield, and San Juan counties .... *B. salicina*

5(3). Leaves mainly entire; panicles terminating short lateral branches; plants of Washington County .... *B. viminea*
— Leaves usually serrate; panicles terminating main stems; plants of Washington and Kane counties .... *B. glutinosa*

Baccharis emoryi **Gray in Torr.** Shrubs, mainly 1–2 (3) m tall, the branches green to olive or brownish, ascending, subfastigiate, more or less glutinous; leaves 1.2–8.5 cm long, 3–20 mm wide, spatulate-oblanceolate to elliptic or linear, cuneate to a slender petiole, thick, entire or sparingly and irregularly toothed, obtuse to acute apically; heads numerous in a conic to pyramidal panicle; pistillate involucres 7.3–8.3 mm high, 4.5–7 mm wide, the bracts in several series, scarious, often glutinous, with thickened green or brown to reddish tips and hyaline margins; staminate involucres 3.7–5.3 mm high, 3.7–4.8 mm wide; pistillate corollas 4.5–5.5 mm long, the pappus 11–13 mm long; achenes 10-ribbed. Stream and canal banks and hanging gardens at 825 to 1220 m in Kane and Washington counties; Arizona, Texas, and California; Mexico; 19 (iv).

Baccharis glutinosa **Pers.** Shrubs, mainly 1–3 m tall, the branches straw colored to brownish or greenish, ascending-spreading, not fastigiate, glutinous; leaves 1.2–12.5 (15) cm long, 4–18 mm wide, elliptic to narrowly lanceolate, acuminate to attenuate, cuneate to a short petiole, evenly serrate to entire; heads numerous in terminal cymose panicles (less commonly in lateral ones) with pistillate and staminate heads about the same size; involucres 3.5–4.5 mm high, 4–5.5 (7.5) mm wide; corollas 2.2–3 mm long, the pistillate pappus 3.5–4.5 mm long; involucral bracts in several series, chartaceous, greenish in the center, the margins scarious, not glutinous; achenes 5-ribbed. Stream bars and banks, and in seeps, at 670 to 1130 m in Kane and Washington counties; Colorado and Nevada to Texas and California; South America; 6 (ii).

Baccharis salicina **T. & G.** Shrubs, mainly 1.5–3 m tall, the branches green to brownish, subfastigiate, glutinous; leaves 1.4–8 cm long, 4–18 mm wide, elliptic to oblanceolate or linear, cuneate to a short petiole, thick or thin, entire or sparingly toothed or lobed mainly near the apex, acute to rounded apically; heads few to numerous in axillary and/or terminal panicles; pistillate involucres 6–6.5 mm high, 4–6 mm wide, the bracts in several series, scarious, often glutinous, with thickened greenish to reddish tips and hyaline margins; staminate involucres 5.3–6 mm high, 5–10 mm wide; pistillate corollas 2.5–3.5 mm long, the pappus 8-10 mm long; achenes 10-ribbed. Stream banks and hanging gardens at 1220 to 1525 m in Emery, Garfield, Grand, and San Juan counties; Colorado to Kansas, south to New Mexico and Texas; 7 (iv). Our material of *B. salicina* has long been mistaken for *B. emoryi*, to which it is allied. The shorter pistillate involucres and broader staminate involucres are diagnostic.

Baccharis sarothroides **Gray** Broom Baccharis. Shrubs, mainly 1–3 m tall, the branches green to brown, fastigiate, glutinous, finally almost leafless; leaves 1–3.5 cm long, 2–5 mm wide, linear to oblong, entire, ridged; heads solitary at tips of fastigiate branches forming a hemispheric panicle; pistillate involucres 6–8 mm high, 5–10 mm wide, the bracts in several series, cream colored; staminate involucres 3–4 mm high, 4–8 mm wide, the bracts green apically; pappus 6–11 mm long; achenes 10-ribbed. Reported for Washington County (UT), where presumably it occurs along streams; California to New Mexico; 0 (0).

Baccharis sergilloides **Gray** Squaw Waterweed. Shrubs, mainly 0.3–2 m tall, the branches green to brown, fastigiate, glutinous, finally almost leafless; leaves 0.5–2.5 cm long, 1–10 mm wide, spatulate to obovate, entire or few toothed, thick; heads numerous, borne in conic to pyramidal panicles; involucres 2.5–3.5 mm high, 2.5–3.5 mm wide, the bracts in several series, straw colored, or with thickened brownish centers; pappus 2.5–3 mm long; achenes 10-ribbed. Stream bars and banks at 670 to 825 m in Washington County; California and Arizona; 3 (i).

Baccharis viminea **DC.** Mule-fat. Shrubs, mainly 2–3 m tall, the branches green to straw colored or brownish, spreading-ascending, not fastigiate, glutinous; leaves 0.8–9.5 cm long, 2–9 mm wide, elliptic to lance-elliptic or narrowly oblong, attenuate to acute, cuneate to a short petiole, entire to evenly serrate; heads few to many in terminal cymose panicles on short lateral branches, with pistillate and staminate heads about the same size; involucres 3–5.7 mm high, 6–9 mm wide; corollas 2.5–3.8 mm long; pistillate pappus 5–6 mm long; involucral bracts in several series, chartaceous, commonly with reddish centers, the margins scarious, not glutinous; achenes 5-ribbed. Stream bars and banks at 650 to 900 m in Washington County; California and Arizona; 10 (ii).

BAHIA Lag.

Biennial or short-lived perennial herbs with watery juice, arising from taproots; stems erect or ascending, puberulent; leaves alternate, once to twice ternately divided; heads few to numerous, in corymbose panicles; involucral bracts subequal, in 1 or 2 series, greenish; ray flowers present, yellow, pistillate, fertile; disk flowers perfect, fertile; pappus none; style branches flattened; ach enes 4-angled, 12-nerved.

Bahia dissecta **(Gray) Britt.** [*Amauria dissecta* Gray]. Biennial or short-lived perennial herbs, the stems 2–8 dm tall, minutely puberulent; leaves 1–10 cm long, the blade 1- to 3-ternately divided, oval to cordate in outline, strigulose; peduncles glandular hairy; involucres hemispheric, 3.4–6 mm high, 8–12 mm wide, the bracts more or less glandular hairy (or merely villous), greenish, abruptly contracted to a broadened apex; rays mainly 10–15, yellow, 4.5–9 mm long; achenes glabrous. Sagebrush, pinyon-juniper, mountain brush, aspen, lodgepole pine, ponderosa pine, and spruce communities at 1700 to 2930 m in Beaver, Garfield, Grand, Kane, Sevier, Uintah, Washington, and Wayne counties; Nevada to Wyoming, south to California, Arizona, and Mexico; 24 (iii). Those species treated elsewhere in this work as *Platyschkuhria* belong to *Bahia* in a broad sense and are probably best treated in the latter genus, but their combination is not implied here.

BAILEYA Harv. & Gray

Annual, biennial, or perennial herbs from taproots, with watery juice; stem erect, white-tomentose; leaves alternate, 1- or 2-pinnatifid to entire; heads solitary or few in cymose clusters; involucral bracts subequal, white-tomentose; receptacle naked; ray flowers persistent, yellow, pistillate, fertile; disk flowers perfect, fertile; pappus none; style branches short, truncate; achenes oblong or clavate, striate.

1. Ray flowers 7 or fewer; plants slender annuals with involucres less than 8 mm wide .... *B. pauciradiata*
— Ray flowers 20 or more; plants annual, biennial, or perennial, with involucres 10–26 mm wide 2

2(1). Rays 11–22 mm long; peduncles (4.5) 12–32 cm long in anthesis; involucres 5.7–7.5 mm high, 13–26 mm wide .... *B. multiradiata*
— Rays 8–10 mm long; peduncles 1–8 (11) cm long in anthesis; involucres 3–5.5 mm high, 10–16 mm wide .... *B. pleniradiata*

Baileya multiradiata **Harv. & Gray** Biennial or short-lived perennial herbs; stems 1.9–5 (5.2) dm tall, white-tomentose; leaves 0.8–10 cm long, the blade 1- to 2-pinnately lobed to entire, ovate-oval to linear, white-tomentose; peduncles (4.5) 13–32 cm long in anthesis, white-tomentose; involucres 5–7.5 mm high, 13–26 mm wide, the bracts slender, greenish, white-tomentose; rays 25–40 or more, yellow, 11–22 mm long; achenes glabrous. Creosote bush, Joshua tree, burrobush, blackbrush, and sagebrush communities at 670 to 1320 m in western Kane and Washington counties; Nevada and California south to Mexico; 36 (iii).

Baileya pauciradiata **Harv. & Gray** Annual herbs; stems mainly 1.5–4 (6) dm tall, densely floccose-lanate; leaves 3–10 cm long, the blades entire or the lower irregularly pinnatifid (or bipinnatifid), linear or linear-lanceolate, white-tomentose; peduncles 2–5 cm long in anthesis, tomentose; involucres 5–6 mm high, 5–8 mm broad, the bracts slender, greenish, loosely tomentose; rays 5–7, yellow, 5–8 mm long; achenes glabrous. Reported from Washington County by Meyer (1976), where it was collected at Warner Valley Spring; California, Arizona, and Mexico; 0 (0).

Baileya pleniradiata **Harv. & Gray** Annual to short-lived perennial herbs; stems 0.8–5 dm tall, white-tomentose; leaves 0.8–12 cm long, the blades 1- to 2-pinnately lobed to entire, obovate to linear, white-tomentose; peduncles 1–8 (11) cm long in anthesis, white-tomentose; involucres 3.5–5.5 mm high, 6–13 mm wide, the bracts slender, greenish, white-tomentose; rays 18–58, yellow, 8–10 mm long; achenes glabrous. Creosote bush, blackbrush, shadscale, mesquite, sagebrush, and pinyon-juniper communities at 820 to 1100 m in Washington County; Nevada and California to Texas; Mexico; 29 (ii).

BALSAMORHIZA Nutt.

Perennial scapose or subscapose herbs from taproots, the juice watery; leaves mainly basal, simple and entire or variously pinnatifid, reduced and bractlike upward; heads solitary, or few to several; involucral bracts in several series, imbricate or subequal, herbaceous; receptacle chaffy, convex, the bracts enclosing the achenes; ray flowers present, pistillate, fertile, usually yellow; disk flowers numerous, perfect, fertile, yellow; pappus none; style branches slender; achenes compressed. **Note:** The genus is notorious for the lack of genetic barriers to hybridization. Any two taxa can intergrade where they occur together.

1. Leaves sagittate, with entire margins .... *B. sagittata*
— Leaves pinnatifid or variously cleft 2

2(1). Leaves mainly 3–6 dm long, with segments mainly 5–12 cm long, these entire or few lobed or toothed .... *B. macrophylla*

— Leaves mainly 1–3 dm long, with segments mostly 1–5 cm long, these entire or variously lobed or toothed 3

3(2). Involucral bracts abruptly tapering to a long-attenuate apex; stem leaves relatively well developed, pinnatifid or bipinnatifid; reported for northern Utah, but no specimens have been seen .... *B. hirsuta* Nutt.

— Involucral bracts gradually tapering to an attenuate apex; stem leaves lacking or small and inconspicuous .... *B. hookeri*

Balsamorhiza hookeri **Nutt.** Hooker Balsamroot. Perennial scapose herbs from a thick taproot, mainly 0.9–4.5 (5.2) dm tall; leaves 6–30 cm long, (0.3) 1.5–11 cm wide, pinnatifid or bipinnatifid, the segments to 5.5 cm long; peduncles naked or with a few inconspicuous, linear, entire or pinnatifid bracts near the base; heads solitary; involucres 13–24 mm high, 21–47 mm wide, the bracts lance-linear, evenly tapering to the apex or somewhat enlarged at the base, long-ciliate, glandular to tomentose dorsally; rays mainly 10–16, yellow, 16–40 mm long; achenes glabrous. Phases of this taxon are known to form intermediates with *B. sagittata*, and presumably with *B. macrophyllum*. Ours are separable into two modestly distinctive varieties.

1. Involucres densely villous-tomentose dorsally; plants of Daggett, Duchesne, and Uintah counties .... *B. hookeri* var. *neglecta*

— Involucres glandular to glabrous dorsally; plants of broad distribution, occasionally of Daggett and Duchesne counties .... *B. hookeri* var. *hispidula*

Var. *hispidula* **(Sharp) Cronq.** [*B. hispidula* Sharp]. This is the common phase of the species in Utah, and it has been confused with *B. hirsuta* Nutt., with which it is compared in the key. Bunchgrass, sagebrush, mountain brush, juniper, pinyon-juniper, and salt desert shrub communities at 1240 to 2745 m in Beaver, Box Elder, Daggett, Duchesne, Juab, Salt Lake, Tooele, Utah, Wasatch, and Washington counties; Nevada, Idaho, and Wyoming (?); 31 (ii).

Var. *neglecta* **(Sharp) Cronq.** [*B. hirsuta* var. *neglecta* Sharp].Salt desert shrub, sagebrush, pinyon-juniper, and ponderosa pine communities at 1640 to 2625 m in Daggett, Duchesne, and Uintah counties; Nevada, Idaho, and Wyoming (?); 18 (ii). Plants of this variety form hybrids with *B. sagittata*.

Balsamorhiza macrophylla **Nutt.** Cutleaf Balsamroot. Perennial scapose herbs from a thick taproot, mainly 3–7 dm tall; leaves 15–60 cm long, 3.7–25 cm wide, pinnatifid, the segments entire, few toothed or lobed, up to 12.5 cm long; peduncles sparingly long shaggy-villous, naked, or with one to few reduced leaves near the base; heads solitary; involucres 23–35 mm high, 30–60 mm wide, the bracts lance-linear, attenuate, long-ciliate, glandular and more or less long-villous dorsally; rays 9–14, yellow, 30–55 mm long; achenes glabrous. Mountain brush and sagebrush or bunchgrass communities at 1525 to 2290 m in Box Elder, Cache, Salt Lake, Summit, Utah, and Weber counties; Idaho to Montana and Wyoming; 7 (0).

Balsamorhiza sagittata **(Pursh) Nutt.** Arrowleaf Balsamroot. [*Bupthalmium sagittatum* Pursh]. Perennial scapose herbs, from thick taproot, mainly 1.5–8 dm tall; leaves (including long slender petioles) 5–45 cm long, 1.5–15 cm wide, sagittate, entire, or the cauline ones from near the summit to near the middle of the subscapose stem and linear to elliptic; peduncles villous-tomentose; heads solitary (or with additional reduced ones); involucre 15–30 mm long, 20–50 mm wide, the bracts lance-linear, attenuate, villous-tomentose; rays 8–25, yellow, 25–60 mm long; achenes glabrous. Sagebrush, mountain brush, pinyon-juniper, ponderosa pine, Douglas fir, aspen, and fir communities at 1340 to 3020 m in Beaver, Box Elder, Cache, Davis, Garfield, Iron, Juab, Kane, Millard, San Juan, Salt Lake, Sanpete, Sevier, Summit, Tooele, Uintah, Utah, and Washington counties; British Columbia to Montana and South Dakota, south to California, Nevada, and Colorado; 43 (vii).

BELLIS L.

Scapose perennial herbs, with fibrous roots and short stolons, the juice watery; stems leafless, simple; leaves all basal, simple, petiolate, toothed to entire; heads solitary; involucral bracts in 2 subequal series, herbaceous; receptacle conic to hemispheric, naked; rays white, pink, or purple, numerous, pistillate; disk flowers numerous, perfect, yellow; pappus lacking; style branches flattened; achenes flattened, usually 2-nerved, pubescent.

Bellis perennis L. European Daisy. Plants 0.2–2 dm tall; leaves all basal, with short to long petioles, the blades 0.7–3 (4) cm long, 5–25 mm wide, obovate to oval or orbicular, dentate to entire, obtuse to rounded or emarginate apically, pubescent on both sides with coarse spreading hairs; scapes pubescent with ascending hairs; heads solitary; involucres 4–7 mm high, 9–15 mm wide, the bracts ovate to broadly lanceolate, rounded to obtuse apically, sparsely hairy dorsally, often suffused with purple, mostly 8–10 mm long, 1.5–2.5 mm wide; pappus lacking; achenes flattened. Cultivated ornamental, escaping and persisting in lawns of lower valleys in Salt Lake and Utah counties; adventive from Europe; 4 (0).

BIDENS L.

Annual herbs with fibrous roots, or rooting along the lower stem, the juice watery; stems decumbent to erect, commonly branched; leaves opposite, simple or pinnately compound; heads few to several in cymose inflorescences; involucral bracts in 2 series, the outer herbaceous, the inner somewhat petaloid and striate; receptacle flat or slightly convex, chaffy throughout, the chaff similar to the inner involucral bracts; ray flowers present, yellow, neutral or pistillate, or lack ing; disk flowers numerous, perfect, fertile, yellow; pappus of (1) 2–4 awns or teeth, these retrorsely barbed, persistent; style branches flattened; achenes flattened, pubescent, usually 2- to 4-awned.

SHERFF, E. E. 1937. The genus *Bidens*. Field Mus. Pub. Bot. 16:1–709.

1. Leaves simple, the middle and upper ones (at least) sessile or subsessile ...... *B. cernua*
— Leaves pinnately compound, with 3–5 leaflets, all petiolate .... *B. frondosa*

Bidens cernua L. Bur-marigold. Plants 1–13 dm tall, the stems sparingly spreading-hairy to glabrous; leaves simple, 1.5–15 cm long, 0.5–4 cm wide, narrowly lanceolate to lance-ovate, coarsely serrate to subentire, glabrous; heads nodding in age; outer involucral bracts 5–8, green, foliaceous, unequal, spreading or reflexed, the inner bracts erect, mostly 6–15 mm long; rays 6–8, yellow, or lacking; achenes mainly 5–7 mm long, tan, the 2–4 awns retrorsely barbed. Wet meadows, bogs, stream banks, bars, and shores, at 1300 to 2380 m in Cache, Garfield, Juab, Kane, Salt Lake, Sevier, Summit, Uintah, and Tooele counties; widely distributed in the Northern Hemisphere; 27 (iii).

Bidens frondosa L. Devil's Beggarticks. Plants 2–12 dm tall, the stems short-hairy to glabrous; leaves petiolate, pinnately compound with 3–5 leaflets, these 2–10 cm long, 0.5–3 cm wide, lanceolate, serrate; heads erect in age; outer involucral bracts 5–8, green, subfoliaceous, subequal, erect or spreading, the inner bracts erect, mostly 5–8 mm long; rays usually lacking; achenes 5–9 mm long, dark brown to black, the 2 awns barbed. Marshes, pond and lake shores, bars, wet meadows, and irrigation canals at 1190 to 1650 m in Davis, Grand, Salt Lake, and Utah counties; widespread in North America; 12 (ii). **Note:** The panboreal weed, *Bidens tripartita* L., might occur in our area. It is distinguished from *B. frondosa* in its simple but trifid leaves, and from *B. cernua* in its petiolate trifid leaves.

BRICKELLIA Ell. Nom. Cons.

Perennial herbs, subshrubs or shrubs; leaves alternate or opposite, simple; heads campanulate or cylindric, cymose or paniculate, discoid; flowers all perfect, fertile; involucral bracts imbricate in several series, striate; receptacle almost flat, naked; style branches flattened, with long-papillate appendage; achenes 10-ribbed; pappus of barbellate, smooth, or subplumose bristles.

ROBINSON, B. L. 1917. A monograph of the genus *Brickellia*. Mem. Gray. Herb. 1: 1–151.

1. Leaves spinulose-serrate, or spinulose tipped; low rounded shrubs of Washington and San Juan counties .... *B. atractyloides*
— Leaves entire or toothed, not spinulose; herbs, subshrubs, or tall shrubs of various distribution 2
2(1). Plants herbaceous; heads reflexed, broadly campanulate; leaves sagittate- to cordate-ovate, longer than broad .... *B. grandiflora*
— Plants, shrubs, or subshrubs; heads narrowly cylindric, or, if campanulate, erect; leaves ovate to linear, if cordate, about as broad as long or broader 3
3(2). Leaves petiolate, the blades cordate-ovate to ovate or suborbicular, 1–5 cm broad .... *B. californica*
— Leaves sessile or subsessile, linear to narrowly lanceolate, or, if broader, mainly less than 1 cm broad 4
4(3). Leaves linear to lanceolate or narrowly elliptic; shrubs 6–15 dm tall or more; flowers 3–5 per head .... *B. longifolia*
— Leaves ovate to oval or oblong to linear; shrubs or subshrubs less than 5 dm tall; flowers many per head 5
5(4). Leaves 5–10 times longer than broad or more, entire or nearly so, sessile; involucres 10–20 mm high .... *B. oblongifolia*
— Leaves only somewhat longer than broad, often toothed or lobed, at least some evidently petiolate; involucres 8–12 mm high .... *B. microphylla*

Brickellia atractyloides Gray Shrubs, much branched, mostly 3–5 dm tall, the branchlets greenish to straw colored, soon gray; leaves alternate, short-petiolate, the blades 0.6–3.2 cm long, 0.3–2.2 cm wide, lance-ovate to ovate, obtuse to rounded basally, spinulose-serrate to entire, acuminate and spinulose tipped apically, thick and prominently veined, glabrous or minutely glandular puberulent; heads solitary, terminating the branches; peduncles 1–5.2 cm long, glandular-puberulent; involucres 10–13.5 mm high, 8–16 mm wide, the outer bracts ovate-lanceolate, acuminate apically, many veined; the inner narrower, glandular-puberulent dorsally; flowers 50–75 or more; achenes black, 3.8–4.2 mm long, hirtellous on the ribs. Rock crevices and talus slopes, creosote bush, blackbrush, and indigo bush communities at 820 to 1130 m in San Juan (confluence of San Juan and Glen Canyon arms of Lake Powell) and Washington counties; Nevada and Arizona; 9 (i). The type is from the Colorado River (Utah?), Palmer sn, 1870 (US!).

Brickellia californica Gray [*Bulbostylis californica* T.& G.; *Coleosanthus californicus* (T. & G.) Kuntze]. Subshrubs, mainly 5–10 dm tall, the branchlets whitish to brownish; leaves alternate, petiolate, the blades 1.7–5.2 cm long, 1.3–4.5 cm wide, cordate-ovate to ovate or orbicular, truncate to cordate basally, crenate-serrate, rounded to obtuse apically, the veins not prominent, glandular-scabrous; heads clustered in a leafy-bracteate panicle; sessile or shortly pedunculate; in vol ucres 5.5–8 mm high, 4–7 mm wide, the outer bracts very short, rounded apically, few veined, the inner long and slender, often suffused with red or purple, glabrous; flowers 8–18; achenes straw colored, 2.5–3.5 mm long. Canyons and rock outcrops at 825 to 2135 m in Garfield, Kane, San Juan, Utah, and Washington counties; Colorado to California and south to Texas and Mexico; 15 (iii).

Brickellia grandiflora **(Hook.) Nutt.** [*Eupatorium grandiflorum* Hook.]. Perennial herb, from a caudex and taproot, the stems green to straw colored, 2.5–9.5 dm tall; leaves alternate, petiolate, the blades sagittate to cordate-ovate, 1.5–9 (11) cm long, 0.6–6.5 cm wide, cordate to truncate basally, serrate to doubly so, attenuate to acuminate apically, the veins not prominent, minutely puberulent or hirtellous; heads several to numerous in short corymbose panicle, commonly reflexed; involucres 7–12 mm high, 6–10 mm wide, the outer bracts lance-acuminate, the inner abruptly acuminate, puberulent dorsally; flowers mostly 20–40 (70); achenes brown to black, 3.5–4.5 mm long, hirtellous. Pinyon-juniper, mountain brush, ponderosa pine, aspen, Douglas fir–white fir, spruce, and bristlecone pine communities at 1640 to 3200 m in Beaver, Duchesne, Garfield, Iron, Juab, Kane, Salt Lake, San Juan, Tooele, Utah, and Washington counties; Washington east to Missouri, south to Mexico; 34 (vii).

Brickellia longifolia **Wats.** [*Coleosanthus longifolia* (Wats.) Kuntze]. Shrubs, with stems and white to tan bark, mainly 10–15 dm tall; leaves alternate, sessile or subsessile, 1.2–13.5 cm long, 3–8 mm broad, lance-linear to lance-elliptic, obtuse to acute basally, attenuate apically, the veins not prominent, glabrous, glandular-resinous; heads numerous in panicles; involucres 3.4–6.2 mm high, 2.3–4 mm wide, the outer bracts ovate, acute, the inner, longer and slender, glabrous; flowers 3–5; achenes 1.8–2.4 mm long, brown, glabrous. Canyon bottoms, stream margins, seeps, and hanging gardens at 750 to 1590 m in Emery, Garfield, Grand, Kane, San Juan, Washington, and Wayne counties; California, Nevada, Arizona; 23 (viii).

Brickellia microphylla **(Nutt.) Gray** [*Bulbostylis microphyllus* Nutt.]. Shrubs or subshrubs, with tan to whitish bark, mainly 2–7 dm tall; leaves alternate, shortly petiolate to subsessile or sessile, 3–14 (20) mm long, 1–9 (12) mm wide, ovate to suborbicular, toothed to entire, commonly glandular-villous or -hispidulose, the veins not especially prominent, rounded to acute apically; heads solitary or few at tips of branches, racemosely arranged in leafy-bracteate panicles; involucres 7–10.3 mm high, 4–8.5 mm wide, the outer bracts oval to ovate, with thickened glandular tips, the inner often lacking glands and more or less 3-lobed or 3-veined; flowers 8–18; achenes 3.5–4.3 mm long, blackish, hirtellous or glabrous. Two distinctive phases, which have been treated at specific level, are present in Utah. There is justification for treating them at specific rank, but they are similar in vegetative features and general aspect.

1. Flowers 8–11 per head; involucres 7–10 mm long; 4–7.5 mm wide; plants of the Green, Colorado, and Virgin river systems .... *B. microphylla* var. *scabra*
— Flowers (12) 17–18 per head; involucres 8.5–10.3 mm long, 6.5–10 mm wide; plants of the Great Basin .... *B. microphylla* var. *watsonii*

Var. *scabra* Gray Blackbrush, rabbitbrush, sagebrush, shadscale, Grayia, greasewood, juniper, and pinyon-juniper communities mainly on sandstone outcrops at 885 to 2170 m in Daggett, Duchesne, Emery, Garfield, Grand, Kane, San Juan, Uintah, and Washington counties; Colorado, Nevada, Arizona. Our material is uniformly hispidulose-glandular along upper stems at least, and has 8–11 flowers per head; 35 (xi). **Note:** A peculiar specimen from San Juan County (Anderson A-6 BRY) has heads nearly all clustered at branch tips.

Var. *watsonii* (Robins.) Welsh comb. nov. [based on *Brickellia watsonii* Robins. Mem. Gray Herb. 1:42. 1917]. Sagebrush, shadscale, mountain brush, and juniper communities at 1525 to 2440 m in Juab, Millard, Sevier, Tooele, and Utah counties; Nevada and California. All modern floras distinguish *B. microphylla* by its heads "about 22-flowered." Our material fits well within the concept of *B. watsonii* Robins., which has heads "18-flowered." Specimens from the Great Basin of Utah are uniformly 18-flowered, except in *depauperate* heads that vary downward to 12 flowers per head. Stems are villous to glandular-villous, with the type of *B. watsonii* Robins. (Watson 494 US!) at the villous end of a cline; 7 (ii).

Brickellia oblongifolia **Nutt.** Subshrubs or subherbaceous, with green to tan branches, mainly 1–5.5 dm tall; leaves alternate, sessile or nearly so, 0.9–4 cm long, 1–11 (15) mm wide, elliptic to oblong, or lance-oblong, entire or essentially so, glandular-hispidulous, the veins not especially prominent, acute to attenuate or obtuse apically; heads solitary and terminating branches, or corymbosely arranged; involucres 10.8–15 mm long, 12–22 mm wide, the bracts all acute to acuminate, glabrous or glandular to glandular-puberulent; flowers (11) 26–40 (50); achenes 4.8–5.8 mm long, blackish, hispidulous. Grayia, shadscale, rabbitbrush, blackbrush, desert almond, juniper, pinyon-juniper, and ponderosa pine communities at 1280 to 2500 m in Beaver, Duchesne, Emery, Garfield, Juab, Kane, Millard, San Juan, Sevier, Uintah, Utah, Wasatch, Washington, and Wasatch counties; British Columbia to Montana, south to California, Arizona, and New Mexico. Our material is assignable to var. ***linifolia*** (D.C. Eaton) Robins. [*B. linifolia* D.C. Eaton, type from Jordan Valley, American Fork] which is distinguished by its achenes being hispidulous, not glandular-hispidulous or glandular. The segregation is tenuous at best; 41 (x).

Calycoseris Gray

Annual subscapose or caulescent herbs, with milky juice, from taproots, beset with tacklike stipitate glands above; leaves mostly basal, pinnately parted; heads solitary or few on leafy-bracteate peduncles; involucral bracts in 2 series, herbaceous, the inner with hyaline margins; receptacle with capillary bristles; corollas all raylike, yellow or white tipped; achenes fusiform, 5- or 6-ribbed, tapering to a short beak, this produced apically into a low denticulate cup; pappus abundant, white, of barbellate capillary bristles falling attached.

1. Rays white, with pink or purple dots or streaks dorsally; stipitate glands pale ... . *C. wrightii*
— Rays yellow; stipitate glands purple .... *C. parryi*

Calycoseris parryi Gray Annual herbs, mainly 0.7–3 dm tall, the stems simple or with spreading branches; leaves basal and alternate along stem, pinnately parted, the lobes linear, reduced and entire above, glabrous except for a few tangled long hairs on lower surface; peduncles mainly 0.5–4 cm long, clad with tacklike, long-stipitate, purple or purplish-black glands; involucres 11–15 mm high, 8–14 mm wide (when pressed), the bracts linear-subulate to lance-subulate, more or less stipitate-glandular, attenuate apically; rays yellow, 10–20 (25) mm long; pappus surpassing the achene. Creosote bush and Joshua tree communities, reported for Utah by Munz (1959. Calif. Flora p. 1300); to be expected in Washington County; California and Arizona. Measurements are from Arizona and California materials; 0 (0).

Calycoseris wrightii Gray Annual herbs, mainly 1.4–4 dm tall, the stems commonly with spreading branches; leaves basal and alternate along the stem, pinnately parted, the lobes linear, reduced and subentire upward, glabrous except for a few long tangled hairs on lower surface; peduncles mainly 0.3–5 cm long, clad with tacklike long-stipitate pale glands; involucres 12–17 mm long, 12–20 mm wide, the bracts linear-subulate to lance-subulate, more or less stipitate-glandular, attenuate apically, rays 10–25 mm long, white, with pink or purple markings dorsally; pappus shorter than achene. Creosote bush and Joshua tree communities in Washington County; California, Nevada, Arizona; 1 (0).

Carduus L.

Biennial or annual herbs with taproots, the juice watery; stems erect, simple or branched; leaves alternate simple, pinnatifid to bipinnatifid or merely pinnately lobed, often decurrent, spiny; heads solitary or few, borne in corymbose cymes; involucral bracts imbricated in several series, spine tipped; receptacle hemispheric, densely bristly; disk flowers only present, perfect, red-purple, with long slender lobes; pappus of barbellate bristles; style branches connate, shortly hairy at base of branches; achenes compressed.

Carduus nutans L. Nodding Thistle; Musk Thistle. Rank biennial or annual herbs, mostly 0.6–20 (25) dm tall; stems arachnoid-tomentose to glabrate; leaves alternate, decurrent, 3–40 cm long, 0.5–20 cm wide (or more), lance-linear to elliptic, glabrous, or tomentose along veins beneath; heads commonly solitary, nodding; involucres 20–30 mm long, 30–80 mm wide, the bracts 2–8 mm wide, ovate-lanceolate to lanceolate, glabrous or nearly so, spinose tipped, at least the outermost reflexed near the middle, the midrib prominent; flowers red-purple; achenes 3.5–4.5 mm long, smooth, marked with vertical lines, umbonate. Disturbed sites along roads and in fields and pastureland at 1340 to 2440 m in Daggett, Juab, Salt Lake, Sanpete, and Utah counties, and probably universal; introduced Old World plants, now widely established in the United States; 15 (ii).

CENTAUREA L.

Annual, biennial, or perennial herbs with taproots or rhizomes, the juice watery; stems erect or ascending; leaves alternate, entire to pinnatifid; heads solitary, or few to numerous, discoid; involucral bracts imbricate in several series, spine tipped or some of them enlarged and with scarious or hyaline erose to lacerate or pectinate appendages; receptacle bristly; flowers all tubular, perfect, or the marginal ones sterile and falsely subradiate; purple, blue, yellow, pink, or white; pappus of bristles, scales, or none; style branches more or less connate, with a thickened often hairy ring at the base; achenes obliquely or laterally attached to receptacle. Note: This is a large genus, mainly of the Mediterranean region of the Old World, but with some indigenous to North America, Australia, and South America. All of ours are introduced, and the potential for other introductions in this remarkable genus is great. In Flora Europaea, our species are treated within three genera: *Amberboa* (Pers.) Less. (*C. moschata* L.), *Acroptilon* Cass (*C. repens* L.), and *Centaurea* for the others.

1. Involucral bracts definitely spine tipped, at least some with spines 1–20 mm long 2
— Involucral bracts definitely not spine tipped, or, if shortly spinose as in *C. maculosa* and *C. scabiosa*, the heads 6–25 mm wide 5

2(1). Stem definitely winged, the leaf bases decurrent; pappus present (central flowers, at least) 3
— Stems angled, not winged; pappus none 4

3(2). Apical spine of involucral bract 5–9 mm long; plants arachnoid when young; flowers all with evident pappus .... *C. melitensis*
— Apical spine of involucral bract 11–20 mm long; plants persistently tomentose; flowers in center only with a pappus .... *C. solstitialis*

4(2). Apical spine of bracts 5–15 mm long or more .... *C. calcitrapa*
— Apical spine of bracts 1–4 mm long .... *C. virgata*

5(1). Leaves entire or merely toothed, not pinnatifid 6
— Leaves pinnatifid or deeply pinnately lobed 8

6(5). Leaves linear to lance-linear, entire or nearly so, less than 1 cm wide .... *C. cyanus*
— Leaves various, but, if as above, plants rhizomatous 7

7(6). Plants rhizomatous; leaves mainly 2–10 mm wide; pappus evident, 6–11 mm long .... *C. repens*
— Plants not rhizomatous; leaves 6–15 mm wide; pappus 2–5 mm long .... *C. jacea*

8(5). Leaves merely pinnately lobed; involucral bracts entire or nearly so .... *C. moschata*
— Leaves pinnately divided, the lobes linear to narrowly oblong; involucral bracts pectinately lobed 9

9(8). Involucres 15–25 mm wide; lobes of leaves often again toothed or lobed .... *C. scabiosa*
— Involucres mainly 6–10 mm wide; lobes of leaves usually entire .... *C. maculosa*

Centaurea calcitrapa L. Star-thistle. Biennial herbs, from taproots, the stems usually branched, 1–8 dm tall, arachnoid-villous to glabrate; leaves 0.5–4.5 cm long, pinnatifid, the lobes linear to oblong, attenuate, or the upper ones entire; heads few to numerous; involucres urn shaped, 10–18 mm high, mainly 8–12 mm wide, the bracts weakly spinose-ciliate, with a stout apical spine mainly 5–30 mm long; flowers few, purple; pappus none. Roadside weeds, Utah County (Wadley & Holmgren 381 UT); introduced from Eurasia; 1 (0).

Centaurea cyanus L. Bachelor's Button; cornflower. Annual or biennial herbs from taproots, the stem usually branched, mostly 1–8 (12) dm tall, arachnoid-tomentose; leaves 2–10 (13) cm long, 1–8 mm wide, entire or some with slender lobes, attenuate; heads few to numerous; involucres hemispheric, 10–16 mm high, 10–23 mm wide, the bracts with a tapering pectinate or fringed tip, often purplish suffused, the central apical tooth not especially spinose; flowers several, blue, purple, pink, or white, the marginal ones enlarged, irregular; pappus 2–3 mm long. Cultivated ornamental, now established in disturbed sites in Cache, Salt Lake, Tooele, Utah, Wasatch, and Washington counties; adventive from Europe; 6 (0).

Centaurea jacea L. Perennial herbs from taproots, the stems simple or branched from the middle, mostly 5–12 dm tall, glabrous or somewhat arachnoid; leaves entire or toothed to shallowly lobed, the basal ovate to lanceolate, petiolate, becoming smaller upward; heads few to numerous; involucre 12–18 mm high, 12–15 mm wide, ovoid, the bracts with orbicular appendages, scarious, brown, darker in middle, the outer denticulate to pectinate-lacerate, the inner less so and often bifid; flowers purple or white, the outer more or less radiate; pappus none or very short. Cultivated ornamental, now established in Salt Lake County; adventive from Europe; 0 (0). **Note:** The large headed *C. montana* L., is cultivated in Utah. It has wedge-shaped involucral bracts and decurrent large leaves.

Centaurea maculosa Lam. Biennial or short-lived perennial, the stems simple or commonly branched above the middle, mainly 3–10 (15) dm tall, tomentose and sparingly scabrous-puberulent; leaves 1–9 cm long, pinnatifid, the lobes linear to lanceolate or oblong, entire or variously toothed or lobed, reduced and bracteate in the inflorescence; heads few to many, hemispheric to vase shaped; involucres 10–13 mm high, 10–13 mm wide, the bracts with short dark pectinate tip, the central tooth produced as a spine to 0.5 mm long; flowers pink or purplish, rarely white, the marginal ones radiate; pappus to 2 mm long, rarely lacking. Roadsides in Beaver, Juab, and Tooele counties; adventive from Europe; 3 (i).

Centaurea melitensis L. Annual or biennial, the stems sparingly branched from middle or below, 1.5–8 dm tall, winged by decurrent leaf bases; basal and lower cauline leaves oblanceolate, toothed to lyrate-pinnatifid or sinuately lobed, reduced upward, finally entire; heads solitary, terminating branches, or 2 or 3 in clusters; involucres 8–15 mm high, 8–12 mm wide, tapering apically, the middle and outer bracts spine tipped, the spines 5–8 mm long; flowers yellow, all alike; pappus 1.5–3 mm long. Adventive Old World species of disturbed sites in Salt Lake County (Without collector UT); 1 (0).

Centaurea moschata L. [*Amberboa moschata* (L.) DC.]. Annual herbs; simple or sparingly branched, mainly 3–7 dm long, sparingly tomentose; leaves 1–9.5 cm long, 1–3 cm wide, pinnatifid, the lowermost petiolate, becoming sessile upward; heads solitary, on peduncles 8–15 cm long or more; involucres vase shaped, 12–14 mm high, 18–22 mm wide, the bracts oval, with purplish margins, only the inner with broad, reflexed, entire appendage; flowers pink; pappus shorter to about equaling the achenes. Cultivated ornamental, escaping and persisting in Washington County; adventive from Asia; 1 (0).

Centaurea repens L. Russian Knapweed. [*C. picris* Pallas ex Willd.; Acroptilon repens

(L.) DC.]. Perennial rhizomatous herbs, mostly 3–8 dm tall, arachnoid-tomentose to glabrate; leaves in a basal rosette and cauline, the basal leaves often withered by flowering time, the cauline mainly 1–6 cm long, 2–12 mm wide, entire or serrate; heads few to numerous, terminating branches; involucre 9–15 mm high, 5–12 mm wide, more or less urn shaped, middle and outer bracts broad, glabrous, with broader rounded, subentire hyaline tips, the inner bracts narrow, tapering, and with plumose hairy tips; flowers pink to purplish, all alike; pappus bristle subplumose, 6–11 mm long. Introduced Old World primary noxious weed, now widely established at 1220 to 2380 m in Cache, Daggett, Duchesne, Emery, Garfield, Grand, Kane, San Juan, Salt Lake, Tooele, Uintah, and Utah counties; widespread in North America; adventive from Eurasia; 28 (ii).

Centaurea scabiosa **L.** Perennial herbs, mostly 5–15 dm tall, scabrous-puberulent; leaves 4–20 cm long or more, the lowermost long-petiolate, once to twice pinnatisect, the segments linear to oblong, entire or dentate-serrate to lobed, the upper pinnately divided, sessile; heads few to several, terminating branches; involucres 13–20 mm high, 18–25 mm wide, ovoid-globose; bracts ovate, glabrous or arachnoid, the appendages triangular-ovate, brown or black, with pale brown teeth; flowers purple, alike or nearly so; pappus 4–5 mm long. Cultivated ornamental, persisting and escaping, Salt Lake County and probably elsewhere; adventive from Europe; 2 (0).

Centaurea solstitialis **L.** Annual or biennial, grayish tomentose, the stems 1–6 (10) dm tall, evidently winged; leaves mainly 1–12 (20) cm long, 0.1–3 (5) cm wide, the basal ones lyrate to pinnatifid, the cauline ones progressively smaller and entire upwards, linear to linear-subulate; heads few to numerous, terminating branches; involucres 8–15 mm high, 7–15 mm wide, urn shaped, the middle and outer bracts with central apical spines 10–20 (30) mm long, the inner with a small hyaline appendage; flowers yellow, all alike; pappus of marginal flowers none, that of the central ones 3–5 mm long. Roadsides and abandoned fields at 915 to 1900 m in Wasatch, Washington, and Weber counties; adventive from Europe; 4 (i).

Centaurea virgata **Lam.** Perennial, from a caudex, more or less grayish tomentose, the stems 4–9 dm tall, branched above; leaves mainly 0.5–15 cm long, 0.1–6 cm wide, the basal ones petiolate, once to twice pinnately divided, the lobes linear, these often again toothed or lobed; cauline leaves smaller, sessile, and lobed to entire; heads several to numerous, terminating short branches; involucre 7–10 mm high, 3–5 mm wide, the bracts pale or suffused with red or purple, with a slender apical spine 1–2 mm long; flowers pink; pappus about 1.5 mm long. Roadsides and other disturbed sites in Grand, Juab, and Utah counties at 1525 to 1830 m; adventive from Eurasia; 5 (i).

CHAENACTIS DC.

Annual, biennial, or perennial herbs, from taproots; leaves alternate or mainly basal, pinnately dissected to entire; heads solitary or few to several, borne in corymbose cymes, discoid, the flowers white, or cream to pink, all perfect, the marginal ones sometimes enlarged and raylike; involucral bracts in 1–3 series, herbaceous; receptacle flat, naked; pappus of 4–20 hyaline scales; style branches slightly compressed; achenes clavate, terete or more or less compressed.

STOCKWELL, P. 1940. A revision of the genus *Chaenactis*. Contr. Dudley Herb. 3:89–168.

1. Plants perennial from a simple or branching caudex; 2–9 cm tall; stemless or with few short internodes; of high elevations .... *C. alpina*
— Plants annual or biennial, rarely perennial, the caudex seldom developed; stems mainly 10–30 cm tall, or, if less, plants definitely not perennial; distribution usually of middle and lower elevations 2

2(1). Basal rosette well developed; plants biennial or short-lived perennials; pappus scales 10–16 .... *C. douglasii*

— Basal rosettes poorly, if at all, developed; plants annual; pappus scales 4 or 5 (rarely 8) 3

3(2). Lower and upper cauline leaves simple, the middle ones few lobed; Washington County .... *C. fremontii*

— Lower, middle, and upper leaves pinnately divided, or only the uppermost simple 4

4(3). Heads mostly 15–22 mm high; flowers pink, much surpassing the involucre; anthers included .... *C. macrantha*

— Heads mostly 8–10 mm high; flowers white or cream, only slightly surpassing the involucre; anthers exserted 5

5(4). Involucral bracts blunt or nearly acute apically; plants widely distributed .... *C. stevioides*

— Involucral bracts long-attenuate and bristle tipped apically; plants of Washington and Millard counties .... *C. carphoclina*

Chaenactis alpina **(Gray) Jones** Alpine Dusty-maiden. [*C. douglasii* var. *alpina* Gray]. Perennial, from a simple or branched, sometimes soboliferous caudex, 3.5–9 cm tall; stems with few contracted internodes, very short, or not developed; leaves 1.3–5 cm long, pinnately divided, the lobes again toothed or lobed, 1–7 mm long, gray tomentose to glabrate; heads solitary or sometimes 2, the peduncles tomentose or glandular, 0.5–6 cm long; involucres (7.5) 10–13 mm long, (8) 10–17 mm wide, the bracts often suffused with purple, glandular or tomentose; corolla purplish to white, glandular or sparingly tomentose; pappus of 10 oblong-spatulate rounded hyaline scales, in 2 series; achenes 6–8 mm long, hairy. Boulder stripes and talus in alpine tundra or upper montane communities at 2980 to 3965 m in Duchesne, Salt Lake, Summit, and Utah counties; Oregon to Montana, California and Colorado. Our materials are separable into two more or less distinctive phases; a glandular phase, with distribution mainly in the Wasatch Mountains, which is var. ***alpina*** [including *C. rubella* Greene; *C. alpina* var. *rubella* (Greene) Stockwell], and a tomentose phase, mainly from the Uinta Mountains, which might be assignable to var. ***leucopsis*** (Greene) Cockerell [*C. leucopsis* Greene]. More work is necessary, including evaluation of the type specimen of var. *leucopsis;* 10 (i).

Chaenactis carphoclina **Gray** Annual, from a taproot, 6–28 (40) cm tall; stems well developed, more or less flexuous; leaves 0.8–5.6 cm long, mealy-puberulent, 1- to 2-pinnatifid, the segments linear-filiform, 1–20 mm long; heads few to numerous, on slender farinose to glandular peduncles 0.4–3 cm long; involucres 6–9 mm high, 6–15 mm wide, the bracts lance-attenuate into slender, bristlelike tips, glandular; flowers white to cream; pappus of central flowers usually of 4 lance-acuminate scales, those of marginal flowers sometimes shorter; achenes 3.5–4.5 mm long, hairy. Larrea community at 850 to 1000 m in Washington County; California, Nevada, Arizona; 10 (0).

Chaenactis douglasii **(Hook.) H. & A.** Douglas Dusty-maiden. [*Hymenopappus douglasii* Hook.; *C. achilleaefolia* H. & A.; *C. douglasii* var. *achilleaefolia* (H. & A.) A. Nels.; *C. douglasii* var. *montana* Jones; *C. brachiata* Greene, type from Springdale; *C. brachiata* var. *stansburyi* Stockwell, type from Stansbury Island]. Biennial or short-lived perennial, from a taproot, seldom with a caudex, mainly 5–50 (60) cm tall, sparsely to densely tomentose; stems with few to many well developed internodes; leaves 0.6–12 (15) cm long, 1–3 pinnatifid, the lobes 1–3 cm long, tomentose to glabrate; heads solitary or several in a corymbose cyme; involucre 7–16 mm high, 8–25 mm wide, the bracts glandular to glandular-tomentose, oblong to narrowly oblanceolate or linear, blunt apically; flowers white to pink; pappus of 10–16 scales in 2 series; achenes 6–8 mm long, hairy. Shadscale, sagebrush, pinyon-juniper, mountain brush, ponderosa pine, white fir, Douglas fir, aspen, and limber pine communities at 1340 to 3050 m in all Utah counties; British Columbia to Montana, south to California, Arizona, and Colorado. It does not seem reasonable to attempt to segregate our materials into varieties. The variability apparently does not demonstrate geographic correlation; 132 (xx).

Chaenactis fremontii **Gray** Annual or winter annual, from a taproot, 10–25 (40) cm tall, glabrate or sparingly tomentose when young; leaves 0.6–6.5 cm long, the lower and upper simple, linear, the middle few lobed, glabrous; heads solitary to several on tomentose to glabrate (glandular?) peduncles 1–5 cm long; involucres 8–10 mm high, 10–12 mm wide, glabrous or tomentose, attenuate but not caudate; flowers white to pinkish, the outer ones enlarged; pappus of central flowers of 4 scales; achenes hairy. Creosote bush and Joshua tree communities at 670 to 885 m in Washington County; Arizona, Nevada, California; 2 (0).

Chaenactis macrantha **D.C. Eaton** Annual or winter annual, from a taproot, mainly 6–25 cm tall, branching from the base or simple, floccose-tomentose to glabrate; leaves 0.5–5 cm long, 1- to 2-pinnatifid, the lobes to 1 cm long, broad, floccose to glabrate; heads solitary to several, on tomentose peduncles 0.5–5 cm long; involucres 12–17 mm high, 8–22 mm wide, the bracts oblong-lanceolate, rather abruptly short-acuminate, tomentose; corollas pink to white, all about alike; anthers included; pappus of 4 linear-oblong scales and 2–4 short outer ones or these lacking; achenes hairy. Shadscale, pinyon-juniper, creosote bush, and blackbrush communities at 885 to 2135 m in Beaver, Juab, Kane, Millard, Tooele, and Washington counties; California, Nevada, Arizona; 17 (iii).

Chaenactis stevioides **H. & A.** Annual or winter annual, from a taproot, mainly 4–42 cm tall, branching from the base or simple, more or less tomentose; leaves 0.3–10 cm long, 1–2 pinnatifid, the lobes to 2.5 cm long, linear to oblong, sometimes all or nearly all simple in depauperate specimens; heads solitary to several on glandular peduncles 0.3–3 cm long; involucres 6–11 mm high, 8–22 mm wide, the bracts oblong-lanceolate to linear, acute to shortly acuminate apically, glandular; corollas white to cream, the outer ones enlarged; pappus of 4 oblong-lanceolate scales; achenes hairy. Creosote bush, blackbrush, mat-atriplex, shadscale, indigo bush, and juniper communities at 915 to 1891 m in Beaver, Carbon, Duchesne, Emery, Garfield, Grand, Juab, Kane, San Juan, Washington, and Weber counties; Wyoming south to Nevada, west to California; 63 (vi).

CHAMAECHAENACTIS Rydb.

Perennial scapose herbs from a long-pilose caudex, clothed with marcescent leaf bases, and taproot, with watery juice; leaves all basal, petiolate, simple; heads solitary; involucres turbinate, the bracts subequal or the outer shorter; receptacle naked; rays none; disk flowers perfect, fertile, cream colored to pink; pappus of hyaline scales; style branches flattened, papillate; achenes 4-angled, hairy.

Chamaechaenactis scaposa **(Eastw.) Rydb.** [*Chaenactis scaposa* Eastw.] Plants 2–9 cm tall, the scapes long-villous; leaves petiolate, the blades 0.4–1.8 cm long, 3–13 (15) mm wide, lance-oblong to ovate, to oval or orbicular, obtuse to rounded apically, obtuse to truncate basally, villous beneath, strigose to strigulous or villous above; heads solitary; involucre 7–17 mm high, 10–23 mm wide, the bracts oblong or linear-oblong, the outer densely villous, green or suffused with red-purple, the margin hyaline; corollas cream to pink; pappus scales oblanceolate-spatulate, rounded; achenes black, hirsute-pilose. Shadscale, galleta, pygmy sagebrush, mountain brush, pinyon-juniper, and ponderosa pine communities at 1580 to 2565 m in Carbon, Duchesne, Emery, Garfield, Grand (?), and San Juan counties; Arizona and Colorado; 40 (v).

CHAMOMILLA S.F. Gray

Annual herbs, aromatic in some; leaves alternate, 2- or 3-pinnatifid, with linear filiform ultimate segments; heads radiate or discoid, solitary or corymbose; involucral bracts greenish-chartaceous, the margins hyaline, in 2 or 3 series, subequal to imbricate; receptacle conic, hollow, naked; marginal flowers pistillate; rays (when present) white, the central disk flowers perfect and fertile, the style branches truncate, tufted-hairy apically; pappus a short crown of minute scales, or vestigial or lacking; achenes subcylindric, the ventral face with 3–5 narrow ribs, the dorsal face smooth and convex.

1. Heads radiate; disk corollas 5-lobed; involucre 11–25 mm in diameter ...... *C. recutita*
— Heads discoid; disk corollas 4-lobed; involucre 4–10 mm in diameter ... *C. suaveolens*

Chamomilla recutita **(L.) Rauschert** Chamomile. [*Matricaria chamomilla* L.]. Annual herbs; stems 0.2–4 (6) dm tall, erect or ascending, branched above; herbage glabrous or puberulent; leaves 2–6 cm long; heads solitary or more commonly few to many and corymbosely arranged; involucres saucer shaped, 3–4 mm high, 11–25 mm wide, the bracts subequal, the margins broadly hyaline, the midstripe greenish to brownish; rays 10–20, white, 4–10 mm long. Moist disturbed soils at low to moderate elevations in Salt Lake and Wasatch counties; adventive from Europe; 2 (0).

Chamomilla suaveolens **(Pursh) Rydb.** [*Matricaria matricarioides* (Less.) Porter]. Annual herbs; stems 0.4–4 dm tall, erect or ascending, branched from the base or simple; herbage glabrous or pubescent; leaves 1–5 (9) cm long; heads few to many, paniculately arranged; involucres saucer shaped, 2–6 mm high, 4–10 mm wide, the bracts subequal to somewhat imbricate, the margins hyaline, the midstripe greenish; rays lacking; disk flowers 4-lobed. Disturbed sites at 1310 to 2810 m in Box Elder, Cache, Carbon, Rich, Salt Lake, Sevier, Utah, and Weber counties; adventive from Europe; 16 (0).

CHRYSANTHEMUM L.

Perennial herbs from a rhizome or a caudex, with watery juice; stems erect or nearly so; leaves alternate, serrate to pinnatifid; heads solitary or few to numerous in open corymbose clusters; involucral bracts imbricate, in 2–4 series, greenish or straw colored, the margins brownish-scarious; receptacle naked; ray flowers white, numerous, pistillate, fertile, or lacking; disk flowers numerous, perfect, fertile, yellow; pappus lacking or a short crown; style branches flattened; achenes several nerved, beakless, glabrous.

1. Leaves finely serrate; heads usually numerous, small, commonly rayless ..*C. balsamita*
— Leaves coarsely serrate or pinnatifid; heads larger, fewer, commonly with rays 2
2(1). Heads solitary or few; involucres 7–10 mm high; rays 1–2 cm long; leaves serrate to more or less once pinnatifid .... *C. leucanthemum*
— Heads several to numerous; involucres 3–4.5 mm high; rays 2–6 mm long .... *C. parthenium*

Chrysanthemum balsamita **L.** Costmary. [*Balsamita major* Desf.]. Perennial herbs, from a caudex, commonly 5–10 (12) dm tall; stems strigose, at least above; leaves petiolate below, sessile or subsessile above, the blades 0.9–10 (15) cm long, 0.6–5 (8) cm wide, elliptic to oblanceolate, finely serrate, strigose; heads numerous, corymbose; involucres 3.7–4.6 mm high, 6–8 mm wide, the bracts oblong, sparingly strigose, the tip hyaline; ray flowers (when present) 4–6 mm long. Fields, roadsides, and cemetaries at 1370 to 2135 m Salt Lake, Summit, Tooele, and Utah counties; escaped from cultivation, now widely established in the United States; 5 (i).

Chrysanthemum leucanthemum **L.** Oxeyedaisy. [*Leucanthemum vulgare* Lam.] Perennial rhizomatous or subrhizomatous herbs, commonly 2–8 (10) dm tall; stems glabrous or nearly so, mainly simple; leaves petiolate below, becoming smaller and sessile above, the blades 0.8–5 cm long, oblanceolate to obovate or linear, serrate, crenate, or pinnately lobed, glabrous or villosulose; heads solitary; involucres 7–10 mm high, 15–23 mm wide, the bracts lance-ovate to oblong-linear, with brown margins, hyaline apically; rays mainly 15–30, white, 10–22 mm long; pappus none. Roadsides, fields, and other disturbed sites at 1525 to 2135 m in Salt Lake, Utah, Wasatch, and Weber counties; widespread in North America; adventive from Eurasia; 6 (0).

Chrysanthemum parthenium **(L.) Bernh.** [*Matricaria parthenium* L.; *Leucanthemum parthenium* (L.) Gren. & Godron; *Pyrethrum parthenium* (L.) Sm.; *Tanacetum parthenium* (L.) Schultz-Bip.]. Perennial herbs with caudex and taproot; commonly 3–9 dm tall;

stems glabrous, or puberulent above; leaves petiolate, becoming smaller, but still petiolate above, the blades 0.5–8 cm long, 0.6–4.5 (6) cm wide, pinnatifid or doubly so; heads several to numerous, the inflorescence corymbose; involucres 3–4.5 mm high, 7–10 mm wide, the bracts oblong, with a dark center, otherwise scarious except the tip hyaline; rays 10–20, white, 4–8 mm long; pappus a crown or none. Cultivated ornamental, escaping and persisting at 1525 to 1950 m in Carbon, Salt Lake, Utah, and Weber counties; widely established in the United States; adventive from Europe; 5 (0).

CHRYSOTHAMNUS Nutt.

Shrubs with white bark, or the surface obscured by a tomentum, this often glandular-resinous; leaves alternate, linear to oblong, or lanceolate, sessile, entire; heads white or yellow, discoid, narrow, in contracted to open paniculate inflorescences; flowers perfect, fertile; involucral bracts imbricate, more or less keeled, in 4 or 5 vertical or obscure ranks, chartaceous or coriaceous, or the tip herbaceous; receptacle naked; style branches flattened; achenes slender, flattened, angled, or terete, hairy or glabrous; pappus of numerous capillary bristles.

1. Flowers white; leaves terete; plants of western tier of counties (except Iron and Washington) ..... *C. albidus*
— Flowers yellow; leaves various, but, if terete, of Washington County or rarely elsewhere 2

2(1). Leaves terete, resinous punctate; stems more or less fastigiate; plants of Washington County ..... *C. paniculatus*
— Leaves commonly more or less flattened, resinous-punctate or not; stems not especially fastigiate; plants of broad or other distribution 3

3(2). Stems obscured by a tomentum, this often impregnated with resinous-glandular material 4
— Stems glabrous or puberulent, the surface readily apparent 5

4(3). Involucral bracts long-attenuate, membranous; inflorescence more or less racemose ..... *C. parryi*
— Involucral bracts obtuse to acute, rarely attenuate, but, if so, chartaceous; inflorescence cymose ..... *C. nauseosus*

5(3). Leaves lanceolate to lance-oblong, not contorted; shrubs mainly 6–20 dm tall; plants of the Uinta and Navajo basins ..... *C. linifolius*
— Leaves linear, oblong, or lanceolate, but, if lanceolate, twisted and shrubs mainly less than 6 dm tall; distribution various 6

6(5). Achenes hairy 7
— Achenes lacking hairs, sometimes glandular, or, if sparingly hairy, the involucre over 10 mm long 8

7(6). Involucral bracts acuminate-cuspidate; leaves 1–2 mm wide ..... *C. greenei*
— Involucral bracts acute to obtuse; leaves various ..... *C. viscidiflorus*

8(6). Flowers 10–12 mm long, surpassed by the pappus; plants of Emery, Wayne, and San Juan counties ..... *C. pulchellus*
— Flowers 7–9 mm long, surpassing or subequal to the pappus; distribution various 9

9(8). Involucral bracts strongly ranked; involucres 9.2–13 mm long ..... *C. depressus*
— Involucral bracts not strongly ranked; involucres 6.2–7.5 mm long ..... *C. vaseyi*

Chrysothamnus albidus **(Jones) Greene** Alkali Rabbitbrush; White Rabbitbush. [*Bigelovia albida* Jones]. Shrubs, mainly 5–10 dm tall, more or less fastigiately branched, white barked, glabrous, resinous-viscid, aromatic; leaves 0.5–3.5 cm long, terete, 0.5–1 mm thick, glandular-punctate, mucronate, crowded, often with axillary fascicles; heads clustered at branchlet apices; involucres 6.8–9 mm high, 3–7 mm wide, the bracts obscurely 4- to 5-ranked, the outer ones lance-ovate, thickened in lower half, abruptly subulate-attenuate, the inner oblong, acuminate to acute, the margin hyaline, glandular to tomentose; corollas white, 6–7.5 mm long; achenes 4–4.5 mm long, pilose and glandular; pappus abundant. Local in salt grass, pickleweed, and alkali-saccaton communities at 1450 to 1650 m in Beaver, Box Elder, Juab, Millard, and Tooele counties; California, Nevada; 8 (iii).

Chrysothamnus depressus **Nutt.** Dwarf Rabbitbrush. Low, spreading shrubs, the ascending to erect, subherbaceous stems 0.6–3 dm tall, white barked, scabrous-puberulent or glandular-puberulent; leaves 0.4–2 cm long, 1–4 (5) mm wide, flat, narrowly lanceolate to oblanceolate or spatulate, flat, scabrous-puberulent, obtuse, rounded or sharply apiculate; heads clustered at branch apices; involucres 9.2–13 mm high, 4.5–7 mm wide, the bracts in 4 or 5 definite vertical ranks, keeled, lance-attenuate, the subulate tip soft, the outer more or less herbaceous (sometimes suffused with purple) and the inner with broad hyaline margins; corollas yellow, 7.5–9 mm long; achenes (5) 6–7 mm long, glabrous or sparingly stipitate-glandular; pappus off-white to brownish, abundant. Sagebrush, salt desert shrub, juniper, pinyon-juniper, mountain brush, ponderosa pine and alpine fir communities at 1550 to 2900 m in Carbon, Duchesne, Emery, Garfield, Iron, Juab, Kane, Millard, Piute, San Juan, Sanpete, Sevier, Summit, Uintah, Utah, Wasatch, Washington, and Wayne counties; Colorado, New Mexico, Arizona, and Nevada; 34 (iv).

Chrysothamnus greenei **(Gray) Greene** Greene Rabbitbrush. Low, ascending to erect shrubs, with subherbaceous stems from a woody crown, mainly 1–3.5 dm tall, white-barked, glabrous; leaves 0.3–3.5 cm long, 0.8–1.2 mm wide, flat, linear, glabrous or scabrous-ciliate; heads numerous, corymbosely clustered at branch tips; involucres 5–7.1 mm high, 2.5–4 mm wide, the bracts obscurely ranked, the outer ones herbaceous-thickened near the tip, gradually acuminate-cuspidate, the inner ones abruptly narrowed, glabrous or more or less tomentose, narrowly if at all hyaline-margined; corollas yellow, 3.5–4.8 mm long; achenes 3.3–4 mm long, pilose. Rabbitbrush, black sagebrush, shadscale, winterfat, sagebrush, and pinyon-juniper communities at 1280 to 2745 m in Carbon, Duchesne, Emery, Garfield, Grand, Juab, Millard, Piute, Tooele, Uintah, Utah, and Wayne counties; Colorado, New Mexico, Arizona, and Nevada; 53 (vi). This entity forms intermediates with phases of *C. viscidiflorus*.

Chrysothamnus linifolius **Greene** Spreading Rabbitbrush. Tall shrubs, the branches erect-ascending, mainly 8–20 (35) dm tall, white barked, glabrous; leaves 0.9–7.7 cm long, 1–9 mm wide, flat, plane (not contorted or rarely somewhat so), thick, oblong to elliptic or narrowly lanceolate, glabrous, scabrous-ciliate, attenuate to acute; heads numerous, corymbosely arranged at branch tips; involucres 4.3–7.2 mm long, 1.8–3 mm wide, the bracts indistinctly ranked, the outer distinctly herbaceous at tip, the inner often merely glandular thickened at midrib, all obtuse to rounded, glabrous; corollas yellow, 4.5–5.8 mm long; achenes 2.1–2.8 mm long, pilose. Stream banks and terraces, irrigation canals, seeps and springs in riparian communities at 1130 to 2535 m in Carbon, Daggett, Duchesne, Emery, Garfield, Grand, Kane, San Juan, Sanpete, Sevier, Uintah, and Wayne counties; Montana to Arizona and New Mexico; 54 (xvii).

Chrysothamnus nauseosus **(Pallas) Britt.** Rubber Rabbitbrush. Low to tall shrubs, the branches erect-ascending, mainly 2–20 (30) dm tall, the bark obscured by a tomentum, this often resinous-glandular impregnated; leaves 0.6–7 (10) cm long, 0.5–5 (10) mm wide, 1- to 3-nerved, tomentose to glabrate or glabrous, subcylindric to flat, if the latter then commonly plane, linear to narrowly oblong, acute to apiculate apically; heads numerous, in terminal paniculate cymes; involucres (6) 6.5–11.5 (13) mm high, 1.5–7.2 mm wide, the bracts obscurely to definitely ranked, the outer ones sparingly tomentose to glabrous, the inner commonly glabrous, oblong, chartaceous to more or less herbaceous-thickened, obtuse to acute or shortly acuminate apically; corollas yellow or yellow-orange, 6–10.3 (12) mm long; achenes 2.5–5.5 mm long, glabrous or hairy. The *nauseosus* complex in Utah is represented by a diverse assemblage of more or less geographically and ecologically segregated races, which are placed in some 14 varieties. The following arbitrary key will serve to identify most specimens.

1. Shrubs usually 3 dm tall or lower; plants local endemics in Piute, Sanpete, Sevier, Carbon, Emery, Daggett, and Duchesne counties 2
— Shrubs usually more than 3 dm tall, seldom lower, but then of different distribution 4

2(1). Involucres glabrous, 8.5–9.5 mm high; plants of Emery, Carbon, Wasatch and Duchesne counties .... *C. nauseosus* var. *psilocarpus*
— Involucres tomentose or glabrous, 10–12 (13.5) mm high; plants of Sanpete, Sevier, and Piute counties 3

3(2). Involucres glabrous; corollas 7.8–9 mm long; plants local on Arapien shale in Sanpete and Sevier counties .... *C. nauseosus* var. *iridis*
— Involucres tomentose; corollas 10–12 mm high; plants local in Piute County .... *C. nauseosus* var. *glareosus*

4(1). Achenes and ovaries glabrous 5
— Achenes and ovaries pilose 8

5(4). Flowers 5–8 mm long; involucres 7–8.5 (9) mm long, 1.5–3 mm wide (when pressed) .... *C. nauseosus* var. *abbreviata*
— Flowers 8.3–10 mm long; involucres 9–11 mm long, 3.7–7 mm wide (when pressed) 6

6(5). Involucres subcylindric; plants of dunes and deep sands of western Utah and in the Uinta Basin .... *C. nauseosus* var. *turbinatus*
— Involucres tapering to the base; plants of south central and southeastern Utah 7

7(6). Achenes 5–5.5 mm long; plants low, commonly less than 5 dm tall; known from San Juan and Emery counties .... *C. nauseosus* var. *bigelovii*
— Achenes 2.5–4 mm long; plants taller, commonly over 5 dm tall; known from Kane County .... *C. nauseosus* var. *nitidus*

8(4). Involucres over 10 mm long; corollas 9.5–10.5 mm long 9
— Involucres 6.5–8.6 (9.5) mm long (to 11 mm long in var. *junceus*); corollas 5–8.6 (10) mm long 10

9(8). Involucres cylindric, the bracts neither strongly keeled nor ranked; plants of dune areas in western and northeastern Utah .... *C. nauseosus* var. *turbinatus*
— Involucres tapering, clavate, the bracts strongly keeled and aligned; plants of Kane County .... *C. nauseosus* var. *arenarius*

10(8). Leaves 3–5 (10) mm wide; plants of central to north central Utah .... *C. nauseosus* var. *salicifolius*
— Leaves 0.5–3 mm wide; plants of various distribution 11

11(10). Corolla lobes commonly long-pilose (glabrate in age); leaves often deciduous by anthesis; plants of southeastern Utah .... *C. nauseosus* var. *junceus*
— Corolla lobes glabrous; leaves present or absent at anthesis; distribution various 12

12(11). Corolla lobes 0.4–0.9 mm long .... *C. nauseosus* var. *gnaphaloides*
— Corolla lobes 1–2 mm long 13
13(12). Leaves (1) 3- to 5-nerved, commonly 1–3 mm wide .... *C. nauseosus* var. *glabratus*
— Leaves 1-nerved, commonly 0.5–1.5 mm wide 14
14(13). Leaves and/or stems usually grayish or whitish tomentose or green, not especially yellow-green; involucres more or less tomentose .... *C. nauseosus* var. *albicaulis*
— Leaves and/or stems usually yellowish-green, the tomentum commonly resinous-matted; involucres glabrous .... *C. nauseosus* var. *consimilis*

Var. *abbreviatus* (Jones) Welsh comb. nov. [based on: *Bigelovia leiosperma* var. *abbreviata* Jones Proc. Calif. Acad. II, 5: 693. 1895; type from Clear Creek Canyon, Sevier County; *C. nauseosus* var. *leiosperma* (Gray) Hall; *C. nauseosus* ssp. *leiospermus* (Gray) H. & C.; *Bigelovia leiosperma* Gray, type from St. George.] Blackbrush, Grayia, shadscale, black sagebrush, Vanclevea, pinyon-juniper, and ponderosa pine communities at 1070 to 2745 m in Emery, Garfield, Grand, Kane, Millard, Piute, Sevier and Washington counties; Nevada, California; 15 (v). The materials from Emery and Grand counties have leaves that are very slender and subterete. The condition is presumably derived from introgression with var. *bigelovii*.

Var. *albicaulis* (Nutt.) Rydb. [*C. nauseosus* var. *albicaulis* Nutt.]. Saltgrass, sagebrush, pinyon-juniper, and ponderosa pine communities at 1310 to 2290 m in Box Elder, Cache, Carbon, Juab, Kane, Millard, Morgan, Salt Lake, San Juan, Uintah, Utah, Wasatch, and Weber counties; Oregon to Wyoming, south to California, Nevada, and New Mexico; 24 (i). This taxon forms intermediates with var. *glabratus*. In low elevation phases of saline substrates the stems are white-pannose.

Var. *arenarius* (L.C. Anderson) Welsh comb. nov. [based on: *C. nauseosus* ssp. *arenarius* L.C. Anderson Phytologia 38: 311. 1978.]. Sagebrush, juniper, and pinyon-juniper communities at 1675 to 1830 m in Kane County; Arizona; 3 (i). This is a plant of deep sandy alluvium.

Var. *bigelovii* (Gray) Hall [*C. nauseosus* ssp. *bigelovii* (Gray) H. & C.; *Linosyris (Chrysothamnus) bigelovii* Gray]. Grayia and pinyon-juniper communities 1460 to 1950 m in Emery and San Juan (Lavender Mesa) counties; Arizona, Colorado, New Mexico; 2 (i). More collections of this entity are required.

Var. *consimilis* (Greene) Hall [*C. nauseosus* ssp. *consimilis* (Greene) H. & C.; *C. consimilis* Greene]. Saline meadows, riparian zones, and terraces in saltgrass-alkali saccaton, shadscale, sagebrush, rabbitbrush, mountain brush, pinyon-juniper, and ponderosa pine communities at 1280 to 3000 m in all Utah counties except Grand and San Juan; Oregon to Wyoming, south to California, Arizona and New Mexico; 100 (xxv). This is the common narrow-leaved phase with cone-shaped panicles. They occur frequently in saline moist sites, such as the travertine mounds at Monroe Hot Springs.

Var. *glabratus* (Gray) Cronq. [*Bigelovia graveolens* var. *glabrata* Gray; *C. nauseosus* ssp. *graveolens* (Gray) Piper; *C. nauseosus* var. *graveolens* (Gray) Hall]. Desert willow-baccharis, willow-cottonwood, greasewood-tamarix, sagebrush, shadscale, mountain brush, and ponderosa pine communities at 750 to 2475 m in Summit, Wasatch, Utah, Sanpete, Sevier, Piute, Iron, and Washington counties, and in all counties east of those; Idaho to North Dakota, south to Arizona, and New Mexico; 88 (xxiii).

Var. *glareosus* (Jones) Welsh stat. nov. [based on: *Bigelovia glareosa* Jones Zoe 2: 247. 1891, type from Marysvale; *C. nauseosus* ssp. *glareosa* (Jones) H. & C.]. The type specimen is lost, and the ultimate disposition of this taxon is uncertain; it should be sought in the canyon north of Marysvale, on Tertiary igneous substrates; endemic; 0 (0).

Var. *gnaphaloides* (Greene) Hall [*C. speciosus* var. *gnaphaloides* Greene; *C. nauseosus* ssp. *hololeucus* (Gray) H. & C., in part]. Shadscale, pigmy sagebrush, rabbitbrush, sagebrush, and pinyon-juniper communities at 1070 to 2380 m; known in all Utah counties except Box Elder, Daggett, Duchesne, Kane, Morgan, Rich, Summit, and Wayne, and likely in them also; California, Nevada, and Arizona (?); 73 (vii). This taxon is a near ally of ssp. *hololeucus* (Gray) H. & C., and should that taxon be placed within a quadrinomial, then the var. *gnaphaloides* would be placed within it. However, no such combination is implied or proposed herein.

Var. *iridis* (L.C. Anderson) Welsh stat. nov. [based on: *C. nauseosus* ssp. *iridis* L.C. Anderson Great Basin Nat. 41:311. 1981, type from Rainbow Hills, Sevier County]. Rabbitbrush-sagebrush community on an incipient seep in Arapien shale at ca 1980 m in Sevier Co.; endemic; 2 (i).

Var. *junceus* (Greene) Hall [*C. nauseosus* ssp. *junceus* (Greene) H. & C.; *Bigelovia juncea* Greene]. Blackbrush, shadscale, rabbitbrush, matchweed, and pinyon-juniper communities at 1220 to 1800 m in Emery, Garfield, Grand, Kane, San Juan and Wayne counties; Arizona; 18 (iv). The nonglandular, clear straw-colored, long involucres with bracts usually aligned are distinctive of this variety.

Var. *nitidus* (L.C. Anderson) Welsh stat. nov. [based on: *C. nauseosus* ssp. *nitidus* L.C. Anderson Phytologia 38: 313. 1978]. Vanclevea-ephedra community at about 1250 m in Kane County; Arizona; 1 (0). This variety has the general aspect of vars. *bigelovii* and *abbreviata*. It is a taller plant than either, and differs otherwise as set forth in the key.

Var. *psilocarpus* Blake [*C. nauseosus* ssp. *psilocarpus* (Blake) L.C. Anderson]. Sagebrush and salina wildrye communities at 1925 to 2290 m in Carbon, Duchesne, Emery, and Wasatch counties; endemic; 5 (0). These peculiar low shrubs occasionally produce taller intermediates with var. *glabratus* (q.v.)

Var. *salicifolius* (Rydb.) Hall [*C. salicifolius* Rydb., type from Strawberry Valley; *C. nauseosus* ssp. *salicifolius* (Rydb.) H. & C.]. Sagebrush, pinyon-juniper, mountain brush, and aspen communities at 1310 to 2870 m in Box Elder, Carbon, Duchesne, Emery, Juab, Salt Lake, Sanpete, Sevier, Summit, Tooele, Utah, and Wasatch counties; endemic; 19 (iii). This entity forms intermediates with var. *glabratus*, and might represent nothing more than a broad-leaved extension of that taxon.

Var. *turbinatus* (Jones) Blake [*Bigelovia turbinata* Jones, type from Kane County; *C. nauseosus* ssp. *turbinatus* (Jones) H. & C.]. Rabbitbrush, saltbush, ephedra, juniper, and greasewood communities at 1370 to 1710 m in Beaver, Iron, Juab, Kane, Millard, and Uintah counties; Nevada(?); 10 (iii). Both glabrous and pilose achenes occur in this distinctive taxon. It shares the feature of villous corolla lobes with the sand-loving var. *junceus* of the Navajo Basin. The Uintah Basin materials differ in the more keeled and attenuate involucres and flowers that are more exserted from the involucre.

***Chrysothamnus paniculatus* (Gray) Greene** [*Bigelovia paniculata* Gray]. Tall shrubs, the branches subfastigiate, mainly 6–20 dm tall, the bark green, becoming tan to gray in age, resinous-punctate; leaves 0.4–3 cm long, about 0.5 mm wide, linear-filiform, terete, mucronate apically; heads numerous, in usually conic panicles; involucres 4.8–6.5 mm high, 2–3 mm wide, the bracts indistinctly ranked, chartaceous-indurate, scarcely if at all glandular, thickened at midrib, obtuse, glandular; corollas yellow, 5.5–6 mm long; achenes 1.8–3.4 mm long, pilose. Roadsides, stream banks, terraces, and slopes in creosote bush, Joshua tree, and baccharis communities at 670 to 1220 m in Washington County; Nevada, Arizona, California; 9 (iii). The plants begin to flower in October and continue into November.

***Chrysothamnus parryi* (Gray) Greene** Low to moderate shrubs, the branches not especially fastigiate, mainly 2–6 dm tall, the bark pannose-tomentose or the tomentum glandular-resinous; leaves 0.6–6 (8) cm long, 1–2 mm wide, 1- to 3-nerved, green, viscid or sometimes tomentulose, flat, usually plane, linear to narrowly oblong; heads several to many, the inflorescences tending to be elongate and subracemose; involucres 9–14.5 mm high, 4–8 mm wide, the bracts obscurely to definitely ranked, puberulent to glabrous, the outer usually with elongate herbaceous tips, the inner chartaceous, with glandular-thickened midrib, abruptly to gradually acuminate-attenuate or attenuate; corollas yellow or creamy yellow, 8–10 mm long; achenes 3.3–7.5 mm long, pilose. Plants of the *parryi* complex form hybrid derivatives with phases of *C. nauseosus*, and with other named segregates within the complex. Except for varieties *parryi* and *nevadensis*, only arbitrary segregation appears possible. Thus, the conservative treatment as outlined below seems to best reflect the nature of *C. parryi* in Utah.

1. Flowers usually more than 10 per head .... *C. parryi* var. *parryi*
– Flowers commonly 5–9 per head 2
2(1). Involucral bracts mainly 24–28; plants of southwestern Utah .... *C. parryi* var. *nevadensis*
– Involucral bracts mainly 12–22; plants of south central, central, and northeastern Utah .... *C. parryi* var. *attenuatus*

Var. *attenuatus* (Jones) Kittell in Tidestr. & Kittell [*Bigelovia howardii* var. *attenuata* Jones, type from near Marysvale; *C. parryi* ssp. *attenuatus* (Jones) H. & C.; *C. affinis*. A. Nels.; *C. parryi* ssp. *affinis* (A. Nels.) L.C. Anderson; *Linosyris howardii* Parry in Gray; *C. parryi* ssp. *howardii* (Parry) H. & C.; *C. parryi* var. *howardii* (Parry) Kittell in Tidestr. & Kittell]. Meadows, sagebrush, juniper, pinyon-juniper, mountain brush, ponderosa pine, and aspen communities at 1740 to 2930 m in Beaver, Carbon, Daggett, Duchesne, Garfield, Grand, Iron, Kane, Piute, Sanpete, Sevier, Uintah, Utah, Wasatch, and Wayne counties; Wyoming and Nebraska, south to Arizona and New Mexico; 55 (xv). The *howardii* phase differs supposedly in the bracteate leaves overtopping the inflorescence and in the pale colored flowers; both characters fail as diagnostic features.

Var. *nevadensis* (Gray) Kittell in Tidestr. & Kittell [*Linosyris howardii* var. *nevadensis* Gray; *C. parryi* ssp. *nevadensis* (Gray) H. & C.]. Sagebrush, juniper, pinyon-juniper, mountain brush, and ponderosa pine communities at 1830 to 2565 m in Beaver, Iron, Millard, and Washington counties; Arizona; 10 (ii). The var. *nevadensis* differs only in degree from var. *attenuatus*, with which it is contiguous, if not partially sympatric, to the east. Should the two be combined, then the correct name will be var. *nevadensis*, since that name has priority in rank. Plants with leaves overtopping the inflorescence occur; technically they would key to the *howardii* phase of var. *attenuatus*.

Var. *parryi* [*Linosyris parryi* Gray]. Ponderosa pine and spruce-fir communities at 2075 to 2625 m in Beaver, Emery (?), Garfield, Kane, Millard, and Washington counties; Wyoming, Colorado, New Mexico, and Nevada; 9 (ii).

Chrysothamnus pulchellus* (Gray) Greene** Low to moderately tall shrubs, the branches not fastigiate, mainly 5–10 dm tall, the bark white, becoming tan or brown in age, glabrous or puberulent above; leaves 0.4–3 cm long, 1–2 mm wide, linear to narrowly oblanceolate, glabrous or puberulent, flat or revolute, mucronate; heads few to many, in corymbose panicles; involucres 11.5–15 mm high, 4.5–6 mm wide, the bracts distinctly aligned, more or less herbaceous toward the apex, glandular, attenuate to sharply acute; corollas yellow, 9–10 (14) mm long; achenes 3.8–4.5 mm long, sparingly hirsute and glandular. Shadscale, blackbrush, ephedra, pinyon-juniper, and ponderosa pine communities at 1370 to 2350 m in Emery, Wayne, and San Juan counties; Arizona to Kansas, south to Mexico; 4 (i). Our material belongs to var. ***baileyi (Woot. & Standl.) Blake [ssp. *baileyi* (Woot. & Standl.) H. & C.].

***Chrysothamnus vaseyi* (Gray) Greene** [*Bigelovia vaseyi* Gray]. Low shrubs, mainly 1–3 dm tall, the branches not especially fastigiate, the bark green, becoming whitish tan or finally gray in age, puberulent; leaves 0.3–3.7 cm long, 0.8–3 mm wide, linear to oblong or narrowly oblanceolate, glabrous or glandular, flat, plane, mucronate; heads numerous in compact terminal cymes; involucres 6.2–7.5 mm high, 3–6 mm wide, the bracts more or less aligned, commonly herbaceous or thickened near the apex, glandular, obtuse, the margins fimbriate-hyaline; corolla yellow, 4.8–7 mm long; achenes 2.6–4 mm long, glabrous. Meadows, sagebrush, rabbitbrush, juniper, mountain brush, and ponderosa pine communities at 1675 to 2900 m in Beaver, Carbon, Emery, Garfield, Juab, Kane, Iron, Piute, San Juan, Sanpete, Sevier, and Utah counties; Nevada, Wyoming, Colorado, New Mexico; 21 (ii).

Chrysothamnus viscidiflorus **(Hook.) Nutt.** Low to moderate shrubs, mainly 2–10 dm tall, the branches fastigiate or not, the bark green to tan or white, finally gray in age, glabrous or puberulent; leaves 0.3–4.5 (6) cm long, 0.5–4 (10) mm wide, 1- to 5-nerved, linear to oblong, elliptic or oblanceolate, often twisted, mucronate; heads numerous, in compact to open terminal cymes; involucres 5–7.5 mm high, 2–4 mm wide, the bracts not well aligned, commonly herbaceous or thickened near the apex (at least the outer), glandular or puberulent, obtuse, or abruptly acute, the margin narrow, hyaline; corollas yellow, 3.8–6 mm long; achenes 3–4 mm long, pilose. The *viscidiflorus* complex is separable into two groups on the basis of pubescence of upper stems or the lack of pubescence. The segregation is not complete, because pubescence or its absence is not an absolute criterion. There is a cline in the amount of pubescence from abundant to few (or none), and the adoption of a position that one hair equals pubescence and, therefore one part of the complex and not the other, will lead to absurdity. Within the hairy phase of the complex are two more or less distinctive but largely sympatric varieties. The "glabrous" portion of the species is more difficult to separate into its constituent entities. Anderson (Great Basin Nat. 40: 117–20, 1980) reviewed this portion of the complex; concluding that there are three taxa involved, i.e. ssp. *axillaris*, ssp. *viscidiflorus* var. *viscidiflorus*, and ssp. *viscidiflorus* var. *stenophyllus*. Only arbitrary separation of the three is possible, and segregation of the *axillaris* phase is problematical. In my view it is not practical to attempt recognition of more than two taxa, i.e. var. *stenophyllus* (including *axillaris*) and var. *viscidiflorus*. They are all recognized herein at varietal level, but probably would best fit within an expanded ssp. *viscidiflorus* as varieties (a course not intended or implied herein). The following key will allow for identification of most specimens.

1. Stems (at least above) and/or leaves puberulent to hispidulous 2
— Stems and leaves glabrous, or the leaves ciliate, or rarely with a few short hairs on stems or with glandular excrescences in the inflorescence 3
2(1). Leaves 0.5–2 mm wide; stems finely puberulent above .... *C. viscidiflorus* var. *puberulus*
— Leaves 2–5 mm wide; stems hispidulous-puberulent above .... *C. viscidiflorus* var. *lanceolatus*
3(1). Leaves 0.5–1.5 mm wide; plants mainly 2–3 dm tall .... *C. viscidiflorus* var. *stenophyllus*
— Leaves mainly 1–4 mm wide (or more); plants mainly 3–10 dm tall .... C. viscidiflorus var. *viscidiflorus*

Var. *lanceolatus* (Nutt.) Greene [*C. lanceolatus* Nutt.; *C. viscidiflorus* ssp. *lanceolatus* (Nutt.) H. & C.]. Sagebrush, pinyon-juniper, mountain brush, aspen, Douglas fir, lodgepole pine, spruce-fir, and alpine meadow communities at 1375 to 3200 m in all Utah counties except Kane and Washington, and likely there also; British Columbia to South Dakota, and south to California, Nevada, Arizona, and New Mexico; 112 (xii).

Var. *puberulus* (D.C. Eaton) Jepson [*Linosyris viscidiflora* var. puberula D.C. Eaton; *C. viscidiflorus* ssp. *puberulus* (D.C. Eaton) H. & C.]. Rabbitbrush, black sagebrush, shadscale, sagebrush, pinyon-juniper and ponderosa pine communities at 1460 to 2200 m in the western tier of counties, east to Piute, Sevier, Emery, Carbon, Utah, and Salt Lake counties; Oregon and Idaho south to California, Nevada, and Arizona; 44 (vii).

Var. *stenophyllus* (Gray) Hall [*Bigelovia douglasii* var. *stenophylla* Gray; *C. viscidiflorus* ssp. *stenophylla* (Gray) H. & C.; *C. axillaris* Keck; *C. viscidiflorus* ssp. *axillaris* (Keck) L.C. Anderson]. Ephedra, blackbrush, rabbitbrush, sagebrush, galleta, shadscale, and pinyon-juniper communities at 1280 to 2075 m in all Utah counties except Piute, Sevier, Sanpete, Carbon, Duchesne, Wasatch, Utah, Salt Lake, Davis, Weber, Morgan, Summit, and Cache; Oregon to Wyoming and south to California,, Nevada, Arizona, and Colorado; 34 (vii).

Var. ***viscidiflorus*** [*Crinitaria viscidiflora* Hook.; *C. viscidiflorus* var. *pumilus* authors, not (Nutt.) Jeps. (?). Rabbitbrush, shadscale, sagebrush, pinyon-juniper, mountain brush, white fir, ponderosa pine, and aspen communities at 1460 to 2900 m in all or nearly all Utah counties; Washington to Nebraska, south to California, Nevada, Arizona, and Colorado; 100 (xx). The var. *viscidiflorus* forms intermediates with all other taxa in the species, and with *C. greenei* also.

CICHORIUM L.

Perennial herbs, with milky juice, from taproots; leaves alternate, toothed to pinnatifid; heads sessile or subsessile, numerous, borne in clusters at nodes of a spicate, simple, or branched inflorescence; involucral bracts biseriate, the outer shorter; corollas all raylike, perfect; pappus of 2 or 3 series of scales, sometimes minute; achenes angular or somewhat compressed, glabrous.

Cichorium intybus L. Chickory. Plants 3–10 dm tall or more, hirsute or glabrous; lower leaves petiolate, the blades 6–20 cm long, 1–5 (7) cm wide, sinuate-dentate to runcinate-pinnatifid, becoming smaller and sessile upward, some finally subentire; heads large and showy, 1–3 per node of inflorescence; flowers pure blue, rarely white; involucre 9–15 mm high, the outer bracts chartaceous at base, herbaceous apically; achenes 2–3 mm long. Roadsides and disturbed sites at 1340 to 2135 m in Duchesne, Iron, Kane, Salt Lake, Tooele, and Utah counties; widespread in North America; native of Eurasia; 8 (i). The herb *C. endiva* L. is grown in Utah; the extent is not known.

CIRSIUM Mill.

Annual, biennial, or perennial, caulescent or acaulescent, spiny herbs from taproots, with caudices or rhizomes in some, the juice watery; leaves basal and cauline, alternate; heads solitary to several; involucral bracts in several series, subequal to imbricate, some or most of them spine tipped; receptacle densely bristly; corollas all discoid, pink, purple, red, or creamy white, perfect or imperfect; pappus of plumose bristles (or those of the outermost flowers merely barbellate); style with a thickened minutely hairy ring below the nearly connate lobes; achenes glabrous, flattened or 4-angled, 4- to many-nerved. **Note:** This is a particularly complex genus taxonomically, with both introduced and indigenous species. The indigenous members are especially difficult, due in part to hybridization, mainly within species groups. The following treatment is tentative, but represents an attempt to categorize the variation present in Utah plants and to provide a legitimate name for each. Several taxa previously reported from the state are excluded, or they are treated within the constituent taxa. All involucral measurements are in pressed condition!

MOORE, R. J. AND C. FRANKTON. 1963a. Cytotaxonomic notes on some *Cirsium* species of the western United States. Canad. J. Bot. 41: 1553–1567.

______. 1963b. A clarification of *Cirsium foliosum* and *Cirsium drummondii*. Canad. J. Bot. 42: 451–461.

______. 1965. Cytotaxonomy of *Cirsium hookerianum* and related species. Canad. J. Bot. 43: 597–613.

______. 1973. The *Cirsium arizonicum* complex of the southwestern United States. Canad. J. Bot. 52: 543–551.

PETRAK, F. 1917. Die nordamerikanischen Arten der Gattung *Cirsium*. Beih. Bot. Centralbl. (Abt. 2), 35: 223–567.

1. Flowers mainly imperfect; heads unisexual; plants perennial, from rhizomes; introduced weed of consequence .... *C. arvense*

— Flowers perfect; plants biennial or perennial, seldom if ever with rhizomes 2

2(1). Leaves roughly hispid above, green; stems conspicuously winged decurrent; plants biennial, introduced .... *C. vulgare*

— Leaves villous, floccose, arachnoid, tomentose, or glabrous, white to gray or green; stems not winged-decurrent, except in some species; plants indigenous biennials or perennials 3

3(2). Basal rosettes to 10 dm across, the mature leaves commonly 10–30 cm wide, green, glabrate or glabrous on both sides; heads small, with long, tapering, recurved spines; plants of hanging gardens in southeastern Utah, rarely below them .... *C. rydbergii*

— Basal rosettes rarely to 5 dm across, the mature leaves usually less than 8 cm wide, floccose, tomentose, arachnoid, or glabrous on one or both sides; plants seldom of hanging gardens in southeastern Utah 4

4(3). Bracts, at least the innermost, conspicuously dilated (but not lacerate), or definitely tan to silvery in appearance, contrasting with the overall aspect of the bracts; plants commonly of meadows .... *C. scariosum*

— Bracts all spinose, or the innermost occasionally twisted to contorted at the tips, but not especially dilated or conspicuously different in color or texture from the overall aspect of bracts (see *C. centaureae*); plants of various habitats 5

5(4). Involucral bracts (at least the outer) pinnately spinose; plants green, with yellowish spines, of high elevations in the Wasatch, Tushar, and Uinta mountains .... *C. eatonii*

— Involucral bracts not, or rarely, pinnately spinose (except in *C. clavatum*, *C. scopulorum*, and *C. ownbeyi*); plants of low to high elevations, but, if pinnately spinose, of other distribution or of low elevations 6

6(5). Heads 1.8–2.7 cm high, and about as wide; inner bracts with coarsely lacerate margins; plants of lower middle elevation meadows .... *C. centaureae*

— Heads 1.5–3 cm high, 1.5–4.5 (6) cm wide; inner bracts not lacerate; leaves thinly textured, finely to coarsely spined, definitely tomentose or glabrous; plants of various distribution 7

7(6). Herbage definitely white- to gray-tomentose (or rarely green); involucres 1.5–2 cm high, 1.5–2.5 cm wide; known from white shale outcrops in the Uinta Basin .... *C. barnebyi*

— Herbage green, or white- to gray-tomentose; involucres mainly longer and broader, but if not, then of different distribution 8

8(7). Stems definitely winged-decurrent; heads mainly 1.3–2 cm high, 1.2–3.2 cm wide; herbage white- to gray-tomentose; plants of Sanpete and Washington counties 9

— Stems not winged, or if so, the herbage green and glabrous or nearly so, or the heads commonly larger; plants of various distribution 10

9(8). Leaves of upper stem merely spinose-toothed, tapering from base to apex; plants of Washington County only .... *C. virginensis*

— Leaves of upper stem definitely lobed, the lobes spinose-toothed, with parallel sides from base to near apex; plants not of Washington County .... *C. subniveum*

10(8). Herbage glabrous or glabrate, green 11

— Herbage tomentose, floccose-tomentose, gray or white, or only the upper leaf surfaces green 16

11(10). Flowers bright red or carmine; corolla lobes 15–18 mm long; spines of middle involucral bracts 7–11 mm long or more; plants of San Juan County .... *C. rothrockii*

— Flowers pink, pink-purple, or white; corolla lobes less than 15 mm long; spines of middle involucral bracts 1–6 mm long; plants of various distribution 12

12(11). Outer bracts not pinnately spinose; mainly low elevation plants, usually in gypsiferous soils, in the Navajo Basin .... *C. calcareum*

— Outer bracts more or less pinnately spinose; plants of the Navajo and Uinta basins 13

13(12). Stems strongly winged almost or quite the length of upper internodes; main upper leaves tripinnatifid; plants of lower elevations in northern Uintah and Daggett counties .... *C. ownbeyi*

— Stems not winged, or rarely some internodes with incipient wings; main upper leaves pinnatifid to bipinnatifid; plants of moderate to high elevations in the southern end of the Uinta Basin and southward 14

14(13). Involucral bracts ciliate with long yellowish or brownish multicellular hairs; spines of bracts 6–15 mm long or more; plants of the east Tavaputs Plateau and La Sal Mountains .... *C. scopulorum*

— Involucral bracts more or less ciliate with whitish hairs or a tomentum; spines of bracts mainly 3–7 mm long; plants from the Tavaputs Plateau and south westward 15

15(14). Involucral bracts scabrous dorsally, at least the innermost; herbage not at all tomentose; plants of the Henry Mountains .... *C. calcareum*

— Involucral bracts not scabrous dorsally; herbage more or less tomentose; plants not of the Henry Mountains .... *C. clavatum*

16(11). Heads campanulate, mainly 3.5–6.5 cm wide at anthesis, or, if narrower, bracts commonly glandular-thickened dorsally 17

— Heads turbinate to subcylindric, mainly 2–3.5 cm wide at anthesis; involucral bracts seldom glandular-thickened dorsally 18

17(16). Involucral bracts appearing brown to gray-brown, the spines arising from the body of the bract, not from spreading long-attenuate herbaceous terminal portions; bracts of inflorescence usually prominent; plants of broad distribution .... *C. undulatum*

— Involucral bracts appearing green or fresh green or at least herbaceous, the spines arising from the apex of spreading long-attenuate terminal portions; bracts of inflorescence much reduced; plants of various distribution .... *C. neomexicanum*

18(16). Corollas bright red or carmine; plants from Garfield and Iron counties southward .... *C. arizonicum*

— Corollas pale pink, pink, rose-purple, or white; plants from Garfield and Iron counties northward 19

19(18). Involucral bracts (at least the inner) tapering, wedge-shaped, definitely scabrous roughened on dorsal surface, often suffused with red or purple .... *C. calcareum*

— Involucral bracts smooth dorsally, seldom only somewhat scabrous, not conspicuously tapering, and seldom conspicuously suffused with red or purple .... *C. wheeleri*

Cirsium arizonicum **(Gray) Petrak** Arizona Thistle. [*Cnicus arizonicus* Gray]. Biennial or short-lived perennial herbs from a taproot, the caudex sometimes developed; leaves of basal rosettes 7–36 cm long, bipinnately lobed or parted, the lobes again lobed or toothed, the main spines 1–6 mm long, white to grayish tomentose below, more or less tomentose and greenish to green above; stems 4–7.5 dm tall, more or less floccose-tomentose; cauline leaves 3–35 cm long, 1–8 cm wide, with lobing and vesture similar to the basal, reduced and less deeply lobed upward; involucres 22–30 mm high, 20–50 mm wide, subcylindric to turbinate, the bracts tomentose at margins, and over back, smooth and often shiny medially, rarely glandular-thickened, the apical portions, especially of the inner definitely scabrous; spines yellowish, 3–10 (15) mm long; corollas crimson to carmine, 25–34 mm long, the tube 8–13 mm long, throat 1.5–11 mm long, the lobes 10–19 mm long. Two more or less distinctive but intergrading phases are present.

1. Heads subcylindric to turbinate; spines 3–10 mm long; plants mainly of the Colorado drainage system (also in western Garfield, and in Iron counties) .... *C. arizonicum* var. *arizonicum*

— Heads turbinate to broadly so; spines 3–15 mm long or more; plants mainly of the Great Basin and Virgin drainages (also in eastern Iron and western Garfield counties) .... *C. arizonicum* var. *nidulum*

Var. *arizonicum* Salt desert shrub, pinyon-juniper, ponderosa pine, spruce-fir, and hanging garden communities at 1220 to 3050 m in Garfield, Iron, Kane, Piute, San Juan, and Washington counties; Arizona; 26 (iv).

Var. *nidulum* **(Jones) Welsh comb. nov.** [based on: *Cnicus nidulus* Jones Proc. Calif. Acad. II. 5: 705. 1895]. Pinyon-juniper, mountain brush, aspen, ponderosa pine, Douglas fir, white fir, and spruce-fir communities at 1890 to 3200 m in Beaver, Garfield, Iron, Kane, San Juan and Washington counties; Arizona, Nevada; 37 (iii). Relationships apparently lie with *C. rothrockii, C. calcareum*, and, to a lesser extent, with *C. wheeleri*.

Cirsium arvense **(L.) Scop.** Creeping or Canada Thistle. [*Serratula arvensis* L.]. Perennial rhizomatous herbs, the stems mostly 5–10 dm tall, glabrous or sparingly tomentose; leaves 3–15 cm long, 1–6 cm broad, deeply pinnatifid or lobed to merely toothed, glabrous to tomentose above and beneath; heads several to many, mainly unisexual; involucres 10–20 (25) mm high, 10–25 mm wide, the bracts lance-ovate, at least the outer ones and often all of them spine tipped, tomentose to glabrous; corollas pink-purple to white; pappus of pistillate heads longer than the corollas, that of staminate heads shorter than the corollas; achenes 3–5 mm long. Roadsides, fields, and other disturbed sites, but also invading native plant communities, at 1280 to 2535 m, probably in all Utah counties; widespread in North America; adventive from Eurasia; 42 (iii). We have two phases of creeping thistle in Utah; the one with merely toothed (unlobed) leaves is var. ***mite*** Wimm. & Grab., and the common one with deeply lobed leaves is var. ***horridum*** Wimm. & Grab. This common weed and the bull thistle are our only two introduced thistles in the genus *Cirsium*, which makes up a huge assemblage in the Old World. We can expect more introductions.

Cirsium barnebyi **Welsh & Neese in Welsh** Barneby Thistle. Perennial herbs from a caudex and taproot, the caudex clothed with black marcescent leaf bases; leaves of basal rosettes 11–25 cm long, bipinnately lobed or parted, the lobes again lobed or toothed, the main spines 3–5 mm long, whitish- to grayish tomentose on both sides; stems 3–5 dm tall, whitish tomentose (rarely green); cauline leaves 2–30 cm long, 1–8 cm wide, with lobing and vesture similar to the basal, reduced and less deeply lobed upwards; involucres 15–22 mm high, 20–30 mm wide, turbinate, the bracts glabrate or sparingly arachnoid on margins, glutinous dorsal ridge inconspicuous, smooth medially, the apical portions of the inner often contorted, not scabrous dorsally; spines 2–7 mm long, flattened apically, more or less spreading; corollas bluish pink. Sagebrush, juniper, cryptantha, ephedra, wildrye, and rabbitbrush communities at 1525 to 2257 m in Uintah County; endemic; 7 (iii). The Barneby thistle is apparently related to the *undulatum* complex.

Cirsium calcareum **(Jones) Woot. & Standl.** Cainville Thistle. [*Cnicus calcareus* Jones, type from Cainville]. Perennial herbs from a caudex and taproot, the caudex with brownish black to castaneous marcescent leaf bases; leaves of basal rosettes 6–35 cm long, pinnatifid to bipinnatifid, glabrous and green or tomentose on one or both surfaces, the main spines 3–8 mm long; stems mainly 2–5 dm tall, glabrous or more or less floccose-tomentose, winged-decurrent or not; cauline leaves 3–28 cm long, 0.8–7 cm wide, bipinnatifid, with lobing and vesture like the basal, reduced upward, the main spines 3–8 mm long; involucres 19–34 mm long, 15–45 mm wide, the bracts ovate-lanceolate to linear, more or less tomentose at the margins, smooth and often shiny medially, the dorsal ridge glandular-thickened or not, the apical portions of at least the inner scabrous; spines straw colored, 1.5–6 mm long; corollas pink to blue-pink. The *calcareum* complex is a portion of the *arizonicum* group of thistles, and has long been misinterpreted. There are three more or less confluent varieties present in Utah. Specimens collected are few, especially in the critical southeastern portion of the state. More work is indicated.

1. Herbage permanently tomentose, the leaves grayish tomentose beneath .... *C. calcareum* var. *pulchellum*
— Herbage green, the leaves rarely sparingly tomentose along the midveins beneath 2
2(1). Leaves definitely decurrent, the stems winged 2–6 cm below leaf base; plants of San Juan and Wayne counties .... *C. calcareum* var. *calcareum*
— Leaves not or scarcely decurrent; plants of other distribution .... *C. calcareum* var. *bipinnatum*

Var. *bipinnatum* (Eastw.) Welsh stat. nov. [based on: *Cnicus drummondii* var. *bipinnatum* Eastw. Zoe 4: 8. 1893]. Aspen, Douglas fir, and riparian communities at 1130 to 3150 m in Garfield, Kane, and San Juan counties; Colorado, New Mexico, and Arizona; 8 (i).

Var. *calcareum* [*Cirsium pulchellum* var. *glabrescens* Petrak type from Elk Mountains, San Juan County]. Riparian communities at 1460 to 2200 m in Carbon, San Juan, and Wayne counties; endemic (?); 4 (i). Jones (Proc. Calif. Acad. II., 5: 704. 1895) cited two collections with the protologue; i.e., Jones 5695bh from Bromide Pass in the Henry Mountains and Jones 5696 from Cainville. His description best fits the Cainville materials, and that collection is here selected as lectotype. The material from Bromide Pass seems best to fit var. *bipinnatum* (q.v.). A peculiar plant with thin leaves that are glabrous on both sides and subentire is known from Cedar Canyon (Atwood and Higgins 5918 BRY). How it fits into the scheme of Utah thistles is not known, but the plant appears to be intermediate between this and some other thistles. The status of the Cainville thistle, as strictly interpreted, beyond Utah is unknown; it seems likely that it does not occur outside the state.

Var. *pulchellum* (Greene) Welsh comb. nov. (based on: *Carduus pulchellus* Greene ex Rydb. Fl. Colorado 400, 401. 1906). Rabbitbrush, sagebrush, tamarix, rabbitbrush, pinyon-juniper, and aspen communities at 1340 to 2745 m in Carbon, Emery, Garfield, Grand, Kane, San Juan, Uintah, Utah, and Wayne counties; Colorado, New Mexico, Arizona; 41 (vii). Both winged and wingless stems are present within our material. There are plants from the San Rafael Swell with winged stems and they are similar to *C. ochrocentrum* Gray of New Mexico, but they appear to be transitional in every way with the wingless plants. And it seems probable that they are not conspecific with that plant as it occurs beyond Utah. Possibly they do warrant taxonomic recognition. Further collections are necessary.

Cirsium centaureae (Rydb.) K. Schum. [*Carduus centaureae* Rydb.]. Fringed Thistle. Perennial herbs from a simple caudex and taproot, the caudex with chestnut leaf bases; leaves of basal rosette 2–28 cm long, 1–8 cm wide, pinnatifid, the lobes often again toothed, tomentose below, thinly tomentose to glabrous above, the main spines 1–5 mm long; stems 3–12 dm tall, not succulent, arachnoid or glabrous; cauline leaves with lobing and vesture like the basal, the spines 3–8 mm long; involucres 18–27 mm high, and about as wide, the outer bracts lance-ovate, the inner with coarsely lacerate margins, usually dilated in the upper half, tomentose to glabrous on the margins, the dorsal ridge not well developed, the longest spines 2–5 mm long, straw colored; flowers white to pink or purple. Montane communities at 3355 m in San Juan Co.; Wyoming and Colorado; 2 (0).

Cirsium clavatum **(Jones) Petrak** Fish Lake Thistle. [*Cnicus clavatus* Jones, type from Fish Lake]. Perennial or biennial herbs from a taproot, and often with a caudex, the caudex clothed with marcescent chestnut-brown leaf bases; leaves of basal rosettes 2.5–22 cm long, bipinnately parted to merely toothed, green on both sides or more or less tomentose below, the main spines 1–6 mm long; stems 3–10 dm tall, glabrous or thinly tomentose; cauline leaves 3–26 cm long, 0.5–7 cm wide, with lobing and vesture like the basal, reduced and less lobed above; involucres 18–23 (32) mm high, 22–30 (55) mm wide, the bracts more or less villous-tomentose on margins, the outer ones usually pinnately spiny, smooth medially, the dorsal ridge not especially glandular, apical portions of the inner ones often scabrous, sometimes slightly dilated-erose; spines yellowish, 3–8 (18) mm long; corollas white or less commonly pink. Sagebrush, meadow, aspen, Douglas fir, and spruce-fir communities at 2135 to 3200 m in Beaver, Carbon, Emery, Garfield, Grand, Kane, Piute, Sanpete, Sevier, Uintah, and Wayne counties; endemic; 27 (viii). The Fish Lake thistle is apparently related to the allopatric *C. eatonii.* It is more or less transitional to *C. wheeleri*, and probably other taxa, especially those with scabrous inner bracts. Rarely some have decurrent leaf bases, and when the pinnately spinose bracts are poorly developed, this thistle approaches *C. calcareum.* Moore and Frankton (1965) proposed that *C. clavatum* was a hybrid between *C. eatonii* and *C. centaureae.* However, despite its possible origin from hybridization, the taxon seems to be organized on about the same basis as other thistles. Further, its distribution is distinct from that of the putative parents. There does not seem to be justification for recognition of this entity as a hybrid.

Cirsium eatonii **(Gray) Robins.** Eaton Thistle. [*Carduus eatonii* Gray]. Perennial herbs from a simple or rarely branched caudex and taproot, the caudex clothed with brownish black to brown marcescent leaf bases; leaves of basal rosette 4–20 cm long, more or less bipinnatifid, green and glabrous or nearly so on both sides, the main spines 1.5–4 mm long; stems 1.5–5 dm tall, glabrous or nearly so; cauline leaves 3–25 cm long, 0.6–5.5 cm wide, with lobing like the basal, reduced upward; involucres 20–37 mm high, 25–50 mm wide, the bracts ovate-lanceolate to lance-linear, tomentose to long-villous marginally (rarely overall), the outer ones usually pinnately spiny, smooth to roughened medially, the dorsal ridge not developed, the apical portions of the inner ones sometimes contorted; spines 5–18 mm long, straw colored; corollas pink to white. Three more or less distinctive varieties are present.

1. Involucral bracts copiously gray- to brown-villous with multicellular hairs; corollas ocroleucous; plants of the Uinta Mountains from Lake Fork eastward .... *C. eatonii* var. *murdockii*

— Involucral bracts merely white-tomentose or rarely with short multicellular hairs; corollas mainly pink or rose; plants of western Uinta Mountains, and elsewhere 2

2(1). Involucral bracts commonly suffused with dark purple; involucres not obscured by outer spinose bracts; plants of the Tushar Mountains .... *C. eatonii* var. *harrisonii*

— Involucral bracts green or variously purplish; involucres with copious pinnate spines, mainly obscuring the surface of inner bractlets; plants of western Uinta and Wasatch mountains, and Great Basin ranges .... *C. eatonii* var. *eatonii*

Var. ***eatonii*** [*C. eriocephalum* var. *leiocephalum* D.C. Eaton; this is the basionym for *C. eatonii* in a strict sense, which was renamed by Gray in honor of D.C. Eaton who collected with Sereno Watson in 1869]. The lectotype came from the head of the Bear River, in Summit County (Watson 691, 1869 US!), with syntypical material being taken under the same number in Cottonwood Canyon (now Salt Lake County). Lodgepole pine and spruce communities upwards into alpine tundra at 2375 to 3420 m in Duchesne, Juab, Salt Lake, Summit, Tooele, and Weber counties; Nevada and Colorado; 31 (iv). Specimens from the Deep Creek Mountains have few lateral spines on the outer bracts, and approach *C. clavatum* in technical features. More material is needed to determine their status and relationships.

Var. ***harrisonii*** Welsh Talus slopes and alpine meadows at 2975 to 3450 m in Beaver and Piute counties; endemic; 6 (v). This low phase of the Eaton thistle stands geographically apart from the remainder of the species, isolated on the islandlike Tushar Mountains.

Var. ***murdockii*** Welsh The plants grow in talus slopes and on rock stripes at 3230 to 3660 m in Daggett, Duchesne, and Uintah counties; endemic; 7 (iii). This variety has been regarded as constituting a portion of *C. tweedyi* (Rydb.) Petrak. That entity was reviewed by Moore and Frankton (1965) and was mapped to include northeastern Utah in its range. However, no specimens were cited from Utah. I have seen the type of that taxon, and other material within its range in northwestern Wyoming, and they differ in pubescence of involucral bracts being merely white tomentose along the margins.

Cirsium neomexicanum Gray Biennial herbs from taproots; leaves of basal rosette 5–25 cm long (or more), pinnatifid, the lobes again toothed or lobed, white tomentose below and less so above, the main spines 1–6 mm long; stems 6–15 dm tall, whitish tomentose; cauline leaves 1.5–35 cm long, 0.5–7 cm wide, tomentose, appearing filmy greenish white, lobed like the basal ones, rather abruptly reduced upward, finally minute spiny bracts; involucres 20–30 mm high, 40–65 mm wide, the bracts green or greenish, narrowly lanceolate, tomentose marginally (or overall), the outer ones often reflexed, the inner minutely serrulate-ciliate, long-attenuate apically, the spine a continuation of the attenuation, smooth medially, the glandular dorsal ridge more or less well developed, the apical portions of the inner often contorted; spines 1–9 mm long, yellowish; corollas creamy white.

1. Involucral bracts green throughout, the attenuate apex not differing in texture from the body of the bract .... *C. neomexicanum* var. *neomexicanum*
— Involucral bracts not green throughout, the attenuate apex differing in texture from the body of the bract .... *C. neomexicanum* var. *utahense*

Var. ***neomexicanum*** Creosote bush, Joshua tree, blackbrush, shadscale, sagebrush, and pinyon-juniper communities at 915 to 2050 m in Beaver, Garfield, Grand, Juab, Kane, Millard, San Juan, Tooele, and Washington counties; Nevada, Arizona, New Mexico; 26 (vii). This is one of the most distinctive species of thistle in Utah. The tall slender stems, with one or few large heads with creamy white flowers, stand in candelabra form in the arid portions of western and southern Utah. Ghostlike stalks of previous years persist for a time, reminding one of the regime which allowed their growth.

Var. ***utahense*** (Petrak) Welsh comb. nov. [based on: *C. utahense* Petrak Beih. Bot. Centr. 35(2): 470. 1917.] Salt desert shrub, sagebrush, pinyon-juniper, and mountain brush communities at 1220 to 2300 m in Cache, Carbon, Emery, Millard, Rich, Salt Lake, Tooele, and Utah counties; Colorado (?); 24 (ii). This taxon has long been confused with *C. undulatum* with which it shares the grayish tomentum, large heads, and tall stature. They have been separated previously on the basis of glandular development of the dorsal ridge; a feature which is, unfortunately, not diagnostic. The long-attenuate bract apices from which the spines arise are apparently distinctive for this taxon. It is essentially intermediate between *undulatum* and *neomexicanum* in a strict sense. The type is from Silver Reef, Washington County, but the main area of distribution for this variety is apparently along the Wasatch Mountains in northern Utah.

Cirsium ownbeyi Welsh Ownbey Thistle. Perennial herbs from caudex and taproot, the caudex with marcescent dark brown leaf bases; leaves of basal rosettes 5–13 cm long, 1.5–3 cm wide, tripinnatifid, green on both sides, sparingly tomentose along lower side of midrib; cauline leaves with vesture and lobing like the basal; stems 5–7 dm tall, winged-decurrent, sparingly tomentose; involucres 1.8–2.5 cm high, 1.5–2.5 cm wide, the outermost bracts more or less pinnately spinose, lance-attenuate, smooth medially, the dorsal ridge not well developed, not scabrous, sparingly tomentose along margins, the inner more or less contorted apically; spines 3–8 mm long; corollas rose-pink. Juniper, sagebrush, and riparian communities at 1678 to 1891 m in Daggett and Uintah counties; endemic; 2 (i). Relationships of the Ownbey thistle apparently lie with *C. eatonii.*

Cirsium rothrockii **(Gray) Petrak** Rothrock Thistle. [*Cnicus rothrockii* Gray; *Cnicus rothrockii* var. *diffusus* Eastw., type from Willow Creek, San Juan County]. Perennial or biennial herbs from a caudex and taproot, the stems 5–8 dm tall, sparingly tomentose or glabrate to glabrous; cauline leaves 3.5–30 cm long, 2–9 cm wide, bipinnatifid, green and glabrous or nearly so on both sides, carried well to the inflorescence; involucres (19) 23–28 (34) mm long, 20–35 mm wide, the bracts lanceolate to lance-linear, more or less tomentose along the margins, smooth medially, the dorsal ridge not or only somewhat glandular, sometimes purplish apically, the apical portions of the inner definitely scabrous, the spines 7–17 mm long; corollas red to carmine. Mixed shrubs and ponderosa pine woods at 1830 to 2560 m in San Juan County; Arizona; 3 (0). This entity is poorly known in Utah; its relationship is with both *C. calcareum* and *C. arizonicum.* It is a green subglabrous plant with red flowers and long involucral spines.

Cirsium rydbergii **Petrak** Rydberg Thistle. [*Cirsium lactucinum* Rydb., type from Bluff]. Perennial herbs from a definite caudex and taproot, the caudex clothed with blackish brown leaf bases; leaves of basal rosette mainly 30–90 cm long, 15–40 cm wide, bipinnatifid, the lobes narrow to very broad, glabrous to glabrate on both surfaces, the main spines 2–11 mm long; stems 6–12 dm tall or more, glabrous; cauline leaves glabrous, less lobed and much reduced upwards; involucres 10–17 mm high (not measuring the reflexed outer bracts), 13–26 mm wide, the outer bracts lance-ovate, rather abruptly contracted into recurved spines 3–25 mm long, sparingly tomentose marginally; dorsal glandular ridge lacking, the inner attenuate, not scabrous; flowers pink. Hanging gardens, or rarely in canyons below them, at 1125 to 1525 m in Grand, Kane, San Juan, Wayne (and probably in Garfield) counties; Arizona (?).; 15 (v). Both *C. rydbergii* Petrak and *C. lactucinum* Rydberg are based on the same type collection from the hanging gardens near Bluff. The Rydberg thistle is a plant with huge basal rosettes, tall slender flowering stems, and small heads.

Cirsium scariosum **Nutt.** Meadow Thistle. [*Carduus lacerus* Rydb., type from near Midway; *Carduus olivescens* Rydb., type from the Aquarius Plateau; *Cirsium acaule* var. *americanum* Gray; *Cnicus drummondii* var. *acaulescens* Gray; *C. foliosum* authors, not T. & G.; *C. drummondii* authors, not T. & G.]. Perennial herbs from a simple caudex and taproot, the caudex with chestnut leaf bases; leaves of basal rosette 2–28 cm long, 1–8 cm wide, merely spiny toothed to bipinnatifid, the lobes often again toothed, tomentose to glabrate below, thinly tomentose to glabrous above, the main spines 1–5 mm long; stems lacking, or 1–12 dm tall or more, often succulent and edible, arachnoid to glabrous; cauline leaves (when stems present) bipinnatifid or merely pinnatifid, the spines 3–35 mm long, with vesture like the basal; involucre 22–35 mm high, 20–65 mm wide, the outer bracts lance-ovate, the inner progressively more lance-attenuate, smooth medially, the margins smooth to minutely scabrous, tomentose to glabrous on margins, the dorsal ridge not well developed, the longest spines mainly 2–5 mm long, straw colored, the inner with tips more or less contorted, dilated, or fimbriate, usually whitish or silvery; flowers white to pink or pink-purple. Our specimens fall into two rather distinctive varieties.

1. Heads 25–35 mm high, 35–80 mm wide; inner bracts slender, sometimes contorted, not especially dilated; plants mainly 6–12 dm tall .... *C. scariosum* var. *thorneae*

— Heads 22–30 mm high, 20–40 mm wide; inner bracts often dilated or contorted, sometimes fimbriate; plants 0–6 dm tall .... *C. scariosum* var. *scariosum*

Var. *scariosum* [*Cirsium acaule* var. *americanum* Gray]. This taxon, as here interpreted, consists of an amazingly diverse assemblage that has passed under a series of names including those cited above; and, if it is demonstrated that *C. foliosum* (Hook.) DC. is actually conspecific, that name has priority. Saline seeps and salt marshes, stream sides, terraces, and other meadowlands at 1310 to 3175 m in Carbon, Duchesne, Emery, Garfield, Juab, Millard, Salt Lake, Sanpete, Sevier, Summit, Tooele, and Utah counties; British Columbia to Montana, south to California, Arizona, and Colorado; 43 (x). This phase of *C. scariosum* has passed under the names *C. acaulescens* (Gray) Schum., *C. coloradoense* (Rydb.) Cockerell; *C. tioganum* (Congdon) Petrak, *C. drummondii* T. & G., and *C. foliosum*. Nomenclature is still unclear, and more work is indicated. Our highly variable material is transitional from acaulescent to caulescent within populations, with stems, when present, fleshy and edible. This is our common thistle of meadowlands, and it is unfortunate that nomenclatural entanglements have not allowed selection of an unequivocal name. Reported for the state is *C. parryi* (Harrington, Flora of Colorado, 1952), but I have seen no specimens of that entity from Utah. It would key to *C. scariosum* in the present work. It has densely arachnoid involucral bracts, with at least the innermost dilated-fringed at the tips; flowers are greenish yellow and the leaves are glabrate on both surfaces.

Var. *thorneae* Welsh Stream terraces and seeps or springs at 1650 to 2475 m in Beaver, Garfield, Iron, Kane, Millard, and Piute counties; endemic (?); 10 (vi). In addition to the features noted above, the cauline leaves are thick, with coarse veins, and spines 8–35 mm long.

Cirsium scopulorum **(Greene) Cockerell in Daniels** [*Carduus scopulorum* Greene]. Perennial herbs from taproots; leaves of basal rosettes 3–28 cm long, 0.8–8 cm wide, with spines 2–6 mm long, unlobed to bipinnatifid, tomentose below, glabrate to glabrous and green above; stems mainly 3–7 dm tall, sparingly arachnoid, not winged-decurrent; cauline leaves mainly bipinnatifid, or the upper ones merely pinnatifid, green above, glabrous to sparingly tomentose below, rather gradually reduced upward; heads in a compact subglobose terminal cluster; involucres 30–35 mm high, 30–55 mm wide, the bracts lance-attenuate, abundantly villous marginally, with long yellowish to brownish multicellular hairs, the outer ones usually pinnately spiny, the dorsal crest not glandular, smooth medially, the apical portions of the inner ones often contorted; spines 10–18 mm long, yellowish; corollas pale yellow to cream. Sagebrush, aspen, and spruce-fir communities at 2135 to 3000 m in Grand, San Juan (?), and Uintah counties; Colorado; 3 (0).

Cirsium subniveum **Rydb.** Perennial herbs from taproots; basal rosettes not seen; stems mainly 6–10 (13) dm tall, tomentose, winged-decurrent; cauline leaves 3–25 cm long or more, 1–6 cm wide, pinnatifid, tomentose on both sides, or less so above, the bases decurrent; involucres 17–25 mm high, 20–30 mm wide, the bracts ovate-lanceolate, smooth medially, the glandular dorsal ridge more or less developed, none scabrous, tomentose marginally; spines 3–5 mm long; corollas apparently white to cream. Pinyon-juniper community at 1890 m in Rich and Sanpete counties; Oregon to Montana; 2 (0).

Cirsium undulatum **(Nutt.) Spreng.** Gray Thistle. [*Carduus undulatus* Nutt.]. Perennial herbs from a simple caudex and taproot, the caudex more or less clothed with persistent leaf bases; leaves of basal rosette mainly 7–25 cm long, 1.5–6 cm wide, merely toothed to bipinnatifid, tomentose on both sides, white-tomentose below, white to greenish above, the main spines 1–6 mm long; stems 2–10 (12) dm tall, tomentose; cauline leaves bipinnatifid or the upper ones merely pinnatifid, with vesture as in the basal ones, rather gradually reduced upward; involucres (15) 20–30 mm high, 20–60 mm wide, the bracts brown or brownish, lance-ovate to lanceolate, tomentose on margins or overall, the dorsal ridge strongly glutinous to undeveloped, the spinose tips spreading, with yellowish spines mainly 2–5 (10) mm long, smooth medially, the apical portion of the innermost more or less contorted; corollas pink, pink-purple, or creamy white.

1. Heads mainly less than 2.5 cm wide, even the largest, commonly (1) 3–10 or more per stem .... *C. undulatum* var. *tracyi*
— Heads mainly more than 2.5 cm wide, at least the largest, commonly 1–3 per stem .... *C. undulatum* var. *undulatum*

Var. *tracyi* (Rydb.) Welsh comb. nov. [based on: *Carduus tracyi* Rydb. Bull Torrey Bot. Club. 32: 133. 1905]. Sagebrush, mountain brush, juniper, aspen, and Douglas fir communities at 1525 to 2900 m in Duchesne, Emery, Grand, Juab, Summit, and Uintah counties; Colorado; 26 (iii). This variety grades with the type variety, and separation is at least partially arbitrary.

Var. *undulatum* Desert shrub, sagebrush, pinyon-juniper, mountain brush, ponderosa pine, and aspen communities at 1400 to 2600 m in Cache, Carbon, Daggett, Duchesne, Emery, Garfield, Juab, Grand, Rich, San Juan, Salt Lake, Sanpete, Sevier, Summit, Tooele, Uintah, Utah, Wasatch, and Weber counties; British Columbia to Minnesota, south to Arizona, New Mexico, and Missouri; 59 (vi).

***Cirsium virginensis* Welsh** Virgin Thistle. Perennial(?) herbs from taproots; leaves of basal rosettes 6–35 cm long, 1–5 cm wide, unlobed, pubescent like the cauline ones, with spines 1–4 mm long; stems 6–15 dm tall, tomentose, winged by definitely decurrent leaf bases; cauline leaves 1.5–15 cm long or more, sinuate-dentate to pinnatifid, whitish tomentose on both sides, or greenish above, often reduced to spiny bracts upwards; involucres 13–20 mm tall, 12–32 mm wide, the bracts ovate-lanceolate to narrowly lanceolate, brownish to straw colored, or often suffused with purple, tomentose marginally (or overall), the outer not especially reflexed, the inner serrulate or entire, smooth medially, the glandular dorsal ridge more or less developed, the apical portions of the inner often contorted; spines 2–6 (8) mm long, yellowish; corollas pink to lavender (or white?). Saline seeps and stream terraces at 850 to 950 m in Washington Co.; Arizona; 9 (i). The small heads and long decurrent leaf bases are diagnostic. The relationships of the Virgin thistle are unknown. It does not appear to be closely related to other species groups represented in our area.

***Cirsium vulgare* (Savi) Ten.** Bull Thistle. [*Carduus vulgaris* Savi]. Biennial herbs from taproots; leaves of basal rosette mainly 5–25 cm long, 2–8 cm wide, merely doubly serrate-dentate to doubly pinnatifid, tomentose beneath, coarsely hispid above; stems mainly 3–12 (15) dm tall, spiny-winged by decurrent leaf bases; cauline leaves mainly bipinnatifid, with vesture as in the basal ones; involucres 28–40 mm high, 35–70 mm wide, the bracts narrowly lanceolate, with spreading spine-tips, tomentose marginally, the dorsal ridge not developed, the inner sometimes contorted apically; spines 1–4 mm long, yellowish; corollas rose-purple. Meadows, fields, roadsides, and other disturbed sites from 1340 to 2745 m in most, if not all, Utah counties; widespread in North America; 52 (i).

***Cirsium wheeleri* (Gray) Petrak** Wheeler Thistle. [*Cnicus wheeleri* Gray]. Perennial or biennial herbs from a simple or branched caudex and taproot, the caudex clothed with persistent brown to dark brown leaf bases; leaves of basal rosettes mainly 7–20 cm long, 1–5 cm wide, once to twice pinnatifid, or merely toothed or spinose-serrate, grayish or whitish tomentose below, thinly so to glabrous and green above, the main spines 0.5–4 mm long; stems 2.5–7 dm tall; cauline leaves 2–25 (32) cm long, 0.5–5 (7) cm wide, with lobing and vesture similar to the basal, carried well to the inflorescence, though reduced above; involucres 20–27 mm high, 20–35 mm wide, the bracts lance-ovate to lance-linear, more or less tomentose along the margins, smooth medially, the dorsal ridge not or only somewhat glandular, sometimes purplish tipped, the apical portions of at least the inner more or less scabrous; corollas pink to pink-purple, or less commonly white. Mountain brush, pinyon-juniper, white fir, aspen, and spruce-fir communities at (1980) 2165 to 3150 m in Beaver, Emery, Garfield, Iron, Juab, Kane, Millard, San Juan, Sanpete, and Sevier counties; Colorado, New Mexico, and Arizona. Our materials apparently intergrade with *C. undulatum*, *C. nidulum*, and possibly *C. scariosum*. The moderate sized heads, usually pink or pink-purple flowers, low stature, essentially nonglandular bracts, and usually green upper leaf surface appears to be diagnostic. The phases from Cedar Canyon (Iron County), with merely spinose unlobed leaves, are striking, but probably not more than minor variants; 39 (iv).

CNICUS L.

Annual caulescent spiny herbs from taproots, the juice watery; leaves alternate; heads solitary, terminating branches; involucral bracts in several series, spine tipped, the inner ones pinnately spiny; receptacle densely bristly; corollas all discoid, yellow, perfect; pappus in 2 series, the outer smooth, long, alternating with short sparingly pectinate ones; style with a ring of hairs at base of divergent branches; achenes terete, strongly ribbed, glabrous.

Cnicus benedictus L. Blessed Thistle. Plants 1–5 dm tall or more, branching from near the base; stems villous; leaves mainly 8–15 cm long, pinnatifid, more or less glandular and sparingly villous, the spines 0.5–1.5 mm long, the lower ones petiolate, becoming sessile above; involucres 3–4 cm high, closely subtended and obscured by the foliose bracteate upper leaves; corollas yellow. Waste places and gardens at 885 m in Washington County; widespread in the U.S.; adventive from Europe; 1 (0).

CONYZA Less. Nom. Cons.

Annual herbs from taproots, with watery juice; stems erect, commonly branched; leaves alternate, simple; heads numerous, in cylindric to conic panicles; involucral bracts more or less imbricate, herbaceous medially; receptacle flat or nearly so, naked; rays minute, white or purplish, scarcely surpassing the pappus; disk flowers seldom more than 20, perfect, fertile; pappus of capillary bristles; achenes 1- or 2-nerved or nerveless.

Conyza canadensis (L.) Cronq. Horseweed. [*Erigeron canadensis* L.]. Annuals, mainly 0.5–10 dm tall, glabrous or spreading-hairy; leaves 2–8 (10) cm long, 2–8 cm wide, linear to oblanceolate, ciliate-serrate, often deciduous by late anthesis; heads numerous, inconspicuous; involucres 2–3.5 (4) mm high, (2.5) 3–7 mm wide, the bracts lance-subulate, the midvein glandular-thickened, herbaceous medially, glabrous or strigose; rays white or purplish. Weedy species, often in riparian or other moist disturbed sites at 850 to 2135 m in all (?) Utah counties; widespread in North America; Europe; 30 (vi). Our material belongs to var. ***glabrata*** (Gray) Cronq.

CREPIS L.

Annual, biennial, or perennial caulescent or subacaulescent herbs, from taproots, with milky juice; leaves basal and cauline, alternate, pinnatifid to toothed or entire; heads few to numerous, in corymbose or paniculate clusters; involucral bracts in 1 or 2 series, herbaceous; receptacle naked; corollas all raylike, perfect, yellow or yellowish; pappus of numerous white capillary bristles; achenes terete or nearly so, 10- to 20-ribbed, often beaked.

1. Plants annual, adventive, of disturbed sites .... *C. capillaris*
— Plants perennial, indigenous, neither weedy nor of disturbed sites 2
2(1). Leaves and stems glabrous (or glandular-hispid only above); plants subacaulescent or subscapose 3
— Leaves and stems more or less tomentose or puberulent to setose or glandular hispid; plants caulescent 4
3(2). Plants less than 10 cm tall, soboliferous, of high elevations .... *C. nana*
— Plants mainly 15–40 cm tall, never soboliferous, of lower-elevation meadows .... *C. runcinata*
4(2). Heads narrowly cylindric; involucral bracts 5–7 (8), the inner commonly glabrous; flowers mostly 5–10 .... *C. acuminata*
— Heads narrowly to broadly campanulate; involucral bracts 8–15, tomentose and often setose-hispid; flowers mostly 8–60 5

5(4). Leaf segments linear to narrowly lanceolate, entire or nearly so, the terminal lobe more than 5 cm long; achenes commonly green .... *C. atrabarba*

— Leaf segments narrowly lanceolate to triangular, some usually toothed, the terminal lobe less than 5 cm long; achenes mainly yellowish to brownish 6

6(5). Involucres more than twice longer than broad; leaves usually green, runcinate-pinnatifid .... *C. intermedia*

— Involucres less than twice longer than broad, or leaves not green or not runcinate-pinnatifid 7

7(6). Involucre and stems not or sparingly setose, but, if setose, the setae gland-tipped .... *C. occidentalis*

— Involucre and/or stems conspicuously setose, the setae not glandular .... *C. modocensis*

Crepis acuminata **Nutt.** Perennial herbs, 2.5–8.5 dm tall, with 1-several stems from a caudex, the caudex clothed with dark brown marcescent leaf bases; herbage more or less tomentose to glabrate; basal and lowermost cauline leaves 8–33 (40) cm long, 2–12 cm wide, petiolate, the blade elliptic to oblanceolate in outline, pinnatifid to runcinate-pinnatifid, the lobes triangular to narrowly subulate, sometimes toothed or lobed; heads mainly 20–75 or more, cylindric, 5- to 10-flowered; involucres (8) 9–13.5 (16) mm high, 3–7 mm wide, the inner ones 5–8, glabrous or sometimes shortly villous-tomentose, the outer bracts much shorter, commonly tomentose; corollas 10–18 mm long, yellow; achenes yellow to brown, narrowed above. Sagebrush, mountain brush, white fir, aspen, and spruce-fir communities at 1430 to 2900 m in most if not all Utah counties; Washington to Montana, south to California, Arizona, and New Mexico; 69 (viii).

Crepis atrabarba **Heller** [*C. occidentalis* var. *gracilis* D.C. Eaton]. Perennial herbs, 2–4.5 dm tall, with 1-several stems from a caudex, the caudex with dark brown to purplish marcescent leaf bases; herbage gray villous-tomentose to glabrate, basal and lowermost cauline leaves 6–22 cm long, 1.5–4 cm wide, petiolate, the blade lance-elliptic in outline, pinnatifid, the lobes linear or linear-subulate, the terminal lobe 5–9 cm long, entire; heads mainly 2–15, campanulate, commonly 10- to 40-flowered; involucres 9–15 mm long, 7–13 mm wide, the inner ones 8–10, usually grayish tomentulose and often with few glandless black setae; corollas 10–18 mm long, yellow; achenes usually greenish, attenuate at the apex. Sagebrush, ponderosa pine, Douglas fir, and white fir communities at 1890 to 2870 m in Daggett, Garfield, Salt Lake, Summit, Tooele, Uintah, and Utah counties; British Columbia and Alberta, south to Nevada and Colorado; 8 (i). The species is evidently uncommon in Utah. It is known to form apparent hybrids with *C. acuminata*, and probably with other taxa as well.

Crepis capillaris **(L.) Wallr.** Slender Hawksbeard. Annual or biennial herbs, the stems erect, simple or branched, mostly 1–6 dm tall, sparingly spreading-hairy; basal leaves 3–20 cm long, 0.5–3 cm broad, lanceolate to oblanceolate, denticulate to pinnatifid or bipinnatifid, glabrous or pubescent with stiff spreading hairs, especially along the lower midvein, petiolate; cauline leaves reduced upward, sessile and auriculate-clasping; heads (1) several to numerous, mostly 20- to 60-flowered, borne in an open inflorescence; involucres 5–8 mm high, 5–14 mm wide, the inner bracts lance-attenuate, 8–16, tomentose, often glandular-hairy, glabrous within, the outer bracts lance-linear; achenes 2–5 mm long, pale brown to straw colored; achenes 2–5 mm long, pale brown to straw colored, not beaked. Ruderal weed of Salt Lake County; widely scattered in North America; adventive from Europe; 1 (0).

Crepis intermedia **Gray** Gray Hawksbeard. [*C. barbigera* Leiberg, in part]. Perennial herbs, 2.5–7 dm tall, with 1-several stems from a caudex, the caudex clothed with pale to dark brown marcescent leaf bases; herbage more or less tomentose or villous; basal and lowermost cauline leaves 15–30 cm long, 2–10 cm wide, petiolate, the blade elliptic to oblanceolate in outline, pinnatifid to runcinate-pinnatifid, the lobes triangular to linear-subulate, sometimes toothed or lobed, the terminal lobe less than 5 cm long; heads mainly 10–60, campanulate, 7- to 16-flowered; involucres 11–20 mm high, 6–12 mm wide, the inner ones 7–12, tomentulose (rarely glabrate), sometimes setose with nonglandular setae, the outer bracts much shorter; corollas 13–20 mm long, yellow; achenes mainly yellowish or brownish, narrowed above. Sagebrush, pinyon-juniper, and mountain brush communities at 1525 to 2575 m in Beaver, Cache, Duchesne, Garfield, Salt Lake, Sevier, Utah, Wasatch, and Washington counties; Washington to Alberta, south to California, Nevada, and Colorado; 16 (iii). The *intermedia* assemblage consists of a series of apomictic intermediates involving *C. acuminata* as one of the parental types, and one or more of the other taxa (i.e., *occidentalis* or *modocensis*) to complete the complex. Included here is the concept of *C. barbigera* as it has been applied in Utah; it consists of a similar hybrid sequence of polyploid apomicts from outside our area.

Crepis modocensis **Greene** Modoc Hawksbeard. Perennial herbs, 1.5–3.7 dm tall, with 1-several stems from a caudex, the caudex clothed with pale to brown marcescent leaf bases (the stem base often yellow); herbage more or less tomentose; basal and lowermost cauline leaves 9–25 cm long, 2–5 cm wide, petiolate, the blade elliptic to oblanceolate in outline, bipinnatifid, the lobes linear to lance-subulate, again toothed or lobed, the terminal lobe less than 5 cm long; heads 1–9, 10- to 60-flowered; involucres 11–16 mm high, 11–23 mm wide, the inner bracts 10–15, tomentulose, commonly setose, the setae not glandular, the outer bracts much shorter; corollas 13–22 mm long, yellow; achenes greenish black to reddish brown, attenuate. Sagebrush, pinyon-juniper, and mountain brush communities at 1640 to 3175 m in Beaver, Box Elder, Cache, Daggett, Juab, Millard, Rich, Salt Lake, Sanpete, Sevier, Tooele, Uintah, and Utah counties; British Columbia to California, Nevada, and Colorado; 24 (0). The peculiar numerous slender lateral lobes of the deeply dissected or parted leaf blades are diagnostic.

Crepis nana **Richards.** Dwarf Hawksbeard. Perennial caespitose herbs, the stems much branched, often soboliferous, mostly 0.2–1.1 dm tall, contracted, usually obscured by the leaves, glabrous; basal leaves mainly 1–7.5 cm long, 0.2–1.8 cm wide, the blades spatulate to orbicular, elliptic, or ovate, glabrous, petiolate; cauline leaves similar to the basal, not clasping; heads few to numerous, mostly 4- to 12-flowered, borne in a compact cushionlike inflorescence; involucre 7–12 mm high, 3–6 mm wide, the inner bracts narrowly oblong, 8–12, greenish or blackish, glabrous, the outer much shorter; achenes brownish, ribbed, shortly beaked. Alpine communities, mainly in talus, at 3050 to 3425 m in Juab, Piute, and Utah or Salt Lake counties; Alaska to Labrador, south to California and Utah; 10 (iii).

Crepis occidentalis **Nutt.** Western Hawksbeard. Perennial herbs, 1–4 dm tall, with 1-several stems from a caudex, the caudex clothed with brown marcescent leaf bases (the stem base often yellow); herbage tomentose; basal leaves mainly 6–30 cm long, 1–5 cm wide, petiolate, the blade lanceolate to elliptic in outline, pinnatifid to bipinnatifid, the lobes triangular to oblong or linear-subulate, usually again toothed or lobed, the terminal lobe less than 5 cm long; heads 2–25, 12- to 30-flowered; involucres 10–20 mm high, 6–15 mm wide, the inner bracts (7) 8–13 (18), tomentose, the outer ones much shorter; corollas 10–22 mm long, yellow; achenes pale to dark brown, not much attenuate apically. There are three rather weak and arbitrarily recognizable varieties of this species, with some geographical correlation, in Utah. Intermediates occur between the varieties and with other taxa as well.

1. Largest heads 12- to 14-flowered, with 8 or 9 involucral bracts; plants mainly of the Great Basin .... *C. occidentalis* var. *costata*
— Largest heads with more than 15 flowers, with 10–13 involucral bracts; plants of various distribution 2

2(1). Involucres with few glandular setae, or none; plants mainly 2–3 dm tall, of the Great Basin .... *C. occidentalis* var. *pumila*

— Involucres with few to numerous glandular setae; plants mainly 1–2 dm tall, of the Colorado drainage system, less commonly in the southern Great Basin .... *C. occidentalis* var. *occidentalis*

Var. *costata* Gray Sagebrush, pinyon-juniper, mountain brush, and aspen communities at 1525 to 2200 m in Box Elder, Juab, Millard, Salt Lake, Tooele (type from Stansbury Island), Utah, and Washington counties; British Columbia to California and Colorado; 23 (0).

Var. *occidentalis* Shadscale, rabbitbrush, sagebrush, pinyon-juniper, and ponderosa pine communities at 1280 to 2565 m in Beaver, Daggett, Duchesne, Garfield, Kane, Piute, Sanpete, Sevier, San Juan, and Washington counties; Oregon to Wyoming, south to California and New Mexico; 25 (v).

Var. *pumila* (Rydb.) Babcock & Stebbins [*Crepis pumila* Rydb.]. Sagebrush, pinyon-juniper, and mountain brush communities at 1700 to 2100 m in Millard and Tooele counties; 7 (0).

***Crepis runcinata* (James) T. & G.** [*Hieracium runcinatum* James]. Perennial herbs, 1.5–5 (7) dm tall, with 1-several stems from a caudex, the short caudex clothed with brown marcescent leaf bases; herbage glabrous or hispid above (puberulent in some), not tomentose; basal leaves mainly 2–25 cm long, 1–6 (8) cm wide, petiolate or not, spatulate to oblanceolate, or the blades ovate to oval, oblong, or oblanceolate, more or less pinnatifid to lobed or entire, commonly glaucous; heads 1–30, with 20–50 flowers; involucres campanulate, 8–16 mm high, 6–15 mm wide or more, the inner bracts mainly 10–16, puberulent or hispid, the outer ones much shorter; corollas 9–18 mm long, yellow; achenes light to dark brown, attenuate, or shortly beaked. Three distinctive varieties are present.

1. Involucres merely puberulent; plants mainly of saline meadows .... *C. runcinata* var. *glauca*

— Involucres hispid with black hairs (resembling species of *Hieracium*); plants of saline or nonsaline sites 2

2(1). Basal leaves definitely petiolate, the blade 2–4 times longer than broad .... *C. runcinata* var. *hispidulosa*

— Basal leaves broadly winged-petiolate, the blade 4–8 times longer than broad ... . *C. runcinata* var. *runcinata*

Var. *glauca* (Nutt.) Welsh stat. nov. [based on: *Crepidium glaucum* Nutt., Trans. Amer. Phil. Soc. II. 7: 436. 1841]. Meadows, lake shores, seeps, and hot springs in salt grass, rush, alkali sacaton, and common reed communities at 1220 to 2200 m in Carbon, Daggett, Duchesne, Emery, Grand, Juab, Kane, Millard, Piute, San Juan, Sevier, Tooele, Uintah, Utah, and Wayne counties; Idaho to Saskatchewan, south to Arizona and New Mexico; 34 (xii). This variety has been collected in full flower on 27 April at Monroe Hot Springs.

Var. *hispidulosa* Howell ex Rydb. Sedge-willow and meadow communities at 1370 to 2535 m in Box Elder, Duchesne, Kane, Piute, Rich, Sanpete, Sevier, Summit, and Utah counties; Washington to Montana, south to California and Colorado; 14 (ii). The meadows are seldom saline where this plant occurs.

Var. *runcinata* [*C. runcinata* var. *alpicola* Rydb.]. Bogs in Salt Lake and Utah counties; Manitoba to Minnesota, south to Idaho and New Mexico; 1 (0). This variety is evidently uncommon in Utah.

DICORIA T. & G.

Annual herbs; leaves alternate or the lower ones opposite, simple, entire or toothed; heads unisexual or perfect, discoid; involucral bracts strongly dimorphic, the ca 5 outer ones small, herbaceous, the inner subtending the 1 or 2 pistillate flowers, subscarious, accrescent, much larger than the outer at maturity; chaff narrow, tardily deciduous; pistillate flowers without corolla; staminate flowers with funnelform corolla, the anthers distinct; achenes plano-convex, black, toothed to pectinately wing margined; pappus lacking.

1. Foliose bracts of inflorescence orbicular to broadly ovate; plants of Washington County .... *D. canescens*
— Foliose bracts of inflorescence lance-ovate to lanceolate; plants not of Washington County .... *D. brandegei*

Dicoria brandegei **Gray** [*D. paniculata* Eastw.; *D. wetherillii* Eastw., a monstrous form]. Plants branched from the base upwards, 1.5–5.5 dm tall, the herbage white-pilosulose to strigose, the hairs multicellular; lower cauline leaves linear to lanceolate, more or less hastately lobed, toothed, or subentire, 1–7 cm long (including petiole), 0.2–1.5 cm wide; foliose bracts linear to oblong, lanceolate or ovate, rarely if ever orbicular, the blades 0.6–4 cm long; outer involucral bracts oblong, 1.5–3 mm long, the inner ones suborbicular, glandular-puberulent, accrescent in fruit; achenes 5–8 mm long, the winged margin toothed to pectinate, black like the body or pale. In dunes and other sandy sites, in wavy-leaf oak, eriogonum, amsonia, old-man sagebrush, rabbitbrush, ephedra, and vanclevea communities at 1130 to 1830 m in Emery, Garfield, Grand, Kane, San Juan, and Wayne counties; Arizona, New Mexico, and Colorado (?); 21 (v).

Dicoria canescens **Gray in Torr.** Plants branched from base upward, 2.5–9 dm high, the herbage white-pilosulose to strigose and glandular, the hairs multicellular; lower cauline leaves deltoid-lanceolate, dentate, 1–5 cm long; foliose bracts ovate to orbicular, the blades 0.6–1.5 cm long; outer involucral bracts oblong, 2–3 mm long, the inner ones suborbicular, glandular-puberulent, accrescent in fruit, to 10 mm long or more; achenes 5–6 mm long, the winged margin toothed to pectinate, black like the body, or pale. Dunes and other sandy sites in blackbrush and creosote bush communities at 825 to 1000 m in Washington County; Arizona, Nevada, and California; 4 (1). Our material belongs to ssp. *clarkae* (Kennedy) Keck.

Dyssodia Cav.

Annual or perennial herbs or subshrubs from taproots, the juice watery; herbage with conspicuous translucent oil glands; stems striate, numerous; leaves opposite or alternate, entire to pinnatisect; heads solitary at branch ends, or few to several in cymose clusters; involucral bracts in 2 series, distinct or united, and usually with a much shorter outer set; receptacle flat or convex, puberulent; ray flowers yellow, pistillate, fertile; disk flowers fertile; pappus of 10–15 bristle-tipped scales, or these dissected into 3 or more bristles; style branches with a short, conic appendage.

Strother J. L. 1969. Systematics of *Dyssodia* Cavanilles (Compositae: Tageteae). Univ. Calif. Publ. Bot. 48: 1–88.

1. Plants annual; leaves bipinnatisect; stems villosulous .... *D. papposa*
— Plants perennial, herbs or subshrubs; leaves simple or merely pinnatisect; stems hispidulous 2
2(1). Heads borne on elongate merely bracteate peduncles; leaves pinnately 5-lobed, shortly hispid; pappus scales tipped with usually a solitary bristle .... *D. pentachaeta*
— Heads sessile or essentially so; leaves simple, entire or rarely irregularly few lobed; glabrous or merely ciliate; pappus scales with 3–5 bristles .... *D. acerosa*

Dyssodia acerosa **DC.** Dogweed. Plants suffruticose, 10–25 cm tall, forming compact clumps, from taproots; herbage glabrous or villosulous; leaves opposite (or alternate above), simple or irregularly lobed, 3–18 mm long, 0.5–1 (2) mm wide, glandular, ciliate or glabrous; heads sessile or subsessile; involucres turbinate-cylindric, 5–7 mm high, 3–4 mm wide; involucral bracts ca 13, connate, each bract with conspicuous orange glands; ray flowers 7–8, lemon-yellow; disk flowers 18–25, pale yellow; pappus of ca 20 scales, each dissected into 3–5 bristles; achenes dark brown, 3–3.5 mm long, strigose. Blackbrush communities at 1130 to 1350 m in Garfield, Washington, and San Juan counties; Arizona and New Mexico, south to Mexico; 5 (ii).

Dyssodia papposa **(Vent.) A.S. Hitchc.** [*Tagetes papposa* Vent.]. Plants annual, 1.5–4 dm tall; herbage glabrous to sparingly puberulent; leaves opposite below, alternate above, 1.5–3 (5) cm long, pinnatisect into 11–15 lobes, these sometimes again lobed; heads shortly pedunculate to subsessile; involucres turbinate to campanulate, 6–10 mm high, and about as wide; involucral bracts 6–12, oblanceolate, with yellowish oil glands, connate only at the base; ray flowers 8 or fewer, yellow-orange; disk flowers mainly 20–40, dull yellow; pappus of ca 20 scales, each dissected into 5–10 bristles; achenes black, 8–35 mm long. Sandy roadsides at 1450 to 1500 m in Carbon, Duchesne, Sanpete, and Tooele counties; through much of the United States and Mexico; 4 (0).

Dyssodia pentachaeta **(DC.) Robins.** [*Hymenatherum pentachaetum* DC.] Plants suffruticose, 8–28 cm tall, forming rounded clumps, from taproots; leaves opposite, pinnately parted into 3–5 rigid linear lobes, 0.5–2 cm long, sparingly hirtellous; peduncles 1–8 cm long; involucres turbinate, 4.8–6 mm high, 5–10 mm wide; involucral bracts in 2 series, connate for much of their length, with distinctive yellow oil glands; ray flowers usually 13, bright yellow; disk flowers 50–70, dull yellow; pappus usually of 10 scales, these awnless or with 1–3 awns; achenes brown, 2.2–3 mm long, hispid to glabrous. Blackbrush, ephedra, shadscale, creosote bush, and Joshua tree communities at 700 to 1220 m in Garfield, Kane, San Juan, and Washington counties; Nevada and California to Texas and Mexico; South America; 30 (vi). Our material has been assigned to var. ***belinidium*** (DC.) Strother [*D. thurberi* (Gray) Woot. & Standl.].

ENCELIA Adams

Shrubs; stems ascending to erect, grayish or whitish, the branchlets commonly pubescent; leaves alternate, simple, petiolate, entire or toothed; heads solitary or in cymose clusters, radiate or discoid; involucral bracts in 2 or 3 series; receptacle convex to flat, chaffy, the scales clasping the achenes and falling with them; ray flowers (when present) sterile, yellow; disk flowers perfect, yellow; pappus lacking (or of 2 awns); achenes flat, obovate, villous-ciliate and pubescent on the surfaces.

BLAKE, S. F. 1913. A recision of *Encelia* and some related genera. Proc. Amer. Acad. 49: 358–376.

1. Leaves white-tomentulose; peduncles glabrous; heads in branching cymes; plants rare in Washington County .... *E. farinosa*

— Leaves strigose to hispid, green; peduncles scabrous to strigose; heads solitary at branch ends; plants of Washington County, and elsewhere .... *E. frutescens*

Encelia farinosa **Gray** Incienso. Plants mainly 3–10 dm tall, aromatic; leaves clustered at apex of current stems, 2–8 cm long, ovate, entire or toothed, silvery tomentose, petiolate; peduncles elongate, cymosely branched or simple; heads showy, the disk 1–1.5 cm wide; involucres 4–7 mm high, villous and glandular dotted; rays 8–12 mm long, orange-yellow; achenes narrowly obovate. Blackbrush community at 1280 m in Washington County; Nevada, Arizona, and California; Mexico; 1 (0).

Encelia frutescens **Gray** Bush Encelia. [*Simsia frutescens* Gray]. Plants mainly 3–12 (15) dm tall; leaves scattered along current stems, the blades commonly 0.5–2.5 cm long, 0.3–2 dm wide, ovate to orbicular or lanceolate, entire or toothed, strigose to hispid with pustular-based hairs; heads showy or not, the disk 1–3 cm wide; involucres 6–10 mm high, strigose or glandular; rays lacking or 1–16 (or more), 2–12 mm long, yellow; achenes obovate. Two distinctive varieties are present in Utah.

1. Herbage strigose, also with some pustular-based hairs; involucral bracts abruptly caudate-acuminate, strigose; plants of Washington County .... *E. frutescens* var. *virginensis*

— Herbage hispid with pustular-based hairs; involucral bracts gradually attenuate, more or less glandular (sometimes strigose) .... *E. frutescens* var. *frutescens*

Var. *frutescens* [*E. frutescens* var. *resinosa* Jones in Blake] Talus and slickrock in blackbrush and shadscale communities at 1130 to 1830 m in Emery, Grand, Kane, and San Juan counties; Arizona, California; 15 (vii). There is a cline of glandularity in leaves from definitely glandular in the southern portion of the range in Utah to no glands at all in the northern material. Also, our plants vary from discoid to radiate.

Var. *virginensis* (A. Nels.) Blake [*E. virginensis* A. Nels.]. Creosote bush, Joshua tree, and blackbrush communities at 760 to 1325 m in Washington County; Nevada, Arizona, and California; 23 (i).

ENCELIOPSIS (Gray) A. Nels.

Perennial scapose or subscapose herbs, from tuberous roots or taproots and subterranean to superficial caudex; herbage pilosulose to velutinous; leaves all basal (rarely some reduced bracteate ones along the scape), the blades spatulate, lanceolate, oblanceolate, ovate, or orbicular; heads solitary; involucral bracts in 2 or 3 series, herbaceous throughout; receptacle flat to convex, chaffy, the scales clasping the achenes; rays yellow, sterile (but apparently pistillate), or lacking; disk flowers numerous, perfect, fertile, yellow; pappus of 2 awns and with or without small scales between, or none; achenes flattened, blackish.

1. Heads discoid; herbage pilose-hirsutulose; plants arising from a subterranean tuberous root .... *E. nutans*
— Heads radiate; herbage tomentulose; plants arising from a superficial caudex 2
2(1). Petioles broadly winged, mainly shorter than the blades; plants reported from the Virgin Narrows section of Washington County, but none have been seen by me .... *E. argophyllus* (D. C. Eaton) A. Nels.
— Petioles slender, not or only narrowly winged, mainly longer than the blades; plants commonly in eastern and west central portions of the state .... *E. nudicaulis*

Enceliopsis nudicaulis **(Gray) A. Nels.** [*Encelia nudicaulis* Gray]. Scapose, caespitose perennials from a superficial, branching caudex, 10–43 cm tall, the herbage tomentulose, silvery white; petioles 0.7–17 cm long, narrowly if at all winged; leaf blades 2–9 cm long, 1.3–10 cm wide, ovate to elliptic, orbicular or spatulate, cuneate to subcordate basally, obtuse to rounded apically; scapes often with a reduced foliose bract; involucres 1.3–2.2 cm high, 3–5.6 cm wide, the bracts ovate-lanceolate to lanceolate or linear-lanceolate, attenuate to acuminate; rays 13–21, yellow, 22–38 mm long; achenes 10–12 mm long, long silky-pilose, cuneate, black or dark brown; pappus commonly of 2 awns connected by a crown of short connate scales (or none). Commonly on gypsiferous semibarren knolls in blackbrush, rabbitbrush, ephedra, shadscale, grayia, and pinyon-juniper communities in Beaver, Emery, Garfield, Grand, Millard, Piute, San Juan, Sevier, Uintah, and Wayne counties; Idaho, Nevada, Arizona, and California; 66 (xiii).

Enceliopsis nutans **(Eastw.) A. Nels.** [*Encelia nutans* Eastw.]. Scapose, discoid perennials, 10–25 cm tall, from a subterranean caudex (2–15 cm long) and tuberous root to 4 cm thick, the herbage strigose to pilosulose (antrorsely on the upper surface, retrorsely so below), green; petioles 2–6.5 cm long, often narrowly winged; leaf blades 2–7.5 cm long, 1.4–6 cm wide, ovate to orbicular or spatulate, cuneate basally, obtuse to rounded apically; scapes not bracteate; involucres 0.9–1.5 cm high, 2.5–4 cm wide, the bracts lance-attenuate; rays lacking; achenes 9–11 mm long, oblanceolate, long silky-pilose, brown; pappus lacking. Mainly in finely textured soils in shadscale, budsage, galleta, and ephedra communities at 1310 to 1830 m in Carbon, Duchesne, Emery, Grand, Uintah, and Wayne counties; Colorado (a Colorado Basin endemic); 35 (iii).

ERIGERON L.

Annual, biennial, or perennial herbs from caudices, rhizomes, stolons, or taproots, with watery juice; stems decumbent to ascending or erect, rarely prostrate; leaves alternate, simple, entire, toothed, or pinnatifid to palmatifid; heads solitary or few to numerous in corymbose or paniculate inflorescences; involucral bracts equal, or slightly to definitely imbricate, slender, herbaceous (or scarcely herbaceous) throughout; receptacle flat, naked; rays white, pink, purple, bluish, or yellow, numerous, pistillate, or lacking; disk flowers numerous, yellow or tinged reddish; pappus of capillary bristles, sometimes with an outer series of short bristles or scales; style branches with lanceolate and acute or triangular and obtuse appendages; achenes flattened, 2 (rarely 4–14) -nerved. **Note:** This is a large and complex genus. The species, although mainly distinctive, are distinguished by minute features that can be interpreted variously. The genus is a near congener of both *Aster* and *Conyza*, and is not always separable from either.

CRONQUIST, A. C. 1947. Revision of the North American species of *Erigeron* north of Mexico. Brittonia 6: 121–302.

1. Plants with yellow ray flowers, known from Box Elder County .... *E. linearis*
— Plants with ray flowers pink, pink-purple, blue, blue-purple, or white, but not yellow, of various distribution 2
2(1). Plants annual, biennial, or short-lived perennials from usually slender taproots, lacking rhizomes (except in some specimens of *E. proselyticus*) or woody caudices .... **KEY I**
— Plants definitely perennial, often from rhizomes or caudices 3
3(2). Plants silvery pubescent; achenes with 4 or more nerves; involucral bracts definitely imbricate .... **KEY II**
— Plants green, or less commonly silvery pubescent; achenes with 2 nerves, or, if with more nerves, involucral bracts subequal 4
4(3). Involucres woolly-villous to spreading villous, or villous-hirsute with at least some long spreading multicellular hairs .... **KEY III**
— Involucres merely glandular, glabrous, puberulent, or with appressed simple or multicellular hairs, rarely with some spreading long hairs near the base .... **KEY IV**

Key I.

Plants annual, biennial, or short-lived perennials from slender taproots, lacking rhizomes or woody caudices.

1. Pistillate corollas very numerous, filiform, the rays short, erect, not exceeding the disk, or the inner ones tubular and lacking rays 2
— Pistillate corollas few to numerous (rarely lacking), the tube generally cylindric, the rays well developed and spreading, rarely reduced or absent 3
2(1). Cauline leaves narrowly lanceolate to oblong, or less commonly linear; rayless pistillate flowers present between the ray and disk flowers; inflorescence corymbose, the peduncles curved-ascending, or the heads solitary .... *E. acris*
— Cauline leaves linear to oblong; rayless pistillate flowers lacking; inflorescence racemose, the peduncles erect or nearly so, or the heads solitary ...... *E. lonchophyllus*
3(1). Pappus of ray and disk flowers unlike, that of the disk flowers composed of bristles and short outer setae, that of the ray flowers lacking bristles; plants tall adventive weedy species 4
— Pappus of ray and disk flowers alike, consisting of bristles, sometimes also with outer setae or scales; plants indigenous, low to tall 5
4(3). Foliage ample; plants mainly 6–12 (15) dm tall; pubescence of stem long and spreading (at least below); plants introduced, weedy .... *E. annuus*
— Foliage sparse; plants mainly 3–7 dm tall; pubescence various; plants to be sought in Utah .... *E. strigosus Muhl.*

5(3). Plants diffusely branched, annual; leaves linear to linear-oblong; hairs of stem short and incurved; pappus simple .... *E. bellidiastrum*

— Plants various, but seldom as above, or, if so, the pappus double 6

6(5). Disks mainly over 1 cm wide; stems commonly simple, with solitary or few heads, and broad cauline leaves .... *E. glabellus*

— Disks mostly less than 1 cm wide; stems commonly branched, often with several to many heads 7

7(6). Stems with hairs all spreading .... *E. divergens*

— Stems with hairs appressed or ascending, or glabrous 8

8(7). Leaves entire; plants with sterile flagellate branches .... *E. flagellaris*

— Leaves pinnately lobate or toothed, or if entire then the plants lacking sterile flagellate branches 9

9(8). Ray flowers commonly 40–80; plants psammophytes of eastern Washington and western Kane counties .... *E. religiosus*

— Ray flowers commonly 25–40; plants of various substrates in eastern Washington and Kane counties 10

10(9). Involucres 2.5 mm high or less; stems 1–11 cm tall; peduncles sparingly villous; plants known from seeps and moist sandstone in Zion National Park .... *E. sionis*

— Involucres 2.5–3 mm high; stems 14–25 cm long; peduncles hirsute; plants from limestone and sandstone outcrops in eastern Iron and adjacent Kane counties .... *E. proselyticus*

KEY II.

Plants perennial, silvery pubescent; achenes 4 (or more) -nerved; involucral bracts imbricate.

1. Achenes glabrous, with 8–14 nerves; caudex clothed with marcescent leaf bases, the midribs evident in age; plants of higher elevations in southern Utah .... *E. canus*

— Achenes more or less hairy, with 3–8 nerves; caudex lacking marcescent leaf bases, or if these present then the midribs not evident; plants of low to moderate elevations, more widely or otherwise distributed 2

2(1). Involucres villous-hirsute with multicellular spreading hairs, the bracts more or less glandular apically; achenes with 3–5 nerves .... *E. pulcherrimus*

— Involucres more or less strigose with simple hairs; achenes 4- to 8-nerved 3

3(2). Basal leaves evident, tufted, persistent; heads one per stem; plants through much of Utah .... *E. argentatus*

— Basal leaves mostly withered at anthesis, not forming a conspicuous tuft; plants mainly of southeastern Utah .... *E. utahensis*

KEY III.

Plants perennial; achenes mostly 2-nerved; bracts mostly subequal, villous with woolly or spreading multicellular hairs.

1. Plants with pinnatifid or palmatifid or merely lobed leaves, low-spreading, more or less mat or clump forming, of high elevations 2

— Plants with entire leaves, or, if some of them lobed, otherwise differing; low to tall, of various elevations 4

2(1). Plants soboliferous, the caudex divided into elongate spreading branches; leaves merely toothed, or if lobed not as below .... *E. vagus*

— Plants not soboliferous, the caudex branches short; leaves pinnately to palmately lobed or divided 3

3(2). Leaves pinnately lobed; plants of the La Sal Mountains .... *E. mancus*

— Leaves palmately lobed or divided; plants widespread .... *E. compositus*

4(1). Involucres long- and shaggy-villous, the hairs sometimes obscuring the bract surface from middle to base 5

— Involucres hirsute to shortly villous, or, if long and shaggy-villous, the hairs not obscuring the bract surface even in the lower portion 7

5(4). Plants 4–7 dm tall or more; known from southeastern Utah .... *E. elatior*

— Plants mainly 0.3–1 dm tall; distribution various 6

6(5). Hairs of involucre with black or dark purple cross-walls; basal leaves rounded to retuse apically; plants of the La Sal mountains .... *E. melanocephalus*

— Hairs of involucre with pale cross-walls or some with bright reddish purple to dark purple cross-walls; basal leaves acute to abruptly obtuse apically; plants of the Uinta, Deep Creek, Tushar, and La Sal Mountains .... *E. simplex*

7(4). Cauline leaves ample, usually lanceolate or broader; plants tall, erect (more or less asterlike) 8

— Cauline leaves usually much reduced, subulate, linear, oblong oblanceolate, or, if broader, the plants not tall or not erect 11

8(7). Hairs of involucre with black cross-walls near their bases; rays white; plants rare, known from the Wasatch Mountains .... *E. coulteri*

— Hairs of involucre with pale cross-walls; rays white, pink, or purple; abundance and distribution various 9

9(8). Plants with cauline leaves well developed and equably distributed, only gradually reduced upward, the middle ones as large as or larger than the lower ones .... *E. speciosus*

— Plants with cauline leaves rather abruptly reduced upward, those of the middle smaller than the lower ones 10

10(9). Involucres glandular or viscid toward the apex; stems curved at base .... *E. formosissimus*

— Involucres seldom if at all glandular or viscid; stems erect .... *E. glabellus*

11(7). Ray flowers lacking .... *E. aphanactis*

— Ray flowers present 12

12(11). Plants subscapose, the bracteate leaves very small; caudex branches with persistent leaf bases 13

— Plants not subscapose, the leaves merely reduced upward; caudex branches with or without persistent leaf bases 16

13(12). Stems and involucres with long, contorted villous hairs; plants of Box Elder and Daggett counties .... *E. nanus*

— Stems and involucres strigose, pilosulose, or hispidulous, the hairs appressed or ascending to spreading; distribution various 14

14(13). Leaves linear; herbage strigose; rays 7–11 mm long; plants mainly of lower elevations in the Navajo and Great basins .... *E. compactus*

— Leaves narrowly oblanceolate to spatulate; herbage strigose to pilosulose or hispidulous; rays 4–8.2 mm long; plants of the Uinta Basin and Wasatch Plateau 15

15(14). Involucres long-villous with spreading multicellular hairs; rays 6.8–8.2 mm long; plants of the Wasatch Plateau .... *E. carringtonae*

— Involucres short-hispidulous; rays 4–6.5 mm long; plants of the Uinta Basin .... *E. untermannii*

16(12). Caudex branches robust, 1–2.5 cm thick; plants of western Beaver and Washington counties .... *E. wahwahensis*

— Caudex branches mainly less than 1.5 cm thick, or, if broader, of different distribution 17

17(16). Stems spreading-hairy 18

— Stems strigose, or with ascending hairs 21

18(17). Leaves linear to linear-oblanceolate; plants without a prominent caudex, mainly of lower elevations .... *E. pumilus*

Leaves oblanceolate to spatulate; plants with prominent caudex, of low to middle or higher elevations 19

19(18). Stems glandular, with sand grains adhering; plants of lower elevations in Emery and Wayne counties .... *E. maguirei*

— Stems lacking glands; plants of moderate and higher elevations 20

20(19). Stems commonly purplish at the base; leaves thin; plants of broad or other distribution .... *E. eatonii*

— Stems green throughout; leaves thickish; plants of the Uinta and Wasatch mountains .... *E. goodrichii*

21(17). Caudex with spreading subrhizomatous branches, with numerous fibrous roots; stems and lower leaf bases purplish; plants sod forming, of higher elevations .... *E. ursinus*

— Caudex not subrhizomatous, seldom if ever with roots; stem and leaf bases not purple; plants of various elevations 22

22(21). Stems decumbent, sharply bent from apex of caudex 23

— Stems ascending to erect, not sharply bent from caudex apex 24

23(22). Herbage glaucous, sparingly hairy; rays 15–22; basal leaf bases greatly expanded, long-ciliate; plants of eastern Washington County .... *E. canaani*

— Herbage green, not especially glaucous, sparingly to moderately hairy; basal leaf bases not greatly expanded, short-ciliate; plants of broad distribution ....*E. eatonii*

24(22). Cauline leaves moderately well developed, the basal ones linear-oblanceolate; involucres 9–12 mm wide; plants of lower elevations .... *E. engelmannii*

— Cauline leaves much reduced, the basal ones spatulate; involucres less than 8 mm wide 25

25(24). Basal leaves acute or acutish; rays blue to red-purple; pappus subequal to disk corollas; plants widely distributed .... *E. tener*

— Basal leaves obtuse to rounded; rays white to pink; pappus shorter than disk corollas; plants of the Bear River Range, Cache County .... *E. cronquistii*

KEY IV.

Plants perennial, green; achenes mostly 2-nerved;
involucres mostly lacking; long, spreading multicellular hairs.

1. Plants substoloniferous; leaves spatulate; involucres mainly less than 8 mm wide; plants of hanging gardens in San Juan County .... *E. kachinensis*
— Plants not substoloniferous; leaves various; involucres mainly over 8 mm wide; plants not or seldom of hanging gardens, variously distributed 2

2(1). Cauline leaves ample, usually lanceolate or broader; plants tall and erect (more or less asterlike) 3
— Cauline leaves definitely reduced upward, mostly linear to oblanceolate, or broader in some low species; stems often spreading or decumbent 5

3(2). Rays mainly 2–3 mm wide .... *E. peregrinus*
— Rays 1–2 mm wide 4

4(3). Cauline leaves glabrous or minutely glandular, not ciliate, subequal to or shorter than the internodes .... *E. superbus*
— Cauline leaves ciliate or otherwise pubescent, sometimes also glandular, usually longer than the internodes .... *E. speciosus*

5(2). Pubescence of the stem widely spreading or glandular-scabrous 6
— Pubescence of the stem appressed, ascending, or lacking 8

6(5). Involucre canescent with fine white hairs, sometimes also glandular .... *E. caespitosus*
— Involucre glandular and more or less spreading hairy or strigose 7

7(6). Stems hirsute with short spreading hairs, conspicuously decumbent; involucres glandular and spreading hairy .... *E. jonesii*
— Stems glandular-scabrous, ascending or erect; involucres glandular (rarely sparingly strigose) .... *E. nauseosus*

8(5). Basal leaves broadly oblanceolate or usually broader, the blade well-developed, usually abruptly contracted to the petiole 9
— Basal leaves linear to oblanceolate or spatulate, tapering gradually to the petiole 11

9(8). Rays purple; achenes 4- to 7-nerved; pappus simple .... *E. peregrinus*
— Rays various; achenes 2-nerved (occasionally more, but rays then pale and pappus double) 10

10(9). Stems essentially scapose, the upper bracts linear; plants known from the Wasatch Mountains .... *E. garrettii*
— Stems subscapose, the upper bracts oblong; plants rather broadly distributed .... *E. leiomeris*

11(8). Peduncles and involucres densely glandular, not hairy; stems glabrous or essentially so; plants of the Wasatch Mountains .... *E. arenarioides*
— Peduncles not glandular, or, if so, the stem more or less hairy; involucres and distribution various 12

12(11). Bases of basal leaves neither enlarged nor of different texture than the blades; blades linear or linear-filiform; plants known from Cache and Daggett counties .... *E. filifolius*

—	Bases of basal leaves somewhat enlarged, membranous or thickened, or otherwise different from above; blades not linear	13
13(12).	Leaves glabrous or nearly so, the hairs, if present, short and appressed	*E. leiomeris*
—	Leaves hairy, the hairs spreading or curved-ascending	14
14(13).	Plants subscapose; cauline leaves reduced to acicular bracts; plants of the Uinta Basin and west Tavaputs Plateau	*E. nematophyllus*
—	Plants caulescent; cauline leaves well developed	15
15(14).	Stems decumbent-ascending, commonly curved at the base; basal leaves sheathing basally; heads mainly solitary	*E. abajoensis*
—	Stems erect or nearly so; basal leaves not especially sheathing; heads mainly 2–4	*E. awapensis*

Erigeron abajoensis **Cronq.** Abajo Daisy. Perennial herb, with a taproot and stout caudex, the caudex branches clothed with brown marcescent leaf bases; stems decumbent to spreading at the base, 5–20 cm long, strigose to strigulose, the hairs ascending; basal leaves oblanceolate, 2–7 cm long, 2–6 mm wide, more or less sheathing basally; cauline leaves several to many, oblong to lance-oblong, mostly 0.6–2.5 cm long, 1.5–4 mm wide; heads solitary, less commonly 2–4; involucres 4–5.2 mm high, 7–12 mm wide, the bracts subequal or slightly imbricate, somewhat thickened dorsally, greenish brown, strigose to strigulose, the hairs multicellular; rays about 40–60, pink-purple to blue (or white), 3–8 mm long, 1–1.8 mm wide; pappus double, the inner of 12–20 bristles, the outer of setae or scales; achenes 2-nerved, hairy. Pinyon-juniper, ponderosa pine, and spruce-fir communities at 2135 to 3450 m in Garfield, Piute, San Juan, and Wayne counties; endemic; 4 (i).

Erigeron acris **L.** Bitter Fleabane. Short-lived perennial, with a slender taproot and poorly developed caudex; stems erect or decumbent at the base, 8–32 cm tall, spreading-hairy and more or less glandular; basal leaves spatulate-oblanceolate, 0.5–6.5 cm long, 2–10 mm wide, entire or sparingly toothed; cauline leaves several to many, oblong to narrowly oblanceolate, lanceolate, or linear, mostly 0.8–7 cm long, 1–8 mm wide; heads solitary, or more commonly few to numerous, on short to elongate peduncles; involucres 4.5–8 mm high, 9–17 mm wide, the bracts imbricate, not especially thickened, green or tinged pink apically in some, sparingly hairy with spreading to ascending stiff multicellular hairs and beset with short glandular processes; rays numerous, pink or white, erect, about 2–4.5 mm long, the inner pistillate flowers eligulate, with corolla tubular; pappus of ca 25–35 slender barbellate white to reddish bristles, surpassing the disk corollas; achenes 2-nerved, sparingly hairy. Lodgepole pine, spruce, and fir communities at 2800 to 3500 m in Duchesne, Summit, and Uintah counties; Alaska to Labrador, south to California, Colorado, Michigan, and Maine; circumboreal; 11 (ix). Varietal status of our few specimens is unclear. One of the specimens has few heads and has essentially eglandular bracts, one is monocephalus and has glandular involucres, and the others are polycephalus and have glandular involucres. Names available are var. *asteroides* (Andrz.) DC. and var. *debilis* Gray, but there appear to be three rather poorly differentiated taxa involved. Decisions as to proper names must await further study.

Erigeron annuus **(L.) Pers.** Annual Fleabane. Plants annual, with slender taproots; stems erect, 6–12 (15) dm tall, sparingly to densely hirsute with long spreading hairs, becoming appressed upward; basal leaves commonly withered at anthesis, ovate to suborbicular, petiolate; cauline leaves numerous, lanceolate to oblong, mainly 1.5–8 cm long, 3–20 mm wide, serrate to entire; heads several to numerous, in a leafy inflorescence; involucres 7.5–12 mm wide, 3–5 mm high, the bracts subequal or the outer somewhat shorter, greenish to brownish, acuminate-attenuate, glandular and sparingly villous-hirsute with multicellular hairs; rays ca 80–125, white (rarely bluish), 4–10 mm long, 0.5–1 mm wide; pappus double; achenes 2-nerved, hairy. Roadsides, fields, and other disturbed sites at 1370 to 1830 m in Utah and Wasatch counties; widespread in the United States; Europe; 8 (ii).

Erigeron aphanactis **(Gray) Greene** Hairy Daisy. [*E. concinnus* var. *aphanactis* Gray]. Perennials with definite branching caudex; stems decumbent to ascending or erect, 5–20 (30) cm tall, sparingly to copiously spreading-hirsute with multicellular hairs; basal leaves narrowly oblanceolate to spatulate, 0.5–8 cm long, 1–6 mm wide, petiolate; cauline leaves well developed or essentially lacking; heads solitary or several; involucres 7–15 mm wide, 3.5–6 mm high, finely to coarsely spreading-hirsute and sometimes also finely glandular; bracts subequal or somewhat imbricate, slender, acuminate, green or greenish brown, the midrib thickened; pistillate flowers present, tubular, eligulate, or sometimes with rays shorter than the disk; pappus double; achenes 2-nerved, sparsely hairy. This species is represented in Utah by two rather weak varieties.

1. Plants essentially scapose; corolla lobes sometimes becoming reddish or purplish .... *E. aphanactis* var. *congestus*
— Plants with leafy stems; corolla lobes commonly yellowish .... *E. aphanactis* var. *aphanactis*

Var. *aphanactis* Salt desert shrub, sagebrush, pinyon-juniper, sagebrush, and mountain brush communities at 1300 to 2700 m in Beaver, Garfield, Juab, Piute, Sanpete, Sevier, Washington, and Wayne counties; Oregon and Idaho south to California, Arizona, and Colorado; 21 (iii).

Var. *congestus* **(Greene) Cronq.** [*E. congestus* Greene]. Juniper-black sagebrush, sagebrush, and aspen communities at 1830 to 2600 m in Garfield and Sevier counties; California; 3 (0).

Erigeron arenarioides **(D.C. Eaton) Gray** [*E. stenophyllus* D.C. Eaton, not H. & A.; *Aster arenarioides* D.C. Eaton ex Gray]. Perennial herbs, with definite branching caudex, the caudex branches clothed with brownish marcescent leaf bases; stems ascending to erect, 6–25 (30) cm tall, slender, glabrous or glandular below the heads; leaves glabrous or sparingly strigose, the basal ones linear-filiform to linear-oblanceolate, 1.5–6 (8) cm long, 0.5–2 (4) mm wide, entire; heads solitary or 2 or 3 (rarely more); involucres 7–9 mm wide, 3.7–5 mm high, the bracts imbricate in several series, greenish brown, finely glandular, the tips often purplish; rays 10–25, blue, 4–8 mm long, 0.8–1.8 mm wide; pappus of about 10–16 bristles, and with a few short setae; achenes 2-nerved, sparsely strigose. Crevices in limestone and quartzite outcrops, rarely in beach sand, at 1300 to 2440 m in Salt Lake, Tooele, Utah, and Weber counties; endemic; 8 (0).

Erigeron rgentatus **Gray** Silver Daisy. [*Wyomingia argentata* (Gray) A. Nels.]. Perennial herbs, with definite branching caudex, the caudex branches more or less clothed with brown marcescent leaf bases, the midribs not especially persistent; stems erect, 9–28 (40) cm tall, finely strigose and silvery to gray-green; basal leaves tufted, spatulate to oblanceolate, 1.5–7 cm long, 1–4 (6) mm wide, petiolate, entire; cauline leaves reduced upward; heads solitary; involucres 10–18 mm wide, 5.5–9 mm high, the bracts strongly imbricate, silvery strigose with appressed antrorse hairs; rays ca 20–50, blue, lavender, or pink to white, 9–15 mm long, 1.6–2.8 mm wide; pappus double; achenes pilose. Salt desert shrub, sagebrush, pinyon-juniper, and mountain brush communities at 1600 to 2440 m in Beaver, Box Elder, Emery, Garfield, Iron, Juab, Millard, Piute, Sanpete, Sevier, Tooele, and Utah counties; Nevada, California; 29 (iii).

Erigeron awapensis **Welsh** Awapa Daisy. Perennial herbs from a branching caudex, the caudex branches clothed with ragged brown marcescent leaf bases; stems erect or nearly so, 10–24 cm long, strigose, the hairs ascending; basal leaves 1.5–7 cm long, 2–8 mm wide, not especially sheathing; cauline leaves well developed, oblong to linear, mostly 1–4 cm long, 2–4 mm wide; heads 2–4, rarely solitary; involucres 3–9 mm wide, 3.7–4.5 mm high, the bracts more or less imbricate, thickened near the base dorsally, greenish, strigulose, the hairs multicellular; rays 35–45, pink-purple to pink (or white?), 5–6 mm long, 0.9–1.8 mm wide; pappus apparently simple, of 15–20 slender bristles, and with a few inconspicuous shorter setae in some; achenes 2-nerved, hairy. Pinyon-juniper and sagebrush communities at 2135 to 2260 m in Garfield and Wayne counties; endemic; 2 (1).

Erigeron bellidiastrum **Nutt.** Plants annual (or biennial), the stems 3.5–32 (50) cm tall, erect or ascending, often intricately branched; herbage strigulose with incurved multicellular hairs; leaves mainly cauline, 0.5–4 cm long, 1–3 (6) mm wide, linear to oblanceolate, entire (or sparingly toothed to pinnatifid), petiolate, becoming sessile upward; heads solitary to numerous; involucres 5–11 mm wide, 3–5 mm high, the bracts hirtellous with spreading curved multicellular hairs, thick, greenish, subequal, or the outermost shorter; rays ca 30–70, pink or white, 4–6 mm long, ca 1 mm wide; pappus of ca 15 deciduous bristles; achenes 2-nerved, hairy. Vanclevea-ephedra, blackbrush, and pinyon-juniper communities at 1125 to 1830 m in Garfield, Grand, Kane, San Juan, and Washington counties; Wyoming and South Dakota to New Mexico and Texas; 23 (ii).

Erigeron caespitosus **Nutt.** Tufted Daisy. [*E. caespitosus* var. *laccoliticus* Jones]. Perennial herbs with a branching caudex, the caudex branches clothed with brown or blackish marcescent leaf bases; stems decumbent at the base, 4–25 (30) cm tall, hirtellous with short spreading hairs (especially above); basal leaves oblanceolate to spatulate, generally rounded to obtuse apically, 1–9 cm long, 2–13 mm wide, 1- to 3-nerved; cauline leaves reduced upward; heads solitary or few to several; involucres 9–18 mm wide, 4–7 mm high, the bracts subequal to imbricate, thickened on the back, green, strigose to pilose with multicellular hairs spreading laterally from the midrib; rays ca 30–100, blue, pink, or white, 5–15 mm long, 1–2 mm wide; pappus double; achenes 2-nerved, hairy. Sagebrush, pinyon-juniper, aspen, lodgepole pine, spruce, and tundra communities at 2135 to 3570 m in Daggett, Duchesne, Emery, Garfield, Salt Lake, Sevier, Summit, Uintah, Utah, Wasatch, and Wayne counties; Alaska and Yukon south to Arizona, New Mexico, and Nebraska; 40 (viii). This is a variable species with many phases in Utah, each differing in stature, nature of vesture, size of heads, and other features that fail singly and in combination as diagnostic criteria. The species interfaces with *E. nauseosus*, *E. abajoensis*, and probably with other taxa.

Erigeron canaani **Welsh** Canaan Daisy. Perennial herbs from a simple (or branched?) caudex, this clothed with brown marcescent leaf bases, the taproot prominent; stems 7–20 cm tall, decumbent to ascending, sometimes purplish at the base, sparingly pubescent with ascending hairs; leaves pubescent like the stem, the basal ones tufted, 1-nerved, 1.4–9 cm long, 0.7–1 mm wide, linear, involute, sharply acute, conspicuously expanded and long-ciliate basally; cauline leaves numerous, reduced upward; heads 1–3; involucres 9–13 mm wide, 5.3–6.5 mm high; bracts imbricate, conspicuously glandular and sparingly to moderately villous-pilose with multicellular hairs, green or variously suffused with purple; rays 15–22, white or pinkish, 3.5–5 mm long, 1.8–2.1 mm wide; pappus single, of ca 20 slender bristles; achenes 2-nerved, hairy. Ponderosa pine community at 1585 to 2075 m in Washington County; endemic; 2 (i). The Canaan daisy is similar in general aspect to *E. eatonii* (q.v.). The involute linear glaucous leaves and few ray flowers appear to be diagnostic.

Erigeron canus **Gray** Hoary Daisy. Perennial herbs, with branching caudex, the caudex branches clothed with persistent leaf bases, the marcescent midribs prominent; stems erect or nearly so, 5–30 (35) cm tall, appressed strigose; basal leaves oblanceolate, mostly 1–6 cm long and 1–5 (7) mm wide, hairy like the stems; cauline leaves reduced upward; heads solitary (rarely up to 4); involucres 9–16 mm wide, 5–7 mm high, the bracts strigulose with ascending to spreading multicellular hairs and more or less glandular, imbricate; rays ca 30–40, blue or white, 7–12 mm long, 0.8–1.4 mm wide; pappus double; achenes ca 8- to 14-nerved. Gravelly substrates of the Cedar Breaks (Wasatch) Formation in ponderosa pine and sagebrush communities at 2300 to 2500 m in Garfield County; Wyoming and South Dakota to Arizona and New Mexico; 3 (i).

Erigeron carringtonae **Welsh** Carrington Daisy. Pulvinate perennial herbs with a pluricipital caudex, the branches clothed with conspicuous brown to straw colored or ashy marcescent leaf bases; leaves mainly basal, thickish, 0.6–3.5 cm long, 1–5 mm wide, spatulate to oblanceolate, strigose to pilosulose, obtuse to rounded apically; scapes 2.5–8 cm tall; heads solitary; involucres 9.8–15 mm wide, 5.8–7 mm high, the bracts imbricate, suffused with purple or green, the inner greenish with scarious margins, spreading-villous with long multicellular hairs; rays 18–30, pink to pink-purple, 6.8–8.2 mm long, 1.4–2.3 mm wide; pappus double, the inner of 25–35 barbellate bristles, the outer of short setae; achenes 2-nerved, pilose. Meadows and escarpment margins, commonly on Flagstaff Limestone at 3050 to 3355 m in Emery and Sanpete counties; endemic; 6 (i).

Erigeron compactus **Blake** [*E. pulvinatus* Rydb.]. Perennial pulvinate herbs with a branching caudex, the caudex branches clothed with marcescent leaf bases; leaves mainly basal, 4–20 mm long, 0.6–1.4 mm wide, linear, finely strigose; scapes 2–10 cm tall; heads solitary; involucres 7–17 mm wide, 5–8.5 mm high, the bracts more or less imbricate, straw colored or greenish brown to green, hispidulous with short spreading hairs; rays mainly 15–50, white or pink, 7–11 mm long, 1.4–2.5 mm wide; pappus double; achenes 2-nerved. Two geographically segregated races are recognizable as varieties.

1. Leaves yellowish green; involucral bracts appressed strigose; plants of the Great Basin .... *E. compactus* var. *compactus*
— Leaves grayish green; involucral bracts spreading-hispidulose; plants of the Colorado Drainage system .... *E. compactus* var. *consimilis*

Var. ***compactus*** Pinyon-juniper community at 1830 to 2135 m in Beaver, Box Elder, Millard, and Tooele counties; Nevada and California; 4 (0).

Var. ***consimilis*** **(Cronq.) Blake** Salt desert shrub and pinyon-juniper communities in Daggett, Duchesne, Emery, and Wayne counties; Arizona; 11 (i). The general aspect of this variety is similar to that of *E. pulcherrimus* (q.v.), with which it is sympatric in much of its range; the 2-nerved achenes and low subscapose stems are diagnostic.

Erigeron compositus **Pursh** Fern-leaf Daisy. Perennial caespitose cushion plants, with a shortened pluricipital caudex, the caudex branches densely clothed with brown marcescent leaf bases; herbage glandular and more or less spreading-hairy; leaves mainly basal, mostly 2- or 3-ternately lobed or dissected, 0.5–7 cm long; cauline leaves few and reduced upward, simple or ternate; stems subscapose, 2–20 (25) cm tall; heads solitary; involucres 8–20 mm wide, 5–10 mm high, the bracts glandular and spreading-hairy, commonly purplish at the tips; rays lacking, or developed and 20–60, blue, pink, or white, to 12 mm long and 2 mm wide; pappus simple; achenes 2-nerved, villous-hirsute. Sagebrush, rabbitbrush, aspen, aspen-fir, lodgepole pine, spruce-fir, and alpine tundra communities at 2375 to 3965 m in Beaver, Box Elder, Daggett, Duchesne, Emery, Garfield, Iron, Juab, Millard, Piute, Salt Lake, Sanpete, Sevier, Summit, Tooele, Uintah, Utah, Wasatch, Wayne, and Weber counties; Alaska to Greenland, south to California, Arizona, Colorado, South Dakota, and Quebec; 77 (xvi). This is an extremely variable apomictic species, with rare sexual individuals. Our material has been assigned to var. ***glabratus*** Macoun, which is separable from the type variety only problematically.

Erigeron coulteri **T.C. Porter in Port. & Coult.** Coulter Daisy. Perennial herbs from a rhizome or caudex; stems more or less spreading-hairy, mainly 1–6 dm tall; basal and cauline leaves ample or the cauline ones somewhat reduced, entire or toothed, the largest 6–15 cm long, 1–2.5 cm wide, oblanceolate to elliptic, lanceolate, oblong, or ovate; heads solitary or 2 or 3; involucres 10–15 mm wide, 6–10 mm high, the bracts densely white hirsute below with hairs having purplish black cross-walls, at least near the base, glandular to the tips; rays 40–80, ca 10–15 mm long, white to pink-purple; pappus simple; achenes sparsely hairy. Moist slopes in Salt Lake and Utah counties; Oregon to Wyoming, south to California, Nevada, and New Mexico; 8 (0).

Erigeron cronquistii **Maguire** Cronquist Daisy. Perennial herb, with short caudex branches clothed with brown leaf bases; stems 1.5–7 cm long, sparingly strigose; basal leaves 0.5–4 cm long, spatulate to oblanceolate or elliptic, petiolate, sparingly strigose; cauline leaves few or wanting; heads solitary, sometimes 2; involucres 5–8 mm wide, 3–5 mm high, glandular and spreading-hirsute, the bracts imbricate, green, often suffused with purple; rays 10–25, white or pale pink, 5–6 mm long, 1.3–2.1 mm wide; pappus single, or with a few shorter outer ones; achenes 2-nerved, sparingly hairy. Limestone cliffs at 1750 to 2600 m in the Bear River Range, Cache County; endemic; 2 (0). This beautiful, tiny plant is a near congener of *E. tener* (q.v.).

Erigeron divergens **T. & G.** Spreading Daisy. [*E. divaricatus* Nutt., not Michx.]. Annual, biennial, or short-lived perennial herbs from taproots; stems branched from the base and above, pubescent with spreading hairs, 0.5–5 (7) dm tall; basal leaves oblanceolate to spatulate, mainly 1–7 cm long, 2–10 mm wide, spreading-hairy, petiolate, usually lacking at anthesis; cauline leaves reduced upward; heads several to numerous; involucres 7–11 mm wide, 4–5 mm high, finely glandular and hirsute with long, spreading hairs, the bracts green, attenuate; rays ca 75–150, blue, pink, or white, ca 5–10 mm long, 0.5–1.2 mm wide, sometimes scarcely developed; pappus double; achenes 2 (4) -nerved, sparsely hairy. Riparian, rabbitbrush, sagebrush, pinyon-juniper, mountain brush, ponderosa pine, and aspen-spruce communities at 975 to 2900 m in Beaver, Cache, Daggett, Davis, Duchesne, Emery, Garfield, Grand, Iron, Kane, Millard, Piute, Salt Lake, San Juan, Sevier, Tooele, Uintah, Utah, Wasatch, Washington, and Weber counties; British Columbia to South Dakota, south to California, Arizona, and Mexico; 109 (xiii). Our materials have been segregated into two weak varieties differentiated as follows: var. ***cinereus*** Gray, with earliest flowers borne on long naked peduncles and plants later with long leafy stolons; and var. ***divergens,*** with earliest heads on leafy peduncles and plants not developing leafy stolons. The var. *cinereus* is evidently rare in Utah; 5 (ii).

Erigeron eatonii **Gray** Eaton Daisy. [*E. eatonii* f. *molestus* Cronq., type from the Stansbury Mountains]. Perennial herbs, from a short simple or branched caudex, this clothed with brown marcescent leaf bases, the taproot prominent; stems 5–38 cm tall, decumbent to ascending, usually purplish at the base, strigose or rarely more or less hirsute; leaves pubescent like the stem, the basal ones tufted, 1- (or more commonly) 3-nerved, acute, mainly 1.2–12 (15) cm long, 1–10 mm wide; cauline leaves numerous, reduced upward; heads 1–3 (7); involucres 8–15 mm wide, 5–8 mm high, the bracts imbricate, conspicuously glandular and more or less hirsute with spreading-ascending multicellular hairs, green or the tips purplish; rays about 20–50, white to blue or pink, mainly 4–10 mm long, 1–2.5 mm wide; pappus single or with a few short outer setae; achenes 2 (3) -nerved. Sagebrush, mountain brush, pinyon-juniper, ponderosa pine, aspen, spruce-fir, and alpine tundra communities at 1890 to 3630 m in all Utah counties except for Box Elder and Morgan; Oregon to Wyoming, south to California, Arizona, and Colorado; 171 (xxv). This is a widespread and variable species, with variants differing in size, in head dimensions, and in nature of the pubescence. The hirsute phase from the Stansbury Mountains has been designated as f. ***molestus*** Cronq.

Erigeron elatior **(Gray) Greene** Tall Daisy. [*E. grandiflorus* var. *elatior* Gray]. Perennial herbs, from a short caudex (seldom collected); stems mainly 4–7 dm tall, often purplish below, leafy throughout, spreading-hairy and more or less glandular above; leaves mainly 2.2–10 cm long, 6–28 mm wide, the lowermost smaller than the middle ones and commonly withered at anthesis, ovate-lanceolate to lanceolate, entire, the lower petiolate, becoming sessile and somewhat clasping upward; heads 1–3 (6); involucres 12–20 mm wide, 7–11 mm high, the bracts densely woolly-villous with long, flattened, shiny, multicellular hairs, some of which may have reddish purple cross-walls, subequal, long-attenuate apically, the tips glandular, purple, and reflexed; rays ca 75–150, pink or pink-purple (white), 12–20 mm long, 0.8–1.6 mm wide; pappus double; achenes 2-nerved, hairy. Meadows and openings in mountain brush and spruce-fir communities at 2440 to 3050 m in the La Sal Mountains of Grand and San Juan counties; Colorado and Wyoming. This is a beautiful asterlike plant with equably leafy stems and densely villous involucres; 4 (0).

Erigeron engelmannii **A. Nels.** Engelmann Daisy. Perennial herbs, with short branching caudex, this clothed with straw-colored to brown marcescent leaf bases; taproot definite; stems 3–24 (30) cm tall, decumbent to erect, strigose or the hairs ascending, multicellular; basal leaves 1–6 (10) cm long, 1.5–5 mm wide, linear-oblanceolate, the blades hairy like the stems, the basal margins long and coarsely ciliate; cauline leaves reduced but well distributed upward; heads 1–4; involucres 7–12 mm wide, 4–7 mm high, the bracts hirsute and more or less glandular, subequal, green, with brownish midrib and scarious apices; rays ca 35–100, white (rarely pink or blue), 5–12 mm long, 0.6–2 mm wide; pappus double; achenes 2-nerved, hairy. Salt desert shrub, sagebrush, rabbitbrush, and pinyon-juniper communities at 1370 to 2200 m in Box Elder, Cache, Daggett, Duchesne, Grand, Juab, Millard, Salt Lake, Sanpete, Sevier, Summit, Tooele, Uintah, and Utah counties; Oregon to Wyoming and Colorado; 28 (iii).

Erigeron filifolius **Nutt.** Thread-leaf Daisy. Perennial herbs, with branching woody caudex, the caudex branches clothed with brownish marcescent leaf bases; stems 10–30 (50) cm tall, more or less strigose; leaves 1–8 cm long, 0.3–3 mm wide, linear or filiform, strigose, the cauline ones distributed along the stem but smaller than the basal ones; heads 1-several; involucres 5–15 mm wide, 4–6 mm high, the bracts villous to strigose and commonly glandular as well, subequal or somewhat imbricate, greenish; rays ca 15–75, blue to pink or white, 3–12 mm long, 1–2 mm wide; pappus single or with a few outer setae; achenes 2-nerved, more or less hairy. The species is reported from Utah (Cache County, Logan, C. P. Smith 1737 RM) by Cronquist (1947), also Daggett County; British Columbia and Montana to California and Nevada; 1 (0).

Erigeron flagellaris **Gray** Trailing Daisy. Biennial or short-lived perennials, with a poorly developed caudex (if at all) and slender taproot; herbage strigose or with spreading hairs at stem base; stems 3–25 (40) cm tall, the fertile ones terminated by a solitary head, the sterile ones developed as leafy stolons; basal leaves 1–5 cm long, 1.5–8 mm wide, oblanceolate to spatulate; cauline leaves smaller upward, linear to oblanceolate; heads solitary; involucres 7–13 mm wide, 3.5–5 mm high, the bracts with appressed or spreading hairs, glandular, green to purplish; rays mostly ca 50–100, white, pink, or blue, 5–10 mm long, 0.8–1 mm wide; pappus double; achenes 2-nerved, hairy to almost glabrous. Sagebrush, juniper, ponderosa pine, aspen, spruce-fir, and alpine meadow communities at 1980 to 3180 m in Beaver, Carbon, Daggett, Duchesne, Emery, Garfield, Grand, Iron, Kane, Millard, San Juan, Sanpete, Sevier, Summit, Washington, and Wayne counties; British Columbia to Nevada, Arizona, and Texas; 63 (xi).

Erigeron formosissimus **Greene** Pretty Daisy. [*E. frucetorum* Rydb.]. Perennial herbs, with a simple or sparingly branched subrhizomatous caudex; herbage variously hirsute, glandular, or glabrous, the stems more or less glandular above, mainly 1.5–3 (4.5) dm tall; basal leaves the largest, mainly 2–10 (15) cm long, 4–10 (15) mm wide, oblanceolate to spatulate; cauline leaves commonly much reduced upward, lanceolate to oblong or ovate; heads 1–6; involucres 10–20 mm wide, 5–8 mm high, the bracts subequal, linear, acuminate, glandular, and more or less hirsute; rays ca 75–150, 8–15 mm long, ca 1 mm wide, blue, pink, or white; pappus double; achenes 2-nerved, hairy. Meadows in aspen and mountain brush communities at 2440 to 1840 m in Grand, Iron, Salt Lake, San Juan, and Sevier counties; Alberta south to Arizona and New Mexico; 5 (i). The species is poorly known in Utah (reports of the species in Iron county are from Cronquist 1947).

Erigeron garrettii **A. Nels.** Garrett Daisy. [*E. controversus* Greene]. Perennial subscapose herbs, with branching caudex, the caudex branches clothed with brown leaf bases; stems 3–23 cm tall, sparingly strigose; basal leaves 1.2–12 cm long, 3–13 mm wide, oblanceolate to spatulate, glabrous, sparingly ciliate; cauline leaves lacking or greatly reduced; heads solitary; involucres 8–17 mm wide, 5–8 mm high, the bracts finely strigose and obscurely glandular, moderately imbricate; rays ca 20–35, white to pink, 7–13 mm long, 1.4–2.7 mm wide; pappus double; achenes 2-nerved, hairy. Moist cliff faces and crevices at 2750 to 3570 m in Salt Lake, Utah, and Wasatch counties; endemic; 17 (0).

Erigeron glabellus **Nutt.** Smooth Daisy. Perennial or biennial herbs with simple or branched caudices, the caudex, when present, clothed with brown to blackish leaf bases; herbage strigose to hirsute; stems 1–6.5 dm tall, erect or nearly so; basal and lower leaves mainly 3–15 cm long, 3–18 mm wide, oblanceolate, entire or toothed, petiolate; middle cauline leaves lanceolate to linear, reduced upward; heads 1–12 (15), borne on bracteate peduncles; involucres 10–20 mm wide, 5–9 mm high, the bracts subequal to slightly imbricate, acuminate, strigose to strigulose; rays ca 125–175, blue to pink, or white; pappus double; achenes 2-nerved, hairy. Meadows and stream sides at 1370 to 1770 m in Beaver, Cache, Daggett, Davis, Duchesne, Salt Lake, Uintah, Utah, and Wasatch counties; Alaska and Yukon, south to Utah, Colorado, South Dakota, and Wisconsin; 12 (0). This is a tall handsome daisy of lower elevations in Utah.

Erigeron goodrichii **Welsh** Goodrich Daisy. Perennial herbs from a stout taproot and caudex, the caudex branches with dark brown marcescent leaf bases; stems 3–10 cm tall, decumbent-ascending to erect, spreading-hairy; basal leaves 0.4–6 cm long, 1.2–5 mm wide, narrowly oblanceolate, the veins not apparent, pilosulose, obtuse apically; cauline leaves more or less developed, but much reduced upward; heads solitary; involucres 10.5–18 mm wide, 6.4–7.8 mm high; bracts imbricate, spreading villous-pilose with multicellular hairs, thickened basally, green or the apices suffused purplish, the inner with scarious margins, the attenuate apices more or less glandular and sometimes spreading; rays 40–65, pink-purple to pink or white, 6.8–10.4 mm long, 1.5–2 mm wide; pappus apparently single, of 20–30 minutely barbellate bristles; achenes 2-nerved, pilose. Engelmann spruce krummholz and meadow communities, often on rock outcrops or talus at 3050 to 3400 m in Duchesne, Summit, Uintah, and Utah counties; endemic; 8 (0).

Erigeron jonesii **Cronq.** Jones Daisy. Perennial herbs, from a branching or simple caudex, the caudex branches clothed with blackish or dark brown marcescent leaf bases; herbage hirsute with short spreading hairs; stems mainly 10–25 cm tall, conspicuously decumbent and often purplish at the base; basal leaves 3-nerved, 1.5–8 cm long, 3–12 mm wide, oblanceolate to elliptic or spatulate, petiolate, entire or toothed; cauline leaves smaller than the basal; heads 1–4; involucres 9–15 mm wide, 5–7 mm high, the bracts glandular and spreading-hairy, slightly thickened dorsally, more or less imbricate, green, with tips often purplish; rays ca 25–50, blue, pink, or white, 4–8 mm long, 1.4–1.8 mm wide; pappus single or with a few short outer setae; achenes 2-nerved, hairy. Sagebrush, pinyon-juniper, mountain brush, and alpine meadow communities at 1890 to 3350 m in Juab, Tooele, and Washington counties; Nevada; 5 (iii). The Jones daisy simulates *E. eatonii* in habit and stature, but the definite spreading hairs of the herbage are apparently definitive in most instances. Possibly it would best be treated at some infraspecific rank within *E. eatonii*.

Erigeron kachinensis **Welsh & Moore** Kachina Daisy. Perennial herbs, from a short thick branching or simple caudex, the caudex branches clothed with brown marcescent leaf bases; herbage glabrous throughout; stems 6–18 cm tall, decumbent to erect; basal leaves 1.3–5 cm long, 2–13 mm wide, oblanceolate to obovate or spatulate, the blade tapering to the petiole, rounded or retuse apically, entire; cauline leaves 5–11, reduced upward; heads solitary or 2–4, the involucres 5–6 mm broad, 3.2–4 mm high, the bracts distinctly imbricate, some purplish at the tip, glabrous or minutely glandular; rays 10–15, white or pinkish, 3.5–5.5 mm long, 0.9–1.1 mm wide; pappus double; achenes 2-nerved, hairy. Seeps and hanging gardens at 1680 to 1890 m in White (type from Natural Bridges National Monument) and Dark Canyons, San Juan County, Utah, and Montrose County, Colorado; 3 (ii). This distinctive dwarf daisy is a Colorado Plateau endemic.

Erigeron leiomerus **Gray** Glaber Daisy. Perennial herbs, from a branching caudex, the caudex branches clothed with brown marcescent leaf bases; herbage glabrous or merely strigose; stems 4–12 (15) cm tall, decumbent to erect; basal leaves 1.3–7 cm long, 2–11 (15) mm wide, oblanceolate to spatulate or obovate, rounded to retuse apically, enlarged and often purplish basally, glabrous or strigose to glabrate; cauline leaves reduced upward, usually several, becoming acutish; head solitary, the involucres 7–13 mm wide, 4–6 mm high, the bracts somewhat imbricate, purplish overall or at tips, finely glandular; rays ca 15–60, purplish to blue or white, 6–11 mm long, 1.5–2.5 mm wide; pappus double; achenes 2-nerved, short-hairy. Talus slopes, boulder fields, and meadows in spruce and lodgepole pine and alpine tundra communities at 2950 to 3750 m in Beaver, Box Elder, Cache, Daggett, Duchesne, Juab, Piute, Salt Lake, Summit, Tooele, and Uintah counties; Nevada and Idaho to Wyoming, Colorado, and New Mexico; 27 (x).

Erigeron linearis **(Hook.) Piper** [*Daucopappus linearis* Hook.]. Perennial herbs from a pluricipital caudex, the branches of the caudex clothed with broad clasping brownish marcescent leaf bases; herbage strigose; stems 5–20 cm tall; basal leaves 1–9 cm long, 0.5–3 mm wide, linear to linear-oblanceolate, acute, the bases enlarged, more or less sheathing, straw colored and strongly ciliate; cauline leaves reduced upward; heads solitary or 2 or 3; involucres 8–13 mm wide, 4–7 mm high, strigose-villous with multicellular hairs and more or less glandular; bracts subequal to somewhat imbricate, green or greenish to straw colored, attenuate, thickened dorsally; rays ca 20–45, yellow, 4–11 mm long, 1.3–2.5 mm wide; pappus double, the inner of 10–20 barbellate bristles, the outer of scales; achenes 2-nerved, short hairy. Sagebrush and juniper communities at 1675 to 2000 m in Box Elder County; British Columbia, Washington, and Oregon, east to Idaho and Wyoming, and south to Nevada; 1 (0).

Erigeron lonchophyllus **Hook.** Short-lived perennial or biennial (?) herbs, with slender taproots and subfibrous roots from a poorly developed caudex; stems decumbent to erect, 5–55 (60) cm long, sparsely to densely spreading-hairy; basal leaves oblanceolate to spatulate, 1.2–11 (15) cm long, 2–12 mm wide; cauline leaves several to many, mostly 0.6–8 cm long, 2–6 mm wide; heads few to numerous, rarely solitary, borne on nearly erect peduncles; involucres 4–9 mm high, 7–17 mm wide, the bracts evidently imbricate, not especially thickened basally, greenish to brownish or yellowish, the tips commonly purplish, sparsely to moderately strigulose with multicellular hairs; rays numerous, white or pinkish, about 2–4 mm long, lacking inner eligulate pistillate corollas; pappus of ca 20–30 slender barbellate white bristles, surpassing the disk corollas; achenes 2-nerved, sparsely hairy. Marshes, stream banks, seeps, and wet meadows at 1370 to 2900 m in Beaver, Daggett, Duchesne, Garfield, Grand, Juab, Piute, Rich, Salt Lake, Sanpete, Sevier, Summit, Tooele, Utah, and Washington counties; Alaska and southern Yukon, south to California and New Mexico, and east to Quebec and South Dakota; 39 (vii).

Erigeron maguirei **Cronq.** Maguire Daisy. Perennial herbs, with a branching caudex, the caudex branches clothed with brown to straw-colored marcescent leaf bases; herbage spreading hirsute; stems 7–18 cm high, decumbent to sprawling or erect; basal leaves 2–5 cm long, 3–8 mm wide, oblanceolate to spatulate, rounded apically; cauline leaves well developed, but somewhat reduced upward, becoming acutish; heads solitary or 2–5; involucres 5–6.5 mm high, 7–11 mm wide, the bracts imbricate, not much thickened, green or yellowish, the inner less pubescent and with scarious purplish tips, all finely glandular also; rays 12–20, white or pinkish, ca 6–8 mm long, 1.1–2 mm wide; pappus of 13–25 slender barbellate sordid bristles, with a few shorter outer ones; achenes 2-nerved, hairy. Canyon bottoms in Wingate (?) and Navajo formations at 1640 to 1740 m in Emery and Wayne counties; endemic; 5 (ii). For the past four decades the Maguire daisy was known officially from the type locality in the San Rafael Swell in Emery County. Now, other material has been discovered at BRY and relocated in the field, which is distinguishable only technically from specimens at the type locality. These latter specimens tend to have more heads per stem, have narrower ray corollas, and shorter disk corollas. All of these may be the result of ecological responses, but they are recognized as var. ***harrisonii*** Welsh.

Erigeron mancus **Rydb.** [*E. pinnatisectus* (Gray) A. Nels. var. *insolens* Macbr. & Pays.]. Pulvinate caespitose subscapose perennials from a usually branched caudex, the caudex clothed with dark brown to straw-colored marcescent leaf bases; herbage more or less hirtellous and puberulent or minutely glandular; stems mainly 2–6 cm long, erect or ascending; basal leaves 1.2–4 cm long, 2–4 mm wide, pinnatifid, the lobes lanceolate, sometimes again lobed; cauline leaves much reduced; heads solitary; involucres 5–6.5 mm high, 7–12 mm wide, glandular, villous with multicellular hairs, the bracts subequal, somewhat thickened basally, the acuminate tips often purplish; ray flowers lacking; pappus simple or nearly so, of 20–30 bristles; achenes 2-nerved, hairy. Alpine forb and grass-sedge communities at 3050 to 3660 m in the La Sal Mountains, astride the Grand–San Juan County line; endemic; 3 (0).

Erigeron melanocephalus **(A. Nels.) A. Nels.** [*E. uniflorus* var. *melanocephalus* A. Nels.]. Perennial herbs, from a simple or branched caudex, the caudex branches clothed with dark brown marcescent leaf bases; herbage more or less villous with multicellular hairs; stems commonly 5–12 cm tall, erect; basal leaves 0.8–6 cm long, oblanceolate to spatulate, rounded or retuse apically; cauline leaves much reduced upward; heads solitary; involucres 10–14 cm wide, 5–9 mm high, the bracts more or less densely villous with multicellular hairs, the cross-walls black or dark purple, equal, attenuate, green, with purplish tips or purplish throughout; rays 50–70, white or pink, 7–11 mm long, 1.2–2 mm wide; pappus single, of ca 20–25 bristles; achenes 2-nerved, sparsely hairy. Alpine meadows at 3355 to 3720 m in Grand and San Juan counties (La Sal Mountains); Wyoming, Colorado, and New Mexico; 4 (0). Specimens from the Uinta Mountains, which have involucral hairs with purple cross-walls, have been assigned here previously, but they seem to represent nothing more than phases of *E. simplex* (q.v.).

Erigeron nanus **Nutt.** Dwarf Daisy. [*E. inamoenus* A. Nels.]. Perennial herbs, from a branching caudex, the caudex branches clothed with imbricate ashy to straw-colored marcescent leaf bases; stems 3–8 cm high, villous with contorted multicellular hairs, subscapose; basal leaves linear-oblanceolate, 1.2–4 cm long, 1–2 mm wide, hirtellous to sparingly villous or glabrous, ciliate toward base with spreading long hairs, the bases conspicuously enlarged; heads solitary; involucres 7–13 mm wide, 5–8 mm high, long-villous with multicellular hairs and more or less finely glandular; bracts subequal, the midstripe brown to purplish, the margins green to scarious or purplish; rays 15–35, purplish, 5–10 mm long, 1.3–2.4 mm wide; pappus of 15–25 bristles and some outer setae; achenes 2-nerved, hirsute. Sagebrush and sagebrush-grass communities, often on windswept ridges, at 2135 to 3270 m in Box Elder and Daggett counties; Idaho and Wyoming; 5 (0).

Erigeron nauseosus **(Jones) A. Nels.** Marysvale Daisy. [*E. caespitosus* Nutt. var. *nauseosus* Jones, type from near Marysvale]. Perennial herbs, from a stout branching brittle caudex, the branches clothed with dark brown marcescent leaf bases, the taproot similarly colored; stems 6–25 cm tall, ascending to erect, glandular-scabrous; basal leaves 2.3–10 cm long, 2–15 mm wide, oblanceolate to spatulate, rounded apically, tapering to the petiole, commonly 3-nerved; cauline leaves well developed, only gradually reduced upward; heads solitary, rarely 2; involucres 8–17 mm wide, 5–8 mm high, finely glandular (rarely sparingly strigose as well); bracts imbricate, somewhat thickened, often purplish, attenuate; rays 30–60, white or purplish, 6–12 mm long, 1.3–2 mm wide; pappus double, the inner of 12–23 bristles, the outer of inconspicuous setae; achenes 2-nerved, hairy. Crevices in limestone, quartzite, and igneous outcrops, and in talus in pinyon-juniper, sagebrush, mountain brush, and Douglas fir–white fir communities at 1830 to 2900 m in Beaver, Garfield, Millard, Piute, and Sevier counties; White Pine County, Nevada; a Great Basin endemic; 24 (iii).

Erigeron nematophyllus **Rydb.** Needleleaf Daisy. Perennial herbs, from a branching caudex, the caudex branches clothed with fibrous ashy to brown marcescent leaf bases; herbage strigose to subglabrous; stems 4–15 cm tall; basal leaves 1–8 cm long, 1–3 mm wide, linear to linear-oblanceolate, ciliate near the enlarged sheathing base; cauline leaves few and reduced, not especially exceeding the basal cluster; heads solitary; involucres 6–13 mm wide, 4–6.5 mm high;

bracts more or less imbricate, moderately strigulose, green or brown, the inner often with scarious margins and purplish tips; rays 15–55, white (less commonly pink), 4–8 mm long, 1.2–2.3 mm wide; pappus of ca 15–25 bristles; achenes 2-nerved, shortly hairy. Sagebrush, mountain brush, and pinyon-juniper communities, often on Green River Shale, at 2280 to 2870 m in Carbon, Daggett, Duchesne, and Uintah counties; Wyoming and Colorado; 7 (i).

Erigeron peregrinus **(Pursh) Greene** Strange Daisy. [*E. callianthemus* Greene; *E. peregrinus* ssp. *callianthemus* (Greene) Cronq.; *E. regalis* Greene; *E. peregrinus* var. *eucallianthemus* Cronq.; *E. peregrinus* var. *scaposus* (T. & G.) Cronq.; *E. salsuginosus* var. *scaposus* T. & G.]. Perennial herbs, from a rhizome, the rhizome sometimes short, dark brown; stems 0.9–5.5 (7) dm tall, glabrous or sparingly to moderately villous below, often densely villous below the heads; basal leaves 2–16 (20) cm long, 0.8–3.2 (4.5) cm wide, oblanceolate to spatulate or obovate, tapering or abruptly contracted to the petiole, obtuse or rounded to acute apically, glabrous or rarely sparingly villous, ciliate; cauline leaves reduced upward, becoming sessile and more or less clasping; heads solitary, or 2–6; involucres 12–22 (25) mm wide, 6–9 (11) mm high; bracts subequal, reflexed at the attenuate apices, glandular and purplish throughout; rays ca 30–75, 8–17 (25) mm long, 1.8–4 mm wide, rose-purple to white; pappus of ca 20–30 bristles, sometimes with a few outer setae; achenes 4- to 7-nerved, sparingly hairy. Aspen, spruce-fir, lodgepole pine, and sedge communities at 2280 to 3570 m in Box Elder, Cache, Duchesne, Garfield, Grand (?), Salt Lake, San Juan, Summit, Uintah, Wasatch, Weber, and Washington counties; Alaska south to California and New Mexico; 57 (x). Our materials were segregated by Cronquist (1947) into a dwarf alpine var. *scaposus* (T. & G.) Cronq. and a taller montane var. *eucallianthemus*. On the basis of the rather abundant materials at hand, there does not seem to be any means of recognition of those taxa, except arbitrarily. Thus, all our specimens are herein considered as belonging to ssp. ***callianthemus*** (Greene) Cronq. var. ***callianthemus***.

Erigeron proselyticus **Nesom** Professor Daisy. [*E. flagellaris* Gray var. *trilobatus* Maguire ex Cronq.]. Perennial herbs, from a subrhizomatous or substoloniferous caudex, the caudex branches with weakly persistent brown marcescent leaf bases; stems 14–25 cm tall, decumbent to ascending or erect, sparingly strigose; basal leaves 0.5–6.5 (7.5) cm long, 2–11 mm wide, oblanceolate to spatulate or linear, entire to pinnately few toothed or lobed, glabrous to sparingly strigose, acute to obtuse or rounded apically; cauline leaves gradually to abruptly reduced upward, entire or the lower few toothed; heads 3 to several; involucres 3.5–7 mm wide, 2.5–4.5 mm high, sparingly to moderately hirtellous; bracts subequal, brown, suffused with purple, or the inner greenish, with chartaceous margins; rays 22–46, white to purplish, 5.4–8.5 mm long, 1–1.4 mm wide; pappus double, the inner of 10–19 bristles, the outer of short setae; achenes 2- or 4-nerved, sparsely hairy. Bristlecone pine, spruce-fir, and aspen communities on sandstone and marly limestone formations at 2440 to 3050 m in Iron and Kane counties; endemic; 8 (i).

Erigeron pulcherrimus **Heller** Basin Daisy. Perennial herbs, from a branching caudex, the caudex branches with exfoliating brownish bark, not especially clothed with persistent leaf bases; herbage silvery or grayish strigose; stems (5) 9–32 (35) cm tall, erect; basal leaves 0.8–7 cm long, 1–3 (5) mm wide, linear to linear-oblanceolate; cauline leaves reduced upward, but generally developed to stem middle or above; heads solitary; involucres 10–20 mm wide, 6–9 mm high, coarsely villous with spreading-ascending, multicellular hairs, obscurely glandular apically; bracts imbricate, greenish, the midrib often brown, the margins chartaceous, acuminate-attenuate, especially the inner; rays ca 25–60, white, pink, or violet, 8–15 mm long, 2–3.7 mm wide; pappus of ca 30–50 bristles, the outer series more or less developed; achenes (2-) 3- to 5-nerved, densely hairy. Salt desert shrub and pinyon-juniper communities on saline and seleniferous clays, clay-silts, and gravelly pediments at 1310 to 2105 m in Carbon, Duchesne, Emery, Grand, Uintah, and Wayne counties; Wyoming, Colorado, and New Mexico. Our materials have been treated as belonging to a wide-leaved (1.5–5 mm) var. *wyomingia* (Rydb.) Cronq. and a narrow-leaved (1–1.5 mm) var. *pulcherrima*. However, only arbitrary segregation appears to be possible, and it seems best not to attempt recognition of infraspecific taxa; 61 (xiv).

Erigeron pumilus Nutt. Vernal Daisy. Perennial herbs, arising from a caudex, the branches clothed with ashy to brown marcescent leaf bases; herbage more or less hirsute with spreading hairs; stems 4–50 cm tall, leafy or subscapose; basal leaves 0.4–8 cm long, mostly 2–5 mm wide, linear-oblanceolate to oblanceolate; cauline leaves well developed, somewhat reduced, or much reduced upward, or almost lacking; heads solitary or few to numerous; involucres 7–15 mm wide, 4–7 mm high, sparingly to densely spreading-villous with multicellular hairs; bracts subequal, acuminate to attenuate, green, with brownish midrib; rays mostly 50–100, white or pink to lavender, 6–15 mm long, 0.7–1.5 mm wide (or more); pappus double, the inner of 7–20 coarse bristles, the outer of evident bristles or scales; achenes 2-nerved, sparsely to moderately hairy. Blackbrush, shadscale, sagebrush, pinyon-juniper, and mountain brush communities at 885 to 2960 m in all Utah counties; Washington to Saskatchewan, south to California, Arizona, New Mexico, and Kansas. Our highly variable material was segregated on technical characteristics by Cronquist (1947) into two subspecies, each with two varieties. The bulk of the Utah specimens belong to ssp. ***concinnoides*** Cronq., segregated in large measure from the much less common and more northern ssp. ***intermedius*** Cronq. by the fewer (7–15, not 13–20) inner pappus bristles and evidently puberulent (not glabrous or slightly puberulent) corolla tubes. The varieties *intermedius* (var. *euintermedius* Cronq.) and *gracilior* Cronq. of ssp. *intermedius* are only arbitrarily separable by stem thickness and head number. The weakly segregated varieties within ssp. *concinnoides*, var. *concinnoides* (var. *euconcinnoides* Cronq.) and var. *condensatus* (D. C. Eaton) Cronq., differ in degree of development of cauline leaves, with the former having more equably leafy stems and the latter tending to be subscapose. It seems best to treat our material as belonging to two variable taxa; ssp. *intermedius* and ssp. *concinnoides;* 212 (xxvi).

Erigeron religiosus **Cronq.** Religious Daisy. Short-lived perennial (or biennial?) herbs from a slender taproot and poorly developed caudex; herbage more or less strigose and glandular below the heads; stems 6–35 cm tall, decumbent-ascending to erect; basal leaves 2–5.5 (7) cm long, 2–8 mm wide (or more), oblanceolate to spatulate, entire or some pinnately toothed or lobed; cauline leaves gradually reduced upward; heads 2 to numerous; involucres 5.5–7.5 mm wide, 2–3.5 mm high, sparingly to moderately villous and more or less glandular; bracts with brown midrib, somewhat thickened, scarious apically; rays 35–85, white or pinkish, 3.4–6.8 mm long, 0.5–1.4 mm wide; pappus double, the inner of 6–12 bristles, the outer of short setae; achenes 2-nerved, sparsely hairy. Ponderosa pine-oak and pinyon-juniper communities at 1525 to 1830 m in Kane and Washington (type from Clear Creek Canyon) counties; endemic; 9 (iv).

Erigeron simplex **Greene** Greene Daisy. Perennial herbs, from a simple or branched caudex, the caudex clothed with dark brown marcescent leaf bases; herbage more or less viscid-villous with multicellular hairs; stems commonly 2–15 (20) cm tall; basal leaves 0.8–6 (8) cm long, 2–10 (13) mm wide, oblanceolate to spatulate, obtuse to abruptly acute or mucronate apically; cauline leaves reduced; heads solitary; involucres 8–22 mm wide, 5–10 mm high, moderately to densely villous and somewhat viscid, the hairs with clear to reddish purple or purplish black cross-walls; bracts equal, suffused with purple or green, appressed or some reflexed; rays 50–125, blue-purple to pink (or white), 7–11 mm long, 1.2–2.5 mm wide; pappus double, the inner of ca 10–15 barbellate bristles, the outer of conspicuous setae; achenes 2-nerved, sparsely hairy. Lodgepole pine, Engelmann spruce, alpine fir, and alpine meadow and tundra communities at 3355 to 3660 m (in Deep Creek, Tushar, La Sal, and Uinta mountains) in Beaver, Daggett, Duchesne, Juab, Piute, San Juan, Summit, and Uintah counties; Oregon to Montana, south to Nevada, Arizona, and New Mexico; 30 (vi). Our variable materials include specimens with purplish-black cross-walls of the multicellular hairs, especially on the involucres and below the heads. These have been placed with the similar and related *E. melanocephalus* (q.v.), but differ in shape of lower leaves and general aspect of the plants.

Erigeron sionis **Cronq.** Zion Daisy. Low perennial herbs, with short stoloniferous branches arising from a slender taproot; stems 1.5–13.5 cm long, decumbent to erect, glabrous or appressed pubescent; basal leaves 0.5–3.5 cm long, 2–10 mm wide, oblanceolate to obovate, entire or more commonly 3- to 5-lobed, glabrous or sparsely strigose; heads solitary or 2 to several; involucres 5–7 mm wide, 2–3 mm high, glandular and sparsely to moderately spreading-hairy; bracts suffused purplish or the inner green with chartaceous margins; rays 23–38, white, the midstripe below purplish, 3.9–6.1 mm long, 1–1.6 mm wide; pappus double, the inner of 7–13 bristles, the outer of slender setae; achenes 2-nerved, sparsely pubescent. Seeps and hanging gardens in ponderosa pine and riparian communities in Navajo and Wingate sandstones at 1350 to 1600 m in Zion National Park, Washington and Kane (?) counties; endemic; 3 (i).

Erigeron speciosus **(Lindl.) DC.** Oregon Daisy. Rhizomatous perennial herbs with the caudex more or less developed; stems 1.5–9 cm tall, ascending to erect, spreading-hairy to subglabrous or glandular above; basal leaves often lacking at anthesis, the lowermost cauline ones oblanceolate to spatulate, petiolate, commonly 5–15 cm long, 4–20 mm wide; middle cauline leaves lanceolate to oval, oblanceolate, or elliptic, 2–11 cm long, 5–28 mm wide; upper leaves gradually to markedly reduced, lanceolate to obliquely ovate, ciliate, the surfaces glabrous, spreading-hairy, or glandular (or a combination); heads 1–15 (or more); involucres 11–22 mm wide, 5.5–9 mm high, glandular, with a few long hairs, or more or less spreading-hairy; bracts subequal, acuminate or attenuate, the tips more or less spreading, often suffused purplish; ray flowers ca 75–150, pink, pink- or blue-purple, or white, 7–18 mm long, 0.7–1 mm wide; pappus double, the inner of 20–30 bristles, the outer of more of less evident setae; achenes 2- to 4-nerved, hairy. The *speciosus* complex in Utah, as herein interpreted, consists of four variable, and more or less intergrading, largely sympatric infraspecific taxa. All have been treated previously at specific rank, or they have been treated within *E. speciosus,* in part. Cronquist (1947) discussed the problem of intermediacy in the complex but hesitated to combine the taxa because "such a treatment would distort the facts as well as being unwieldy." It is here contended that they are unwieldy apart; it seems therefore best to combine them as follows:

1. Leaves spreading-hairy on one or both surfaces; involucres spreading-hairy and more or less glandular .... *E. speciosus* var. *mollis*
— Leaves glabrous on both surfaces or minutely glandular, or with minute strigose hairs, rarely with a few spreading multicellular hairs 2
2(1). Leaves glandular on the surfaces (especially the upper ones), and also ciliate .... *E. speciosus* var. *uintahensis*
— Leaves glabrous on both surfaces, ciliate 3
3(2). Involucral bracts merely glandular, rarely also somewhat spreading-hairy; upper leaves often ovate .... *E. speciosus* var. *macranthus*
— Involucral bracts glandular and commonly also spreading-hairy; upper leaves lance-attenuate .... *E. speciosus* var. *speciosus*

Var. ***macranthus*** **(Nutt.) Cronq.** [*E. grandiflorus* Nutt., not Hook.; *E. macranthus* Nutt.]. Sagebrush, snowberry, aspen, spruce-fir, and alpine meadow communities at 1760 to 3420 m in Beaver, Box Elder, Cache, Carbon, Duchesne, Emery, Garfield, Grand, Juab, Kane, Millard, Piute, Rich, Salt Lake, Sanpete, Sevier, Tooele, Utah, Wasatch, Washington, and Weber counties; Washington and Alberta south to Nevada, Arizona, and New Mexico; 104 (xv). This is our most common phase, but it is only arbitrarily separable from var. *speciosus,* to which it is completely transitional.

Var. ***mollis*** **(Gray) Welsh comb. nov.** [based on: *Erigeron glabellus* var. *mollis* Gray

Proc. Acad. Nat. Sci. Philadelphia 1863: 64. 1864.]. Aspen, spruce-fir, and meadow communities at 2070 to 3050 m in Carbon, Duchesne, Garfield, Grand, Juab, Salt Lake, San Juan, Sanpete, Sevier, Uintah, Utah, and Wasatch counties; Montana to South Dakota, and south to New Mexico and Nebraska; 20 (i). This variety includes what has traditionally been called *E. subtrinervis* Rydb.

Var. *speciosus* [*Stenactis speciosa* Lindl.]. Mountain brush, sagebrush, ponderosa pine, aspen, spruce-fir, and alpine meadows at 2040 to 3300 m in Duchesne, Garfield, Grand, Iron, Juab, Piute, San Juan, Sanpete, Sevier, and Utah counties; British Columbia and Montana, south to Nevada and New Mexico; 23 (iv).

Var. *uintahensis* (Cronq.) Welsh comb. nov. [based on: *Erigeron uintahensis* Cronq. Bull. Torrey Bot. Club 70: 270. 1943]. Sagebrush, mountain brush, ponderosa pine, aspen, lodgepole pine, spruce-fir, and alpine meadow communities at 2070 to 3420 m in Beaver, Carbon, Daggett, Duchesne, Juab, Piute, Sanpete, Sevier, Summit, Uintah, Utah, and Wasatch counties; Wyoming; 39 (vi). The glandular condition of the leaves varies in amount and position, and the Uinta phase passes by degree into other taxa of the *speciosus* complex. Because of the intergradation it seems best that this most distinctive portion of the variation should be treated within an expanded *E. speciosus*.

***Erigeron superbus* Greene ex Rydb.** Splendid Daisy. Rhizomatous perennial herbs and with the caudex more or less developed, the perennating branches bearing brown marcescent leaf bases; herbage glabrous or glandular above and villous in some below the heads; stems 1–6 dm tall, erect; basal leaves smaller than the cauline and commonly present at anthesis, 3–15 cm long, 6–25 (33) mm wide, oblanceolate to obovate or spatulate, petiolate; middle cauline leaves somewhat smaller than the lower ones, oblong to elliptic or lanceolate, glandular (glabrous), the uppermost sessile and glandular, rarely some denticulate, not ciliate; heads 1–7; involucres 11–19 mm wide, 7–10 mm high; bracts subequal, glandular, sometimes with long spreading hairs near the base, acuminate, sometimes suffused purplish; rays 40–95, 1–2 mm wide, 12–20 mm long, rose-purple or white; pappus double, the inner of 20–25 pinkish or tawny bristles, the outer of setae; achenes 2-nerved, hairy. Aspen, Douglas fir, lodgepole pine, and spruce-fir communities at 2250 to 3050 m in Carbon, Garfield, Kane, Piute, San Juan, Summit, and Uintah counties; Wyoming south to Arizona and New Mexico; 18 (v).

***Erigeron tener* Gray** Thin Daisy. Perennial herbs, from a branching caudex, the slender branches with ashy to brownish marcescent leaf bases; herbage strigose; stems slender, decumbent, ascending, or erect, 3–15 cm tall; basal leaves 1–7.5 cm long, oblanceolate to elliptic, rhombic, or obovate, petiolate, acute to obtuse apically; cauline leaves much reduced; heads solitary or 2 or 3; involucres 6–10 (12) mm wide, 3.5–5 mm high, glandular and with spreading multicellular hairs; bracts imbricate, somewhat thickened, brownish, the inner membranous or somewhat scarious, sometimes suffused with purple; rays ca 15–40, purplish or white, 4–8 mm long, 1–1.7 mm wide; pappus double, the inner of 15–30 bristles, usually with slender outer setae; achenes 2-nerved, hairy to subglabrous. Sagebrush, mountain brush, pinyon-juniper, and white fir–Douglas fir communities, often on limestone outcrops at 1980 to 2900 m in Beaver, Juab, Millard, Rich, Sanpete, Tooele, and Utah counties; Oregon to Wyoming south to California and Nevada; 10 (i)

***Erigeron untermannii* Welsh & Goodrich** Untermann Daisy. Perennial pulvinate herbs with an intricately branched caudex, the caudex branches mainly basal, 0.8–3.3 cm long, 1–4 mm wide, narrowly oblanceolate to spatulate, pilosulose with ascending, often curved, hairs; scapes 2–6 cm tall; heads solitary; involucres 7–11 mm wide, 5–5.7 mm high, the bracts more or less imbricate, green, or the inner somewhat chartaceous, the margins hyaline, the tips suffused with purple (sometimes throughout), densely hispidulous with short spreading hairs; rays 14–26, white, 4–6.5 mm long, 1.5–2.1 mm wide; pappus apparently single, of ca 20 slender fragile bristles; achenes 2-nerved, pilose. Pinyon-juniper community on calcareous shales and sandstones of the Uinta and Green River formations at 2135 to 2380 m in Duchesne and Uintah counties; endemic; 4 (0).

Erigeron ursinus **D.C. Eaton** Bear Daisy. Perennial rhizomatous sod-forming herbs, the perennating organs arising from short superficial branches clothed with brown marcescent leaf bases; herbage subglabrous to strigose or variously ascending- or spreading-hairy; stems ascending, 5–25 (30) cm tall; basal leaves 1.2–12 cm long, 2–11 mm wide, oblanceolate to oblong, commonly acute or acutish apically, ciliate, the surfaces glabrous or variously hairy; cauline leaves reduced upward; heads solitary or 2 or 3; involucre 9–19 mm wide, 5–7 mm high, glandular and spreading-hairy with multicellular heads; bracts subequal, green or suffused purplish at the usually reflexed tips; rays ca 30–100, pink or blue-purple, 6–15 mm long, 1–2 mm wide; pappus double, the inner of ca 10–20 bristles, the outer of setae or scales; achenes 2-nerved, hairy. Sagebrush, aspen, lodgepole pine, and spruce-fir communities, often in forb-grass or forb-sedge meadows at 2440 to 3660 m in Beaver, Cache, Carbon, Daggett, Duchesne, Emery, Garfield, Grand, Iron, Juab, Kane, Piute, San Juan, Sanpete, Sevier, Summit, Uintah, Utah, Wasatch, and Wayne counties; Idaho and Montana, south to Nevada and Arizona; 95 (x).

Erigeron utahensis **Gray** Utah Daisy. Perennial herbs from a branching caudex, the branches with grayish marcescent leaf bases and usually densely clothed with white villous-pilose hairs; stems 10–60 cm tall, erect, appearing grayish or silvery due to strigose hairs; basal and lowermost cauline leaves 1.5–10 cm long, 1–6 mm wide, linear-oblanceolate, commonly withered or lacking at anthesis; cauline leaves gradually reduced upward; heads solitary or few to many; involucres 5–15 mm wide; 3–7 mm high, strigose and often glandular apically; bracts imbricate, brownish, the inner with scarious margins; rays ca 10–40, blue, pink, or white, 4–18 mm long, 1–2.7 mm wide; pappus double, the inner of ca 20–30 bristles, the outer of setae; achenes 4-nerved, more of less pilose. Two rather weakly separable varieties are present in Utah, as follows:

1. Stem bases not densely white-pilose; involucres mainly less than 8 mm wide; plants uncommon .... *E. utahensis* var. *sparsifolius*
— Stem bases densely white-pilose; involucres commonly more than 10 mm wide; plants common .... *E. utahensis* var. *utahensis*

Var. *sparsifolius* (Eastw.) Cronq. [*E. sparsifolius* Eastw. and *Wyomingia vivax* A. Nels, both types from San Juan County]. Sandstone outcrops in salt desert shrub and pinyon-juniper communities, often in shaded mesic areas, at 1220 to 1900 m in Emery, Garfield, Kane, and San Juan counties; Colorado and Arizona; 9 (iv).

Var. *utahensis* [*E. stenophyllus* var. *tetrapleuris* Gray]. Creosote bush, blackbrush, warm desert shrub, pinyon-juniper, and Mountain brush communities at 900 to 2000 m in Emery, Garfield, Grand, Iron, Kane, San Juan, Washington, and Wayne counties; Colorado and Arizona; 75 (vii).

Erigeron vagus **Payson** Payson Daisy. Caespitose perennial herbs, from a diffuse caudex, the branches commonly soboliferous; herbage moderately villous and glandular; leaves mainly basal, tufted at the apex of the caudex branches, 0.5–2.5 cm long, palmately 3-toothed or -lobed; heads solitary, subscapose; involucres 8–16 mm wide, 5–7.5 mm high, spreading-hairy and more or less glandular; bracts subequal, commonly suffused purplish at the attenuate apices; rays ca 25–35, white or pink, 4–7 mm long, 1–2 mm wide; pappus simple, of about 20 bristles; achenes 2-nerved, sparingly hairy. Ponderosa pine western bristlecone pine, and sedge-forb communities at 2375 to 3660 m in Garfield, Grand, Iron, and San Juan counties; California east to Colorado; 9 (0).

Erigeron wahwahensis **Welsh** Wah Wah Daisy. Perennial herbs, from a branched caudex, the caudex branches with conspicuous fibrous brown to ash-colored marcescent leaf bases; stems 15–40 cm long, decumbent to ascending; basal leaves 3–18 cm long, 4–13 mm wide, linear-oblanceolate to oblanceolate or elliptic, 3-nerved, petiolate, appressed to spreading-hairy with curved hairs; cauline leaves reduced, sessile, and bracteate above; heads solitary or 2 or 3; involucres 13–17 mm wide, 6–7 mm high, spreading-villous with multicellular hairs, glandular apically; bracts imbricate, green, the tips reddish, thickened basally; rays 30–40, pink or white, 5.5–7 mm long, 1.7–2.2 mm wide; disk corollas 3.5–4.2 mm long, the tube ca 2 mm long, the lobes 0.4 mm long; pappus of 15–20 bristles, with inconspicuous outer setae; achenes 2-nerved, short-hairy. Sagebrush, oak-maple, and pinyon-juniper communities at 1670 to 2440 m in Beaver and Washington counties; endemic; 7 (iii). The Wah Wah daisy stands between the distributions of *E. jonesii* and *E. eatonii*, and it shares features of both. The specimens examined from Washington County have appressed strigose stems, and are highly variable. Those from the Wah Wah Mountains have spreading hairy stems. Additional work is indicated.

ERIOPHYLLUM Lag.

Annual or perennial woolly herbs; leaves alternate, entire or toothed to lobed; heads solitary or corymbosely clustered; radiate; rays few, pistillate and fertile, yellow or white; involucres campanulate or hemispheric; bracts 1 (apparently 2) -seriate, firm, erect; receptacle flat to low-conic, naked; disk flowers perfect, fertile, the tube glandular or hairy; pappus of firm nerveless chaffy scales; style branches flattened; achenes 4-angled.

CONSTANCE, L. 1937. A systematic study of the genus *Eriophyllum*. Univ. California Publ. Bot. 18: 69–136.

1. Plants perennial .... *E. lanatum*
— Plants annual 2
2(1). Rays white; pappus of unequal scales .... *E. lanosum*
— Rays yellow; pappus of equal scales or reduced to a short crown .... *E. wallacei*

Eriophyllum lanatum **(Pursh) Forbes** Perennial herbs, the herbage tomentose; stems erect or decumbent from a ligneus base, mainly 10–20 cm tall; leaves mainly 1–4 cm long, entire or 3- to 5-toothed or -lobed; heads solitary or corymbose on naked peduncles 3–10 cm long; involucres campanulate, 6–10 mm wide, 6–8 mm high; bracts 5–8 (10), carinate, distinct, the tips erect; rays 5–8 (10), yellow, 6–10 mm long, 2–5 mm wide; pappus of 8–10 variable scales; achenes 2.5–4 mm long, 4-angled, variously glabrous, hairy, or glandular. Sagebrush community (reported from Utah in the Pacific Northwest Flora); British Columbia to Montana, south to California, Nevada, and Wyoming; 0 (0). Our material likely belongs to var. *integrifolium* (Hook.) Smiley.

Eriophyllum lanosum **(Gray) Gray** [*Actinolepis lanosa* Gray]. Annual floccose-tomentose herbs; stems mainly 2–10 cm tall, simple and erect or branching from the base; leaves 0.5–1.8 cm long, 1–2 mm wide, linear to linear-oblanceolate, entire or essentially so; heads turbinate, solitary on named peduncles 0.5–5 cm long; involucres 5–6.5 mm wide, 5–7 mm high; bracts 8–10, oblong, acute, distinct or nearly so; rays 5–10, white, 3–5 mm long, 2.5–3.5 mm wide; pappus of ca 5 slender hyaline awn-tipped scales; achenes 2.5–4.5 mm long, slender, sparsely strigulose. Creosote bush, blackbrush, and Joshua tree communities at 700 to 900 m in Washington County; California, Nevada, and Arizona; 13 (i).

Eriophyllum wallacei **(Gray) Gray** [*Bahia wallacei* Gray]. Annual tomentose herb; stems mainly 1–8 cm tall, simple or branched from the base; leaves 0.5–1.5 cm long, spatulate to obovate, entire or 3-lobed; heads solitary, turbinate-cylindric, on short peduncles; involucres 4–6 mm wide, 5–7 mm high; bracts 6–10, ovate, distinct; rays 5–10, yellow, 3–4 mm long, 2.5–3.5 mm wide; pappus of 6–10 scales or none; achenes ca 2 mm long, linear, hairy or glabrous. Larrea, blackbrush and Joshua tree communities at 700 to 900 m in Washington Co.; California, Nevada, Arizona, and Mexico; 32 (iii).

EUPATORIUM L.

Perennial herbs; leaves alternate, opposite, or whorled, simple; heads discoid, the flowers all perfect and tubular; involucres cylindric to campanulate, the bracts striate, imbricate; receptacle naked, mainly flat; anthers obtuse and entire basally, or minutely sagittate; style branches with short stigmatic lines and an elongate papillate appendage; pappus of numerous capillary bristles; achenes 10-nerved.

1. Leaves alternate; plants of Box Elder County .... *E. occidentale*
— Leaves opposite or whorled; plants of various distribution 2
2(1). Leaves opposite; flowers white to cream .... *E. herbaceum*
— Leaves whorled; flowers purple or purplish .... *E. maculatum*

Eupatorium herbaceum **(Gray) Greene** [*E. ageratifolium* var.? *herbaceum* Gray]. Perennial herbs from a woody caudex; stems 4–7 dm tall, branched above; herbage scabrous-puberulent; leaves mainly opposite, the blades 1.5–6 cm long, 0.5–4 cm wide, ovate, the bases cordate or truncate, coarsely crenate-serrate, acute; heads numerous, in dense corymbose clusters; involucres 3.5–5 mm wide, 3–4 mm high; bracts green, puberulent, subequal; corollas white; achenes black, 1.5–2 mm long. Ponderosa pine and spruce-fir communities at 1585 to 2745 m in Piute and Washington counties; California and Arizona; 2 (ii).

Eupatorium maculatum **L.** Joe-Pye Weed. [*E. bruneri* Gray]. Robust perennial herbs from short subrhizomatous caudices; stems mainly 6–15 dm tall, branching in the inflorescence; herbage puberulent and glandular-dotted; leaves in whorls of 3 or 4, mainly 6–25 cm long and 1.5–7 cm wide, lanceolate to lance-elliptic or lance-ovate, sharply serrate; heads numerous in corymbose clusters; involucres 3.5–5 mm wide, 6.5–9 mm high, the outer puberulent, the inner glabrous dorsally, often ciliate, purplish to straw colored; flowers purple; achenes ca 3 mm long, green to brown, glandular-dotted. River and canal banks, wet meadows, bogs, and seeps at 1370 to 1865 m in Box Elder, Cache, Kane, Uintah, and Utah counties; British Columbia to Newfoundland, south to New Mexico, Illinois, and Michigan. Our material belongs to var. ***bruneri*** (Gray) Breitung; 15 (i).

Eupatorium occidentale **Hook.** Perennial herbs from a rhizome and with a branching caudex; stems 1.5–7 dm tall, often branched above; herbage scabrous-puberulent; leaves alternate, the blades mainly 1.5–6 cm long, 0.6–3 cm wide, deltoid or deltoid-ovate, serrate or subentire; heads numerous, in compact corymbose clusters; involucres 3–5 mm wide and as high; bracts subequal, puberulent, green or suffused with purple; flowers pink or purplish; achenes ca 3 mm long, brown, glandular-dotted. Rock crevices and talus (usually in quartzite) at 2135 to 2745 m in Box Elder and Tooele counties; Washington to Idaho, south to California and Nevada; 2 (0).

FILAGO L.

White-tomentose annual herbs; leaves entire, alternate; heads discoid, small, in capitate clusters; involucre reduced, the bracts resembling those of the receptacle; outer flowers pistillate, fertile, with tubular-filiform corolla, in several series, the outer epappose and subtended by concave, partly enclosing bracts, the inner bractless and with pappus of capillary bristles; central flowers 2–5, apparently perfect, but often sterile, bractless, with capillary bristles; achenes subterete, nerveless.

Filago californica **Nutt.** Annual herbs, the stems erect, simple or branched above, 0.5–3 dm tall; leaves 0.8–2 cm long, narrowly oblong to oblanceolate; heads ovoid, 3–4 mm high, subequal to involucrate leaves; bracts of outer pistillate flowers 8–10, tomentose, boat shaped, the tips hyaline, the inner ones thinner and less hairy, the inner florets ca 12–20; inner achenes papillose. Warm desert shrub at 915 to 1070 m in Washington County; Arizona and California; 3 (2).

FLAVERIA Juss.

Annual herbs; leaves opposite, sessile, more or less connate; heads several to numerous, in compact corymbose clusters; involucres cylindric; bracts carinate, striate, 2–5, subequal; receptacles naked; ray flowers pistillate, fertile, commonly 1 per head, yellowish, inconspicuous; disk flowers 2–5, perfect, fertile, yellowish; anthers not caudate at the base; pappus none; achenes 8- to 10-ribbed, glabrous.

Flaveria campestris **J.R. Johnst.** Plants 12–85 cm tall, simple or branched, glabrous or hairy at the nodes; leaves 1–8 cm long, 0.4–1.5 cm wide, lance-oblong to linear, serrate to subentire, commonly 3-veined, glabrous; inflorescence leafy bracted; involucres 5–8 mm high, the longer inner bracts mostly 3, strongly keeled, glabrous;

rays ca 1–2 mm long; achenes black, ca 3 mm long. Sand bars, stream banks, and seeps at 1220 to 1680 m in Grand and Tooele counties; Colorado to Missouri, south to New Mexico and Texas; 7 (iii).

Gaillardia Foug.

Perennial (or biennial or annual) herbs; leaves alternate or mainly basal, entire or pinnatifid; heads radiate, the rays yellow, 3-lobed, neuter or sometimes pistillate and fertile; involucres 2- or 3-seriate, herbaceous, more or less spreading, reflexed in fruit; receptacle convex, with numerous setae; disk flowers perfect, fertile; anthers auricled at the base; pappus of 5–10 scarious, awned scales; achenes broadly obpyramidal, long-hairy.

1. Disk flowers purple or purplish 2
— Disk flowers yellow 3
2(1). Base of involucral bracts densely long-villous or the corolla lobes 5–11 mm long, or both; plants mainly montane in northeastern Utah .... *G. aristata*
— Base of involucral bracts not especially hairy, the corolla lobes mainly less than 5 mm long; plants of lower elevations in southeastern to southwestern Utah .... *G. pinnatifida*
3(1). Stems with well developed, pinnately dissected cauline leaves; plants of canyon bottoms of the Tavaputs Plateau .... *G. flava*
— Stems subscapose, or, if the cauline leaves well developed, merely toothed or lobed, and plants mainly of other distribution 4
4(3). Pappus scales broadly oblong or oval, awnless or abruptly short awned; plants annual, reported for southern Utah .... *G. arizonica* Greene
— Pappus scales oblong-lanceolate, awned; plants perennial, rarely flowering the first year 5
5(4). Leaves mainly basal, entire or rarely some of them toothed or lobed .... *G. parryi*
— Leaves cauline, toothed, lobed or entire .... *G. spathulata*

Gaillardia aristata **Pursh** Blanketflower. Perennial herbs from a slender taproot; stems 20–80 cm tall, commonly foliose to middle or above, less commonly with basal leaves only; leaves 1.5–16 cm long, 3–25 mm wide, oblong to oblanceolate or elliptic, entire or toothed to pinnatifid, puberulent and sparingly long-villous with multicellular hairs; heads solitary or few, long peduncled; disk mainly 2–2.5 cm wide, purple; involucral bracts (and/or peduncle apex) commonly long-villous basally, green or suffused with purple, attenuate; rays 6–16, yellow, often purplish at the base, the lobes 5–12 mm long; setae of receptacle well developed; disk corollas densely woolly-villous, the hairs with reddish purple cross-walls, often obscuring the attenuate lobes; pappus of slender lance-attenuate scales, the caudate apex entire; achenes ca 1.5 mm long, ruffous-pilose. Pinyon-juniper, ponderosa pine, aspen, lodgepole pine, and spruce-fir communities at 2135 to 2870 m in Daggett and Uintah counties; British Columbia to Saskatchewan, south to Oregon, Colorado, and South Dakota; 9 (ii). A specimen by Neese (5711 BRY) is only sparingly villous on the basal portion of the bracts. The species is known from cultivation in Utah and Emery counties; 3 (0).

Gaillardia flava **Rydb.** Perennial herbs from a subrhizomatous woody caudex; stems 20–50 cm tall, foliose to the middle or above; leaves 2–5 cm long, 4–25 mm wide, pinnately incised, minutely puberulent and glandular-punctate; heads solitary, on peduncles to 25 cm long; disk 17–32 mm wide, yellow; involucral bracts sparingly to moderately villous, green, caudate-attenuate; rays 8–12, yellow, the lobes 3–5 mm long; setae of receptacle well developed, coarse and spinescent; disk corollas sparingly villous, the hairs with colorless cross-walls, the lobes acute; pappus scales oblong to oblanceolate, abruptly contracted to a barbellate appendage; achenes ca 1–1.5 mm long, yellowish pilose. Stream terraces and valley bottoms, commonly in cottonwood, willow, and tamarix communities at 1280 to 1650 m in Emery (type from Lower Crossing) and Grand counties; endemic; 6 (v). The plants are extremely resinous glandular, with a very bitter-flavored exudate.

Gaillardia parryi **Greene** [*G. acaulis* Gray]. Perennial herbs from a woody caudex; stems 10–35 cm tall; foliose basally, less commonly with some leaves cauline; leaves 2.5–9 cm long, 8–25 mm wide, petiolate, the blades ovate to elliptic, sparingly puberulent, minutely glandular-punctate, entire or irregularly lobed, obtuse; heads solitary on scapose peduncles; disks 17–32 mm wide, yellow; involucral bracts sparingly villous, green, attenuate; rays ca 8–12, yellow, the lobes 3–5 mm long; setae of receptacle copious, surpassing achenes; disk corollas sparingly villous, hairs with translucent cross-walls, the lobes acutish; pappus scales lanceolate, rather abruptly contracted to a smooth bristle; achenes ca 1.5 mm long, yellowish pilose. Pinyon-juniper and ponderosa pine communities, often in disturbed sites, at 1525 to 1830 m in Garfield, Kane, and Washington counties; northern Arizona; 7 (i).

Gaillardia pinnatifida **Torr.** [*G. mearnsii* Rydb.; *G. crassifolia* Nels. & Macbr., type from LaVerkin; *G. gracilis* A. Nels., type from Diamond Valley; and *G. straminea* A. Nels., type from LaVerkin]. Perennial (less commonly biennial or annual) herbs, the caudex seldom well developed; stems 8–55 cm tall, foliose to the middle, less commonly all leaves basal; leaves 1–7.5 cm long, 2–15 mm wide, petiolate; blades ellliptic to oblanceolate or linear-oblong, puberulent and minutely glandular-punctate, pinnatifid to entire, acute to obtuse; heads solitary, on long peduncles; disks 15–35 mm wide, purple; involucral bracts moderately to sparingly villous, green or suffused purplish, caudate-attenuate; rays 7–12, yellow, the lobes 2–5 mm long; setae of receptacle spinescent; disk corollas sparingly villous, hairs with translucent or reddish cross-walls, the lobes acute; pappus scales oblanceolate, abruptly contracted to a scabrous awn; achenes ca 2 mm long, white-pilose. Blackbrush, shadscale, ephedra-vanclevea, and pinyon-juniper communities at 915 to 1830 m in Carbon, Emery, Garfield, Grand, Kane, San Juan, Washington, and Wayne counties; Colorado and Arizona to Texas and Mexico; 75 (ix).

Gaillardia spathulata **Gray** Perennial herbs from a taproot and caudex; stems 6–35 cm tall, commonly foliose to middle or above; leaves 1–7.5 cm long, 0.4–2.3 cm wide, petiolate to sessile; blades oblanceolate to elliptic or ovate to oval, sparingly villous and glandular-punctate, entire or variously toothed or lobed, obtuse; heads solitary or few, on long peduncles; disks 18–33 mm wide, yellow; involucral bracts moderately to densely villous-pilose, green, lance-attenuate; rays 7–10, yellow, the lobes 2–4 mm long; setae of receptacle short, spinescent; disk corollas shortly villous on the obtuse lobes, the hairs with colorless cross-walls; pappus scales oblong-lanceolate, abruptly contracted to a scabrous awn; achenes ca 3.5 mm long, yellowish pilose. Salt desert shrub and shrub-grass communities at 1220 to 2320 m in Carbon, Emery, Garfield, Grand, and Wayne counties; endemic; 58 (xi).

GERAEA T. & G.

Annual herbs; leaves alternate; heads radiate, showy, solitary or few in a corymbose panicle; involucres hemispheric, 2- or 3-seriate; bracts white-ciliate; receptacle convex, the bracts clasping the achenes; rays neuter, yellow; pappus of two awns, connected by a low whitish crown; disk achenes flat, cuneate, villous-ciliate, black.

Geraea canescens **T. & G.** Desert Sunflower. Annual herbs; stems 2–6 dm tall, simple or branched, white-hirsute, glandular; leaves 1–7 cm long, 0.8–4 cm wide, lanceolate to oblanceolate or ovate, acute to obtuse, entire or few toothed, reduced upward; heads showy, borne on slender, often bracteate peduncles; involucres 10–25 mm wide, 7–12 mm high; bracts green, strongly ciliate, lance-acuminate; rays 10–21, yellow, 7–20 mm long; achenes 6–7 mm long. Warm desert shrub communities at 700 to 900 m in Washington County; Nevada, Arizona, and California; 3 (0).

Glyptopleura D.C. Eaton

Low annual herbs; leaves rosettiform, with a few-toothed, white, crustaceous margin; heads many, short peduncled, the flowers all raylike, white or pale yellowish (or drying pinkish); involucres of 7–12 scarious-margined bracts subtended by a basal group of pinnatifid or toothed bractlets; pappus of capillary white bristles in several series, the outer falling separately; achenes oblong, 5-angled, each face with 2 rows of tubercles, abruptly beaked.

1. Ray flowers showy, long exserted, 1.5–2.5 cm long; plants of Washington County ..... *G. setulosa*
— Ray flowers inconspicuous, only shortly exserted, mainly less than 10 mm long; plants broadly distributed ..... *G. marginata*

Glyptopleura marginata **D.C. Eaton** Depressed annual herbs; stems 0.5–4 cm long; leaves crowded on the short stems, mainly 0.5–4 cm long, pinnatifid, the margins white-crustose, extended into irregular white processes; involucres 10–13 mm high, urceolate; bracts green, the margins hyaline; bractlets with white, irregular, branched processes, crustose at the apex; rays mainly 4–7 mm long, withered and pinkish on drying; achenes 4–5 mm long, tan, sculptured. Desert shrub communities at 1240 to 1590 m in Beaver, Box Elder, Iron, Piute, San Juan, Sevier, and Uintah counties; Oregon and Nevada; 9 (i).

Glyptopleura setulosa **Gray** Low annual herbs; stems 1.5–6 cm long; leaves crowded on the short stems, mainly 0.3–5 cm long, pinnately lobed, the margins white-crustose into teeth; involucres 10–13 mm high, urceolate; bracts green or purplish tipped, the bracts with expanded apices bearing simple or coalescent processes; rays mainly 1.5–2.5 cm long, pale yellowish, showy; achenes 4–5 mm long, tan, sculptured. Larrea, blackbrush, and Joshua tree communities at 700 to 915 m in Washington County; Arizona, Nevada, and California; 6 (0).

Gnaphalium L.

Annual or perennial tomentose herbs; leaves alternate, entire; heads discoid, the flowers white, yellowish, or suffused with pink, borne in spikes, corymbs, or panicles; involucres campanulate to ovoid; bracts imbricate, scarious apically (at least); receptacle naked; outer flowers numerous, slender and pistillate, the few inner ones broader and perfect; style branches of inner flowers flattened, truncate, the stigmatic portion not sharply differentiated; anthers caudate; pappus of capillary bristles; achenes small, nerveless.

1. Heads large, mostly 4–7 mm high; clusters of heads not or rarely surpassed by leafy bracts; plants often over 20 cm tall 2
— Heads small, the involucres 2–4 mm long; clusters of heads commonly surpassed or equaled by leafy bracts; plants mainly 4–20 cm tall 3

2(1). Leaves strongly decurrent; bracts of involucre yellowish or fading yellowish ..... *G. chilense*
— Leaves not strongly decurrent; bracts of involucre pearly white ..... *G. wrightii*

3(1). Leaves spatulate to oblong, mainly 3–8 mm wide; plants loosely tomentose ..... *G. palustre*
— Leaves linear to narrowly oblanceolate, mainly 1–3 mm wide; plants rather closely tomentose 4

4(3). Leafy bracts commonly less than 1.5 cm long, more loosely tomentose than the following ..... *G. exilifolium*
— Leafy bracts commonly more than 1.5 cm long, the tomentum appressed ..... *G. uliginosum*

Gnaphalium chilense **Spreng.** Annual or biennial herbs, the tomentose stems 15–40 cm tall or more; leaves 1.5–7 cm long, 2–8 mm wide, oblong to linear or the lowermost oblanceolate, decurrent, tomentose, reduced upward; heads numerous, in capitate clusters at stem apices; involucres 4–7 mm high, the bracts yellowish, tomentose only at the base. Disturbed, often moist sites at 1370 to 1770 m in Daggett, Duchesne, Kane, Salt Lake, and Utah counties; British Columbia to Montana, south to California, Arizona, and Texas; 5 (0).

Gnaphalium exilifolium **A. Nels.** [*G. grayi* Nels. & Macbr.]. Annual herbs; stems 8–25 cm tall, simple or branching from the base, tomentum appressed or somewhat loose; leaves 0.4–4 cm long, 1–3 mm wide, linear to linear-oblanceolate; heads clustered, in capitate cymes or spicate, subtended by leafy bracts that surpass them; involucres ca 3 mm high; bracts with hyaline brownish tips, tomentose at the base. Sedge-grass community, known in Utah from Wasatch (Lewis sn 1975 BRY) and Washington (Albee 2936b BRY); Colorado, New Mexico, and Arizona; 2 (0). This plant simulates *G. uliginosum*, with which it has been synonymized by some workers. More material is necessary to provide a definitive solution as to its proper taxonomic position.

Gnaphalium palustre **Nutt.** Annual herbs; stems 3–20 (30) cm tall, simple or more commonly much branched, loosely tomentose; leaves 1–3.5 cm long, 2–6 (10) mm wide, oblong to oblanceolate; heads clustered in capitate terminal or axillary cymes, subtended by leafy bracts that equal or surpass them; involucres 3–4 mm high; bracts brown, usually with whitish tips, tomentose below. Tamarix-willow, mountain brush, ponderosa pine, Douglas-fir, and sedge-grass communities, often on sand bars, lake shores, and pond margins, at 1370 to 2600 m in Cache, Garfield, Iron, Juab, Millard, Piute, Salt Lake, Sanpete, Sevier, Tooele, Uintah, Utah, Washington, and Wayne counties; British Columbia and Alberta, south to California and New Mexico; 31 (iii).

Gnaphalium uliginosum **L.** Annual herbs; stems 3–15 (25) cm tall, simple or more commonly much branched, closely tomentose; leaves 1–5 cm long, 1–3 mm wide, linear to linear-oblanceolate; heads clustered in capitate terminal or axillary cymes, subtended by leafy bracts that much surpass them; involucres 3–4 mm high; bracts brown with pale tips, tomentose below. Lake and pond margins and other disturbed sites at 2410 to 2830 m in Garfield and Sevier counties; 4 (0).

Gnaphalium wrightii **Gray** Perennial herbs; stems 3–8 dm tall, branched in the inflorescence; leaves 1.5–7 cm long, lance-linear, the lower ones spatulate; panicle open, with capitate clusters of heads not subtended or surpassed by bracteate leaves; involucres 5–6 mm high; bracts pearly white, tomentose below. Ponderosa pine and live oak communities at 1585 to 1830 m in Washington County; California to Texas, south to Mexico; 3 (0).

GRINDELIA Willd.

Annual, biennial, or perennial herbs, sometimes woody at the base; leaves alternate, simple, more or less resinous-punctate, usually sessile, often clasping; heads radiate or discoid, the rays 10–45, pistillate, fertile, yellow; involucres imbricate, more or less resinous; bracts thickish, with pale appressed base and often squarrose or revolute herbaceous tips; receptacle naked, flattish; disk flowers fertile, yellow; style branches with slender hispidulous appendages; pappus of 2–8 stiff, often curved, deciduous awns; achenes compressed to angular, glabrous.

1. Heads discoid 2
— Heads radiate 3

2(1). Plants perennial; involucral bracts much thickened apically .... *G. fastigiata*
— Plants annual or biennial; involucral bracts only somewhat thickened .... *G. aphanactis*

3(1). Involucral bracts, at least middle and upper ones, with appressed or erect tips, these not revolute or thickened .... *G. laciniata*

— Involucral bracts spreading or recurved apically, often thickened apically 4

4(3). Rays mostly 12–25, rarely more; leaves entire or sharply toothed, not callous-serrulate; achenes usually with one or more knobs on the apical margin; plants perennial .... *G. nana*

— Rays mostly 25–40, rarely fewer; leaves regularly callous-serrulate to sharply toothed or entire; achenes mainly lacking apical knobs; plants biennial or perennial .... *G. squarrosa*

Grindelia aphanactis **Rydb.** Biennial herbs; stems 1.5–9 dm tall, uniformly leafy, glabrous; leaves mainly 2.5–7 cm long, 2–12 mm wide, oblong or oblanceolate, entire, crenulate-serrate or denticulate to pinnatifid, glabrous, the margin scabridulous; heads discoid, campanulate; involucres 7–20 mm high, 10–28 mm wide, resinous, mostly in 5 or 6 series, the upper portion loosely to moderately reflexed, glabrous; pappus awns 2 or 3; achenes 2.3–3 mm long, brown, mainly truncate apically. Weedy species of disturbed sites in Kane and San Juan counties; Colorado, Arizona, and Texas; 1 (0).

Grindelia fastigiata **Greene** Perennial herbs; stems 5–10 dm tall or taller, glabrous; leaves mainly 1.5–13 cm long, 10–18 mm wide, oblanceolate to lance-oblong, entire or denticulate to dentate or serrate, glabrous; heads discoid; involucres campanulate, 10–14 mm high, 9–17 mm broad; bracts in ca 6 series, only the upper third or fourth spreading, with revolute, thickened tips; pappus awns 2 or 3; achenes oblong, 3.5–5 mm long. Sandy terraces and washes at 1125 to 1375 m in Emery, Grand, and San Juan counties; Colorado; 9 (iv); a Plateau endemic.

Grindelia laciniata **Rydb.** Perennial herbs; stems 2.5–4.5 dm tall, glabrous; leaves mainly 2–6 cm long, 3–1.5 mm broad, pinnatifid or the upper subentire or entire, narrowly oblanceolate to oblanceolate, glabrous; heads radiate; involucres 7–10 mm high and wide; bracts with upper one-third to one-half spreading, glabrous; pappus awns 3–5; achenes 2.5–3.5 mm long. Sandy washes in San Juan County (type from San Juan County); Arizona; 1 (0).

Grindelia nana **Nutt.** Low Gumweed. [*G. brownii* Heller; *G. nana* f. *brownii* (Heller) Steyermark]. Perennial herbs; stems 0.8–6.5 (8) dm tall, glabrous; leaves mainly 1.5–10 cm long, 5–30 mm wide, oblanceolate, scarcely clasping; heads radiate; involucres campanulate; bracts in 5–7 series, reflexed or revolute in the upper third to fifth; rays 11–28, yellow, 5–11 mm long; pappus awns 2; achenes 3.5–4 mm long. Ruderal weed at ca 1585 to 1650 m in Cache County; Washington to Montana, south to California and Idaho; 4 (0).

Grindelia squarrosa **(Pursh) Dunal** Curly Gumweed. [*Donia squarrosa* Pursh; *G. squarrosa* f. *depressa* Steyermark, type from Salt Lake County]. Perennial or biennial herbs; stems 1–8 (10) dm tall, glabrous; leaves mostly 2–5 cm long, oblong, regularly callous toothed, sometimes sharply toothed or entire, the upper clasping; heads radiate, strongly resinous; bracts with the green tips strongly rolled back; rays 25–40, yellow, 7–15 mm long; pappus awns 2 or 3 (to 6); achenes 2.3–3 mm long. Two more or less distinctive varieties are present in Utah.

1. Main upper cauline leaves 2–4 times longer than broad, oblong-ovate to oblong .... *G. squarrosa* var. *squarrosa*

— Main upper cauline leaves 5–8 times longer than broad, narrowly oblong to oblanceolate .... *G. squarrosa* var. *serrulata*

Var. *serrulata* **(Rydb.) Steyermark** [*G. serrulata* Rydb.]. Salt desert shrub, sagebrush, saline meadow, and mountain brush communities at 1310 to 1420 m in all Utah counties; Wyoming south to New Mexico and Arizona, and introduced widely elsewhere; 72 (vii).

Var. *squarrosa* [*G. serrulata* f. *depressa* Steyermark, type from west of Salt Lake

City]. Waste places at 1300 to 2135 m in Duchesne, Juab, Salt Lake, Utah, and Wasatch counties; widespread mainly to the east of our area; 6 (0).

GUTIERREZIA Lag.

Perennial shrubs or subshrubs, glutinous, glabrous or hirtellous; leaves alternate, linear, often punctate; heads radiate, small, numerous; rays pistillate or neutral, yellow, or lacking; involucres cylindric to turbinate, the bracts imbricate, chartaceous; receptacles naked or bristly, convex; disk flowers few to many, yellow, perfect or sterile; pappus of 10–12 unequal scales; achenes obovoid or oblong, pubescent.

LANE, M. 1982. Generic limits of *Xanthocephalum*, *Gutierrezia*, *Amphiachris*, *Gymnosperma*, *Greenella*, and *Thurovia* (Compositae: Asteraceae). Systematic Botany 7: 405–417.

SOLBRIG, O. T. 1960. Cytotaxonomic and evolutionary studies in the North American species of *Gutierrezia* (Compositae). Contr. Gray Herb. 188: 1–63.

1. Heads cylindric, the ray and disk flowers 1 or 2 each .... *G. microcephala*
— Heads turbinate, with more than 4 flowers 2

2(1). Ray and disk flowers 3–8 each; involucres 2–3 mm thick; heads often clustered at ends of branches; plants widespread .... *G. sarothrae*
— Ray flowers 4–10, disk flowers 5–23; involucres 2–7 (9) mm thick; heads solitary or in pairs at branch ends; plants of restricted distribution 3

3(2). Disk flowers 5–12, 3.5–4.5 mm long; ray flowers 2–5 mm long; plants of Uintah County .... *G. pomariensis*
— Disk flowers 15–23, ca 3 mm long; ray flowers 5–7 (10) mm long; plants of eastern Millard County .... *G. petradoria*

Gutierrezia microcephala **(DC.) Gray** Thread Snakeweed. [*Brachyris microcephala* DC.; *G. sarothrae* var. *microcephala* (DC.) Benson; *Xanthocephalum microcephalum* (DC.) Shinners]. Rounded shrub, 30–100 cm tall; stems slender, grayish to straw colored or green above, from a woody crown; leaves dimorphic, the cauline 2–5 cm long, 2–4 mm wide, linear or linear-lanceolate, and with shorter, narrower fasciculate axillary ones, often one or both lacking at anthesis; heads clustered at branch ends, sessile; involucre 3–4 mm long, 1–1.5 mm wide, cylindric; bracts fewer than 10, lanceolate, the tip greenish, slightly thickened; ray flowers 1 or 2, 3–4 mm long; disk flowers 1–3, 2–3 mm long; pappus of ca 8 scales; achenes of disk flowers abortive, those of ray flowers fertile, 2–3 mm long, hairy. Blackbrush, vanclevea-ephedra, saltbush, purple sage, rabbitbrush, and pinyon-juniper communities at 850 to 1830 m in Emery, Garfield, Grand, Juab, Kane, Millard, San Juan, Utah, Washington, and Wayne counties; Nevada and California to Colorado, south to Texas and Mexico; 27 (viii).

Gutierrezia petradoria **(Welsh & Goodrich) Welsh** comb. nov. [based on: *Xanthocephalum petradoria* Welsh & Goodrich Brittonia 33: 301. 1981]. Goldenrod Snakeweed. Perennial, suffrutescent; stems herbaceous except at the base, hirtellous, simple below the inflorescence, loosely caespitose, from a stout taproot and branching, mostly underground, woody caudex; leaves arranged singly along the stems, linear, 0.5–4.5 cm long, 1–3 (4) mm wide, reduced upward, secondary fascicled leaves in some lower axils; heads solitary or in pairs on bracteate peduncles, or some almost sessile; involucres 5–9 mm high, 3–7 mm wide (to 9 when pressed), campanulate, the bracts ca 20, in 3 (4) series, greenish, the tips thickened; ray flowers 4–10, 5–10 mm long, 1–4 mm wide, when fresh; disk flowers 15–23, ca 3 mm long; pappus scales ca 10–12; achenes 3–4 mm long, pubescent, abortive in disk flowers. Sagebrush, oakbrush, mountain mahogany, and white fir communities at 1920 to 2590 m in eastern Millard County (Canyon and Pavant ranges); type from the Canyon Mountains; endemic; 9 (0).

Gutierrezia pomariensis **(Welsh) Welsh** comb. nov. [based on: *Gutierrezia sarothrae* var. *pomariensis* Welsh Great Basin Nat. 30: 19. 1970; *Xanthocephalum sarothrae* var.

pomariense (Welsh) Welsh]. Orchard Snakeweed. Rounded subshrubs; stems 1.2–4.5 dm tall, several to many from a persistent woody base; leaves 1.5–5.2 cm long, 0.5–2.5 mm wide, linear, entire, glabrous or scabrous, glandular-punctate; heads in corymbose inflorescences, solitary or 2 or 3 clustered at stem ends; involucres 5–7.5 mm high, 2–5 mm broad, turbinate to cylindric; bracts broadly obtuse, with a greenish subapical spot, resin coated; ray flowers 5–9, the corollas 2–5 mm long; disk flowers 5–12, the corollas 3.5–4.5 mm long; pappus scales ca 5–8; achenes 1–2 mm long, hairy. Mixed desert shrub community at 1460 to 2135 m in Duchesne and Uintah (type from Dinosaur National Monument) counties; endemic; 17 (iv).

***Gutierrezia sarothrae* (Pursh) Britt. & Rusby** Broom Snakeweed. [*Solidago sarothrae* Pursh; *Xanthocephalum sarothrae* (Pursh) Shinners]. Rounded shrubs; stems 9–90 cm tall, profusely branched from the base, otherwise in the inflorescence, from a woody caudex and stout taproot; leaves dimorphic, the main cauline ones 2–7 cm long, 1–3 mm wide, linear to linear-lanceolate, the fascicled secondary ones in lower axils, entire, glabrous to tomentulose; heads in corymbose inflorescences, usually in clusters of 3–10 at branchlet ends, seldom solitary; involucres 3–4.5 mm high, 2–3.5 mm wide, turbinate; bracts narrow, acute, with green thickened tip; ray flowers 3–7, yellow, 2–5 mm long; disk flowers mostly 3–8, 2–3 mm long; pappus of 8–10 scales; achenes 1–2 mm long, hairy. Warm desert shrub, sand sagebrush, live oak, sagebrush, rabbitbrush, mountain brush, and pinyon-juniper communities, often in disturbed sites, at 760 to 2440 m in probably all Utah counties; British Columbia east to Saskatchewan and south to Mexico. Our variable material adjusts to disturbances and increases on grazed native rangelands; it is not considered to be palatable; 208 (xlv).

HAPLOPAPPUS Cassini

Annual or perennial herbs, subshrubs, or shrubs, usually resinous or glandular; leaves alternate, entire or toothed to lobed; heads discoid or radiate, usually small to large, variously clustered or solitary; involucres cylindric to turbinate or campanulate, the bracts imbricate, not aligned; receptacle flat to convex, naked; rays yellow when present; disk flowers perfect, yellow; pappus of barbellate capillary bristles; achenes angled or striate to smooth.

HALL, H. M. 1928. The genus *Haplopappus*. Carnegie Institution of Washington. 391 pp.

1. Plants low, rounded, branched shrubs, or tall slender shrubs or subshrubs 2
— Plants annual or perennial herbs, branched or unbranched 11
2(1). Heads borne on stems 2.5–5 dm long; plants of saline sandy drainages or sandstone outcrops in southern Utah 3
— Heads borne on stems less than 2.5 dm long; plants of various substrates and distribution 4
3(2). Plants definitely shrubby, the mature branchlets ashy gray or white, of sandstone outcrops and canyons .... *H. scopulorum*
— Plants shrubby only at the base, the branchlets straw colored to greenish; plants of saline drainage bottoms and terraces .... *H. drummondii*
4(2). Stems of the season white-tomentose; involucres 10–13 mm long, the bracts only somewhat imbricate; plants commonly of high elevations .... *H. macronema*
— Stems glabrous, glandular, or hairy, not tomentose; involucres mainly less than 10 mm long, but, if longer, otherwise differing 5
5(4). Involucres campanulate, 8–12 mm long; heads showy, the rays 8–10 mm long; plants of lower elevations in Washington County .... *H. linearifolius*
— Involucres turbinate to cylindric or campanulate, commonly less than 8 mm long; heads not especially showy, the rays mainly 2–5 mm long, or lacking 6

6(5). Leaves densely glandular punctate, linear; ray flowers present; plants known from Washington County .... *H. laricifolius*

— Leaves not glandular-punctate, narrowly to broadly oblanceolate or oblong; ray flowers lacking; plants more broadly or otherwise distributed 7

7(6). Heads 12–22 mm high, the bracts subequal, the outer herbaceous and the inner chartaceous and with broad hyaline margins; plants of limestone outcrops in the Paunsagunt and Markagunt plateaus, or mainly of igneous outcrops in the Pine Valley Mountains 8

— Heads 5.5–9.5 mm high, the bracts imbricate in several series, variously herbaceous or chartaceous, but seldom any with broad hyaline margins; plants of various substrates and distribution 9

8(7). Involucral bracts 1-nerved; achenes evenly though sparingly hairy; plants of the Pine Valley Mountains, Washington County .... *H. crispus*

— Involucral bracts 3-nerved; achenes glabrous except for a few hairs apically; plants of the Paunsagunt and Markagunt plateaus .... *H. zionis*

9(7). Leaves densely stipitate-glandular, oblanceolate, acute, the margins not especially repand .... *H. watsonii*

— Leaves lacking stipitate glands, narrowly oblanceolate to oblong, or, if oblanceolate, the margins repand-undulate 10

10(9). Leaves oblanceolate, 2–5 mm wide .... *H. cervinus*

— Leaves narrowly oblanceolate to oblong, 0.5–2 mm wide .... *H. nanus*

11(1). Leaves strongly 3-nerved and veiny, thick and leathery; caudices thick, woody, branched 12

— Leaves not 3-nerved and veiny; caudices simple, or, if branched, not woody 13

12(11). Bracts obtuse to rounded or less commonly acutish, strongly imbricate; plants of the Colorado drainage system .... *H. armerioides*

— Bracts acute to attenuate, subequal to strongly imbricate; plants widespread .... *H. acaulis*

13(11). Leaves with lobes or teeth spinulose tipped; involucral bracts spinulose tipped 14

— Leaves entire or toothed, but then not spinulose tipped; involucral bracts not spinulose tipped 15

14(13). Involucral bracts glabrous or glandular dorsally; leaves pinnatifid; plants perennial .... *H. spinulosus*

— Involucral bracts strigose dorsally, also minutely ciliate; leaves lobed or merely toothed to entire; plants annual .... *H. gracilis*

15(13). Stems mainly 20–40 cm tall, loosely tomentose above; involucres 15–30 mm wide; plants evidently rare .... *H. croceus*

— Stems 5–20 cm tall, or, if taller, not or seldom loosely tomentose, or the heads smaller 16

16(15). Heads racemosely or spicately arranged; stems erect or nearly so, not strongly bent at the base .... *H. racemosus*

— Heads solitary or corymbosely (rarely racemosely) arranged; stems strongly bent at the base 17

17(16). Involucres 12–15 mm high, 20–30 mm wide; plants not hairy in the leaf axils .... *H. clementis*

— Involucres 5–10 mm high, 10–20 mm wide, or, if larger, the plants with hair tufts in basal leaf axils 18

18(16). Involucral bracts herbaceous throughout; achenes glabrous; plants rare, known only from the Tushar Mountains .... *H. apargoides*
— Involucral bracts herbaceous only apically; achenes hairy; plants locally common in saline meadows .... *H. lanceolatus*

Haplopappus acaulis **(Nutt.) Gray** Stemless Goldenweed. [*Chrysopsis acaulis* Nutt.; *C. caespitosa* Nutt.]. Perennial caespitose herbs from a thick ligneous pluricipital caudex and stout taproot, the caudex branches clothed with brown to ashy marcescent leaf bases and leaves; herbage resinous, scabrous to glabrous; stems mainly 5–20 cm tall; basal leaves 0.3–6 cm long, 1.5–10 mm wide, rigid, narrowly to broadly oblanceolate, sharply mucronate, 1- to 3-nerved; cauline leaves few, developed or reduced upward; heads solitary (rarely 2); involucres hemispheric, 6–10 mm high, 8–20 mm wide; bracts in 3 series, more or less mucronate; rays 6–15, 8–12 mm long, 2–4 mm wide; pappus white to brownish; achenes silky-villous or glabrous. This is a variable taxon, with several morphological phases. Despite the tendency for some of the variations to be correlated geographically, it seems best to regard our materials as consisting of two mainly sympatric varieties.

1. Cauline leaves well developed, often the main foliage leaves; herbage merely resinous-glandular; plants of the Great Basin .... *H. acaulis* var. *glabratus*
— Cauline leaves usually much reduced, surpassed in size by the basal ones; herbage scaberulous or merely resinous-glandular; plants more widely distributed .... *H. acaulis* var. *acaulis*

Var. *acaulis* Sagebrush-grass, pinyon-juniper, mountain brush, ponderosa pine, western bristlecone, and spruce-fir communities at 1430 to 2685 m in Beaver, Box Elder, Cache, Daggett, Emery, Garfield, Juab, Kane, Millard, Sanpete, Sevier, Summit, Tooele, Uintah, and Utah counties; Oregon to Wyoming, south to California, Nevada, and Colorado; 60 (ix). There is a narrow-leaved glabrous phase of this taxon in the southern portion of Duchesne County, mainly on Green River Shale. Possibly it deserves recognition at some taxonomic rank.

Var. *glabratus* **D.C. Eaton** [*Stenotus falcatus* Rydb., type from Iron County; *S. latifolius* A. Nels., type from Utah County]. Black sagebrush, wildrye, pinyon-juniper, mountain brush, and grass-shrub communities at 1525 to 2900 m in Beaver, Iron, Juab, Millard, Tooele, and Utah counties; Saskatchewan south and west to California and Nevada; 22 (iv).

Haplopappus apargoides **Gray** Perennial shortly caulescent herbs, 3–8 (15) cm tall, from a taproot and simple or branched caudex, this clothed with brown marcescent leaf bases; basal leaves mainly 2–6 cm long, 2–6 mm wide, lanceolate to narrowly oblanceolate; cauline leaves reduced upward, sessile, the margins scabrous or ciliate; herbage sparingly long-villous with multicellular hairs; heads solitary; involucres hemispheric, 8–12 mm high, 10–14 mm broad; bracts imbricate, lanceolate to oblong, acute, cuspidate, herbaceous almost or quite to the base, glabrous dorsally, the margins long-ciliate; ray flowers 15–40, yellow, 8–15 mm long; pappus tawny; achenes glabrous. Alpine tundra community at 3355 m in Piute County (Tushar Mountains); California and Nevada; 1 (i). The specimen examined (Welsh and Thorne 12982 BRY) is tentatively assigned to this species, which is known otherwise only from the eastern Sierra Nevada and adjacent Nevada.

Haplopappus armerioides **(Nutt.) Gray** [*Stenotus armerioides* Nutt.]. Perennial caespitose herbs from a thick ligneous pluricipital caudex and stout taproot, the caudex branches clothed with brown to ashy marcescent leaf bases and leaves; herbage resinous-glandular, otherwise glabrous or with scabrous leaf margins; stems 0.5–20 cm tall; basal leaves 1.5–8 cm long, 1.5–10 mm wide, rigid, linear to oblanceolate, sharply mucronate; 1- to 3-nerved; cauline leaves few, reduced upward; heads solitary (rarely 2); involucres campanulate, 8–13 mm high, 10–18 mm wide; bracts in 3 or 4 series, imbricate, oblong to oval or obovate, obtuse, sometimes lobed below the apex, greenish near the apex, glabrous; rays 8–12, 10–12 mm long, yellow, 3–5 mm wide; pappus white; achenes silky-villous. This distinctive species is represented in Utah by two phases, which are more or less morphologically distinctive and geographically correlated.

1. Stems mainly 3–8 cm tall; leaves linear to linear-oblanceolate, mainly 1–3 mm wide; plants of the Green River Formation, Uintah County .... *H. armerioides* var. *gramineus*
— Stems usually over 8 cm tall; leaves oblanceolate, mainly 3–10 mm wide; plants widespread .... *H. armerioides* var. *armerioides*

Var. *armerioides* Blackbrush, black sagebrush, pigmy sagebrush, salt desert shrub, pinyon-juniper, mountain brush, and ponderosa pine communities at 1340 to 2120 m in Carbon, Daggett, Duchesne, Emery, Garfield, Grand, Kane, San Juan, Sevier, and Uintah counties; Montana to Arizona, east to New Mexico and Nebraska; 85 (xii).

Var. *gramineus* Welsh & F. J. Smith Desert shrub and pinyon-juniper communities at ca 1585 to 1895 m in Duchesne and Uintah counties; endemic; 17 (0).

Haplopappus cervinus **Wats.** Shrubs, 1–4 dm tall, much branched; branchlets grayish to straw colored; leaves 6–18 mm long, 2.2–6 mm wide, oblanceolate, straight or curved, entire or repand-undulate, attenuate basally, cuspidate apically, glabrous or resinous; heads few, cymose; peduncles 3–10 mm long; involucres 6.5–7.5 mm high, 5–8 mm wide; bracts imbricate in several series, the outer greenish ones narrowly acuminate with straight or spreading tips, the inner chartaceous ones narrowly oblong, acute or cuspidate, all glabrous but resinous; ray flowers 5–7, yellow, 2.5–4 mm long, ca 1 mm wide; disk flowers 5–11, glabrous or the tube sparingly puberulent; pappus tawny; achenes strigose. Black sagebrush, shadscale, pinyon-juniper, and mountain brush communities at 1670 to 2440 m in Millard and Sevier counties; Arizona; 5 (0). The type came from a place called Antelope Canyon (possibly in present-day western Millard County). More collections are needed.

Haplopappus clementis **(Rydb.) Blake** [*Pyrrocoma clementis* Rydb.; *P. subcaesia* Greene, type from Panguitch Lake; *P. lapathifolia* Greene, type from "Utah"]. Perennial herbs from a simple caudex and stout taproot, the subrhizomatous caudex clothed with brown, often shredded marcescent leaf bases; stems 10–30 (40) cm tall, decumbent-ascending from an abruptly curved base, villous; basal leaves mostly 2–15 cm long, 4–17 mm wide, oblanceolate, glabrous or sparingly puberulent, entire or dentate, tapering to a petiole, acute; cauline leaves reduced upward, sessile and somewhat clasping; heads solitary (rarely 2 or 3); involucres broadly hemispheric, 8–16 mm high, 18–30 mm wide; bracts in several series, oblong to lanceolate, green throughout or the base chartaceous, villous; ray flowers 30–60, yellow or golden, 8–14 mm long; pappus tawny; achenes hairy. Grass-sagebrush, spruce-fir, sedge-forb, and meadow communities at 2590 to 3390 m in Beaver, Daggett, Duchesne, Emery, Garfield, Iron, Kane, Piute, Sanpete, Summit, and Uintah counties; Wyoming to Colorado; 39 (vi). Specimens from Utah that have been determined as *H. integrifolius* Gray apparently fall here, including the type of *Pyrrocoma lapathifolia*, which was discussed by Hall (1920). Involucral bracts vary from herbaceous throughout to chartaceous at the base. More work is indicated.

Haplopappus crispus **L.C. Anderson** Shrubs, much branched from the base, 3–5 dm tall (or more); branchlets covered with short-stalked glands; leaves 1.5–3 cm long, 3–8 mm wide, entire, green, spatulate to oblong-oblanceolate, acuminate, the margins undulate-crisped, glutinous with low glands, not crowded below the inflorescence; heads 1 or 2, more commonly more, per branch, loosely paniculate to congested and cymose; involucres campanulate, the heads 12.5–16 mm long, 5–9 mm wide; bracts in several series, finely glandular, the outermost green, leaflike; rays lacking; disk flowers 14–24, pale yellow; pappus tawny; achenes 6.5–8.5

mm long, sparsely but evenly hairy. Ponderosa pine, fir, manzanita, and aspen communities at (915?) 2471 to 3050 m in Washington and Millard (?) counties; endemic; 8 (0).

Haplopappus croceus **Rydb.** Perennial herbs, mainly 2–6 cm tall, from a simple caudex and stout taproot, the caudex clothed with fibrous marcescent leaf bases; basal leaves 8–20 cm long, 6–25 (40) mm wide, elliptic to oblanceolate, petiolate, entire or undulate, obtuse to acutish, glabrous or puberulent; cauline leaves reduced upward, sessile, more or less clasping; heads solitary (rarely more); involucres hemispheric, 12–18 mm high, 20–30 mm wide; bracts in several series, ovate to oblong or oblanceolate, herbaceous apically, chartaceous to leathery basally; ray flowers 25–70, burnt orange, 10–25 mm long; pappus brownish; achenes glabrous or pilose. Mountain brush community at ca 2470 m in San Juan (La Sal Mountains) and Washington (Kolob Reservoir) counties; Wyoming south to Arizona and New Mexico; 2 (0).

Haplopappus drummondii **(T. & G.) Blake** [*Linosyris drummondii* T. & G.]. Perennial subshrub, the stems subherbaceous, arising from a woody base, 25–75 cm tall, straw colored to tan, longitudinally striate, glabrous; leaves 1.5–7.5 cm long, 1–16 mm wide, entire or irregularly lobed, linear to spatulate, glabrous, resinous; heads few to numerous, borne in corymbose cymes, peduncled; involucres turbinate, 6–8 mm high, 4–7.2 mm wide; bracts in 4 or 5 series, lance-oblong, coriaceous, with a thick green or brownish subapical spot, acute, resinous; ray flowers lacking; pappus tawny; achenes silky. Saline riparian areas in greasewood, saltgrass, rabbitbrush, saltbush, and tamarix communities at 1050 to 1800 m in Emery, Garfield, Grand, Kane, and San Juan counties; Colorado, Arizona, New Mexico, and Texas; 25 (vii).

Haplopappus gracilis **(Nutt.) Gray** [*Dieteria gracilis* Nutt.]. Annual herbs, 3–25 (30) cm tall, commonly branched from near the base; leaves 4–25 mm long, 1–3 mm wide, linear to narrowly spatulate, spinulose-dentate to pinnatifid, white-strigose, progressively reduced and entire upward; heads solitary or few to several and corymbosely arranged; involucres 6–8.5 mm high, 8–12 mm wide; bracts in 5 or 6 series, linear-lanceolate, awn tipped, herbaceous medially, strigulose, not glandular; rays 15–30, yellow, 6–9 mm long; strigulose, not glandular; rays 15–30, yellow, 6–9 mm long; pappus tawny to white; achenes pilose. Larrea-gutierrezia, ponderosa pine, and spruce-fir communities at 850 to 960 m in Iron, Kane, and Washington counties; California to Colorado, south to Mexico; 10 (0).

Haplopappus lanceolatus **(Hook.) T. & G.** [*Donia lanceolata* Hook.; *H. tenuicaulis* D.C. Eaton; *H. lanceolatus* var. *tenuicaulis* (D.C. Eaton) Gray; *Pyrrocoma subviscosa* Greene; *H. lanceolatus* ssp. *subviscosus* (Greene) Hall; *Donia uniflora* Hook.; *H. uniflorus* (Hook.) T. & G.]. Perennial herbs from a simple caudex and stout taproot, the caudex clothed with brown to ashy marcescent, often fibrous, leaf bases; stems decumbent-ascending, abruptly bent at the base, 5–68 cm long; basal leaves 3–16 cm long, 3–35 mm wide, elliptic-oblong or lanceolate, glabrous or tomentose, petiolate, entire or dentate to lobed, often densely tomentose in the axils; cauline leaves reduced upward, finally sessile and clasping; heads solitary or few to several, and subcorymbose or less commonly racemose; involucres hemispheric, 5–12 mm high, 10–18 mm wide; bracts imbricate in 3 or 4 series, with green tips, glabrous or tomentulose; ray flowers 10–45, yellow, 5–10 mm long; pappus tawny; achenes densely hairy. Saline meadows at 1300 to 2500 m in Beaver, Cache, Carbon, Duchesne, Emery, Garfield, Iron, Juab, Millard, Piute, Rich, Salt Lake, Sevier, Tooele, and Utah counties; Oregon to Saskatchewan, south to California, Nevada, Colorado, and Nebraska; 42 (xi). This is a highly variable taxon of saline meadows through much of our area. Heads vary from solitary to numerous, from solitary to corymbosely or racemosely arranged. Vesture is lacking or tomentose, or rarely glandular. Recognition of taxonomic categories within the variation appears to be only arbitrarily possible, and it seems best to treat our specimens conservatively.

Haplopappus laricifolius **Gray** Rounded shrubs 3–8 dm tall; branchlets resinous, yellowish, becoming gray in age; leaves 5–18 mm long, 1–1.5 mm wide, thick, linear, resinous-punctate; heads few to several in compact cymes, shortly pedunculate; involucres campanulate, 3–5 mm high, 3–6 mm wide; bracts imbricate in ca 3 series, narrowly oblong, acute, yellowish or hyaline, glabrous or puberulent-ciliate; ray flowers 3–6, yellow, 4–5 mm long; disk flowers 9–16, glabrous or minutely pubescent; pappus tawny; achenes white hairy. Saltgrass seep margin in warm desert shrub at 1220 m in Washington County; Arizona to Texas and Mexico; 2 (ii).

Haplopappus linearifolius **Gray** [*H. interior* Cov.; *H. linearifolius* ssp. *interior* (Cov.) Hall]. Shrubs, mainly 4–10 (12) dm tall; branchlets yellowish, resinous, becoming gray in age; leaves 6–28 mm long, 1–2.5 mm wide, thickish, linear to narrowly oblanceolate, resinous-punctate; heads few to many, solitary on naked peduncles mainly 2–7 cm long; involucres hemispheric, 8–10 mm high, 10–18 mm wide; bracts biseriate, lance-linear, acute or acuminate, herbaceous medially, sometimes minutely glandular; rays 12–18, yellow, 9–15 mm long, 4–5 mm wide; disk flowers numerous; pappus white; achenes densely hairy. Joshua tree, creosote bush, blackbrush, juniper, live oak, and sagebrush communities at 700 to 1375 m in Washington County; California, Nevada, Arizona, and Baja California; 30 (ii). Our material is assignable to var. ***interior*** (Cov.) Jones.

Haplopappus macronema **Gray** [*Macronema discoideum* Nutt.]. Shrubs, mainly 1–5 dm tall; branchlets white-tomentose; leaves 8–32 mm long, 2–7 mm wide, oblanceolate to oblong, entire or more commonly undulate-crisped, acute to obtuse, mucronate, glandular-scabrous; heads solitary or 2 to several; involucres campanulate, 9–13 mm high, 6–12 mm wide; bracts subequal, the outer few herbaceous, oblong, the inner lance-acuminate, chartaceous, glandular-scabrous; ray flowers lacking; disk flowers 10–25; pappus tawny; achenes villous. Douglas fir, lodgepole pine, spruce-fir, and alpine tundra communities at 2135 to 3420 m in Beaver, Box Elder, Duchesne, Garfield, Iron, Juab, Piute, Salt Lake, Sanpete, Sevier, Tooele, Salt Lake, and Utah counties; Oregon to Wyoming, south to California, Nevada, and Colorado; 38 (vi).

Haplopappus nanus **(Nutt.) D.C. Eaton** [*Ericameria nana* Nutt.]. Compact shrubs, mainly 1–3 (5) dm tall; branchlets yellowish, resinous, becoming gray in age; leaves 3–18 mm long, 0.5–2 mm broad, narrowly oblanceolate to linear, entire, acute, resinous but not punctate; heads solitary or few to several in compact cymes, sessile or shortly pedunculate; involucres narrowly turbinate, 5.5–8.5 mm high, 3–7 mm wide; bracts imbricate in 4 or 5 series, the outer often greenish medially, the inner chartaceous, with hyaline margins, glabrous; rays 1–7, yellow, 2–3 mm long; disk flowers 4–10; pappus tawny; achenes villous or glabrous. Desert shrub, shrub-grass, and juniper or pinyon-juniper communities at 1310 to 2820 m in Beaver, Juab, Millard, Piute, Sevier, Tooele, and Washington counties; Oregon, California, Nevada, and Idaho; 18 (iii).

Haplopappus racemosus **(Nutt.) Torr.** [*Homopappus racemosus* Nutt.]. Perennial herbs, from a simple caudex and stout taproot, the caudex clothed with fibrous marcescent leaf bases; stems 20–60 (100) cm tall, erect, not abruptly bent at the base (in ours); basal leaves mainly 6–25 cm long, 5–30 mm wide, the blades elliptic to oblong or oblanceolate, petiolate, rigidly erect, entire or toothed, glabrous or puberulent; cauline leaves reduced, sessile, clasping; heads racemose, in panicles or spikes, shortly pedunculate; involucres 8–12 mm high, 4–18 mm wide; bracts in 3 or 4 series, with green tips and coriaceous bases, abruptly pointed apically; rays 10–35, yellow, 5–12 mm long; pappus tawny; achenes hairy or glabrous. Saline meadows at 1370 to 1470 m in Millard and Utah counties; Oregon to Idaho, south to California and Nevada; 2 (i). Utah lies at the eastern margin of the range of this species complex, in which Hall (1928) recognized nine subspecies. Our material is hardly representative of the variation within the assemblage of forms that lie to the west of this region. One of our specimens (Welsh et al. 14514 BRY) belongs to the spiciform narrow-headed var. ***sessiliflorus*** (Greene) Welsh stat. nov. (based on: *Pyrrocoma sessiliflora* Greene Leafl. Bot. Obs. & Crit. 2: 12. 1909), and the other is a paniculiform large-headed phase apparently nearest to var. ***prionophyllus*** (Greene) Welsh stat. nov. (based on *Pyrrocoma prionophylla* Greene Leafl. Bot. Obs. & Crit. 2: 12. 1909). Much more material is required to evaluate the nature of the specimens in Utah. Racemose phases of the closely related *H. lanceolatus* (q.v.) have been mistaken for *H. racemosus*. The erect or suberect stems and stiffly erect leaves appear to be diagnostic for our specimens of *H. racemosus*.

Haplopappus scopulorum **(Jones) Blake** [*Bigelovia menziesii* var. *scopulorum* Jones, type from Zion Canyon; *H. scopulorum* var. *hirtellus* Blake, type from Cedar Canyon]. Shrubs, mainly 3–10 dm tall; branchlets green to straw colored or white, glabrous; leaves 0.7–7.8 cm long, 1–8 mm wide, narrowly lanceolate to oblong, entire, 3-nerved, glabrous, the margins scabrous, attenuate to a spinulose apex; heads few to many, borne in loose to subcompact cymes, peduncled; involucre narrowly campanulate, 6.5–9.5 mm high, 3–5.5 mm wide; bracts in 5 or 6 series, oblong, chartaceous and pale, or the tips greenish or often brownish, rounded-obtuse, glabrous, not resin coated; ray flowers lacking; disk flowers 10–20; pappus white; achenes white-pilose. Pinyon-juniper, mountain brush, and ponderosa pine communities at 1370 to 1830 m in Iron, Kane, San Juan, and Washington counties; Arizona; 10 (vii).

Haplopappus spinulosus **(Pursh) DC.** [*Amellus spinulosus* Pursh]. Perennial herbs from a ligneus caudex; stems mainly 12–50 (60) cm tall, branching above the base; leaves 0.5–6 cm long, 1–10 mm wide, pinnatifid to bipinnatifid or the upper ones entire, or merely toothed, spinulose; heads solitary, or few in corymbose clusters; involucres 5–8 mm high, 8–12 mm wide; bracts in 4–6 series, linear, awn-tipped, herbaceous medially, glandular, not strigulose; rays 15–50, yellow, 8–10 mm long; pappus brownish; achenes pilose. Desert shrub community at ca 1300 m in San Juan County (Atwood 7175 BRY); Alberta to Minnesota, south to California, Arizona, New Mexico, Texas, and Mexico; 1 (0).

Haplopappus watsonii **Gray** Shrubs, 1–4 dm tall; herbage stipitate-glandular; branchlets yellowish, becoming whitish to straw colored or grayish in age; leaves 4–28 mm long, 3–10 mm wide, oblanceolate to obovate or spatulate, entire or undulate, abruptly cuspidate-acuminate apically; heads several to numerous (rarely some solitary) in loose cymes, the peduncles 1–7 mm long; involucres subcylindric to narrowly campanulate, 5.5–8 mm high, 3–76 mm wide; bracts in ca 5 series, the outer ones greenish, the inner chartaceous or greenish at the tips; rays 5–10, yellow, 4–6 mm long; disk flowers 5–15; pappus brownish; achenes hairy. Rock outcrops (limestone, sandstone, or quartzite) in desert shrub, pinyon-juniper, mountain brush, and ponderosa pine communities at 1310 to 3440 m in Beaver, Box Elder, Cache, Davis, Juab, Millard, Salt Lake, Summit, Tooele, and Weber counties; Nevada and Utah; 33 (ii). Our material belongs to one of a vicarious pair of infraspecific taxa within the Great Basin known as var. *rydbergii* (Blake) Welsh comb. nov. (based on: *H. rydbergii* Blake Contr. U.S. Natl. Herb. 25: 545. 1925, nom. nov. pro *Macronema obovatum* Rydb. Bull. Torrey Bot. Club. 27: 68. 1900, type from City Creek Canyon). The var. *rydbergii* differs in having fewer disk flowers (5–15 not 15–25). Other supposedly diagnostic features (i.e., the green outer involucral bracts) fail, being present to a greater or lesser degree in both phases. The type variety has not been discovered in Utah, but should be expected in the western border region.

Haplopappus zionis **L.C. Anderson** Shrubs, mainly 1–3 dm tall; herbage minutely and shortly stipitate-glandular; leaves 0.8–3.5 (4) cm long, 2–4.5 (7) mm wide, oblong to narrowly oblanceolate, 1-nerved, entire, abruptly mucronate; heads solitary or 2 or 3, in cymose clusters, peduncled; involucres cylindric-campanulate, 12–15 mm high, 6–12 mm wide; bracts subequal, herbaceous (outer) and greenish, the inner chartaceous or with a subapical green spot and broadly hyaline margins; rays lacking; disk flowers 8–21; pappus tawny; achenes glabrous below, strigose apically. Ponderosa pine and spruce-fir communities, commonly on limestone members of the Cedar Breaks (Wasatch) Formation, at 2440 to 3050 m in Garfield, Iron, and Kane counties; endemic; 5 (i).

Helenium L.

Annual or perennial herbs; leaves alternate, glandular-punctate, decurrent or clasping; heads solitary or few to numerous in corymbose clusters, radiate, yellow; involucral bracts in 2 or 3 series, the bracts subequal or the inner shorter and narrower, herbaceous or essentially so, soon deflexed; receptacle naked, convex or conic; rays pistillate or neuter; disk flowers numerous, perfect; pappus of 5–10 scarious or hyaline scales; achenes truncately obpyramidal, 4- or 5-angled, with as many intermediate ribs.

1. Leaves sessile, clasping; stems not winged; plants of aspen communities and upward .... *H. hoopesii*
— Leaves decurrent; stems winged below the leaf bases; plants of riparian communities at lower elevations .... *H. autumnale*

Helenium autumnale L. Common Sneezeweed. Perennial herbs; stems mainly 1.5–10 (12) dm tall, puberulent and glandular, corymbosely branched above; leaves 1.5–15 cm long, 3–35 (40) mm wide, serrate to entire, glandular-punctate; heads 3 to many, the disk hemispheric to subglobose, yellow, 1–2 cm wide; rays 10–20, yellow, mainly 8–12 mm long, soon reflexed; pappus scales lance-ovate, with slender awn-tip as long as the body; achenes ca 1.5 mm long, hirsute and glandular. Cattail-willow, tamarix-greasewood, and sedge-rush communities at 1220 to 1830 m in Box Elder, Daggett, Emery, Rich, Uintah, and Utah counties; British Columbia to Quebec, south to Arizona, and Florida; 18 (iii). This species is poisonous to livestock.

Helenium hoopesii Gray Orange Sneezeweed. [*Heleniastrum hoopesii* (Gray) Kuntze; *Dugaldia hoopesii* (Gray) Rydb.]. Perennial herbs, mainly 2–8 (10) dm tall, with a subrhizomatous caudex and fibrous roots; herbage more or less villous-tomentose to glabrate; basal leaves 2–30 cm long, 0.5–5 cm wide, oblanceolate, tapering to a clasping base; cauline leaves reduced upward, oblanceolate to elliptic or lanceolate, entire; heads 2–11, in loose corymbs; disks hemispheric, 2–3.5 cm wide; involucres 5–8 mm high, the bracts lanceolate to elliptic; rays 13–21, yellow or yellow-orange, 15–35 mm long, finally reflexed; pappus scales hyaline, lanceolate, attenuate; achenes 3–4 mm long, hairy. Sagebrush, mountain brush, aspen, and spruce-fir communities, often in openings or riparian zones, at 1830 to 3200 m in Beaver, Box Elder, Carbon, Duchesne, Garfield, Iron, Juab, Piute, San Juan, Sevier, Summit, Utah, Wasatch, and Washington counties; Oregon to Wyoming, south to California, Arizona, and New Mexico; 69 (xiv). This is a poisonous plant, causing spewing sickness in sheep.

HELIANTHELLA T. & G.

Perennial herbs; leaves simple, opposite or alternate, entire; heads radiate, solitary or few to several in loose subcorymbose clusters; bracts imbricate to subequal, more or less herbaceous; receptacle plano-convex, chaffy throughout, the persistent bracts clasping the achenes; disk flowers numerous, fertile, yellow, or purple; rays yellow; pappus of 2 slender awns and short scales; achenes strongly compressed at right-angles to involucral bracts.

WEBER, W. A. 1952. The genus *Helianthella* (Compositae). Amer. Midl. Naturalist 48: 1–35.

1. Heads 3–12 or more, mainly less than 20 mm broad; rays 7–13 mm long, inconspicuous; disk flowers normally purple .... *H. microcephala*
— Heads solitary or 2 or 3, mainly over 20 mm broad; rays 15–30 mm long, showy; disk flowers yellow 2
2(1). Heads erect; involucral bracts lance-oblong, short-ciliate .... *H. uniflora*
— Heads nodding; involucral bracts oblong-ovate, long-ciliate with multicellular hairs .... *H. quinquenervis*

Helianthella microcephala (Gray) Gray [*Encelia microcephala* Gray]. Perennial herbs; stems 20–65 cm tall; herbage appressed hispidulous; basal leaves mainly 4–30 cm long, 0.5–3 cm wide, petiolate, the blades elliptic to lanceolate, scabrous and harshly ciliate, acute to obtuse; cauline leaves reduced upward; heads 3–12 or more; bracts imbricate in ca 3 series, oblong to lanceolate or oblanceolate, strigose and roughly ciliate and glandular; rays 8–10, yellow, 7–13 mm long; disk flowers commonly purple; achenes 7–8 mm long, long-pilose. Desert shrub, pinyon-juniper, ponderosa pine, mountain brush, and Douglas fir-limber pine communities at 1220 to 2745 m in Carbon, Duchesne, Emery, Garfield, Grand, Kane, San Juan, Sevier, and Uintah counties; Colorado and Arizona; 34 (x). In one plant from Navajo Mountain the disk flowers are apparently yellow. A single collection from west of Richfield (Welsh et al. 17487 BRY) is the only record examined for the Great Basin.

Helianthella quinquenervis **(Hook.) Gray** [*Helianthus quinquenervis* Hook.]. Perennial herbs; stems 5–15 dm tall, glabrous or villous above; basal leaves 0.3–40 cm long, 0.8–4 cm wide, petiolate, the blades elliptic to oblong or oblanceolate, entire, obtuse to acute; cauline leaves often enlarged to near stem middle then reduced, becoming subsessile or sessile, the largest (at least) prominently 5-nerved; heads nodding, solitary or 2 or 3; disk 2.5–4 cm wide; bracts ovate-lanceolate, acuminate, long-ciliate; rays 12–21, yellow, 15–35 mm long; achenes 8–10 mm long, pilose. Sagebrush, aspen, ponderosa pine, and spruce-fir communities at 2115 to 3175 m in Carbon, Daggett, Duchesne, Emery, Garfield, Grand, San Juan, Sevier, Summit, Uintah, and Wasatch counties; Oregon to South Dakota, south to Nevada, Arizona, and New Mexico; 13 (0).

Helianthella uniflora **(Nutt.) T. & G.** [*Helianthus uniflorus* Nutt.]. Perennial herbs from a branching caudex; stems mainly 3–10 dm tall, glabrous below or more or less spreading-hairy throughout; basal leaves 3–15 cm long, 0.6–5.5 cm wide, petiolate, the blades oblanceolate to elliptic or lanceolate, entire, obtuse to acute; cauline leaves often enlarged to near stem middle, then reduced, becoming sessile or subsessile, the largest prominently 3-nerved; heads erect, solitary or 2 or 3; disk 1.5–3 cm wide; bracts lance-linear, acuminate or obtuse, scabrous-puberulent, shortly ciliate; rays 13–17, yellow, 2–4.5 cm long; achenes 6–7 mm long, pilose. Sagebrush, pinyon-juniper, mountain brush, ponderosa pine, aspen, and spruce-fir communities at 1525 to 3175 m in Beaver, Box Elder, Cache, Carbon, Davis, Duchesne, Garfield, Grand, Iron, Millard, Morgan, Piute, Rich, Salt Lake, Sanpete, Sevier, Summit, Tooele, Uintah, Utah, Wasatch, and Weber counties; Alberta to Montana, south to Nevada and Colorado; 64 (v).

Helianthus L.

Annual or perennial herbs; leaves simple, opposite below, usually alternate above; heads radiate, showy, solitary or few in corymbs; involucral bracts imbricate or subequal, herbaceous; receptacle flat to convex, chaffy throughout, its bracts clasping the achenes; ray flowers conspicuous, yellow, neuter; disk flowers yellow or reddish, fertile; pappus usually of 2 main awns, scalelike at base, sometimes with additional scales present; achenes narrowly obovate in outline, 4-angled or obcompressed.

Blauer, A. C. 1965. *Helianthus* (Compositae) in Utah. Proc. Utah Academy 42: 240–251.

Heiser, C. B. Jr. 1947. Hybridization between sunflower species *Helianthus annuus* and *H. petiolaris*. Evolution 1: 249–262.

1. Plants perennial; disk flowers yellow; leaves mainly opposite, lanceolate to linear-lanceolate .... *H. nuttallii*
— Plants annual; disk flowers reddish brown to purplish; leaves mainly alternate; leaves lanceolate to ovate 2

2(1). Involucral bracts linear to narrowly lanceolate; pappus of numerous unequal scales 3
— Involucral bracts lanceolate to ovate; pappus commonly of 2 distinct awns 4

3(2). Involucral bracts surpassing the disk; pappus scales linear; stems moderately hirsute to glabrous; plants widespread .... *H. anomalus*

— Involucral bracts subequal to the disk; pappus scales ovate; stems markedly hirsute; plants of Washington County .... *H. deserticola*

4(3). Leaves canescent on both sides; involucral bracts narrowly lanceolate; plants of San Juan County .... *H. niveus*

— Leaves hispid to strigose; involucral bracts lanceolate to ovate; plants widespread 5

5(4). Involucral bracts ovate, rather abruptly narrowed to an acuminate tip, the central ones inconspicuously hairy; leaves often cordate and with serrate margins .. .. *H. annuus*

— Involucral bracts lanceolate, tapering to the tip, the central ones often white bearded apically; leaves seldom cordate, usually entire .... *H. petiolaris*

Helianthus annuus* L.** Common Sunflower. Annual herbs; stems commonly hispid and rough, 3–40 dm tall, simple or branched; leaves alternate above (3) 5–40 cm long, 2–40 cm wide, lance-ovate to broadly ovate, acute to obtuse, serrate, truncate or cordate (alternate) basally, hispid to hispidulous on both sides, petiolate; heads solitary or few; disks mainly 2–5 cm wide; involucral bracts lance-ovate to ovate, attenuate to caudate, hispid to hispidulous, ciliate; disk corolla lobes purplish red (rarely yellow); pappus of 2 awnlike ovate-lanceolate scales; achenes glabrous to strigose. Saltgrass-muhly grass, desert shrub, pinyon-juniper, and mountain brush communities, commonly where disturbed, at 1200 to 2440 m, probably in all Utah counties; widespread in the United States, Canada, Mexico, and elsewhere; 70 (xv). Our common weedy sunflower is assignable to ssp. ***lenticularis (Dougl.) Cockerell; the cultivated large-headed phase to var. *macrocarpus* (DC.) Cockerell.

***Helianthus anomalus* Blake** Sand Sunflower. Annual herbs; stems sparingly hispid to glabrate, 5–70 cm tall; leaves mainly alternate, petiolate, the blades 1.2–10 cm long, 0.4–4 cm wide, narrowly lanceolate to lance-ovate, yellowish green, acute, cuneate to obtuse basally, hispidulous to hispid on both sides; heads solitary or few, showy; disks mainly 12–24 mm wide; involucral bracts linear, commonly 10–25 mm long and 2–3 mm wide, hispid above, definitely hispid-ciliate, at least below, often some much surpassing the disk; disk corolla lobes purple; pappus of 2 large linear scales and numerous similar subequal scales; achenes 3.5–5.5 mm long, appressed pilose. Blackbrush, ephedra, purple-sage, vanclevea, psorothamnus, and pinyon-juniper communities, commonly in dunes or other sandy sites, at 1150 to 1830 m in Emery, Garfield, Grand, Juab, Kane, Millard, San Juan, Tooele, and Wayne (type from near Hanksville) counties; Arizona; 33 (xi). This is a Colorado Plateau endemic, with an extension onto dunes of the eastern Great Basin.

***Helianthus deserticola* Heiser** Desert Sunflower. Annual herbs; stems strongly hispid (at least below), 2–12 dm tall; leaves mainly alternate, petiolate, the blades 2–6 cm long, 0.5–2 cm wide, lanceolate to lance-ovate, green, acute, cuneate to obtuse basally, hispid to hispidulous on both sides; heads few to several (solitary), showy; disks 1.3–2.5 cm wide; involucral bracts linear, 8–14 mm long, 1.5–2.5 mm wide, hispid dorsally and ciliate, subequal to the disk; disk corolla lobes purple; pappus of 2 large lanceolate to lance-ovate scales and ca 10 smaller ones; achenes 4–5 mm long, pilose. Blackbrush, creosote bush, matchweed, and live oak communities at 850 to 1070 m in Washington County; Arizona and Nevada; 2 (0). This is an obscure taxon, despite the passage of two decades since its description; more specimens are required. Perhaps it is too nearly allied to *H. anomalus,* with which it shares some morphological features.

***Helianthus niveus* (Benth.) Brandegee** Snowy Sunflower. [*Encelia nivea* Benth.]. Annual herbs; stems mainly 5–15 dm tall, canescent and hispid; leaves mainly alternate, petiolate, the blades 3–12 cm long, 0.9–6 cm wide or more, lanceolate to ovate, entire or serrate, mostly acute apically, canescent on both sides; heads solitary or few to many; disk 1–2.5 cm wide; bracts narrowly lanceolate, 1.5–2.5 mm wide, 8–12 mm long, subequal to the disk; disk corolla lobes purplish;

pappus of 2 lanceolate scales and several shorter scales. Sandy sites at ca 1375 m in San Juan Counties; Texas to California and Mexico; 1 (0). Our limited material is assignable to ssp. ***canescens*** (Gray) Heiser [*H. petiolaris* var. *canus* Britt.].

Helianthus nuttallii **T. & G.** Nuttall Sunflower. [*H. bracteatus* E.E. Watson, type from Logan; *H. giganteus* var. *utahensis* D.C. Eaton, type from Wasatch Mountains; *H. utahensis* (D.C. Eaton) A. Nels.]. Perennial rhizomatous herbs with tuberous roots; stems 3–20 dm tall or more, glabrous or sparingly scabrous or hispid; leaves mainly opposite, shortly petiolate, the blades 4–16 cm long, 0.8–3 cm wide, narrowly lanceolate, acute to attenuate, entire or denticulate, cuneate basally, scabrous on both sides; heads solitary or few to many; disks mainly 12–28 mm wide; bracts lance-linear, 1.5–3 mm wide, subequal to, or surpassing, the disk, attenuate, appressed pubescent and more or less ciliate; disk corolla lobes yellow; pappus of 2 narrow awnlike scales; achenes 3–4 mm long, glabrous. Seeps, springs, wet meadows, and canal banks at 1280 to 2200 m in Cache, Carbon, Duchesne, Garfield, Juab, Rich, Salt Lake, Summit, Tooele, Uintah, Utah, Wasatch, Washington, and Weber counties; British Columbia to Saskatchewan, south to Nevada, Arizona, and New Mexico; 18 (0). **Note:** The perennial sunflower, *H. tuberosus* L., is grown for its edible roots in our area. It persists following cultivation and is difficult to eradicate. The leaves are broadly lanceolate to ovate.

Helianthus petiolaris **Nutt.** Prairie Sunflower. Annual herbs; stems 0.5–12 dm tall, strigose to hispid or glabrous; leaves mainly alternate, petiolate, the blades 1–8 cm long, 4–25 (30) mm wide, lanceolate to ovate, acute to obtuse, entire or rarely serrate, cuneate to truncate basally, hispidulous to strigose; heads solitary or few; disk 10–25 mm wide; involucral bracts 2–5 mm wide, 7–15 mm long, lanceolate, acuminate or attenuate, hispidulous, usually short-ciliate; disk corolla lobes purplish; pappus of 2 lanceolate awnlike scales; achenes 3–4.5 mm long, hairy. Salt desert shrub, desert shrub, pinyon-juniper, and riparian communities, often where disturbed, at 1220 to 1920 m in Beaver, Duchesne, Emery, Garfield, Grand, Kane, Millard, San Juan, Sevier, Uintah, Wasatch, Washington, and Wayne counties; Alberta to Maine, south to California, Arizona, New Mexico, Texas, Louisiana, and South Carolina; 62 (xxii). Our material has been assigned to ssp. ***fallax*** Heiser. The material appears to be indigenous in the Colorado drainage system, but the rare specimens in the Great Basin seem to be adventive.

HELIOMERIS Nutt.

Annual or perennial herbs; leaves opposite (at least below), simple; heads radiate, solitary or cymose; involucres 2- or 3-seriate; rays yellow, neuter, pubescent dorsally; receptacles chaffy, the chaffy bracts clasping the achenes; disk flowers fertile; pappus none; achenes laterally compressed, 4-angled.

1.	Plants perennial, widespread in montane habitats, less commonly in saline low elevation sites	*H. multiflora*
—	Plants annual, restricted in low elevation saline habitats	2
2(1).	Plants subscapose, with long naked peduncles; leaves ovate to lanceolate	*H. soliceps*
—	Plants caulescent, the peduncles bracteate or leafy; leaves linear	3
3(2).	Leaves canescent with appressed hairs; plants of southern Utah	*H. longifolia*
—	Leaves hispidulous; plants of central and western Utah	*H. hispida*

Heliomeris hispida **(Gray) Blake** Hairy Goldeneye. [*H. multiflora* var. *hispida* Gray; *Gymnolomia hispida* var. *ciliata* Robins. & Greenm., type from Utah; *Viguiera ciliata* (Robins. & Greenm.) Blake]. Annual herbs; stems simple or variously branched, 10–70 cm tall, hispidulous; leaves 0.6–9 cm long, 1–3 mm wide, linear, hispid and hispid-ciliate, acute; heads solitary or 2–5 or more; disks 7–15 mm wide, the corollas yellow; rays ca 9–15, yellow, 6–13 mm long; involucral bracts 5.5–10 mm long, lance-attenuate, hispid and coarsely ciliate; pappus lacking; achenes ca 2.5 mm long, glabrous. Saline marshes and meadows at ca 1300 to 1470 m in Millard, Salt Lake, and Utah counties; Arizona, New Mexico, and Mexico; 9 (ii).

Heliomeris longifolia **(Robins. & Greenm.) Cockerell** [*Gymnolomia longifolia* Robins. & Greenm.; *Viguiera longifolia* (Robins. & Greenm.) Blake]. Annual herbs; stems simple or variously branched, 14–60 cm tall, strigose; leaves 1–6 cm long, 1.2–7.5 mm wide, linear to oblong, strigose, rarely hispid-ciliate near the bases, acute; heads solitary, or 2 to numerous; disks 7–10 mm wide, the corollas yellow; rays ca 8–10, yellow, 6–12 mm long; involucral bracts lance-acuminate to -attenuate, strigose, not especially ciliate; pappus lacking; achenes 2–2.5 mm long, brown, glabrous. Salt desert shrub and pinyon juniper communities at 1150 to 1525 m in Kane and Washington counties; Arizona to Texas and Mexico; 7 (iii). Our material is assignable to var. ***annua*** (Jones) Yates [*Gymnolomia multiflora* var. *annua* Jones, type from Utah?].

Heliomeris multiflora **Nutt.** Showy Goldeneye. [*Viguiera multiflora* (Nutt.) Blake]. Perennial herbs, from a woody taproot and pluricipital caudex; stems 2–10 (13) dm tall, strigose to scabrous-puberulent; leaves lanceolate to linear, mainly opposite, entire or serrate, 1–8 (10) cm long, 2–20 (25) mm wide, short-petiolate, plane or revolute, acute to obtuse; heads commonly 2 to several; disk 6–14 mm wide; involucral bracts linear or narrowly lanceolate, strigose; rays 10–14, yellow, 7–18 mm long; pappus lacking; achenes 1.2–1.8 mm long, brown, glabrous. Two weakly discernible varieties are included in our material.

1. Leaves commonly over 5 mm wide, plane; plants of mesic montane sites .... *H. multiflora* var. *multiflora*
— Leaves commonly less than 5 mm wide, the margins revolute; plants of arid plains and mountains .... *H. multiflora* var. *nevadensis*

Var. ***multiflora*** Sagebrush, juniper, cottonwood, pinyon-juniper, aspen, and spruce-fir communities, often in riparian sites, at 1340 to 2870 m in all Utah counties; Montana south to California, Arizona, and New Mexico; 137 (xvi).

Var. ***nevadensis*** **(A. Nels.) Yates** [*Gymonolmia nevadensis* A. Nels.]. Shadscale, mat-atriplex, pinyon-juniper, and mountain brush communities at 1370 to 2135 m in Grand, Juab, Uintah, and Washington counties; Nevada; 13 (i).

Heliomeris soliceps **(Barneby) Yates** Tropic Goldeneye. [*Viguiera soliceps* Barneby]. Annual herbs, 10–41 cm tall; stems branched below, terminating in subscapose, merely bracteate peduncles that overtop the foliage; leaves opposite below, the blades 15–38 mm long, 6–20 mm wide, ovate to lanceolate, strigose, 3-nerved, petiolate, obtuse to cuneate, becoming smaller upwards; peduncles 7–28 cm long; involucres biseriate, the bracts lance-acuminate, acute, 5–6 mm long, strigose; rays 10–12, yellow, 10–15 mm long; pappus lacking; achenes 2.8–3.3 mm long, blackish. Mat-saltbush community on Tropic Shale Formation at 1400 to 1470 m in Kane County; endemic. This is a striking species, forming masses of yellow blossoms in years of adequate rainfall; 5 (ii).

Heterotheca Cass.

Annual, biennial, or perennial herbs; leaves alternate, simple, entire; heads radiate; involucres campanulate to hemispheric; bracts numerous, narrow, imbricated in several series; receptacle convex, naked; rays yellow, pistillate and fertile; pappus of capillary bristles; disk flowers numerous, the pappus present and usually double, the inner of capillary bristles, the outer (when present) of short scales or bristles; achenes hairy.

Wagenknecht, B. L. 1960. Revision of *Heterotheca*, Section Heterotheca (Compositae). Rhodora 62:61–76, 97–109.

1. Plants low, creeping, arising from subrhizomatous caudex branches; heads nodding, solitary or 2 or 3, known from sandy sites in Garfield, Kane, and Washington (?) counties .... *H. jonesii*

— Plants various in habit, the caudex branches, if present, not rhizomatous; heads few to numerous, seldom nodding, distribution various 2

2(1). Plants perennial, from a woody root crown, the stems numerous, forming rounded clumps, common .... *H. villosa*

— Plants annual or biennial, the root crown herbaceous; stems solitary or few, not forming rounded clumps, rare 3

3(2). Upper leaves cordate-clasping basally; involucres glandular-puberulent and canescent .... *H. psammophila*

— Upper leaves tapering to a sessile base; involucres glandular, pubescent, not canescent .... *H. grandiflora*

Heterotheca grandiflora **Nutt.** Telegraph Weed. Annual or biennial herbs; stems stout, branched above, 5–12 (20) dm tall, hirsute, glandular-pubescent; leaves 2–6 cm long, 0.8–2.5 cm wide (or more), ovate to elliptic, oblong, or oblanceolate, serrate, the lower petiolate and lobed at base; heads numerous; involucres 7–9 mm high; rays 25–35, 6–8 mm long, ca 1 mm wide, the tube hairy; disk flowers numerous, slender; pappus tawny. Sandy roadside at ca 915 m in Washington County; California and Arizona; 1 (i). Our material has the pappus merely tawny, not brick red as reported elsewhere for the species.

Heterotheca jonesii **(Blake) Welsh & Atwood** Jones Goldenaster. [*Chrysopsis caespitosa* Jones, not Nutt.; *Chrysopsis jonesii* Blake]. Perennial caespitose herbs from a creeping subrhizomatous caudex; stems 4–8 cm tall, loosely villous; leaves 5–11 mm long, 1.5–4 mm wide, petiolate, the blades obovate to spatulate, pilose; heads solitary or 2 or 3; involucres 5–7.5 mm high, 6–10 mm wide, the bracts narrowly lance-oblong, strigose-pilose, the hyaline margins reddish; ray flowers 5–13, yellow, 4–6 mm long, 1.5–2.5 mm wide; pappus tawny; achenes 2–3 mm long, hairy. Ponderosa pine, manzanita, and Douglas fir communities, on sandstone or in sand, at 1580 to 2745 m in Garfield, Kane, and Washington (?) counties (the type presumably came from Springdale); endemic; 7 (ii).

Heterotheca psammophila **Wagenkn.** [*H. subaxillaris*, authors]. Annual or biennial herbs; stems stout, 5–12 (20) dm tall, branching above, hispid hirsute and glandular upward; leaves mainly 1–7 cm long, ovate to lance-oblong, serrate to subentire, the lower petiolate, the upper cordate-clasping; heads numerous; involucres 8–12 mm high, glandular and canescent; rays 20–30, yellow, mainly 3–7 mm long; pappus tawny; achenes 2.4–3.8 mm long. Sandy roadside at ca 970 to 1350 m in Grand and Washington counties; Arizona to Texas, south to Mexico; 1 (i). The specimen from Grand County (Welsh & Moore 2745) is missing from BRY, the Washington County locality is reported by Meyer.

Heterotheca villosa **(Pursh) Shinners** Hairy Goldenaster. [*Amellus villosus* Pursh; *Chrysopsis villosa* (Pursh) Nutt. ex DC.]. Perennial herbs, from a ligneous root-crown and taproot; stems several to numerous, forming rounded clumps, mainly 1.5–5 dm tall; herbage hirsute to strigose and more or less glandular; leaves 0.5–5 cm long, 2–10 mm wide, oblanceolate to spatulate or elliptic, green or silvery to gray-green, petiolate or subsessile; heads few to numerous, mainly corymbose; involucres 7–10 mm high, 7–12 mm wide; bracts lance-linear, green or chartaceous, the margins hyaline, sometimes reddish; rays 10–25, yellow, 6–10 mm long; pappus tawny; achenes 2–3 mm long, hairy. Our materials represent only a small portion of the vast array of variation within the *villosa* complex. Three infraspecific taxa are apparent among our specimens, but application of names is difficult. The following treatment is therefore tentative, with a definitive treatment awaiting monographic study.

1. Leaves green or gray-green, the surface apparent through the spreading to subappressed hairs; plants widespread .... *H. villosa* var. *hispida*

— Leaves silvery or grayish, the surface seldom apparent through the usually appressed hairs; plants restricted 2

2(1). Stems mainly appressed hairy, or with some hairs ascending to spreading .... *H. villosa* var. *villosa*

— Stems with appressed and spreading contorted long hairs .... *H. villosa* var. *foliosa*

Var. *foliosa* (Nutt.) V.L. Harms [*Chrysopsis foliosa* Nutt.]. Mountain brush and bunchgrass (*Agropyron* et al.) communities at 1280 to 2135 m in Davis, Duchesne, Salt Lake, San Juan (?), Utah, and Weber counties; widespread in western U.S.; 9 (0).

Var. *hispida* (Hook.) V.L. Harms [*Diplopappus hispidus* Hook.; *Chrysopsis hispida* (Hook.) Nutt.; *C. villosa* var. *scabra* Eastw. (?), type from San Juan County; *C. viscida* var. *cinerascens* Blake, type from Beaver Canyon]. Shadscale-rabbitbrush, ephedra-lycium-dropseed, sagebrush-grass, pinyon-juniper, mountain brush, ponderosa pine-manzanita, and aspen communities at 1150 to 2745 m in all Utah counties; widely distributed in the western U.S.; 105 (xii).

Var. *villosa* Blackbrush, pinyon-juniper, and ponderosa pine communities at 1090 to 2785 m in Garfield, Kane, Washington, and Wayne counties; widespread in western U.S.; 8 (iii).

Hieracium L.

Perennial rhizomatous herbs with milky juice; leaves alternate or basal and still alternate, entire or toothed, simple; heads few to numerous, in corymbose clusters; flowers all raylike, yellow to orange or white; involucres cylindric to hemispheric; bracts more or less imbricate; receptacle naked; pappus usually of brownish capillary bristles; achenes terete or prismatic, more or less strongly ribbed.

1. Flowers white; stems long-setose basally if at all, the petioles and leaves long-setose on the lower midrib .... *H. albiflorum*

— Flowers yellow; stems long-setose throughout or only above; leaves variously setose or glabrous 2

2(1). Leaves glabrous or short-hairy, 2–10 cm long, mainly basal, the stems merely bracteate .... *H. gracile*

— Leaves long-hairy, mainly 10–20 cm long, the cauline ones well developed, reduced above .... *H. cynoglossoides*

Hieracium albiflorum **Hook.** White Hawkweed. Perennial herbs; stems erect, 15–75 cm tall, long-hairy at the base, becoming glabrous upward; basal leaves 2–12 (17) cm long, 0.8–4.5 cm wide, oblanceolate, petiolate, entire or remotely toothed, long-hairy on petioles and midvein, commonly long-ciliate; cauline leaves sessile, reduced upward; stellate hairs lacking; heads few to many, on slender peduncles, the inflorescence open; involucres 6–11 mm high, blackish green, glandular or sparingly long-hairy, or glabrous; flowers 12–35, white; pappus tawny. Lodgepole pine, spruce, and spruce-fir communities at 1980 to 3420 m in Daggett, Duchesne, Sanpete, Uintah, and Utah counties; Alaska and Yukon to Saskatchewan, south to California, Nevada, and Colorado; 12 (ii).

Hieracium cynoglossoides **Arv.-Touv.** Houndstongue Hawkweed. [*H. griseum* Rydb.; *H. scouleri*, authors]. Perennial herbs; stems erect, 20–75 cm tall, pubescent with long, coarse, loose or spreading white setae that dry yellowish; basal leaves commonly withered at anthesis; lower cauline leaves 10–25 cm long, 1–3 cm wide, petiolate, the blades oblanceolate to elliptic, long-hairy; middle and upper leaves reduced, sessile; heads yellow, few to many, 15- to 40-flowered, corymbose, the inflorescence more or less open; involucres 7–12 mm high; bracts greenish, the margins chartaceous to hyaline, minutely stellate and stipitate-glandular; pappus tawny. Grass-forb, aspen, and spruce-fir communities at 200 to 2990 m in Box Elder, Salt Lake, Summit, Utah, Wasatch, and Weber counties; British Columbia and Alberta, south to Oregon and Wyoming; 18 (0).

Hieracium gracile **Hook.** Slender Hawkweed. Perennial herbs; stems erect, 8–40 cm tall, tomentulous to glabrous; basal leaves 2–10 cm long, 0.4–2 cm wide, petiolate, blades oblanceolate, entire or denticulate, stipitate-glandular to glabrous or less commonly with a few long blackish setae; cauline leaves much reduced; heads solitary or more commonly greenish black, stellate hairy, and with long black setae; pappus tawny. Lodgepole pine, spruce-fir, and grass-forb communities at 3050 to 3390 m in Duchesne, Summit, and Uintah counties; Alaska and Yukon to Mackenzie, south to California and New Mexico; South America; 13 (v).

Hofmeisteria Walp.

Shrubs; leaves opposite below, alternate above, simple, petiolate; heads discoid, few to several in terminal corymbose clusters; involucre campanulate; bracts striate, narrow, imbricated; receptacle naked; disk flowers whitish; pappus of 10–12 scabrous bristles and other short scales; achenes 5-angled, callous-thickened.

Hofmeisteria pluriseta **Gray** Arrowleaf. Shrubs, low, rounded, and intricately branched, mostly 3–8 dm tall; branchlets green, glandular-puberulent, becoming white barked in age; leaves long petioled, the petioles 0.8–4 cm long, the blades hastately lobed to entire, 4–10 mm long, 2–4 mm wide; heads small; involucres 4–9 mm high; bracts 3-lined, acuminate; disk flowers whitish. Reported for Utah in Munz (Flora of California, p. 267); to be sought on rock outcrops at lower elevations in Washington County; Nevada, California, and Arizona; 0 (0).

Hulsea T. & G.

Perennial viscid-pubescent aromatic herbs; leaves alternate, simple; heads radiate; involucres hemispheric, the bracts subequal in 2 or 3 series, herbaceous, finally reflexed; receptacle convex, naked; ray flowers yellowish to purplish, pistillate, fertile; disk flowers perfect, fertile; pappus of 4 hyaline scales united at the base; achenes compressed, angled, villous.

Hulsea heterochroma **Gray** Perennial herbs from a stout taproot; herbage viscid-villous, scented, 3–10 (12) dm tall; basal leaves oblanceolate or spatulate, tapering to a broadly petioled base, dentate; cauline leaves mainly 3–10 cm long, 1.5–3.5 cm wide, sessile, and more or less clasping; heads conspicuous, in racemose or corymbose clusters; bracts with long-attenuate, often reddish tips, subequal to the disk; rays reddish to purple or yellowish, hairy and glandular; pappus scales unequal, lacerate; achenes 6–7 mm long. Pinyon-juniper community at 2135 m in the Beaverdam Mountains, Washington County (Higgins 1410 BRY); Nevada and California; 1 (0).

Hymenoclea T. & G.

Xerophytic shrubs; leaves alternate, linear, usually entire; heads discoid, small, numerous, mostly glomerate-paniculate, with both sexes in each leaf axil, the staminate above the pistillate; staminate heads several-flowered; pistillate heads 1-flowered; involucre becoming indurated and beaked in fruit, the bracts persistent as scarious wings; pappus none.

Hymenoclea salsola **T. & G.** Burrobrush. Shrubs, 6–12 (15) dm tall; branchlets green, becoming straw colored to gray in age; herbage yellow green, resinous, glabrous or scabrous; leaves 2–5 cm long, linear, entire; staminate heads 2–3 mm high, 2.5–5 mm wide, the bracts obtuse to rounded, ciliate on the hyaline margin; pistillate heads mainly 6–9 mm high at maturity, the middle and upper bracts with white, chartaceous, broadly rounded, erose margins, longitudinally veined. Blackbrush, creosote bush, and Joshua tree communities at 670 to 900 m in Washington County; Nevada, Arizona, and California; 19 (ii).

Hymenopappus L'Her

Perennial herbs; leaves alternate or mainly basal (and still alternate), mainly pinnatifid; heads discoid, the flowers perfect; involucral bracts in 2 or 3 series, subequal, at least the inner with broad rounded scarious or hyaline margins; receptacle flat, naked or rarely chaffy; corollas yellow or white; anthers sagittate; pappus of several membranous scales; achenes 15- to 20-nerved, 4- or 5-angled.

Turner, B. L. 1956. A cytotaxonomic study of the genus *Hymenopappus* (Compositae). Rhodora 58:163–308.

Hymenopappus filifolius **Hook.** Perennial subscapose herbs; stems 5–60 (100) cm tall, tomentose to glabrate; basal leaves 3–20 cm long, twice pinnately dissected, the ultimate divisions mainly 2–25 mm long, minutely punctate; cauline leaves lacking or several, much reduced upward; heads solitary or more commonly few to numerous, turbinate to campanulate, with 10–59 flowers or more, on peduncles 0.5–10 cm long or more; involucral bracts mainly 3–14 mm long; corollas yellow or white, 2–7 mm long; pappus of narrowly oblong scales; achenes 3–7 mm long, densely hairy. This is a polymorphic species, which consists of a series of geographic and/or edaphically correlated infraspecific taxa. Those taxa peripheral to the main body of the species in the Colorado Plateau province are the most distinctive. The following treatment differs from that of Turner (1956) and represents a more conservative approach.

1. Basal leaf axils sparingly tomentose or glabrous; stems scapose, or with 1 or 2 leaves; plants of high elevations .... *H. filifolius* var. *alpestris*

— Basal leaf axils prominently white-tomentose; stem leaves often more than 2; plants of middle and lower elevations 2

2(1). Corollas 2–3 mm long; flowers fewer than 30; plants of Daggett and Uintah counties .... *H. filifolius* var. *luteus*

— Corollas 3–7 mm long, or, if shorter, not of Daggett or Uintah counties; flowers in main heads often more than 30; leaves more coarsely dissected; plants of various distribution 3

3(2). Flowers white; achene hairs 0.5–1 mm long; plants of Washington County .... *H. filifolius* var. *eriopodus*

— Flowers yellow; achene hairs 1–2 mm long; plants more widely distributed 4

4(3). Leaves mainly basal; plants of the Great Basin .... *H. filifolius* var. *nanus*

— Leaves cauline and basal; plants of the Colorado drainage system .... *H. filifolius* var. *cinereus*

Var. *alpestris* (Maguire) Shinners [*H. nudipes* var. *alpestris* Maguire; *H. nudipes* Maguire; *H. filifolius* var. *nudipes* (Maguire) Turner]. Ponderosa pine, western bristlecone pine, sagebrush-grass, limber pine, aspen, and alpine tundra communities, commonly on limestone or thermally modified igneous outcrops, at 2445 to 3450 m, in Beaver, Carbon, Duchesne, Emery, Iron, Garfield, Kane, Millard, Piute, Sanpete, Sevier, Summit, Utah, and Washington counties; Wyoming; 46 (ix). This is the most distinctive of the varieties within *H. filifolius* in Utah.

Var. *cinereus* (Rydb.) Johnst. [*H. cinereus* Rydb.; *H. lugens* Greene; *H. filifolius* var. *lugens* (Greene) Jepson; *H. filifolius* var. *megacephalus* Turner, as to Utah materials; *H. pauciflorus* Johnst., type from near Bluff; *H. filifolius* var. *pauciflorus* (Johnst.) Turner; *H. tomentosus* Rydb., type from St. George; *H. filifolius* var. *tomentosus* (Rydb.) Turner; *H. niveus* Rydb., type from Springdale]. Blackbrush, warm desert shrub, salt desert shrub, sand sagebrush-ephedra, pinyon-juniper, ponderosa pine, and sagebrush communities at 1065 to 2685 m in Carbon, Daggett, Duchesne, Emery, Garfield, Grand, Kane, San Juan, Uintah, Washington, and Wayne counties; Colorado, California, Arizona, New Mexico, and Texas; 144 (xxix). The variety *cinereus*, as interpreted herein, includes three largely sympatric phases that were treated by Turner (1956) at varietal rank. Although there is a tendency for these phases to be geographically correlated, they are connected completely by series of intermediates, and they can be segregated only arbitrarily. Turner noted that herbarium specimens of var. *megacephalus* from eastern Utah, inter alia, carried a "hodge-podge of annotations: *H. lugens, cinereus, pauciflorus, tomentosus, eriopodus*, etc.," and further that "the possibility exists that the variety [*megacephalus*] here typified includes only the individuals from Clark County, Nevada, and vicinity, and that most of the remaining material to the east represents either a weakly defined separate variety or a common area of extensive hybridization and introgression among the several peripheral taxa mentioned above, . . ." A phase of the *cinereus* complex from Washington County has cauline leaves well developed and plant bases appearing bulbous due to a copious tomentum. These plants are apparently intermediate between var. *tomentosus* (Rydb.) Turner, in a narrow sense, and var. *eriopodus* (A. Nels.) Turner, which share the feature of the "bulbous" bases.

Var. *eriopodus* (A. Nels.) Turner [*H. eriopodus* A. Nels., type from Diamond Valley]. Pinyon-juniper community at 1675 to 2135 m in Washington County; California to Nevada; 3 (0). This variety is evidently rare in Utah, and might best be treated within an expanded var. *cinereus* (q.v.).

Var. *luteus* (Nutt.) Turner [*H. luteus* Nutt.]. Salt desert shrub, mixed cool desert shrub, and pinyon-juniper communities at 1525 to 1830 m in Daggett, Summit, and Uintah counties; Wyoming and Colorado; 7 (ii). The small flowers and finely divided leaves appear to be diagnostic for this variety.

Var. *nanus* (Rydb.) Turner [*H. nanus* Rydb.]. Black sagebrush-rabbitbrush, pinyon-juniper, and ponderosa pine communities at 1490 to 2300 m in Beaver, Garfield, Iron, Juab, Millard, Piute, Sevier, Tooele, and Washington counties; Nevada, California, and Arizona; 26 (v).

HYMENOXYS Cass.

Perennial or biennial herbs from a taproot and commonly with a pluricipital caudex; stems simple or branched; leaves basal or basal and cauline, simple and entire or pinnately to ternately divided; heads radiate, pedunculate; involucres hemispheric; bracts in 2 or 3 series, the outer distinct or connate basally, subequal or imbricate, herbaceous or cartilaginous; receptacle naked, hemispheric; ray flowers yellow, pistillate, fertile, prominently veined, 3-toothed; disk flowers perfect, fertile; pappus scales usually 5, hyaline, nerved or nerveless, the nerve often produced into an awn; achenes obpyramidal, more or less 5-angled, appressed hairy.

1. Leaves entire, essentially all basal 2
— Leaves pinnatifid or palmatifid, or some entire, the cauline ones well developed 5
2(1). Involucral bracts sparsely pubescent or glabrous apically, the margins thin and scarious or hyaline 3
— Involucral bracts moderately to densely villous-pilose or some rarely glabrous, the margins not at all or only narrowly scarious 4
3(2). Plants depressed pulvinate-caespitose, acaulescent; outer involucral bracts recurved, thickened and reddish apically; disks less than 10 mm wide .... *H. lapidicola*
— Plants merely caespitose, scapose; outer involucral bracts erect, not thickened and seldom reddish apically; disks over 10 mm wide .... *H. torreyana*
4(2). Plants pulvinate-caespitose; caudex branches clothed with a marcescent thatch of erect-ascending leaf bases; leaves mainly linear, cuspidate apically .... *H. depressa*
— Plants seldom pulvinate-caespitose; caudex branches without a definite thatch of ascending or erect leaf bases; leaves various, sometimes cuspidate apically .... *H. acaulis*
5(1). Disks 18–30 mm wide or more; involucral bracts similar, distinct, in 2 or 3 indefinite subequal series; herbage villous-tomentose; plants of high elevations .... *H. grandiflora*
— Disks 7–22 mm wide; involucral bracts in 2 dissimilar series, the outer thickened and united at the base 6
6(5). Plants silvery-canescent; leaves entire or 3-cleft, the blades or segments 1.5–4 mm wide .... *H. subintegra*
— Plants green, or, if silvery-canescent, the leaves commonly 3- to 5-cleft 7
7(6). Plants apparently biennial, with an evident basal rosette and taproot; cauline leaves numerous, gradually reduced upward, ternate or palmatifid .... *H. cooperi*

— Plants perennial, from a taproot and caudex; cauline leaves rather well developed, palmatifid to entire 8

8(7). Stems merely glandular or glandular-scabrous; plants of low elevation saline meadows in western Utah .... *H. lemmonii*

— Stems more or less villous; plants of various habitats, but seldom of saline meadows and not of western Utah 9

9(8). Stems few to several from a pluricipital caudex; leaf bases conspicuously long-villous below; leaf segments mainly 1–2.5 mm wide .... *H. richardsonii*

— Stems solitary or few from a simple or branched caudex; leaf bases glabrous or only somewhat hairy; leaf segments 2–6 mm wide .... *H. helenoides*

Hymenoxys acaulis **(Pursh) Parker** [*Gaillardia acaulis* Pursh]. Perennial caespitose herbs from a short multicipital caudex, the caudex branches clothed with short brownish or blackish marcescent leaf bases, 2–50 cm tall, villous to glabrous; leaves 1–6 cm long, 2–8 mm wide, all basal or some cauline, glandular-punctate or epunctate, linear to oblanceolate, entire; heads solitary (rarely 2); disk 7–20 mm broad; bracts distinct, in 2 or 3 subequal series, 4–9 mm high; rays 5–9, yellow, 6–15 mm long; pappus scales 2.5–4.5 mm long, acute or shortly awned; achenes 2.5–4.5 mm long. This is a complex entity, consisting of a series of morphological phases, which are more or less geographically or edaphically correlated.

1. Plants with 1–4 (or more) cauline leaves; stems simple or branched .... *H. acaulis* var. *ivesiana*

— Plants scapose, with cauline leaves lacking or rarely with 1; scapes unbranched 2

2(1). Leaves linear to linear-oblanceolate, conspicuously glandular-punctate, sparingly long-hairy to glabrous; plants of the Colorado drainage system .... *H. acaulis* var. *arizonica*

— Leaves narrowly to broadly oblanceolate, inconspicuously glandular-punctate, merely punctate, or epunctate, or plants of the Great Basin, densely pilose to villous or glabrous 3

3(2). Leaves epunctate or nearly so, glabrous or less commonly silky-hairy; plants of the Colorado drainage system .... *H. acaulis* var. *caespitosa*

— Leaves punctate, silky-hairy, or less commonly glabrous; plants of the Great Basin .... *H. acaulis* var. *acaulis*

Var. *acaulis* Sagebrush, mixed desert shrub, pinyon-juniper, and bunchgrass communities, often on windswept ridges, at 1525 to 2990 m in Beaver, Box Elder, Juab, Millard, Sanpete, Sevier, Tooele, and Washington counties; Idaho east to Saskatchewan, south to Nevada, Colorado, and Texas; 42 (viii). Specimens from the Great Basin might not belong to var. *acaulis* in a strict sense, and perhaps should be regarded as a separate variety. The problem cannot be solved on the basis of Utah specimens alone.

Var. *arizonica* **(Greene) Parker** [*Tetraneuris arizonica* Greene]. Salt and sandy desert shrub, pinyon-juniper, sagebrush, blue grama, aspen, Douglas fir, white fir, and ponderosa pine communities at 1220 to 3175 m in Carbon, Daggett, Duchesne, Emery, Grand, Kane, San Juan, and Uintah counties; Colorado and Arizona; 108 (xvi).

Var. *caespitosa* **(A. Nels.) Parker** [*Tetraneuris acaulis* var. *caespitosa* A. Nels.; *Tetraneuris epunctata* A. Nels., type from Dyer Mine]. Shadscale-eriogonum, black sagebrush, sagebrush, pinyon-juniper, mountain brush, and alpine tundra, often on plateau margins and windswept ridges, at 1585 to 3510 m in Carbon, Daggett, Duchesne, Emery, Grand, Sanpete, Sevier, Summit, and Uintah counties; Wyoming south to New Mexico; 87 (viii).

Var. *ivesiana* **(Greene) Parker** [*Tetraneuris ivesiana* Greene; *H. ivesiana* (Greene) Parker]. Sand sagebrush, ephedra, pinyon-juniper, and ponderosa pine communities at 1150 to 2505 m in Garfield, Grand, Kane, San Juan, and Wayne counties; Colorado, New Mexico, and Arizona; 66 (xii). This variety approaches phases of the partially sympatric var. *arizonica* in stature, and it is possible to confuse some specimens when cauline leaves are lacking and the stems are unbranched. The varieties *acaulis, arizonica,* and *caespitosa* are tetraploids, i.e., 2n = 60, whereas var. *ivesiana* is diploid, i.e., 2n = 30. Because of this difference, Parker (1960. Leafl. W. Bot. 9: 93) elevated this taxon to specific rank.

Hymenoxys cooperi **(Gray) Cockerell** [*Actinella cooperi* Gray; *A. biennis* Gray, type from Washington County?]. Biennial or short-lived perennial herbs; stems 16–60 (80) cm tall, leafy, simple below, branched in a corymbose inflorescence above, often reddish, scurfy villous, canescent; basal rosette leaves mainly 2–10 cm long, pinnately divided, the linear lobes often again divided, mainly 1–1.5 mm wide; stem leaves longer than the internodes; heads (1) 3–50; involucres 5–6 mm high, 10–24 mm wide, hemispheric; bracts thickened and united basally, more or less pubescent and glandular; rays 7–13, yellow, 6–15 mm long; pappus scales acuminate; achenes 2–3 mm long, densely pilose. Sagebrush and pinyon-juniper communities at 975 to 2380 m in Garfield, Juab, Kane, and Washington counties; Nevada, California, and Arizona; 18 (i).

Hymenoxys depressa **(T. & G.) Welsh & Reveal** [*Actinella depressa* Gray]. Pulvinate-caespitose scapose perennial herbs from a multicipital caudex, the caudex branches clothed with conspicuous, commonly erect marcescent leaf bases (often forming a thatch), 1–4 cm tall; scapes villous; leaves 0.4–3 (4) cm long, 1–2 (4) mm wide, linear to oblanceolate, the outer sparingly if at all glandular-punctate, the inner definitely so, sparingly villous to glabrous, cuspidate; heads solitary; disk 6–10 mm wide; involucres 4–6 mm high; bracts in 2 or 3 subequal series, long villous, the margins nonscarious, the apices erect; rays 5–7, yellow, 3–6 mm long; pappus scales 2–3 mm long, long-acuminate; achenes 2–3 mm long. Ephedra, sagebrush, shadscale, and pinyon-juniper woodland at 1340 to 2170 m in Duchesne, Emery, and eastern Sevier counties; endemic? There is justification for inclusion of *H. depressa* within the *H. acaulis* complex, at some infraspecific rank. And the plants have been suggested as merely depauperate phases of that group. However, if they are ecologically controlled variations, they should be expected through much of the range of *H. acaulis;* but they are not. Dwarf forms of *H. acaulis*, especially of the var. *caespitosa,* have been mistaken for this species, but they are more hairy, have usually broader leaves, and lack glandular punctate. There is also a question of typification; the type of *H. depressus* was taken by Fremont, on his second expedition in the Rocky Mountains. Fremont evidently traversed the area occupied by *H. depressa* in 1845, and the material could have come from western Emery County; 24 (iv).

Hymenoxys grandiflora **(T. & G.) Parker** [*Actinella grandiflora* T. & G.]. Perennial herbs from a taproot and usually simple caudex, this clothed with brown marcescent leaf bases; stems mainly 5–25 cm tall, 1 to several, simple or branched basally, densely villous; leaves basal and cauline, 2–10 cm long, 2- or 3-times ternately or palmately divided, the lobes linear, villous to glabrate; heads solitary; disk 1.5–3 cm wide or more; involucral bracts subequal, in 2 or 3 series, 8–14 (16) mm high, densely villous-tomentose; rays 15–50, yellow, 25–35 mm long; pappus scales 3.5–7 mm long, attenuate; achenes 3–5 mm long. Sedge-forb communities at or above timberline, often in talus or rockstripes, at 3050 to 3660 m in Duchesne, Grand, Salt Lake, San Juan, Summit, and Utah counties (Uinta, Wasatch, and La Sal mountains); Idaho to Montana, south to Colorado; 14 (ii). This is a strikingly beautiful yellow sunflower of alpine tundra in our mountains.

Hymenoxys helenioides **(Rydb.) Cockerell** [*Picradenia helenioides* Rydb.]. Perennial herbs from a simple or branched caudex, this clothed with broad brown marcescent leaf bases; stems mainly 25–45 cm tall, simple below, branched above, scurfy and more or less villous; leaves basal and cauline, mainly 5–15 cm long, entire or 2- to 5-lobed, the lobes mainly 3–8 mm wide, finely glandular-punctate, glabrous or puberulent; heads 3–13, in corymbose clusters; disks 10–21 mm wide; involucres 6.5–8 mm high, the outer bracts green, connate in the lower portion, more or less villous and glandular; rays 5–11, yellow, 8–19 mm long; pappus scales 2.5–3.5 mm long, acuminate; achenes 2.5–3 mm long. Mountain brush, sagebrush, and aspen communities, often in meadows, at 2440 to 2990 m in Emery, Garfield, Sanpete, and Sevier counties; Colorado and Arizona; 10 (i). This handsome plant has long remained obscure in Utah, partially due, no doubt, to its resemblance to *Helenium hoopesii* (q.v), with which it occurs in the aspen communities of central and southern Utah.

Hymenoxys lapidicola **Welsh & Neese** Pulvinate caespitose herbs from a multicipital caudex, this densely clothed with brown marcescent leaf bases, acaulescent; leaves all basal, 0.3–1.2 cm long, 0.8–2 mm wide, narrowly oblanceolate, the inner conspicuously glandular-punctate, the blades glabrous, the axils long-villous; heads solitary, immersed in the leaves; disks 5.5–9 mm wide; involucres 5–8 mm high; bracts distinct, in 2 or 3 subequal series, sparingly villous and suffused reddish, the margins scarious, the tips more or less squarrose-spreading and somewhat thickened; rays 5 or 6, yellow, 5–6 mm long; pappus scales lance-acuminate, 2.3–3 mm long; achenes 2–2.5 mm long, pilose. Pinyon-juniper and ponderosa pine-manzanita communities, often in rock crevices, at 1830 to 2476 m in Uintah County; endemic; 4 (0).

Hymenoxys lemmonii **(Greene) Cockerell** [*Picradenia lemmonii* Greene; *H. lemmonii* ssp. *greenei* Cockerell, type from Washington County (?)]. Perennial herbs from a taproot and short ligneus caudex, the caudex clothed with brown to straw-colored or purplish clasping leaf bases; stems 20–60 cm tall, 1 to few, glabrous; leaves cauline and basal, 2–15 cm long, pinnately parted, the lobes linear, 2–3 mm wide, glabrous, glandular-punctate; cauline leaves longer than the internodes, the uppermost often unlobed; heads 5–12; involucres 4.5–7 mm high, hemispheric, 8–14 mm wide; outer bracts green, sparsely scurfy and glandular, thickened dorsally and connate below; rays 6–10, yellow, 6–13 mm long; pappus lance-attenuate, 1.6–2 mm long; achenes 2.5–3 mm long, pilose. Saline rabbitbrush-alkali sacaton meadows at 1660 m in Millard, Tooele, and Washington (?) counties; Nevada and California; 3 (i).

Hymenoxys richardsonii **(Hook.) Cockerell** Colorado Rubberweed. [*Picradenia richardsonii* Hook.]. Perennial caespitose herbs from a pluricipital ligneus caudex, the caudex branches clothed with a thatch of marcescent brown leaf bases, usually with villous leaf axils; stems few to numerous, 6–40 (50) cm tall, simple below, branched; leaves basal and cauline 2–12 (15) cm long, ternate or with 5–7 linear segments, or some entire, pubescent to glabrous; involucres hemispheric, 5–8 mm high, the outer bracts connate basally, thickened dorsally, green or chartaceous, more or less villous; rays 9–14, yellow, 8–20 mm long; pappus 2–4.5 mm long, acuminate; achenes 2.5–4 mm long, pilose. Salt desert shrub, cool desert shrub, pinyon-juniper, sagebrush, mountain brush, ponderosa pine, aspen, fir, and western bristlecone pine communities at 1460 to 2870 m. Our material falls into two varieties, a low plant with 1–5 large heads of Daggett and Uintah counties, belonging to var. ***richardsonii***, and a taller plant with 3–20 smaller heads of Beaver, Carbon, Duchesne, Emery, Garfield, Kane, Millard, Piute, Sanpete, Sevier, Uintah, and Wayne counties, belonging to var. ***florabunda*** (Gray) Parker; Alberta and Saskatchewan to Arizona and Texas; 129 (xvii). The plants are considered poisonous to sheep, cattle, and goats.

Hymenoxys subintegra **Cockerell** Perennial (or biennial) herbs from a taproot; stems solitary or few, 10–60 cm tall, branched above; herbage silvery canescent; basal leaves often withered at flowering; cauline leaves numerous, 1.5–8 cm long, 2–4 mm wide, entire or 2- or 3-lobed; heads few to several; disks 9–12 mm wide; involucres 5–7 mm high; outer bracts connate basally, villous; rays ca 12–20, yellow, 5–10 mm long; pappus scales lance-acuminate, 2.8–3.2 mm long; achenes ca 3 mm long. Ponderosa pine, aspen, and spruce-fir communities in Sanpete (Maguire 20049 BRY) and Washington (reported by Meyer) counties; Arizona; 1 (0).

Hymenoxys torreyana **(Nutt.) Parker** [*Actinella torreyana* Nutt.]. Perennial caespitose scapose herbs from a stout pluricipital caudex, the caudex branches densely clothed with brown to straw-colored or ashy leaf bases, 3–10 cm tall, villous; leaves 1–7.5 (9) cm long, 2–6 mm wide, all basal, glandular-punctate, narrowly oblanceolate, entire; heads solitary; disk 12–20 mm wide; involucres hemispheric, 5–10 mm high; bracts distinct, in 2 or 3 subequal series, less pubescent to glabrous apically, the margins scarious, not thickened apically, the tips erect, sometimes reddish; rays 10–16, yellow, 8–20 mm long; pappus scales ovate-acuminate, 2.8–3.5 mm long; achenes 2–3 mm long. Pinyon-juniper, sagebrush, and mountain brush communities at 1830 to 2200 m in Daggett and Uintah counties; Wyoming; 6 (0).

HYPOCHAERIS L.

Perennial subscapose herbs from taproots, the juice milky; leaves primarily basal, simple, pinnately lobed to pinnatifid, the cauline leaves small and bractlike; heads solitary or few in a branching inflorescence; involucral bracts in several series, greenish black, the inner ones with hyaline margins; receptacle chaffy; corollas of ray flowers only, perfect, yellow or purplish on the dorsal surface; pappus of plumose capillary bristles; style branches semicylindrical; achenes several-nerved, subterete, minutely roughened, long beaked.

Hypochaeris radicata L. Cat's-ears. Plants 1.5–5 dm tall, the stems simple or branched above, glabrous or spreading-hairy below; basal leaves 3–16 (25) cm long, 0.5–3.5 (5) cm broad, oblanceolate, pinnately toothed or pinnatifid, sparsely to moderately spreading-hairy above and below, rounded to obtuse apically, tapering to a broad petiole basally; cauline leaves alternate, minute or lacking; heads solitary, or more commonly 2–5; peduncles glabrous; involucres 5–15 mm high, 7–20 mm wide; bracts glabrous or stiffly hairy along the midribs; corollas numerous, longer than the bracts; achenes 4–7 mm long, the beak mostly 2–3 mm long. Weedy species of disturbed soils in Davis and Salt Lake counties; widespread in North America; adventive from Europe; 2 (0).

INULA L.

Perennial tomentose herbs; leaves basal and cauline, alternate; heads radiate, large, hemispheric, few to numerous in cymose clusters; involucral bracts imbricate in several series; receptacle naked; ray flowers pistillate, yellow, 3-toothed; disk flowers perfect, fertile; anthers sagittate at the base; style branches of disk flowers linear; pappus of capillary bristles; achenes 4- or 5-ribbed.

Inula helenium L. Elecampane. Perennial herbs, mainly 6–20 dm tall, from thick roots; stems simple below; basal leaves 2–5 dm long, petiolate, the blades ovate to oblong, denticulate, rough-hairy above, velvety beneath; cauline leaves reduced upward, cordate-clasping, acute; heads large and showy; involucres 15–23 mm high, 30–50 mm wide; outer bracts foliaceous, ovate; ray flowers numerous, 18–30 mm long, narrow; achenes glabrous. Canal banks and moist meadows at 1370 to 1830 m in Sanpete and Utah counties; widespread in North America; adventive from Eurasia; 2 (i).

IVA L.

Annual or perennial herbs; leaves opposite, at least below; heads discoid, the pistillate flowers few, with corolla tubular or lacking; involucres campanulate; bracts subequal or imbricate in 1–3 series, sometimes with a short inner series subtending the achenes; receptacle chaffy, the receptacular bracts linear to spatulate; staminate flowers with abortive pistils, the styles undivided, the filaments monadelphous; anthers obtuse basally, almost distinct; pappus none; achenes compressed.

1. Leaves sessile or shortly petiolate, entire; plants rhizomatous, mainly less than 40 cm tall, of saline low-elevation sites .... *I. axillaris*

— Leaves petiolate, serrate; plants taprooted annuals, mainly much over 40 cm tall, ruderal weeds .... *I. xanthifolia*

Iva axillaris L. Poverty Weed. Perennial herbs from elongate rhizomes; stems 15–50 (60) cm tall, branched from the base; herbage strigose to strigulose and more or less glandular; leaves opposite below, alternate above, 0.8–4.5 cm long, 4–15 mm wide, elliptic to obovate or lanceolate; heads numerous in terminal bracteate spicate clusters, nodding, 3–7 mm wide; bracts connate, shallowly 4- or 5-lobed; pistillate flowers 4–8, perfect; achenes 2–3 mm long, glandular. Commonly in saline riparian sites in the warm desert shrub, salt desert shrub, pinyon-juniper, and aspen communities at 760 to 2440 m in all Utah counties; British Columbia to Manitoba, south to California, New Mexico, and Oklahoma; 60 (viii).

Iva xanthifolia **Nutt.** Marsh-elder. Coarse perennial herbs, mainly 4–25 dm tall, simple or branched, essentially glabrous below, glandular above; leaves opposite below, petiolate, the blades 4–20 cm long and about as wide, broadly ovate to lance-ovate, serrate and sometimes lobed, green above, canescent beneath; heads 2–4 mm thick, numerous, borne ebracteate in paniculate clusters; involucral bracts distinct, ovate; pistillate flowers 5; achenes sparsely pilose apically, ca 2 mm long. Ruderal weeds of disturbed soils at 1370 to 2290 m in Beaver, Duchesne, Emery, Iron, Kane, Millard, Salt Lake, Sevier, Summit, Uintah, Utah, and Wayne counties; Alberta to Saskatchewan, south to Washington, Arizona, and New Mexico; widely distributed elsewhere; 22 (iii).

KUHNIA L.

Perennial herbs from a woody caudex and taproot; stems branched, erect or ascending; leaves alternate or some lower ones opposite; entire or lobed; heads discoid, several to numerous in paniculate clusters; involucres campanulate; involucral bracts in 4–7 series, the outer ones only graduated; receptacle naked; disk flowers perfect, fertile, whitish; style tips flattened, clavate; pappus of plumose bristles; achenes 10-ribbed.

Kuhnia chlorolepis **Woot. & Standl.** Perennial clump-forming herbs; stems 30–75 cm tall, much branched, minutely hairy; leaves 8–50 mm long (or more), 1–3 mm wide, entire or with a pair of basal lobes, linear; involucres 8–12 mm high; bracts linear to narrowly oblong, striate; corollas 6–7.5 mm long; achenes 4.8–5.2 mm long, dark brown, short-hairy. Rabbitbrush community in intermittent stream courses at 1890 to 2045 m in Uintah County; Colorado to Arizona, New Mexico, Texas, and Mexico; 2 (i).

LACTUCA L.

Annual, biennial, or perennial herbs; leaves alternate, entire or pinnatifid; flowers all raylike, yellow, blue, or white; heads paniculately arranged; involucres cylindrical; bracts imbricate in several series; receptacle flat, naked; pappus copious, of white or brownish capillary bristles; achenes oval, oblong, or linear in outline, compressed, ribbed on each face, short- to long-beaked.

1. Plants perennial, rhizomatous; rays long-exserted, blue .... *L. tatarica*
— Plants annual or biennial; rays not long-exserted, yellow (often fading blue) or blue to white (in *L. biennis*) 2
2(1). Achenes prominently 1-nerved on each side 3
— Achenes prominently several nerved on each side 4
3(2). Involucres 10–15 mm high in fruit; pappus 5–7 mm long; achenes 4.5–6.5 mm long, including the beak .... *L. canadensis*
— Involucres 15–22 mm high in fruit; pappus 7–12 mm long; achenes 7–10 mm long .... *L. ludoviciana*
4(2). Involucres cylindrical at anthesis; flowers not fading blue; plants cultivated and occasionally escaping .... *L. sativa*
— Involucres tapering to the apex at anthesis; flowers fading blue 5
5(4). Achenes with a long filiform beak as long as or longer than the body of the achene; pappus white .... *L. serriola*
— Achenes with a short beak much shorter than the body of the achene; pappus brownish .... *L. biennis*

Lactuca biennis **(Moench) Fern.** [*Sonchus biennis* Moench]. Annual or biennial, glabrous or hairy (on midvein of leaves) herbs; stems erect, mainly 6–20 (35) dm tall; leaves mainly 10–40 cm long, 4–20 mm wide, pinnatifid or merely toothed; heads 13- to 50-flowered, numerous, arranged in a narrow paniculate inflorescence; rays bluish to white; pappus brownish; achenes 4–5.5 mm long, prominently several nerved on each face, beakless or short beaked. Moist sites at ca 1800 m in Salt Lake County (Arnow 2561 BRY, UT); Alaska to Newfoundland, south to California, Colorado, and North Carolina; 1 (0).

Lactuca canadensis **L.** Annual or biennial, glabrous or hirsute herbs; stems erect, 3–25 dm tall; leaves mainly 10–35 cm long, 1–12 cm wide, entire to pinnatifid; heads mostly 13- to 22-flowered, arranged in open panicles; rays yellow (fading blue); pappus white; achenes black, obovate, transversely rugose and with 1 prominent longitudinal vein on each face, 4.5–6.5 mm long, including the beak from half as long to as long as the body. Weedy species of moist sites at ca 1155 m in Kane County (Atwood 4118 BRY); widespread in U.S.; 1 (0).

Lactuca ludoviciana **(Nutt.) Riddell** [*Sonchus ludovicianus* Nutt.]. Biennial or short-lived perennial herbs; stems 6–15 dm tall or more; leaves 10–35 cm long or more, mainly 1–10 (20) cm wide, commonly pinnatifid and weakly spinose-toothed, setose-hispid on the lower midrib, the uppermost auriculate-clasping; heads numerous in an open paniculate cluster, the peduncles bracteate; involucres 15–22 mm high in fruit; heads mostly 20- to 50-flowered, the flowers yellow or sometimes blue, fading blue; pappus white, 7–10 mm long at maturity; achenes flattened, blackish, with a longitudinal median nerve on each face, transversely rugulose, 4–5 mm long. Collected once in Salt Lake County (without collector, UT); widespread in the northwestern U.S.; 1 (0).

Lactuca sativa **L.** Lettuce. Annual herbs; stems erect, mostly 5–12 dm tall, glabrous; leaves mainly 10–30 cm long and as broad, undulate-crisped and serrate, glabrous; involucres 7–10 mm high; heads ca 15-flowered, the flowers yellow, not fading blue, numerous in a paniculate cluster; pappus white; achenes brownish, oblanceolate in outline, flattened, hispid apically, 3.5–4.5 mm long, with 5–7 longitudinal nerves on each face, the beak 2.5–3.5 mm long. Cultivated food plant in much of Utah; introduced from Europe; 2 (0).

Lactuca serriola **L.** Prickly Lettuce. [*L. scariola, scarriola*, orthographic variants]. Biennial or winter annual herbs; stems erect, 3–18 dm tall, hispid below or glabrous overall; leaves mainly 3–30 cm long, 1–10 cm wide, pinnatifid or pinnately lobed, or merely spinose-toothed, the blades vertically oriented (twisted at the base), setose-hispid on main veins beneath; involucres 7–15 mm high at maturity; heads mostly 6- to 12-flowered, the flowers yellow, fading blue, several to numerous in a paniculate cluster; pappus white; achenes brown, the body obovate to oblong in outline, flattened, hispid along margin apically, 3–4.5 mm long, with 5–8 longitudinal nerves on each face, the beak 3–7 mm long. Ruderal weeds at 850 to 2440 m, probably in all Utah counties, widely distributed in the U.S.; adventive from Europe; 37 (v). This species invades lower elevation range lands, where it is eaten by wildlife and livestock. It is reported to produce fertile hybrids with *L. sativa* (q.v.).

Lactuca tatarica **(L.) C.A. Mey.** Blue Lettuce. Perennial rhizomatous herbs; stems 2–12 dm tall, glabrous; leaves 4–20 cm long, 5–35 mm wide, linear to lanceolate or oblong, entire, toothed, lobed, or pinnatifid, short-petiolate below, sessile above; involucres 10–20 mm high; heads cylindric, 15- to 50-flowered, the flowers blue, numerous in an elongate paniculate cluster; pappus white; achenes black to pale, oblong-lanceolate in outline, flattened, 4–7 mm long, with several longitudinal nerves on each face, the beak ca 2 mm long. Marshes, canal and stream banks, and roadsides at 1370 to 2440 m in Cache, Daggett, Duchesne, Garfield, Grand, Iron, Juab, Kane, Millard, Piute, Salt Lake, Sevier, Tooele, Uintah, Utah, and Weber counties; Alaska to Minnesota, south to California and Missouri; 39 (vii). Our material belongs to ssp. ***pulchella*** (Pursh) Stebbins [*Sonchus pulchellus* Pursh], the North American phase of a circumboreal species.

LAPSANA L.

Annual herbs from taproots, the juice milky; leaves alternate, simple, subentire to toothed or lyrate-pinnatifid; heads numerous; involucral bracts in 2 series, the inner ones large and keeled, the outer minute, greenish; receptacle naked; corollas of ray flowers only, perfect, yellow; pappus none; style branches semicylindrical; achenes subterete, several-nerved, tapering at both ends, beakless.

Lapsana communis **L.** Nipplewort. Plants mostly 2.5–10 dm tall, the stems erect, simple or branched, pubescent with stipitate glands or glabrous; leaves mostly 3–10 cm long and 1.4–5 (7) cm wide, the blades subentire to toothed, or the lower ones lyrate-pinnatifid, sparsely hairy to glabrous above and below; heads numerous, the peduncles glabrous or nearly so; involucres 5–8 mm high, 3–9 mm broad, the bracts glabrous; flowers mostly 10–14; achenes 3–5 mm long. Weedy species of disturbed sites in Salt Lake County (Arnow 4747, BRY; UT); widely established in North America; adventive from Eurasia; 1 (0).

LAYIA H. & A.

Annual herbs from taproots; leaves mainly alternate, subentire to toothed or pinnatifid; heads radiate, solitary or few to several, subcorymbose; ray and disk flowers both fertile; involucres campanulate to broadly hemispheric; bracts with thin margins abruptly dilated below, enclosing the ray achenes; receptacle plano-convex, chaffy marginally; ray flowers 8–24, yellow or with the tips white; pappus of numerous bristles, awns, or scales, the bristles often plumose below; ray achenes obcompressed, commonly glabrous and epappose; disk achenes pubescent and pappose.

1. Ray flowers yellow with a white tip; pappus setae merely scabrous; anthers black; plants rare in San Juan County .... *L. platyglossa*
— Ray flowers white; pappus setae plumose; anthers yellow; plants locally common, widespread .... *L. glandulosa*

Layia glandulosa **(Hook.) H. & A.** Tidytips. [*Blepharipappus glandulosus* Hook.]. Plants slender, the stems simple or branched, 0.8–3 dm tall or more, often reddish, with long spreading-ascending multicellular setae; leaves 0.8–6 cm long, 1.5–16 mm wide, often mainly basal, hispid, toothed to lobed, the cauline ones reduced upward and finally entire; heads solitary or 2 to numerous; involucres 6–9 mm high, 10–18 mm wide; bracts hispid and with some tacklike purplish black stipitate glands; rays white, 6–15 mm long; disk flowers numerous; ray achenes 3–4 mm long; disk achenes 3–6 mm long; pappus of 10–12 white flattened setose scales plumose to above the middle with straight capillary and tangled woolly hairs. Sagebrush-grass, grassland, and pinyon-juniper communities at 1370 to 1865 m in Daggett, Garfield, Juab, Kane, Millard, Salt Lake, Sanpete, Tooele, Utah, and Washington counties; British Columbia, south to Baja California and Arizona; 24 (i).

Layia platyglossa **(Fisch. & Mey.) Gray** [*Callichroa platyglossa* Fisch. & Mey.]. Plants slender, the stems erect, simple or branched, setose with long, multicellular hairs, often reddish; leaves mainly 1–6 cm long, 2–7 mm wide, with long, slender, spreading multicellular hairs, the cauline leaves reduced upward and finally entire; heads solitary or few; involucres 6–12 mm high, 12–20 mm wide; bracts hairy like the leaves and with some tacklike purplish black stipitate glands; rays yellow with white tips, 6–18 mm long; disk flowers numerous; ray achenes 3–4 mm long; disk achenes 3–5 mm long; pappus of scabrous setae. Dunes at ca 1375 m in San Juan County (Harrison 2545 BRY); California. Our material apparently belongs to var. ***breviseta*** Gray [ssp. *campestris* Keck], and this is apparently the only known station for the species east of California. The collection was taken in 1927. The plants resemble those of *Gaillardia*, in a general way, and our material has been filed for more than four decades in a folder of that genus.

LEPIDOSPARTUM Gray

Shrubs; leaves alternate, linear, entire; heads several to numerous, in corymbose or racemose clusters; heads discoid, the flowers perfect, yellow; involucres subcylindric; bracts chartaceous, inbricate in several series, rounded apically (at least the inner); receptacle flat, naked; anthers sagittate; style branches flattened; pappus of copious capillary bristles; achenes oblanceolate in outline, long-pilose.

Lepidospartum latisquamum **Wats.** Nevada Broomshrub. Shrubs mainly 6–15 dm tall or more; branchlets with prominent longitudinal striae, the striae glandular, the intervening areas tomentose; leaves 0.5–3 cm long, linear, 0.5–1 mm wide, apiculate; heads 4- to 7-flowered; involucres 8–10 mm high, 3.5–6 mm wide; bracts chartaceous, tomentose, the outer apiculate, very short, the inner broadly rounded and more or less hyaline margined; achenes 4–5 mm long, long-pilose with copious white hairs 3–4 mm long. Rabbitbrush community along a wash at 1705 to 1740 m in Millard County (Pine Valley); Nevada and California; 7 (iii).

LEUCELENE Greene

Perennial rhizomatous herbs; leaves alternate, simple, entire, linear or subulate; heads radiate, solitary or few to many; involucres turbinate; bracts imbricate in several series, green, the margins scarious; ray flowers white or tinged pink, pistillate; disk flowers perfect, fertile, yellow; pappus of capillary bristles; achenes subcylindric or somewhat compressed.

SHINNERS, L. H. 1946. Revision of the genus *Leucelene* Greene. Wrightia 1:82–89.

Leucelene ericoides **(Torr.) Greene** Roseheath. [*Inula ? ericoides* Torr.; *L. arenosa* Heller; *Aster bellus* Blake; *A. leucelene* Blake; *A. hirtifolius* Blake]. Perennial herbs from a branching caudex and rhizome, simple or more commonly branched, 3–17 cm tall, strigose and more or less glandular; leaves 2–10 mm long, 1–2 (3) mm wide, linear to spatulate, becoming subulate upward; heads solitary or few to many; involucres 5–7 mm high, 5–12 mm wide; bracts in 3–5 series; rays 12–25, white to pink, 3–6 mm long; achenes appressed-hairy. Blackbrush, desert shrub, salt desert shrub, pinyon-juniper, and ponderosa pine communities at 1370 to 2595 m in Beaver, Carbon, Daggett, Duchesne, Emery, Garfield, Grand, Iron, Juab, Kane, Millard, Piute, Salt Lake, San Juan, Sanpete, Sevier, Tooele, Uintah, Utah, Washington, and Wayne counties; Nevada and California, east to Kansas, south to Arizona and Mexico; 145 (xvii).

LYGODESMIA D. Don

Perennial or annual herbs with milky juice; leaves alternate or mainly basal and still alternate, entire or pinnatifid; heads solitary or few to many in corymbose or paniculate clusters; flowers all raylike, pink to pink-purple or white; involucres cylindric; bracts mostly 5–9, with some more or less reduced outer ones; receptacle naked; pappus of numerous capillary bristles; achenes linear, subterete, prominently several nerved.

1. Rays 10–12 mm long, ca 4 mm wide; pappus 6–9 mm long .... *L. juncea*
— Rays 15–25 mm long, 6–10 mm wide; pappus 12–17 mm long 2
2(1). Flowers white (or pink?, and drying pinkish); stems ligneous, branching from the base, forming rounded clumps; leaves stiff, spreading; plants of Emery and Grand counties .... *L. entrada*
— Flowers pink or pink-purple; stems various, but, if branched from the base, the leaves either lax or the plants of different distribution .... *L. grandiflora*

Lygodesmia entrada **Welsh & Goodrich** Entrada Rushpink. Perennial herbs from a subterranean caudex, branching from the base, the branches ligneus and wiry, mainly 25–45 cm tall; leaves entire, linear or acicular, 5–30 (70) mm long; peduncles with numerous bracts, 12–20 cm long; involucral bracts hyaline-margined, the outer 5–10 mm long, fimbrillate, the inner ca 6, 16–18 mm long, puberulent at the apex; rays white, ca 3 cm long; pappus barbellate, sordid, 10–15 mm long; achene ribs glabrous. Juniper and mixed desert shrub communities at 1340 to 1465 m in Emery and Grand (type from near

Courthouse Wash) counties; endemic; 3 (i). The status of this entity is unclear; certainly it is a portion of the *grandiflora* complex. Further work is indicated.

Lygodesmia grandiflora **(Nutt.) T. & G.** Showy Rushpink. [*Erythremia grandiflora* Nutt.]. Perennial herbs from deeply placed elongate rhizomes; stems 0.6–5 dm tall, simple or branched from the base or above; leaves alternate, 0.5–10 cm long or more, 1–5 mm wide, attenuate, gradually to abruptly reduced upward; involucres cylindric, 18–25 mm high, densely hairy to glabrous (?), the outer mostly short and ovate to lance-ovate, the inner 5–9 equal, narrowly oblong; rays 5–10, pink, pink-purple, or rarely white, mostly 2–4 cm long; pappus of numerous barbellate tawny bristles; achenes 12–18 mm long, ribbed, glabrous. Our material consists of three taxa, which have been regarded at specific rank. Intermediates between the taxa suggest a more conservative approach.

1. Main involucral bracts 8 or 9; flowers 8–12; plants of east central and northeastern Utah .... *L. grandiflora* var. *grandiflora*
— Main involucral bracts 5 or 6; flowers 5–7 (10); plants of southeastern and western Utah 2
2(1). Uppermost leaves reduced to linear scales mainly 3–10 mm long; achenes 13–19 mm long, smooth on the lower surface .... *L. grandiflora* var. *dianthopsis*
— Uppermost leaves not reduced to scales, mainly 20–40 mm long; achenes 10–13 mm long, rugose on the lower surface .... *L. grandiflora* var. *arizonica*

Var. *arizonica* (Tomb) Welsh comb. nov. [based on: *Lygodesmia arizonica* Tomb Sida 7:530. 1970]. Blackbrush-ephedra and Indian ricegrass-dropseed communities at 1125 to 1590 m in Kane and Wayne counties; Arizona; 7 (ii).

Var. *dianthopsis* (D.C. Eaton) Welsh comb. nov. [based on: *Lygodesmia juncea* var. *dianthopsis* D.C. Eaton in Watson Rep. U.S. Geol. Explor. 40th Parallel, Bot. 5:200. 1871; *L. dianthopsis* (D.C. Eaton) Tomb]. Sagebrush-grass, pinyon-juniper, and mountain brush communities at 1370 to 2440 m in Beaver, Cache, Kane, Millard, Salt Lake, Sevier, and Utah counties; Nevada; 22 (iii). Intermediate specimens transitional to var. *arizonica* occur in south central Utah.

Var. *grandiflora* [*L. grandiflora* var. *stricta* Maguire, type from south of Price]. Shadscale, sagebrush, pinyon-juniper, mountain brush, ponderosa pine, and aspen-sagebrush communities at 1460 to 2750 m in Carbon, Daggett, Duchesne, Emery, Garfield, Grand, and Uintah counties; Wyoming south to New Mexico; 37 (vii). The var. *stricta* is a phase with stiffly erect leaves, but seems to represent only an ecological variant. Specimens of intermediate nature occur southward with both varieties *arizonica* and *dianthopsis*.

Lygodesmia juncea **(Pursh) D. Don** [*Prenanthes juncea* Pursh]. Perennial glabrous herbs from a deeply placed elongate root (rhizome?); stems mainly 1.5–6 dm tall, much branched; leaves stiff, entire, mainly 1–4 cm long, 1–4 mm wide, the upper ones reduced to subulate scales; heads few to several, mainly 5 (4–10) -flowered; flowers pink or less commonly white; involucres 9–16 mm high, with 4–8 main bracts and several shorter outer ones; pappus tawny; achenes ca 5–7 mm long, several nerved. Our few specimens from sandy sites in mixed desert shrub and juniper communities at ca 1400 to 1590 m in Emery and Juab counties; British Columbia to Minnesota, south to Arizona and Arkansas; 3 (0). This is mainly a Great Plains species, with disjunct populations westward, often in sandy habitats.

MACHAERANTHERA Nees

Annual, biennial, or perennial herbs from taproots; leaves alternate, entire or pinnatifid to toothed or lobed, spinulose apically and the teeth, when present, spinulose; heads solitary or 2 to numerous; involucral bracts in several series, herbaceous apically, chartaceous or coriaceous basally, mainly squarrose; rays pistillate and fertile, pink, lavender, pink-purple, or white, or lacking; receptacle naked; anthers not caudate; pappus of capillary bristles; achenes narrowly oblong in outline.

CRONQUIST, A. AND D. D. KECK. 1957. A reconstitution of the genus *Machaeranthera*. Brittonia 9:231–239.

1. Heads discoid; leaves spinose-toothed .... *M. grindelioides*
— Heads radiate; leaves various, but not conspicuously spinose-toothed 2
2(1). Plants perennial, from a definite caudex, of montane sites, commonly on granite, limestone, or quartzite .... *Aster kingii* D.C. Eaton (q.v.)
— Plants biennial, winter annual, or annual (rarely short-lived perennial), the caudex not well developed; plants of various habitats and substrates 3
3(2). Leaves pinnately dissected; plants annual .... *M. tanacetifolia*
— Leaves merely toothed to entire; plants mainly biennial or short-lived perennial 4
4(3). Involucral bracts with green tip commonly equaling or longer than the chartaceous base, the long-tapering apices often reflexed .... *M. bigelovii*
— Involucral bracts with green tip much shorter than the chartaceous base, the reflexed to erect tips shortly attenuate to acute .... *M. canescens*

Machaeranthera bigelovii **(Gray) Greene** [*Aster bigelovii* Gray; *M. mucronata* Greene, sensu Utah materials]. Short-lived perennial (biennial in some?) herbs from a taproot, a caudex not or only poorly developed; stems 11–35 cm long, puberulent below, becoming glandular to stipitate-glandular above; basal leaves often withered at anthesis; cauline leaves oblanceolate to linear or oblong, mainly 1–7.5 cm long, 1.5–8 mm wide, the surfaces glabrous and more or less glandular or stipitate-glandular, ciliate, entire to spinose-toothed; heads few to many in corymbose inflorescences; involucres 9–12 mm high, 12–23 mm wide; bracts lance-linear, attenuate apically, the green apex subequal to the coriaceous base, especially in the outer bracts, commonly spreading-reflexed, glandular and glandular-ciliate; rays 21–31, violet or pink-purple, 10–15 mm long, 2–4.2 mm wide; pappus off-white; achenes glabrous or sparingly strigose, 2.5–4.2 mm long. Mountain brush, aspen, spruce-fir, and alpine meadow communities at 2440 to 3355 m in Garfield, Iron, Kane, and Washington counties (Henry Mountains, Markagunt Plateau, and Kolob Terrace); Colorado, New Mexico, and Arizona; 18 (iii).

Machaeranthera canescens **(Pursh) Gray** [*Aster canescens* Pursh]. Biennial (winter annual) or short-lived perennial herbs from a taproot, a caudex seldom developed; stems 8–60 cm tall or more, variously glabrous, glandular, or puberulent; basal leaves withered or persistent at anthesis; cauline leaves linear to oblong or oblanceolate, 1–10 cm long, 1–22 mm wide, the surfaces glabrous, puberulent, or glandular, commonly ciliate, entire or toothed; heads few to many in paniculate to corymbose clusters; involucres 6–10 (12) mm high, 6–18 mm wide; bracts linear to oblong, attenuate to abruptly attenuate, the green apex commonly much shorter than the coriaceous base, sometimes spreading-reflexed, glandular and or puberulent; rays 15–25, pink to pink-purple or white, 5–12 mm long, 1.5–2.5 mm wide; pappus off-white; achenes pilose, ca 2.5 mm long. The *canescens* complex consists of a series of intergrading taxa, which, in the extreme, are distinctive and geographically or edaphically correlated. Many names have been applied to members of the complex, and specimens often bear annotations of several of the names involved. This is partially in recognition of the intermediate nature of the specimens and partially due to the quality of diagnostic criteria. It seems best to treat the materials from Utah as belonging to a single polymorphic species, consisting of four intergrading varieties.

1. Leaf surfaces glabrous, the upper leaves commonly glandular to stipitate-glandular; upper branches usually with numerous bracteate leaves; plants of southeastern Utah, rarely elsewhere .... *M. canescens* var. *vacans*
— Leaf surfaces puberulent, the upper leaves sometimes also glandular; upper branches lacking bracteate leaves or variously so; plants of broad distribution, but not of southeastern Utah 2

2(1). Upper branches with numerous bracteate leaves; rosette leaves abruptly and angularly lobed or toothed; plants biennial, of central and southwestern Utah ... . *M. canescens* var. *leucanthemifolia*

— Upper branches seldom especially bracteate; rosette leaves various; plants biennial or short-lived perennial, of various distribution 3

3(2). Involucral bracts 1–1.5 (2) mm broad, abruptly attenuate apically; plants often perennial, mainly of higher middle elevations .... *M. canescens* var. *commixta*

— Involucral bracts 0.5–1 mm wide, rather gradually attenuate apically; plants often biennial, mainly of lower to middle elevations .... *M. canescens* var. *canescens*

Var. *canescens* [*M. pulverulenta* (Nutt.) Greene]. Salt desert shrub, mixed desert shrub, pinyon-juniper, mountain brush, aspen-sagebrush, Douglas fir, and lodgepole pine communities at 1250 to 2900 m in Beaver, Carbon, Daggett, Duchesne, Emery, Garfield, Grand, Iron, Juab, Kane, Millard, Piute, Salt Lake, Sanpete, Sevier, Summit, Uintah, and Washington counties; British Columbia to Saskatchewan, south to California, Arizona, and Colorado; 102 (xiii). This is a variable complex of forms that differ in several morphological features, but further segregation seems unwarranted. I have been unable to distinguish *M. tephrodes* (Gray) Greene from among our rather large collection.

Var. *commixta* (Greene) Welsh comb. nov. [based on: *Machaeranthera commixta* Greene Pittonia 4:71. 1899, type from the Henry Mountains; *M. latifolia* A. Nels., type from Big Cottonwood Canyon, *M. leptophylla* Rydb., type from Logan; *M. paniculata* A. Nels., type from Parleys Canyon; *M. rubricaulis* Rydb.; *Aster rubrotinctus* Blake]. Mountain brush, aspen, Douglas fir, sagebrush, spruce-fir, and alpine meadow communities at 1705 to 3420 m in Beaver, Cache, Carbon, Duchesne, Emery, Garfield, Iron, Juab, Millard, Salt Lake, Sanpete, Sevier, Summit, Tooele, Uintah, Utah, and Wayne counties; Wyoming and Colorado; 82 (v).

Var. *leucanthemifolia* (Greene) Welsh comb. nov. [based on: *Aster leucanthemifolius* Greene Erythaea 3:119. 1895; *M. leucanthemifolia* (Greene) Greene]. Blackbrush, mixed desert shrub, pinyon-juniper, mountain brush, and ponderosa pine communities at 915 to 2135 m in Beaver, Iron, Juab, Sanpete, Sevier, Utah, and Washington counties; Nevada and Arizona; 43 (xiii). This plant is mainly a xerophyte of sandy and silty habitats at lower elevations in the Great Basin and lower Virgin River drainage systems; it is transitional at higher elevations with the preceding varieties. Phases of var. *canescens* from northeastern Utah have been regarded as portions of this variety, but they seem not to fit the concept of var. *leucanthemifolia*, whose type is from Mineral County, Nevada.

Var. *vacans* (A. Nels.) Welsh comb. nov. [based on: *Machaeranthera pulverulenta* var. *vacans* A. Nels. Bot. Gazette 56:70. 1913, type from San Juan County, Utah]. Salt desert shrub, mixed desert shrub, pinyon-juniper, and ponderosa pine communities at 1155 to 2380 m in Carbon, Emery, Garfield, Grand, Kane, Juab, San Juan, and Washington counties; Colorado, Arizona, and New Mexico; 61 (xix). This material has been treated as *M. linearis* Rydb., a glabrous-leaved phase of *M. canescens* whose type came from Yellowstone Park, Wyoming. Work of a monographic nature is necessary for the entire *canescens* complex. Additional research might indicate an older name at varietal rank for this taxon.

***Machaeranthera grindelioides* (Nutt.) Shinners** [*Eriocarpum grindelioides* Nutt.; *Haplopappus nuttallii* T. & G.]. Perennial herbs from a woody caudex and stout taproot, the caudex branches more or less clothed with marcescent leaf bases; stems 2–30 cm tall, pilosulose or spreading-hairy below, stipitate-glandular and/or hairy above; basal leaves withered or persistent at anthesis; cauline leaves oblanceolate to spatulate or oblong, mainly 0.5–4.5 cm long, 2–12 mm wide, serrate, the teeth with spinulose tips 1–3 mm long, the surfaces pilosulose and/or stipitate-glandular; heads solitary or few to many in corymbose clusters; involucres 6.5–9.5 mm high, 8–15 mm wide;

bracts narrowly oblong, attenuate to an acute apex, the apical portion green or brown, the base chartaceous, erect, glandular; rays lacking; pappus off-white to brownish; achenes densely pilose, ca 3 mm long. Two distinctive varieties are present in Utah.

1. Plants dwarf, often monocephalous; leaves commonly clustered at stem bases; plants of semibarren habitats in the Great Basin .... *M. grindelioides* var. *depressa*
— Plants seldom dwarf, often with more than 1 head; leaves mainly cauline; plants seldom of the Great Basin .... *M. grindelioides* var. *grindelioides*

Var. *depressa* (Maguire) Cronq. & Keck [*Haplopappus nuttallii* var. *depressa* Maguire, type from Millard County]. Mixed desert shrub, pinyon-juniper, and mountain brush communities at 1465 to 2320 m in Beaver, Juab, and Millard counties; Nevada, a Great Basin endemic; 24 (xiv).

Var. *grindelioides* Blackbrush, mixed desert shrub, sagebrush, pinyon-juniper, and mountain brush communities at 1340 to 3175 m in Carbon, Daggett, Duchesne, Emery, Garfield, Grand, Juab, Kane, Millard, Rich, San Juan, Sanpete, Sevier, Summit, Uintah, and Utah counties; Montana to Saskatchewan, south to Nevada, Arizona, and New Mexico; 98 (xiii). There is a tendency for leaves of plants from the Great Basin to be more glandular than for those in the main body of distribution in the Colorado drainage system.

***Machaeranthera tanacetifolia* (H.B.K.) Nees** [*Aster tanacetifolius* H.B.K.]. Annual (winter annual) herbs; stems 8–50 cm tall, glandular-puberulent and more or less villous; leaves 1–6 cm long, 1- or 2-pinnatifid, the segments ending in spinulose bristles; heads 1 to many, in corymbose clusters; involucres 8–12 mm high, 10–18 mm wide, hemispheric; bracts lance-linear, attenuate, chartaceous basally, green apically, spreading, the reflexed tips glandular; rays 11–23 (36), pink- or blue-purple, 11–14 mm long; pappus off-white; achenes ca 2.5 mm long, pilose. Mixed desert shrub, salt desert shrub, and pinyon-juniper communities at 1125 to 1830 m in Emery, Garfield, Grand, Juab, Kane, San Juan, Sevier, Utah, Wasatch, Washington, and Wayne counties; 31 (vi). The plants are somewhat weedy, colonizing disturbed sandy and silty soils. The similar *M. parviflora* Gray [*Aster parvulus* Blake] is reported for Utah by various authors. It differs in having once-pinnatifid leaves, involucres 4–6 mm long, and rays 5–7 mm long. No material has been seen from Utah by me.

MADIA Molina

Annual or biennial tar-scented herbs from taproots; leaves opposite below, alternate above, simple, entire; heads radiate, the rays pistillate, fertile, yellow, or inconspicuous; involucral bracts uniseriate, equal, enfolding the ray achenes; receptacle flat or convex, with a single series of bracts between the ray and disk flowers; disk flowers perfect; pappus none, a short crown, or a few scales; achenes finely striate, commonly incurved, compressed.

1. Heads turbinate-ovoid, 6–12 mm wide (when pressed); rays 4–7 mm long, showy .... *M. gracilis*
— Heads ellipsoid, 2–5 mm wide (when pressed); rays to 2.5 mm long, or lacking . ... *M. glomerata*

***Madia glomerata* Hook.** Tarweed. Annual herbs; stems mainly 8–40 (60) cm tall; herbage strigose and with long setiform multicellular hairs on leaf bases and on stems above, and stipitate-glandular upward, malodorous; leaves 1.2–9 cm long, 1.5–7 mm wide, linear; heads in dense terminal clusters or sometimes open; involucres 5.5–9 mm high, 2–5 mm wide; rays inconspicuous, mostly 1.5–2.5 mm long, yellow or purplish; disk flowers 1–10; achenes 5-nerved, glabrous. Sagebrush, mountain brush, aspen, spruce-fir, grass-forb, and alpine meadow communities at 1830 to 3175 m in Cache, Carbon, Davis, Duchesne, Emery, Iron, Juab, Piute, Salt Lake, Sanpete, Sevier, Summit, Tooele, Utah, Wasatch, Washington, and Weber counties; Alaska to Saskatchewan, south to California, Arizona, and Colorado; 38 (iv).

Madia gracilis (Smith) **Keck** [*Sclerocarpus gracilis* Smith in Rees]. Annual herbs; stems mainly 10–60 (100) cm tall; herbage pilosulose, becoming hirsute with long multicellular hairs upward, stipitate-glandular with dark capitate glands on the peduncles and sepals; leaves 1–10 cm long, 2–7 (10) mm wide, linear to elliptic or oblong; heads several to many in an open corymbose cluster; involucres 6–11 mm high, 6–12 mm wide; rays conspicuous 5–13, yellow, 4–7 mm long; disk flowers 15–35; achenes often mottled. Opening in mountain brush community at ca 1925 m in Salt Lake County; British Columbia to Montana, south to California; 1 (0).

MALACOTHRIX DC.

Annual (winter annual) or perennial herbs from taproots with milky juice; leaves alternate or mainly basal, mostly pinnatifid; heads of ray flowers only, long-peduncled, solitary or few to several and more or less corymbose; flowers yellow; involucres campanulate; bracts subequal in 2–4 series, with a few short outer ones; receptacle flat, setose or naked; rays 5-lobed; pappus of capillary bristles, these more or less united at the base and falling together or with some persistent; achenes columnar, glabrous, 10- to 15-ribbed, crowned or denticulate at the summit.

WILLIAMS, E. W. 1957. The genus *Malacothrix* (Compositae). Amer. Midl. Naturalist 58:494–512.

1. Leaves merely dentate, elliptic to oblong or lanceolate, the cauline ones clasping basally; involucral bracts orbicular to ovate and with broad scarious margins ..... *M. coulteri*
— Leaves pinnatifid or incised to pinnately lobed, the cauline ones not especially clasping; involucral bracts linear to narrowly lanceolate 2

2(1). Leaves linear-filiform or pinnately dissected into linear segments ..... *M. glabrata*
— Leaves with triangular to oblong lobes or teeth, these sometimes attenuate but not linear 3

3(2). Involucres longer than broad (when pressed); persistent pappus setae 1 or 2; stems decidedly tapering upward; plants rare, in Washington County . *M. clevelandii*
— Involucres broader than long (when pressed); persistent pappus setae 1–5 or lacking; stems various 4

4(3). Leaves with lateral lobes regularly toothed; involucres mainly less than 10 mm long; achenes 2–2.8 mm long; pappus bristles all deciduous ..... *M. sonchoides*
— Leaves with lateral lobes irregularly toothed or lobed; involucres more than 10 mm long; achenes 3–4 mm long; pappus often with 1 or few persistent bristles ..... *M. torreyi*

Malacothrix clevelandii **Gray** Cleveland Malacothrix. Annual herbs; stems mainly 10–40 cm tall, often branched, glabrous, commonly reddish; leaves basal and cauline, 1–10 cm long, 5–15 mm wide, oblanceolate to elliptic, pinnately lobed or merely toothed; heads few to many in a subcorymbose cluster; involucres campanulate, 6–7 mm high; main involucral bracts linear, glabrous, green, the tips often purple, the margins narrowly scarious; rays yellow, ca 2–3 mm long; pappus deciduous or with 1 or 2 persistent bristles; achenes ca 2 mm long, slender, striate. Pinyon-juniper and live oak communities at ca 1375 m in Washington County; California, Nevada, and Arizona; 2 (0).

Malacothrix coulteri **Harv. & Gray in Gray** Snakeshead Malacothrix. Annual (winter annual) herbs; stems mainly 10–50 cm tall, often branched, glabrous and straw colored to whitish tan; leaves basal and cauline 1.2–10 cm long, oblong to oblanceolate or lanceolate, the cauline ones clasping basally; heads few to several, corymbose; involucres hemispherical, 10–15 mm high; bracts imbricate, suborbicular to ovate, with broad scarious margins, the midline broad, purplish; rays yellow to off-white, 5–18 mm long; pappus with 1–4 persistent bristles; achenes

2–2.8 mm long, striate. Warm desert shrub community at ca 950 m in Washington County (Galway sn BRY); Arizona and California; 2 (0).

Malacothrix glabrata **(D.C. Eaton) Gray** [*M. californica* var. *glabrata* D.C. Eaton]. Annual (winter-annual) or biennial herbs; stems mainly 10–60 cm tall, often branched from the base and above, glabrous; leaves basal and cauline, 0.5–15 cm long, pinnately lobed, glabrous or more or less villous, with rachis and lobes linear to linear-filiform, the cauline ones similar to the basal except reduced upward; head solitary or more commonly few to many and subcorymbosely arranged; involucres broadly campanulate 10–14 mm high, the main bracts linear to narrowly oblong, with narrow hyaline margins, glabrous, the outer bracts commonly more or less villous; rays yellow, 10–20 mm long; pappus with usually 2 persistent bristles; achenes 2–3 mm long, striate. Joshua tree, blackbrush, Vanclevea-ephedra, and pinyon-juniper communities at 700 to 1525 m in Kane, Millard, San Juan, and Washington counties; Oregon to Idaho, south to California and Arizona; 22 (0).

Malacothrix sonchoides **(Nutt.) T. & G.** [*Leptoseris sonchoides* Nutt.]. Annual or winter annual herbs; stems mainly 6–37 cm tall, often branched from the base and above, glabrous or with short yellowish glandular hairs in the inflorescence; leaves basal and cauline, 0.7–12 cm long, 1–28 mm wide, the basal ones at least pinnatifid and the lobes regularly toothed; heads solitary or more commonly few to many and subcorymbosely arranged; involucres campanulate 7.5–10.2 mm high, 6.5–12 (14) mm wide, the main bracts lance-oblong to linear, with narrowly hyaline margins, glabrous, the outer sometimes with yellowish stipitate glands; rays yellow, 7–12 mm long; pappus bristles all deciduous; achenes 2–2.8 mm long, striate. Blackbrush, krameria-psorothamnus, mixed desert shrub, sagebrush, and pinyon-juniper communities at 915 to 1856 m in Beaver, Duchesne, Emery, Garfield, Grand, Juab, Kane, Millard, San Juan, Tooele, Uintah, Washington, and Wayne counties; California and Nevada, east to Nebraska and New Mexico; 72 (vi).

Malacothrix torreyi **Gray** [*M. sonchoides* var. *torreyi* (Gray) Williams]. Annual or winter annual herbs; stems mainly 8–29 cm tall, often branched from the base and above, glabrous, or with yellowish stipitate glands in the inflorescence; leaves basal and cauline, 1.7–9.5 cm long, 5–27 mm wide, the basal ones at least pinnatifid, and the lobes irregularly toothed or lobed, often more or less white villous; heads solitary, or more commonly few to several or many and subcorymbosely arranged; involucres broadly campanulate, 10.5–15 mm high, 12–21 mm wide, the main bracts lance-linear, with hyaline margins, glabrous or some with stipitate yellowish glands, the outer bracts often stipitate-glandular; rays yellow, 10–14 mm long; pappus all deciduous or with 1–5 persistent setae; achenes 3–4 mm long, striate. Shadscale, greasewood, other salt desert shrub, and mixed desert shrub communities at 1460 to 1925 m in Beaver, Box Elder, Carbon, Duchesne, Emery, Garfield, Grand, Juab, Millard, Piute, Salt Lake, Sevier, Tooele (type from Great Salt Lake), and Uintah counties; Oregon to Wyoming, south to California and Arizona; 28 (i).

MATRICARIA L.

Biennial or perennial herbs; leaves alternate, 2- to 3- pinnatisect, with ultimate segments linear-filiform; heads radiate, few to many in corymbose clusters; involucres broadly campanulate, the bracts in several series, the margins scarious; receptacle hemispheric, solid, naked; rays pistillate, white; disk flowers 5-lobed, perfect, yellow; pappus a small crown; achenes laterally compressed, with 3 smooth ribs on the ventral surface and 1 or 2 (rarely more) resin glands at the apex of the dorsal face. **Note:** Tentatively I have chosen to follow authors of Flora Europaea (Vol. 4) in segregating *Chamomilla* (q.v.) from *Matricaria*. The genera are much alike and are separated mainly on technical characteristics that are discernible only when fruit is mature.

Matricaria maritima **L.** Biennial or, less commonly, perennial, essentially unscented herbs; stems 1–6 dm tall, glabrous or nearly so; leaves 1–8 cm long, the ultimate segments long and slender; heads several to many, the disk 8–15 mm wide; rays 10–25, white, 6–13 mm long. Ruderal weed of moist sites at 1830 to 2135 m in Salt Lake, Sanpete, and Sevier counties; widespread in North America; adventive from Europe; 2 (i).

MICROSERIS D. Don

Annual or perennial, scapose or caulescent taprooted herbs with milky juice; leaves alternate or all basal, entire or pinnatifid; heads many flowered, erect or nodding in bud; involucres cylindric to campanulate, the innermost bracts lance-attenuate, subequal, the outer ones shorter and imbricate; receptacle naked; corollas all raylike, showy, yellow to yellow-orange (fading bluish); pappus of awn-tipped scales or of plumose capillary bristles; achenes columnar to fusiform, not or only short beaked, ca 10-ribbed.

1. Plants annual; pappus of 5 scales, entended into scabrous bristles apically .... *M. lindleyi*
— Plants perennial; pappus of numerous plumose capillary bristles arising from short scales .... *M. nutans*

Microseris lindleyi **(DC.) Gray** [*Calais lindleyi* DC.; *Microseris linearifolia* (Nutt.) Schultz-Bip; *Uropappus linearifolius* Nutt.]. Annual herbs from slender taproots; herbage puberulent or glabrate; stems lacking or more or less developed, the scapose peduncles 10–25 cm high; leaves 6–15 (30) cm long, pinnately lobed to entire, linear to narrowly elliptic; heads many flowered, erect, the main bracts lance-attenuate, 15–30 mm long, subequal, the outer ones shorter and unequal; rays yellow (drying blue); pappus 10–20 mm long, silvery, deciduous, of 5 lance-linear scales, each terminating in a scabrous awn from a bifid apex; achenes dark brown, 9–13 mm long, tapering apically, scabrous on the ribs. Blackbrush, creosote bush, and pinyon-juniper communities at 915 to 1375 m in Washington County; Washington to Idaho, south to Baja California and Arizona; 5 (i).

Microseris nutans **(Geyer) Schultz-Bip** [*Scorzonella nutans* Geyer]. Perennial herbs from tuberous roots; herbage glabrous or sparsely scurfy; stems more or less developed, the scapose peduncles mainly 12–40 (60) cm high, pinnately lobed to entire, linear to elliptic, lanceolate, or oblanceolate; heads solitary or 2–5, many flowered, nodding in bud, the main bracts 10–20 mm long, lance-attenuate, subequal, the outer bracts shorter and unequal; rays yellow (drying lavender or blue); pappus of numerous narrow scales, each with a plumose terminal bristle. Sagebrush, pinyon-juniper, mountain brush, Douglas fir, and aspen communities at 1675 to 2745 m in Box Elder, Cache, Daggett, Davis, Juab, Millard, Rich, Salt Lake, Sanpete, Sevier, Summit, Uintah, Utah, and Weber counties; British Columbia to Montana, south to California, Nevada, and Colorado; 33 (ii).

MONOPTILON T. & G. ex Gray

Annual herbs, branched from base, the herbage hispid; leaves alternate, spatulate, entire; heads radiate, solitary on branch tips, closely subtended by upper leaves; involucre campanulate, the bracts subequal, linear, herbaceous; receptacle flat, naked; ray flowers pistillate, white to pink; disk flowers perfect, fertile, yellow (purplish); pappus of a short scarious cup and 1 apically plumose bristle, or of numerous bristles alternating with short scales; achenes compressed, marginally nerved, pubescent.

1. Pappus of usually several nonplumose bristles alternating with scales; disk corollas sparsely if at all pilose; reported for Utah by Abrams and Ferris (Illustrated Flora of the Pacific States), but not seen by me . *M. bellioides* (Gray) Hall
— Pappus consisting of minute scales and a single apically plumose bristle; disk corollas densely pilose below .... *M. bellidiforme*

Monoptilon bellidiforme **T. & G. in Gray** Depressed annual branching herbs; stems 1–5 cm high; leaves 4–10 mm long, 0.5–2.5 mm wide, narrowly oblanceolate; heads showy;

involucres 4–5 mm high; bracts linear, attenuate or acuminate, hirsute, and minutely glandular; rays 12–20, ca 4–5 mm long, the tube pilose; pappus of 1 apically plumose bristle and several shorter scales, or the pappus rarely lacking; achenes ca 2 mm long. Warm desert shrub at 700 to 900 m in Washington County; California, Nevada, and Arizona; 2 (0).

Onopardum L.

Biennial caulescent spiny herbs from taproots, the juice watery; leaves basal and cauline, alternate, winged-decurrent; heads solitary or few to several; involucral bracts in several series, imbricate, spine tipped; receptacle flat, fleshy, honeycombed, often with short bristles on the partitions, not densely bristly; corollas all discoid, reddish purple or pink, perfect; pappus bristles barbellate; achenes glabrous, subquadrangular, 4- or 5-ribbed.

Onopardum acanthium **L.** Biennial herbs; stems mainly 5–15 (30) dm tall; leaves of basal rosettes 5–50 cm long or more and 2–15 cm wide, pinnately lobed and serrate-dentate, tomentose on both surfaces, but less so above, spinose; cauline leaves pinnatifid, tomentose to glabrate, strongly winged-decurrent along the stem length; involucres 25–35 mm high, 30–65 mm wide, the bracts lance-attenuate, with spreading spine tips, tomentose to glabrate marginally, the inner erect; spines 3–5 mm long, yellowish; corollas reddish purple to pink. Ruderal weeds at low elevations in Millard, Tooele, Utah, Wasatch, and Washington counties; adventive from Europe; 6 (ii). This handsome but troublesome thistle is spreading through the state, but less vigorously than the musk thistle, *Carduus nutans* (q.v.).

Oxytenia Nutt.

Perennial riparian herbs from a ligneus caudex; leaves alternate, pinnately divided or some entire, the segments linear-filiform, involute; heads discoid, numerous, in elongate paniculate inflorescences; marginal flowers 5, pistillate, inner flowers 10–30, staminate; flowers yellowish white; involucral bracts 5, orbicular, mucronate; receptacle chaffy, the chaffy bracts slender, with dilated villous tips; pappus lacking; achenes obovoid, densely villous, 1-ridged on each face.

Oxytenia acerosa Nutt. Copperweed. Perennial herbs; stems erect, mainly 5–12 dm tall, broomlike in the inflorescence, striate; leaves 3–15 cm long, pinnately 3- to 7-lobed, or the upper ones simple; herbage strigulose; heads 3–4 mm wide, erect or ascending; involucral bracts herbaceous, strigulose; achenes 1.5–2 mm long, black, long villous-pilose. Saline riparian areas and near seeps and springs at 1220 to 2135 m in Carbon, Emery, Garfield, Grand, Kane, San Juan, and Washington counties; Colorado, New Mexico, Arizona, Nevada, and California; 25 (vii). Copperweed is poisonous to livestock.

Palafoxia Lag.

Annual herbs; leaves alternate, entire; heads discoid, few to several, corymbose or paniculate; involucres cylindric; bracts in 1 series, herbaceous; receptacle flat, naked; flowers white, all alike or the outer with unequal lobes; pappus scales 4–8, slender, unequal, with a strong nerve; achenes linear, quadrangular.

Palafoxia linearis **(Cav.) Lag.** Spanish Needle. [*Ageratum lineare* Cav.]. Annual herbs; herbage hispid with slender multicellular hairs, glandular upward; stems commonly branched above the base, 1–7 dm tall; leaves petiolate, the blades 1–7.5 cm long, 2–8 mm wide, linear-lanceolate, long-attenuate; involucres 12–18 mm high, glandular, and more or less hispid, 10- to 20-flowered, the corollas white with pink exserted styles; pappus scales usually 4; achenes strigose. Warm desert shrub community at 700 to 1000 m in Washington County; California to Arizona and Mexico; 5 (0).

Parthenium L.

Herbs or shrubs; leaves alternate, entire or lobed; heads solitary or few and more or less clustered, inconspicuously radiate; ray flowers 5, white, pistillate, fertile, persistent; disk flowers staminate; receptacle plano-convex, chaffy throughout; pappus of 2 or 3 awns or scales; ray achenes dorsiventrally compressed, rotund in outline, the margins thickened into riblike structures attached to the contiguous pair of infertile disk flowers and the subtending bract, the achene, the 2 attached flowers, and the bract falling as a unit.

ROLLINS, R. C. 1950. The guayule rubber plant and its relatives. Contr. Gray. Herb. 179: 1–73.

1. Plants shrubs, the internodes apparent; heads seldom solitary; known from Washington County .... *P. incanum*
— Plants pulvinate-caespitose herbs, the internodes not apparent; heads solitary; plants of eastern Utah .... *P. ligulatum*

***Parthenium incanum* H.B.K.** Aromatic shrub, 4–10 dm tall, much branched, the branchlets loosely tomentose, becoming glabrate; leaves short-petioled, the blades 0.5–5 cm long, 0.4–1.5 cm wide, lobed, white-tomentose below, less so above; heads several to many, corymbose, 3–5 mm wide, outer involucral bracts oblong, acute, villous, the inner ones suborbicular, membranous; rays white, emarginate to incised, 1–2 mm long; pappus of 2 or more pubescent awns; achenes black, oblanceolate, 1.5–2 mm long, pubescent on the ventral surface. Limestone cliffs in creosote bush-blackbrush community at ca 1220 m in Washington County (Higgins 4102 BRY); Arizona to Texas, south to Mexico; 1 (0).

***Parthenium ligulatum* (Jones) Barneby** [*P. alpinum* var. *ligulatum* Jones, type from Theodore (Duchesne); *Bolophyta ligulata* (Jones) W.A. Weber]. Pulvinate caespitose to merely caespitose acaulescent mound-forming herbs to ca 3 cm high, from a taproot and branched caudex, the caudex branches densely clothed with brownish marcescent leaf bases and often with ashy leaves of the previous year; leaves 3–20 mm long, 1.5–4 mm wide, spatulate to oblanceolate, strigose; heads solitary at branch ends, sessile, 5–7 mm high, 4.5–6 mm wide; outer bracts oblong, densely pubescent apically; pappus scales distinct or adnate to the corolla tube; rays white, 1–2 mm long, emarginate; achenes oblanceolate, densely hairy, 4–5 mm long, 2–3 mm wide. Barren or semibarren calciferous or gypsiferous outcrops of the Green River, Uinta, Ferron, and Carmel formations in salt desert shrub and pinyon-juniper communities at 1705 to 2135 m in Daggett, Duchesne, Emery, and Uintah counties; Colorado (a Colorado Plateau endemic); 42 (iv). This amazing plant is one of a series of edaphically restricted mound-formers in semibarren habits on shales and clays of arid sites in Utah. It belongs to a closely related assemblage of two or three taxa within section Bolophytum, and has been regarded at specific status within the segregate genus *Bolophyta*. Its phylogenetic position was reviewed by Rollins (1950), and its status within *Parthenium* seems to represent best its generic affinities.

PECTIS L.

Annual herbs; leaves opposite, entire, glandular-dotted; heads radiate, few to several in cymose clusters; involucres turbinate to subcylindric; bracts 3–12 in one series, expanded basally, enclosing the ray flowers, often with translucent glands; receptacle naked; ray flowers perfect, yellow; disk flowers few; anthers entire, obtuse at base; style branches short, hispidulous; pappus of short-plumose bristles on disk flowers, that of ray flowers a short crown of united scales; achenes terete.

***Pectis papposa* Harv. & Gray in Gray** Chinch-weed. Annual herbs; stems dichotomously branched, often decumbent-spreading, 5–20 (25) cm long, the herbage yellowish green; leaves 6–40 (60) mm long, 0.5–2 mm wide, with a few setae at the base, glabrous, bearing oval to elliptic large yellowish glands; heads on peduncles mainly 0.3–1 (2) cm long; involucres gibbous at the base, rounded dorsally, sparingly glandular like the leaves; ray flowers yellow, 7–9, ca 4–6 mm long; achenes 4–5 mm long, stipitate-glandular. Sandy soil in warm and sandy desert shrub communities at 850 to 1650 m in Kane, San Juan, and Washington counties; California to New Mexico, and south to Mexico; 9 (i).

PEREZIA Lag.

Perennial herbs from a caudex, this clothed with rusty woolly hairs; leaves alternate, simple, clasping; heads numerous in corymbose cymes, apparently discoid; involucres campanulate, strongly imbricate; flowers perfect, pink to pink-purple, the corollas bilabiate, the outer lip 3-toothed, the inner lip recurved, 2-toothed; anthers appendaged; style branches flattened, truncate apically; pappus of white capillary bristles; achenes subterete, minutely glandular.

Perezia wrightii **Gray** [*Acourtia wrightii* (Gray) Reveal & King]. Perennial herbs; stems 4–6 (10) dm tall, often purplish at the base, the rusty hairs at stem base copious; leaves lance-oblong to ovate or lanceolate, spinulose-dentate, glandular-puberulent on both sides, the lower ones petiolate, becoming sessile and clasping upward; involucres 5–8 mm high and about as broad, the bracts graduated, the outer ones ovate, the inner lance-oblong, obtuse, green, the margins often purplish, ciliate; corollas pink to pink-purple; achenes 4.8–5.2 mm long. Warm desert shrub and juniper communities at 915 to 1525 m in Kane, San Juan, and Washington counties; Arizona to Texas, south to Mexico; 6 (i).

Perityle Benth.

Annual herbs or perennial subshrubs; leaves mostly opposite below, alternate above, simple, petiolate; heads few to numerous, corymbose, radiate or discoid; involucres hemispheric or turbinate, the bracts somewhat keeled, in 1 or 2 subequal series; receptacle flat, naked; ray flowers (when present) pistillate, white or yellow; disk flowers perfect; anthers subentire to auriculate at the base; style branches linear or subulate; achenes flattened; pappus of scales, or of 1 or 2 awnlike bristles, or lacking.

Powell, A. M. 1973. Taxonomy of *Perityle* section Laphamia (Compositae-Helenieae-Peritylinae). Sida 5: 61–128.

______. 1974. Taxonomy of *Perityle* section Perityle (Compositae-Peritylinae). Rhodora 76: 229–305.

1. Plants annual .... *P. emoryi*
— Plants subshrubs 2
2(1). Heads radiate; plants glandular-hispidulous, of the Great Basin .... *P. stansburyi*
— Heads discoid; plants villous or glandular-hispidulous, of the Colorado or Virgin drainages 3
3(2). Herbage short-villous and more or less glandular; pappus bristles 1; plants of Washington County .... *P. tenella*
— Herbage hispidulous; pappus of 3 (4) unequal bristles; plants of Grand County .... *P. specuicola*

Perityle emoryi **Torr. in Emory** Emory Rock-daisy. Annual herbs, mainly 2–5 dm tall; stems erect or spreading, commonly branched above, puberulent; leaves mostly alternate, petiolate, the bases 0.5–4 cm long, 0.6–3 (5) cm wide, ovate, cordate, or suborbicular, toothed, lobed, cleft, or divided, the lobes again toothed or lobed, hirsute to glandular-pubescent; heads radiate; involucres 5–6 mm high and usually broader; rays 8–12, white, 1.5–5 mm long; disk flowers numerous; pappus vestigial or a crown of scales and 1 slender bristle; achenes 2–3 mm long, the flattened faces nearly glabrous, the margin thickened and bearing short stiff hairs. Sand sagebrush community at lower elevations in Washington County (Tanner sn 1941 BRY); Nevada, California, Arizona, and Mexico; 1 (0).

Perityle specuicola **Welsh & Neese** Alcove Rock-daisy. Perennial suffruticose herbs, mainly 50–75 cm tall; stems sprawling or pendulous, much branched; herbage glandular-hispidulose; leaves mostly alternate, short-petiolate, the blades 3–6 mm long, 1.5–3 mm wide, ovate-elliptic, entire, hispidulous; heads few to many in a branching corymbose inflorescence; involucres 3.5–5 mm high, 5–6 mm wide; bracts 11–16, oblong to elliptic, keeled; ray flowers lacking; disk flowers numerous, ca 2.5 mm long, whitish (?); pappus of 3 unequal scabrous bristles and often with 1 apically flattened and sigmoid scale; achenes 3–3.8 mm long, the faces flattened, glabrous, the margin thickened and with short ascending hairs. Hanging garden communities at ca 1220 m in Grand County; endemic; 2 (ii).

Perityle stansburyi **(Gray) Macbride** Stansbury Rock-daisy. [*Laphamia stansburyi* Gray, type from Stansbury Island]. Suffruticose perennials, clump-forming, 7–30 cm tall and as broad or more; herbage glandular-hirtellous; leaves mainly alternate, the blades 3–14 mm long, 1.5–12 mm wide, broadly ovate to deltoid or orbicular, typically few to several lobed; petioles 1–14 mm long; heads few to many in a branching corymbose inflorescence; involucres 5–6.5 mm high, 5–10 mm wide; bracts 16–21, lanceolate to oblanceolate, strongly keeled; ray flowers 10–14, yellow, 3–5.5 mm long; disk flowers numerous, yellow, 4–5 mm long; pappus of 1 stout bristle and a very short crown of hyaline scales; achenes 2.3–3.5 mm long, with thin callous margins, short-pubescent on margins and on faces. Limestone, dolomite, and igneous ignimbrite (ashflow tuff) outcrops, in mixed desert shrub, pinyon-juniper, and mountain brush communities, at 1280 to 1895 m in Beaver, Juab, Millard, Salt Lake, Sanpete, Sevier, and Juab counties; Nevada (a Great Basin endemic); 39 (v).

Perityle tenella **(Jones) Macbride** Jones Rock-daisy. [*Laphamia palmeri* Gray, type from Beaverdam, Arizona?, not *P. palmeri* Wats.; *L. palmeri* var. *tenella* Jones, type from Springdale]. Suffruticose perennials, clump-forming, 9–25 cm tall and as broad or more; herbage villous and glandular; leaves mainly alternate, the blades 4–13 mm long, 3–15 mm wide, deltoid-ovate, the base obtuse to truncate or cordate; petioles 1–8 mm long; heads solitary or few to many, corymbose; involucres 4–6.5 mm long, 5–10 mm wide; bracts 11–18, lance-elliptic, keeled; ray flowers absent; disk flowers numerous, yellow, 3–4 mm long; pappus of a single bristle; achenes 2.5–3 mm long, with thin callous margins, short-pubescent on margins and on faces. Joshua tree, creosote bush, blackbrush, warm desert shrub, pinyon-juniper, and ponderosa pine communities at 915 to 2135 m in Washington County; Arizona; a Mohave endemic; 7 (0). Plants from the Beaverdam Mountains have heads that average larger, but they seem not to differ otherwise from the typical materials taken near Zion National Park.

PETRADORIA Greene

Suffrutescent perennials from a taproot and woody caudex; stems herbaceous, leafy; leaves basal and cauline, alternate, entire, 3- to 5-veined, coriaceous; heads radiate (in ours), congested at branch ends in an open corymbose inflorescence; involucres cylindric; bracts in several series, in more or less vertical ranks; flowers 4–7, yellow, the corollas glabrous; pappus of brownish capillary bristles; achenes somewhat compressed, glabrous.

ANDERSON, L. C. 1964. Studies on *Petradoria* (Compositae); anatomy, cytology, taxonomy. Trans. Kansas Acad. Sci. 66: 632–684.

Petradoria pumila **(Nutt.) Greene** Rock Goldenrod. [*Chrysoma pumila* Nutt.]. Plants from a well-developed caudex, the caudex branches clothed with dark to ashy or tan marcescent leaf bases; leaves 1.5–12 cm long, 1–11 mm wide, oblanceolate to lanceolate, elliptic, or linear; cauline leaves reduced upward; heads numerous; involucres 5–9.5 mm high, 1.3–2.8 mm wide; involucral bracts 10–21, in 3–6 series, more or less keeled; flowers 2–8, the rays 1–3, yellow, 4–9 mm long; achenes 4–5 mm long, glabrous, 6- to 9-nerved. Shadscale, mixed desert shrub, pinyon-juniper, sagebrush, and ponderosa pine communities at 1525 to 3050 m in all (?) Utah counties; Idaho and Wyoming, south to Nevada, California, Arizona, and New Mexico; 100 (xv). Most of our specimens belong to the broad-leaved var. ***pumila,*** but one specimen from Emery County (Harris 546 BRY) seems to be clearly allied to var. ***graminea*** (Woot. & Standl.) Welsh comb nov. [based on: *Petradoria graminea* Woot. & Standl. Contr. U.S. Natl. Herb. 16: 183. 1913; ssp. *graminea* (Woot. & Standl.) L.C. Anderson]. That taxon has been known previously only from Arizona.

PLATYSCHKUHRIA (Gray) Rydb.

Perennial herbs from a woody caudex and rootstock; leaves alternate, simple, coriaceous, often impressed-punctate; heads few to many in a cymose paniculate cluster, radiate, campanulate to hemispheric; involucral bracts subequal in 2 series; receptacle essentially flat, naked; rays pistillate, fertile, yellow; disk flowers numerous, perfect; anthers more or less sagittate basally; pappus of 8–16 scales with midribs sometimes produced apically; achenes narrowly obpyramidal and 4-sided, hairy or glabrous on the sides.

ELLISON, W. L. 1971. Taxonomy of *Platyschkuhria* (Compositae). Brittonia 23: 269–279.

Platyschkuhria integrifolia **(Gray) Rydb.** [*Schkuhria integrifolia* Gray; *Bahia nudicaulis* Gray; *B. integrifolia* (Gray) Macbride]. Perennial herbs; stems solitary or few to several, mainly 12–55 cm tall; herbage white-strigulose or stipitate-glandular, especially above; main leaves near the stem base, petiolate, the blades 1.5–9.5 cm long, 0.5–4 cm wide, ovate to lanceolate, elliptic, or oblanceolate; cauline leaves reduced upward, finally merely bracteate; heads (1) 2–10; rays 7–11, yellow, 6–14 mm long; achenes 5–8 mm long. Three rather distinctive varieties are present in eastern Utah, as indicated below.

1. Stems leafy almost or quite to the apex; plants of San Juan County .... *P. integrifolia* var. *oblongifolia*
— Stems leafy mainly below the middle; plants not known from San Juan County 2
2(1). Pubescence of upper stems merely white-strigulose; involucral bracts caudate-attenuate .... *P. integrifolia* var. *ourolepis*
— Pubescence of upper stems stipitate-glandular; involucral bracts mainly obtuse to acute .... *P. integrifolia* var. *desertorum*

Var. *desertorum* **(Jones) Ellison** [*Bahia desertorum* Jones, type from Cisco]. Salt desert shrub, pinyon-juniper, and mountain brush communities, mainly in saline substrates, at 1280 to 2565 m in Carbon, Duchesne, Emery, Garfield, Grand, Sevier, Uintah, and Wayne counties; Colorado; a Colorado Plateau endemic. A report by Ellison (1971) of var. *integrifolia* (a Wyoming-Montana endemic) belongs here; 39 (xi). The var. *desertorum* is closely allied with var. *integrifolia*, as indicated by pubescence and bract shape similarities. This variety is transitional with var. *ourolepis*.

Var. *oblongifolia* **(Gray) Ellison** [*Schkuhria integrifolia* var. *oblongifolia* Gray; *Bahia oblongifolia* (Gray) Gray; *Platyschkuhria oblongifolia* (Gray) Rydb.]. Desert shrub communities in San Juan County; Arizona, Colorado, New Mexico; 0 (0). The variety is reported from San Juan County, but no specimens have been seen by me.

Var. *ourolepis* **(Blake) Ellison** [*Bahia ourolepis* Blake, type from Green River]. Salt desert shrub and pinyon-juniper communities at 1280 to 1830 m in Duchesne, Emery, Grand, and Uintah counties; endemic; 24 (iii). The main body of this variety lies in Uintah County.

PLUCHEA Cass.

Shrubs; leaves alternate, simple, entire, sericeus; heads discoid, few to several, aggregated in terminal cymose clusters; involucres campanulate; bracts imbricate in several series, scarious, the outer ones sericeus; receptacle flat or concave, naked; outer flowers pistillate, numerous, their filiform corollas 3- or 4-toothed; central flowers perfect but the innermost sterile, their tubular corollas 5-toothed; anthers sagittate basally; pappus of outer flowers merely capillary bristles, those of inner flowers clavate apically.

Pluchea sericea **(Nutt.) Cov.** Arrowweed. [*Polypappus sericeus* Nutt.; *Tessaria sericea* (Nutt.) Shinners]. Shrubs with slender, erect, willowlike branches, mainly 0.8–3 m tall, sericeus throughout, longitudinally striate; leaves 0.8–4.5 cm long, 2–9 mm wide, elliptic to narrowly lanceolate or lanceolate, entire, sessile; heads more or less conspicuous; involucres 3.5–5 mm high, 4–7 mm wide; outer bracts ovate to ovate-lanceolate, abruptly acute, deciduous, often purplish; pistillate flowers purplish, numerous; perfect flowers purplish, fewer; achenes glabrous; pappus bristles of perfect flowers dilated apically. Riparian areas at 460 to 1220 m in Garfield, Kane, San Juan (?), and Washington counties; California to Texas, south to Mexico; 22 (iii). The genus *Pluchea*, in a broad sense, includes annual and perennial herbs and shrubs. *Tessaria*, when segregated from *Pluchea*, consists of the shrubby species that have dimorphic corollas and the inner perfect flowers with apically flared pappus bristles. The residue within *Pluchea* contains only herbs with uniformly 4-lobed corollas and pappus of uniform barbellate capillary bristles. I follow tradition in maintaining our species in *Pluchea*.

POROPHYLLUM (Vaill.) Adans.

Suffruticose perennial; leaves alternate or opposite, simple, with at least some elliptic to oval oil glands; heads discoid, solitary, or few to several in corymbose clusters; involucres cylindric, the bracts usually 5, in subequal series, glandular like the leaves; receptacle naked; flowers perfect, fertile, purplish; anthers rounded basally; style branches slender, hirtellous, subulate; pappus of scabrous bristles; achenes slender, striate.

Porophyllum gracile **Benth.** Odora. Rounded bushy perennials from a woody base; stems much branched, 1.5–4 dm tall; herbage dark green or often purplish, glaucous, odoriferous; leaves 1–4 cm long, linear-filiform, entire; involucre subcylindric, 10–15 mm long; bracts 5, dark green, tinged purplish, oblong, the hyaline margin pink, gibbous basally, bearing conspicuous glands, especially apically; corollas purplish, white; pappus bristles pinkish; achenes 8–9 mm long, hispidulous. Desert shrub communities in Washington County (Cottam 5522 UT); California to Arizona and Mexico; 1 (0).

PRENANTHELLA Rydb.

Annual herbs; leaves basal and alternate, simple, pinnately lobed, toothed, or pinnatifid; heads small, few to numerous; involucres campanulate; bracts in 2 series, the inner subequal, 3 or 5, the outer much reduced, 1 or 2, herbaceous; flowers all raylike, 4 or 5; achenes 5-ribbed; pappus of white capillary bristles.

Prenanthella exigua **(Gray) Rydb.** [*Prenanthes exigua* Gray; *Lygodesmia exigua* (Gray) Gray]. Annual; stems branched from the base, forming rounded clumps, 7–24 (30) cm tall; inflorescence paniculate, comprising more than half the plant height; lower leaves 1–4 (6.5) cm long, 3–12 (20) mm wide, spatulate to oblanceolate, the rosette often withered at anthesis; cauline leaves reduced upward, finally bracteate scales; herbage sparingly stipitate-glandular; involucres 3–5.5 mm long, 1.2–3.5 mm wide; inner bracts oblong, herbaceous, apically constricted in bud; rays pink or white, 1.5–2 mm long; achenes 3–3.5 mm long, 5-ridged, scabrous; pappus of white capillary bristles. Blackbrush, creosote bush, other warm desert shrub, salt desert shrub, and pinyon-juniper communities at 850 to 1925 m in Beaver, Carbon, Emery, Garfield, Grand, Juab, Kane, Millard, San Juan, Tooele, Uintah, and Washington counties; California, Nevada, Colorado, Arizona, and New Mexico; 20 (ii).

PSATHYROTES Gray

Annual or perennial (?) herbs; leaves alternate, petiolate, simple, entire or lobed to toothed; heads discoid, the flowers yellow or purplish in age; involucres campanulate; bracts biseriate, the outer often shorter or otherwise different; receptacle flat, naked; anthers minutely sagittate; style branches flattened; achenes hairy; pappus of capillary bristles.

1. Plants lanate-tomentose as well as scurfy; outer involucral bracts expanded apically, oblong-obovate; reported for Utah by Munz (A California Flora), but not seen by me .... *P. ramosissima* (Torr.) Gray
— Plants scurfy and less commonly somewhat tomentose; outer involucral bracts tapering apically, lanceolate 2

2(1). Leaves entire; herbage scurfy and with long-piliferous multicellular hairs .... *P. pilifera*
— Leaves toothed; herbage scurfy but not long-piliferous .... *P. annua*

Psathyrotes annua **(Nutt.) Gray** Mealy Rosettes [*Bulbostylis annua* Nutt.]. Annual or winter annual herbs forming low rounded cushions, mainly 2–18 cm tall; leaves petiolate, the blades 5–17 mm long, 5–20 mm wide, orbicular to fan shaped, dentate; herbage scurfy; heads few to numerous, corymbose; involucres 5.5–7.5 mm high, 5–8 mm wide; outer bracts lanceolate to oblong, more or less constricted above the middle, scurfy and ciliate; disk corollas 3.5–4.2 mm long, yellow, becoming purplish; achenes 2–2.5 mm long, pilose. Warm desert shrub, salt desert shrub, and pinyon-juniper communities, commonly on limestone and dolomitic gravels, at 790 to 1740 m in Juab, Millard, Tooele, and Washington counties; Idaho south to California, Nevada, and Arizona; 17 (iv).

Psathyrotes pilifera Gray Annual or winter annual herbs forming hemispheric cushions, mainly 5–15 cm tall; leaves petiolate, the blades 5–15 mm long, 4–16 mm wide, obovate, ovate, or oval-elliptic, entire; herbage scurfy and piliferous with long multicellular hairs; heads few to many, corymbose; involucres 8.5–10 mm high, 4–5.5 mm wide; outer bracts lanceolate, seldom constricted above the middle, scurfy and with long piliferous setae marginally; disk corollas 6–6.5 mm long, yellow, becoming purplish; achenes 3.8–4.8 mm long. Warm desert shrub and salt desert shrub, commonly on gypsiferous substrates of the Moenkopi and Chinle formations, at 760 to 2260 m in Grand, Kane, and Washington counties; Arizona; endemic; 9 (iii).

Psilocarpus Nutt.

Low floccose-woolly annual herbs; leaves opposite, simple, entire; heads discoid, subglobose; involucre per se essentially lacking; receptacle chaffy, subglobose; pistillate flowers numerous, imbricate, each enclosed by and deciduous with its subtending bract, woolly, with sides meeting in the center, bearing below the rounded tip on inner side a scarious appendage; corollas filiform; pappus lacking; perfect flowers few, central, ebracteate, the corollas 4- or 5-toothed, epappose; anthers sagittate.

Psilocarphus brevissimus **Nutt.** Low white-woolly annuals; stems simple or with decumbent-prostrate branches mainly 1.5–20 cm long; leaves 5–15 mm long, 1–3 mm wide, spatulate to lanceolate, apiculate; heads solitary or clustered, long-woolly, ca 5–7 mm thick, subtending leaves about as long as the head or longer; pistillate flowers 20–34 or more, the enclosing bracts 2.5–3.2 mm long, woolly, the appendage horizontally produced to erect, ca 0.5 mm long; perfect flowers ca 6–10; achenes subcylindric, terete, 1.3–2 mm long. Lake and reservoir beds at ca 1710 m in Cache and Salt Lake counties; Washington to Montana, south to California, Mexico, and South America; 6 (0).

Psilostrophe DC.

Perennial herbs or shrubs; leaves alternate, simple, entire or merely lobed; heads few to many, corymbose; involucres campanulate; bracts in 1 series, subequal; receptacle naked; ray flowers yellow, pistillate, becoming papery and persistent; disk flowers perfect, 5-lobed; anthers obtuse basally; style branches truncate; pappus of 4–6 hyaline scales; achenes obtusely angled, glabrous or hairy.

1. Plants shrubby; stems closely white-tomentose; of Washington County .... *P. cooperi*
— Plants herbaceous, from a definite caudex; stems glabrous or loosely tomentose; not of Washington County 2
2(1). Stems loosely tomentose; involucres densely white villous-tomentose; plants of Grand County .... *P. bakeri*
— Stems glabrous, or tomentose only at the base; involucres sparingly tomentose, greenish; plants of Wayne, Garfield, and Kane counties .... *P. sparsiflora*

Psilostrophe bakeri **Greene** Perennial herbs from a caudex; stems 10–35 cm tall, densely white-woolly below, loosely tomentose upward; leaves 0.8–10 cm long, 2–15 mm wide, spatulate to oblanceolate, entire or lobed, pubescent like the stems; cauline leaves reduced upward; involucres loosely villous-tomentose, 5–9 mm high, ca 3–4 mm wide; rays 3–6, yellow, 6–12 (15) mm long; pappus scales ca 2 mm long, rounded; achenes whitish, ca 2–2.5 mm long. Sandy warm desert shrub community at ca 1285 m in Grand County (Trotter 101 BRY); Colorado (a Plateau endemic?); 1 (0).

Psilostrophe cooperi **(Gray) Greene** Paperflower. [*Riddellia cooperi* Gray]. Shrubs; stems closely white-tomentose, mainly 30–60 cm tall; leaves 1.2–7 cm long, linear, entire, sparingly tomentose, finally glabrate; involucres tomentose, 6–8 mm high, 5–8 mm wide; rays 4–8, yellow, 8–20 mm long; pappus scales ca 2 mm long, acute; achenes whitish, 4.5–7 mm long. Joshua tree, creosote bush, blackbrush, and pinyon-juniper communities at 915 to 2135 m in Washington County; Nevada, California, Arizona, and New Mexico; 11 (ii).

Psilostrophe sparsiflora **(Gray) A. Nels.** [*Riddellia tagetina* var. *sparsiflora* Gray]. Perennial herbs from a caudex; stems 14–60 cm tall, densely to moderately pilose basally, sparingly villous-tomentose upward; leaves 0.9–11.5 (14.5) cm long, 1–11 mm wide, spatulate to oblanceolate or linear, pubescent like the stems or glabrate; involucres 4.5–6 mm high, 4–6 mm wide; rays usually 3, yellow, 6–12 mm long; pappus scales 1.5–2.5 mm long, acutish; achenes yellowish, 2.5–3 mm long. Salt desert shrub, pinyon-juniper, and sagebrush communities at 1430 to 2045 m in Garfield, Kane, and Wayne counties; Arizona, New Mexico, and Mexico; 42 (vi).

RAFINESQUIA Nutt.

Annual herbs; stems fistulous; leaves alternate, pinnatifid; heads 2 to several, large, showy, with white or rose-tinged flowers; involucres essentially cylindric; bracts 7–15, in 2 series, the inner subequal, the outer ones much shorter, obtuse or subcordate basally; flowers all raylike; pappus white or tawny, of 8–15 slender long-plumose bristles; achenes terete, obscurely few ribbed, attenuate into a beak.

1. Rays mainly 5–8 mm long; achene beak as long as the body; plumose hairs of pappus straight; plants reported for Utah by Munz (A California Flora), but not seen by me .... *R. californica* Nutt.
— Rays mainly 12–18 mm long; achene beak shorter than the body; plumose hairs of pappus crinkled; plants of Washington County .... *R. neomexicana*

Rafinesquia neomexicana **Gray** Desert Chicory. Annual (winter annual) herbs; stems mainly 15–40 (50) cm tall, simple or branched, often growing up through shrubs; basal leaves 1.2–9 cm long, pinnatifid, often withered at anthesis; cauline leaves sessile and auriculate-clasping, reduced upward; involucre 15–25 mm high, 5–9 mm wide; main bracts lance-attenuate, the margins scarious, the outer ones more or less cordate basally; rays 12–18 mm long, white or suffused with pink, 5-toothed or -lobed apically; pappus bristles white, the bases flattened, plumose to near the apex; achenes 12–15 mm long, papillate-puberulent. Joshua tree, creosote bush, blackbrush, and desert almond communities at 700 to 1070 m in Washington County; California to Texas and Mexico; 6 (i).

RATIBIDA Raf.

Perennial herbs from a caudex and stout taproot; leaves alternate, pinnatifid; heads radiate, solitary or few and corymbose; rays neuter, commonly yellow (sometimes purple in part or throughout); involucre in 1 series, green; receptacle columnar, chaffy throughout, the bracts more or less clasping the achenes; disk flowers perfect, fertile; anthers sagittate; style branches flattened; achenes compressed at right angles to the involucral bracts, glabrous, the margins sometimes ciliate; pappus of an evident tooth and sometimes with a second one.

Ratibida columnifera **(Nutt.) Woot. & Standl.** Prairie Coneflower. [*Rudbeckia columnifera* Nutt.; *R. columnaris* Pursh]. Perennial herbs; stems mainly 3–6 (12) dm tall, several, often branched above, strigose; leaves 2–9 cm long, pinnatifid, with the terminal division often the largest; heads borne on slender peduncles 6–18 cm long, the disk grayish in bud, purplish brown in flower, 1.5–3 cm long; rays 3–7, yellow (or purple), 1–3 (4.5) cm long, spreading or reflexed; pappus an evident awn tooth on the inner angle of the achene, often also a shorter one on the outer edge; achenes ciliate and more or less winged on the inner edge. Salt desert shrub and sagebrush communities at 1585 to 2565 m in Garfield, Millard, and Washington counties; British Columbia to Minnesota, south to Arizona, Texas, and Mexico; 4 (i). Our material appears to be adventive from the main body of the species in the prairies and plains provinces to the east of Utah.

RIGIOPAPPUS Gray

Annual herbs; leaves alternate, linear, entire; heads radiate, solitary or few to several, cymose; rays pistillate, fertile, yellow, inconspicuous; involucres campanulate; bracts oblong-alternate, subequal, partly clasping outer achenes; receptacle flat, with a row of bristles between ray and disk flowers; disk flowers perfect, fertile, yellow; anthers not toothed; style branches flattened; pappus usually of 3–5 awnlike scales (or lacking); achenes linear, transversely rugulose.

Rigiopappus leptocladus **Gray** Wireweed. Slender annual herbs; herbage puberulent to glabrate; stems 2–20 (30) cm tall; lateral branches, when present, very slender, overtopping the early flowers; leaves 0.3–2 (3) cm long, linear, the lower often withered at anthesis; heads small; involucres 4–7 mm high and about as broad; bracts herbaceous, glabrous, thickened dorsally; rays few, yellowish, 1.5–2 mm long; pappus scales linear-subulate, ca 3 mm long; achenes 5–6 mm long. Reported for Utah by Cronquist (Flora of the Pacific Northwest), but not seen by me; 0 (0).

RUDBECKIA L.

Perennial caulescent herbs; leaves alternate, serrate or pinnately to palmately lobed; heads radiate or discoid, the rays (when present) neuter, commonly yellow; involucral bracts in 2 or 3 series, mainly unequal, herbaceous, spreading or reflexed; receptacle conic or columnar, chaffy throughout, the bracts clasping the achenes; disk flowers fertile; anthers obtuse or sagittate basally; style branches flattened; pappus a crown or none; achenes quadrangular or flattened at right angles to the involucral bracts.

1. Heads radiate; disks 1–2 cm wide and about as long, little elongate in fruit; plants of San Juan County .... *R. laciniata*
— Heads discoid; disks 1.5–2.5 cm wide, mostly 2–5 cm long, elongating in fruit; plants not of San Juan County 2

2(1). Leaves laciniately lobed; plants glabrous or merely scabrous-ciliate on leaf margins; known from Iron and Washington counties .... *R. montana*
— Leaves crenate-serrate, dentate, undulate, or entire, not lobed; plants evidently short-hairy to almost glabrous; known from mountains of central northern to south central Utah .... *R. occidentalis*

Rudbeckia laciniata **L.** Cutleaf Coneflower. Perennial herbs; stems erect from a coarse ligneus base, mainly 5–10 (20) dm tall, glabrous or scabrous-ciliate; leaves petiolate, the blades laciniate-pinnatifid to palmatifid, mainly 4–15 cm long and as broad; heads showy, the disk 1–2 cm wide and about as high; rays yellow, 6–16, deflexed-spreading, 2–5 cm long; pappus a short crown. Moist meadows at 1890 to 2200 m in San Juan County; Montana to Quebec, south to Arizona and Florida; 2 (0).

Rudbeckia montana **Gray?** Perennial herbs; stems erect, from a short subrhizomatous caudex, 6–12 dm tall, glabrous; leaves petiolate, the blades laciniate-pinnatifid, mainly 4–20 cm long and about as broad; heads discoid, the disk 1.5–2.5 cm wide, 3–5 cm high; rays lacking; pappus an irregularly margined, almost toothed crown. Iron and Washington counties; Colorado; 2 (0).

Rudbeckia occidentalis **Nutt.** Western Coneflower. Perennial herbs; stems erect from a coarse ligneus rhizome, mainly 5–20 dm tall, glabrous or strigulose; leaves petiolate, the blades 5–20 cm long, 2.5–10 cm wide, ovate to ovate-lanceolate or lanceolate, attenuate to acuminate, entire, crenate-serrate, or dentate; heads discoid, the disks 1.5–2.5 cm wide, 3–6 cm long; rays lacking;

pappus a short crown. Mountain brush, aspen, grass-tall forb, and spruce-fir communities at 2135 to 3175 m in Cache, Carbon, Duchesne, Emery, Piute, Salt Lake, Sanpete, Sevier, Summit, Tooele, Utah, Wasatch, and Weber counties; Washington to Montana, south to California and Wyoming; 42 (iii).

SENECIO L.

Annual, biennial, or perennial herbs with rhizomes, caudices, or taproots, the juice watery; stems erect, ascending, or decumbent at the base; leaves alternate, simple, entire, toothed, or lobed to pinnatifid; heads solitary, or few to many in corymbose cymes; involucral bracts in 1 series, often with smaller bractlets at the base, green throughout or the margins scarious or hyaline, or variously colored; receptacle flat or convex, naked; ray flowers yellow or orange, or sometimes lacking; pappus or capillary bristles; style branches flattened; achenes subterete, 5- to 10-nerved, glabrous or pubescent. **Note:** This genus consists of a series of species that intergrade freely when they are in contact with others of the group. Because of hybridization the species lines tend to be blurred, and it is not possible to place all specimens with confidence. Keys are, and have been, based on features that are subject to interpretation; the present one is not an exception, being tentative at best.

BARKLEY, T. M. 1978. *Senecio*. N. Amer. Flora II. 10:50–139.

1.	Leaves pinnatilobate with linear-filiform divisions or entire and linear-filiform; stems with leaves only gradually reduced upward, often more or less woody below	2
—	Leaves variously lobed, toothed, or entire, but the segments and leaves not linear-filiform; stems with leaves various, seldom, if at all, woody at the base	3
2(1).	Heads cylindric, subcylindric, or narrowly campanulate; main involucral bracts 8–13, the outer ones much reduced and inconspicuous; plants glabrous	S. *spartioides*
—	Heads campanulate to broadly campanulate; main involucral bracts 13–21, the outer ones conspicuous, or, if inconspicuous, the plants tomentose	S. *douglasii*
3(2).	Heads nodding, especially in bud, or, if erect, with both distinctly black triangular tips on involucral bracts and cauline leaves prominently clasping	4
—	Heads erect, even in bud; plants various but not as above	7
4(3).	Heads discoid	5
—	Heads radiate	6
5(4).	Heads 8–12 mm high, 6–9 mm wide, narrowly campanulate, conspicuously pedunculate	S. *pudicus*
—	Heads 12–20 mm high, 14–20 mm wide, broadly campanulate, short-pedunculate	S. *bigelovii*
6(4).	Heads erect, the involucral bracts black-tipped	S. *crassulus*
—	Heads nodding, the involucral bracts often suffused with purple throughout, but not especially black tipped	S. *amplectens*
7(3).	Plants annual or winter annual, introduced weedy species	S. *vulgaris*
—	Plants perennial, indigenous species	8
8(7).	Stems uniformly leafy to the inflorescence, or the leaves concentrated upward	9
—	Stems few leaved, or the upper leaves definitely reduced in size and distribution	12
9(8).	Stems 1–3 dm tall, more or less sprawling, arising from a subrhizomatous caudex	S. fremontii
—	Stems mostly 2–15 dm tall, erect or ascending, arising from a rhizome or a caudex	10

10(9). Plants mainly 2–4 dm tall; leaves pinnatifid to lobed or laciniate; involucral bracts with dark tips .... *S. eremophilus*

— Plants mainly 5–10 dm tall; leaves dentate to serrate; involucral bracts uniformly greenish or brownish 11

11(10). Leaf blades acute to obtuse basally, the teeth all about alike .... *S. serra*

— Leaf blades truncate to obtuse basally, or more or less hastately lobed, the lowermost teeth often the largest .... *S. triangularis*

12(8). Plants glaucous tall herbs, semiaquatic; leaves entire or denticulate, thick and leathery .... *S. hydrophilus*

— Plants not or seldom glaucous, terestrial; leaves entire, toothed, or pinnatifid, not thick and leathery 13

13(12). Rays orange or orange-red (see also S. *pauperculus*) .... *S. crocatus*

— Rays yellow or lacking 14

14(13). Heads discoid; plants tomentose, soboliferous .... *S. fendleri*

— Heads radiate (or rarely discoid in some individuals); plants tomentose, glabrate, or glabrous, not soboliferous (except in S. *werneriifolius*) 15

15(14). Leaves pinnatifid, at least the cauline ones, or the basal ones commonly rounded apically or oblanceolate to ovate or oval in outline 16

— Leaves serrate to entire, the basal ones variously shaped, but mainly acute to attenuate apically 20

16(15). Basal leaves distinctly pinnately divided, the lobes often again toothed .... *S. multilobatus*

— Basal leaves merely toothed to subentire 17

17(16). Basal and lower cauline leaves entire to dentate, but not pinnatifid .... *S. hartianus*

— Basal and lower cauline leaves toothed to pinnatifid 18

18(17). Middle and upper cauline leaves clasping with large auriculate bases .... *S. dimorphophyllus*

— Middle and upper cauline leaves without a prominent clasping or auriculate base 19

19(18). Basal leaves obovate to oblanceolate or ovate, rounded apically, thickish; plants of dryish habitats .... *S. streptanthifolius*

— Basal leaves oblanceolate to elliptic, obtuse, but usually pointed apically, thin; plants of meadows .... *S. pauperculus*

20(15). Cauline leaves rounded and more or less clasping basally, long-attenuate apically, entire or denticulate .... *S. integerrimus*

— Cauline leaves tapering to the base or with a few basal clasping lobes in some, usually not attenuate apically 21

21(20). Stems subscapose, the cauline leaves none or few and bractlike; plants often soboliferous or with a branching rhizomatous caudex .... *S. werneriifolius*

— Stems more or less leafy, the cauline leaves gradually reduced upward, but hardly bractlike; plants seldom as above 22

22(21). Involucral bracts ca 8 or fewer; heads 5–6 mm wide, mainly 20–60 per inflorescence .... *S. atratus*

— Involucral bracts mostly 13–21; heads 8–12 mm wide or more, fewer or larger than above 23

23(22). Achenes glabrous; plants often less than 20 cm tall 24
— Achenes hirtellous or hispidulous; plants often over 20 cm tall 25

24(23). Main leaves regularly and evenly pinnatifid or pinnatisect; plants often with slender rhizomes .... *S. fendleri*
— Main leaves entire to dentate, not as above; plants shortly rhizomatous .... *S. canus*

25(23). Main leaves 10–15 cm long or more, entire or denticulate; plants 50–70 cm tall, of northern Utah .... *S. sphaerocephalus*
— Main leaves 2–8 cm long, dentate, serrate, or subentire; plants mainly 15–35 cm tall, of southern Utah .... *S. neomexicanus*

Senecio amplectens **Gray** Alpine Groundsel. Perennial short-rhizomatous herbs; stems ascending to erect, mainly 8–30 cm tall; herbage glabrous or sparingly tomentose; main leaves middle and lower cauline, the lower ones broadly petiolate, more or less clasping the stem, the blades 3–10 cm long, 0.8–3 cm wide, dentate to shallowly lobed; cauline leaves becoming short-petiolate or sessile upward, finally bractlike; heads 1–5 (rarely more), conspicuously nodding, corymbose; involucres broadly hemispheric, 10–15 mm long and about as wide or wider; bracts mainly ca 21, usually brown, with scarious margins, glabrous; outer bracts to about half as long as the inner; rays 7–17, yellow, 10–25 mm long; pappus white; achenes glabrous. Spruce-fir and alpine tundra communities, often in talus or on ridge margins, at 3050 to 3570 m in Beaver, Grand, Piute, San Juan, Sanpete, and Utah counties (Wasatch, Tushar, and La Sal mountains, and Wasatch Plateau); Montana, Wyoming, Colorado, and Nevada; 24 (v). Our material belongs to var. *holmii* (Greene) Harrington [S. *holmii* Greene; *Ligularia holmii* (Greene) W.A. Weber].

Senecio atratus **Greene** Perennial subrhizomatous herbs from a branching caudex; stems erect or ascending, 2–8 dm tall; herbage floccose-tomentose; basal and lower cauline leaves petiolate, mainly 8–30 cm long, 1–4 cm wide, the blade oblanceolate or oblong, conspicuously dentate to subentire; cauline leaves gradually reduced upward, becoming sessile or subsessile and finally bracteate; heads ca 15–60, in more or less compact corymbose clusters; involucres 6–8 mm high, 3–6 mm wide; main bracts 8 or fewer, greenish to brownish, the margins scarious, the tips black, tufted-hairy apically; rays 3–5, yellow, 4–8 mm long; pappus white; achenes glabrous. Aspen, spruce-fir, mixed conifer, and tall forb communities at 2440 to 3335 m in Duchesne, Garfield, Iron, San Juan, Salt Lake, Sanpete, and Uintah counties; Colorado and New Mexico; 22 (iv).

Senecio bigelovii **Gray in Torr.** Bigelow Groundsel. Perennial subrhizomatous herbs; stems erect, mainly 3–8 (10) dm tall; herbage floccose-tomentose to glabrate or glabrous; main leaves cauline, largest below, reduced gradually upward, petiolate below, sessile and clasping to auriculate above, mostly 7–15 cm long, 0.6–3 (5) cm wide, the blades oblanceolate to oblong or elliptic, subentire to serrate; heads 3–8, nodding, racemosely arranged; involucres 8–12 mm long, 12–25 mm wide; bracts mainly ca 21, usually brown, with scarious margins, the outer to half as long as the inner, all sparingly tomentose; ray flowers lacking; achenes glabrous. Mountain brush, ponderosa pine, aspen, and spruce-fir communities at 2745 to 3175 m in San Juan County; Wyoming south to New Mexico and Arizona; 2 (0). Our material has been assigned to var. ***hallii*** Gray; the type variety is more southern.

Senecio canus **Hook.** Gray Groundsel. [S. *purshianus* Nutt.; S. *convallium* Greenm., type from Rabbit Valley]. Perennial short-rhizomatous herbs, often with a caudex; stems 8–30 cm tall (rarely more), erect or ascending; herbage woolly-tomentose; basal leaves petiolate, the blades 1–5 cm long, 3–30 mm wide, lanceolate to oblanceolate, elliptic or ovate, entire or denticulate, obtuse to rounded apically; cauline leaves reduced upward, the upper ones often clasping, finally bracteate, occasionally lobed in some introgressant forms; heads mainly 2–10, subumbellate or corymbose; involucres 3–8 mm long, 4–10 mm wide; main bracts 13–21, lance-attenuate, greenish or with brownish midstripe, glabrous or tomentose; outer bracts very short; rays 8–13, yellow, 5–10 mm long; achenes glabrous. Pinyon-juniper, sagebrush, Douglas fir, aspen, spruce-fir, and alpine tundra communities, often in talus or on windswept ridges, at 2105 to 3815 m in Beaver, Box Elder, Cache, Carbon, Daggett, Duchesne, Garfield, Iron, Juab, Millard, Piute, San Juan, Sanpete, Sevier, Summit, Uintah, and Utah counties; British Columbia to Manitoba, south to California, Nevada, Colorado, and Kansas; 56 (xiii). This attractive grayish white species forms intermediates with S. *multilobatus*, S. *streptanthifolius*, and S. *werneriifolius*.

Senecio crassulus **Gray** Perennial short-rhizomatous herbs, often with a caudex; stems 15–50 cm tall or more, erect; herbage glabrous; lower leaves broadly petiolate, the main ones 3–15 cm long, 0.6–3 (5) cm wide, lanceolate to elliptic or oblanceolate, dentate to entire; cauline leaves reduced upward, becoming sessile and clasping; heads solitary or 2–12, corymbose; involucres 8–13 mm high, 12–21 mm wide; main bracts 8–21, oblong to lance-oblong, greenish to brown, with scarious margins, the tips black and tufted-hairy; outer bracts to half as long as the inner or more; rays 8–13, yellow, 5–12 mm long; achenes glabrous. Aspen, lodgepole pine, and spruce-fir communities, often in forb-grass meadows, at 1830 to 3355 m in Box Elder, Cache, Carbon, Duchesne, San Juan, Salt Lake, Sanpete, Sevier, Summit, and Utah counties; Oregon to Montana, south to New Mexico; 34 (iv).

Senecio crocatus **Rydb.** Perennial subrhizomatous herbs, the caudex more or less developed; stems erect, mainly 2–8 dm tall; herbage glabrous or with minute hairs in the inflorescence; basal leaves with long slender petioles, the blades 1–8 cm long, 1–4 cm wide, ovate to oblong, lanceolate, or elliptic, subcordate to acute basally, often rounded apically, entire to crenate-dentate; cauline leaves reduced upward, becoming lobed or sublyrate, sessile and sometimes auriculate and/or clasping; heads mainly 3–30; involucres 4–8 mm long, 5–8 mm wide; main bracts 13–21, lance-oblong, green or suffused with red or purple; outer bracts very short; rays 6–13, orange or orange-red; pappus white; achenes glabrous. Rush-grass, willow, aspen-forb, and lodgepole pine communities at 2195 to 2990 m in Cache, Duchesne, Rich, Summit, and Utah counties; Colorado; 23 (i). One specimen from Rich County (Thorne 1465 BRY) is apparently intermediate with S. *eremophilus*. The species is remarkably like the next.

Senecio dimorphophyllus **Greene** Perennial subrhizomatous herbs; stems erect, mainly 30–70 cm tall; herbage glabrous or essentially so; basal leaves with long slender petioles, the blades 1–7 cm long, 1–5 cm wide, oval to oblong or elliptic, subcordate to acute basally, commonly rounded apically; cauline leaves becoming sessile, lyrate-pinnatifid, and auriculate-clasping, the auricles often lobed; heads mainly 2–25, subumbellately to corymbosely arranged; involucres 5–8 mm high, 6–10 mm wide; main bracts 13–21, lance-attenuate, green, sometimes suffused reddish, the tips not black, tufted-hairy; outer bracts very short; rays 8–13, yellow, 5–8 mm long; pappus white; achenes glabrous. Two weakly discernible varieties are present in Utah.

1. Cauline leaves merely lobed to subentire; plants of the La Sal Mountains .... S. *dimorphophyllus* var. *intermedius*
— Cauline leaves sharply lobed; plants of Uinta Mountains and Wasatch Plateau .... S. *dimorphophyllus* var. *dimorphophyllus*

Var. *dimorphophyllus* Aspen-tall forb and spruce-fir communities at 1860 to 3265 m in Duchesne, Emery, Sanpete, and Utah counties; Wyoming and Colorado; 9 (0). Utah materials approach S. *crocatus* in most morphological features, including the tall stature. If the flower color is discounted and the larger heads are not definitive, then the specimens could be considered as a portion of S. *crocatus*. Some specimens from Duchesne County appear to be transitional to S. *sphaerocephalus*.

Var. *intermedius* **T.M. Barkley** Wet meadows at 3050 to 3115 m in the La Sal Mountains, San Juan County (type from Geyser Pass); endemic; 2 (0).

Senecio douglasii **DC.** Suffrutescent perennials; stems erect or ascending, mainly 3–8 (10) dm tall; herbage glabrous or tomentose; leaves simple and linear-filiform or pinnatifid into linear-filiform segments, 2–11 cm long, 0.8–3 mm wide; heads few to numerous, in paniculately branched subcorymbose cymes; involucres campanulate, mainly 5–10 mm long, 6–14 mm wide; main bracts 13–21, lance-oblong, green, with scarious margins, minutely tufted-hairy apically; the outer bracts short and inconspicuous or to half as long as the inner ones; rays 8–17, yellow, 10–18 mm long; pappus white; achenes hairy. Two infraspecific taxa, previously treated at specific rank with some justification, are present in Utah.

1. Herbage grayish or whitish tomentose; outer involucral bracts short and inconspicuous; plants rather broadly distributed .... *S. douglasii* var. *longilobus*
— Herbage green, glabrous or essentially so; outer involucral bracts to about half as long as the inner ones; plants of Washington County ... *S. douglasii* var. *monoensis*

Var. ***longilobus*** **(Benth.) L. Benson** [*S. longilobus* Benth.; *S. filifolius* var. *jamesii* T. & G., nom. illeg.]. Warm desert shrub, salt desert shrub, sagebrush-rabbitbrush, saltgrass, and pinyon-juniper communities at 1095 to 2200 m in Beaver, Duchesne, Garfield, Iron, Kane, Millard, Piute, San Juan, Sevier, Washington, and Wayne counties; Arizona to Texas; 52 (x).

Var. ***monoensis*** **(Greene) Jepson** [*S. monoensis* Greene]. Creosote bush, blackbrush, other warm desert shrub, and pinyon-juniper communities at 760 to 1465 m in Washington County; California to Texas; 23 (vi).

Senecio eremophilus **Richards.** Perennial subrhizomatous herbs; stems rather equably leafy, erect or ascending, mainly 2.5–9 dm tall; herbage glabrous or essentially so; lower leaves often deciduous or withered at anthesis; cauline leaves 2–15 cm long (or more), 0.4–5 (7) cm wide, oblanceolate to elliptic, or lanceolate in outline, pinnatifid or pinnately lobed or toothed, the lower ones petiolate, becoming sessile upward; heads several to numerous, corymbose; involucres 5–8 mm high, 6–10 mm wide; main bracts 8–17, lance-oblong, brownish or greenish, with scarious margins, blackish tips, and hair-tufted apices; outer bracts very short; rays 7–10, yellow, 5–10 mm long; pappus white; achenes glabrous or puberulent along the ribs. Grass-forb,· ponderosa pine, aspen, lodgepole pine, spruce-fir, and alpine tundra communities, at 1615 to 3450 m in Beaver, Carbon, Duchesne, Emery, Garfield, Grand, Iron, Juab, Piute, San Juan, Salt Lake, Sanpete, Sevier, Summit, Tooele, Uintah, Utah, Wasatch, Washington, and Wayne counties; British Columbia and Mackenzie south to Arizona and New Mexico; 104 (xiv). Our material belongs to var. ***kingii*** (Rydb.) Greenm. [S. kingii Rydb., type from Cottonwood Canyon]. This plant forms intermediates with S. *spartioides*.

Senecio fendleri **Gray** Perennial rhizomatous herbs, with a caudex more or less developed; stems mainly 5–30 cm tall, erect or ascending; herbage floccose-tomentose; basal leaves petiolate, the blades 1–6 cm long, 4–20 mm wide, pinnatifid or pinnately lobed; cauline leaves reduced upward, becoming sessile, finally bracteate; heads 3 to many, corymbose; involucres 4–6 mm high, 5–8 mm wide; main bracts ca 13, lance-attenuate, greenish, the margins scarious or hyaline, minutely hairy apically, more or less tomentose below; outer bracts very short; ray flowers lacking; pappus white; achenes glabrous. Ridge tops on limestone barrens near Musinea Peak, at ca 2960 to 3295 m in Sanpete County (Lewis 4274, 5516 BRY); Wyoming south to New Mexico; 2 (0). Our specimens approach S. *canus*, more or less.

Senecio fremontii **T. & G.** Perennial herbs, subrhizomatous or from a caudex and taproot; stems 0.6–4 dm tall; herbage glabrous; leaves cauline, 1–6 cm long, 0.5–2 cm wide, oblanceolate to obovate, shortly petiolate or sessile and somewhat clasping, dentate to subentire; heads 1–5; involucres 6–12 mm high, 7–12 mm wide; main bracts 8–17, lance-oblong or lance-attenuate, green or brown, the margins scarious, tufted hairy apically; outer bracts short and inconspicuous or to half as long as the inner ones; rays 7–10, yellow, 5–12 mm long; pappus white; achenes glabrous or hairy. Two rather weak varieties are present.

1. Involucres mostly 8–10 mm high; stems mostly less than 20 cm high .... S. *fremontii* var. *fremontii*
— Involucres 10–12 mm high; stems often over 30 cm tall ...... S. *fremontii* var. *blitoides*

Var. *blitoides* (Greene) Cronq. [S. *blitoides* Greene]. Alpine communities, often in talus or on rock outcrops, at 2745 to 3355 m in Salt Lake (?), Tooele, and Utah counties; Wyoming to Colorado; 9 (0).

Var. *fremontii* Spruce-lodgepole pine and alpine tundra communities at 3050 to 3965 m in Duchesne, San Juan, Salt Lake, Summit, Uintah, and Utah counties; British Columbia and Alberta, south to Oregon and Wyoming; 16 (v).

***Senecio hartianus* Heller** Perennial herbs from a subrhizomatous or stoloniferous caudex; stems erect, 2–5 dm tall; herbage floccose-tomentose, sometimes glabrate; basal leaves petiolate, the blades 1–5 cm long, 0.5–3 cm wide, oval to obovate or elliptic, serrate or crenate, rounded apically; cauline leaves reduced upward, subpinnatisect to entire; heads 3–12, corymbose; involucres 4–7 mm high and as broad; main bracts 13–21, lance-attenuate, greenish, the tips glabrous; rays ca 10–13, yellow, 5–8 mm long; achenes glabrous. Ponderosa pine community at ca 2290 m in Kane County (Atwood 7425 BRY); Arizona; 1 (0).

***Senecio hydrophilus* Nutt.** Water Groundsel. Perennial subaquatic herbs from a caudex and fibrous roots; stems erect, mainly 4–10 dm tall; herbage glacuous, blue-green; basal and lower cauline leaves petiolate, the broad petioles with clasping bases, the blades 5–35 cm long or more, 1–10 cm wide, elliptic to oblanceolate, entire or denticulate, thick and leathery; cauline leaves reduced upward, becoming sessile, finally bracteate; heads numerous in a branching corymbose cluster; involucres 5–8 mm long, 4–76 mm wide; main bracts 8–13, oblong or lance-attenuate, yellowish, the tips often black, tufted-hairy; rays 3–5 or lacking, yellow, 3–8 mm long; pappus white; achenes glabrous. Stream banks, pond margins, and wet meadows at 1375 to 2745 m in Carbon, Garfield, Juab, Kane, Piute, Salt Lake, Sanpete, Sevier, Summit, and Utah counties; British Columbia, south to California and Colorado; 25 (iv).

***Senecio integerrimus* Nutt.** Wet-the-bed. Perennial herbs with a short subrhizomatous caudex; stems mainly 1–6 (7) dm tall, erect; herbage arachnoid-villous or glabrate; basal and lower cauline leaves broadly petiolate, 3–20 cm long, 0.8–4 cm wide, lanceolate to elliptic or oblanceolate to oblong, entire or serrate to dentate, rounded to obtuse apically; cauline leaves reduced upward; heads few to many, in a corymbose to subumbellate cyme; involucres 6–12 mm high, 8–18 mm wide; main bracts 13–21, lance-attenuate, green, with scarious margins and black tips, the tips tufted-hairy; outer bracts very short; rays 8–13 (or lacking), yellow, 4–15 mm long; pappus white; achenes glabrous. Sagebrush, pinyon-juniper, forb-grass, mountain brush, ponderosa pine, aspen, and spruce-fir communities at 1460 to 3660 m in probably all Utah counties; British Columbia to Montana, south to California; 132 (xiv). Presumed hybrids with S. *dimorphophyllus* are known (Hansen sn 1976 BRY).

***Senecio multilobatus* T. & G.** Uinta Groundsel. [S. *lapidum* Greenm., type from Silver Reef]. Perennial (or biennial?) herbs from a taproot; stems mainly 1–6 dm tall; herbage glabrous, glabrate, or tomentose throughout or only in axils of basal leaves; basal leaves 2–12 cm long, 0.3–3.5 cm wide, spatulate to obovate in outline, pinnatifid to lyrate-pinnatifid, the segments variously again toothed, petiolate; cauline leaves reduced upward, finally bracteate; heads few to many, corymbose or subumbellate; involucres 4–9 cm high, 4–10 mm wide; main bracts 13–21, lance-attenuate or oblong-attenuate, the margins scarious, the apices hair tufted; rays 7–13, yellow, 4–10 mm long, or lacking; pappus white; achenes glabrous. Blackbrush, sandy desert shrub, pinyon-juniper, sagebrush, mountain brush, ponderosa pine, aspen, lodgepole pine, and spruce-fir communities at 915 to 3420 m in all Utah counties (type from the Uinta River); Idaho and Wyoming to California, Arizona, and New Mexico; 312 (xliv). This widespread and common species forms presumed hybrids with *S. streptanthifolius* and *S. neomexicanus*.

Senecio neomexicanus **Gray** Perennial (or biennial?) herbs from a taproot; stems 14–40 cm tall, erect; herbage tomentose; basal and lower cauline leaves petiolate, the blades 1–5 cm long, 0.6–2 cm wide, oblanceolate to obovate or oval, dentate, serrate or subentire, toothed to obtuse apically; cauline leaves reduced upward, toothed to lobed or entire, bracteate in inflorescence; heads few to many, corymbose or subumbellate; involucres 4–7 mm high, 5–12 mm wide; main bracts 13–21, lance-attenuate, green or brown, with scarious margins, not especially hairy apically; rays 8–13, yellow, 4–10 mm long; pappus white; achenes pubescent. Sagebrush, mountain brush, ponderosa pine, and aspen communities at 2105 to 3050 m in Garfield, Kane, San Juan, and Wayne counties; Colorado, New Mexico, and Arizona; 10 (0). Our materials are assigned to var. ***mutabilis*** (Greene) Barkley [*S. mutabilis* Greene]. Through this variety there is virtually a complete intergrading series into *S. werneriifolius*, *S. streptanthifolius*, and *S. multilobatus* (Barkley 1978).

Senecio pauperculus **Michx.** Perennial herbs from a subrhizomatous caudex; stems erect, mainly 2–4 dm tall; herbage glabrous or somewhat tomentose in axils of basal leaves; basal leaves petiolate, the blades mainly 2–6 cm long, 0.5–3 cm wide, oblanceolate to elliptic, obovate or ovate, crenate, dentate, or subentire; cuneate basally, toothed to obtuse apically; cauline leaves reduced upward, becoming sessile, pinnatifid, not especially auriculate, finally bracteate; heads few to many, corymbose or subumbellate; involucres 4–8 mm long, 5–9 mm wide; main bracts 13–21, lance-attenuate, often with scarious margins, the tips not especially tufted-hairy; outer bracts very short; rays 8–13, yellow or yellow-orange, 4–10 mm long; pappus white; achenes glabrous or puberulent along the angles. Lodgepole pine and spruce-fir communities, usually in moist meadows, at 2345 to 2745 m in Daggett, Garfield, and Rich counties; Alaska to Labrador, south to Oregon and Georgia; 4 (0). Our material is intermediate to both *S. streptanthifolius* and *S. crocatus*.

Senecio pudicus **Greene** [*S. cernuus* Gray, not L.f.; *Ligularia pudica* (Greene) W.A. Weber]. Perennial herbs from a subrhizomatous caudex; stems 20–50 cm tall, erect; herbage glabrous; basal and lower cauline leaves petiolate, the blades 3–15 cm long, 0.5–3 cm wide, lanceolate to oblanceolate or narrowly elliptic, tapering basally, acute apically, entire or shallowly dentate; cauline leaves reduced upward, finally bracteate; heads few to many, nodding; involucres 5–9 mm long and as broad; main bracts 8–13, lance-oblong, green to brown, the margins scarious, tufted-hairy apically; outer bracts very short; ray flowers lacking; pappus white; achenes glabrous. Aspen, spruce-fir, and alpine tundra communities at 2650 to 3480 m in Carbon and Garfield counties; Colorado; 11 (i).

Senecio serra **Hook.** Perennial herbs from a caudex, with coarse, felt-covered roots; stems equably leafy, erect, 4–15 dm tall (or more), glabrous or sparingly tomentose; leaves 3–15 cm long, 0.4–4 cm wide, short-petiolate, the blades lanceolate to narrowly lanceolate or linear, dentate to subentire; heads several to numerous, corymbose; involucres 4–11 mm high, 2–10 mm wide; main bracts 8–13, lance-oblong, greenish to brownish, the margins scarious, black-tipped, hair tufted; outer bracts very short; rays 5–8, yellow, 3–10 mm long; pappus white; achenes glabrous or essentially so. Two rather distinctive varieties are present.

1. Involucral bracts 4–6 mm long, 2–6 mm wide; disk flowers ca 12; plants of central and northern Utah .... *S. serra* var. *serra*

— Involucral bracts 6–8 mm long, 6–10 mm thick; disk flowers ca 20; plants of San Juan County .... *S. serra* var. *admirabilis*

Var. ***admirabilis*** **(Greene) A. Nels.** [*S. admirabilis* Greene]. Ponderosa pine community at ca 1830 m in San Juan County; Wyoming and Colorado; 1 (0).

Var. *serra* Sagebrush, mountain brush, aspen, forb-grass, lodgepole pine, and spruce-fir communities at 1830 to 3035 m in Box Elder, Cache, Davis, Duchesne, Juab, Rich, Salt Lake, Summit, Utah, and Weber counties; Washington to Montana, south to California and Nevada; 42 (vi).

Senecio spartioides **T. & G.** Broom Groundsel. Perennial herbs from a taproot; stems equably leafy, erect or ascending, 2–10 dm tall or more, often in clumps; herbage glabrous; leaves 2–10 cm long or more, linear, simple and entire or with linear lobes, mainly 1–3 mm wide (wider in some hybrid derivatives); heads several to many in branching corymbose cymes; involucres subcylindric to narrowly campanulate, 5–10 mm high, 4–8 mm wide; main bracts 8–13, lance-linear, green, the margins scarious, not tufted-hairy; outer bracts very short; rays 4–8, yellow, 7–12 mm long; pappus white; achenes white-hairy. Two intergrading varieties are present.

1. Leaves simple and unlobed, or, if lobed, lower cauline leaves often over 4 mm wide; plants widespread .... S. *spartioides* var. *spartioides*
— Leaves commonly with 4–6 lateral lobes, seldom if ever more than 2.5 mm wide; plants of southeastern Utah .... S. *spartioides* var. *multicapitatus*

Var. *multicapitatus* (Greenm. in Rydb.) Welsh comb. nov. [based on: *Senecio multicapitatus* Greenm. in Rydb. Bull Torrey Bot. Club 33: 160. 1906]. Warm desert shrub and pinyon-juniper communities, often in saline riparian sites, at 1220 to 1895 m in Garfield, Grand, San Juan, and Wayne counties; Colorado, Arizona, New Mexico, and Texas; 11 (vii). Barkley (1978) hesitated to combine S. *multicapitatus* with S. *spartioides*, because of field distinctions. They are, however, much alike and evidently lack diagnostic criteria that will allow segregation of all specimens. Further, specimens intermediate between S. *spartioides* and S. *eremophilus* bear "multicapitatus" leaves. I follow a moderate course in maintaining this taxon at varietal level.

Var. *spartioides* [S. *incurvus* A. Nels., type from Zion National Park]. Warm desert shrub, pinyon-juniper, sagebrush, mountain brush, and aspen communities, often in sand, at 1155 to 2870 m, in Beaver, Duchesne, Emery, Garfield, Grand, Iron, Kane, Piute, San Juan, Sanpete, Sevier, Uintah, Washington, and Wayne counties; Wyoming to South Dakota, south to California and New Mexico; 75 (xxv). Intermediates are formed with S. *eremophilus*.

Senecio sphaerocephalus **Greene** [S. *lugens* var. *hookeri* D.C. Eaton, type from Summit (?) County]. Perennial herbs from a short stout rhizome; stems erect or ascending, 3–8 dm tall; herbage tomentose; basal leaves petiolate, the blades 4–15 cm long, 1–3.5 cm wide, oblanceolate to elliptic, entire or denticulate, obtuse apically; cauline leaves reduced upward, becoming sessile, finally bracteate; heads few to many, corymbose; involucres 3–7 mm long, 6–12 mm wide; main bracts 13–21, oblong- to ovate-lanceolate, greenish or brownish, with scarious margins, the tips black, hair-tufted apically; outer bracts very short; rays 8–13, yellow, 4–10 mm long; pappus white; achenes hairy. Lodgepole pine and spruce-fir communities, in meadows, at 2315 to 3205 m in Daggett, Duchesne, Summit, and Wasatch counties; Oregon and Montana, south to Nevada and Wyoming; 10 (i).

Senecio streptanthifolius **Greene** [S. *aquariensis* Greenm., type from Aquarius Plateau; S. *jonesii* Rydb., type from Alta; S. *leonardii* Rydb., type from American Fork Canyon; S. *malmstenii* Blake in Tidestr., type from Wasatch Mountains; S. *rubricaulis* var. *aphanactis* Greenm., type from Logan; S. *wardii* Greene, type from Fish Lake Mountain]. Perennial herbs from a taproot and simple or branched and infrequently subrhizomatous caudex; stems erect, mainly 8–47 cm tall; herbage glabrous or rarely sparingly tomentose; leaves thickish; basal leaves petiolate, the blades 1–5 cm long, 0.3–3 cm wide, oblanceolate to obovate, suborbicular, elliptic, or ovate, crenate, dentate, or subentire, less commonly lobed; cauline leaves reduced upward, commonly some of them pinnatifid, finally bracteate; heads few to many, corymbose to subumbellate; involucres 4–8 mm high, 5–12 mm wide; main bracts 8–21, lance-oblong, green or brownish, the margins scarious, sparingly hair-tufted apically; outer bracts very short; rays 8–13, yellow, 5–8 mm long; pappus white; achenes glabrous. Sagebrush, mountain brush, ponderosa pine, aspen, lodgepole pine, spruce-fir, and alpine tundra communities, often in meadows, at 1370 to 3415 m in Box Elder, Cache, Carbon, Daggett, Duchesne, Emery, Garfield, Grand, Juab, Kane, Millard, Salt Lake, Sanpete, Sevier, Summit, Tooele, Uintah, Utah, Wasatch, Washington, Wayne, and Weber counties; Yukon to Northwest Territories, south to California and New Mexico; 107 (vii). This species forms a plexus around which revolves such species as *S. pauperculus*, *S. multilobatus*, *S. neomexicanus*, and *S. canus*, as judged from morphological intermediates, which are presumed to be hybrids.

Senecio triangularis **Hook.** Arrowleaf Groundsel. Perennial herbs from a caudex and more or less well-developed rhizome; stems equably leafy, erect, 2.5–12 dm tall or more; herbage glabrous or sparingly tomentose; leaves petiolate, the blades mainly 3–15 cm long, 0.5–6 cm wide, lance-oblong to triangular, abruptly contracted or subhastate at the base, dentate to sinuate dentate or subentire, finally bracteate in the inflorescence; heads few to many, subcorymbose; involucres 6–12 mm high, 8–17 mm wide; main bracts 8–12, lance-attenuate, the margins often scarious, tufted-hairy apically; outer bracts very short; rays 5–9, yellow, 6–15 mm long; pappus white; achenes glabrous. Aspen-mountain brush, Douglas fir-white fir, lodgepole pine, and spruce-fir communities at 1765 to 3265 m in Cache, Duchesne, Grand, Salt Lake, Summit, Utah, and Weber counties; Alaska and Yukon, south to California and New Mexico; 25 (viii).

Senecio vulgaris **L.** Common Groundsel. Plants annual or biennial, with fibrous roots, 1–5.5 dm tall, the stems glabrous or sparingly villous; basal leaves smaller than the main cauline ones, often withered by anthesis; cauline leaves not much reduced upward, 2–10 cm long, 0.5–4.5 cm wide, irregularly pinnatifid, the lobes again toothed, glabrous or more or less villous, especially along the veins beneath, the lower ones petiolate, the upper ones becoming sessile and auriculate-clasping; heads few to many; involucres 5–8 mm high, 4–10 mm wide; the outer bracts short and black tipped, the inner lance-linear, green, with scarious margins, black tipped; ray flowers lacking; pappus white; achenes hairy. Weedy species of disturbed sites in Salt Lake and Utah counties; adventive from Europe; 6 (0).

Senecio werneriifolius **(Gray) Gray** [*S. aureus* var. *werneriifolius* Gray]. Plants commonly rhizomatous or soboliferous herbs; stems erect or ascending, 3–18 cm tall; herbage tomentose, often glabrate or glabrous in age; basal leaves petiolate, the blades 0.6–3 cm long, 0.4–2 cm wide, oval to elliptic, obovate, or oblanceolate, thickish, sometimes revolute; cauline leaves few, commonly inconspicuous and bracteate; heads 1–4; involucres 4–10 mm long, 7–15 mm wide; main bracts 13–21, lance-oblong, green or suffused with purple, the margins scarious, hair tufted apically; outer bracts to half as long as the inner; rays 8–13, yellow, 4–10 mm long; pappus white; achenes glabrous. Ponderosa pine, western bristlecone pine, aspen-conifer, and spruce-fir communities, often in semibarrens, at 2375 to 3600 m in Beaver, Duchesne, Garfield, Iron, Juab, Piute, Salt Lake, Summit, and Utah counties; Idaho and Montana, south to California, Nevada, and Arizona; 28 (ii).

SOLIDAGO L.

Perennial herbs from a caudex or rhizome; leaves alternate, simple; heads numerous, radiate, yellow, borne in paniculate, racemose, or cymose clusters; involucres imbricate in several series or subequal, commonly chartaceous or with the tips green; receptacle flat, naked; ray flowers fertile; disk flowers perfect, fertile; anthers subentire basally; style branches with lanceolate appendages; pappus of capillary bristles; achenes few nerved, pubescent.

1. Heads in corymbs or flat-topped cymes; leaves punctate; plants of lower elevations riparian habitats [Euthamia] .... *S. occidentalis*
— Heads racemose or panicled; leaves not punctate; plants of various habitats 2
2(1). Stems glabrous 3
— Stems puberulent with short incurved hairs or villous with multicellular hairs 4

3(2). Plants definitely rhizomatous; involucres 2.5–4 mm long; plants of lower elevations .... *S. missouriensis*
— Plants subrhizomatous; involucres 4–6 mm long; plants of higher elevations .... *S. spathulata*

4(2). Stems villous with multicellular hairs; petioles long-ciliate .... *S. multiradiata*
— Stems puberulent with short incurved hairs; petioles scabrous or strigose marginally 5

5(4). Involucres 6–11 mm high, the outer bracts subfoliaceus .... *S. parryi*
— Involucres 2–5 mm high, the bracts not subfoliaceus 6

6(5). Leaves very numerous and much longer than the internodes, gradually attenuate or acuminate, not dimorphic, strongly 3-nerved .... *S. canadensis*
— Leaves not very numerous, often less than twice as long as the internodes, acute or rounded apically, often dimorphic, with lateral nerves obscure or moderately apparent 7

7(6). Leaves sparingly hairy to glabrous, the margins rough-hairy; plants widespread and common .... *S. sparsiflora*
— Leaves cinereus-puberulent with disoriented hairs, the margins hairy like the surfaces; plants more restricted and less common .... *S. nana*

Solidago canadensis **L.** Goldenrod. [*S. altissima* L.; *S. lepida* DC.]. Perennial herbs from creeping rhizomes; stems 3–12 dm tall or more; herbage puberulent with short incurved hairs, or the stems glabrous below; basal leaves often deciduous or withered at anthesis; cauline leaves numerous and crowded, 2–10 cm long or more, 3–20 mm wide, lanceolate to lance-linear, or narrowly elliptic, tapering to a sessile base, 3-nerved, serrate to entire, attenuate to acuminate apically; inflorescence commonly (but not always) of recurved branches with secund heads; involucres 2–5 mm high and about as broad, the bracts lance-attenuate, scarious or greenish; rays 10–17, yellow, 1–3 mm long. Riparian and other mesic sites at 350 to 2290 m in all Utah counties; widespread in North America; 87 (xvi). This plant serves as host for a peculiar red and black leaf beetle. A phase of the species is cultivated as an ornamental in Utah. Designation of varietal level in Utah seems academic. The species is transitional to *S. sparsiflora*.

Solidago missouriensis **Nutt.** Missouri Goldenrod. Perennial herbs from creeping rhizomes; stems 2–5 (9) dm tall; herbage glabrous or sparingly puberulent in inflorescence only; basal leaves oblanceolate, often withered at anthesis; main cauline leaves 2–13 cm long, 0.4–1.5 cm wide, oblanceolate to elliptic or linear, tapering to a sessile base, mainly 3-nerved, entire or essentially so, acute to obtuse apically; inflorescence compact, with ascending branches, somewhat or not at all secund; involucres mostly 3–5 mm high and as broad, the bracts lance-attenuate, greenish to scarious; rays 7–13, yellow, 2–3 mm long. Riparian communities at 1525 to 2475 m in Box Elder, Carbon, Daggett, Duchesne, Emery, Salt Lake, Sanpete, Summit, Uintah, and Wasatch counties; British Columbia to Ontario, south to Arizona, Texas, and Tennessee; 13 (ii).

Solidago multiradiata **Ait.** Low Goldenrod. [*S. ciliosa* Greene]. Perennial herbs from a rhizome or rhizomatous caudex; stems 5–45 cm tall; herbage villous with multicellular hairs, at least on upper stem and petiole bases; basal and lower cauline leaves 1.5–14 cm long, 5–24 mm wide, oblanceolate to spatulate or elliptic, tapering to a conspicuously ciliate petiole, obscurely 3-nerved, entire or serrate, rounded to obtuse apically; inflorescence loosely to densely corymbose; involucres 4–6 mm high, 5–7 mm wide, the bracts lance-oblong, green apically, with prominent midvein; rays ca 13, yellow, 4–5 mm long. Aspen, lodgepole pine, spruce-fir, and alpine tundra communities at 2745 to 3660 m in Beaver, Cache, Carbon, Duchesne, Garfield, Grand, Iron, Juab, Kane, Piute, San Juan, Salt Lake, Sanpete, Sevier, Summit, Uintah, and Utah counties; Alaska to Quebec, south to California and New Mexico; 84 (xvii). Our specimens belong to var. ***scopulorum*** Gray.

Solidago nana Nutt. Dwarf Goldenrod. [*S. radulina* Rydb., type from Cottonwood Canyon]. Perennial herbs from a rhizome or subrhizomatous caudex; stems 13–48 cm tall; herbage densely canescent with fine hairs of mixed orientation; basal and lower cauline leaves petiolate, 1.5–9 cm long, 0.7–2.3 cm wide, oblanceolate to spatulate, tapering to a petiole, weakly 3-nerved, entire or slightly toothed, rounded to obtuse apically; cauline leaves definitely reduced upward; inflorescence corymbose, seldom if at all secund; involucres 4–6 mm high and about as broad; rays 5–8, yellow, 3–4 mm long. Desert shrub upward to spruce-fir communities, mainly in riparian or wet meadow sites, at 1460 to 2745 m in Duchesne, Kane, Salt Lake, Sevier, Summit, Uintah, Utah, and Wasatch counties; Idaho to Montana, south to Arizona and Colorado; 13 (i).

Solidago occidentalis (Nutt.) T. & G. Western Goldenrod. [*Euthamia occidentalis* Nutt.]. Perennial herbs from elongate rhizomes; stems erect, branched above, mainly 4–12 (20) dm tall; herbage essentially glabrous; leaves numerous, sessile, linear to lance-linear, 2–10 cm long, 1–10 mm wide; inflorescence usually large, leafy-bracted, broadly rounded; involucres 3.5–4.5 mm high and about as broad, the bracts narrowly oblong, greenish apically, the midnerve conspicuous; rays 15–30, yellow, 1.5–2.5 mm long. Riparian habitats at 850 to 1650 m in Box Elder, Cache (?), Carbon, Duchesne, Emery, Garfield, Grand, Juab, Kane, San Juan, Salt Lake, Uintah, Utah, Washington, and Weber counties; British Columbia and Alberta, south to California, New Mexico, and Nebraska; 42 (x). I follow tradition by including this taxon in *Solidago;* it might best be treated in *Euthamia*.

Solidago parryi (Gray) Greene Parry Goldenrod. [*Haplopappus parryi* Gray; *H. parryi* var. *minor* Gray, type from Alta]. Perennial rhizomatous herbs; stems erect or ascending, 8–50 cm tall; herbage scabrous to hispidulose; basal and cauline leaves petiolate, mainly 3–20 cm long, 0.9–3.8 cm wide, oblanceolate to elliptic, entire, obtuse to rounded apically; cauline leaves becoming sessile and smaller upward, more or less clasping; heads few to many in compact branched cymes; involucres 8–11 mm high, 7–14 mm wide; outer bracts ovate to ovate-lanceolate, green, ciliate, the bases often scarious; inner bracts narrower and with scarious or hyaline margins; rays 12–20, yellow, 5–8 mm long. Aspen, tall forb, lodgepole pine, spruce-fir, and alpine tundra communities at 2285 to 3570 m in Beaver, Carbon, Duchesne, Emery, Garfield, Juab, Kane, Millard, Piute, San Juan, Salt Lake, Sanpete, Sevier, Summit, Tooele, Uintah, Utah, and Wasatch counties; Wyoming, New Mexico, Arizona; 50 (ix).

Solidago sparsiflora Gray [*S. garrettii* Rydb., type from Big Cottonwood Canyon]. Perennial rhizomatous herbs; stems erect or ascending, mainly 15–50 dm tall; herbage puberulent (often sparingly so on leaf surfaces); leaves cauline or basal, oblanceolate to elliptic or spatulate, mainly 1–10 cm long, 2–25 mm wide, entire or less commonly some of them serrate, acute to attenuate or obtuse to rounded apically, often dimorphic, with the upper ones reduced in size; inflorescence a pyramidial to conic or cylindric cluster, compact or with branches curved and heads secund; involucres 4–6 mm high and about as broad; bracts oblong to subulate, chartaceous basally, green apically, the midvein conspicuous; rays 5–10 or more, yellow, 3–4 mm long. Pinyon-juniper, mountain brush, sagebrush, aspen, ponderosa pine, and spruce-fir communities at 1125 to 3050 m in all Utah counties (except Box Elder and Morgan); Wyoming and South Dakota, south to Arizona and Nevada; 141 (xix). Our materials are far from uniform; in the hanging gardens of southeastern Utah they are transitional to S. *canadensis* (having more ray flowers), and at high elevations they are more or less intermediate with S. *spathulata*. Possible additional influence of S. *mollis* Bartl. and/or S. *nemoralis* Ait. is indicated, although neither of them is known from the state currently.

Solidago spathulata DC. Perennial herbs from a subrhizomatous caudex; stems 5–30 cm tall (rarely more), erect or ascending; herbage glabrous or somewhat scabrous and often glutinous above; basal leaves oblanceolate to spatulate, 2–15 cm long, 8–30 mm wide, serrate to entire, obtuse to rounded apically; cauline leaves reduced upward, finally sessile and more or less clasping; inflorescence compact to elongate, narrow, the heads not secund; involucres 4–6 mm high and as broad or more; bracts oblong, scarious or greenish along the prominent midvein; rays 5–10, yellow, 2.5–4 mm long. Aspen, spruce-fir, and alpine tundra communities at 2440 to 3510 m in Beaver (?), Daggett, Duchesne, Emery, Garfield, Grand, San Juan, Sevier, Summit, and Uintah counties; Alaska to Quebec, south to California, Arizona, and New Mexico; 21 (v). Two completely intergrading phases, regarded as varieties, are present in Utah; a tall montane phase known as var. ***neomexicana*** (Gray) Cronq. [*S. multiradiata* var. *neomexicana* Gray], and a dwarf alpine phase known as var. ***nana*** (Gray) Cronq. [*S. humilis* var. *nana* Gray; *S. decumbens* Greene].

Sonchus L.

Annual or perennial herbs from taproots or deep-seated, rhizome-like roots, the juice milky; leaves chiefly cauline, alternate, simple, entire to lobed or pinnatifid; heads few to several; involucral bracts imbricate in several series, green or greenish (drying brownish), the inner ones with hyaline margins; receptacle naked; corollas of ray-flowers only, yellow, perfect; pappus of capillary bristles; style branches semicylindrical; achenes compressed, several to many nerved, beakless, glabrous.

1. Plants perennial, spreading from rhizomelike roots; involucres more than 14 mm long in fruit 2
— Plants annual from taproots; involucres less than 14 mm long in fruit 3
2(1). Involucres and peduncles bearing coarse stipitate glands .... *S. arvensis*
— Involucres and peduncles glabrous or tomentose, not stipitate-glandular .... *S. uliginosus*
3(1). Leaves sharply and narrowly toothed, and sometimes lobed; achenes not transversely wrinkled, merely longitudinally nerved .... *S. asper*
— Leaves sharply and broadly toothed, or merely toothed and lyrate pinnatifid; achenes transversely wrinkled and longitudinally nerved .... *S. oleraceus*

Sonchus arvensis **L.** Field Sow-thistle. Plants perennial with deep-seated rhizomelike roots; stems 4–10 dm tall or more, pubescent with coarse stipitate glands, at least above, and often glabrous below; leaves 5–40 cm long, 0.8–10 cm broad, more or less pinnatifid, auriculate-clasping basally, acute to obtuse apically, prickly margined; heads few to several, the peduncles stipitate-glandular; involucres 14–20 mm high and 10–30 mm broad in fruit, the bracts lance-oblong to lance-linear, glandular like the peduncles; rays yellow, mostly 10–20 mm long; achenes transversely wrinkled. Weedy species of disturbed soils at 1370 to 2135 m in Cache, Duchesne, Salt Lake, and Utah counties; widely distributed and considered as a "noxious" weed in North America; adventive from Europe; 10 (0).

Sonchus asper **(L.) Hill** Spiny Sow-thistle. Plants annual from taproots; stems 3–10 dm tall, pubescent with coarse stipitate glands, at least above, often glabrous below (less commonly throughout); leaves 3–15 cm long, 1–5 cm broad, merely lobed or lobeless, auriculate-clasping basally, acute to acuminate or less commonly obtuse apically, the margins armed with slender sharp prickles; heads few to several, the peduncles stipitate-glandular or glabrous; involucres 9–14 mm long and 10–16 mm wide in fruit, the bracts lance-oblong to lance-linear, glabrous or with few stipitate glands; rays yellow, mostly 5–10 mm long; achenes 2–3 mm long, several nerved, not transversely wrinkled. Weed of disturbed sites at 760 to 2135 m in Box Elder, Duchesne, Garfield, Grand, Kane, Millard, Piute, San Juan, Salt Lake, Sevier, Tooele, Uintah, Utah, and Washington counties; widespread in North America; adventive from Europe; 27 (ii).

Sonchus oleraceus **L.** Common Sow-thistle. Plants annual from taproots, the stems 2–10 dm tall or more, glabrous throughout or sometimes with stipitate glands above; leaves 4–20 cm long, 0.6–10 cm broad, more or less lyrate-pinnatifid, auriculate-clasping basally, acute to obtuse apically, irregularly and broadly toothed, the teeth weakly prickly; heads few to several, the peduncles glabrous or stipitate-glandular; involucres 10–13 mm high and 8–20 mm broad in fruit, the bracts lance-linear to lance-oblong, glabrous or with a few stipitate glands; rays yellow, mostly 8–12 mm long; achenes 2–3 mm long, several nerved and transversely wrinkled. Weeds of disturbed sites at 850 to 2135 m in Duchesne, Garfield, Salt Lake, Utah, and Washington counties; widely distributed in North America; adventive from Europe; 9 (i).

Sonchus uliginousus **Bieb.** Meadow Sowthistle. Plants perennial from deeply seated rhizomelike roots; stems 4–10 dm tall or more; herbage glabrous or obscurely tomentose; leaves 5–40 cm long, 0.8–10 cm wide, pinnatifid, auriculate-clasping basally, acute to obtuse apically, prickly margined; heads few to several, the peduncles glabrous; involucres mainly 14–16 mm high and 10–20 mm broad in fruit; bracts lance-linear to oblong, glabrous or tomentose; rays yellow, mostly 10–20 mm long; achenes 2–3.5 mm long, several nerved, transversely wrinkled. Weeds of disturbed sites at 1220 to 2260 m in Daggett, Duchesne, Garfield, Grand, Juab, Salt Lake, Uintah, and Utah counties; widespread in North America; adventive from Europe; 22 (ii). Authors of Flora Europaea (Tutin et al. 1976) treat this entity as S. *arvensis* ssp. *uliginosus* (Bieb.) Nyman. Arnow et al. (Flora of the Central Wasatch Front, Utah) discount the usefulness of stipitate glands as diagnostic features, noting that glandular and eglandular plants occur together in the same populations, and that glands are not correlated with other features. On a statewide basis the plants act like legitimate taxa, and the eglandular plants do seem to have somewhat smaller heads.

SPHAEROMERIA Nutt.

Perennial herbs or subshrubs; leaves alternate or mainly basal, simple and entire or pinnatifid to palmatifid; heads discoid, few to several, corymbose to subcapitate; involucres hemispheric to campanulate; bracts in 2 or 3 series, imbricate to subequal; receptacle conic or concave, naked; outer flowers pistillate, fertile; disk flowers perfect, fertile; pappus lacking or a short crown; achenes usually 5- to 10-ribbed, glabrous or glandular.

HOLMGREN, A. H., L. M. SHULTZ, AND T. K. LOWREY. 1976. *Sphaeromeria*, a genus closer to *Artemisia* than to *Tanacetum* (Asteraceae: Anthemidae). Brittonia 28: 255–262.

1. Plants pulvinate-caespitose; heads capitately arranged on subscapose branches; known from Garfield County .... S. *capitata*
— Plants caulescent subshrubs; heads in paniculate or corymbose clusters on leafy branches, not of Garfield County 2
2(1). Leaves pinnatifid, at least some, tomentose; heads paniculate; plants of Washington County .... S. *ruthiae*
— Leaves entire or pinnatifid, glabrous; heads corymbose; plants not of Washington County .... S. *diversifolia*

Sphaeromeria capitata **Nutt.** [*Tanacetum capitatum* (Nutt.) T. & G.]. Pulvinate-caespitose herbs; herbage canescent with malpighian hairs; stems subscapose, 2–12 (20) cm tall; leaves mainly basal, 4–10 mm long, 1- or 2-palmately lobed, the cauline entire and reduced upward; heads few to numerous in a compact headlike cluster; involucres 3–5 mm high, the broad bracts with hyaline margins; corollas 2.5–3 mm long. With western bristlecone pine on Cedar Breaks limestone, at ca 2380 m in Garfield County; Montana and Wyoming; 1 (0).

Sphaeromeria diversifolia **(D.C. Eaton) Rydb.** [*Tanacetum diversifolium* D.C. Eaton]. Subshrubs, mainly 1–4 dm tall; herbage glabrous; leaves simple, entire, or some of them pinnately lobed, 8–55 mm long, 0.5–5 mm wide, linear; heads several to many in compact to open corymbose clusters; involucres 3–4 mm high, the broad bracts with hyaline margins; corollas 2–2.5 mm long.

Juniper, mountain brush, mixed conifer, and aspen communities upward to alpine tundra, often in rock crevices, at 1370 to 3205 m in Davis, Juab, Millard, Salt Lake, Tooele, and Utah counties; Nevada; 33 (i). This is a Great Basin endemic.

Sphaeromeria ruthiae **Holmgren, Shultz, and Lowrey** Subshrubs, mainly 3–7 dm tall; herbage tomentose-canescent with malpighian hairs; leaves pinnately lobed or the upper ones entire, 1–9 cm long, 2–4 mm wide or more; heads several to many, paniculate; involucres 3–5 mm high, the broad bracts with hyaline margins; corollas 1.8–2 mm long, yellow. Crevices in Navajo Sandstone, ponderosa pine community, in Washington County; endemic; 3 (0).

STEPHANOMERIA Nutt. Nom. Cons.

Annual, biennial, or perennial herbs with milky juice; leaves alternate, often pinnatifid; flowers all raylike, perfect, pink or white; involucres cylindric; main bracts few, subequal; outer bracts much shorter; receptacle naked; pappus of plumose bristles (barbellate in *S. spinosa*); achenes 5-angled or -ribbed.

1. Plants annual, from slender taproots .... *S. exigua*
— Plants perennial, a caudex often more or less developed 2
2(1). Plants spinescent; pappus barbellate .... *S. spinosa*
— Plants unarmed; pappus plumose 3
3(2). Involucres 12–15 mm high; heads with 10 or more flowers .... *S. parryi*
— Involucres 5–12 mm high (rarely higher); heads with 3–9 flowers 4
4(3). Main leaves runcinate-pinnatifid; plants commonly 1–2 dm tall .... *S. runcinata*
— Main leaves entire or pinnatifid, often deciduous at anthesis; plants commonly 2–8 dm tall 5
5(4). Stems very slender; leaves filiform to linear, entire or dentate; pappus bristles white (rarely brownish), plumose to the base .... *S. tenuifolia*
— Stems not very slender; leaves linear-subulate, often pinnatifid or lobed; pappus brownish, scabrous toward the base .... *S. pauciflora*

Stephanomeria exigua **Nutt.** Annual or biennial (winter annual) herbs from slender taproots; herbage glabrous or puberulent; stems 5–60 cm tall, erect and commonly branched from the base upward, often fistulous; main leaves 1–6 cm long, pinnatifid to bipinnatifid, deciduous or withered by anthesis; cauline leaves soon reduced and bracteate upward; heads more or less corymbose, terminating bracteate branchlets; involucres 5–10 mm high, 3–4.5 mm wide; main bracts usually 3–5; rays pink or white, 3–5 mm long; pappus of white to off-white bristles plumose in the upper half; achenes 3–4 mm long, tuberculate. Warm, mixed cool, and salt desert shrub, and pinyon juniper communities, often in sand, at 850 to 2230 m in Beaver, Emery, Garfield, Grand, Kane, Millard, San Juan, Sevier, Tooele, Uintah, Utah, Washington, and Wayne counties; Oregon to Wyoming, south to California and New Mexico; 84 (x).

Stephanomeria parryi **Gray** Perennial herbs; stems 1 to few, weak, branching, 8–25 cm tall; herbage glabrous; leaves 2–8 cm tall, runcinate-pinnatifid, thickish, the lobes weakly spinulose-tipped; heads terminating very short bracteate branches, 10- to 14-flowered; involucres 12–15 mm high; rays whitish, 15–20 mm long; pappus bristles tawny, scabrous at the base only; achenes 3–4 mm long, not rugose. Blackbrush community at ca 1460 m in Kane County (Atwood & Allen 2822a BRY); California to Arizona; 1 (0).

Stephanomeria pauciflora **(Torr.) A. Nels. in Coult. & Nels.** [*Prenanthes? pauciflora* Torr.]. Perennial herbs (or somewhat woody below) from a caudex, branched from the base, mostly 30–60 cm tall; herbage glabrous; main leaves 2–7 cm long, runcinate-pinnatifid, the lobes weakly spinulose-toothed; heads terminating short to elongate branchlets, 3-to 5-flowered; involucres 8–10 high, 3–5 mm wide; main bracts 5; rays pink or white, mainly 4–7 mm long; pappus bristles brownish, plumose except at the base; achenes 3.5–7 mm long, striate, more or less wrinkled. Warm, salt, and mixed desert shrub, and juniper communities, often in sandy soil, at 760 to 1525 m in Beaver, Garfield, Grand, Juab, Kane, Millard, San Juan (?), Tooele, and Washington counties; California to Kansas, south to Texas and Mexico; 26 (v).

Stephanomeria runcinata Nutt. Perennial herbs from a caudex; stems branched from the base, mostly 8–25 (30) cm tall; herbage glabrous, scabrous, or sparingly villous; main leaves 2–7 cm long, runcinate-pinnatifid, the lobes merely cuspidate; heads terminating naked or sparingly bracteate branchlets, commonly 5-flowered; involucres 9–12 mm high, 3.5–7 mm wide; rays pink, mainly 8–12 mm long; pappus bristles white, plumose almost to the base; achenes 4–5 mm long, tuberculate. Salt Desert shrub and pinyon-juniper communities at 1250 to 2535 m in Daggett, Duchesne, Emery, Grand, Uintah, and Wayne counties; Montana to Nebraska and Colorado; 17 (i).

***Stephanomeria spinosa* (Nutt.) Tomb** [*Lygodesmia spinosa* Nutt.]. Perennial herbs from a woody caudex, the caudex branches clothed with brownish marcescent leaf bases, the axils copiously villous-hairy; stems 11–52 cm tall, thorny; herbage glabrous upward or the branches puberulent; leaves linear 0.5–7 cm long, 1–3 mm wide, reduced to bracteate scales upward, often lacking at anthesis; heads terminal on short lateral branches or sessile, 3- to 5-flowered; involucres 5.7–10 mm high, 3–5 mm wide; main bracts oblong to lance-oblong, green or often suffused with purple; outer bracts proportionately broader; rays pink, 3–5 mm long; pappus bristles off-white, scabrous throughout; achenes 4–6.5 mm long, smooth. Desert shrub, sagebrush-grass, pinyon-juniper, mixed conifer, and aspen communities, often in moist sites, at 1675 to 3050 m in Beaver, Emery, Garfield, Juab, Kane, Millard, Piute, Sevier, Tooele, Washington, and Wayne counties; British Columbia to Montana, south to California and Arizona; 41 (ii).

***Stephanomeria tenuifolia* (Torr.) Hall** Slender Wirelettuce. [*Prenanthes? tenuifolia* Torr.]. Perennial herbs from a woody caudex; caudex branches lacking or with few marcescent leaf bases, not hairy; stems 25–100 cm tall or more; herbage glabrous or puberulent; leaves filiform to linear, 1–8 (11) cm long, 1–3 (8) mm wide, entire or dentate, much reduced upward; heads terminating elongate or short lateral bracteate branchlets, 5-flowered; involucres 8–11.2 (16) mm high, 3–5 mm wide; main bracts lance-oblong, green, puberulent or glabrous; outer bracts very short; rays 4–8 (10) mm long, pink; pappus bristles white, dull white, or less commonly brownish, plumose to the base; achenes 4–6 mm long, longitudinally ribbed, smooth. Two more or less distinctive phases are present, recognizable as varieties.

1. Involucre 10–16 mm high, the bracts attenuate; basal leaves bipinnatifid, at least some; plants of Uintah County .... S. *tenuifolia* var. *uintaensis*
— Involucres mainly 8–11.2 mm high, the bracts not especially attenuate; basal leaves seldom if ever bipinnatifid; plants of rather broad distribution .... S. *tenuifolia* var. *tenuifolia*

Var. *tenuifolia* Desert shrub, hanging garden, pinyon-juniper, mountain brush, ponderosa pine, and white-fir communities, at 1155 to 2746 m in Beaver, Duchesne, Emery, Garfield, Grand, Iron, Kane, Piute, San Juan, Sevier, Uintah, Washington, and Wayne counties; British Columbia to Montana, south to California, Arizona, and Texas; 46 (xvi). The great sprawling plants of the canyonlands portion of Utah might be worthy of taxonomic consideration; sometimes they approach S. *pauciflora* in having tawny pappus bristles.

Var. ***uintahensis* Goodrich & Welsh** Ponderosa pine community at ca 2490 m in Uintah County; endemic; 2 (0).

STYLOCLINE Nutt.

Woolly annual herbs; stems commonly branched; leaves alternate, simple, entire; heads discoid, leafy bracted; involucre per se lacking; outer receptacular bracts subtending and enclosing pistillate flowers; receptacle cylindric; pistillate flowers many, deciduous with the enclosing bract, the bract apex hyaline; corollas filiform; pappus none; perfect flowers (functionally staminate) few, surrounded by linear hyaline bracts; corollas tubular, the ovaries vestigial; pappus of 3–5 deciduous bristles; anthers sagittate basally; achenes ellipsoid, few nerved.

Stylocline micropoides **Gray** Desert Neststraw. Annual woolly herbs; stems usually branched, 4–12 cm tall; leaves 4–12 mm long, 0.5–1.5 mm wide, acute; bracteate leaves 6–10 mm long, 1.5–2.5 mm wide, lanceolate; heads clustered at branch tips, densely woolly; pistillate flowers with bracts boat shaped, densely long-woolly, hyaline margined; staminate flowers with pappus of 3–5 deciduous bristles; achenes ellipsoid, ca 1.5 mm long. Blackbrush, bursage, and indigo bush communities at 915 to 1160 m in San Juan and Washington counties; California to New Mexico, south to Mexico; 3 (i).

Syntrichopappus Gray in Torr.

Annual herbs; stems simple or branched; leaves alternate (or some opposite below), simple, entire or lobed; heads radiate, many, terminating branchlets; involucres subcylindric; bracts few, in 1 series, partly enclosing ray achenes; receptacle flat, naked; ray flowers pistillate, fertile, yellow; disk flowers perfect, fertile, yellow; anthers obtuse at base; style branches flattened; pappus of barbellate bristles; achenes 5-angled.

Syntrichopappus fremontii **Gray** Annual herbs, 2–14 cm tall; herbage floccose-tomentose; leaves 5–22 mm long, narrowly spatulate to spatulate, rounded to 3-lobed apically, cuneate basally; heads few to many; involucres 5–6 mm high, 3–4 mm wide; bracts 5, oblong, greenish, with scarious margins, abruptly acute apically; rays 5, yellow, 2–5 mm long; disk corollas numerous, yellow; pappus of white barbellate bristles falling together. Joshua tree, creosote bush, blackbrush, sagebrush, and juniper communities at 760 to 1375 m in Washington County; California, Nevada, Arizona; 6 (i).

Tanacetum L.

Perennial herbs from a rhizome; leaves alternate, 2- to 3-pinnatifid; heads discoid, numerous, corymbose; flowers perfect; involucres hemispheric; bracts in 2 or 3 series, more or less imbricate, the margins scarious; receptacle low-convex, naked; anthers entire at the base; pappus a minute crown; achenes 5-angled, truncate.

Tanacetum vulgare **L.** Tansy. Aromatic, glabrous or sparingly tomentose perennials, 3–10 (15) dm tall; leaves 6–15 cm long, sessile or subsessile, the blades 2- to 3-pinnatifid; heads many, discoid, yellow; involucres ca 4–5 mm high and 6–10 mm broad; bracts lanceolate; marginal flowers 3-lobed; inner flowers 5-lobed; achenes glandular, 5-angled, ca 1 mm long. Weedy species of disturbed soils at 1370 to 1985 m in Emery, Uintah, and Utah counties; widespread in the U.S.; adventive from Europe; 3 (0).

Taraxacum Hall.

Perennial scapose herbs with milk juice, from taproots; leaves all basal, pinnatifid to subentire; heads solitary on a scape; involucral bracts in 2 series, herbaceous, the outer shorter, the inner often dilated or appendaged apically, usually with broad hyaline or scarious margins, at least basally; receptacle naked; corollas of ray flowers only, perfect, yellow; pappus of capillary bristles; style branches semicylindric; achenes angular or terete, prominently nerved or ribbed, usually spinulose or with ridges near the body apex, glabrous, beaked.

1. Inner involucral bracts commonly dilated or bearing appendages apically, over 10 cm long; plants indigenous, of high elevations .... *T. ceratophorum*
— Inner involucral bracts usually not dilated or with appendages apically; plants various 2
2(1). Outer bracts reflexed or spreading, the inner ones 12–18 mm long; achenes straw colored to olive drab or brownish; plants adventive .... *T. officinale*
— Outer bracts erect, the inner ones 6–10 mm long; achenes black to grayish; plants indigenous at high elevations .... *T. lyratum*

Taraxacum ceratophorum (Ledeb.) DC. Rough Dandelion. [*Leontodon ceratophorus* Ledeb.]. Plants mostly 4–10 cm tall, from a simple or branched caudex; leaves 4–8 cm long, 0.7–2 cm broad, subentire to toothed; scapes sparingly villous, moderately so below the head; involucres 12–17 mm high in flower, the outer bracts ovate to lanceolate, appressed or ascending, the inner ones lance-oblong, attenuate, the apex dilated or appendaged; rays yellow; achene bodies 3–7 mm long, straw colored to olive-drab or brownish, the beak usually 2–4 times longer than the body; pappus white. Spruce krummholz and sedge-forb meadows at 3230 to 3660 m in Daggett, Duchesne, and Uintah counties (Leidy Peak); Alaska to Yukon, east to the Atlantic, south to California, New Mexico, and Massachusetts; circumboreal; 2 (0).

Taraxacum lyratum (Ledeb.) DC. Alpine Dandelion. [*Leontodon lyratus* Ledeb.]. Plants mostly 2–8 cm tall, from a simple or branched caudex; leaves 1–6 cm long, 0.3–1 cm wide, pinnately lobed to pinnatifid or subentire; scapes glabrous or nearly so; involucres 6–10 mm high, the outer bracts lanceolate-ovate, appressed or ascending-spreading, the inner ones lance-oblong to oblong, scarcely or slightly dilated; rays yellow (fading bluish); achene bodies 3–6 mm long, black or grayish, the beak subequal to the body; pappus white. Alpine tundra and meadows in spruce-fir communities at 3325 to 3965 m in Duchesne and Summit counties; Alaska and Yukon, south to Nevada, Arizona, and Colorado; Asia; 5 (i).

Taraxacum officinale Weber ex Wiggars Common Dandelion. Plants mostly 3–60 cm tall, from a simple or branched caudex; leaves 5–40 cm long, 1–10 cm wide, pinnately lobed to pinnatifid, the terminal lobe broader than the lateral ones; scapes villous to subglabrous, often moderately to densely villous below the head; involucres 15–25 mm high in flower, the outer bracts lance-acuminate, reflexed, the inner ones lance-attenuate, not or scarcely dilated apically, rarely appendaged; rays yellow, or bluish externally; achene bodies 3–4 mm long, straw colored to olive drab, the beak usually 2–4 times longer than the body; pappus white. Ubiquitous brightly flowered weedy species at 885 to 3205 m throughout Utah; widespread in North America; adventive from Eurasia; 65 (xiii). This handsome plant is among the earliest of our spring flowers, and among the last to bloom in autumn.

TETRADYMIA DC.

Armed or unarmed shrubs; stems pannose-tomentose; leaves alternate, entire, foliaceous or modified as spines, with secondary leaves fasciculate in the axils; heads discoid, corymbose or racemose; involucres cylindric to turbinate or hemispheric; receptacle naked; bracts 4–6, equal or nearly so; flowers 4–8, yellow or cream; style branches truncate to rounded or conic apically; anthers sagittate basally; pappus of capillary bristles or barbellate scales; achenes striate.

STROTHER, J. L. 1974. Taxonomy of *Tetradymia* (Compositae: Secenioneae). Brittonia 26:177–202.

1. Heads solitary or 2 or 3, axillary; primary leaves modified as spines 2
— Heads several to many in terminal corymbose clusters; primary leaves foliaceous or modified as spines 3

2(1). Spines commonly recurved, mainly 5–20 mm long, pannose-tomentose; achenes 6–8 mm long; plants widespread, not of Washington County .... *T. spinosa*
— Spines straight, mainly 20–40 mm long, glabrescent; achenes 4–5 mm long; plants of Washington County .... *T. axillaris*

3(2). Primary leaves modified as persistent spreading, straight or recurved spines 5–25 mm long .... *T. nuttallii*
— Primary leaves not modified as persistent spines, if at all spinescent then appressed-ascending 4

4(3). Primary leaves linear-subulate, spinescent apically, appressed-ascending, tomentose; secondary leaves obtuse apically, glabrous or essentially so .... *T. glabrata*
— Primary leaves various but not spinescent, not contrasting in shape and pubescence with the secondary ones .... *T. canescens*

Tetradymia axillaris **A. Nels.** Longspine Horsebrush. Spiny shrubs, mainly 4–12 dm tall; branchlets evenly white-pannose; primary leaves modified as persistent spines 1–5 cm long, straight or becoming curved, tomentose at first, becoming glabrate; secondary leaves linear to spatulate, 2–12 mm long, essentially glabrous; heads solitary or 2 or 3, from nodes of the previous year; involucres 8–11 mm high; bracts 5, subequal, tomentose; flowers 5–7, pale yellow, the corollas 7.5–9 mm long; pappus of slender bristles; achenes 4.5–5.5 mm long; achenes pilose, the hairs 9–11 mm long. Salt and warm desert shrub communities at 850 to 1375 m in Washington County; Nevada and California; 18 (ii). Our material belongs to var. *longispina* (Jones) Strother [*T. spinosa* var. *longispina* Jones, type from St. George].

Tetradymia canescens **DC.** Gray Horsebrush. [*T. linearis* Rydb., type from Iron County]. Unarmed shrubs, mainly 1–9 dm tall; branchlets white-pannose except for glabrate streaks below the primary leaves; primary leaves 0.5–4 cm long, 1–6 mm wide, lanceolate to oblanceolate or spatulate, tomentose; secondary leaves similar to the primary ones but shorter and narrower; heads few to several at branch tips; involucres 6–8 mm high or more; bracts 4, subequal, tomentose; flowers 4, yellow to cream, the corollas 7–11 mm long; pappus of white or tawny bristles; achenes 2.5–5 mm long, glabrous or hairy. Sagebrush-grass, mountain brush, ponderosa pine, mixed conifer, and aspen communities at 1525 to 3150 m throughout Utah; British Columbia to Montana, south to California, Arizona, and New Mexico; 75 (viii).

Tetradymia glabrata **T. & G.** Shrubs, mainly 3–12 dm tall; branchlets pannose except for glabrate or glabrous streaks below the primary leaves; primary leaves mainly 5–15 mm long, 0.8–1.4 mm wide, linear-subulate, spinose tipped, soon deciduous; secondary leaves linear to narrowly spatulate, glabrous or thinly tomentose; heads few to many on branch tips; involucres 7–10 mm high; bracts 4, subequal, tomentose to glabrous; flowers 4, yellow to cream, the corollas 9–10 mm long; pappus of white bristles; achenes 3–5 mm long, hirsute. Shadscale, greasewood, sagebrush, rabbitbrush, and juniper communities at 1370 to 2370 m in Emery, Juab, Millard, Sanpete, Sevier, Tooele, and Wayne counties; Oregon and Idaho, south to California and Nevada; 44 (v).

Tetradymia nuttallii **T. & G.** Nuttall Horsebrush. Spinescent shrubs, 3–12 dm tall; branchlets white-pannose except for glabrescent streaks below the primary leaf bases; primary leaves modified as persistent straight or recurved spines 5–25 mm long, tomentose to glabrous; heads in terminal clusters of (2) 3–6; involucres 6–9 mm high; bracts 4, equal; flowers 4, yellow, the corollas 8–10 mm long; pappus of white or tawny bristles; achenes 4–6 mm long, hirsute. Shadscale, greasewood, sagebrush-rabbitbrush and pinyon-juniper communities at 1370 to 1830 m in Box Elder, Daggett, Duchesne, Juab, Millard, Tooele, and Uintah counties; Wyoming and Nevada; 25 (i).

Tetradymia spinosa **H. & A.** Spinescent shrubs, 3–12 dm tall; branchlets evenly pannose; primary leaves modified as spines, 5–20 mm long, tomentose, finally glabrate; secondary leaves linear to spatulate, glabrous or glabrescent; heads borne singly or in pairs, laterally, on stems of the previous season; involucres 8–12 mm high; bracts 4–6, subequal, tomentose; flowers 5–8, yellow, the corollas 6–10 mm long; pappus of slender bristles, white; achenes 6–8 mm long, hairy, the trichomes 9–12 mm long. Mixed desert shrub, shrub-grass, and pinyon-juniper communities at 1250 to 1925 m in Carbon, Daggett, Duchesne, Emery, Garfield, Grand, Juab, Millard, Salt Lake, Uintah, and Utah counties; Oregon to Montana and Wyoming, south to California, Nevada, and New Mexico; 15 (vi).

THELESPERMA Less.

Perennial glabrous or sparingly puberulent herbs; leaves opposite, pinnately to palmately parted, or the upper ones entire; heads pedunculate, solitary or few per stem; involucres hemispheric to campanulate; bracts in 2 unlike series, the outer ones spreading and distinct, the inner ones connate to the middle and calyxlike; receptacle flat, chaffy with broad scarious scales; rays present (or lacking), neuter, yellow; disk flowers perfect, fertile; anthers not caudate basally; pappus of 2 retrorsely hispid awns, a crown, or lacking; achenes oblong to linear.

1. Plants 30–80 cm tall; rays normally lacking; pappus of 2 awns; known from San Juan and Washington counties .... *T. megapotamicum*
— Plants 3–35 cm tall; rays normally present; pappus a crown or none ..... *T. subnudum*

Thelesperma megapotamicum **(Spreng.) Kuntze** Greenthread. [*Bidens megapotamica* Spreng]. Perennial herbs from a caudex and stout root; stems 30–80 cm tall; leaves mainly 2–7 cm long, once or twice pinnatifid, the lobes linear, or the uppermost simple; outer bracts 4–6, oblong to ovate, obtuse, much shorter than the inner; inner bracts 6–12 mm high, connate to above the middle, the lobes with narrow scarious margins; rays lacking; disk flowers yellow (or brownish); pappus of 2 or 3 retrorsely hispid awns; outer achenes somewhat papillose dorsally. Desert shrub community at ca 915 to 1375 m in San Juan and Washington counties; Wyoming to Nebraska, south to Arizona, Texas, and Mexico; 1 (0).

Thelesperma subnudum **Gray** Perennial herbs from a taproot and less commonly with a caudex and creeping rootstock; stems 3–35 cm tall, subscapose; leaves mainly at base of stem, 1.5–9 cm long, pinnately to subpalmately lobed or some or all of them entire; petioles often ciliate and blades more or less puberulent; involucres 6.3–14 mm high, 9–22 mm wide; outer bracts oblong to lanceolate, with narrow scarious margins, to half as long as the inner ones; inner bracts united to below the middle, conspicuously scarious-margined; rays present and bright yellow, 10–28 mm long and 6–18 mm wide, or lacking; disk flowers yellow; pappus a toothed crown or lacking; achenes glabrous or hairy apically, 3.5–4.5 mm long. This taxon is variable being radiate or discoid, in division of leaves, and in position of leaves along the stem. They occur mainly at elevations below 2135 m elevation. A dwarf alpine phase occurs above that elevation, and because of its small size, lack of rays, and apparent ecotypical differences these plants are herein designated at varietal level.

1. Plants mainly 3–7 cm tall; involucres 6.3–9 mm high, 9–14 mm wide; heads discoid .... *T. subnudum* var. *alpinum*
— Plants mainly 9–35 cm tall; involucres 8–14 mm high, 12–22 mm wide; heads commonly radiate .... *T. subnudum* var. *subnudum*

Var. *alpinum* **Welsh** Pinyon-juniper, mountain brush, and western bristlecone pine communities at ca 2745 m in Wayne County; endemic; 2 (0).

Var. *subnudum* Mixed desert shrub, salt desert shrub, and pinyon-juniper communities at 1065 to 2135 m in Carbon, Duchesne, Garfield, Grand, Iron (type from Red Creek), Kane, San Juan, Uintah, Washington, and Wayne counties; Colorado, Arizona, and New Mexico; 109 (xiv).

TOWNSENDIA Hook.

Annual, biennial, or perennial herbs, caulescent or acaulescent; leaves alternate, entire or rarely lobed or toothed; heads radiate, solitary or few, terminating branches, or sessile; receptacle convex, naked; involucres campanulate to hemispheric; bracts in 2–7 series; rays pistillate, fertile, the corollas white, pink, or yellow; disk flowers perfect, yellow; disk pappus of barbellate capillary bristles; ray pappus similar to that of the disk or shortened; achenes 2- or 3-ribbed, compressed, usually hairy.

BEAMAN, J. H. 1957. The systematics and evolution of *Townsendia* (Compositae). Contr. Gray Herb. 183:1–151.

REVEAL, J. L. 1970. A revision of the Utah species of *Townsendia* (Compositae). Great Basin Nat. 30:23–52.

1. Plants caulescent, the internodes apparent, annual or biennial (short-lived perennial) 2
— Plants acaulescent, the internodes not elongating, perennial 5

2(1). Plants annual or winter annual; disk pappus shorter than disk-corollas; plants of southeastern Utah (Navajo Basin) .... *T. annua*
— Plants biennial or short-lived perennials; disk pappus subequal to or longer than the disk corollas 3

3(2). Achenial hairs unevenly branched; ray flowers usually dark pink-purple dorsally; plants biennials of western Utah .... *T. florifer*
— Achenial hairs glochidiate; ray flowers variously colored, but if dark pink-purple dorsally then the plants perennial and of different distribution 4

4(3). Stems gray-white, the pubescence dense; plants of broad distribution, perennial .... *T. incana*
— Stems thinly strigose, evident beneath the hairs; plants of the Uinta Basin, biennial .... *T. strigosa*

5(1). Involucral bracts linear to narrowly lanceolate, in 5–7 series 6
— Involucral bracts lanceolate to ovate or elliptic, in 2–5 series 9

6(5). Involucral bracts hair tufted apically, linear, acuminate; plants of Carbon, Duchesne, and Daggett counties .... *T. hookeri*
— Involucral bracts not hair tufted apically, narrowly lanceolate, acute; plants variously distributed 7

7(6). Rays glandular dorsally; leaves canescent; plants of Duchesne and Uintah counties .... *T. mensana*
— Plants glabrous or sparingly pubescent dorsally; leaves greenish or grayish-canescent; plants not or seldom of Duchesne and Uintah counties 8

8(7). Disk pappus 3–6 mm long; leaves green, the midveins not conspicuous; plants of the Wasatch Plateau and Uinta Mountains .... *T. leptotes*
— Disk pappus 6–11 mm long; leaves grayish canescent, the midveins conspicuous; plants of Sevier, Iron, Wayne, and Garfield counties .... *T. exscapa*

9(5). Rays yellow ventrally, densely glandular and often purplish dorsally; ray pappus 1–2 mm long; plants of Emery and eastern Sevier counties .... *T. aprica*
— Rays white or pink or bluish, or rarely yellow ventrally, but, if yellow, the ray pappus 2–4.5 mm long and plants of other distribution 10

10(9). Plants green or greenish; flowers often bluish or purplish to pink, mainly of higher elevations in mountains and plateaus .... *T. montana*
— Plants grayish canescent or whitish; flowers seldom bluish or purplish, usually white to pink or yellowish ventrally; mainly of low elevations 11

11(10). Involucral bracts sparingly strigose; ray pappus 2–4.5 mm long; plants mainly of western Utah .... *T. jonesii*
— Involucral bracts moderately strigose; ray pappus 0.3–0.6 mm long; plants mainly of eastern Utah .... *T. incana*

Townsendia annua **Beaman** Caulescent annual or winter annual herbs, 2–18 cm tall; herbage strigose; leaves of basal rosettes soon withered or poorly developed; cauline leaves 5–28 mm long, 1–5 mm wide, oblanceolate to spatulate or linear, sparingly to moderately strigose, green or greenish; heads solitary or few; involucres 4.5–7 mm long, 6–14 mm wide; bracts in 2–4 series, green or suffused with purple, scarious, ciliate; rays 13–34, the corollas white or pink to lavender, 4–8 mm long, 1–2.3 mm wide, glabrous; disk corollas yellow, 2.2–3.5 mm long; achenes 1.9–2.6 mm long, pubescent with glochidiate hairs; ray pappus 0.2–0.8 mm long, that of disk flowers 1.8–3 mm long. Sandy desert shrub and blackbrush communities at 1125 to 1590 m in Carbon, Emery, Garfield, Grand, Kane, and San Juan counties; Colorado, Arizona, New Mexico, and Texas; 23 (v).

Townsendia aprica **Welsh & Reveal** Pulvinate-caespitose acaulescent perennial herbs from a caudex, 1.5–2.5 cm tall; leaves 7–13 (16) mm long, 1–3.5 mm wide, spatulate to oblanceolate, strigose; heads sessile, submersed in the leaves; involucres 4–8 mm high, 7–13 mm wide; bracts in 3–4 series, lanceolate, fimbriate, red-scarious, hyaline-ciliate, the outermost sparsely strigose; rays 13–21, the corollas yellow to golden ventrally, purplish dorsally and glandular, 4–7 mm long; disk corollas yellow, 3.7–4.5 mm long; achenes 2–2.5 mm long, 2-ribbed, the hairs glochidiate; ray pappus 0.7–1 mm long; pappus of disk flowers 4–5 mm long. Salt desert shrub and pinyon-juniper communities, commonly on clay or clay-silt exposures of the Mancos Shale (Blue Gate Member), at 1860 to 2440 m in Emery and adjacent Sevier (type from south of Fremont Junction) counties; endemic; 10 (ii). The yellow flowers and short pappus of ray flowers are diagnostic.

Townsendia exscapa **(Richards.) T.C. Porter** [*Aster? exscapa* Richards.]. Caespitose acaulescent perennial herbs from a simple or branched caudex, 2–3.5 cm high; leaves 0.6–5 cm long, 1–3.5 mm wide, oblanceolate to linear, acute and mucronate apically, strigose, with midvein apparent; involucres 10–18 mm high, 15–30 mm wide; bracts in 4–7 series, linear to narrowly lanceolate, ciliate on scarious margins, sparingly strigose to glabrous; ray flowers 21–40, the corollas white or pinkish, 8–15 mm long, 1.2–3 mm wide; disk corollas yellow; achenes 2- or 3-ribbed, pubescent with glochidiate hairs; ray pappus 4–8 mm long; disk pappus 6–12 mm long. Ponderosa pine, mountain sagebrush, and spruce-fir communities, often in meadows, at 2135 to 3295 m in Garfield, Iron, Sevier, and Wayne counties; British Columbia to Manitoba, south to Nevada, Arizona, Mexico, and Texas; 8 (ii).

Townsendia florifer **(Hook.) Gray** [*Erigeron? florifer* Hook.; *T. watsonii* Gray, type from Stansbury Island; *T. scapigera* var. *ambigua* Gray, type from Rabbit Valley; *T. florifer* var. *communis* Jones, type from Marysvale]. Caulescent winter annual or biennial herbs 3–20 cm tall; basal leaves 6–50 mm long, 3–12 mm wide, spatulate; cauline leaves narrowly oblanceolate to linear, 10–40 mm long, 1–5 mm wide, strigose, petiolate, grayish; heads solitary or few; involucres 6.5–13 mm high, 15–30 mm wide; bracts in 3 or 4 series, green or suffused with purple, scarious, ciliate; rays 13–34, the corollas white or pink ventrally, dark pink or lavender dorsally, 7–12 mm long, 1.2–3 mm wide, often glandular; disk corollas yellow, 3.3–6 mm long; achenes 3.3–4.5 mm long, pubescent with unequally forked hairs; ray pappus 1–6 mm long; disk pappus 3.5–7.5 mm long. Mixed desert shrub communities at 1280 to 1985 m in Beaver, Box Elder, Garfield, Juab, Millard, Sanpete, Sevier, Tooele, Utah, and Wayne counties; Washington to Idaho, Oregon, and Nevada; 56 (vii).

Townsendia hookeri **Beaman** Caespitose acaulescent perennial herbs from a simple or branched caudex, 2.5–3.5 cm high; leaves 10–40 mm long, 1–2.5 mm wide, linear to linear-oblanceolate, strigose; involucres 9–13 mm high, 9–14 mm wide; bracts in 5–7 series, linear to lance-linear, tufted-hairy apically, green or suffused with purple, strigose; rays 13–34, the corollas 6–9 mm long, 1–1.9 mm wide, white or pink ventrally, pinkish dorsally, glabrous; disk corollas yellow, 4.5–6 mm long; achenes 3.5–4.5 mm long, pubescent with glochidiate hairs; ray pappus 1–1.5 mm long; disk pappus 5.5–8.5 mm long. Sagebrush, sagebrush-grass, and mixed conifer communities at 2165 to 2716 m in Carbon, Daggett, Duchesne, and Uintah counties; Yukon to Saskatchewan, south to South Dakota and Colorado; 5 (0).

Townsendia incana **Nutt.** [*T. incana* var. *ambigua* Jones, type from Thompson]. Subcaulescent to acaulescent caespitose herbs, the caudex often branched; stems conspicuously white strigose, mainly 2–6 cm high, forming clumps to 2 dm wide; leaves 5–40 mm long, 1–5 mm wide, spatulate to oblanceolate, strigose; heads solitary or few; involucres 7–11 mm high, 8–20 mm wide; bracts in 3 or 4 series, lanceolate, green, the margins scarious and ciliate, strigose; rays 13–34, the corollas white ventrally, pink to lavender dorsally, 6–10 mm long, 1.5–3 mm wide; achenes 2.5–4.5 mm long, pubescent with glochidiate hairs; ray pappus 0.3–0.6 mm long; disk pappus 4–7.5 mm long. Blackbrush, salt desert shrub, mixed desert shrub, pinyon-juniper, and sagebrush communities at 1310 to 2290 m in Beaver, Carbon, Daggett, Duchesne, Emery, Garfield, Grand, Iron, Kane, Piute, San Juan, Sevier, Uintah, and Wayne counties; Wyoming to Nevada, Arizona, and New Mexico; 183 (xxiii). This is the common townsendia of the Colorado drainage system in Utah; its Great Basin counterpart is *T. jonesii*, from which it can be distinguished by the white strigose stems and shorter ray pappus.

Townsendia jonesii **(Beaman) Reveal** [*T. mensana* var. *jonesii* Beaman, type from Mammoth]. Subcaulescent to acaulescent caespitose herbs, the caudex commonly branched; stems not conspicuously white strigose, mainly 2–4 cm tall, forming clumps to 1 dm wide; leaves 10–40 mm long, 1–4 mm wide, oblanceolate to spatulate or almost linear, strigose; heads mostly solitary; involucres 9–12.5 mm high, 8–14 mm wide; bracts in 4 or 5 series, lanceolate, green or suffused purple, sparsely strigose; rays 13–21, the corollas white to pink, cream, or yellow ventrally, pink to red-purple dorsally, glandular, 4–7 mm long; disk corollas yellow, ca 3.5 mm long; achenes 3–5.5 mm long; pubescent with glochidiate hairs; ray pappus 2–4.5 mm long; disk pappus 5–8 mm long. Two weak, but geographically and edaphically correlated, varieties are present.

1. Ray flowers yellow to lemon-yellow ventrally; plants of gypsiferous substrates in Sevier and Piute counties .... *T. jonesii* var. *lutea*
— Ray flowers pink to white or cream ventrally; plants of various substrates, rather broadly distributed .... *T. jonesii* var. *jonesii*

Var. *jonesii* Sagebrush, shadscale, rabbitbrush, pinyon-juniper, mountain brush communities at 1525 to 2745 m in Beaver, Juab, Millard, Sanpete, and Sevier counties; Nevada; 13 (ii). The type of *T. mensana* var. *jonesii* consists of strictly acaulescent plants with very slender leaves and smallish heads; it is unmatched in the specimens examined, and it is understandable why the taxon was placed initially with *T. mensana*.

Var. *lutea* **Welsh** Salt desert shrub and juniper communities at ca 1675 to 1830 m in Sevier and Piute counties (on Arapien shale and clays in volcanic rubble); endemic; 6 (i).

Townsendia leptotes **(Gray) Osterh.** [*T. sericea* var. *leptotes* Gray]. Perennial acaulescent herbs from a simple or more commonly branched caudex, 1–3 cm tall; herbage sparingly strigose, greene; leaves 0.6–4 cm long, 1.3–2.6 mm wide, linear to narrowly oblanceolate; involucres 5–10 mm high, 9–14 mm wide; bracts in 4–7 series, lanceolate to linear, the margins scarious, ciliate, often suffused purple; rays 13–34, the corollas white, cream, or pink ventrally, sometimes lavender dorsally, 6–10 mm long, 1.2–2 mm wide; disk corollas yellow, 3–5 mm long; achenes pubescent with glochidiate hairs; ray pappus 0.8–6.5 mm long; disk pappus like the ray pappus. Montane sagebrush and grass-forb communities, often on ridge crests and plateau margins at 2680 to 3145 m in Duchesne, Sanpete, and Summit counties (Uinta Mountains and Wasatch Plateau); Idaho and Montana, south to California, Nevada, and New Mexico; 7 (0).

Townsendia mensana **Jones** Perennial acaulescent herbs from a simple or more commonly branched caudex 1–2.5 cm high; herbage strigose; leaves 3–17 mm long, 0.6–1.3 mm wide, narrowly oblanceolate to linear; involucres 5–9 mm high, 76–10 mm wide; bracts in 4 or 5 series, lanceolate, the margin scarious and ciliate; rays 13–21, the corollas whitish, cream, or pinkish, glandular dorsally, 5–7.5 mm long, 0.9–1.4 mm wide; disk corollas yellow, 3.5–4.8 mm long; achenes pubescent with glochidiate hairs; ray pappus 2.5–4 mm long; disk pappus 5–6.5 mm long. Salt desert shrub, pinyon-juniper, and sagebrush communities, especially on barren and semibarren sites, at 1705 to 2715 m in Duchesne (type from near Duchesne, then Theodore) and Uintah counties; Colorado (?); a Uinta Basin endemic; 38 (v).

Townsendia montana **Jones** Perennial acaulescent or rarely subcaulescent herbs from a simple or branched caudex, sometimes with soboliferous rhizomatous branches, from a taproot, 2–6 cm high; herbage glabrate to strigose; leaves 5–40 mm long, 2–8 mm wide, spatulate, thickish; involucres 6–12 mm high, 8–20 mm wide; bracts in 3–6 series, oblong, obovate, oblanceolate or lanceolate, glabrous or sparingly strigose, the margins scarious; ciliate, often suffused with purple; rays 12–30, the corollas blue, pink, lavender, or white, 6–12 mm long, 1–3.5 mm wide; achenes 3.7–5.2 mm long, glabrous or sparingly pubescent with bifurcate or glochidiate hairs; ray and disk pappus alike, 3–5.5 mm long. Three more or less distinctive varieties are present.

1. Heads usually sessile; leaves mainly 1–3.5 mm wide, rather abruptly obtuse apically; plants of Garfield and Kane counties .... *T. montana* var. *minima*
— Heads usually at least shortly pedunclulate; leaves mainly broader (at least some), rounded to obtuse; plants not of Garfield or Kane counties 2

2(1). Leaves rounded apically, broadly spatulate; plants of calciferous outcrops in southern Duchesne, Wasatch, and Sanpete counties ...... *T. montana* var. *caelilinensis*
— Leaves obtuse to subacute apically; plants of various substrates in the Uinta and Wasatch mountains .... *T. montana* var. *montana*

Var. *caelilinensis* **Welsh** Pinyon-juniper, spruce-fir, and limber pine communities on Flagstaff Limestone and Green River formations at 2135 to 3735 m in southern Duchesne, Wasatch, and Sanpete counties; endemic; 13 (i).

Var. *minima* **(Eastw.) Beaman** [*T. minima* Eastw., type from Bryce Canyon]. Ponderosa pine, western bristlecone, limber pine, and Douglas fir–white fir communities, on white and pink members of the Cedar Breaks Formation, at 2375 to 3115 m in Garfield and Kane counties; endemic; 14 (i).

Var. *montana* [*T. dejecta* A. Nels., type from Dyer Mine]. Spruce-fir and lodgepole pine communities at 3050 to 3510 m in Cache, Juab, Salt Lake (type from Alta), Summit, and Uintah counties; Idaho, Montana, and Wyoming; 2 (0).

Townsendia strigosa **Nutt.** Caulescent biennial herbs; stems branched from the base and above, 3–15 cm long; herbage strigose to strigulose; basal leaves 1.2–4.5 cm long, 1.2–7 mm wide, oblanceolate to spatulate, more or less persistent; cauline leaves mostly smaller and narrower, often clustered below and overtopping the heads; involucres 5–10 mm high, 7–20 mm wide; bracts in 3 or 4 series, lance-ovate to lanceolate, the margins scarious, ciliate, strigose; rays 12–30, the corollas white to pink, sometimes darker dorsally, 5–14 mm long, 1.5–3 mm wide; disk corollas 3.3–5 mm long; achenes pubescent with glochidiate hairs; ray pappus 0.5–1.6 mm long; disk pappus 3.3–5 mm long. Salt desert shrub, mixed desert shrub, and pinyon-juniper communities at 1460 to 1895 m in Daggett, Duchesne, and Uintah counties; Wyoming; 14 (ii).

TRAGOPOGON L.

Biennial (annual or perennial) herbs from thickened taproots, the juice milky; leaves alternate, entire, clasping basally; heads solitary or few and corymbose; flowers all raylike, perfect, yellow or purple; involucres cylindric or campanulate; bracts uniseriate, equal; receptacle naked; pappus of plumose bristles united at the base; achenes 5- to 10-nerved, slender-beaked or the outer beakless.

OWNBEY, M. 1950. Natural hybridization and amphiploidy in the genus *Tragopogon*. Amer. J. Bot. 37:487–499.

1. Peduncles scarcely if at all inflated, even in fruit; achenes 15–25 mm long (including the beak); bracts subequal to the rays; plants rare in Utah .... *T. pratensis*
— Peduncles strongly inflated apically; achenes 25–36 mm long (including the beak); bracts usually longer than the rays; plants locally common 2
2(1). Rays purple; involucral bracts mainly 8 or 9 .... *T. porrifolius*
— Rays yellow; involucral bracts usually 13 .... *T. dubius*

Tragopogon dubius **Scop.** Biennial herbs; stems erect, 3–10 dm tall, simple or branched; leaves mainly 5–25 cm long, linear-subulate from an expanded base, floccose, becoming glabrate; peduncles enlarged and fistulous below the heads; involucres cylindric to campanulate; bracts commonly 13 (8 on later heads), 2.5–4 cm long in flower, 4–7 cm long in fruit; rays pale lemon yellow, shorter than the bracts; achenes 25–36 mm long; pappus whitish to tawny. Disturbed soils and in low quality range sites at 1370 to 3205 m in all Utah counties; widely distributed in the U.S.; adventive from Europe; 58 (vi).

Tragopogon porrifolius **L.** Oyster-plant; Salsify. Biennial herbs; stems erect, 3–10 dm tall, simple or branched above; leaves mainly 5–30 cm long, linear-subulate, the apex not recurved; peduncles enlarged and fistulose below the heads; involucres cylindric to campanulate; bracts commonly 8 (5–11), 2.5–4 cm long in flower, 4–7 cm long in fruit; rays purple, subequal to or shorter than the bracts; achenes 25–35 mm long; pappus brownish. Cultivated plants, escaping and persisting on canal banks, in moist meadows, and along roadsides at 1370 to 2595 m in Carbon, Millard, Salt Lake, Sanpete, Summit, and Weber counties; widespread in much of the U.S.; introduced from Europe; 10 (0).

Tragopogon pratensis **L.** Biennial herbs; stems erect, 1.5–8 dm tall, simple or branched; leaves mainly 5–30 cm broad, tapering from a broadly expanded base to 2 cm wide, recurved apically; peduncles not especially enlarged in flower or in fruit; involucres campanulate; bracts commonly 8, 12–24 mm long in flower, 18–38 mm long in fruit; rays chrome-yellow, equaling or surpassing the bracts; achenes 15–25 mm long; pappus off-white. Disturbed sites in Rich, Salt Lake, and Summit counties; widespread in the U.S.; adventive from Europe; 2 (0).

Vanclevea Greene

Shrubs; branchlets glutinous-resinous, green to tan, finally white to gray barked; leaves alternate, sessile, entire or serrate, falcately curved; heads discoid, yellow, solitary or cymose; involucres campanulate; bracts in 4 or 5 series, imbricate, glutinous; receptacle naked, resinous; styles long-exserted, the branches flattened, papillose; achenes clavate, 5-angled; pappus of 12–16 linear persistent slender scales.

Vanclevea stylosa **(Eastw.) Greene** [*Grindelia stylosa* Eastw., type from San Juan County]. Shrubs, mainly 5–12 dm tall; branchlets glutinous-resinous; bark tan to white or grayish black in age; leaves 0.6–3.5 cm long, 1–9 mm wide, narrowly lanceolate to oblong or elliptic, commonly entire, attenuate to a spinulose tip; heads solitary or more commonly few to many in corymbose or cymose clusters; involucres 8–10 mm high, 9–15 mm wide; bracts lanceolate to lance-attenuate, sometimes abruptly acuminate and recurved apically, resin coated; corollas yellow to cream, 6–7 mm long; achenes 4–5 mm long, compressed, glutinous and spreading hairy. Four-wing saltbush, ephedra, sand dropseed, Indian ricegrass, blackbrush, and juniper communities, in sand, at 1125 to 1620 m in Emery, Garfield, Grand, Kane, San Juan, and Wayne counties; Arizona (a Colorado Plateau endemic); 32 (viii). The genus is monotypic.

Verbesina L.

Annual (biennial or perennial?) herbs; leaves opposite, at least below, simple, toothed; heads radiate, showy; involucres biseriate, about equal, herbaceous; receptacle convex, chaffy, the bracts enfolding the achenes; rays yellow or yellow-orange, pistillate; disk flowers perfect, fertile; anthers subentire basally; style branches with hispidulous appendages; pappus of 2 slender awns; achenes flattened, 2-winged.

Verbesina encelioides **(Cav.) Benth.** [*Ximenesia encelioides* Cav.]. Annual herbs; stems 4–10 dm tall, cinereous-strigose, often branched above; lowest leaves opposite, alternate upward, petiolate, often with stipule-like appendages at base; blades 1.2–10 cm long, 0.7–6 cm wide, ovate to lanceolate, acute to attenuate, irregularly toothed, strigose beneath, green and sparingly strigose above; involucres 7–12 mm high, 15–25 mm wide; bracts lance-ovate to lance-linear, herbaceous, strigose; rays 10–15, yellow or yellow-orange, 8–20 mm long; pappus of 2 short slender awns; achenes thickly 2-winged, pubescent. Sagebrush, rabbitbrush, saltgrass, pinyon-juniper, and ponderosa pine communities, often in disturbed sites, at 1280 to 2260 m in Beaver, Garfield, Juab, Kane, San Juan, and Washington counties; Montana to California and Texas; 20 (v). Most of our material belongs to var. ***exariculata*** Robins. & Greenm. The bright flowers contrast sharply with the grayish-strigose pubescence, resulting in a strikingly beautiful plant.

Wyethia Nutt.

Perennial herbs from thick taproots; stems erect or ascending; leaves alternate, simple; heads large, solitary or several, radiate; involucral bracts in 2–4 series, herbaceous or coriaceous; receptacle convex, chaffy, the bracts folded, persistent; rays yellow, pistillate, fertile; disk flowers perfect, yellow; pappus a crown of scales or lacking; achenes trigonal or 4-angled, glabrous or pubescent.

Weber, W. A. 1946. A taxonomic and cytological study of the genus *Wyethia*, family Compositae, with notes on the related genus *Balsamorhiza*. Amer. Midl. Nat. 35:400–452.

1.	Leaves mainly cauline, the basal reduced or lacking, scabrous-roughened; plants of sandy desert shrublands	*W. scabra*
—	Leaves basal and cauline, the basal often larger than the cauline ones, smooth or, if rough-hairy, not of lower elevations	2
2(1).	Herbage glabrous, resinous; upper leaves rounded and clasping basally	*W. amplexicaulis*
—	Herbage hirsute to glabrate; upper leaves petiolate	*W. arizonica*

Wyethia amplexicaulis **(Nutt.) Nutt.** Mulesears. [*Espeletia amplexicaulis* Nutt.]. Perennial herbs; stems mostly 2.5–9 dm tall, glabrous; basal leaves 12–40 cm long, 2–15 cm wide, entire or dentate, petiolate, resinous; cauline leaves smaller, sessile, rounded and clasping basally; heads large, solitary or several; involucres hemispheric, 25–35 mm high, 25–50 mm wide; outer bracts foliaceous, subequal; rays 6–16, yellow, 2.5–4.5 cm long; pappus a crown, sometimes prolonged into filiform awns; achenes 8–10 mm long, glabrous. Sagebrush, oak,, pinyon-juniper, aspen-fir, and forb-grass communities at 1525 to 2745 m in Box Elder, Cache, Juab, Millard, Morgan, Salt Lake, Sanpete, Sevier, Summit, Tooele, Utah, Weber, and Washington counties; Washington to Montana, south to Nevada and Colorado; 38 (ii).

Wyethia arizonica **Gray** Perennial herbs; stems mainly 30–80 cm tall, spreading hairy, especially upward; basal leaves 15–40 cm long or more, 3–15 cm wide, petiolate, the blades oblanceolate to elliptic or lanceolate; cauline leaves smaller, attenuate basally to a short petiole; heads large, solitary or several; involucres hemispheric or campanulate, 20–30 mm high, 15–40 mm wide; outer bracts foliaceous, subequal; rays 6–16, yellow, 2.5–4 cm long; pappus a crown, sometimes prolonged into filiform awns; achenes 8–10 mm long, glabrous. Pinyon-juniper, oak, and ponderosa pine communities at 1430 to 2440 m in Grand, Kane, San Juan, and Washington counties; Colorado, New Mexico, and Arizona; 9 (0).

Wyethia scabra **Hook.** Robust, clump-forming perennial herbs; stems several to many, 1.5–6 dm high or more, scabrous and hispidulose; leaves mainly cauline, the lower ones rudimentary, 3–15 cm long, 3–17 mm wide, elliptic to oblong or linear, scabrous; heads solitary or few, terminating stems and branches; involucres hemispheric, 20–40 mm high, 20–55 mm wide; bracts lanceolate to linear, attenuate to caudate-attenuate; rays 10–23, yellow, 18–40 mm long; pappus a crown; achenes 6–8 mm long, glabrous.

Three more or less distinctive varieties are present. Diagnostic features are based on the nature of surface and habit of the involucral bracts, which in the typical, common phase is almost sufficiently variable as to include the others.

1. Involucral bracts long-attenuate from short dilated bases, ciliate with multicellular hairs, glabrous but with shiny resin droplets dorsally; plants of Kane County .... *W. scabra* var. *attenuata*

— Involucral bracts variable in shape, ciliate or not, scabrous to pubescent and more or less glandular dorsally, but seldom if ever with resin droplets 2

2(1). Involucral bracts closely imbricate, the outer recurved-spreading, pubescent with short fine hairs; plants of San Juan, Grand, and eastern Kane counties .... *W. scabra* var. *canescens*

— Involucral bracts various, scabrous to long-hairy dorsally; plants rather widely distributed .... *W. scabra* var. *scabra*

Var. ***attenuata*** **W. A. Weber** Ponderosa pine, oak, and pinyon-juniper (less commonly in desert shrub) communities, in sand, at 1370 to 1985 m in Kane County (type from north of Kanab); Arizona; 13 (iii). This handsome plant is a botanical motif of the Coral Pink dunes area, and is also present on East Clark Bench.

Var. ***canescens*** **W. A. Weber.** Warm desert shrub and mixed desert shrub communities at 1125 to 1680 m in Grand, Kane, and San Juan counties; Colorado, Arizona, and New Mexico; 4 (i). This is a variable entity transitional to the typical variety, especially in Grand and eastern Kane counties.

Var. ***scabra*** Blackbrush, vanclevea-ephedra, other mixed desert shrub, pinyon-juniper, and ponderosa pine communities at 1220 to 2625 m in Carbon, Daggett, Duchesne, Emery, Garfield, Grand, Kane, and Uintah counties; Wyoming; 48 (vii).

Xanthium L.

Annual herbs with fleshy large cotyledons and a taproot; leaves alternate, petiolate, the blades broad, rough-hairy; heads unisexual, discoid, or the corolla lacking; staminate heads uppermost, many flowered; involucral bracts in 1–3 series, separate; receptacle cylindric, chaffy; filaments monadelphous, the anthers separate; pistil vestigial, the styles unbranched; involucre of pistillate heads enclosing the 2 flowers, forming a 2-chambered bur armed with hooked prickles, the corolla lacking; achenes large, solitary in each chamber; pappus none.

Xanthium strumarium **L.** Cocklebur. [*X. italicum* Moretti; *X. pensylvanicum* Wallr.]. Annual monoecious herbs; stem 1.5–10 dm tall or more, simple or branched, scabrous, often purple mottled; leaves petiolate, the blades mainly 2–12 cm long and about as broad, ovate to oval or orbicular, obtuse to cuneate or cordate basally, scabrous, dentate and often lobed; heads in few to many short axillary clusters; burs broadly cylindric to ovoid, 1–3.5 cm long, with 2 more or less incurved beaks apically, covered with stout hooked prickles. Weedy species of cultivated and other disturbed lands, at 850 to 1925 m in much of Utah; adventive (?) from the eastern U.S. or possibly from Europe; 33 (iii). The seedlings are poisonous to livestock, and they produce dermatitis in some people.

Xylorhiza Nutt.

Subshrubs or suffrutescent perennial herbs; branchlets green to straw colored or whitish; leaves alternate, simple; heads solitary at branch ends; involucres campanulate to hemispheric; bracts imbricate in several series, herbaceous to largely scarious, erect; ray flowers pistillate, fertile, yellow; achenes somewhat compressed, hairy; pappus of tawny to whitish capillary bristles. **Note:** Members of this genus are all primary or secondary selenium indicators.

Cronquist, A. and D. D. Keck. 1957. A reconstitution of the genus *Machaeranthera*. Brittonia 9:231–239.

Watson, T. J. 1977. The taxonomy of *Xylorhiza* (Asteraceae-Astereae). Brittonia 29:199–216.

1. Leaves linear to linear-filiform, the margins entire and more or less involute; plants of Kane and Garfield counties .... *X. confertifolia*
— Leaves serrate to serrate-dentate, or, if entire, of other distribution (except *X. cronquistii*) 2
2(1). Leaves serrate to serrate-dentate (at least some); plants of south central and southwestern Utah, and of canyons of the Colorado 3
— Leaves entire; plants of eastern Utah 4
3(2). Leaves only sparingly serrate, linear-oblanceolate to elliptic; involucral bracts shortly attenuate, short-villous dorsally; plants of north central Kane County .... *X. cronquistii*
— Leaves sharply serrate-dentate, narrowly oblanceolate, elliptic, oblong, or lanceolate; involucral bracts long-attenuate, glandular or villous-pilose dorsally; plants of canyons of the Colorado and southwestern Utah .... *X. tortifolia*
4(2). Peduncles mainly less than 5 cm long; stems usually leafy to much above the middle .... *X. glabriuscula*
— Peduncles mainly more than 5 cm long; stems usually to the middle or below .... *X. venusta*

Xylorhiza confertifolia **(Cronq.) T.J. Watson** [*Machaeranthera glabriuscula* var. *confertifolia* Cronq., type from NE of Henrieville]. Perennial herbs from a woody caudex and taproot, with rootstocks sometimes developed; stems 9–23 cm high, sparingly pilose to glabrate and sparingly to densely stipitate-glandular; leaves 1–4.5 cm long, 1–2.5 mm wide, linear, pilose to glabrate, commonly involute; peduncles 1.8–14 cm long; involucres 9–12 mm high, 12–18 mm wide; bracts lanceolate to lance-acuminate, pilose to glabrate and glandular; rays 4–12, white, 9–18 mm long, 2–4 mm wide; disk flowers yellow, the corollas 6–9 mm long; pappus of capillary bristles to 6.5 mm long; achenes 3.5–6 mm long, pubescent. Salt desert shrub and pinyon-juniper communities at 1675 to 1985 m in Garfield and Kane counties; endemic; 6 (i).

Xylorhiza cronquistii **Welsh & Atwood in Welsh** Cronquist Woody-aster. Subshrubs, forming rounded clumps, from a stout taproot; stems numerous, whitish, ca 30 cm tall, villous at the nodes, almost glabrous otherwise; leaves 2.5–5 cm long, 2.5–5 mm wide, linear-lanceolate, sparingly serrate-dentate to entire, sparsely villous, ciliate, the midrib prominent; heads solitary on branches; involucre 10–12.5 mm high, 13–19 mm wide; bracts oblanceolate to lance-attenuate, acute to acuminate, herbaceous above the middle, chartaceous below, short-villous and glandular dorsally; rays white, 14–16, 20–25 mm long; achenes compressed, villous; pappus of capillary bristles to 7.2 mm long. Pinyon-juniper community, on the Kaiparowits Formation, at 1890 to 2075 m in Kane County; endemic; 1 (0).

Xylorhiza glabriuscula **Nutt.** Subshrubs or suffrutescent perennial herbs from a woody caudex and taproot; stems 7–37 cm tall, villous to glabrous; leaves 1–7.5 cm long, 1–9 mm wide, villous to glabrate, lanceolate to narrowly lanceolate or oblanceolate; heads solitary at branch ends; involucres 9–13 mm high, 15–27 mm wide; bracts lanceolate, attenuate to acute or acuminate, herbaceous above the middle, scarious below, villous to glabrous; rays 10–22, white to bluish or purplish, 11–20 mm long; achenes compressed, villous; pappus of capillary bristles to 5 mm long. Two allopatric varieties are present.

1. Leaves with attenuate bases; rays white; plants of Daggett County .... *X. glabriuscula* var. *glabriuscula*
— Leaves with truncate or rounded bases; rays bluish, purplish, or white; plants of San Juan County .... *X. glabriuscula* var. *linearifolia*

Var. ***glabriuscula*** [*Aster glabriuscula* (Nutt.) T. & G.; *Machaeranthera glabriuscula* (Nutt.) Cronq. & Keck]. Salt and mixed desert shrub communities at ca 1525 to 2135 m in Daggett County; Colorado, Montana, South Dakota, and Wyoming; 0 (0).

Var. ***linearifolia*** **T.J. Watson** Salt desert shrub community, mainly on Chinle and Moenkopi formations, in Grand and San Juan counties; endemic; 3 (iii).

Xylorhiza tortifolia **(T. & G.) Greene** Subshrubs; stems 15–50 cm tall or more, villous or tomentose and more or less stipitate-glandular; leaves 1–10 cm long, 4–20 mm wide, lanceolate to elliptic or oblanceolate, villous to tomentose and glandular, spinulose-dentate; heads terminating branches; involucres mainly 12–20 mm high and 15–30 mm wide; bracts narrowly lance-attenuate to -acuminate, herbaceous above, scarious below; rays 17–60 or more, bluish or purplish to white, 10–33 mm long, 1.8–5.5 mm wide; pappus of capillary bristles to 9 mm long; achenes compressed, pilose. Two varieties are present.

1. Involucres merely glandular dorsally; plants of canyons of the Colorado .... *X. tortifolia* var. *imberbis*

— Involucres villous-pilose as well as glandular; plants of Washington County .... *X. tortifolia* var. *tortifolia*

Var. ***imberbis*** **(Cronq.) T.J. Watson** [*Machaeranthera tortifolia* var. *imberbis* Cronq.]. Blackbrush, pinyon-juniper and sagebrush communities at 1220 to 2290 m in Garfield, Grand, Kane, San Juan, and Wayne counties; Arizona (Colorado canyons endemic); 32 (viii).

Var. ***tortifolia*** [*Haplopappus tortifolius* T. & G.; *Aster abatus* Blake; *Machaeranthera tortifolia* (T. & G.) Cronq. & Keck]. Blackbrush and other warm desert shrub communities at 760 to 1010 m in Washington County; Arizona, Nevada, and California; 10 (i).

Xylorhiza venusta **(Jones) Heller** [*Aster venustus* Jones, type from Cisco]. Suffrutescent to herbaceous perennial herbs from a woody caudex and taproot; stems mainly 10–40 cm tall, glabrous to densely pilose; leaves 2.4–9 cm long, 2–17 mm wide, oblanceolate to spatulate, villous to glabrate, attenuate basally; heads terminating branches; peduncles 5–20 cm long; involucres 10–18 mm high, 18–50 mm wide; bracts lance-attenuate to caudate-acuminate, herbaceous above, scarious below; rays 12–36, white or bluish to purplish, 12–27 mm long; pappus bristles to 10 mm long; achenes sericeus. Salt desert shrub communities at 1250 to 1985 m in Carbon, Daggett, Emery, Garfield, Grand, San Juan, Uintah, and Wayne counties; Colorado (a Colorado Plateau endemic); 99 (xv).

HAPLOPAPPUS CRISPUS AND *H. ZIONIS* (ASTERACEAE): NEW SPECIES FROM UTAH

Loran C. Anderson[1]

ABSTRACT. — The new species, *Haplopappus crispus* and *H. zionis* of section Macronema, are formally described and illustrated. They are endemic to southern Utah. Also, *H. bloomeri* ssp. *compactus* is raised to species. Chromosome numbers of all three are n = 9. Aspects of anatomy are detailed. Comparisons are made to *H. bloomeri* and *H. suffruticosus*. Relationships are discussed, and a key to the species is given.

The only comprehensive monograph of *Haplopappus* is that of H. M. Hall (1928). In recent years the generic integrity of *Haplopappus* has been questioned (see Anderson 1980 for review). Data from anatomy, cytology, and chemistry suggest it is a polyphyletic assemblage. Nevertheless, a suitable taxonomic reorganization of the group has not been achieved. Therefore, I choose to describe new taxa under the name *Haplopappus* even though the species will very probably be placed in some other genus at a later date.

Some years ago I found plants in southern Utah that appeared to be *H. bloomeri* Gray ssp. *compactus* Hall; a chromosome count for the collection, *Anderson 3358*, was published under that name (Anderson et al. 1974). Other collectors had identified similar plants as *H. suffruticosus* (Nutt.) Gray. The combined collections actually represent two new species of section Macronema, and, additionally, *H. bloomeri* ssp. *compactus* should be elevated to species level.

Methods and Materials

Fresh and dried materials were processed for anatomical study as in Anderson (1970a). Five heads from personal collections, along with one to five heads from other collections, were measured (as in Anderson 1964) for involucral and floral data. Cytological methods are those of Anderson (1966).

Voucher specimens for anatomical (a) and morphological (m) studies are: *H. bloomeri: Anderson 1620*, m (FSU), *Anderson 2018*, a and m (FSU), *Anderson 2943*, a (FSU), *Anderson 4539*, m (FSU), *Reveal 1070*, m (FSU); *H. compactus: Ackerman 30797*, m (FSU), *Anderson 6186*, a and m (FSU), *Clokey 8570*, m (UTC); *H. crispus: Anderson 5504*, a and m (FSU), *Cottam 1526*, m (BRY), *Maguire 13386*, m (UTC), *Stanton* in 1927, m (BRY); *H. suffruticosus: Anderson 1023*, m (FSU), *Anderson 2920*, a (FSU), *Anderson 2970*, a and m (FSU), *Goodrich 10133*, m (BRY), *Shultz 3738*, m (UTC), *Yoder-Williams 1311*, a (FSU), *Wiggins 9298*, m (UTC); and *H. zionis: Anderson 3358*, m (FSU), *Anderson et al. 5094*, a and m (FSU), *Arnow 107*, m (UT).

Taxonomy

Haplopappus compactus (Hall) L. C. Anderson, comb. nov.

Basionym: *Haplopappus bloomeri* Gray ssp. *compactus* Hall. Carnegie Inst. Publ. 389:199, fig. 68, 1928. Type. — Nevada: Clark Co., Charleston [Spring] Mountains, *E. C. Jaeger* on 12 Sep 1925 (holotype: POM!; isotype: UC!).

Synonymy: *Haplopappus bloomeri* Gray var. *compactus* (Hall) Blake in Clokey. Univ. Calif. Publ. Bot. 24:231. 1951.

The only description of this taxon is that given by Hall (1928). It is amplified and emended with the following: woody shrubs to 5 dm tall; leaves oblanceolate-spatulate, 2–3.5(4) cm long, (2)2.5–3(5) mm wide; heads (involucres) 12–14.8 mm long, 4.5–5.5 mm wide, phyllaries 18–24; disk flowers 11–16, golden yellow (fading lighter), corollas 9.1–11.4 mm long, tubes glandular, strongly dilated at point of staminal departure (at 50 percent of total corolla length), lobes 0.8–1.6 mm long, styles 12.5–14.5 mm long.

[1]Department of Biological Science, Florida State University, Tallahassee, Florida 32306.

In addition to specimens cited by Hall (1928) and Clokey (1951), the following represent this species: NEVADA: Clark Co., above McWilliams Campground at 8500 ft, Lee Canyon, Spring Mountains, *L. C. Anderson 6186* (BRY, FSU, UNLV, UTC), *A. D. Blauer* & *E. D. McArthur N-144, N-145* (FSU, SSLP), *W. E. Niles 3160* (FSU, UNLV); top of ridge, Charleston Mountain, 11,500 ft, *T. Dawson 7* (UC); top of Sheep Mountains, 9300 ft, *T. L. Ackerman* 30797 (FSU, NY).

The last collection is a range extension for *H. compactus;* the taxon was previously thought to be endemic to the Spring (or Charleston) Mountains.

Haplopappus crispus **L. C. Anderson**, sp. nov.

Frutices lignosi 3–4(5) dm alti; caules foliosi, graciles, erecti, tenuiter glandulosi; folia spatulata vel oblanceolata et acuminata, marginibus undulatis et crispis, (1.5)2–2.5(30) cm longa, (3)5–6(8) mm lata, in ramis altioribus solum parvo minora; inflorescentia cyma solute paniculata vel aliquanto congesta, temporibus paucis solum uno capitulo vel duobus per ramum; capitula campanulata, (12.5)13–14(15) mm longa, (5)6.5–7(9) mm lata, foliis superioribus saepissime separata; phyllaria (24)26–30(35); nulli radii flosculi; disci flosculi (14)15–20(24), luridi, corollis (9.5)10–10.8 mm longis, tubulo aliquanto dilato, lobis 1–1.5 mm longis, stylis 14–18 mm longis, lineis stigmaticis multo brevioribus quam appendicibus; achenia 6.5–8.5 mm longa et raro pubescentia.

TYPE.— Utah: Washington Co., weathered andesite with manzanita in mountain mahogany-fir woods with few pine and aspen along Whipple Valley Trail at 8100 ft, above Pine Valley, 19 air mi NE of St. George in Pine Valley Mountains, T39S, R14W, E1/2 Sec 29, 18 Sep 1981, *L. C. Anderson 5504* (holotype: BRY; isotypes: FSU, MO, NY, RSA, UC, UTC).

Woody shrubs, much branched at base, 3–4(5) dm tall (or taller?); leafy stems slender, erect, covered with short-stalked glands; leaves entire, alternate, green, spatulate to oblong-oblanceolate, acuminate, margins wavy-crispate, glutinous with low glands (not prominently stalked as in *H. suffruticosus*), (1.5)2–2.5(3) cm long, (3)5–6(8) mm wide,

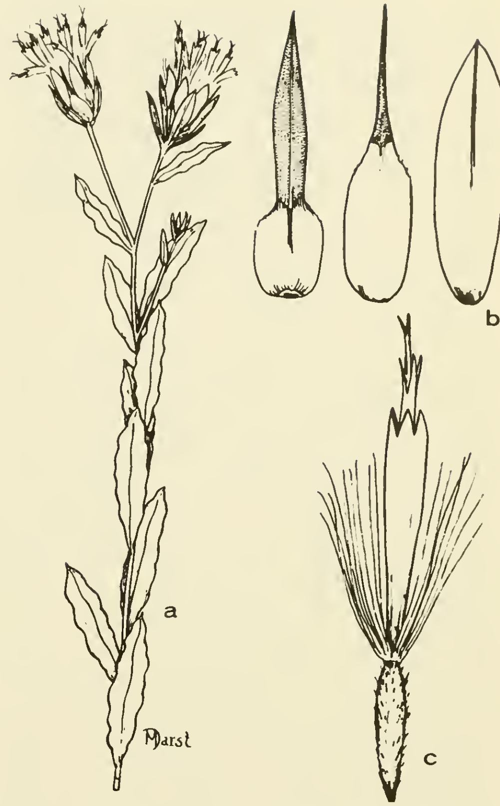

Fig. 1. *Haplopappus crispus* (Anderson 5504): a., flowering branch with crispate leaves and rather naked peduncles; b., involucral bracts, outermost with large green tips, inner ones with narrowed tips, innermost without green tips; c., disk flower with gradually flaring corolla and sparsely strigose achenes. A., x 1; b. and c., x 4.

only slightly reduced toward the inflorescence, but generally not crowding the heads as in *H. zionis;* inflorescence a loosely paniculate to somewhat congested cyme, occasionally reduced to one or two heads per branch (Fig. 1a); heads campanulate, (12.5)13–14(15) mm long, (5)6.5–7(9) mm wide; phyllaries (24)26–30(35), 1-nerved, finely glandular, outermost bracts mostly green, leaflike, inner bracts stramineous, abruptly or gradually narrowed into a slender green tip, innermost bracts stramineous, erose-ciliate apically, but not as pronounced as in *H. zionis;* ray flowers absent; disk flowers (14)15–20(24), pale yellow, corollas (9.5)10–10.8 mm long, tubes glandular pubescent, not abruptly dilated as in *H. compactus* and *H. zionis*, lobes 1–1.5 mm long, styles 14–18 mm long, branches slender, stigmatic lines much shorter than appendages (22–36 percent of total branch length); achenes cylindric, 6.5–8.5 mm long, sparsely but evenly pubescent, pappus 8–9.5 mm long; n = 9. Infrequent, generally in moderately open settings in spruce-pine associations, (3000?) 8100–10,000 ft, apparently endemic to mountains of southwestern Utah. August-September.

Additional specimens examined.— Utah: Millard Co., Pine Valley, *W. D. Stanton* in 1927 (BRY); Washington Co., south end Pine Valley Mountains, 9200 ft, *B. Albee 2911a* (UT), Anderson Valley area, north end Pine Valley Mountains, 8400 ft, *B. Albee 2911b* (UT), Pine Valley Mountains, T39S, R14W, *J. L. Gentry & E. Jensen, Jr., 2245* (BRY, NY, UTC), *R. K. Gierisch 542* (UC, UTC), Pine Valley Mountains, 8500 ft, *W. P. Cottam 5699* (UT), 10,000 ft, *B. Maguire & B. L. Richards, Jr., 13386* (UC, UTC), Santa Clara, 3000 ft, *W. P. Cottam 1526* (BRY, NY, UT). The last collection is so far out of range altitudinally that it may represent a chance introduction; the population has not been found again to determine its persistence. The collection is of further interest for the notation "along ditch banks, 8–10 ft tall"; also, it has heads with greater numbers of phyllaries and flowers than the other collections.

Haplopappus zionis **L. C. Anderson, sp. nov.**

Frutices humiles et diffundentes 1–3 dm alti; corpulenti caules decumbentes vel ascendentes, foliosi in inflorescentiam et glandulosi-hispiduli; folia spatulata et acuminata, (2.5)3–3.5(4) cm longa, 2.4–4(7) mm lata; inflorescentia cyma paniculata et congesta et foliosa; capitula turbinata vel anguste campanulata, (14)16–19(22) mm longa, 6–8 mm lata, bracteis exterioribus in forma folii apicibus longis et acuminatis, interioribus apice villosis, phyllariis (17)20–22(23); nulli radii flosculi; disci flosculi (10)12–18(21), flavi, corollis (9.5)9.8–10.8(11.5) mm longis, tubulis subito dilatis, lobis 1.2–2 mm longis, stylis 18–19 mm longis, lineis stigmaticis multo brevioribus quam appendicibus; achenia 7–8 mm longa et ferme glabra.

Type.— Utah: Iron Co., moderately bare, weathered pink limestone member of Wasatch Formation in aspen, spruce, limber pine, bristlecone pine association near top of Cedar Canyon, 9800 ft, 13.5 air mi SE of Cedar City, 30 Aug 1980, *L. C. Anderson, S. L. Welsh, and M. Chatterley 5094* (holotype: BRY; isotypes: ASU, DS, FSU, MO, NY, RSA, UC, UTC).

Low, branching, spreading shrubs, 1–3 dm tall; stems stout, decumbent or ascending, glandular-hispidulous, leafy into the inflorescence (Fig. 2a); leaves entire, alternate, green, spatulate, acuminate, margins not undulate or crispate, glandular but less glutinous than *H. crispus*, (2.5)3–3.5(4) cm long, 2.5–4(7) mm wide; inflorescence a congested, leafy paniculate cyme; heads turbinate to narrowly campanulate, (14)16–19(22) mm long, 6–8 mm wide, lateral heads fewer flowered than central ones; phyllaries (17)20–22(23), 3-nerved, finely glandular, outermost bracts leaflike and much longer than other bracts, inner bracts stramineous with long green tips, innermost bracts stramineous with praemorse, prominently villous tips (Fig. 2b); ray flowers absent; disk flowers (10)12–18(21), golden yellow, corollas (9.5)9.8–10.8(12) mm long, tubes abruptly dilated at point of staminal departure (at 40 percent of total corolla length), sparsely glandular, lobes 1.2–2 mm long, styles 18–19 mm long, branches slender, stigmatic lines much shorter than appendages (23–31 percent of total branch length); achenes cylindric, 7–8 mm long, essentially glabrous with few hairs apically (Fig. 2c), pappus 9–9.5 mm long; n = 9. Infrequent, usually on gravelly sandy clay from limestones, often with manzanita on rather barren slopes in spruce, fir, pine associations, 8,000–10,000 ft, apparently endemic to mountains of southern Utah. July-September.

Additional specimens examined: Utah, Garfield County, vic. summit between Escalante and Widtsoe, Escalante Mountains, 9000 ft, *W. P. Cottam 6562* (UT), 9100 ft, *L. C. Anderson 3358* (BRY, FSU, KSC, NY, UC, UTC), 10,000 ft, *E. Neese & S. White 3964* (BRY), 2 miles south of Pine Lake, Escalante Mountains, *E. Neese & S. White 3844*; Iron County, Cedar Canyon, southeast of Cedar City, 8000 ft, *L. Arnow 107* (UT), *R. Foster 5297* (BRY), vic. Midway Summit, west of Cedar Breaks, 10,000 ft, *B. Maguire & B. L.*

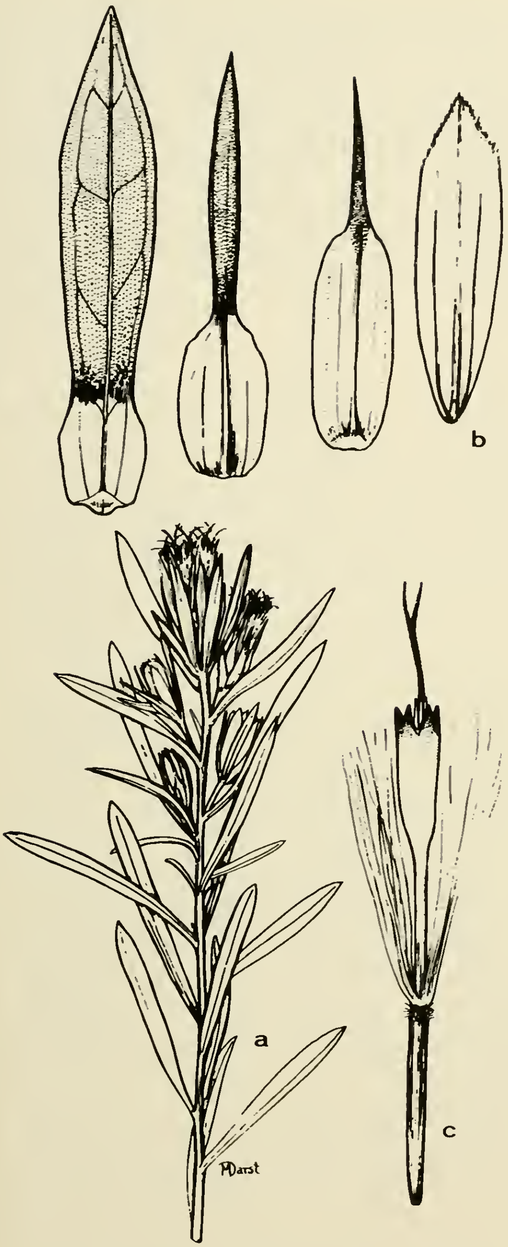

Fig. 2. *Haplopappus zionis* (Anderson et al. 5094): a., flowering branch with foliage overtopping flowering heads; b., involucral bracts, outermost leaflike and 3-nerved, inner ones with elongate green tips, innermost with prominently villous tip; c., disk flower with abruptly dilated corolla tube, long style, and nearly glabrous achene with very few hairs just below pappus. a., x 1; b. and c., x 4.

Richards, Jr. 13389 (UTC); Co. unknown, Dixie National Forest, *R. K. Gierisch 217* (UTC).

CYTOLOGY AND ANATOMY

Chromosome numbers of section Macronema of *Haplopappus* are monotonously uniform at n = 9 with an apparent absence of polyploidy and aneuploidy (Anderson et al. 1974). The new species are also n = 9. Original counts for *H. compactus* and *H. crispus* were made from root tip squashes from *Niles 3160* and *Anderson 5504*, respectively. An earlier count for *H. zionis (Anderson 3358)* was listed as *H. bloomeri* ssp. *compactus* in Anderson et al. (1974).

Meiotic behavior has not been observed for any of the new species, but all three have pollen fertilities above 98 percent (as determined by staining in cotton blue in lactophenol). Embryo sac development appears normal (Polygonum type) in *H. compactus*, *H. crispus*, and *H. suffruticosus;* it was not studied in *H. bloomeri* and *H. zionis.* Mature embryo sacs are long and narrow (280–380 μm long) and 8-nucleate without multiplication of antipodals as found in many *Chrysothamnus* (Anderson 1970b).

Aspects of floral anatomy for the new species and possibly related taxa are summarized in Table 1 (following format in Anderson 1970a); frequency categories are: + +, abundant; +, frequent; –, rare; and 0, absent. General information on the other taxa of *Haplopappus* is in Nelson (1982). Achenes of *H. zionis* have the greatest amount of vasculature, whereas those of *H. crispus* have the least. Secretory canals vary from abundant to absent at selected levels in the achenes and corollas. They are always absent in the styles of these species but present in *H. macronema* (Anderson 1970a).

Achenes of *H. bloomeri*, *H. compactus*, and *H. zionis* are essentially glabrous but with a few twin hairs just below the pappus attachment (the last being the "most glabrous"). A few short glandular trichomes (60–66 μm long) are hidden among the abundant twin hairs on *H. suffruticosus* achenes, and larger glandular hairs (190 μm) occur rarely on achenes of *H. bloomeri.* Glandular trichomes on achenes were so rare that they were omitted from Table 1, and they do not occur in the new species. Pappus bristles are positioned in three closely spaced rows on achenes of *H. zionis* and in two in the other four

TABLE 1. Comparisons for range and aspects of morphology of selected taxa of *Haplopappus*, section *Macronema*.

	H. bloomeri	*H. compactus*	*H. crispus*	*H. suffruticosus*	*H. zionis*
Range	Calif., W Nev., Oregon, S Wash.	S Nev.	SW Utah	Calif., Nev., Idaho, W Wyo., SW Mont.	S Utah
Elevation, ft	3500–9600	7900–11,500	(3000)8100–10,000	7500–12,300	8000–10,000
Habit of growth	tall, 4–5 dm	tall, 4–5 dm	medium, 3–4 dm	low, 1–3 dm	low, 1–3 dm
Leaf size, cm x mm	2–6 x 0.5–3	2–4 x 2–5	1.5–3 x 3–8	1–3 x 1.5–5	2.5–4 x 2.5–7
Leaf shape	filiform-narrowly oblanceolate	oblanceolate-spatulate	spatulate-oblanceolate	oblong-spatulate	spatulate
Leaf margins	smooth	smooth	crispate	crispate	smooth
Head length, mm	7.8–12.2(16)	12–15	12.5–15	8–16	14–22
Head width/length ratio	.29–.35	.36–.40	.45–.48	.45–.60	.38–.41
Phyllary number	17–36	18–24	24–35	17–31	17–23
Ray flower number	(0)1–3	0	0	(0)1–8	0
Disk flower number	4–8(12)	11–16	14–24	15–40	10–21
Disk flower length, mm	7.3–9.4(10.9)	9.1–11.4	9.5–10.8	8.5–11	9.5–12
Corolla tube	straight	dilated	± dilated	straight	dilated
Corolla lobe length, mm	0.9–1.9	0.8–1.6	1.0–1.5	1.0–1.7	1.2–2.0
Style branch, mm	2.5–4.3	3.8–4.4	3.8–4.8	2.6–4.6	4.2–5.2
Achene length, mm	6–7	7.5–8.5	6.5–8.5	7.5–8	7–8
Achene pubescence	glabrous	glabrous	sparsely strigose	villous-sericeus	glabrous

species (contrary to the meaning of the generic name).

The five species have glandular corolla tubes with the trichomes, "g" in Table 1, being similar to those in *Chrysothamnus* (fig. 20–22, Anderson 1970a); however, those in *H. zionis* are less abundant, are longer, and have narrower glandular heads as in Figure 19. Additionally, corollas of *H. crispus* have a few very long, nonglandular villi like Fig. 17 of Anderson (1970a).

Nectaries at the base of the style are most prominent in *H. zionis* and least so in *H. crispus*. The new species have somewhat thicker corollas than do *H. bloomeri* and *H. suffruticosus* as determined by cell number radially through the tubes between adjacent vascular bundles.

Nodal anatomy is trilacunar, three trace for the species. In leaf anatomy, they are similar in that leaves are isolateral with three rows of palisade cells facing each epidermis. Bundle sheath extensions are present only on the midvein—a feature characteristic of all taxa of *Haplopappus* with a chromosome base of x = 9, whereas those with x = 4, 5, or 6 have leaves with bundle sheath extensions on lateral veins as well. A possible exception would be *H. parryi*, (x = 9 group), which has many bundle sheath extensions on bifacial leaves, but it is better placed in *Solidago* (Anderson and Creech 1975).

Some variation exists in leaf thickness. Of leaves studied, those of *H. compactus* and *H. zionis* have blades averaging 336 μm thick with midveins 480 and 350 μm, respectively. Leaves of *H. crispus* are thicker, 355 μm in the blade and 400 at the midvein. Much thinner leaves occur in *H. suffruticosus* with blades 202 and 250 (*Anderson 2970* and *2920*, respectively), and both with midveins about 260 μm thick.

Glandular trichomes on leaves of *H. compactus* and *H. crispus* average 77 μm long with nearly spherical heads 50 μm and 38 μm wide, respectively. Glands on *H. zionis*

TABLE 2. Features of floral anatomy for selected taxa of *Haplopappus*, section Macronema.

	Ovarian bundle number		Secretory canal distribution				
			Achene		Corolla		
Taxon	Average	Range	I	II	III	IV	V
H. bloomeri	5.5	5–6	+	+ +	+	+	+
H. compactus	5.5	5–6	+ +	+ +	+ +	+ +	+
H. crispus	5.0	5	+ +	+ +	0	+	+ +
H. suffruticosus	5.2	5–6	+	+ +	+	+	–
H. zionis	7.0	5–9	+	+	+ +	+ +	+

leaves, thoughsomewhat less abundant, have larger buttressed bases and average 100 μm long with heads 38 μm wide. For *H. suffruticosus*, glands on *Anderson 2970* leaves average 80 μm long with spherical heads, whereas those on *Anderson 2920* have long slender stalks and heads, averaging 220 μm long with the elongate heads 48 μm long and 29 μm wide. Glands on *H. bloomeri* are nearly sessile, only 38–42 μm long with spherical heads 29 μm in diameter.

Relationships

Table 2 gives ranges of the species and summarizes some aspects of their morphology based on my observations; some measurements differ from those of Hall (1928). *Reveal 1070* is an unusual form of *H. bloomeri*, with exceptionally large heads with many long disk flowers (features listed parenthetically in Table 2).

The new species do not occur close geographically to *H. bloomeri* or *H. suffruticosus*, species with which they have been confused. Further, the new species are distinct from the other two in their constant absence of ray flowers. Ray flowers are almost always present in heads of *H. bloomeri* and *H. suffruticosus*, and, although occasionally individual plants may be eradiate, some plants of the population will always have rays.

Haplopappus compactus, once considered a subspecies of *H. bloomeri*, differs from that species in involucral length and width, disk flower number, corolla shape, and achene size as well as the absence of ray flowers and some aspects of leaf shape and size. *Haplopappus compactus* and *H. zionis* appear to be closely related. Both have dilated corolla tubes. They can be distinguished in habit, head size, and style length, and generally so in leaf shape and size. In addition, *H. zionis* usually has leafier involucres. The two also differ anatomically.

Haplopappus crispus is intermediate geographically between *H. compactus* and *H. zionis*, but it is closer to *H. suffruticosus* in relationship even though it is eradiate. In addition to absence of rays, *H. crispus* can be further distinguished from *H. suffruticosus* by its habit, leaf size and thickness, degree of glandularity (and odor), narrower heads, fewer flowers, and sparsely strigose achenes.

A key to the new species and related taxa is presented here.

1. Ray flowers present (at least in the population); widespread but not in S Nevada or S Utah 2
— Ray flowers always absent in each head; plants of S Nevada or S Utah 3

2(1). Achenes densely pubescent (sericeus); heads campanulate with more than 15 flowers .... *H. suffruticosus*
— Achenes essentially glabrous; heads cylindric-turbinate with less than 15 flowers .... *H. bloomeri*

3(1). Achenes sparsely strigose with hairs distributed evenly; leaves crispate .. *H. crispus*
— Achenes essentially glabrous but with few hairs near the pappus; leaves not crispate 4

Table 2 continued.

Nectary length, μm	Trichomes: Achene Freq.	Achene Length, mm	Corolla tube Type	Corolla tube Freq.	Corolla tube Length, μm	Corolla thickness A	B	C	Index of specialization
144	–	0.5	g	+ +	150	7	5	2	6.5
168	–	0.43	g	+	168	8	5	2	5.6
115	+	0.53	g	+ +	165	7	6	2	6.8
			n	–	432				
140	+ +	0.8	g	+ +	160	7	5	2	6.9
240	–	0.52	g	–	270	8	6	2	5.0

4(3). Heads mostly less than 14 mm long; styles less than 15 mm long; woody shrubs 3–5 dm tall .... *H. compactus*
— Heads mostly more than 14 mm long; styles over 17 mm long; low shrubs 1–3 dm tall .... *H. zionis*

In the Asteraceae, amounts of secretory tissue and floral venation bear evolutionary significance with a reduction in both usually indicating advancement. In *Chrysothamnus*, these features (correlated with other characteristics such as karyotypes) were used to develop a phylogenetic index of specialization on a scale of 0–10 for the taxa (Anderson and Fisher 1970).

Section Macronema is close to *Chrysothamnus* with natural hybridization known to occur between *H. macronema* and *C. nauseosus* (Anderson and Reveal 1966). Therefore, the index of specialization developed for *Chrysothamnus* should be applicable for showing relationships among the new species. Index values are listed in Table 2. Reduction in involucral bract vasculature is apparently correlated with that of the ovary wall; phyllaries of *H. zionis* have three vascular bundles each; those of *H. crispus* have one.

Of the taxa studied here and in Anderson (1970a), *H. macronema* (the most widespread species in the section) has the lowest index number of 4.5, and *H. ophitidus* (clearly a derived species that is specialized for serpentine) has the highest at 8.5. Hall (1928) considered *H. suffruticosus* the most primitive member of section Macronema, but *H. macronema* is probably a better candidate. *Haplopappus compactus*, and, especially, *H. zionis*, though much more restricted in range than *H. bloomeri* and *H. suffruticosus*, seemingly represent more primitive stock phylogenetically.

ACKNOWLEDGMENTS

Appreciation is expressed to Stanley L. Welsh for field trip support and to Wesley Niles for seed of *H. compactus*. Melanie Darst prepared the line drawings; Walter Forehand is thanked for assistance with the Latin diagnoses. This study was supported by National Science Foundation Grant DEB 76-10768.

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A BOUQUET OF DAISIES (*ERIGERON*, COMPOSITAE)

Stanley L. Welsh[1]

Abstract. — Described as new are six critical species and one variety of *Erigeron* from Utah. They are *E. awapensis* Welsh, *E. canaani* Welsh, *E. carringtonae* Welsh, *E. goodrichii* Welsh, *E. maguirei* Cronq. var. *harrisonii* Welsh, *E. untermannii* Welsh and Goodrich, and *E. wahwahensis* Welsh.

Erigeron is perhaps the most complex of all genera within the Compositae of Utah. The genus is allied to both *Aster* and *Conyza*, but most of the problems lie within the genus itself. To make matters more difficult *Erigeron* is one of the largest genera in Utah, with more than 60 taxa. Morphological features used as diagnostic characters often involve pubescence and its position on the plants. Other vegetative features have been relied upon also, because of the uniformity of flowers and bracts. Shape of leaves, whether mainly basal, mainly cauline, or distributed along the stem constitute important diagnostic characters. Pubescence type on the involucral bracts is considered as diagnostic in many cases. The technical nature of the distinguishing characters have led to wide misunderstanding of the genus, and most botanists have avoided the members of the group, relying, where possible, on specialists for critical determinations.

Preparation of a manuscript of the Compositae for the Utah flora project has led me to study Erigerons of Utah and the surrounding states in some detail. That study has indicated the presence of several taxa whose descriptions appear to be beyond those previously known to occur within Utah. The specimens have been compared to all other materials at BRY, and duplicates of many have been examined by Arthur Cronquist at NY. I wish to acknowledge his suggestions and consideration, but wish not to share blame for problems created by this author alone in the following interpretations.

Erigeron awapensis **Welsh**, sp. nov. A *E. abajoensis* Cronq. in caulis erectis foliorum basalis non vaginatis et floribus plus numerosis differt.

Perennial herbs from a branching caudex, the caudex branches clothed with ragged brown marcescent leaf bases; stems erect or nearly so, 10–24 cm long, strigose, the hairs ascending; basal leaves 1.5–7 cm long, 2–8 mm wide, not especially sheathing; cauline leaves well developed, oblong to linear, mostly 1–4 cm long, 2–4 mm wide; heads 2–4, rarely solitary; involucres 3–9 mm wide, 3.7–4.5 mm high, the bracts more or less imbricate, thickened near the base dorsally, greenish, strigulose, the hairs multicellular; rays 35–45, pink purple to pink (or white?), 5–6 mm long, 0.9–1.8 mm wide; pappus apparently simple, of 15–20 slender bristles, and with a few inconspicuous shorter setae in some; achenes 2-nerved, hairy. Pinyon-juniper and sagebrush communities at 2135 to 2260 m in Garfield and Wayne counties; endemic.

Type.— USA. Utah. Garfield County, T32S, R2W, S23, igneous bouldery slope in canyon, in *Artemisia* community, at milepost 26.5 south of Antimony, 4 September 1969, S. L. & S. L. Welsh 9388 (Holotype BRY; Isotypes, 4 distributed previously as *E. divergens* T. & G.). Additional specimen: Utah. Wayne County, T29 S, R4E, S20, 1 mi SE of Teasdale, sandy slope in pinyon-juniper community, 7 August 1980, M. E. Lewis 6657 (BRY).

The Awapa daisy is most similar to *E. abajoensis*, but stands apart from that taxon, which has become a catchall for all specimens that run to the end of the key. It seems apparent that the assemblage will be clarified only upon examination of much additional material not now available in collections.

[1]Life Science Museum and Department of Botany and Range Science, Brigham Young University, Provo, Utah 84602.

Erigeron canaani Welsh, var. nov. Similis *E. eatonii* Gray in aspectum et capitulum amplitudem sed in foliis caulino et radicalibus ambo linearibus et involutis folio basalibus ampliato et ciliato et radiis pauciorbus differt.

Perennial herbs from a simple (or branched?) caudex, this clothed with brown marcescent leaf bases, the taproot prominent; stems 7–20 cm tall, decumbent to ascending, sometimes purplish at the base, sparingly hairy with ascending hairs; leaves pubescent like the stem, the basal ones tufted, 1-nerved, 1.4–9 cm long, 0.7–1 mm wide, linear, involute, sharply acute, conspicuously expanded and long-ciliate basally; cauline leaves numerous, reduced upwards; heads 1–3; involucres 9–13 mm wide, 5.3–6.5 mm high; bracts imbricate, conspicuously glandular and sparingly to moderately villous-pilose with multicellular hairs, green or variously suffused with purple; rays 15–22, white or pinkish, 3.5–5 mm long, 1.8–2.1 mm wide; pappus single, of ca 20 slender bristles; achenes 2-nerved, hairy. Ponderosa pine community at 1585 to 2075 m in Washington County; endemic.

TYPE.— USA. Utah. Washington County, with *Petrophytum* and *Panicum*, in crevices in Navajo Sandstone, Canaan Mountain, T43S, R10W, S4, 11 June 1980, John Anderson sn (Holotype BRY; Isotype NY). Additional specimen: Utah. Washington County, Zion National Park, Clear Creek Canyon, T41S, R10W, S24, ponderosa pine community, on Navajo Sandstone, 25 Sept. 1982, S. L. Welsh 21398 (BRY).

The Canaan daisy is similar in general aspect to *E. eatonii*. The involute linear glaucous leaves and few ray flowers appear to be diagnostic.

Erigeron carringtonae Welsh, sp. nov. Affinis *E. untermannii* in foliis crassis sed in pilis involucrorum longioribus et tenuioribus et radiis longioribus differt.

Pulvinate perennial herbs with a pluricipital caudex, the branches clothed with conspicuous brown to straw colored or ashy marcescent leaf bases; leaves mainly basal, thickish, 0.6–3.5 cm long, 1–5 mm wide, spatulate to oblanceolate, strigose to pilosulose, obtuse to rounded apically; scapes 2.5–8 cm tall; heads solitary; involucres 9.8–15 mm wide, 5.8–7 mm high, the bracts imbricate, suffused with purple or green, the inner greenish with scarious margins, spreading-villous with long multicellular hairs; rays 18–30, pink to pink purple, 6.8–8.2 mm long, 1.4–2.3 mm wide; pappus double, the inner of 25–35 barbellate bristles, the outer of short setae; achenes 2-nerved, pilose. Meadows and escarpment margins, commonly on Flagstaff Limestone at 3050 to 3355 m in Emery and Sanpete counties; endemic.

TYPE.— USA. Utah. Sanpete County, T18S, R4W, S33, Manti-La Sal NF, 10 mi 115 degrees from Manti, 3220 m, 3 July 1981, S. Goodrich 15780 (Holotype BRY; Isotypes 14, distributed as *E. simplex*). Additional specimens: Utah. Sanpete County. T20S, R4E, S33, ca 17 mi W of Ferron, 3355 m, Flagstaff Limestone barrens, 13 July 1977, S. L. Welsh and S. Clark 15393 (BRY); do, T18S, R4E, S22, 7 mi due NNW of Ferron Reservoir, 19 July 1977, E. Neese and S. White 3708 (BRY); do, Heliotrope Mountain, 13 July 1977, M. E. Lewis 4915 (BRY). Emery County, Big East Mountain, head of Rilda Canyon, 13 July 1979, M. E. Lewis 6009 (BRY); do, Big East Mountain, above Upper Joes Valley, 8 August 1977, M. E. Lewis 5129 (BRY).

The Carrington daisy has been identified with *E. simplex* by previous workers, but appears to be more clearly allied to *E. untermannii*, at least superficially. It has long, spreading multicellular hairs similar to those of *E. simplex*, but the pulvinate caespitose habit and thick obtuse to rounded leaves of *E. carringtonae* appear to be diagnostic.

The species is named in honor of the memory of Jane Carrington, evidently the first woman to collect Utah plant materials designated as types (Welsh 1982).

Erigeron goodrichii Welsh, sp. nov. Similis et affinis *E. clokeyi* Cronquist sed in caudicibus tenuioribus et capitulis majoribus differt.

Perennial herbs from a stout taproot and caudex, the caudex branches with dark brown marcescent leaf bases; stems 3–10 cm tall, decumbent-ascending to erect, spreading hairy; basal leaves 0.4–6 cm long, 1.2–5 mm wide, narrowly oblanceolate, the veins not apparent, pilosulose, obtuse apically; cauline leaves more or less developed, but much reduced upwards; heads solitary; involucres 10.5–18 mm wide, 6.4–7.8 mm high; bracts imbricate, spreading villous-pilose with multicellular hairs, thickened basally, green or the apices suffused purplish, the inner with scarious margins, the attenuate apices more or less glandular and sometimes spreading; rays 40–65, pink purple to pink or white, 6.8–10.4 mm long, 1.5–2 mm wide; pappus apparently single, of 20–30 minutely barbellate bristles; achenes 2-nerved, pilose. Engelmann spruce krummholz and meadow communities, often on rock outcrops or talus at 3050 to 3400 m in Duchesne, Summit, and Utah counties; endemic.

TYPE.— USA. Utah. Duchesne County, T2N, R8W, S22, Ashley NF, Uinta Mountains, S rim of South Fork of Rock Creek, 14 mi n of Tabiona, 3264 m, with clumps of Engelmann spruce krummholz, on gravelly ground, 29 July 1981, S. Goodrich & R. Jepson 15907 (Holotype BRY; Isotypes NY, CAS, POM, MO, US, UT, UTC, RM). Additional specimens: Utah. Duchesne County, divide between Log Hollow and Rock Creek, 12 mi 355 degrees from Tabiona, 31 July 1979, S. Goodrich 13550 (BRY); do, head of Log Hollow, T2N, R7W, S30, 12 mi N of Tabiona, 3 July 1978, S. Goodrich and L. Hart 11696 (BRY); do, above Wedge Hollow, 11.5 mi and 354 degrees from Tabiona, 1 August 1979, S. Goodrich 13579 (BRY). Summit County, T2N, R12 E, S24, 11.5 mi NW of Kings Peak, East Fork of Blacks Fork, 31 August 1981, S. Goodrich 16203 (BRY). Utah County, Mt. Timpanogos, Emerald Lake, 7 August 1941, E. Castle 101c (BRY).

This dwarf alpine species has been recognized as having affinities with *E. asperugineus* (D.C. Eaton) Gray and *E. clokeyi* Cronquist, each of them dwarf alpine species. The Goodrich daisy differs from the former by its more slender leaves and from the latter by the caudex which lacks the distinctive thatch of gray-brown marcescent leaf bases.

The specific epithet honors the enthusiastic collector of the type and other materials, Sherel Goodrich, student of western botany, whose energetic pursuit of Utah and Nevada plants is unsurpassed.

Erigeron maguirei **Cronq. var. *harrisonii*** **Welsh, var. nov.** Similis var. *maguirei* sed in capitulis plus numerosis, radiis angustioribus, et disci brevioribus differt.

TYPE.— USA. Utah. Wayne County, T29S, R6E, S14, ca 1 mi ENE of Fruita, ca 5700 ft elev., Navajo Sandstone, juniper community, 2 June 1982, S.L. & E.R. Welsh 21178 (Holotype BRY; Isotypes NY; CAS). Additional specimens: Wayne County, canyon near Natural Bridge, 6 April 1934, B.F. Harrison 7385 (BRY); do, Fruita (Hickman Bridge trail), 10 June 1938, D E. Beck s.n. (BRY). The *harrisonii* phase of the *E. maguirei* differs in minor technical ways from materials of the type variety. Both phases are plants of sandy canyon bottoms, and perhaps they represent nothing more than ecological variants of a common theme.

The variety is named in honor of its discoverer, Bertrand F. Harrison, collector, teacher, and student of Utah botany.

Erigeron untermannii **Welsh & Goodrich, sp. nov.** Similis *E. compactus* sed in foliis latioribus pilis ascendentibus vel patentibus et radius brevioribus differt.

Perennial pulvinate herbs with an intricately branched caudex, the caudex branches mainly basal, 0.8–3.3 cm long, 1–4 mm wide, narrowly oblanceolate to spatulate, pilosulose with ascending, often curved, hairs; scapes 2–6 cm tall; heads solitary; involucres 7–11 mm wide, 5–5.7 mm high, the bracts more or less imbricate, green, or the inner somewhat chartaceous, the margins hyaline, the tips suffused with purple (sometimes throughout), densely hispidulous with short spreading hairs; rays 14–26, white, 4–6.5 mm long, 1.5–2.1 mm wide; pappus apparently single, of ca 20 slender fragile bristles; achenes 2-nerved, pilose. Pinyon-juniper community on calcareous shales and sandstones of the Uinta and Green River formations at 2135 to 2380 m in Duchesne and Uintah counties; endemic.

TYPE.— USA. Utah. Duchesne Co., T5S, R6W, S22, Indian Canyon, 17 mi S Duchesne, pinyon-juniper community, on Green River Shale, 4 June 1980, N. D. Atwood 7554 (Holotype BRY; Isotype NY). Additional specimens: Utah. Duchesne County, Tavaputs Plateau, Uinta Formation, junction of Right Fork and Left Fork of Indian Canyon, ca 10 mi SW of Duchesne, steep slopes and narrow ridge tops, shale and marly limestone, 26 May 1976, S. Goodrich 5317 (BRY); do, 13 mi 220 degrees from Duchesne, T5S, R6W, S21, ridge between Right Fork and Left Fork of Indian Canyon, 31 May 1979, S. Goodrich 12402 (BRY). Uintah County, Vernal District, Ashley National Forest, dry ridge top, S rim of Red Pine Canyon, 5 June 1976, S. Goodrich 5652 (BRY).

The Untermann daisy is compared to *E. compactus* Blake in the diagnosis, and it is probably allied to that taxon. However, the similarity to *E. nematophyllus* Rydb. cannot be ignored. It differs from that taxon in the broader leaves, generally harsher and more spreading hairs of the leaves, involucre, and achenes. The plant is named to honor the memory of the late G. E. and B. R. Untermann, an amazing husband and wife team who worked throughout their lives to understand the geology, natural history, and anthropology of the Uinta Basin. They influenced the lives of all persons whom they contacted.

Erigeron wahwahensis Welsh, sp. nov. Herbis similis *E. eatonii* in aspectus sed robustioribus caudicibus crassioribus pilis patentibus pro parte et bracteis crassioribus ad basim et dense vel sparse pilis patentibus differt.

Perennial herbs, from a branching caudex, the caudex branches with conspicuous fibrous brown to ash-colored marcescent leaf bases; stems 15–40 cm long, decumbent to ascending; basal leaves 3–18 cm long, 4–13 mm wide, linear-oblanceolate to oblanceolate or elliptic, 3-nerved, petiolate, appressed to spreading hairy with curved hairs; cauline leaves reduced, sessile, and bracteate above; heads solitary or 2 or 3; involucres 13–17 mm wide, 6–7 mm high, spreading-villous with multicellular hairs, glandular apically; bracts imbricate, green, the tips reddish, thickened basally; rays 30–40, pink or white, 5.5–7 mm long, 1.7–2.2 mm wide; disk corollas 3.5–4.2 mm long, the tube ca 2 mm long, the lobes 0.4 mm long; pappus of 15–20 bristles, with inconspicuous outer setae; achenes 2-nerved, short-hairy. Sagebrush, oak-maple, and pinyon-juniper communities at 1670 to 2440 m in Beaver and Washington counties; endemic.

TYPE.— USA. Utah. Beaver County, T28S, R15W, S31, Wah Wah Mountains, ca 12 mi SSW of Wah Wah Spring, Pine Grove Pass, 2450 m elev, sagebrush and pinyon-juniper community, 12 June 1982, S.L. Welsh 21229 (Holotype BRY; Isotypes NY, CAS, POM, RM, UT, UTC, US, GH, MO, and others to be distributed). Additional specimens: Utah. Beaver County, T29S, R16W, S12. Willow Creek, Wah Wah Mountains, 8 June 1978, K. Ostler & D. Anderson 1274 (BRY); do, T28S, R15W, S31, Wah Wah Mountains, divide between Quartz Creek and Pine Grove Canyon, 22 May 1981, S.L. Welsh 20520 (BRY).

The Wah Wah daisy is more or less intermediate between phases of *E. eatonii* and *E. jonesii*, but has features not shared by either. The pubescence is similar to *E. jonesii*, but the general aspect is more like *E. eatonii*. The plants tend to be larger than either, and the thick caudex appears to be diagnostic.

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NEW TAXA IN *THELESPERMA* AND *TOWNSENDIA* (COMPOSITAE) FROM UTAH

Stanley L. Welsh[1]

Abstract. — Three new taxa are named and described: *Thelesperma subnudum* Gray var. *alpinum* Welsh, *Townsendia jonesii* (Beaman) Reveal var. *lutea* Welsh, and *Townsendia montana* var. *caelilinensis* Welsh.

Preparation of a manuscript of the sunflower family for the Utah flora project demonstrated the existence of diversity within *Thelesperma* and *Townsendia* that seems best treated at taxonomic rank within existing species in those genera. In both genera the plants named are ecological specialists, with plants of each taxon occurring on calciferous or gypsiferous substrates of the Carmel, Flagstaff, Arapien, or other peculiar formations. Each of them belongs to the mound-forming group of substrate specialists of barren or semibarren habitats where water relations are controlled by the parent material. Generally the habitats are arid, despite the large amount of rainfall in the higher elevation sites. In all habitat examples cited there are other similarly restricted specialists, either species or varieties.

Thelesperma subnudum **Gray var.** ***alpinum*** **Welsh,** var. nov. Similis *Thelespermo subnudo* Gray var. *subnudo* sed in habito humilioribus et capitulis parvioribus differt.

Perennial herbs from a taproot and less commonly with a caudex and creeping rootstock; stems 3–7 cm tall, subscapose; leaves mainly basal on the stem, 1.5–4 cm long, pinnately lobed, or the upper entire; petioles ciliate and the blades puberulent; involucres 6.3–9 mm high, 9–14 mm wide; outer bracts oblong to lanceolate, with narrow scarious margins, to half as long as the inner; inner bracts united to below the middle; rays lacking; disk flowers yellow; pappus a toothed crown; achenes glabrous or hairy apically.

Type.— USA. Utah. Wayne County, T28S, R4E, S13 (NE¼), 3 mi due N of Bicknell, bristlecone pine forest on multicolored clay hills, 2745 m, 20 July 1980, D. Atwood and B. Thompson 7646a (Holotype BRY). Additional specimen: Utah. Wayne County, S of Teasdale, 25 July 1978, D. Atwood 6924 (BRY).

This dwarf phase of *Thelesperma subnudum* occurs about 500 m above the uppermost elevations known for the typical variety. Discoid plants are not uncommon for the widespread phase of the species, including at least a portion of the type (taken in Red Canyon, near Paragonah; isotype BRY), but the typical phase is ordinarily radiate. The dwarf alpine plants have involucres that are both shorter and narrower on the average. The plants are apparently restricted to the Carmel Limestone, on the peculiar varicolored phase of that formation as it occurs at the east margin of Rabbit Valley.

Townsendia jonesii **(Beaman) Reveal var.** ***lutea*** **Welsh,** var. nov. Affinis *T. jonesii* var. *jonesii* sed in corollis luteis ventralis differt et in substratis gypsiferis confinis.

Subacaulescent to acaulescent caespitose herbs, the caudex commonly branched; stems not conspicuously white-strigose, mainly 2–3 cm tall, forming clumps to 5 cm wide; leaves 10–30 mm long, 1–4 mm wide, oblanceolate to spatulate or almost linear, strigose; heads mostly solitary; involucres 9–12 mm high, 8–13 mm wide; bracts in 4 or 5 series, lanceolate, green or suffused purple, sparsely strigose; rays 13–21, yellow ventrally, often suffused reddish dorsally, glandular, 4–7 mm long; disk corollas yellow, ca 3.5 mm long; achenes 3–5 mm long, pubescent with glochidiate hairs; ray pappus 2–4.5 mm long; disk pappus 5–8 mm long.

Type.— USA. Utah. Sevier County, Arapien shale outcrop with scattered juniper, ca

[1]Life Science Museum and Department of Botany and Range Science, Brigham Young University, Provo, Utah 84602.

4.2 km E of Sigurd, T23S, R1W, S8, at milepost 14, Utah Hwy 24, 8 May 1975, S.L. Welsh 12700 (Holotype BRY; 2 isotypes distributed previously as *T. aprica* Welsh & Reveal).

Additional specimens: Utah. Sevier County, Rainbow Hills area, 2 mi NE of Glenwood, 7 May 1981, L. Greenwood 5013; do, 4 mi S of Salina, 24 Mar. 1981, L. Greenwood 5003; do, 2 mi E of Sigurd, 7 May 1981, L. Greenwood 5012. Piute County, NE side of Piute Reservoir, 26 Apr. 1979, E. Neese et al. 7149; do 30 Apr. 1981, D. Atwood and E. Neese 7794 (all BRY).

The presence of yellow flowers in *T. aprica* was considered to be noteworthy for the genus, although corollas that dried yellowish were admitted for *T. jonesii* (Reveal 1970). The existence of populations with yellow corollas when fresh in Piute and western Sevier counties at first indicated placement of those plants with *T. aprica*, but the long pappus of the ray flowers indicates relationships with *T. jonesii*, in which the corollas sometimes fade yellowish.

Most of the localities for this variety are situated on the Arapien Shale, which is noted for its deposits of commercial gypsum. The exception involves those plants from near the Piute Reservoir in Piute County, where the plants grow on gypsiferous or calciferous substrates amidst igneous gravels.

Townsendia montana **Nutt. var. *caelilinensis*** **Welsh, var. nov.** A var. *montana* differt in foliis spatulatis late capitulis majoribus et bracteis latioribus.

TYPE:— USA. Utah. Sanpete Co., T20S, R4E, S33, ca 24 km W of Ferron, 3050 m, Flagstaff Limestone, barrens, 13 July 1977, S. Welsh & S. Clark 15385 (Holotype BRY; 3 isotypes distributed previously as *T. montana* Nutt.). Additional specimens: Utah. Duchesne County, Argyle Canyon, 27 June 1978, E. Neese & L. England 5864; do, T6S, R6W, SW of Duchesne, 2 June 1978, E. Neese 5305. Sanpete County, 8 mi E of Spring City, 12 July 1977, E. Neese & S. White 3552; Heliotrope Mountain, 26 June 1977, M.E. Lewis 4254; do, 17 July 1981, D. Atwood 7998; do, head of Bacon Rind Canyon, J. W. Humphrey 52958, 22 July 1927; do, 11 mi 134 degrees from Manti, 3 July 1981, 22 July 1927; South Tent Mountain, 27 July 1976, M. E. Lewis 4365; Skyline at head of Duck Fork, 22 July 1976, M. E. Lewis 4246; do, E of Manti, 28 July 1977, S. Clark 2877. Wasatch County, 27 mi 98 degrees east of Spanish Fork, 19 July 1982, S. Goodrich 17303 (all BRY).

This is the large-headed phase of the species, with broadly rounded spatulate leaves, which lies intermediate with the typical montane materials and the dwarf plants of var. *minima*. The broad leaves and large heads are diagnostic in segregation of this entity from both the typical montane phase and the more southern var. *minima*.

The substrate occupied by var. *caelilinensis* on the Wasatch Plateau is composed of weathered Flagstaff Limestone. The Duchesne County populations occur on calciferous members of the Green River Formation.

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NEW *HAPLOPAPPUS* VARIETY IN UTAH (COMPOSITAE)

Stanley L. Welsh[1] and Frank J. Smith[2]

ABSTRACT. — Reported as a new variety from the Green River Formation of Uintah and Duchesne counties, Utah, is *Haplopappus armerioides* (Nutt.) Gray var. *gramineus* Welsh & F. J. Smith.

The arid Green River Formation, with its peculiar soil relations, has been the spawning ground for numerous narrow endemics. The taxon described herein is another belonging to that unique group of mound-forming, low-growing taxa that grow on the peculiar shale substrates. Relatively little variation occurs within the typical variety of *H. armerioides*. Thus, the variation represented by the taxon proposed below falls well outside that of the typical variety and substantiates its recognition. The main features that distinguish this variety from the main body of the species include the short stature and slender leaves, but the heads are also smaller, on the average, and the involucral bracts tend to be narrower. This latter feature seems to indicate an affinity with the related *H. acaulis* (Nutt.) Gray, but the bulk of the characteristics seem to represent an extension of the basic morphology of *H. armerioides;* hence, the placement with that taxon. The numerous specimens cited below have resulted from the laborious efforts of students of the Utah flora, whose contributions are gratefully acknowledged.

Haplopappus armerioides **(Nutt.) Gray var. *gramineus* Welsh & F. J. Smith**, var. nov. Similis var. *armerioides* sed in staturis humilioribus et folius gracilioribus differt.

Perennial caespitose herbs from a thick ligneus pluricipital caudex and stout taproot, the caudex branches clothed with brown to ashy marcescent leaf bases and leaves; herbage resinous-glandular, otherwise glabrous or with scabrous leaf margins; stems mainly 3–8 cm tall; basal leaves 1.5–4 cm long, 1–3 mm wide, rigid, linear, sharply mucronate, 1- or obscurely 3-nerved; cauline leaves few, reduced upwards; heads solitary; involucres campanulate, 8–11 mm high, 10–14 mm wide; bracts in 3 or 4 series, imbricate, oblong to oval or obovate, obtuse, sometimes lobed below the apex, greenish near the apex, glabrous; rays 8–12, 10–12 mm long, yellow, 3–4 mm wide; pappus white; achenes silky-villous.

TYPE.— USA. Utah. Uintah County, T13S, R25E, S8, Atchee Ridge road, 1.4 km N of Boulevard Ridge, 2727 m elev, Green River Formation, pinyon-juniper, serviceberry, mountain mahogany, and sagebrush community, 29 May 1982, K. Thorne & B. Neely 1836 (Holotype BRY; Isotypes NY; CAS).

Additional specimens: Utah. Duchesne County, Dry Canyon, 40 km due NE of Price, 25 May 1978, E. Neese 4916. Uintah County, along Watson-Ouray rd, 8 km W of Bitter Creek, 26 May 1935, E. H. Graham 8988 (UTC); do, Big Pack Mtn., 16 May 1978, E. Neese & J. S. Peterson 4628; do, ca 45 km S of Ouray, 18 May 1978, E. Neese & J. S. Peterson 4729; do, Johnson Draw, between Hill and Willow creeks, 27 Apr. 1978, E. Neese & J.L. England 4288; do, Long Draw, 2 km S of Ouray-Rainbow road, 18 May 1979, J. L. England 1777; do, Long Draw, ca 4.5 km SW of Rainbow, 16 May 1982, E. Neese & F. J. Smith 11388, 11389; do, Long Draw, ca 4 km W of Rainbow road, 26 May 1982, K. Thorne and B. Neely 1793; do, Bitter Creek and West Fork of Asphalt Wash jct., 26 May 1982, K. Thorne and B. Neely 1798; do, T13S, R25E, S11, 30 May 1982, R. Kass & J. Trent 862; do, Atchee Ridge road, near East Seep Canyon, 7 June

[1]Life Science Museum and Department of Botany and Range Science, Brigham Young University, Provo, Utah 84602.
[2]26 North 100 East, Smithfield, Utah 84335.

1982, F. J. Smith 1639, 1640; do, 4.5 km S of Rainbow, 15 May 1982, F. J. Smith 1596b, 1597; do, Asphalt Wash, 28 May 1982, R. Kass & J. Trent 842 (all BRY, except as noted).

There is a tendency for some plants to have acutish bracts, and the broad subapical spot is only more or less developed. Despite the presence of these features, which are somewhat intermediate with phases of *H. acaulis*, the taxon stands with few intermediates to *H. armerioides* in a strict sense.

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NEW SPECIES OF *HYMENOXYS* AND *PERITYLE* (COMPOSITAE) FROM UTAH

Stanley L. Welsh[1] and Elizabeth Neese[2]

Abstract. — Named as new species are *Hymenoxys lapidicola* Welsh & Neese, from Uintah County, Utah, and *Perityle specuicola* Welsh & Neese, from Grand County, Utah.

Revision of the sunflower family, as part of the Utah Flora project, has led to the recognition of several taxa that were previously known but had been placed within other entities. Additionally, some of the taxa had apparently not been collected previously, but were similar to previously described taxa. Careful observation of each of the numerous specimens in the herbarium at Brigham Young University has led to recognition of the great diversity in our flora. The two taxa described below each occur on sandstone, where they grow in crevices. They are part of a cadre of species with crevice habitats, and both are narrowly restricted endemics. Much more work remains to be done in the areas of the state occupied by massive sandstones, limestones, and other geological strata that produce cliffs and escarpments. The following species are named to indicate the peculiarities of their places of growth.

Hymenoxys lapidicola **Welsh & Neese,** sp. nov. Ab *H. torreyana* (Nutt.) Parker in bracteis recuvatis et capitulis parvioribus differt et a *H. depressa* (T. & G.) Welsh & Reveal in bracteis recurvatis et marginem scariosis differt.

Pulvinate caespitose herbs from a multicipital caudex, this densely clothed with brown marcescent leaf bases, acaulescent; leaves all basal, 0.3–1.2 cm long, 0.8–2 mm wide, narrowly oblanceolate, the inner conspicuously glandular-punctate, the blades glabrous, the axils long-villous; heads solitary, immersed in the leaves; disks 5.5–9 mm wide; involucres 5–8 mm high; bracts distinct, in 2 or 3 subequal series, sparingly villous and suffused reddish, the margins scarious, the tips more or less squarrose-spreading and somewhat thickened; rays 5 or 6, yellow, 5–6 mm long; pappus scales lance-acuminate, 2.3–3 mm long; achenes 2–2.5 mm long, pilose.

Type.— USA. Uintah County, T5S, R25E, S20, Point of Pines camp area, S edge of Blue Mt. Plateau, at 2485 m, in ponderosa pine-manzanita community, sandy loam and standstone outcrop, 12 June 1982, E. Neese and C. Fullmer 11734 (Holotype BRY; Isotype NY).

Additional specimens: Utah. Uintah County, Blue Mountain, cliff face, 11 June 1982, F. Smith & J. Trent 1653 (BRY); do, Point of Pines campground, Weber Sandstone, 11 June 1982, R. Cass & E. Neese 919 (BRY); do, 10 mi E of Jensen in draw at base of Blue Mountain, 14 May 1982, E. Neese et al. 11370 (BRY).

The habit of *H. lapidicola* simulates that of *H. depressa*, but the features of the involucral bracts and the proportionally broader noncuspidate leaves indicate a closer relationship with *H. torreyana*. From that entity it differs in the recurved outer involucral bracts with thickened reddish tips and much smaller heads.

Perityle specuicola **Welsh & Neese,** sp. nov. Similis *Perityle congesta* (Jones) Shinners sed in aspectis et pappo setarum 3 vel 4 (nec 1 vel 2), et in pappo palearum sigmoidis et expansis differt.

Perennial suffruticose herbs, mainly 50–75 cm tall; stems sprawling or pendulous, much branched; herbage glandular-hispidulous; leaves mostly alternate, short-petiolate, the blades 3–6 mm long, 1.5–3 mm wide, ovate-elliptic, entire, hispidulous; heads few to many in a branching corymbose inflorescence; involucres 3.5–5 mm high, 5–6

[1]Life Science Museum and Department of Botany and Range Science, Brigham Young University, Provo, Utah 84602.
[2]Life Science Museum, Brigham Young University, Provo, Utah 84602.

mm wide; bracts 11–16, oblong to elliptic, keeled; ray flowers lacking; disk flowers numerous, ca 2.5 mm long, whitish (?); pappus of 3 unequal scabrous bristles and often with 1 apically flattened and sigmoid scale; achenes 3–3.8 mm long, the faces flattened, glabrous, the margin thickened and with short ascending hairs.

TYPE.— USA. Utah. Grand County, T25S, R21E, S24, 2 mi due N of Moab, 1220 m, hanging garden community, 29 Sept. 1977, S.L. Welsh 16283 (Holotype BRY; 6 isotypes distributed previously as *Laphamia congesta* Jones).

Additional specimens: T25S, R22E, S29, Castle Valley, 2 mi due NNE of Moab, Negro Bill Canyon, 1220 m, Navajo sst, hanging garden community, 6 Oct. 1977, S.L. Welsh 16365 (BRY).

The technical features of this taxon indicate an affinity with *P. congesta*, but the differences in the pappus features, inter alia, suggest the need for recognition of this distinctive plant. It seems to be more than an etiolated shade form of its near ally, from which it is remote geographically by more than 300 km.

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NEW VARIETY OF *STEPHANOMERIA TENUIFOLIA* (COMPOSITAE) FROM UTAH

Sherel Goodrich[1] and Stanley L. Welsh[2]

ABSTRACT. — Named as new is *Stephanomeria tenuifolia* (Torr.) Hall var. *uintaensis* Goodrich & Welsh.

Identification of plants taken in preparation of a flora of the Uinta Basin demonstrated the presence of a *Stephanomeria* whose description is beyond that of other taxa in the genus. Specimens were compared with all other taxa in the genus, and with published keys and descriptions of all contemporary floras. The plants are situated at the margin of the range of S. *tenuifolia*, and are similar in general aspect to other phases of that species that are ecologically stressed. Plants taken on the West Tavaputs Plateau at 2745 m elevation (Welsh & Clark 15923 BRY) are similar to the aberrant materials from the Uinta Basin in general aspect and in leaf features, but the involucres are within the normal size range for typical S. *tenuifolia*.

The material described below grows in one small isolated stand in a ponderosa pine community and shows variation in size of heads and shape of the involucral bracts. The caudex is not well developed, producing solitary or few stems. Recognition at varietal level seems justified. More work in the genus is indicated.

Stephanomeria tenuifolia (Torr.) Hall var. *uintaensis* Goodrich & Welsh, var. nov. A var. *tenuifolia* imprimis in involucris longioribus bracteis attenuatis radiis longioribus et foliis basalibus bipinnatifidis differt.

Perennial herbs from a woody caudex; caudex sparingly branched or the branches lacking, with few marcescent leaf bases, not hairy; stems solitary or 2, 25–40 cm tall; herbage puberulent; leaves 1–11 cm long, 1–8 mm wide, the lower and sometimes the middle cauline ones runcinate-pinnatifid, the upper (at least) entire, linear, finally bracteate; heads solitary at the ends of stems or on branches; involucres 10–16 mm high, 3–5 mm wide; main bracts lance-attenuate, green or suffused with purple, puberulent; outer bracts very short; rays 5, pink, 7–10 mm long; pappus white, plumose to the base; achenes 5–6 mm long, longitudinally ribbed, the angles smooth.

TYPE.— USA. Utah. Uintah County, T2S, R19E, S14, NW¼, 18 mi NW 319 degrees of Vernal, Ashley N.F., Uinta Mountains, Brownie Canyon, 2486 m; ponderosa pine, Douglas fir, *Juniperus scopulorum*, and sagebrush, south exposure, 20 Aug. 1982, Goodrich 17708 (Holotype BRY; isotypes NY, US, CAS, POM, MO, UT, UTC, RM, GH).

Additional specimens: Utah. Uintah County, Brownie Canyon, 13 Sept. 1982, S. Goodrich & D. Atwood 17968 (BRY).

This variety approaches S. *parryi* in bract size, but has the appearance of phases of S. *tenuifolia* at the edge of their ecological tolerance. The tall involucres appear to be diagnostic when taken with the other features mentioned in the diagnosis.

[1]USDA Forest Service, Intermountain Forest and Range Experiment Station, Ogden, Utah 84401, stationed in Provo, Utah, at the Shrub Sciences Laboratory.
[2]Life Science Museum and Department of Botany and Range Science, Brigham Young University, Provo, Utah 84602.

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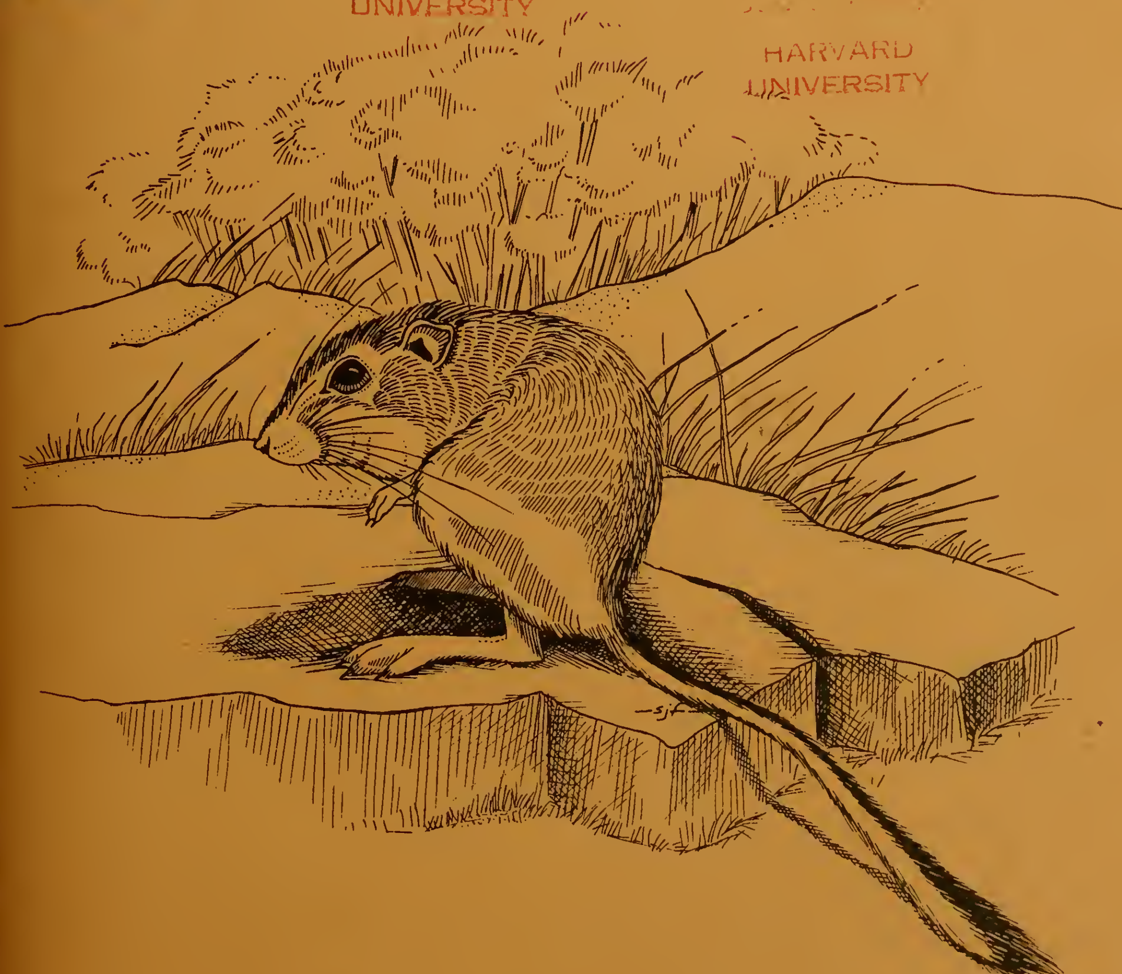

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9-83 650 66769

ISSN 017-3614

The Great Basin Naturalist

PUBLISHED AT PROVO, UTAH, BY
BRIGHAM YOUNG UNIVERSITY

ISSN 0017-3614

VOLUME 43 | July 31, 1983 | No. 3

A RE-EVALUATION OF THE POSTGLACIAL VEGETATION OF THE LARAMIE BASIN, WYOMING-COLORADO

Deborah L. Elliott-Fisk[1], Betty S. Adkins[2], and Jeanine L. Spaulding[3]

ABSTRACT.— Previous work by Wells in the Laramie Basin suggested that a coniferous forest/woodland covered the basin floor in the recent past (until the latest Holocene). We have found no evidence for this woodland and suggest instead that these scattered woodlands along sandstone outcrops and their immediate margins are outliers of the montane forest of the Medicine Bow Mountains, existing in their apparently anomalous locations due to favorable microenvironments set up by the topography and substrate.

During the past two years, we worked at various sites in and surrounding the Laramie Basin in an attempt to collect sufficient information with which to reconstruct postglacial vegetation (and environment) change for the region. The basin's unique geography as one of the few high-altitude basins surrounded by the Rocky Mountains, and the knowledge that a periglacial climate existed here in pre-Holocene times (Mears 1981), encouraged us to seek postglacial paleoclimatic data from not only upper elevations in the mountains (as done traditionally in the Rocky Mountains), but for the basin itself. Faunal, soil, and geomorphic studies here (Hager 1972, Reider et al. 1974, Grasso 1979, Reider and Burgess, in prep.) point to late Pleistocene and Holocene environmental change. In addition, a 116-year-old record of meteorological data is available for the basin, which will aid any climatic reconstructions attempted.

Upon visiting the Sand Creek region of the Laramie Basin (Fig. 1), we were delighted to find an abundance of fossiliferous material, including in situ dead trees (macrofossils) and *Neotoma* (woodrat) middens, as well as living trees that appeared to be at least several centuries old. Both living and dead trees were restricted to the sandstone outcrops and their immediate margins, these outcrops principally lithified sand dunes of the Pennsylvanian Casper Formation (Fig. 2).

It later surprised us when we read in the papers of Wells (1970a, 1970b) on the postglacial vegetation of the Laramie Basin that he believed these trees had in recent times (the latter half of the Altithermal and perhaps part of the Neoglacial) covered the entire floor of the Laramie Basin. Knowing both the ecological requirements of these conifer species (*Juniperus scopulorum* Sarg.—Rocky Mountain juniper; *Pinus flexilis* James—limber pine; and *P. ponderosa* Laws.—ponderosa pine) and the relatively minor degree of climatic change in the Holocene compared to the Pleistocene, we considered Wells's hypothesis not plausible. Instead,

[1]Department of Geography, University of California, Davis, California 95616.
[2]Department of Geography, University of Alberta, Edmonton, Alberta, Canada T6G 2H4.
[3]Department of Geography, University of Wyoming, Laramie, Wyoming 82071.

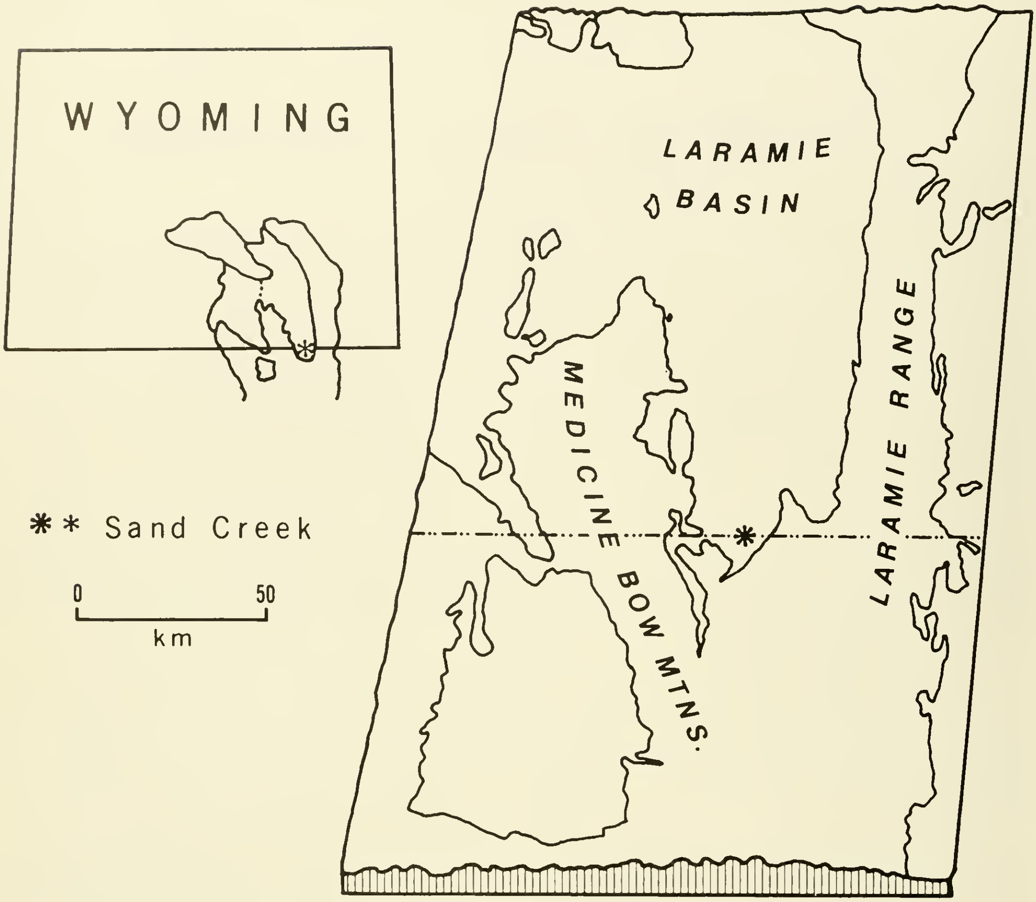

Fig. 1. Map of Sand Creek study area in the Laramie Basin of Wyoming-Colorado.

topography and microenvironmental conditions could have favored a more vigorous woodland (as evidenced by population and individual sizes) on the outcrops sometime in the past.

We therefore decided to critically reevaluate the paleoenvironmental data for the Sand Creek area. This involved examining a larger area than apparently done by Wells (pers. comm. with local ranchers) and also an attempt to tie the botanical data in with other paleoenvironmental studies conducted in the region. The completion of this project awaits radiocarbon dates and further dendroclimatic reconstructions. It is our hypothesis that these scattered woodland stands are outliers of the montane forest of the Medicine Bow Mountains, existing in their apparently anomalous locations due to favorable microenvironments set up by the topography and substrate, and not relicts of a former forest over the basin floor as hypothesized by Wells.

Methods

The methods we have used to solicit information as to the nature and degree of change of past environments at Sand Creek involve gathering various paleoecological materials. As we have yet neither found fossil soils in this immediate area, nor analyzed animal remains found in the *Neotoma* middens, we confine our discussion to the botany and paleobotany of the area.

Extensive hiking and collecting was done in the area outlined in Figure 1 to determine the spatial and temporal extent of conifers in this region. Dead and living individuals were mapped, along with *Neotoma* middens (both

Fig. 2. Study site 1 at Sand Creek (Wells' primary site). The landscape here is characterized by lithified sand dunes of the Pennsylvanian Casper Formation. The tree in the middle of the photo is a Rocky Mountain juniper (*Juniperus scopulorum*) approximately 1000 years of age.

fossil and contemporary). Although collecting has been completed at many of these sites, materials are still being obtained. In addition, the vegetation, regenerative capacity, microclimatic setting, geology, and soils of the sites were recorded.

Initial tree-ring and midden analyses, following the traditional methods of Stokes and Smiley (1968), Fritts (1976), and Wells (1976), have been conducted. Studies on the regenerative capacity of the conifer populations follow the methods outlined by Elliott (1979). We present our initial findings here. We believe these findings are important for those attempting to reconstruct Holocene climatic change for the Western USA, because they offer a radically different conclusion than that presented by Wells (1970a, 1970b). Also, for anyone undertaking recent paleoenvironmental studies, it becomes increasingly important to have a thorough understanding of the life strategy and ecological requirements of the species investigated, and also of the local geography of a site, if one is to accurately reconstruct a climatic record.

RESULTS

The present distribution of trees and tree species is shown in Figure 3. Multiple monospecific and mixed species stands occur along this semicontinuous sandstone ridge extending out from the southwestern Medicine Bow Mountains. The lower forest limit here is 2,500 m, with woodland patches reaching elevations of 2,300 m.

It is important to note that the lowest trees surviving here are not on the floor of the basin proper, but are restricted to the sandstone outcrops (Fig. 4) or their immediate margins. The dead trees (macrofossils) reported by Wells and found by us occupy the same topographic position as the living conifers, where winter snowdrift and summer runoff can supply them with the necessary moisture for survival in this marginal environment (Fig. 5).

It is interesting to note that two of the fallen fossil junipers plus two standing dead stumps in the area are much larger than any living junipers in the area today (Fig. 6). As this species is apparently at its lower mois-

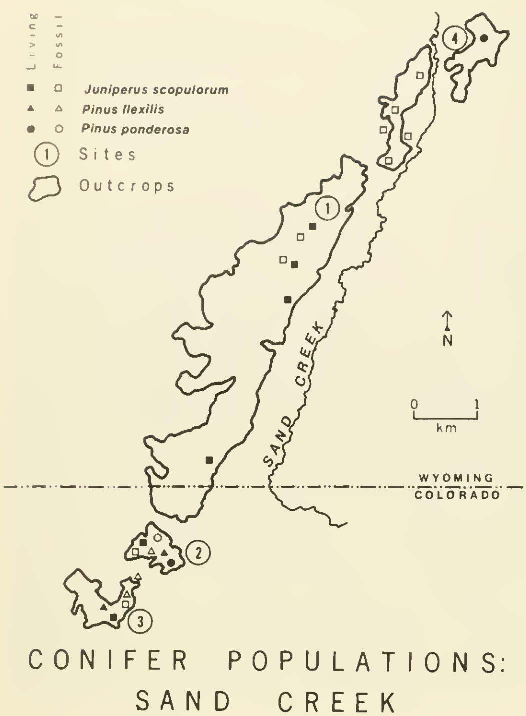

Fig. 3. Distribution of living and fossil (in situ dead) trees in Sand Creek study area. Findings in woodrat middens are not included here. Sandstone outcrops extend from the Medicine Bow Mountains to their southwest, decreasing in elevation toward the northeast.

ture, but not temperature, limit today (Fowells 1965), it seems reasonable to speculate that more moisture (either due to increased precipitation or decreased temperatures/evapotranspiration) was available during at least part of the past life spans of these trees.

This hypothesis is also supported by the fact that no mixed stands of ponderosa pine and juniper (as evidenced in some of the fossil middens) exist here today. Stands of limber pine and juniper do exist, along with mixed stands of all three species and pure stands of juniper or ponderosa pine. Fossil midden equivalents of all stand types mentioned here except the monospecific stands are found.

All three species are successfully sexually regenerating today in each stand in which they occur. This is witnessed by the presence of both viable seed (cones) and juveniles.

It proves difficult to make any type of rigorous statement in reference to the age structures of the tree populations here. This is due not only to a lack of radiocarbon dates for each dead tree (macrofossil), but primarily because both dead and apparently also living trees have been removed from this area for use as fence posts, firewood, etc. Many of the cut junipers we have found were harvested for "cedar table tops" in the 1920s (pers. comm., F. Lilly to B. Mears 1980), a fact that is distressing to paleoecologists trying to reconstruct the history of a site. Cross-dating of the tree rings in mature junipers is also extremely difficult; however, limber and ponderosa pine are easily cross-datable.

Juveniles of all three species, ranging from a few to 50 years in age, are abundant. All age classes (standard 10-year groups) of ponderosa pine are found for the last few hundred years, with no individuals over 350 years old (as yet found) surviving today. Ponderosa pine macrofossils (both in situ dead trees and smaller macrofossils in middens) are infrequent, though we have found cones and seeds at site 1. Limber pine is found up to several hundred years old, with some individuals approaching 1,000 years in age. In situ limber pine macrofossils are common at sites 2 and 3; some of these dead trees were also much larger than those living today. Sampling of these macrofossils is not yet complete.

Juniper appears to have had considerable difficulty through at least the last few thousand years (as documented by Wells's radiocarbon dates) with the establishment of an equilibrium population in this area. The living individuals today are primarily either several hundred to 1,000 years old or under 100 years in age. Juveniles tend to be clustered around singular dead or living mature individuals, which most likely served as the seed (mother) trees. Layering of juveniles from each other (but not from the larger trees) is also found. Occasionally, juveniles are found a great distance (over 1 km) from any possible seed trees. Few young adults are found, an age group in which the two pine species are abundant. Further dendroecological work with response functions for a species may help explain this difference.

One of the most intriguing facets of the Sand Creek sites is the tremendous variation in average tree-ring widths as one looks at living versus dead individuals. The ponderosa pines seem to have found a couple of sites at

Fig. 4. Trees at site 2. The majority of trees in this stand are situated on top of the sandstone outcrop, with individuals occasionally found along the margins. *Juniperus scopulorum*, *Pinus flexilis*, and *Pinus ponderosa* are all present here as both living individuals and fossils.

which they can exist with only occasional stress (as evidenced by very narrow rings every 30 to 40 years which are cross-datable); these individuals show wide, symmetrical crowning with consistently good growth and low mean sensitivities. In contrast, limber pine and juniper appear to have been under considerable environmental (climatic) stress, though this has not precluded the establishment of juveniles in recent times. Narrow rings and high mean sensitivities are common for both species here.

For comparative purposes, we present average ring-width data for several individuals of *Juniperus scopulorum* that we believe are representative of our samples. Whereas two measured, undated fossil trees have average ring widths of 1.09 and 2.38 mm, respectively, the largest living tree at Wells's site (our site 1) has an average ring width of 0.19 mm. One section of a large dead juniper cited by Wells with a radiocarbon date of 940 ± 105 BP (Gx-140F) on the outer wood has an average ring width of 0.17 mm; however, this value is derived from measurements on a branch cross-section and may therefore be expected to be smaller than those from the primary trunk. (All of the other measurements given are from main trunk cores and cross-sections.)

The above data show almost a 25-fold difference in ring-widths. As the living and fossil trees are found in the same habitats, this difference in growth must be attributed to a change in climate, with other environmental factors (topography, etc.) remaining constant. It is not attributable to intrapopulation or age differences.

Conclusion

It appears that Holocene climatic change in the Laramie Basin has been sufficient to trigger the death of conifers in the most marginal low-elevation sites. This is suggested by: (1) change in species composition of some of the lowest woodland stands, with only the most xeric tree species surviving this deterioration, (2) the death of individuals at the most marginal microclimatic/topographic locations, and (3) the decrease in ring width

Fig. 5a. Remains of fossil (dead) *Juniperus scopulorum* at the margin of a sandstone outcrop. This individual, like many in the area, has been partly harvested for lumber. Site 1.

Fig. 5b. Immature (not yet bearing seeds) *Juniperus scopulorum* along the margin of a sandstone outcrop between sites 1 and 2. This is a typical habitat for juniper regeneration. This individual is approximately 80 years old.

Fig. 6. One of two large, dead, fallen junipers at site 1. A cross-section through the midpart of this tree has been cut out, most likely for a table top. Presence of small branches on this individual attest to the fact that it has probably not been dead for more than a few hundred years.

(average growth rate) of the mature conifer populations.

We have found no evidence that a coniferous woodland or forest ever existed over the floor of the Laramie Basin in the Holocene (or even Pleistocene, though this latter time period is out of the scope of this study). It does appear, however, that more and occasionally larger individuals of the extant conifer species did exist on the sandstone outcrops and at their immediate margins in the early Neoglacial and perhaps late Altithermal.

Acknowledgments

This research was initiated while the authors were faculty (Elliott-Fisk) and students (Adkins and Spaulding) in the Department of Geography at the University of Wyoming; we appreciate the use of laboratory facilities there. We are also indebted to several local ranchers in the Laramie Basin for permission to work on their property and for various types of information and to Richard G. Reider, Brainerd Mears, Jr., and Thomas P. Harlan for helpful suggestions. Tree-ring measurements were done by Elliott-Fisk at the Laboratory of Tree-Ring Research, University of Arizona; the use of this facility is very much appreciated. We also thank the many students and faculty who have accompanied us in our field work at Sand Creek.

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COMPARATIVE LIFE HISTORY AND FLORAL CHARACTERISTICS OF DESERT AND MOUNTAIN FLORAS IN UTAH

Patrick D. Collins[1], Kimball T. Harper[1], and Burton K. Pendleton[2]

Abstract.— Life forms and floral characteristics of plants at Arches National Park (desert communities), the Mt. Nebo complex, and a subalpine meadow in the Uinta Mountains (montane and subalpine communities) were compared. Characteristics observed were (1) life form, (2) longevity, (3) pollination system, (4) flower structure, (5) flower symmetry, and (6) flower color. Common families in each flora were also compared. Results showed that there is a significant overrepresentation of shrub species at Arches, and an underrepresentation of perennial forbs. Relative number of perennial forb species was significantly higher at Mt. Nebo and the subalpine meadow than at Arches National Park. Native annuals and wind-pollinated species were significantly overrepresented at Arches. Flowers with open structure that permit free access of most insects to nectar and pollen were overrepresented at Mt. Nebo and in the subalpine meadow. The distribution of flower colors also differs significantly among these ecologically contrasting floras, with yellow being best represented in the desert and white in the mountains.

Because of accelerating development of energy and other natural resources, plant communities of the world are constantly being altered. In the United States, law requires that such disturbed areas be restored to their natural condition (Public Law 95-87, 1977), but little is known of the relative proportion of life histories and floral characteristics that enhance coexistence and self-perpetuation of a variety of wild plant species on common sites. What controls the relative success of pollen transfer by wind or animal in various natural communities? Do the contrasting climatic conditions of certain environments affect the success of species of various life forms, longevity, and/or floral characteristics?

In this paper, we compare characteristics of three Utah floras: the floras are from Arches National Park (desert), the Mt. Nebo complex (midelevation montane vegetation), and a subalpine meadow at high elevation in the Uinta Mountains. Arches National Park is a semiarid, cold desert region in southeastern Utah with an average elevation of about 1,220 m above sea level. Its topography consists of rolling hills and sandstone outcrops. The mean annual precipitation at Moab, near Arches, was 21.7 cm with a standard deviation of 4.3 cm (Nat. Oceanic and Atmosph. Admin. 1971–1979). The average annual temperature was 13.5 C. Mt. Nebo and adjacent mountains form a montane habitat with elevations between 1,829 and 3,621 m, but average elevation is in the neighborhood of 2,500 m. Average annual temperatures at Timpanogos Cave (1,720) 73.3 km north of Mt. Nebo was 9.4 C. The mean annual precipitation at Timpanogos Cave was 55.3 cm for the 1971–1979 period and that at the Payson Guard Station (2,454 m) was 73.3 cm with a standard deviation of 11.9 cm (Whaley and Lytton 1978). The Payson Guard Station is 17.4 km north of the crest of Mt. Nebo. The series of subalpine meadows selected for this study are located just below Bald Mountain Pass at the 28-mile marker (45.1 km) on the Mirror Lake Highway (Utah Highway 150) in Summit County, Utah. Average elevation at these meadows is 3,216 m, whereas mean annual precipitation at Trial Lake (near the meadows) was 102.8 cm with a standard deviation of 18.3 cm (Whaley and Lytton 1978). The mean annual temperature of this site is approximately –2.4 C (Callison and Harper, in review).

Jaccard's community coefficient (1912) shows the Arches and Nebo floras to be 90 percent dissimilar, Arches and Bald Mountain 98 percent dissimilar, and the Nebo and Bald

[1]Department of Botany and Range Science, Brigham Young University, Provo, Utah 84602.
[2]Department of Biological Sciences, Wayne State University, Detroit, Michigan 48202.

Mountain floras 90 percent dissimilar. Because these floras are so dissimilar and occupy such physically different ecological situations, it was hypothesized that there would be statistically significant differences in reproductive strategies of the plant species of the three floras. This paper compares the distribution of life form, longevity, and floral characteristics in the three floras. The comparisons evaluate the relative success of various reproductive strategies of plant species native to these three contrasting environments.

METHODS

Floristic checklists furnish the data on which this study is based. The list for Mt. Nebo and adjacent mountains, Utah County, was compiled from Collins (1979) and Allred (1975). Checklists for Arches National Park were prepared by Harrison et al. (1964) and Allan (1977). The Bald Mountain meadow checklist was taken from Pendleton (1981).

Life history and floral characteristics were determined for all species from preserved specimens in the Brigham Young University Herbarium. There were 734 species (647 native; 12.0 percent introduced) on the Mt. Nebo complex checklist, 356 (322 native; 9.6 percent introduced) on the desert list (Arches National Park), and 134 (all native) on the high elevation meadow list (Bald Mountain). The following information was obtained for each of the native species: (1) longevity, (2) life form, (3) likely pollinating agent, (4) flower symmetry, (5) flower structure, and (6) flower color. All analyses reported in this paper are based on native species only.

Longevity was simply recorded as annual or perennial. Species described in keys as biennials were treated here as annuals, except those species listed as "biennials to short-lived perennials" were considered perennials. Plant life form was noted as tree, shrub, forb, or grass. In respect to pollination system, plant species were classified as anemophilous or zoophilous. It is realized that some of the species may be self-pollinated, but this could not be determined without independent research on each species. Thus, no attempt was made to identify self-pollinated taxa.

Flower symmetry was regarded as either zygomorphic or actinomorphic. Species were also classified according to flower structure. Structure of zoophilous flowers was described as restricted when access to nectar or pollen was difficult for unspecialized pollinators. Restricted access flowers had long corolla or calyx tubes or had nectaries at the base of long spurs, thus limiting access to pollen or nectar. Flowers classified as open-structured were saucer or bowl shaped and appeared incapable of mechanically excluding any pollinator. Moreover, some plants were considered to be only partially restrictive, having short calyx tubes or deeply lobed and/or widely flaring sympetalous corollas: such flowers were listed as semi-restricted. Flower colors were listed as red, violet, blue, yellow, pink, white, or greenish.

Important families for each location were summarized by the number of species found in each flora. Jaccard's similarity index was employed to test compositional similarity between floras. The Chi-square statistic was used to identify departures from random expectations. In the Chi-square analyses, random expectations are based on the proportion of the species in the pooled floras that share a particular trait (e.g., the proportion of the species in the combined floras from the desert and montane environments that have red flowers). If the trait is randomly distributed between the two floras, the proportion of species having the trait in each flora should not differ significantly from the proportion having that trait in the pooled flora. The Chi-square statistic was used to test whether the observed and expected numbers of species (tests use absolute numbers, not the proportions) sharing a trait in the individual floras differed significantly. If there was a significant departure, the trait was considered to be under- or overrepresented in a given flora. Introduced species were omitted from all analyses on the assumption that they may not have achieved stable reproductive characteristics in their new home.

RESULTS AND DISCUSSION

A total of 70 families, 307 genera, and 734 species occurred in the Mt. Nebo flora. There are 60 families, 203 genera, and 356 species reported for the Arches flora. Thirty-six families, 86 genera, and 134 species appear on the Bald Mountain meadows checklist. Jaccard's index (Jaccard 1912) shows the Arches and Nebo floras to be 10.0 percent similar on the basis of species, 32.5 percent similar on the basis of genera, and 75.5 percent similar on the basis of families. The Arches and Bald Mountain floras are 1.5 percent similar on the basis of species, 12.0 percent similar on the basis of genera, and 39.1 percent similar on the basis of families. The Mt. Nebo and Bald Mountain floras show 10.2 percent similarity by species, 23.2 percent by genera, and 45.2 percent by families. Because the families contributing species to these flora are so similar, most of the observed differences in plant adaptations in the three areas can be attributed to ecological selection rather than to differences in basic phylogeny.

Families contributing most of the species in the three floras are reported in Table 1. The families Asteraceae and Poaceae dominate the three floras: Fabaceae holds third place in the Arches flora, Cyperaceae claims that position at Bald Mountain, and Brassicaceae takes that slot on Mt. Nebo. The family Chenopodiaceae contributes over three times as many species in relative terms in the desert as in the mountains. In contrast, species of Rosaceae, Caryophyllaceae, Polemoniaceae, Saxifragaceae, and Scrophulariaceae are twice or more as common in our mountains as in the desert flora considered.

Life Form.— In all three floras, the predominant life form (as represented by number of species) is the broad-leaved herb (forb). At Arches National Park, 64.3 percent of the total flora is contributed by forbs; on Mt. Nebo, 73.0 percent of the species are forbs; and at Bald Mountain, 64.9 percent of the species are forbs (Table 2). Analysis shows that forbs are significantly overrepresented in the midmontane flora, whereas they are underrepresented in the high-elevation meadows and in deserts (Table 3). The shrub life form contributes proportionally over twice as many species in the desert (14.3 percent) as in the mountain floras at Mt. Nebo (7.0 percent) and at Bald Mountain (6.8 percent). That difference is statistically highly significant ($\Sigma X^2 = 30.46$, $P < 0.005$, Table 3A).

The results support the hypothesis that under dry conditions, shrubs are more successful than forbs. Deserts are notorious for unpredictable climatic patterns, and many forbs do not tolerate moisture deficits for long periods (Hironaka 1963, Mueggler 1972, Harner and Harper 1973). Shrubs can tolerate such conditions. They exhibit a variety of adaptations to dry environments, such as deep root systems and reduced reliance on turgor pressure to keep leaves expanded to collect light and carbon dioxide (Sharif and West 1968). Shrubs also have leathery or firm leaves that reduce breakage from heavy winds and are resistant to herbivory; and, finally, shrubs have well-developed secondary meristems

Table 1. A comparison of important families showing the number of species and percent (in parenthesis) of the total floras of Arches National Park, the Mt. Nebo complex, and Bald Mountain meadows, Utah.

Family	Arches No. (%)	Mt. Nebo No. (%)	Bald Mtn. No. (%)
Asteraceae	80 (22.5)	115 (15.7)	20 (14.9)
Poaceae	51 (14.3)	105 (14.3)	18 (13.4)
Fabaceae	25 (7.0)	30 (4.1)	2 (1.5)
Chenopodiaceae	22 (6.2)	14 (1.9)	0 (0.0)
Brassicaceae	17 (4.8)	50 (6.8)	4 (3.0)
Scrophulariaceae	10 (2.8)	36 (4.9)	8 (6.0)
Boraginaceae	10 (2.8)	19 (2.5)	1 (0.7)
Cyperaceae	9 (2.5)	16 (2.2)	12 (9.0)
Rosaceae	7 (2.0)	34 (4.6)	4 (3.0)
Liliaceae	7 (2.0)	14 (1.9)	4 (3.0)
Caryophyllaceae	2 (0.6)	18 (2.5)	6 (4.5)
Ranunculaceae	4 (1.1)	28 (3.8)	5 (3.7)
Polemoniaceae	5 (1.4)	19 (2.6)	1 (0.7)
Saxifragaceae	1 (0.3)	18 (2.5)	3 (2.2)
Salicaceae	6 (1.7)	15 (2.0)	1 (0.7)
Other	100 (28.0)	203 (27.7)	45 (33.6)
Totals	356 (100.0)	734 (100.0)	134 (100.0)

that probably permit individual roots to be longer lived than is possible for species that lack secondary meristems (as in grasses and sedges). During dry periods, shrubs persist and maintain root systems in both lateral and vertical space; when better moisture conditions do return, herbs attempting to colonize barren spaces between shrubs experience extreme competition from the already established root systems of shrubs. Even in moist years, however, the barren interspaces between shrubs are only sparsely clothed with annual plants, but nearby areas that have been deprived of their shrub cover by abusive grazing or mechanical disturbance support a nearly complete cover of annual plants (Hutchings and Stewart 1953).

Graminoides tend to be better represented in the Arches flora (grasses) and at Bald Mountain (sedges) than at Mt. Nebo. Trees are best represented in the midelevation mountain flora (Table 2).

Longevity.— Longevity of species in the desert and montane floras also show significant differences. The deserts have more annual species than one would expect by chance ($\Sigma X^2 = 21.27$, $P < 0.005$, Table 3B). Native annuals contribute 18.9 percent of the 322 species at Arches National Park, 10.5 percent of the 647 species on the Mt. Nebo

TABLE 2. Characteristics of the native floras of Arches National Park, the Mt. Nebo complex, and the Bald Mountain meadows. The table shows the number of species and the percent of the native flora (in parentheses).

	Arches No. Sp. (% flora)	Mt. Nebo No. Sp. (% flora)	Bald Mtn. No. Sp. (% flora)
LIFE FORM			
Trees	13 (4.0)	39 (6.0)	3 (2.2)
Shrubs	46 (14.3)	45 (7.0)	9 (6.7)
Forbs	207 (64.3)	472 (73.0)	87 (64.9)
Graminoides	56 (17.4)	91 (14.0)	35 (26.1)
Total	322 (100.0)	647 (100.0)	134 (100.0)
LONGEVITY			
Annual	61 (18.9)	68 (10.5)	7 (5.2)
Perennial	261 (81.1)	579 (89.5)	127 (94.8)
Total	322 (100.0)	647 (100.0)	134 (100.0)
POLLINATION SYSTEM (annuals excluded)			
Anemophilous	101 (38.7)	162 (28.0)	39 (30.7)
Zoophilous	160 (61.3)	417 (72.0)	88 (69.3)
Total	261 (100.0)	579 (100.0)	127 (100.0)
FLOWER SYMMETRY (zoophilous species)			
Radial	188 (88.7)	395 (84.4)	77 (83.7)
Bilateral	24 (11.3)	73 (15.6)	15 (16.3)
Total	212 (100.0)	468 (100.0)	92 (100.0)
FLOWER STRUCTURE (zoophilous species)			
Open	55 (25.9)	179 (38.2)	42 (45.7)
Restricted	59 (27.8)	128 (27.4)	14 (15.2)
Semirestricted	98 (46.2)	161 (34.4)	36 (39.1)
Total	212 (100.0)	468 (100.0)	92 (100.0)
FLOWER COLOR (zoophilous species)			
White	50 (23.6)	165 (35.3)	30 (32.6)
Yellow	88 (41.5)	148 (31.6)	23 (25.0)
Blue	20 (9.4)	57 (12.2)	8 (8.7)
Violet	27 (12.7)	36 (7.7)	12 (13.0)
Pink	8 (3.8)	34 (7.2)	12 (13.0)
Red	14 (6.6)	15 (3.2)	1 (1.1)
Green	4 (1.9)	8 (1.7)	5 (5.4)
Other	1 (0.5)	5 (1.1)	1 (1.1)
Total	212 (100.0)	468 (100.0)	92 (100.0)

complex, and only 5.2 percent of the 134 species from the Bald Mountain flora.

Climatic unpredictability enhances the success of annuals in deserts (Schaffer and Gadgil 1975), where precipitation is sporadic and scarce. The annual strategy seems well suited for such conditions, whereas perennial forbs consistently contain high levels of tissue moisture (Sharif and West 1968). Our results show that perennial forbs are underrepresented in the desert (Table 3C).

Pollination Systems.— Because shrubs have been shown to be overrepresented at Arches, and because anemophily is heavily favored among woody species (Ostler and Harper 1978, Freeman et al. 1980), we anticipated that anemophily would be most prevalent at Arches. At Arches National Park, 38.7 percent of the perennial flora is anemophilous; on Mt. Nebo only 28.0 percent and at Bald Mountain only 30.7 percent of the species are wind pollinated (annuals have been omitted from this analysis to minimize the possible confusing effect of self-pollinated species, which are believed to be especially common among annuals [Solbrig 1977]). The differences in modes of pollination in the three floras are statistically significant ($\Sigma X^2 = 9.64$, $P < 0.005$, Table 3D).

The reason that there are more anemophilous species in the desert is not that there is more wind movement there. The Arches area receives only half as much wind (1,590.5 km at Moab) as the Mt. Nebo area (2,984.4

Table 3. Chi-square analyses comparing life histories and floral characteristics of the native plant species of Arches National Park, the Mt. Nebo complex, and the Bald Mountain complex of Utah. Observed and expected numbers of species (in parentheses) are shown. Asterisks indicate significance level: single < .05, double < .010, triple < .005 probability.

	Arches	Mt. Nebo	Bald Mtn.	Summation Chi-square values
Life form				
Trees	13 (16.1)	39 (32.3)	3 (6.7)	
Shrubs	46 (29.2)	45 (58.7)	9 (12.1)	
Forbs	207 (223.6)	472 (449.2)	87 (93.1)	
Grasses	56 (53.1)	91 (106.8)	35 (22.1)	30.46***
Growth cycle				
Annuals	61 (39.7)	68 (79.8)	7 (16.5)	
Perrenials	261 (282.3)	579 (567.2)	127 (117.5)	21.27***
Growth cycle/life form				
Perennial forbs	150 (184.5)	406 (370.7)	76 (76.8)	
Other native species	172 (137.5)	241 (276.3)	58 (57.2)	22.99***
Pollination system (annuals excluded)				
Anemophilous	101 (81.5)	162 (180.8)	39 (39.7)	
Zoophilous	160 (179.5)	417 (398.2)	88 (87.3)	9.64***
Flower structure (for zoophilous species)				
All species considered (annuals included)				
Open	55 (75.8)	179 (167.3)	42 (32.9)	
Restricted	59 (55.2)	128 (121.8)	14 (24.0)	
Semirestricted	98 (81.0)	161 (178.8)	36 (35.2)	19.11***
Only perennial species considered (semirestricted taxa ignored)				
Open	46 (59.2)	160 (156.6)	38 (28.2)	
Restricted	61 (47.8)	123 (126.4)	13 (22.8)	14.35***
Flower color (for zoophilous species)				
Red	14 (8.2)	15 (18.2)	1 (3.6)	
Other	198 (203.8)	453 (449.8)	91 (88.4)	6.70*
White	50 (67.3)	165 (148.5)	30 (29.2)	
Other	162 (144.7)	303 (319.5)	62 (62.8)	9.21**
Yellow	88 (71.1)	148 (157.0)	23 (30.9)	
Other	124 (140.9)	320 (311.0)	69 (61.1)	9.82**

km at Lehi) in the April–September period (Whaley and Lytton 1979). Conditions that may favor wind-pollinated species at Arches include dominance of most perennial covers by a few woody species that have large populations, low-growing, open vegetation, and severe, unpredictable periods of drought. Accurate wind movement readings were not available for the Bald Mountain area.

When only perennial species are considered, woody species are much better represented in the Arches flora (22.6 percent) than at Mt. Nebo (14.5 percent) or Bald Mountain (9.4 percent). Furthermore, shrubs dominate all major communities at Arches (Allan 1977). Diversity of perennial species as measured by number of species per 1.0 m^2 (a variable known to reduce the success of wind-pollinated taxa [Ostler et al. 1982]) is shown by Allan (1977) to be 2.6 at Arches (10 communities considered) as compared with 4.3 in the Wasatch Mountains (of which Mt. Nebo is a part [Ostler and Harper 1978, 25 communities reported]) and 6.9 at Bald Mountain (Pendleton 1981, 4 communities reported). Wind pollination is further facilitated at Arches by a plant cover that is more open than that at Nebo. Allan (1977) reported an average of 41.3 percent living cover at Arches, but, considering the fact that 70 percent of the Mt. Nebo study area is dominated by oak woodland or forests of aspen and/or conifer, plant cover there undoubtedly averages well over 65 percent (see Allan 1962, Crowther and Harper 1965, Kleiner 1966, and Harper 1981 for cover estimates for similar vegetations in northern Utah). Vegetative cover in subalpine meadow in the Uinta Mountains averages about 76 percent (Ostler et al. 1982). Finally, annual precipitation is more likely to fall below a level sufficient to support flowering of many species at Arches than in the mountain study areas. Frequent years of sparse or no flowering distributed at random through time should reduce the likelihood that insect pollinators can maintain large enough populations to pollinate all the flowers produced in years of adequate soil moisture. Wind-pollinated species should be favored in such situations provided individual plants are large enough to intercept a reliable flow of air, foliage cover is not so dense that it seriously interferes with pollen movement in the wind, and conspecific individuals are close enough together to insure that most stigmas will receive pollen. On all counts, the Arches area is better suited for wind pollination than the two mountain locations.

Flower Structure.— If reproduction of animal-pollinated species is to be successful, floral structure should encourage the likelihood of sequential visits by specific pollinators. When flowers of coexisting species compete for pollinators, species having flowers that mechanically exclude many kinds of pollinators should be able to conserve more nectar or pollen for adapted visitors than species whose flowers can be worked by any visitor. Thus visits by such adapted pollinators should be reinforced by more dependable nectar or pollen rewards, thus encouraging the pollinator to seek out other flowers of the same type. As a result, flowers with restricted access should be at a reproductive advantage in diverse assemblages of plants that flower simultaneously.

Ostler and Harper (1978) show that flowers that have restricted access to the nectar and/or pollen supply are positively correlated with the diversity of animal-pollinated species per unit area in the Wasatch Mountains of Utah and Idaho. Thus, one might be tempted to hypothesize that, because diversity is lower at Arches than in Utah mountains as noted above, one could expect an overrepresentation of open-structured flowers in the desert. The data show, however, that when all species are considered, the mountain floras have relatively more species with open flowers than the desert ($\Sigma X^2 = 19.11$, $P < 0.005$, Table 3E). Even among perennial species only, that pattern continues to hold ($\Sigma X^2 = 14.35$, $P < 0.005$, Table 3E).

The difference in flower structure among the floras of Arches, Bald Mountain, and Mt. Nebo may be attributable to differences in flowering phenology. Species must flower when moisture conditions are favorable. In the desert, moisture conditions for most species are apparently optimal in the spring, because it is at that time that most desert species flower. Accordingly, although there are fewer species per unit area in the desert, more species may actually flower simultaneously than in the mountain zone. Thus, at certain times, there may be greater competition among plant species for pollinating animals in the desert than in at least midelevation mountains.

In contrast to deserts, midelevation mountain communities have favorable moisture conditions throughout much of the growing season. It is therefore possible for coexisting species to partition the available time by flowering out of synchrony. Such out-of-phase flowering should decrease competition for pollinators and allow for more open flowers (Mosquin 1971). This argument probably does not hold at high elevations where growing seasons are short and flowering of all species is confined to that brief season. In such environments, simultaneous flowering of many species is undoubtedly commonplace. The profusion of open-flowered taxa in the subalpine meadows (Table 2) thus cannot be attributed to low flowering-plant diversity.

It has become clear in recent years that pollinating insect faunas are larger and more diverse in warmer and lower elevation environments than in cold and/or high elevation habitats (Arroyo et al. 1982, Warren et al. 1982). Hymenopteran insects especially appear to decline in colder and higher elevation communities, and Dipteran and Lepidopteran pollinators become relatively more important. It has long been recognized that Hymenopteran pollinators are the most efficient of all insects at manipulation of complex flowers (Faegri and Pijl 1971). It is thus possible that the observed predominance of open flowers in our mountain floras is related to changes in composition of the pollinator fauna along the altitudinal gradient. Open flowers may be favored when there is competition among flowers for an impoverished and less efficient guild of pollinating insects.

Flower Symmetry.— The native flora of Arches National Park consists of 88.7 percent radially symmetrical and 11.3 percent zygomorphic-flowered species. The Mt. Nebo flora includes 84.4 percent radial and 15.6 percent zygomorphic flowers. Finally, the Bald Mountain Flora consists of 83.7 percent radial and 16.3 percent zygomorphic flower (Table 2). Although differences between the three floras are not statistically significant ($\Sigma X^2 = 2.42$), there is a trend toward a greater number of zygomorphic flowers as elevation and diversity increases. Zygomorphic structure is believed to force insects to approach flowers in more stereotyped ways. Thus, in zygomorphic flowered taxa, mutations that result in loss of stamens and stigmas off the regular access route of the insect to the floral reward (nectar and/or pollen) could be accommodated without loss in fecundity. In harsh environments where carbohydrate gains are marginal, zygomorphy and the energy economy associated with reduced numbers of reproductive parts and lower pollen production could be expected to have selective advantages.

Flower Color.— Is there any difference in the distribution of colors among these floras? Ostler and Harper (1978) showed that floral color diversity was positively correlated with species diversity of the communities studied. Our data demonstrate that red and yellow flowers are overrepresented at Arches National Park (Table 3F), with the differences being statistically significant for both ($P <$ 0.05 or better). White flowers are significantly overrepresented at Mt. Nebo and Bald Mountain. White seems to be favored in moist and wooded environments (Ostler and Harper 1978, Del Moral and Standley 1979), whereas yellow flowers are consistently better represented in dry environments (Kevan 1972, Tikhomirov 1966, and Weevers 1951). The results for white flowers were expected in the Nebo flora (but not at Bald Mountain meadow), because white color had been shown to be more abundant in forest understories by both Ostler and Harper (1978) and Del Moral and Stanley (1979). The Mt. Nebo complex is largely dominated by forest or woodland communities, but there is only a minor amount of woodland at Arches National Park and Bald Mountain. Ostler and Harper (1978) speculated that white flowers reflected more light and were more easily found by pollinators in forest understories. Baker and Hurd (1968) noted that moths tend to replace bees as major pollinators in shaded habitats, and moths show a preference for white flowers. Finally, it is possible that the insect eye, like that of the human, is unable to perceive color at low light intensities (Proctor and Proctor 1978). Thus, the insect may react to flower color in shaded environments in terms of contrast alone rather than in terms of different hues per se.

The abundance of white flowers in the subalpine meadows cannot be explained by the foregoing argument. At this point, we can only hypothesize that the importance of white flowers and the diminished abundance of yellow-flowered species in high elevation meadows is somehow related to the cooler, more moist environment or to altered composition of the pollinating insect community (or both) at high elevations.

The proportionally greater number of red and, to a lesser extent, yellow flowers in the Arches flora seems attributable to the nearness of the park to areas of high diversity of hummingbird species in Arizona (up to nine species, see Crosswhite and Crosswhite 1981). Hummingbirds are believed to have been the selective force responsible for the evolution of many orange- and red-flowered species in the American Southwest (Crosswhite and Crosswhite 1981). At the mountain sites, such "hot"-colored species are relatively less common (Table 2). Only four species of hummingbirds occur in the Mt. Nebo area, and three hummingbird species occur infrequently at the high subalpine meadows considered here.

Conclusion

The results demonstrate that there are definite differences in the distribution of plant longevity, life form, mode of pollination, floral structure, and flower colors in the desert and mountain floras compared in this study. Annuals and shrubs are overrepresented in the Arches National Park flora, and zoophily is significantly more abundant in the mountain floras. Open-structured flowers are significantly overrepresented on the mountain floras. White flowers are most common in the mountain floras, whereas red and yellow flowers are best represented in the desert.

Acknowledgments

Sincere appreciation is extended to C. Davidson, Arthur Holmgren, and others who reviewed this manuscript and made valuable suggestions. This paper was funded in part by the U.S. Forest Service, Uinta National Forest, Provo, Utah.

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FLORA OF THE LOWER CRETACEOUS CEDAR MOUNTAIN FORMATION OF UTAH AND COLORADO, PART I. *PARAPHYLLANTHOXYLON UTAHENSE*

G. F. Thayne[1], W. D. Tidwell[2], and W. L. Stokes[3]

Abstract.— *Paraphyllanthoxylon utahense*, sp. nov., is described from the Cedar Mountain Formation and compared with similar fossil and modern woods. Fossil angiosperm woods from the Early Cretaceous are of great interest because very few have been reported from strata of this age. This species demonstrates that the angiosperms had developed many of their modern characteristics by Early Cretaceous time.

The Lower Cretaceous Cedar Mountain Formation is fossiliferous at several localities. Fossils reported from this formation include the wood of conifers, *Tempskya*, and cycadeoids, charophytes, pelecypods, gastropods, ostracods, and fish scales (Stokes 1952, Young 1960, Thayn et al. 1973, Tidwell et al. 1976), as well as dinosaur bones (Bodily 1969).

A species of dicotyledonous wood assigned to the genus *Paraphyllanthoxylon* Bailey 1924, is described in this report from the Cedar Mountain Formation. This is the first report of petrified dicotyledonous wood from the diverse flora in this formation. These angiosperm woods are of great interest in that very few Early Cretaceous angiosperm woods have been previously reported. Since the Cretaceous Period is the assumed time for the origin of the angiosperms, a taxonomic study of Early Cretaceous angiosperm wood is significant in that it expands our knowledge of the early members of this division. The petrified wood described in this study was collected from two localities. Locality 1 is 6 road miles (3.7 km) east of Castle Dale, Utah, and Locality 2 is 9 road miles (5.6 km) east of Ferron, Utah (Figs. 1, 5, 6, 7).

The Cedar Mountain Formation at Locality 1 is composed of brown to grey shales. It contains at least one horizon of nearly coalified material from which *Tempskya* has been collected in growth position (Tidwell and Hebbert 1976). The dicotyledonous woods studied here were collected from a horizon between 10 (3.1 m) and 30 (9.2 m) feet below the overlying Dakota Sandstone, which is represented by 10 (3.1 m) to 20 (6.2 m) feet of coarse brown sandstone that forms a cap rock in the area.

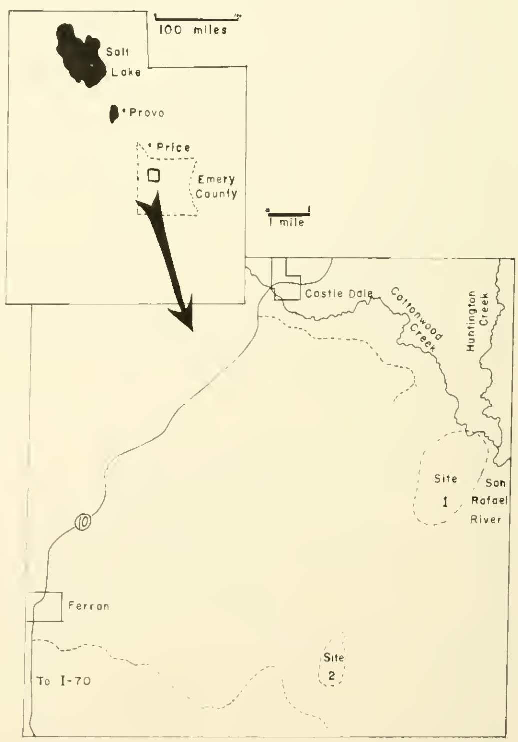

Fig. 1. Index map of collection sites.

[1]Bureau of Land Management, Salt Lake City, Utah 84112.
[2]Department of Botany and Range Science, Brigham Young University, Provo, Utah 84602.
[3]Department of Geology, University of Utah, Salt Lake City, Utah 84112.

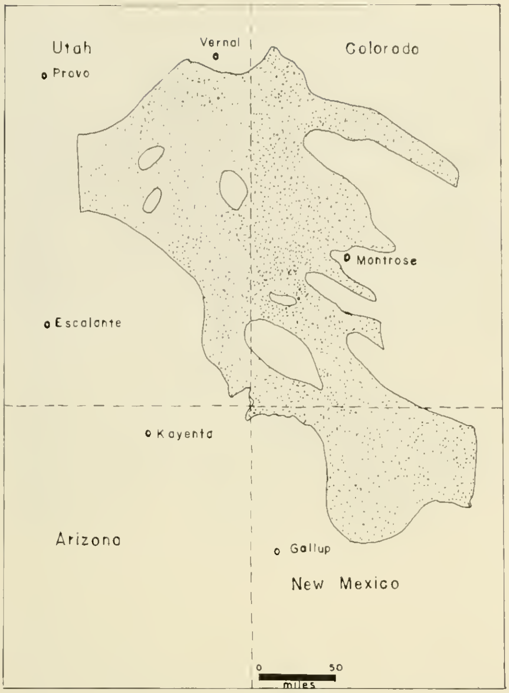

Fig. 2. Geographic extent of the Cedar Mountain Formation (after Young 1960).

Specimens were collected from seven different logs at Locality 2, where the Cedar Mountain Formation consists of a bed of coarse white sandstone underlaid by channel fills of yellow conglomeritic sandstones alternating with grey-green shales. These are, in turn, underlaid by a dark green nodular weathering shale (Figs. 5–7). The Dakota Sandstone is missing at this particular site, but reappears in the section about 3 miles (1.9 km) to the southeast. Dicotyledonous woods were found associated with *Tempskya* and fossil conifer wood at this locality.

Stratigraphy of the Cedar Mountain Formation

Stokes (1944) defined the Cedar Mountain Formation as those sediments lying between the Brushy Basin Member of the Upper Jurassic Morrison Formation and the Lower Cretaceous Dakota Formation. These strata were formerly considered part of the Morrison Formation. Cedar Mountain deposits are present over much of eastern Utah, western Colorado, and northwestern New Mexico

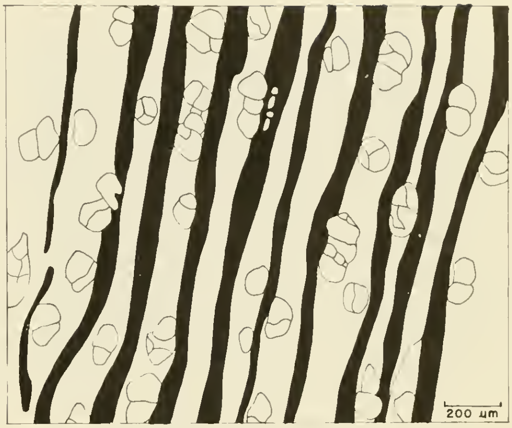

Fig. 3. *Paraphyllanthoxylon utahense*—Illustration of the transverse section showing the relative abundance of ray tissue (dark areas) and the size, shape, and arrangement of the vessel elements (open circles). Note the radial pore multiples.

(Fig. 2). Stokes (1952) defined two members of the formation, the Buckhorn Conglomerate at the base and the Cedar Mountain Shale at the top. At the type locality near Castle Dale, Utah, the Buckhorn Conglomerate is thick and massive, but it generally thins to the east and is absent on the eastern side of the San Rafael Swell. East of the Colorado River a mudstone and conglomeritic sandstone unit occupies the same

Fig. 4. *Paraphyllanthoxylon utahense*—Illustration of the tangential section showing the size, shape, and arrangement of the rays (dark lines) and a vessel element (center).

Fig. 5. Ferron collecting site, showing the lithology. A is white sandstone cap, B is the surface of the yellow conglomeritic channel fill from which the specimens were recovered, and C is the underlying grey-green shale.

relative position as the Cedar Mountain Formation on the west side of the river. These rocks were termed the "Post-McElmo" beds (Coffin 1921), but were later renamed the Burro Canyon Formation (Stokes and Phoenix 1948). Young (1960) proposed that the Burro Canyon Formation and the Cedar Mountain Formation are a physically continuous unit and should both be referred to as Cedar Mountain Formation.

Based on the presence of the pelecypods *Protoelliptio douglassi, Unio farri,* and the conifer *Frenelopsis varians,* as well as the stratigraphic position of the Cedar Mountain Formation, Young (1960) as well as Stokes (1952), suggested that it is Lower Cretaceous in age. Another indication of its age is the presence of *Tempskya,* which Read and Ash (1961) considered to be an index fossil to the Lower Cretaceous (Albian). Fisher et al. (1960) listed the formation as Aptian, but it may be only Albian or, most probably, may include rocks of both ages.

Fig. 6. Overview of the Ferron collecting site. Snow-capped mountains in the background are in the Wasatch Plateau. Dicotyledonous logs along with *Tempskya* were collected from the uppermost layer of sediment shown in the foreground.

Fig. 7. Petrified dicotyledonous wood shown as it is found weathered upon the surface of the Ferron site.

Paraphyllanthoxylon utahense sp. nov.
Figs. 3–4, 8–18

Description.— This species is described from several pieces of black petrified secondary wood. The preservation is excellent, and fine structural detail can be observed.

Growth rings: Lacking.

Vessels: Diffuse porous, approximately 12/mm², solitary or more commonly in radial rows (pore multiples) of 2–3 up to 5 cells long; individual vessels range from 204 μm radial by 165 μm tangential diameter to 58 μm radial by 48 μm tangential, average 105 μm radial by 93 μm tangential diameter; perforations exclusively simple, located on oblique end walls; thin-walled tyloses abundant, obscuring the vessel length; vessel walls 3 μm–5 μm thick; tangential pitting with numerous, often appressed, 6 μm–10 μm diameter; alternate bordered pits with slitlike apertures and occasionally up to 12 μm long, slightly bordered pits with large elliptic apertures probably representing the vessel to parenchyma pitting; radial intervascular pitting similar to tangential; vessel to ray intervascular pitting similar to tangential; vessel to ray pitting consisting of small circular or large, up to 24 μm, scalariform, elliptic to angular slightly bordered pits; 3–6, occasionally more, pits per crossover field.

Axial Parenchyma: Rare, apotracheal diffuse or scanty paratracheal.

Rays: 12/mm², heterogeneous with both uniseriate and multiseriate present; uniseriate

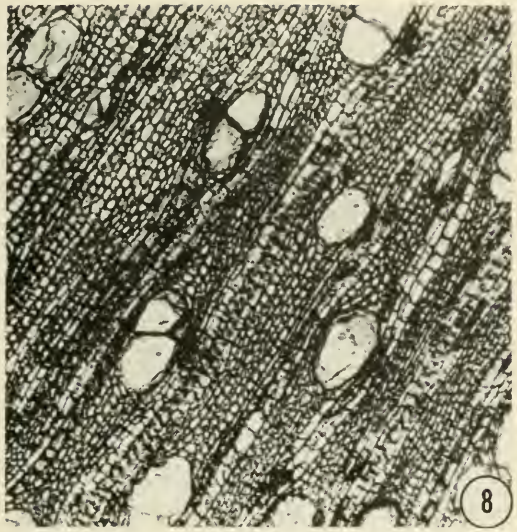

Fig. 8. Transverse section illustrating solitary vessels and vessel chains with tyloses. Note that the axial parenchyma is scarce (65X).

rays rare, many partially biseriate, with both procumbent and upright cells, uniseriate rays range from 2 cells (80 μm) to 6 cells (300 μm) high (average 5 cells, 200 μm–220 μm); multiseriate rays range from 9 cells (380 μm) to 33 cells (1360 μm) high and 2 cells (30 μm) to 5 cells (100 μm), wide with 106 rows (commonly 2) of upright border cells; procumbent cells range from 25 μm–40 μm vertical, 50 μm–80 μm radial, and 25 μm–45 μm tangential diameter; some cubodial cells present, approximately 40 μm in diameter; upright cells approximately same size as procumbent but radial and vertical dimensions reversed; ray cells' walls 2.5 μm thick, pitted and appearing beaded in radial section.

Fibretracheids: Septate, libriform, round to square in cross section, approximately 36 μm in diameter, with approximately 2.4 μm thick walls.

Repository: Brigham Young University, 2190 (Holotype)

Horizon: Cedar Mountain Formation

Age: Early Cretaceous

Discussion

Twelve species of *Paraphyllanthoxylon* have been described in the past. The features generally constant in all of these reported species are as follows:

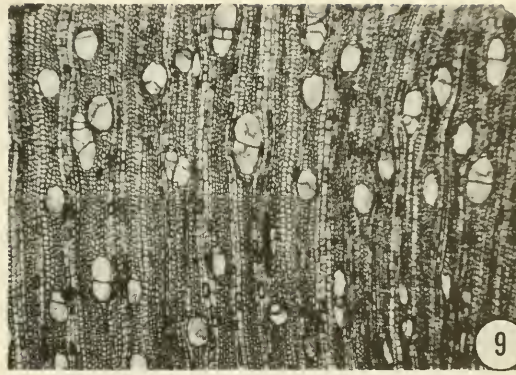

Fig. 9. Transverse section illustrating distribution of vessels and multiseriate rays (30X).

Diffuse porous wood; vessels in radial rows (pore multiples); exclusively simple perforations; alternate intervascular pitting; elongate vessel to ray pitting; rays of two sizes, 1–7 seriate, heterocellular with 107 rows of upright border cells, rays commonly over 1 mm high, axial parenchyma lacking or scanty apotracheal diffuse, scanty paratracheal, or combination of both; septate fibretracheids; vessels commonly with tyloses.

Paraphyllanthoxylon utahense fits well within the boundaries of this genus.

Comparison with Described North American Species

Three species of *Paraphyllanthoxylon* have been described from Cretaceous strata in North America.

Paraphyllanthoxylon arizonense Bailey 1924.—*Paraphyllanthoxylon utahense* differs from the upper Cretaceous *P. arizonense* in several ways. The most obvious variations are the size of the vessels and rays. Although Bailey (1924) gave no measurements and merely stated that the vessels of *P. arizonense* are large, it can be seen that the vessels shown in his figures at 35X are almost as large as those of *P. utahense* at 65X. Also, the rays shown at 35X in his figures are approx imately twice as high and wide and more parallel in outline than those of *P. utahense* at a comparable magnification. Another difference is that *P. arizonense* has slitlike pits on the fiber walls that *P. utahense* lacks. On the basis of these differences, the Utah specimens have been determined to be distinct from *P. arizonense.*

Paraphyllanthoxylon idahoense Spackman 1948.— *Paraphyllanthoxylon utahense* is closer to *P. idahoense,* which was reported

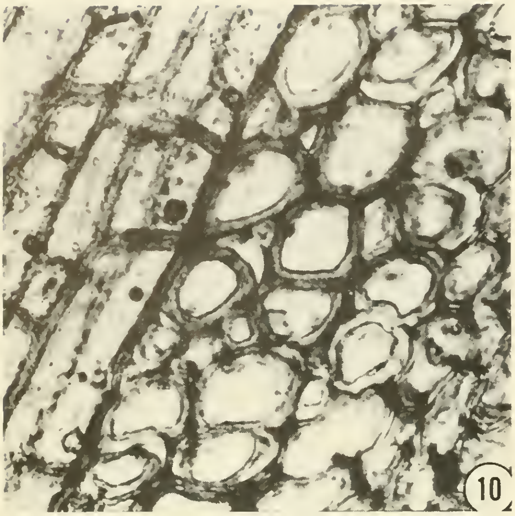

Fig. 10. Transverse section illustrating a closeup view of fibretracheids and a heterocellular multiseriate ray (495X).

Fig. 12. Radial section illustrating the relative size and distribution of the vessels and cells of the heterocellular rays (33X).

from the Lower Cretaceous Wayan Formation of Idaho, than to other *Paraphyllanthoxylon* species. The diameter of the vessels in *P. idahoense* is 60 μm–160 μm.

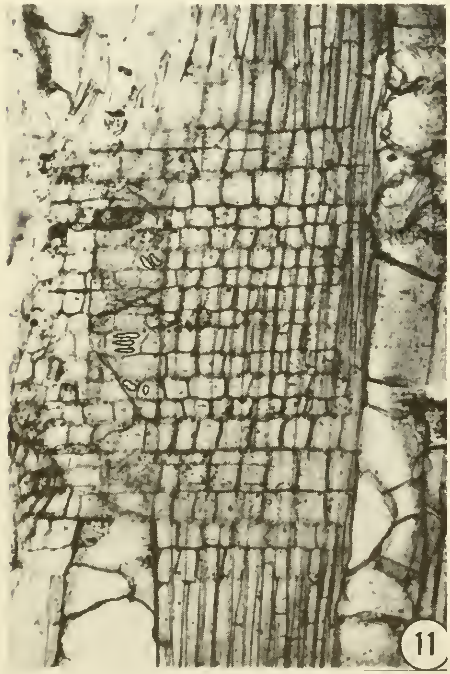

Fig. 11. Radial section with irregularly shaped vessel to ray cell crossover pits inked in. The beaded nature of the ray cell walls can also be seen (100X).

However, in comparing the holotype slides of this species with those of *P. utahense*, it can be seen that the vessels of the former are distinctly larger than those of the latter, which are 48 μm–165 μm in tangential diameter. The pitting is similar in both species, and the intervascular pits are also alternate, circular elliptical, and sometimes compacted and angular. The bordered pits of *P. idahoense* are 10 μm–12 μm in diameter, whereas, those in *P. utahense* vary from 6 μm to 10 μm in diameter. The major differences between these two species are the compaction of the vessels and the size of the rays. The number of vessels per square millimeter was not given for *P. idahoense*, but its vessels are more tightly compacted than those in *P. utahense*. The rays in *P. idahoense* are made up of smaller cells and are narrower than those of *P. utahense*, although both have multiseriate rays from two to five cells wide. Since *P. utahense* has smaller vessels that are fewer in number per square millimeter, and larger rays than *P. idahoense*, these two species are considered distinct from one another.

Paraphyllanthoxylon alabamense Cahoon 1972.– As described by Cahoon (1972) from the Upper Cretaceous Tuscaloosa Formation, this species has a wide range of variation, which can be seen by comparing Figures 5, 11, and 14 of her paper. These photos are all

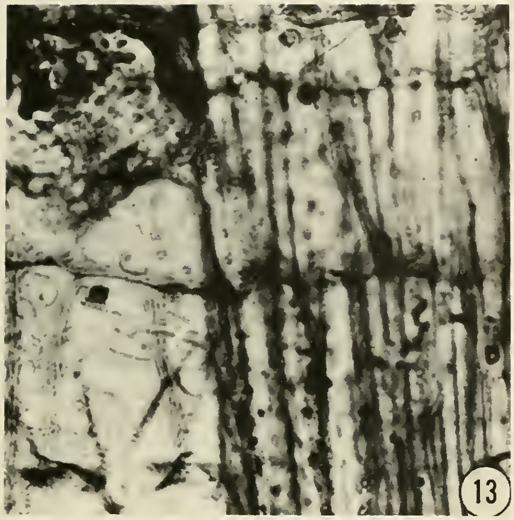

Fig. 13. Radial section illustrating the irregularly shaped, narrowly bordered vessel to parenchyma pits (495X).

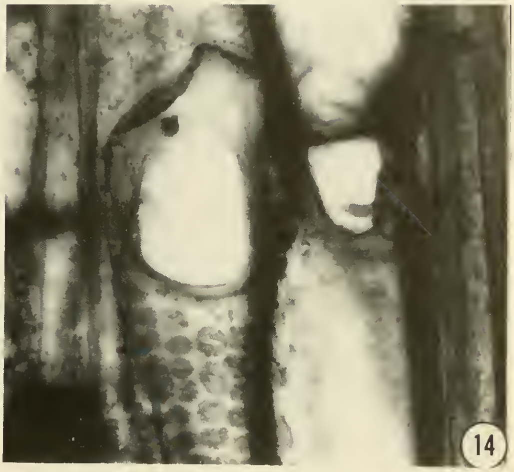

Fig. 14. Radial section illustrating oblique simple perforation plates and oppositely arranged bordered intervascular pits with slitlike apertures on the radial vessel wall (495X).

listed as being magnified 55X, but the rays in Figure 5 are approximately five times wider than those in Figure 14. She stated that this species was described from 11 different type specimens that are all similar but show some variation. The most obvious variation is in the size of the rays. Barghoorn (1941) has shown that such variation could conceivably be found within a species or even within the trunk of an individual tree, but, since paleobotanists are often restricted to working with fragments, they have traditionally described such fragments as form genera and hence form species. Spackman (1948) distinguished *P. idahoense* from *P. arizonense* because *P. idahoense* has smaller vessels, less abundant pitting, and smaller rays and ray cells. He stated that:

> The magnitude and nature of these variations are well within the range of variability found in individuals of many living species, and thus the differences in the two fossils might be accounted for on the basis of the part of the tree from which the specimen was derived, differences in growth rate, etc. In spite of this, however, it seems appropriate, because of these differences to describe this new wood as a new species with the hope that the true relationship of these two fossils will be demonstrated in the future. (Spackman, 1948, p. 108).

We agree with Spackman's reasoning, and therefore believe that *P. alabamense* as it now stands includes at least two or three form species. Therefore, *P. utahense* cannot be accurately compared to it at this time. The holotype specimen shown by Cahoon (1972) appears to differ from *P. utahense* by having larger rays. The other specimens reported by her appear similar to *P. utahense*, although one has larger rays and the other has smaller. Before any conclusions can be drawn as to the species boundaries and relationship between *P. utahense* and the Alabama specimens, more detailed measurements and comparisons need to be made.

Paraphyllanthoxylon pfefferi Platen 1908.— This species was collected from the Tertiary of California. It was originally described as *Carpinoxylon pfefferi* (Platen 1908), but was combined with *Paraphyllanthoxylon* by Madel (1962). *Paraphyllanthoxylon utahense* has larger vessels (up to 204 μm radial diameter as opposed to 137 μm radial diameter), which are fewer per square millimeter (12 compared to 44), and broader rays (100 μm compared to 50 μm) than *P. pfefferi*.

Comparison With Other Paraphyllanthoxylon Species.— Paraphyllanthoxylon utahense differs from species of *Paraphyllanthoxylon* described from geographical areas beyond the boundaries of North America (Table 1) in such features as the size and density of the vessels and dimensions of the

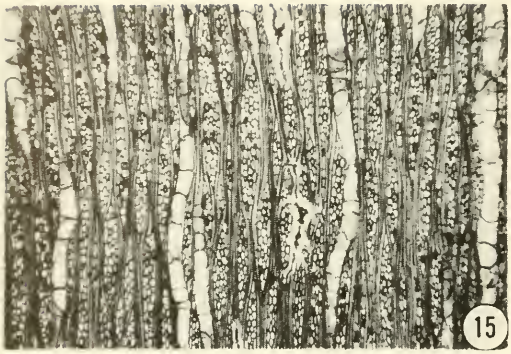

Fig. 15. Tangential section illustrating the relative size and distribution of multiseriate rays, fibretracheids, and vessels with tyloses (30X).

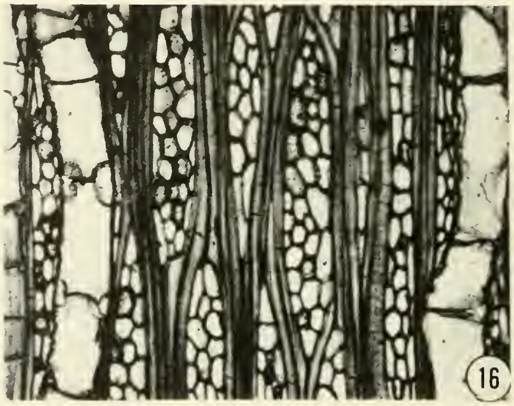

Fig. 16. Tangential section illustrating the heterocellular rays and septa in the fibretracheids (100X).

rays. *Paraphyllanthoxylon utahense* is most similar to *P. capense* but differs in having fewer vessels per square millimeter, and vessels that are larger and fewer per pore multiple.

Affinities of Paraphyllanthoxylon.— The original species, *Paraphyllanthoxylon arizonense*, was described by Bailey (1924) from silicified wood fragments of the Colorado Group in Arizona. He proposed the name to indicate a relationship to *Bridelia* and *Phyllanthus* in the section Phyllanthoidea of the Euphorbiaceae. Madel (1962) combined woods which had been described as *Phyllanthinium* and *Glochidioxylon* into the genus *Paraphyllanthoxylon* and reserved the genus for woods with general structure of the Glochidion wood group of the Euphorbiaceae. Other authors have compared their species to a number of genera in several other families.

Although *Paraphyllanthoxylon alabamense* may be an aggregation of species, further information concerning the affinities of the genus may be inferred by the leaf compressions that occur along with it in the Tuscaloosa sediments. Cahoon (1972) reported that of the families with wood similar to *Paraphyllanthoxylon* only the Sapindaceae, Euphorbiaceae, and Lauraceae are represented by fossil leaves from the Tuscaloosa.

Phylogenetic Considerations.— The processes of convergent and divergent evolution have obscured the genealogy of even modern genera and species. Pax and Hoffman (1931) considered the Euphorbiaceae to be polyphyletic in origin, making it unlikely that the Lower Cretaceous *Paraphyllanthoxylon* species are ancestral to the various groups within the family. The possibility does exist that they are ancestral to at least some members of the Glochidion group. Considering the large number of genera that are similar to the genus, *Paraphyllanthoxylon* could be related to the taxon from which several genera in many families originated.

By comparing the features of *Paraphyllanthoxylon* with Tippo's (1946) list of primitive and advanced wood characteristics (Table 2), it can be seen that the anatomy of the Lower Cretaceous members of the genus supports evidence from fossil leaf com-

TABLE 1. *Paraphyllanthoxylon* species from outside of North America.

Species	Author	Occurrence
pseudohobashiraishi	Ogura, 1932	Tertiary of Japan
sahnii	Prakash, 1958	Tertiary of India
tertiarum	Ramanujam, 1956	Tertiary of India
bangalamodense	Navale, 1960	Tertiary of India
keriense	Dayal, 1968	Tertiary of India
capense	Madel, 1962	Upper Cretaceous of S. Africa
yvardi	Koeniguer, 1967	Neogene of France
teldense	Prive, 1975	Oligocene of France

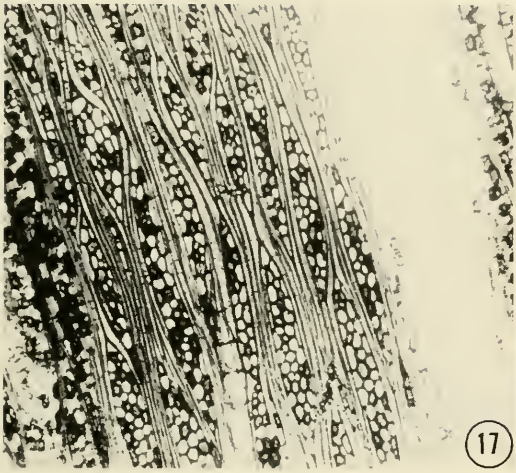

Fig. 17. Tangential section illustrating various sizes and shapes of rays and dark cell contents in many of the ray cells (50X).

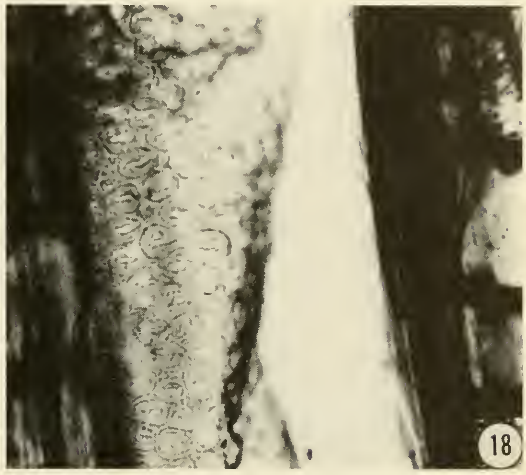

Fig. 18. Tangential section showing appressed, oppositely arranged, bordered pits with slitlike apertures on the tangential vessel wall (495X).

pressions that the angiosperms had developed many of their modern characteristics by Early Cretaceous times.

ACKNOWLEDGMENTS

The authors express appreciation to S. R. Rushforth, J. D. Brotherson, and J. Keith Rigby of Brigham Young University and S. R. Ash of the Department of Geology, Weber State College, Ogden, Utah, who graciously reviewed the manuscript. We also express appreciation to Naomi Hebbert who helped in preparation of the illustrations.

TABLE 2. Comparison with primitive and advanced features.

	Primitive							Advanced						
	Scalariform plates	Oblique end walls	Solitary pores	Diffuse wood parenchyma	Scalariform-transitional pitting	High heterogeneous rays	Nonstratified wood	Simple perforations	Transverse end walls	Pore aggregates	Aggregate wood parenchyma	Alternate pitting	Low heterogeneous or homogeneous rays	Stratified wood
Paraphyllanthoxylon		X[a]		X			X	X		X		X	X[b]	

[a](X) indicates that species of *Paraphyllanthoxylon* possesses that feature.
[b](X) has low heterogeneous rays.

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ACULEATA HYMENOPTERA OF SAND MOUNTAIN AND BLOW SAND MOUNTAINS, NEVADA

R. W. Rust[1], L. M. Hanks,[1,2], and R. C. Bechtel[3]

ABSTRACT.— There were 198 species of aculeata Hymenoptera in 15 families collected from Sand Mountain and Blow Sand Mountains, Nevada. Four species are considered new to science and none are considered endemic to either dune area.

Sand Mountain and Blow Sand Mountains were visited 19 times in a 13-month period for the purpose of surveying selected groups of arthropods. Here we report on the aculeate Hymenoptera collected during the study. Over 2,000 specimens were obtained, representing 198 species in 15 families. Four species are considered new to science and 21 species were identified as "species" in unstudied genera. Most of the unknown species were bees (Apoidea) in the genera *Perdita*, *Dialictus*, *Sphecodes*, and *Hesperapis*. None of the species is considered sand obligate or endemic to either dune.

Previous studies on Hymenoptera in Nevada include the faunistic inventory of the Nevada Test Site conducted by Brigham Young University from 1958 to 1966 that produced almost 8,000 adults and 1,100 immatures (Beck and Allred 1968). Of these, the ants (Cole 1966), mutillid wasps (Ferguson 1967, Allred 1973), tiphiid wasps (Wasbauer 1973), and bees (G. E. Bohart, pers. comm.) have been identified. Wheeler and Wheeler (1978) studied the mountain ants of Nevada and they have produced a manuscript on the ants of Nevada (to be published by Los Angeles County Museum). Pretruszka (1980) obtained almost 2,000 specimens, identified to family, from Fairview Valley, Nevada, from pitfall and malaise trapping.

Study Sites

Sand Mountain (SM) dunes and Blow Sand Mountains (BSM) dunes were sampled from June 1979 through July 1980. Sand Mountain is approximately 46 km ESE of Fallon, Churchill County, Nevada (39°20'N–118°20'W) and is about 1,250 m in elevation. Blow Sand Mountains are approximately 52 km SE of Fallon, Nevada (39°10'N–118°35'W) and are about 1,400 m in elevation. The dunes are separated by 25 km air distance. Sand Mountain is a star dune of approximately 3.2 km^2 and Blow Sand Mountains are complex star and linear dunes of approximately 9.2 km^2. However, both dunes result from the same eolian sand deposited during the Turupah and Fallon formations of about 4,000 years B.P. (Morrison and Frye 1965).

The floras of the two dunes were similar. The dominant vegetation was *Atriplex confertifolia* (Torr. & Frem.), *Tetradymia tetrameres* (Blake), *Chrysothamnus viscidiflorus* (Hookl), *Astragalus lentiginousus* Dougl., and *Psoralea lanceolata* (Pursh.), and at Sand Mountain only *Eriogonum kearneyi* Tidestr. and *Psorothamnus polyadenius* (Torr.). The common grass was *Oryzopsis hymenoides* (R. & S.).

Methods

Several collecting techniques were used to obtain specimens (see Bechtel et al. 1981). Permanent pitfall traps were 0.95 L plastic cartons. They were operative for 30-day periods. Temporary pitfall traps were 15 cm diameter cereal bowls placed level with the sand surface. Temporary pitfall traps were

[1]Biology Department, University of Nevada, Reno, Nevada 89557.
[2]Present address: Department of Entomology, University of Maryland, College Park, Maryland 20742.
[3]Nevada State Department of Agriculture, 350 Capitol Hill Avenue, Reno, Nevada 89502.

used for 12–18 hr during a survey period. Two UV light traps were operated from dusk to dawn. Hand-held UV lamps were used in searching the dunes for fluorescing arthropods. Sand was sifted through two screens 12 × 12 cm and 1.5 × 1.5 cm mesh to recover subsurface arthropods. General collecting involved the use of aerial nets, plant inspection, and walking the dunes at night with lamps to obtain specimens. During a survey period, four or five different sites on the dune were visited and the sites were varied each survey period.

Data are presented in the following manner: For each species its known geographic distribution, present location, numbers obtained, dates of occurrence, and, for the bees, their flower visitation as determined from pollen-load analysis (Hanks and Rust 1983). Once a genus and species of plant is given as a pollen source, subsequent references to it is by use of the first two letters of the genus and species, e.g. *Astraglus lentiginosus* is Asle. Geographic distributions were obtained from the Hymenoptera Catalog (Krombein and Hurd 1979) and are presented as North America (NA), western United States (WUS), southwestern United States (SWUS), Great Basin (GB), or by individual state. For the ants, Formicidae, the number given represents collections and not individual ants.

The following taxonomists identified the material being presented: R. C. Bechtel (Mutillidae), G. E. Bohart (Apoidea), R. M. Bohart (Chrysididae, Vespidae, Sphecidae), A. A. Grigarick (Megachilidae), L. Kimsey (Chrysididae), W. E. LaBerge (Apiodea), A. S. Menke (Sphecidae), F. D. Parker (Sphecidae), J. G. Rosen (Andrenidae), R. W. Rust (Apoidea), R. R. Snelling (Apiodea, Formicidae), R. W. Thorp (Andrenidae), M. S. Wasbauer (Tiphidae, Scoliidae, Pompilidae), and G. C. and J. Wheeler (Formicidae). All specimens, except new specimens, are in the collection of the University of Nevada, Reno.

Results

The most numerous species obtained was the California harvester ant, *Pogonomyrmex californicus* (Buckley), with 26 collections containing hundreds of specimens. One permanent pitfall trap contained over 500 individuals. It was present at both dunes from May through October. Two other ants were common at SM *Veromessor lariversi* M. R. Smith and *Conomyrma insana* (Buckley). *Glyptacros* new species and *Xeroglypta egregia* Mickel and Krombein were perhaps the most interesting wasps collected. They both have wingless females and were collected by sifting sand. Other wingless females obtained, mutillids, were found active on the surface or attracted to UV light traps. Next to the ants, the most numerous species were *Parnopes fulvicornis* Cameron (Chrysididae), *Paranistrocerus toltecus* (Saussure) (Vespidae), *Acanthetropis aequalis* (Fox) (Tiphiidae), *Sphaerophthalma* sp. (Mutillidae), *Microbembex argyropleura* Bohart and *Eucerceris nevadensis* (Dalla Torre) (Sphecidae), and *Agapostemon melliventris* Cresson and *Dialictus* sp. (Halictidae).

Chrysididae

Elampus nitidus Aaron (WUS) SM 3 Aug. Oct.

Holopyga hora Aaron (WUS) SM 1 May.

Hedychridium amabile Cockerell (WUS) SM 5 Aug. Sept.

Hedychridium arietinum Bohart (CA) SM 1 Sept., BSM 1 Sept.

Hedychridium mancopae Bohart (CA) SM 2 April May.

Hedychridium mirum Bohart (CA) SM 14 June July, BSM 1 June.

Hedychridium species (?) BSM 1 June.

Chrysis inflata Aaron (WUS) SM 1 Sept.

Spintharosoma trochilus (duBuysson) (WUS) SM 1 April.

Parnopes fulvicornis fulvicornis Cameron (WUS) SM 132 June July Aug. Sept.

Tiphiidae

Brachysistis lacustris lacustris Malloch (Mojave desert) SM 3 July Aug. Sept., BSM 9 July Aug.

Brachycistis triangularis Fox (SWUS) SM 4 June, BSM 10 June July.

Brachycistis agama (Dalla Torre) (NA) SM 12 July Aug. Sept., BSM 57 July Aug.

Brachycistis species (?) BSM 9 June.

Colocistis crassa (Bradley) (SWUS) BSM 3 June.

Acanthetropis aequalis (Fox) (WUS) SM 30 July Aug. Sept., BSM 31 July Aug. Sept.
Acanthetropis noctivaga (Bradley) (SWUS) SM 16 July Aug., BSM 6 July Aug.
Glyptacros new species (?) SM 5 Sept. Oct., BSM 16 June Aug. Sept.
Xeroglypta egregia Mickel and Krombein (SoCA) SM 1 Aug.

Mutillidae

Sphaeropthalma species (?) SM 57 June July Aug., BSM 26 June July Aug.
Dasymutilla gloriosa (Saussure) (SWUS) BSM 1 Aug.
Dasymutilla satanas Mickel (SWUS) SM 2 June July.

Scoliidae

Crioscolia alcione (Banks) (SWUS) SM 3 July Aug.

Formicidae

Pogonomyrmex californicus (Buckley) (SWUS) SM 26 May to Oct. BSM 14.
Veromessor lariversi M. R. Smith (WUS) SM 11 June July Aug. Sept., BSM 2 June Aug.
Crematogaster species (?) SM 1 Sept., BSM 1 Aug.
Conomyrma bicolor (W. M. Wheeler) (WUS) SM 2 July Aug.
Conomyrma insana (Buckley) (WUS) SM 15 June July Aug. Sept., BSM 2 Aug.
Camponotus vicinus Mayr (US) SM 5 Aug. Sept.
Myromecocystus kennedyi Cole (WUS) SM 4 Feb. Aug., BSM 2 Aug.
Myromecocystus pyramicus M. R. Smith (WUS) SM 3 Aug. Sept., BSM 2 Aug.
Myromecocystus new species (?) SM 4 April May.

Vespidae

Pterocheilus crispocornis Bohart (SWUS) SM 1 June, BSM 1 Aug.
Pterocheilus diversicolor Rohwer (SWUS) BSM 1 Aug.
Pterocheilus hurdi Bohart (CA) BSM 1 June.
Pterocheilus hirsutipennis Bohart (SWUS) SM 1 May.
Pterocheilus laticeps Cresson (WUS) BSM 1 June.
Pterocheilus tricoloratus Bohart (SWUS) BSM 1 June.
Leptochilus species (?) BSM 1 Aug.
Maricopodynerus maricoporum (Viereck) (SWUS) SM 4 April July.
Stenodynerus percampanulatus (Viereck) (WUS) SM 6 June July Aug. Sept., BSM 8 Aug. Sept.
Parancistrocerus toltecus (Saussure) (WUS) BSM 95 June July Aug. Sept.
Euodynerus annulatus sulphureus (Saussure) (WUS) SM 1 June.
Ancistrocerus acatskill halophila Viereck (WUS) SM 2 Oct.

Pompilidae

Pepsis pallidolimbata pallidolimbata Lucas (WUS) SM 2 Sept., BSM 1 Aug.
Hemipepsis ustulata ochroptera Stal. (SWUS) SM 1 June.
Aporus hirsutus (Banks) (WUS) BSM 2 June Aug.
Evagetes padrinus padrinus (Viereck) (WNA) BSM 9 June Aug. Sept.
Agenioideus biedermani (Banks) (SWUS) SM 1 Aug.
Episyron oregon Evans (WNA) SM 1 May, BSM 1 Aug.
Anoplius relativus (Fox) (NA) SM 5 June, BSM 10 June July Aug. Sept. Oct.
Anoplius tenebrosus (Cresson) (NA) SM 1 Sept.
Pompilus orophilus Evans (NA) SM 3 May, BSM 3 Aug.
Pompilus phoenix Evans (WUS) BSM 3 June.
Aporinellus borregoensis Evans (SWUS) SM 1 June.
Aporinellus fasciatus (Smith) (NA) SM 1 June, BSM 1 June.
Aporinellus medianus Banks (NA) SM 12 June July Aug. Sept.
Aporinellus taeniatus taeniatus (Kohl) (NA) Sm 1 Sept.
Aporinellus yucatanensis (Cameron) (NA) SM 1 Sept., BSM 1 June.

Sphecidae

Prionyx canadensis (Provancher) (NA) SM 1 June, BSM 6 June July Aug.

Prionyx subatratus Bohart (WUS) SM 1 Aug.
Podalonia communis (Cresson) (WUS) SM 12 June July, BSM 6 July.
Ammophila aberti Haldeman (WUS) SM 2 May June.
Ammophila polita Cresson (WUS) BSM 4 June.
Ammophila pruinosa Cresson (WUS) SM 2 May Sept.
Ammophila wrightii (Cresson) (WUS) BSM 1 June.
Mimesa coquilletti (Rohwer) (CA NV) SM 13 May Sept., BSM 2 June.
Astata bechteli Parker (SWUS) SM 3 June July Aug.
Astata occidentalis Cresson (WUS) BSM 9 June July Aug.
Larropsis washoensis Bohart and Bohart (NV) SM 3 May June, BSM 11 June July Aug.
Ancistromma granulosa (Bohart and Bohart) (WUS) SM 1 Aug., BSM 1 Aug.
Tachytes ermineus Banks (SWUS) SM 2 June.
Tachytes nevadensis Bohart (WUS) SM 3 Aug. Sept.
Tachytes new species SM 7 June.
Tachysphex apicalis fusus Fox (NA) BSM 3 June.
Tachysphex ashmeadii Fox (WUS) SM 7 Aug.
Tachysphex spinosus Fox (WUS) SM 1 June.
Tachysphex species (?) BSM 14 June.
Plenoculus boregensis Williams (SoCA) SM 1 June.
Pisonopsis species (?) SM 3 May June.
Miscophus species (?) SM 2 May June.
Oxybelus abdominalis Baker (WUS) SM 10 Aug. Sept., BSM 6 June.
Oxybelus pitanta Pate (SWUS) SM 12 Aug. Sept., BSM 2 June.
Crabro opalenscens Bohart (WUS) SM 2 May.
Bicyrtes ventralis (Say) (NA) SM 3 Aug.
Bicyrtes capnopteris (Handlirsch) (NA) SM 3 Aug.
Microbembex argyropleura Bohart (SWUS) SM 39 June July Aug. Sept., BSM 15 July Aug.
Microbembex californica Bohart (SWUS) SM 1 June, BSM 1 July.
Bembix rugosa Parker (AZ) SM 18 Aug.
Bembix stenobdoma Parker (AZ) SM 1 July.
Bembix occidentalis Fox (SWUS) SM 2 June.
Bembix americana comata Parker (SWUS) SM 2 Aug. Sept.
Stictiella corniculata Mickel (WUS) SM 3 Sept.
Stictiella nubilosa Gillaspy (SoCA) SM 2 June July.
Stictiella speciosa (Cresson) (WNA) SM 1 Sept.
Glenostictia argentata (Fox) (SoCA) SM 12 Aug.
Glenostictia megacera (Parker) (WUS) SM 1 Aug.
Glenostictia tenuicornis (Fox) (SWUS) SM 2 Aug.
Philanthus crotoniphilus Viereck and Cockerell (WUS) SM 19 Aug. Sept.
Philanthus multimaculatus Cameron (WNA) SM 13 Aug. Sept.
Philanthus pacificus pacificus Cresson (NA) SM 11 July Aug. Sept., BSM 1 June.
Philanthus pulcher Dall Torre (SWUS) SM 1 May.
Philanthus ventralis (Mickel) (PCS) SM 17 Sept.
Philanthus zebratus Cresson (WUS) SM 1 Sept.
Clypeadon evansi Bohart (SWUS) SM 4 July Aug.
Clypeadon laticinctus (Cresson) (WUS) SM 8 Aug.
Clypeadon utahensis (Baker) (SWUS) SM 7 Aug. Sept.
Clypeadon species (?) SM 1 July.
Cerceris bridwelli Scullen (SoCA AZ) SM 8 Aug.
Cerceris californica Cresson (WUS) SM 5 July Aug.
Cerceris conifrons Mickel (WNA) SM 4 Aug. Sept.
Cerceris crotonella Viereck and Cockerell (WUS) SM 5 June July Aug., BSM 1 June.
Cerceris echo echo Mickel (WUS) SM 3 July Aug. Sept.
Cerceris species (?) SM 1 Aug.
Eucerceris arenaria Scullen (SWUS) SM 9 Aug. Sept.
Eucerceris nevadensis (Dalla Torre) (WUS) SM 74 July Aug. Sept.

Colletidae

Colletes mandibularis Smith (EUS) SM 3 Sept., *Chrysothamnus viscidiflorus*.

Colletes slevini Cockerell (WUS) SM 4 June July Sept., Chvi, *Psorothamnus polydenius.*

Colletes stephani Timberlake (SoCA) SM 1 June.

Colletes species (?) SM 30 June Aug. Sept., BSM 4 June Sept., Chvi, *Eriogonum kearneyi*, Pspo, *Tetradymnia comosa.*

Andrenidae

Andrena (Diandrena) malacothricidis Thorp (SoCA) BSM 2 May, *Malacothrix sonchoides.*

Andrena (Onagrandrena) chylismiae Linsley and MacSwain (ECA) SM 15 April, BSM 2 May.

Andrena (Onagrandrena) linsleyi Timberlake (SWUS) SM 5 April.

Andrena (Thysandrena) vierecki Cockerell (GB) BSM 2 June, *Mentzelia albicaulis.*

Nomadopsis (Nomadopsis) puellae (Cockerell) (WUS) SM 7 May June, SM 32 May June, Maso.

Nomadopsis (Micronomadopsis) phaceliae Timberlake (ECA) SM 2 May, BSM 1 June, *Phacelia* sp.

Nomadopsis new species (?) BSM 35 June July, *Psorothamnus kingii.*

Perdita (Cockerellia) utahensis Cockerell (SWUS) SM 16 July Aug., *Helianthus deserticola.*

Perdita (Perdita) lepidosparti Timberlake (GB) SM 11 July Aug. Sept., *Cleome sparsifolia.*

Perdita (Perdita) hirticeps Timberlake (SWUS) SM 16 June July Aug., Chvi, BSM 5 July.

Perdita (Perdita) phymatae Cockerell (SWUS) SM 2 Sept., Chvi.

Perdita (Procockerellia) albonotata Timberlake (SoCA) SM 1 July.

Perdita species 1 (?) SM 84 Aug. Sept., Chvi.

Perdita species 2 (?) SM 1 Aug., Pspo.

Perdita species 3 (?) SM 51 July, *Tiguilia nuttallii.*

Perdita species 4 (?) SM 15 July Aug., Pspo.

Halictidae

Nomia (Acunomia) howardi Crawford (SWUS) SM 2 Aug., Erke.

Agapostemon femoratus Crawford (WNA) BSM 1 June, Clsp, *Sphaeralcea ambigua.*

Agapostemon melliventris Cresson (WUS) SM 73 June July Aug., BSM 2 Aug. Sept., *Atriplex* sp, *Amaranthus* sp, *Camissonia clavaeformis,* Chvi, Clsp, Hede, Erke, *Psoralea lanceolata* Pspo.

Lasioglossum sisymbrii (Cockerell) (WUS) SM 16 April June July Aug. Sept., *Astragalus lentiginosus,* Chvi.

Evylaeus aberrans (Crawford) (WUS) SM 9 May June July, BSM 2 May June.

Dialictus species 1 (?) BSM 5 April.

Dialictus species 2 (?) SM 78 April May June July Aug. Sept., BSM 37 July Aug. Sept., Chvi, Erke, Hede, Psla, *Stephanomeria exigua, Tetradymia tetrameres.*

Dialictus species 3 (?) SM 9 Aug. Sept., *Abrionia turbinata,* Asle, Chvi, Erke, *Penstemon acuminatus, Phacelia* sp.

Sphecodes species (?) SM 1 Sept.

Melittidae

Hesperapis species (?) SM 22 May, *Phacelia* sp, *Oenothera deltoides.*

Megachilidae

Anthidium rodecki Schwartz (CO NV) SM 15 May June July Aug., BSM 44 July Aug., Psla, Pski, Pspo.

Dianthidium subparvum Swenk (WNA) SM 4, *Chaenactis xantiana,* Chvi.

Anthidiellum notatum robertsoni (Cockerell) (WNA) SM 2 Aug., Psla.

Stelis species (?) BSM 1 June.

Proteriades (Holplitina) bullifacies (Michener) (ECA) SM 3 April May, BSM 5 May June, (Asle) *Phacelia.*

Anthocopa (Eremosmia) robustula (Cockerell) (SWUS) SM 4 April May, BSM 5 June, *Phacelia* sp.

Anthocopa (Eremosmia) timberlakei (Cockerell) (SoCA) SM 28 May June, BSM 15 May June, Asle, Cacl, Meal, Peac, *Phacelia* sp, Pski, Pspo.

Ashmeadiella (Ashmeadiella) aridula Cockerell (WUS) SM 5 Aug., BSM 3 Aug, Clsp, *Phacelia* sp, Psla, Pski, Pspo.

Ashmeadiella (*Ashmeadiella*) *bucconis denticulata* (Cresson) (WUS) SM 1 June, Pspo.

Osmia (*Nothosmia*) *titusi* Cockerell (SoCA) SM 2 April June, Asle, *Phacelia* sp, Pspo.

Megachile (*Derotropis*) *xerophila* Cockerell (SoCA AZ) SM 6 May, BSM 3 June, Chxa, Maso.

Coelioxys (*Coelioxys*) *mitchelli* Baker (SUS) SM 2 May.

Anthophoridae

Diadasia australis (Cresson) (WUS) BSM 12 June, *Opuntia pulchella*, *Mentzelia albicaulis*, Hede.

Diadasia vallicola Timberlake (AZ CA) SM 16 May.

Synhalonia albescens Timberlake (SWUS) SM 3 May.

Synhalonia primaveris Timberlake (SWUS) SM 30 April May, BSM 4 May June, Asle, Meal, Peac, *Phacelia*.

Synhalonia speciosa (Cresson) (WUS) SM 1 May.

Melissodes (*Eumelissodes*) *bimatris* LaBerge (WNA) BSM 2 Sept.

Melissodes (*Eumelissodes*) *lutulenta* LaBerge (WNA) SM 14 June, BSM 2 June July, *Chaetadelpha wheeleri*, Hede, Pspo, Spam, Teco.

Melissodes (*Eumelissodes*) *montana* Cresson (WUS) SM 39 Sept, BSM 1 Sept, Chvi, Erke.

Anthophora (*Anthophora*) *affabilis* Cresson (WUS) SM 31 April May, BSM 3 May, Asle, Cacl, Peac, *Phacelia*.

Anthophora (*Anthophora*) *porterae* Cockerell (WUS) SM 39 April May, BSB 9 May June, Asle, Peac.

Anthophora (*Anthophora*) *urbana* Cresson (WUS) SM 35 Aug. Sept., BSM 7 Aug. Chvi, Clsp, Erke, Stex.

Anthophora (*Micranthophora*) *hololeuca* Cockerell (SWUS) SM 18 June July Aug, BSM 38 June July Aug, Pski, Pspo.

Anthophora (*Micranthophora*) *petrophila* Cockerell (SWUS) SM 11 Aug. Sept., BSM 3 Aug, Chvi.

Centris (*Xerocentris*) *californica* Timberlake (CA AZ) SM 34 Aug. Sept., Clsp.

Ceratina (*Zadontomerus*) *neomexicana* Cockerell (SWUS) SM 10 May June July Aug., BSM 3 June July, Erke, Hede, Maso, Pspo, Stex, Teco.

Apidae

Apis mellifera Linnaeus (world wide) SM 7 April, Asel.

ACKNOWLEDGMENTS

We thank G. E. Bohart, R. M. Bohart, A. A. Grigarick, L. S. Kimsey, W. E. LaBerge, A. S. Menke, F. D. Parker, J. G. Rozen, R. R. Snelling, R. W. Thorp, M. S. Wasbauer, and G. C. and J. Wheeler for the identification of specimens used in this study. Dave Goicoechea, BLM State of Nevada, made the study possible.

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STATUS AND LIFE HISTORY NOTES ON THE NATIVE FISHES OF THE ALVORD BASIN, OREGON AND NEVADA

Jack E. Williams[1] and Carl E. Bond[2]

ABSTRACT.— Three fishes, two species of *Gila*, and an undescribed subspecies of cutthroat trout, are endemic to the Alvord Basin. Historically, the Alvord cutthroat trout, *Salmo clarki* ssp., inhabited the larger creeks of the basin but has been extirpated in pure form because of introgression with introduced rainbow trout, *Salmo gairdneri*. *Gila boraxobius* is restricted to the thermal waters of Borax Lake and its outflows in the northern part of the basin. This species is endangered because of alteration of its fragile habitat. The Alvord chub, *G. alvordensis*, is recorded from 16 localities throughout the basin, including springs, creeks, and reservoirs. Although *G. alvordensis* as a species is not in jeopardy, many populations are small and could be easily eliminated by habitat destruction or by the introduction of exotic fishes. Competition with exotic guppies, *Poecilia reticulata*, has extirpated the Thousand Creek Spring population of Alvord chubs.

Both species of *Gila* are opportunistic omnivores, consuming primarily chironomids, microcrustaceans, and diatoms. The Borax Lake chub also consumed large numbers of terrestrial insects, but specialized feeding on molluscs was noted in the West Spring population of Alvord chubs. Borax Lake chubs spawn throughout the year; however, most spawning occurs in early spring. Borax Lake chubs mature at a small size, occasionally less than 30 mm standard length, and seldom live more than one year. Alvord chubs are typically much larger than the Borax Lake species and live at least into their fifth year.

The Alvord Basin of southeastern Oregon and northwestern Nevada is an endorheic part of the Great Basin province. Aquatic habitats are sparse and consist primarily of Trout Creek in Oregon, the Virgin-Thousand Creek system in Nevada, as well as several small streams and springs (Fig. 1). During the late Pleistocene, a lake of over 1,200 km^2 covered much of the valley floor (Snyder et al. 1964). As pluvial waters dried, fishes were restricted to remaining permanent springs and creeks. Three native fishes are endemic to the Alvord Basin. Chubs, genus *Gila*, occupy many of the isolated waters in the Alvord Basin and have diverged into two species. The Alvord chub, *Gila alvordensis*, is the most common fish in the basin and occurs in a variety of springs and creeks. The Borax Lake chub, *G. boraxobius*, is restricted to Borax Lake and its outflows in Oregon. The Alvord cutthroat trout, *Salmo clarki* ssp., is the third fish native to the basin. Historic habitat for the Alvord cutthroat trout consisted of the larger streams in the basin, such as Trout and Virgin creeks. Another undescribed subspecies of cutthroat trout occurs in Willow and Whitehorse creeks just east of the Trout Creek Mountains in a separate basin. Although exhibiting affinities for the Alvord cutthroat trout, the subspecies found in Willow and Whitehorse creeks will not be treated further in this report.

Our knowledge of the native fishes of the Alvord Basin is limited. The monograph of Great Basin fishes by Hubbs and Miller (1948) provided the first detailed account of the Great Basin ichthyofauna and included a brief discussion of the native Alvord Basin fishes and their isolation. However, all the Alvord Basin fishes remained undescribed until 1972, when Hubbs and Miller (1972) diagnosed the Trout Creek population of *Gila* as *G. alvordensis*. Our studies have resulted in the description of *Gila boraxobius* (Williams and Bond 1980) and a further description of *G. alvordensis* with a taxonomic analysis of seven disjunct populations of the species (Williams 1980, Williams and Bond 1980). Characters of the Alvord cutthroat trout have been provided by Behnke (1979), but the subspecies remains undescribed. The only published life history information on Alvord

[1]Endangered Species Office, U.S. Fish and Wildlife Service, 1230 "N" Street, 14th Floor, Sacramento, California 95814.
[2]Department of Fisheries and Wildlife, Oregon State University, Corvallis, Oregon 97331.

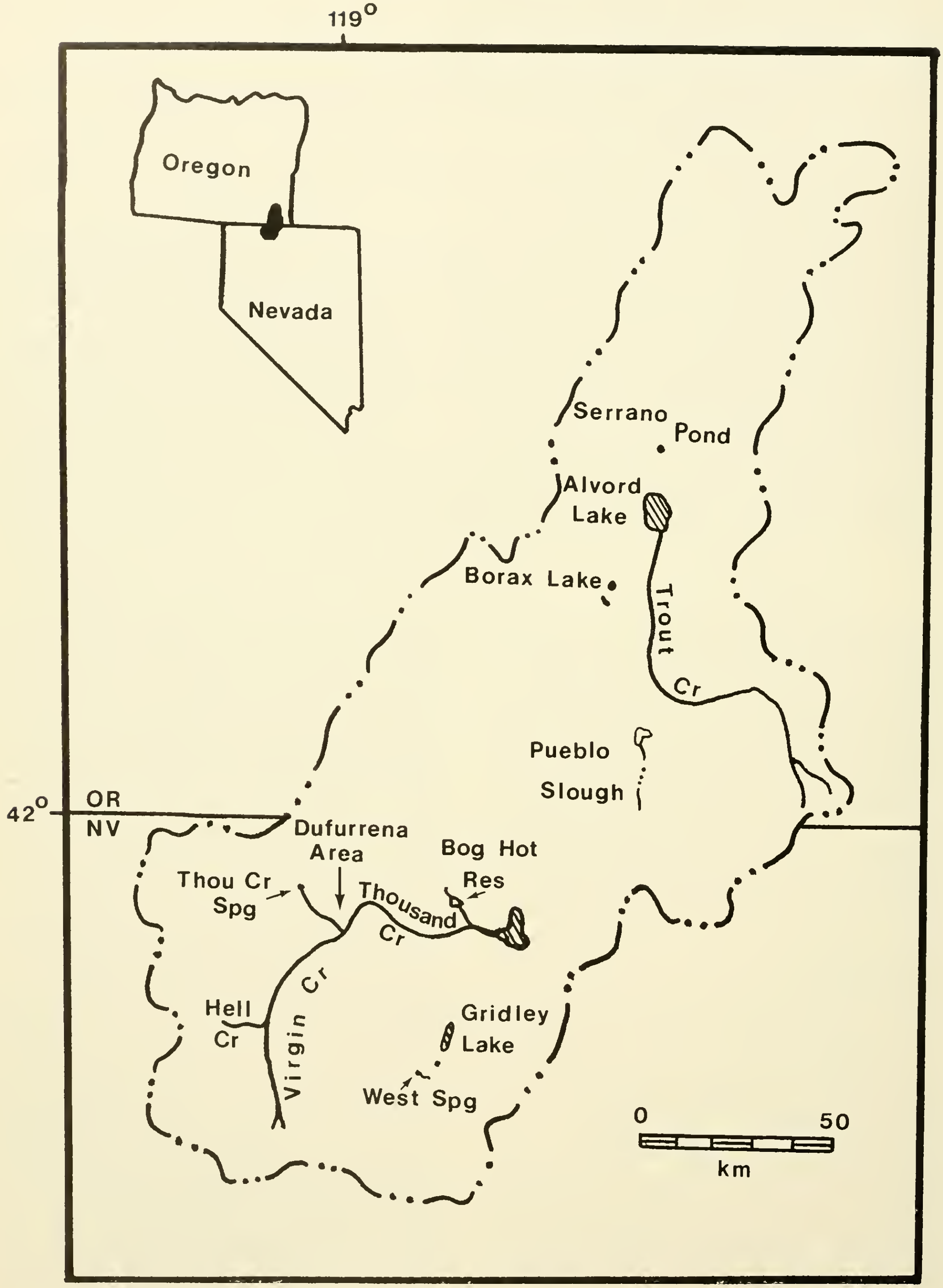

Fig. 1. Map of major aquatic habitats in the Alvord Basin, Oregon and Nevada.

Basin *Gila* consists of a study of feeding ecology by Williams and Williams (1980). This paper documents the distribution and status of the native fishes of the Alvord Basin and presents additional information on their life history.

Materials and Methods

The distribution and status of fishes was determined by field surveys, museum records, and testimony of local residents. Many of the habitats in the Oregon part of the basin were known prior to this work. On the other hand, the Nevada part of the basin had received little attention by ichthyologists, and therefore most of our survey efforts were focused in the southern one-half of the basin. Surveys were conducted from 12 June 1978 to 26 August 1979 and from 13 to 15 April 1982. Habitats were sampled with 3 m seines (9.5 mm mesh), dip nets, fish traps, backpack electroshocker, and 15 m gill nets (51 mm mesh). Fishes utilized in this study are deposited at Oregon State University (OS), The University of Michigan Museum of Zoology (UMMZ), Tulane University (TU), and the University of Nevada, Las Vegas (UNLV).

Information concerning reproduction, longevity, and adult sex ratio was determined for Borax Lake chubs collected monthly from March 1978 to January 1979. Fish were collected from the southwest one-quarter of Borax Lake. Specimens were preserved in 10 percent formalin and transferred to 45 percent isopropanol after one week. Standard length (SL) of specimens was measured to the nearest 0.1 mm with dial calipers. After blotting fish dry on paper towels, wet weight was measured to the nearest 0.01 g. A gonadosomatic index was calculated by weighing the left ovary or testis to the nearest 0.001 g, multiplying by two, thereby accounting for the right gonad, and dividing by fish weight. Three classes of ova were identified: class I—mature ova, yellow color, 0.7 to 1.2 mm diameter; class II—immature ova, opaque white color, 0.4 to 0.6 mm diameter; and class III—immature ova, transparent, 0.1 to 0.3 mm diameter. The number of ova was enumerated in females that possessed only class I and/or class II ova. By this method, accurate counts could be obtained and these numbers are probably more indicative of the actual number of eggs deposited during spawning. In females shorter than 35 mm SL, all ova were counted in both ovaries. In females 35 to 50 mm SL, all ova were counted in the left ovary, then multiplied by two to derive the total number of ova. Ova were enumerated in larger females by multiple subsamples of the ovary. Age was determined by examining annuli of scales taken from the left side of the body above the lateral line. Monthly collections were grouped into seasons as follows: spring (March–May), summer (June–August), fall (September–November), and winter (December–February).

Population Accounts

Alvord Cutthroat Trout, *Salmo clarki* ssp.

The Alvord cutthroat trout, *Salmo clarki* ssp., is now extinct in pure form. This native trout was known from Virgin Creek in Nevada and Trout Creek in Oregon, but probably existed in several of the larger Alvord Basin creeks during recent times (Hubbs and Miller 1948).

Trout Creek (Harney County, Oregon).—The Alvord cutthroat trout occurred in the headwater canyon area of Trout Creek, where it flows through the Trout Creek Mountains. Introgression of introduced rainbow trout, *Salmo gairdneri*, with the native cutthroat was already noticeable in 1934 collections of fish made in Trout Creek by Carl L. Hubbs, although trout from more headwater localities were quite similar in appearance to pure Alvord cutthroat trout (Behnke 1979). Cutthroat trout pigmentation was evident in many specimens collected by one of us (CEB) in 1953 and 1957, but none had basibranchial teeth. Trout collected from Trout Creek in 1972 (Behnke 1979) and 1978 to 1980 (our collections) exhibited only rainbow trout characteristics and we conclude that the native trout has been extirpated from this creek. Collections made from Cottonwood Creek and other streams draining the Trout Creek Mountains yielded only rainbow trout.

Virgin Creek (Humboldt County, Nevada).— Thirty small (<15 cm) Alvord cutthroat trout were collected from Virgin Creek in or near Virgin Creek Gorge by Carl L. Hubbs in 1934 (UMMZ 130532). Behnke (1979) considers these specimens to be pure native cutthroat trout and provides their description as follows: body with fewer than 50 relatively large round spots, spots concentrated posteriorly and above lateral line; few spots on caudal fin. Gill rakers 20 to 26. Lateral series scales 122 to 152. Scales above lateral line 33 to 37. Pelvic fin rays 8 or 9. Branchiostegal rays 8 or 9. Vertebrae 59 to 63. Trout collected in 1971 (OS 3832, OS 3834) from approximately the same region of Virgin Creek exhibited typical rainbow trout features (Behnke 1979). During 1978 surveys, we found only rainbow trout or introgressed trout in Virgin Creek at and upstream of the north end of Virgin Creek Gorge. No fish were found in Virgin Creek Gorge at the nexus of Hell and Virgin creeks. The upstream sections of Virgin Creek, in Virgin Creek Gorge near Alkali Ranch, also are fishless. Although we received reports of large trout from beaver ponds in Virgin Creek Gorge downstream of Wilson Ranch, none could be secured for examination. The large number of introduced rainbow trout in Virgin Creek Gorge would seem to preclude the survival of pure Alvord cutthroat trout in Virgin Creek. An extensive survey of Hell Creek, the only permanently flowing tributary of upper Virgin Creek, revealed only a single fish, which was typically rainbow in character. This individual was apparently able to ascend the falls separating Hell and Virgin creeks during a flood. The negative survey of Hell Creek in 1978 and 1979 causes us to consider the Alvord cutthroat trout to be extinct.

Borax Lake Chub, *Gila boraxobius*

The Borax Lake chub, *Gila boraxobius* Williams and Bond, is restricted to the thermal waters of Borax Lake and its outflows. *Gila boraxobius* was described in 1980 and is considered a dwarf relative of *G. alvordensis* (Williams and Bond 1980).

BORAX LAKE (T37S, R33E, Sec 14; Harney County, Oregon).— Borax Lake is a relatively shallow 4.1 ha natural lake that receives water from several thermal springs. These springs issue into the bottom of the southwest portion of the lake at approximately 35 to 40 C. Lake temperature is typically 29 to 32 C but can vary from 17 to 35 C depending on season, weather, and distance from the spring sources. The water is clear. Substrates range from rocky outcroppings in the southeast portion of the lake to gravels in the north and soft, easily roiled silt in the remainder of the lake. The lake shoreline consists of salt crusts, which have been deposited by the lake waters. These salt deposits have built up over hundreds or, more probably, thousands of years until the lake is now 10 m higher in elevation than the surrounding land. Historically, the lake waters overflowed along the south and southwest shoreline, creating a marsh. These outflows also provided water for Lower Borax Lake, a reservoir southwest of Borax Lake. Adjacent to Borax Lake are two small pools, one about 25 m southwest of Borax Lake and an artificial pool about 75 m west of the lake.

Borax Lake chubs occur throughout Borax Lake except in the hot spring inflows. Observations at Borax Lake indicated that Borax Lake chubs avoided water with a temperature above 34 C. These observations are supported by unsuccessful attempts to chase the chubs into hot spring inflow areas. In aquaria, Borax Lake chubs lost equilibrium when water temperature was raised to 34.5 C, indicating a critical thermal maximum near this temperature. Borax Lake chubs also occurred in small numbers in the two small pools near Borax Lake. The pools are apparently formed from Borax Lake overflow waters.

The Borax Lake chub is a dwarf species that typically reaches maturity at 30 to 35 mm SL. Males as small as 28.6 mm SL are highly tuberculate and females as small as 31.8 mm SL have been found with mature eggs. Typical adult size is 33 to 45 mm SL. The largest male collected from Borax Lake was 50.6 mm SL, whereas two exceptionally large females, 90.4 and 93.0 mm SL, have been collected from Borax Lake.

Most spawning probably occurs in early spring, although some spawning can occur year around. The gonadosomatic index was highest in females during March and April, with mature, class 1 ova present during March, April, and January (Table 1). Ovaries were usually poorly developed during May through August. In males, the gonadosomatic index was highest in April and September, when testes averaged 0.97 and 1.11 percent body weight, respectively. A search of museum specimens disclosed large females with mature ova collected on 17 June (OS 4137) and 11 September (OS 4106). Thus, spawning may occur at any time of the year. However, a major spawning in early spring is supported by observation of numerous larval chubs during April, May, and early June. Young fish, eight to 15 mm SL, typically inhabit the shallow cove areas along the west and south margins of Borax Lake. Water is cool, only a few cm deep, and vegetation is common in the coves.

Ova number increases dramatically with fish length. The number of ova was determined in eight females 32.7 to 93.0 mm SL, that contained only class I and/or class II ova. The smallest females examined, 32.7 and 34.5 mm SL, contained 75 and 82 ova, respectively. Larger females, 39.0, 39.3, 44.6, and 49.4 mm SL contained 252, 246, 380, and 362 ova, respectively. The exceptionally large females, 90.4 and 93.0 mm SL contained 2,143 and 6,924 ova, respectively. Although females larger than 60 mm SL are very rare in Borax Lake, their contribution to recruitment may be substantial.

Most Borax Lake chubs live one year, with few age I and II fish present. Annuli development, although difficult to discern, indicated that the 90.4 and 93.0 mm SL females were probably age III. This appears to be the maximum age achieved by chubs in Borax Lake. A length frequency analysis of 113 individuals collected 5 August 1977 appears in Figure 2. Because most spawning occurs in spring, with young of approximately 10 mm SL prominent in May and June, most fish in the August collection are probably young-of-the-year. Some age I fish, 33 mm to 51 mm SL are present, whereas the two larger individuals are probably age II (Fig. 2). Most older fish are females. Adults (>33 mm SL) typically comprised less than 25 percent of specimens collected during March, April, and May. The percentage of adults in monthly collections then increased until reaching a peak of 82 percent during November.

Based on monthly collections made throughout the year, the sex ratio of 190 individuals greater than or equal to 30 mm SL was 1.0 ♂ :1.3 ♀ . Seasonally, the sex ratio was as follows: spring (n = 23) 1.0 ♂ :1.3 ♀ , summer (n = 67) 1.0 ♂ :1.9 ♀ , fall (n = 50) 1.0 ♂ :1.1 ♀ , and winter (n = 50) 1 ♂ :1 ♀ . The larger number of females may be indicative of higher survivorship following spawning.

The feeding ecology of Borax Lake chubs has been reported by Williams and Williams (1980). The relative importance of foods varied seasonally, but diatoms, microcrustaceans, and chironomid larvae were often the primary foods consumed. Terrestrial insects were important foods during summer and fall (Williams and Williams 1980).

LOWER BORAX LAKE (T37S, R33E, Sec 15; Harney County, Oregon).— Lower Borax Lake is a reservoir that receives water from the southwest outflow creek of Borax Lake. Water levels of Lower Borax Lake fluctuated seasonally, often holding little water during summer. Unfortunately, alteration to Borax Lake during 1979 diverted water away from the reservoir. Prior to the diversions, the reservoir occasionally harbored Borax Lake chubs that entered from the southwest outflow creek. It is doubtful that Borax Lake chubs ever spawned in Lower Borax Lake and the population was probably dependent on an influx of fish from Borax Lake via the outflow creek.

TABLE 1. Monthly reproductive characteristics of female Borax Lake chubs longer than 30 mm SL.

Month	n	x̄ SL	Gonadosomatic index Range	x̄	SD	Classes of ova present
March	3	38.0	0.91–5.01	2.89	2.05	I,II,III
April	5	33.1	0.78–10.56	3.45	4.13	I,II,III
May	4	34.8	0.45–0.55	0.51	0.05	III only
June	7	35.9	0.53–2.38	1.01	0.66	II,III
July	8	44.0	0.50–1.54	1.06	0.37	III only
August	8	37.4	0.16–1.60	0.95	0.41	II,III
September	5	38.3	0.70–4.56	2.48	1.61	II,III
November	5	39.3	1.28–2.13	1.61	0.34	II,III
December	8	42.5	1.20–4.45	2.02	1.03	II,III
January	7	41.4	0.99–2.27	1.59	0.48	I,II,III

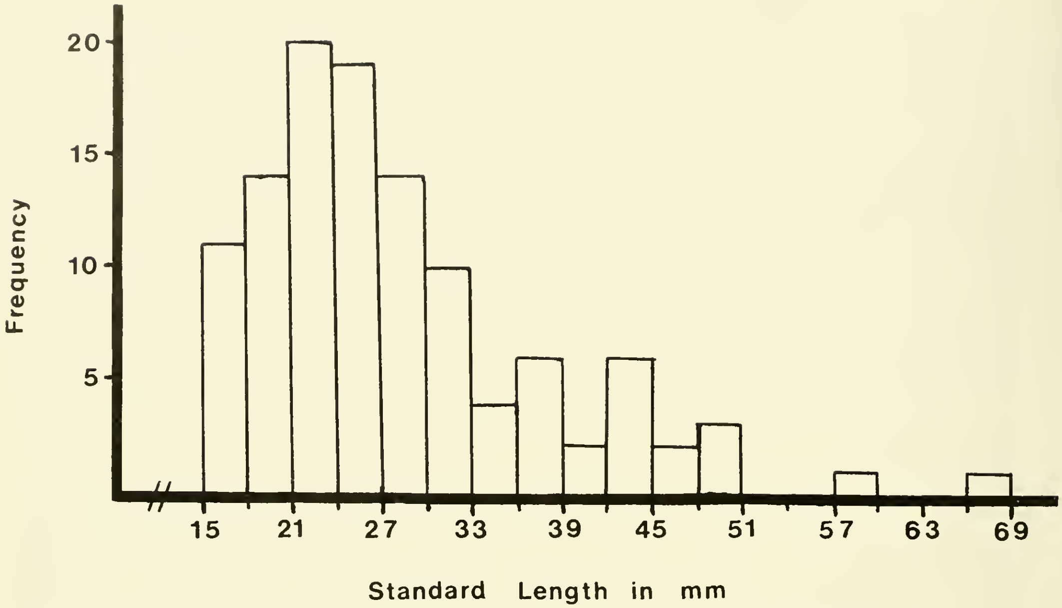

Fig. 2. Length frequency of 113 Borax Lake chubs, *Gila boraxobius*, collected 5 August 1977 from Borax Lake, Oregon.

Alvord Chub, *Gila alvordensis*

The Alvord chub, *Gila alvordensis* Hubbs and Miller, was found in 16 habitats located throughout much of the basin in Oregon and Nevada. The species was collected from a variety of habitats, including springs, creeks, and reservoirs. The species has been collected from Juniper Lake, Oregon (Bond 1974), although its presence appears attributable to an introduction because the lake dries during drought years.

Serrano Pond (T36S, R33E, Sec 1; Harney County, Oregon).— Serrano Pond is a 0.1 ha reservoir that receives water from a coolwater spring approximately 60 m distant. Water flows from the spring at approximately 17 C and water temperature in the pond is typically 16 to 21 C during the summer. The substrate of the relatively shallow pond is primarily silt. The water is somewhat turbid and aquatic vegetation is abundant. Recent alteration to this area has resulted in a diversion canal draining part of the flow away from the pond. Alvord chubs are absent from the spring, but are abundant in remaining waters of the pond and in the diversion creek. More than 100 fish can be easily collected from the pond in a single seine haul during the summer. Adult males are typically about 50 mm SL and adult females average approximately 65 mm SL, but females greater than 80 mm SL are occasionally collected.

Alvord chubs from Serrano Pond are highly opportunistic feeders. Bottom invertebrates are grazed extensively, as are midwater crustaceans and diatoms. Very few foods are consumed from the water's surface. Chironomid larvae, diatoms and cladocerans were the principal foods during summer, and ostracods, harpacticoid copepods, and chironomid pupae were of secondary importance (Williams and Williams 1980). Eighty-nine percent of the intestines examined by Williams and Williams (1980) contained one food that accounted for more than 50 percent of intestinal volume. Thirty-nine percent of the intestines contained one food, chironomid larvae, diatoms, or cladocerans, almost exclusively.

Trout Creek and Alvord Lake (Harney County, Oregon).— Trout Creek is the largest stream in the Alvord Basin and discharges an average of 15 cfs, as measured in the canyon area 8 km east of Trout Creek Ranch (Libbey 1960). The creek heads in Trout Creek Mountains just north of the Nevada border. In the headwaters, Trout Creek flows through canyon areas where its waters are clear and fast-flowing. Water temperature in the canyon is cool during summer, near 15 C, and colder during winter months. As Trout Creek leaves the canyon and enters the valley floor, flows decrease and water temperatures increase. Naturally lower summer flows and irrigation diversions often reduce the lower portions of Trout Creek to an intermittent stream during late summer. Turbidity is often high (visibility 1 cm) in lower reaches during summer. Substrate type changes from mostly gravel in upstream areas to silt in downstream sections. Trout Creek eventually empties into Alvord Lake, a remnant of the large lake that covered the valley during pluvial times. Alvord Lake varies greatly in size and occasionally dries completely during drought years.

Alvord chubs are common, although not abundant, in upstream canyon areas, and abundant in downstream sections. Introduced rainbow trout, *Salmo gairdneri*, also occur in upstream regions of Trout Creek. This is the only habitat where *Gila* occur sympatrically with another fish in the Alvord Basin. Alvord chubs in the canyon area are large, the longest measuring 122 mm SL. Three specimens 113 to 122 mm SL are all age class IV. Downstream areas also produce large Alvord chubs, although maximum length appears somewhat less. Color differences between Alvord chubs in the canyon and downstream areas are striking. Alvord chubs from the canyon are very dark, nearly black, dorsally, with golden sides possessing some black speckles, and a silver belly. In sections of Trout Creek in the valley floor, Alvord chubs are lighter in color, exhibiting a light green color on the dorsal part of the head and body, silver sides without speckles, and a white belly. All fins of *Gila* from Trout Creek are translucent red or orange in color except at the tips, which are white.

Pueblo Slough (T40S, R35E and T41S, R35E; Harney County, Oregon).— Pueblo (=Denio) Slough is a wetland area approximately 13 km long, extending from Tum Tum Lake in the north to just north of the Nevada border in the south. Various marsh, spring, and creek areas south of Tum Tum Lake provide most of the habitat in the slough. Water in Pueblo Slough is provided by Van Horn and Colony creeks, which drain the Pueblo Mountains, as well as at least 25 springs in the slough itself. These springs are mostly cool and shallow. Red Point School (T40S, R35E, Sec 14) is located in approximately the center of the slough. In August, Alvord chubs were collected from a shallow, clear pool at Red Point School where water and air temperatures were 15 and 17 C, respectively. Alvord chubs were abundant in the pool. Despite searches for chubs in streams draining the Pueblo Mountains, none could be found—although small rainbow trout were collected in lower Van Horn Creek.

Bog Hot Reservoir (T46N, R28E, Sec 17; Humboldt County, Nevada).— Bog Hot Reservoir is a relatively small impoundment fed by thermal waters flowing from Bog Hot Springs. Water issues from Bog Hot Springs at approximately 44 C and flows for 1.2 km before entering Bog Hot Reservoir. Water from Bog Hot Springs enters the reservoir at about 30 C. Typical water temperatures in the reservoir are 20 to 21 C during early summer. The waters of Bog Hot Reservoir are slightly turbid (visibility 31 cm), and the substrate is mostly silt with some gravel. Alvord chubs are abundant in Bog Hot Reservoir but are absent in Bog Hot Springs and in practically all the inflow creek between the springs and the reservoir. No Alvord chubs were found upstream of the 31.1 C boundary, where water from the inflow creek enters Bog Hot Reservoir.

Alvord chubs collected from Bog Hot Reservoir on 13 June 1978 were in spawning condition. On that date, water and air temperatures were 20.4 and 20.7 C, respectively. The fish were collected from open, slightly turbid water, 30 to 40 cm deep. Young-of-the-year fish 10 to 15 mm SL were abundant in the reservoir during June 1978, indicating a spawning season from at least April until July. Most young were observed in the shallow northwest end of the reservoir near the warm inflow creek.

Bog Hot Creek (T46N, R28E; Humboldt County, Nevada).— Bog Hot Creek flows for approximately 5.2 km below Bog Hot Reservoir before entering Thousand Creek. Parts of Bog Hot Creek below the reservoir have been diverted or otherwise modified by agricultural practices. Alvord chubs were not collected in Bog Hot Creek except in the lower reaches near Thousand Creek. One poeciliid, probably a guppy, was observed in the highly modified section of the creek about halfway between the reservoir and Thousand Creek. In the downstream part of Bog Hot Creek, Alvord chubs were rare to common during an April 1982 survey and occurred primarily in pools 20 to 46 cm in depth. Water and air temperatures on 15 April 1982 were 2.3 C and 1.5 C, respectively. The water was clear, but appeared brown and quite acidic.

Unnamed spring (T46N, R26E, Sec 31; Humboldt County, Nevada).— This spring, measuring 2.4 m wide and 5 m long at its maximum extent, is by far the smallest habitat supporting fish in the Alvord Basin. Maximum depth is 77 cm. The water is clear and the substrate is an easily roiled silt. Water temperature was 11.4 C (air 7.5 C) during April and 18.2 C (air 20.4 C) during June. The unnamed spring is well isolated from nearby Thousand Creek by approximately 100 m of greasewood flat. The closest waters of Thousand Creek do not support Alvord chubs. The nearest population occurs approximately 1 km away in Dufurrena Pond 19.

A very small population of Alvord chubs, estimated at slightly less than 100 individuals, inhabits the spring. Many seine hauls, each encompassing the entire spring, yielded 52 fish during an April 1982 survey. The Alvord chubs ranged in size from 32 mm SL to, considering the small size of the habitat, an amazingly large 87 mm SL individual. No juveniles were seen during April, but young-of-the-year were observed on 14 June, when water temperature had risen to 18.2 C. Juveniles occurred among rushes, *Juncus* sp., in water only a few cm deep. Adults were occasionally observed darting across the open center of the spring, but spent most of the daylight hours under a narrow band of floating algal mats along the periphery of the spring.

Thousand Creek Spring (T46N, R26E, Sec 31; Humboldt County, Nevada).— Thousand Creek Spring forms the headwaters of Thousand Creek. The clear spring waters achieve a maximum depth of approximately 31 cm. Substrates are mostly fine gravels with some silt. Water and air temperatures during June were 27.1 and 18.2 C, respectively. Currently, the spring is inhabited by swarms of exotic guppies, *Poecilia reticulata*. Guppies have become established here and in the spring pool at nearby Dufurrena Campground. Competition from introduced guppies probably extirpated Alvord chubs from Thousand Creek Spring. Alvord chubs have not been recorded from Thousand Creek Spring, but their historic presence is indicated by the occurrence of Alvord chubs in downstream areas of Thousand Creek and in a nearby spring. Except for the presence of guppies, Thousand Creek Spring appears to provide a suitable habitat for Alvord chubs.

Thousand Creek and Continental Lake (Humboldt County, Nevada).— Thousand Creek heads at Thousand Creek Spring, flows through the Dufurrena area, where it receives Virgin Creek, and then enters Thousand Creek Gorge. Below the gorge, Thousand Creek becomes braided and receives water from Bog Hot Creek before eventually emptying into Continental Lake. In the Dufurrena area, Thousand Creek is dammed at several locations to create reservoirs. Thousand Creek is usually turbid (visibility 7 cm), shallow, and about 1 to 2 m wide. The substrate is mostly silt. In Thousand Creek Gorge, the creek is surprisingly deep (>300 cm) and cool, near 15 C during late summer. Below the gorge, Thousand Creek is often intermittent during summer, when water temperatures can reach 27 C. Typical summer and fall water temperature is 16 to 18 C. Alvord chubs are abundant in Thousand Creek except in some upstream areas where guppies have been introduced or habitat has been altered by reservoir construction. Guppies are abundant in Thousand Creek Spring and occur sporadically in Thousand Creek between Thousand Creek Spring and Dufurrena Pond 19. None were found downstream of Dufurrena Pond 19. Thousand Creek contains many large Alvord chubs; the largest measured 104.9 mm SL. During summer, Alvord chubs concentrate in deep pools in downstream areas of Thousand Creek. Continental Lake usually dries completely during summer, but harbors Alvord chubs during winter months.

The sex ratio of 23 adults greater than 35 mm SL was 1.1 ♂:1.0 ♀. Food habits of Alvord chubs collected during June from Thousand Creek were reported by Williams and Williams (1980). They found 10 foods in the intestines, of which chironomid larvae, cladocerans, copepods, and ostracods were of greatest importance. Chironomid larvae occurred in all intestines examined and accounted for approximately 26 percent mean volume (Williams and Williams 1980). Microcrustaceans comprised almost 45 percent mean volume of intestines, whereas diatoms accounted for only 5 percent mean volume. No terrestrial insects were observed in the intestines. Alvord chubs in Thousand Creek appear to feed primarily on bottom invertebrates and midwater crustaceans, avoiding surface foods.

Dufurrena Pond 19 (T46N, R26E, Sec 32; Humboldt County, Nevada).— Dufurrena Pond 19, approximately 1 km downstream of Thousand Creek Spring, is the first reservoir on Thousand Creek. The reservoir is shallow (typically < 50 cm) and moderately turbid (visibility 14 cm). Alvord chubs occur in the reservoir but are not abundant. Young-of-the-year (<20 mm SL) were abundant during June in the inflow diversion creek feeding the reservoir. At this time, the inflow creek was shallow (< 8 cm) and clear, with water and air temperatures of 14.5 and 13.0 C, respectively.

Dufurrena Pond 22 (T45N, R26E, Sec 2; Humboldt County, Nevada).— Dufurrena Pond 22 is a reservoir fed by waters of Thousand and Virgin creeks. The water is very turbid (visibility 2 cm) and shallow (typically 15 to 20 cm deep). Water level fluctuates greatly with season. During late summer, the reservoir is reduced to a small pool. Water and air temperatures during June were 17.6 and 13.2 C, respectively. Alvord chubs are abundant and achieve a large size in the reservoir.

Virgin Creek (Humboldt County, Nevada).— Virgin Creek heads near the southern extent of the Alvord Basin, flows north through the more than 300-m-deep Virgin Creek Gorge, and then flows east until reaching Thousand Creek. Springs scattered along most of the length of Virgin Creek provide its flow. Alvord chubs are abundant in Virgin Creek from the north end of Virgin Creek Gorge to the nexus of Virgin and Thousand creeks. Alvord chubs are absent in Virgin Creek Gorge, where introduced rainbow trout are common. Virgin Creek below the gorge is cool, relatively shallow, and moderately turbid (visibility 10 cm). Below the gorge, water temperature is typically 15 to 18 C during summer months and maximum depth is usually less than 75 cm. The substrate is mostly silt.

Warm Spring (T45N, R25E; Humboldt County, Nevada).— Warm Spring and its outflow are tributary to Virgin Creek approximately 2.5 km downstream from Virgin Creek Gorge. The outflow creek is a small, clear-water stream with an easily roiled silt bottom. Summer water and air temperatures of the creek just below the spring were 26.0 and 26.4 C, respectively. Alvord chubs are abundant in the outflow creek. The spring itself was not sampled, but Carl Hubbs collected Alvord chubs from the spring in 1934 ("Italian Camp Spring," UMMZ 130533). The steep gradient and low flow of the Warm Spring crenon as it approaches Virgin Creek inhibits mixing between the Virgin Creek and Warm Spring populations of Alvord chubs. Although Warm Spring flows through Virgin Valley Ranch, the spring and outflow creek have been only slightly altered and no exotic fish were present during a 1978 survey of the spring system.

Dufurrena Pond 13 (T45N, R26E, Sec 17; Humboldt County, Nevada).— Dufurrena Pond 13 is the only reservoir on Virgin Creek between Virgin Creek Gorge and Thousand Creek. Water characteristics are typically those of Virgin Creek except that maximum depth is greater (almost 2 m) and aquatic vegetation is abundant. Alvord chubs are common to abundant just upstream and downstream of the reservoir but are rare in the pond itself.

Gridley Springs (T44N, R27E, Sec 22; Humboldt County, Nevada).— Gridley Springs is a series of approximately 17 coolwater springs located on an alkali flat just south of the Gridley Lake playa. Many of the springs are little more than seeps, but a few have spring pools nearly 2 m deep with outflow creeks 30 or 40 m in length. During April 1982, most of the spring waters were

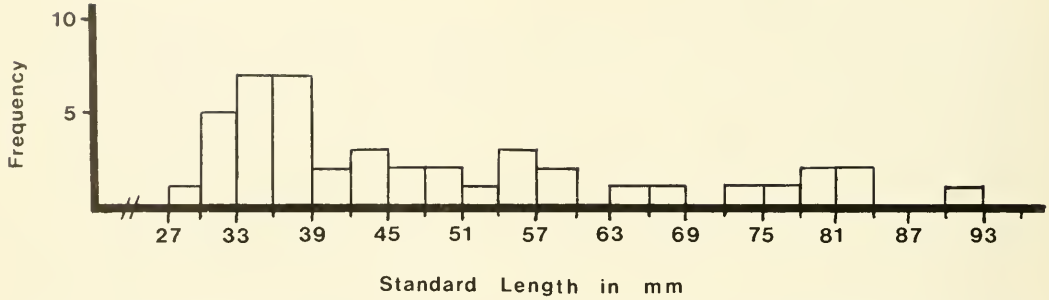

Fig. 3. Length frequency of 44 Alvord chubs, *Gila alvordensis*, collected 14 April 1982 from Gridley Springs, Nevada.

clear, with a temperature of 12 C (air 10 C). Rushes, *Juncus* sp., were the dominant plants around the springs, with some larger springs also harboring pondweed, *Potamogeton* sp., and cattails, *Typha* sp. Only one of the 17 springs examined contained Alvord chubs. This spring is located near the northwestern margin of the Gridley Springs series. Alvord chubs were found in the outflow creek, which extended approximately 40 m and was 3 m wide at its greatest extent. Only a trace of current could be detected in the creek. The water was unusually turbid, visibility 4 cm, with a maximum depth of 30 cm. Water temperature was 11.5 C (air 6.8 C) on 14 April 1982. The bottom was silt. Unlike most of the larger springs in the area, this spring contained only rushes along its margin. The Gridley Springs area is overgrazed by cattle and horses, but it is not known to what extent this is detrimental to the Alvord chub population.

Alvord chubs were not abundant in the outflow creek, but were common enough to collect 50 fish in three short seine hauls. Forty-four individuals collected in April 1982 ranged in size from 27 to 91 mm SL, but were mostly 30 to 38 mm SL (Fig. 3). The sex ratio of 32 individuals greater than 35 mm SL was 1♂:3♀.

West Spring (T44N, R27E, Sec 20; Humboldt County, Nevada).— West Spring issues from the base of Big Mountain and forms West Creek, which flows into the alkali flat south of Gridley Springs. The waters of West Spring are clear and shallow. Maximum depth is 12 cm over a gravel and sand substrate. Water and air temperatures recorded during summer were 21.8 and 20.4 C, respectively. Alvord chubs are common in the spring and its outflow creek. The largest of 33 individuals collected on 18 August 1978 was 62.8 mm SL. The sex ratio of 30 adults greater than 40 mm SL was 1♂:1♀. Alvord chubs collected during August from West Spring fed exclusively or almost exclusively on small hydrobiid snails. This snail, which occurs in great abundance, apparently represents an undescribed species endemic to West Spring (Jerry Landye, pers. comm.).

West Creek (T44N, R27E, Sec 20, 28, 29; Humboldt County, Nevada).— West Creek flows for nearly 3 km before emptying into the alkali flat approximately 2 km south of Gridley Springs. Because West Creek is formed by West Spring, water characteristics are similar for both. The creek is quite small, often 1 to 2 m in width and less than 15 cm deep. Current is moderate in the upper reaches but slows considerably upon reaching the flat. Alvord chubs occur throughout the creek, but are somewhat smaller than those in West Spring.

Discussion

The Alvord cutthroat trout, Alvord chub, and Borax Lake chub are all restricted in distribution to waters of the Alvord Basin. The Alvord cutthroat trout is now extinct but formerly occurred in larger creeks of the basin. Hybridization with introduced trout caused the demise of the native form. The Borax Lake chub has the most restricted natural distribution of the three fishes, occurring only in Borax Lake and adjacent lake outflows. The Alvord chub is relatively widespread in the basin and was recorded from 16 localities, including Bog Hot Reservoir, Bot Hot Creek, Thousand Creek Spring, an unnamed spring, Dufurrena Pond 19, Dufurrena Pond 22, Dufurrena Pond 13, West Spring, and West Creek as new locality records.

Because of the fragility of the small aquatic habitats and the overall paucity of water in the basin, the two extant native fishes are easily threatened by the activities of man. The naturally restricted range of the Borax Lake chub and threats from geothermal energy development prompted the American Fisheries Society to list the species as threatened in 1979 (Deacon et al. 1979). Also during 1979, several portions of the north and east shoreline of Borax Lake were altered so that overflow waters exited the lake to the north and east rather than to the south and west, as was the historical condition. This alteration caused Lower Borax Lake as well as the marsh and pools to the south and west to dry, thus eliminating Borax Lake chubs from these waters. Leasing of surrounding lands for geothermal exploration and alteration of the shoreline caused the U.S. Fish and Wildlife Service temporarily to list the Borax Lake chub as an endangered species on 28 May 1980. As a result of the listing, geothermal exploration was prohibited from a one-mile buffer zone around Borax Lake. The emergency listing has since been supplemented by a final rulemaking that designated the species as endangered pursuant to the Endangered Species Act. The Alvord chub has fared better than the Borax Lake species because of its wider distribution. Nevertheless, competition with exotic guppies has extirpated the Thousand Creek Spring population of Alvord chubs, and other populations are threatened by habitat alteration. The Alvord chub appears easily eliminated by the presence of exotic fishes. Thousand Creek reservoirs stocked with game fish, such as Dufurrena Ponds 20 and 21, lack Alvord chubs. White crappie, *Pomoxis annularis*, pumpkinseed, *Lepomis gibbosus*, and largemouth bass, *Micropterus salmoides*, were collected from Dufurrena Ponds 20 and 21.

Borax Lake chubs are dwarf and typically mature at 30 mm SL. Adults are usually 33 mm to 45 mm SL and typically live for one year. A few Borax Lake chubs, mostly females, live more than one year. Adult Alvord chubs are larger, achieving more than 100 mm SL in Trout and Virgin creeks. Even in very small springs, such as the unnamed spring and Gridley Springs, Alvord chubs achieve 90 mm SL. The presence of large chubs in the cool springs and creeks indicates a longer life span for the Alvord chub than typically occurs for the Borax Lake species. Borax Lake chubs spawn year around in their thermal lake habitat, but a spring spawning peak is indicated. Alvord chubs appear to spawn only once a year in their thermally fluctuating habitats. Both species of *Gila* are opportunistic omnivores, consuming primarily chironomids, microcrustaceans, and diatoms. The Borax Lake species also consumed large quantities of terrestrial insects during summer and fall. The Alvord chubs in West Spring are unusual in that they are greatly dependent on the endemic hydrobiid snail for food.

Acknowledgments

Funds to study the Alvord Basin fishes were provided by U.S. Fish and Wildlife Service contract 14-16-0001-78025 to inventory the fishes of the Sheldon National Wildlife Refuge and by the Department of Fisheries and Wildlife at Oregon State University. The study greatly benefited from the field and editorial assistance of Cynthia D. Williams. Ray S. Taylor, J. J. Long, K. M. Howe, G. DeMott, B. Boccard, A. Tiehm, J. E. Deacon, M. S. Deacon, D. E. Deacon, and E. M. Lorentzen assisted with field collections. Robert R. Miller lent museum specimens and collection notes of our late mentor, Carl Leavitt Hubbs. Reviews of this paper were provided by C. D. Williams, J. E. Deacon, E. P. Pister, and S. V. Gregory. This contribution is Technical Paper 6510 of the Oregon Agricultural Experiment Station.

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KRAMER PALOUSE NATURAL AREA

Del W. Despain[1,2] and Grant A. Harris[1]

Abstract.— The 27-acre Kramer Palouse Natural Area located in southeastern Washington State represents the best remaining example of what was once the most productive portion of the original Palouse Prairie. This area is being maintained in its pristine condition as a key to the past and as a memory to a unique and once extensive prairie land by the Department of Forestry and Range Management at Washington State University.

Many of the most productive rangelands of the past are now agricultural lands. The Palouse Prairie of the inland Pacific Northwest is no exception. Once part of a vast prairieland that extended throughout eastern Washington and Oregon, as well as adjacent Idaho, most of this region has since been turned under by the plow, to become some of the most productive unirrigated farmland in the world.

The Palouse Prairie occupies a region of relatively gentle topography, with the principal relief being low hills having the general appearance of dunes. These wind-deposited loesal materials originated in the arid lands and volcanoes to the west, and were deposited on a basalt rock foundation. Fertile xerolls of silty and clay loam texture have developed under the influence of a semiarid climate. Average annual precipitation is from about 400 to 600 mm (16–24 inches), coming mostly as rain or snow during fall, winter, and spring. Prefarming era vegetation was characteristic of a true grassland region, and was composed of dense stands of caespitose perennial grass species (Daubenmire 1970).

The climax vegetation, though palatable and nutritious, apparently developed without significant grazing use. Dominant species are easily injured by close cropping, and under poor grazing management are replaced by introduced annual grasses (chiefly *Bromus tectorum*). Archeologists estimate that the small bison poulation of the region became extinct about 2,000 years ago, and large herbivore grazing was practically nil from that time until horses from early Spanish missions of the southwest were introduced in about 1730 (Osborne 1953). The region is so remarkably adapted to intensive wheat and pea cropping that today livestock grazing never has become an important land use, except in waste places.

With the development of a side-hill combine and other technologically advanced farm equipment, only the very steepest "eyebrows" and slopes of the loesal deposits of the Palouse have not been tilled. Many of these small islands of native prairie have been used for other purposes and have changed dramatically over the past. Most remaining uncultivated segments are so small as to have been changed to dense stands of brush or weeds through activities on adjacent land including tillage, herbicide applications, and fertilization.

Probably the best remaining example of the more productive portions of this region is the Kramer Palouse Natural Area. Ownership has been obtained by Washington State University in an effort to retain this unique specimen in its natural condition as a reference point to the past for demonstration and research.

Historical Background

The 27-acre Kramer Palouse Natural Area was once part of a producing wheat farm, but it was held out of production by virtue of steep topography and shape of the ownership boundaries of the farm. It reaches over the crest of a high ridge, too steep for even the intrepid Palouse area farmers to cultivate.

[1]Department of Forestry and Range Management, Washington State University, Pullman, Washington 99163.
[2]Present address: School of Renewable Natural Resources, University of Arizona, Tucson, Arizona 85721.

The ownership boundaries included the steepest part of the ridge top, with neighbors on three sides, and no access to the back side without crossing their land. Consequently, the area was not plowed until 1961 when the owner decided to cultivate the lower northern extent of the parcel. However, after having made one pass with the plow, the farmer says he didn't have the heart to continue and left the tract untouched by further distubance. The path of that one pass, half-circle in shape along the base of the ridge, can still be faintly seen today, but the vegetation is now similar to adjacent sites.

The area was occasionally used as a pasture for farm milk cows, but only a small part was noticeably changed where the cattle congregated for resting. A road that once traversed the area for movement of farm equipment and animals is the most evident scar of disturbance from the past, but even this has healed over with native vegetation similar to the undisturbed portions.

Dr. Rexford F. Daubenmire is reported to have found the area in about 1955 during his search for bench mark natural areas in support of his ecological studies. He established permanent study plots there at that time and continued to make observations as needed. He later showed the area to Dr. Grant A. Harris, who pursued the possibility of purchasing the tract through John P. Nagle, then chairman of the Department of Forestry and Range Management at Washington State University. The parcel, previously owned by Caroline Kramer, was not immediately available for purchase. However, following probate settlements for the Kramer estate, the University was able to purchase the 27-acre tract. The deed was filed in the university's name on 28 March 1962. The Department of Forestry and Range Management, with specific assignment to Dr. Harris, was given the responsibility for administration and maintenance of the Natural Area, and this assignment continues at present.

Description

The Kramer Palouse Natural Area, 27 acres in size, is located about 5 miles west of the farming community of Colton, Whitman County, in the southeastern portion of the state of Washington (N ⅔, SE ¼, NE ¼ of Section 25, Township 13 North, Range 44 East, WPM). Aspects are generally steep on the south and north, with elevations of 805 to 869 m. Precipitation at the site averages approximately 550 mm (22 inches) annually.

Zonal vegetation in this environment is expressed in the *Festuca idahoensis/Symphoricarpos albus* association (Daubenmire 1970). A major part of the north slopes of the Natural Area supports this habitat type. Major species include the caespitose grasses, Idaho fescue (*Festuca idahoensis*), bluebunch wheatgrass (*Agropyron spicatum*), and June grass (*Koelaria cristata*), in association with shrubs dominated by snowberry (*Symphoricarpos albus*) and wild rose (*Rosa nutkana* and *Rosa woodsii*). The type has a rich diversity of perennial forbs, creating a virtual sea of flowers across the Natural Area during much of the growing season. The snow-catching boundary fences along the north slope have sufficiently altered the microclimate in places to increase the normal coverage of the tall shrub phase (*Symphoricarpus*), creating a border of dense shrubs including chokecherry (*Prunus virginana*) and occasionally bittercherry (*Prunus emarginata*). There are also small patches of the black hawthorn/cow parsnip (*Crataegus douglassii/Heracleum lanatum*) habitat type at the base of the steep north slopes, typical of bottom lands that are more moist than local zonal soils. The south face of the Natural Area supports a topographic climax cover of the bluebunch wheatgrass/Sandberg's bluegrass (*Agropyron spicatum/Poa sandbergii*) habitat type typical of the more droughty vegetation zone to the west.

Detailed soil and vegetation studies by Aller et al. (1981) on the site have revealed a "perched water table" situation in the solid steep north exposures. On this site, as well as two other similar locations, they found an undescribed topoedaphic climax plant association dominated by *Carex geyeri*, as well as a *Festuca* phase and *Symphorocarpos* phase of Daubenmire's *Festuca idahoensis/Symphorocarpos albus* association that had not previously been reported.

Soils on the site have been classified into the Palouse and Calouse series, which are relatively deep, well-drained soils that formed in loess deposits containing varying amounts of volcanic ash (Donaldson 1980). Approximately 80 percent of the surface is classified as Palouse-Thatuna silt loam, 10 percent Palouse silt loam (SE corner), and 10 percent Calouse silt loam (SW corner). The Palouse-Thatuna series is a complex of approximately 50 percent Palouse and 50 percent Thatuna silt loam, mapped together because of their intermingled occurrence in the field. The Palouse silt loams are generally found on convex slopes and Thatuna on concave slopes, examples of which are found on south and north exposures of the natural area, respectively. All the soils found there are deep, well-drained, and fertile, and, in cultivation, produce excellent crops of wheat, lentils, peas, barley, and alfalfa.

An abundance of wildlife inhabits the area, including coyotes, badgers, and occasionally whitetail deer.

Management philosophy encourages nondestructive scientific study of entire ecosystems found in the Natural Area. Scientists from several university departments, including the Universities of Idaho and Washington, as well as from state and federal agencies, have established short-term biological studies there. In addition to vegetation, studies have investigated natural status of soils, rodents, insects, birds, and atmosphere, all in considerable detail. Interest in the Palouse Natural Area as a bridge to the past continues to increase as research interest in biological subjects increases, and the area will become ever more valuable as time passes.

Access to the Natural Area is somewhat hampered because it is isolated from the local road system and is completely surrounded by cultivated land. The lack of easy access, however, simplifies maintenance of the undisturbed characteristics of the area. Arrangements have been made with the neighbor on the west to walk one-half mile along his fence line southward from Rim Road near its junction with the Colton—Wawawai Road. This provides the principle access for observation and study.

Management Problems

Maintaining a natural area in its natural state, especially one as small as the Kramer Area, is not easy. Most of the problems stem from the "unnatural" interface of the area with adjacent cultivated farmland.

There is some indication that the dense cover of tall shrubs that has developed along some of the fence lines is migrating inward and increasing its extent over the area. The potential loss of the grass-forb- and low-shrub-dominated communities may become a concern in the future.

Because of good cover and protection provided by the shrubs along the fence line, and because of availability of adjacent cultivated crops as forage, the population of Columbian ground squirrels (*Citellus columbianus*) has increased dramatically around the perimeter of the track. In the past, these rodents have stripped adjacent field crops as far as 100 feet out from the boundary. Following complaints from neighboring farmers, attempts were made to control excessive populations of the squirrels, but most methods considered or tried proved to be either largely unsuccessful or involved equipment that was difficult to get to the inaccessible area or that would cause undue disturbance. Recently, however, a very successful control effort has been implemented using a product with the trade name "Ramik Green," made by Velsicol Chemical Corporation. This rodenticide was placed in bait stations located around the perimeter of the area during early spring. The immediate question that has been raised is whether or not this control of rodents changes the natural balance of the ecosystem. It is our opinion that rodent populations prior to control were artificially high due to the adjacent crops as a forage source. No attempt has been made to completely destroy rodent populations, with control efforts directed only at critical locations around the perimeter of the Natural Area. The alternative, legal action taken by neighboring farmers due to obvious crop damage, would clearly endanger the status of the Natural Area.

Another problem of the intensive agriculture interface is herbicide drift from adjacent fields, primarily 2-4-D. The most obvious impact is damage to shrubs along the boundaries. What changes in species composition herbicide drift causes is unknown at this time, but it does not appear to be a serious problem as far as maintaining natural conditions over most of the area.

Except for cheatgrass (*Bromus tectorum*) along the ridge top, noxious, introduced weeds now common to the region have largely been excluded from the unit by the well-established stands of native vegetation. Canada thistle (*Cirsium arvense*) has appeared in a couple of places and could possibly become a problem to deal with in the future.

Research use is encouraged, but care is taken to limit the kinds of uses to those that can be made without significant disturbance to its natural character. A system of approval has developed in which the applicant submits a copy of a detailed proposal for review by the administrator. If destructive procedures are found, negotiations usually modify these so that the work can be completed. Visits by undergraduate classes are not encouraged.

Due to limited access to the Natural Area, disturbance by the general public has not been a problem. Public use has been limited primarily to upland game-bird hunters.

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WINTER FOOD HABITS OF COUGARS FROM NORTHEASTERN OREGON

Chris Maser[1] and Ronald S. Rohweder[2]

Abstract.— Sixty-four cougar (*Felis concolor*) stomachs and 41 intestinal tracts were examined for food items in northeastern Oregon from 1976 through 1979. Food items, in order of decreasing frequency, were mule deer (*Odocoileus hemionus*), North American elk (*Cervus elaphus*), porcupine (*Erethizon dorsatum*), snowshoe hare (*Lepus americanus*), and deer mouse (*Peromyscus maniculatus*).

Bounties existed on cougars in Oregon from 1843, when the Oregon Territorial Government offered them on most "predators," until the bounty system was repealed by the 1961 Oregon Legislature (Ebert 1971, Kebbe 1961). Once found throughout most of Oregon, the decline of the cougar during the 1950s and early 1960s aroused concern for its continued existence within the state. The cougar was classified as a game animal in September 1967 (Oregon State Game Commission 1967). The hunting season was immediately closed and remained closed until December 1971, when the first controlled hunting season was opened. Twenty-two cougars were killed by hunters during the December 1971 and December 1972 hunting seasons.

Little is generally known about food habits of the cougar (Young and Goldman 1964), particularly in Oregon, where indiscriminate bounty hunting kept cougar populations too low for such studies. Maser et al. (1981) and Toweill and Meslow (1977) discussed cougar food habits in general; Toweill and Meslow (1977) also discussed the food habits of those cougars killed during the 1971 and 1972 hunting seasons. The purpose of this paper is to present data on the winter food habits of cougars from northeastern Oregon and to offer some tentative interpretations of these data.

Methods

Sixty cougars were obtained from hunters during four one-month hunting seasons (December 1976, 1977, 1978, 1979) in northeastern Oregon counties: Baker (5), Union (15), and Wallowa (40). An additional four cats were obtained from Umatilla (1) and Wallowa (3) counties; one was killed illegally and three were killed because of their proximity to livestock.

Cats, killed by hunters, were brought into an Oregon Department of Fish and Wildlife office within 48 hours of being killed. Most cats were received intact, but a few had been field dressed.

Each individual was sexed, weighed, measured, and, if intact, eviscerated. Each cat's heart, lungs, liver, stomach and intestinal tract, and reproductive organs were placed in separate plastic bags, labeled, and quick-frozen for later analysis. The present food habit study was done in conjunction with a study of endoparasites, which necessitated separately examining the stomach, small intestine, and large intestine. Each cougar thus had three separate analyses for food items. This procedure worked well because we could determine what appeared to be the contents of two meals for each cat that contained food in its alimentary canal—one meal in the stomach and a different meal in the colon. The two meals "mixed" in the small intestine. Thus, by identifying the stomach contents first, the colon contents second, and the small intestine contents third, we had a cross-check on the content determinations. Materials from the small intestine usually contained elements of both stomach and colon contents and have not been included in the discussion. Further, by identifying the plant

[1]U.S. Department of the Interior, Bureau of Land Management, Forestry Sciences Laboratory, 3200 Jefferson Way, Corvallis, Oregon 97331.
[2]Oregon Department of Fish and Wildlife, Route 2, Box 2283, La Grande, Oregon 97850.

material in the alimentary canal, we could determine, by tree associations and by inference, the general habitat within which the cougar had taken its meal.

Results and Discussion

Results of the food habit study are given in Tables 1 and 2. The sexes of cougars analyzed during this study probably approximates a random sample (Table 3). Although cougars are, in some sense, opportunistic predators (Robinette et al. 1959, Sitton 1977) their main diet was mule deer, North American elk, and porcupine (Table 1), which concurs with studies reviewed in Toweill and Meslow (1977). Stomachs ranged from being empty to containing 3.5 kilograms of mule deer.

Mule deer was the most frequently consumed prey; North American elk was second (Table 1). In eight cases, the consumed elk could be classified as adult or calf. From the limited sample, the five male cougars that had eaten, and presumably killed, adult elk were in the upper size-limit of the overall sample: 68 kg (150 lbs)—the largest cougar—66 kg (146 lbs), 64 kg (140 lbs), 64 kg (140 lbs), and 62 kg (137 lbs). The average weight of the five male cats was 64.8 kg (142.7 lbs). On the other hand, the three cats that had eaten known calf elk were a female (32 kg—70 lbs), a male (41 kg—91 lbs), and another female (50 kg—110 lbs). The average weight of these three cats was 41 kg (91 lbs). The 50-kg female that killed a calf elk was 12.3 kg (27 lbs) lighter than the smallest of the males that killed an adult elk. Thus it seems that the larger a cougar, the larger a prey animal it can kill, and the more energy efficient such a kill will be.

Table 1. Prey species consumed by 60 cougars killed in December.

Content	Stomach % frequency	Colon % frequency
Mule deer	55.3	42.1
Elk	21.3	15.8
Porcupine	10.6	5.2
Unidentified hair	6.4	10.5
Snowshoe hare	4.3	—
Bird	2.1	—
Lagomorph	—	5.2
Cougar hair	—	21.1
Total	100.0	99.9

Porcupine would seem to be an energy-efficient meal as soon as a young cougar is old enough to kill because these large rodents are slow, easily caught, and seem to be readily dispatched by cougars. Although porcupines occurred in the diet with only 10.6 percent frequency in stomachs and 5.2 percent frequency in colons in our study, Robinette et al. (1959) found them to account for 19 percent of the cougar's diet, based on scat analysis, in Utah and Nevada. Evidence—in the form of quills embedded in and around the gum lines, the skinned shoulders and feet, and embedded in stomach walls—indicated that most cougars encounter porcupines at some time during their life. Such quills, represented by their embedded tips, appear as dark streaks. Apparently, a cougar's body readily absorbs the softer, light shaft of a quill but not the harder, dark tip.

Cougars seem to be variously adept at eating porcupines. For example, some cougars appear to avoid the quills as much as possible and have only a few hairs mixed with the porcupine flesh in their digestive tract, whereas others eat almost everything. In addition, a cougar killed in 1973 had eaten a porcupine about an hour prior to being shot. It had consumed the entire porcupine, except the head and digestive tract. The quills had already begun to soften in the cat's stomach.

The proportion of a cougar's diet that is composed of porcupine is probably related to the availability of the prey. Connolly (1949 cited in Robinette et al. 1959), for example,

Table 2. Miscellaneous associated items consumed by 60 cougars killed in December.

Content	Stomach % frequency	Colon % frequency
Grass	20.0	23.8
Douglas-fir needles	17.1	4.8
Grand fir needles	14.3	19.0
Ponderosa pine needles	14.3	14.3
Engelmann spruce needles	11.4	9.5
Twigs	5.7	4.8
Soil	5.7	23.8
Alder leaf	2.9	—
Lichen (*Alectoria fremonti*)	2.9	—
Larch needles	2.9	—
Pebbles	2.9	—
Total	100.1	100.0

indicated that, in his Utah study area, cougars killed one porcupine per week in winter. Of the 64 cougars examined in this study, plus 97 cougars examined prior to this study, none showed ill effects from encounters with porcupines, even when quills remained embedded in a cat's tissues. Such lack of serious damage or infection from porcupine quills has also been noted in the fisher (*Martes pennati*) and spotted skunk (*Spilogale putorius*) (Maser et al. 1981).

The snowshoe hare occurred fourth (of the identifiable items) in the cougars' stomach contents (Table 1). Because these hares were relatively abundant in the coniferous forests of northeastern Oregon during our study, their low frequency (4.3 percent) indicates that they were taken incidentally by the cougars.

The lagomorph remains in the colon (Table 1) were either snowshoe hare or mountain cottontail (*Sylvilagus nuttalli*), but they could not be identified to species once they reached the colon. The bird (Table 1) was probably a grouse.

Miscellaneous items associated with food are given in Table 2. Other than grasses, some of which were intentionally eaten, identifiable vegetation gave clues to the habitats in which the cats presumably had been hunting and had consumed their prey. Of the five stomachs that contained elk and vegetation, Engelmann spruce (*Picea engelmannii*) occurred in 20 percent, western larch (*Larix occidentalis*) in 20 percent, grand fir (*Abies grandis*) in 40 percent, and ponderosa pine (*Pinus ponderosa*) in 20 percent. Of the 13 stomachs that contained deer and vegetation, Engelmann spruce occurred in 15 percent, grand fir in 8 percent, ponderosa pine in 38 percent, and Douglas-fir (*Pseudotsuga menziesii*) in 38 percent. From the conifer needles in the stomachs, it seems that elk were killed primarily in denser, moister forests because the Engelmann spruce, western larch, and grand fir accounted for 80 percent of the needles, whereas ponderosa pine, characteristic of more open habitat, accounted for only 20 percent. With respect to mule deer, on the other hand, ponderosa pine–Douglas-fir, which occurs as a drier, more open forest, accounted for 76 percent of the conifer needles, as opposed to the moister, denser forests of grand fir and Engelmann spruce, which represented 23 percent of the needles. Thus, it seems that the elk were usually killed in dense forest where the advantage would lie with the stalking cougar and the smaller, more easily subdued mule deer was most often hunted in more open habitats.

In addition to vegetation, several cats had eaten much soil—evidence of having cleaned up a kill.

Conclusions

Of the 60 cougars killed during the December hunting season, 31.6 percent had virtually or totally empty stomachs, and 30 percent had empty colons. The 4 cougars killed because of their proximity to livestock also had virtually empty stomachs. Thus, if the stomachs or the colons are used independently as the sole source of food habit data, a large sample is needed. If, on the other hand, both the stomach and colon contents are used independently but together as dietary samples, the chances of getting adequate food habit data are good because it is unlikely that both stomach and colon are simultaneously empty.

Acknowledgments

Murray L. Johnson (Puget Sound Museum of Natural History, University of Puget Sound, Tacoma, Washington), Donald K. Grayson (Department of Anthropology, University of Washington, Seattle, Washington), Maurice Hornocker (USDI, Fish and Wildlife Service Cooperative Wildlife Research Unit, University of Idaho, Moscow, Idaho), and Paul E. Ebert (Oregon Department of Fish and Wildlife, Portland, Oregon) read and improved the paper. Phyllis Taylor-Hill (USDI

Table 3. Year of capture, number, and sex of cougars studied in northeastern Oregon.

Year	No. of cougars	No. of males	No. of females
1976	4	3	1
1977	21	13	8
1978	22	10	12
1979	17	7	10
Total	64	33	31

Bureau of Land Management, Forestry Sciences Laboratory, Corvallis, Oregon) typed the various drafts of the manuscript.

The following Oregon Department of Fish and Wildlife personnel helped collect the cougar viscera: Ronald Bartels, Vic Coggins, Paul Ebert, Mark Henjum, Dick Humphreys, Mike Kemp, and Walt Van Dyke. Laboratory space and partial financing for this study were provided by the USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, Project 1701, Range and Wildlife Habitat Laboratory, La Grande, Oregon. We sincerely appreciate their help.

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A NEW SPECIES OF *PENSTEMON* (SCROPHULARIACEAE) FROM THE UINTA BASIN, UTAH

Elizabeth Neese[1] and Stanley L. Welsh[1]

Abstract.— Described as a new species is *Penstemon flowersii* Neese & Welsh from Utah. An illustration is provided. The species is named in honor of the late Seville Flowers, professor of botany at the University of Utah.

The genus *Penstemon* is large and complex within the state of Utah. The flowers of plants of this genus are among the most beautiful within the state. Several taxa have been described as new from the intermountain region during recent years. It is not surprising that another such novelty should occur in the region. The species was discovered during investigations of the rare plants in the Uinta Basin, a region noted for its narrowly distributed endemics.

Penstemon flowersii **Neese & Welsh, sp. nov.**

Species haec ab *P. immanifesto* N. Holmgren in staminodiorum barbis multo breviore, et ab *P. carnoso* Pennell in floribus roseo non violaceo-caeruleis, ab uterque foliis basalibus nullis differt.

Perennial glabrous glaucous herbs, with simple ascending stems arising from a branching woody caudex, 8–25 (32) cm tall, the basal rosette lacking; cauline leaves all entire, fleshy-thickened, (1.5) 2–5.5 cm long, (4) 10–25 mm broad, the lower shortly petiolate, spatulate, the middle ones larger, sessile, lanceolate or elliptic, obtuse, the upper reduced, broadly ovate, acute; thyrsus cylindric (not secund), with 4–9 verticils, the cymes many flowered; calyx glabrous, 5–6.5 mm long, the lobes broadly lanceolate, acuminate, the margin scarious, suffused with rose; corolla 15–18 mm long, rose within, the striae dark rose-pink, the limb ampliate, 10–12 mm in diameter; staminode equaling the tube, not exserted, the apex shortly barbellate (to 0.1 mm long); stamens included, the anthers glabrous, dehiscent throughout and in the connective, not explanate, the sacs opposite, 1–1.2 mm long; capsules 7–10 mm long.

Type: USA. Utah: Uintah Co., T3S R1E S9–10, 5.6 km W of Randlett, 12 May 1980, Neese & White 8609 (Holotype: BRY; Isotypes: NY, US, RM, CAS, UTC, MINN).

Paratypes: Utah. Uintah Co., T3S R1E S10, 4.8 km W of Randlett, 12 May 1898, Neese & White 8600 (BRY, UT, NY, MO); do T3S R1W S3, 5.8 km S of U.S. Hwy 40, 14 km W of Randlett, 12 May 1980, Neese & White 8606 (BRY, NY, CAS); do T3S R1E S10, 4.8 km W of Randlett, 16 May 1979, E. Neese & B. Welsh 7212 (BRY, NY, GH, MO). Duchesne Co., T3S R2W S21, 3.2 km WNW of Myton, 16 May 1979, Neese & B. Welsh 7218 (BRY, NY); do T3S R2W S12, 4 km due N of Myton, 15 May 1980, Neese & White 8662 (BRY, NY, UC).

The Flowers beardtongue grows in shad scale communities on pale-colored clay slopes and benches between 1,500 and 1,600 m, where old terraces of the Uinta Formation in the Duchesne River drainage are mantled with Pliocene or Pleistocene pedimental gravels. It is common on such habitat in an area of about 8 × 25 km between Randlett and Myton. The species is remarkable in its uniformity in regard to both morphology and habitat. The plants, with their dusty pink flowers and pale gray-green foliage are inconspicuous against the gray clay on which they grow. The near congener, *P. immanifestus,* of central eastern Nevada and western Utah possesses a more prominently bearded staminode. *Penstemon carnosus* Pennell is similar in diagnostic characteristics, but the Flowers beardtongue is quite distinctive in its smaller stature, tufted, usually numerous

[1]Life Science Museum and Department of Botany and Range Science, Brigham Young University, Provo, Utah 84602.

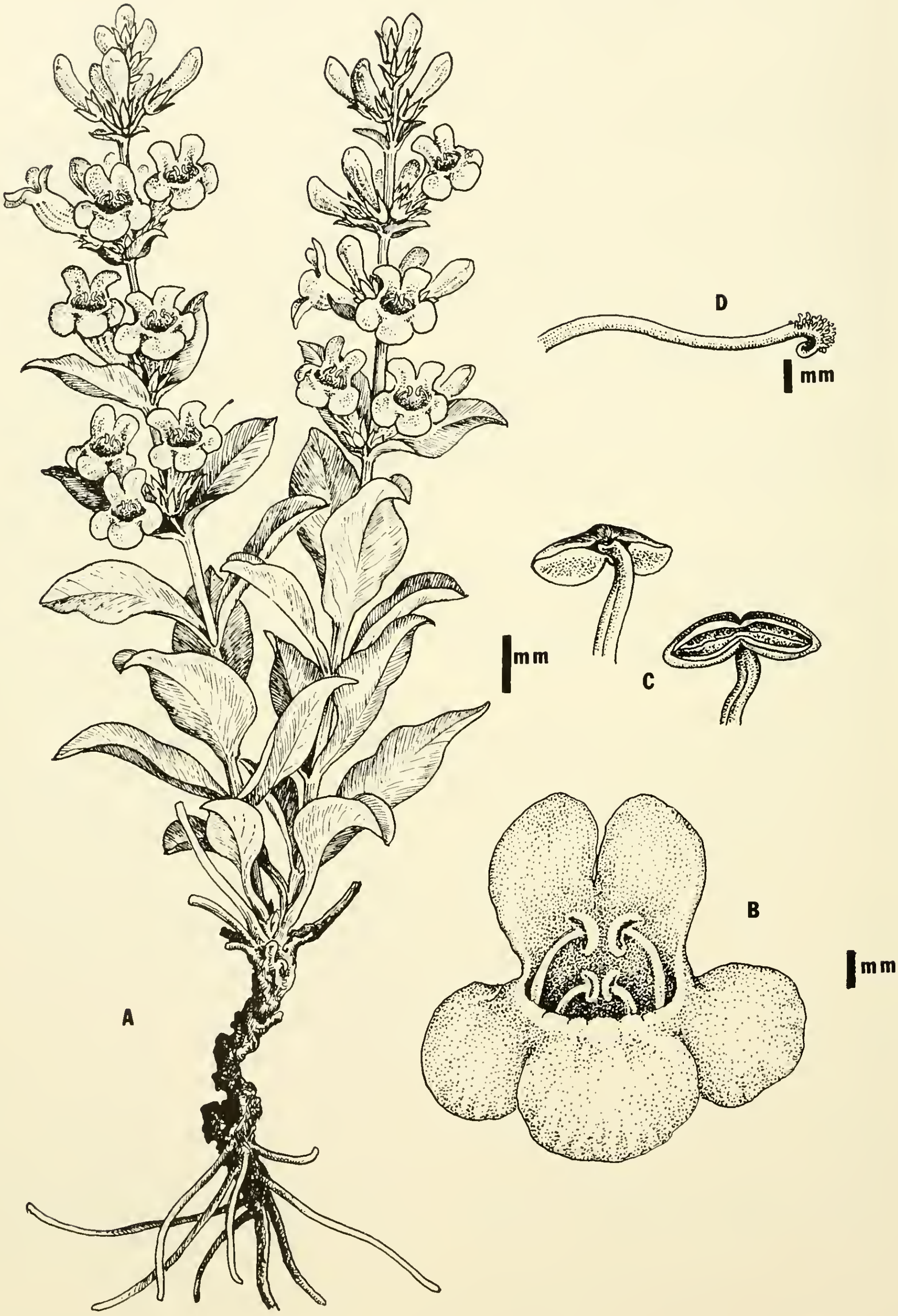

Fig. 1. *Penstemon flowersii* Neese & Welsh: A, Habit. B, Flower. C, Anther-sacs. D, Staminode.

stems, absence of a basal rosette, and pink (not lavender-blue) flowers. *Penstemon carnosus* is a species of the western Colorado Plateau, from the San Rafael Swell and the Henry Mountains westward to Aquarius Plateau (Holmgren 1978).

The plant is named to honor the memory of Dr. Seville Flowers, late professor of botany at the University of Utah. Dr. Flowers was a student of lichens, mosses, and higher plants, and his untimely passing has left a void in the understanding of the plants of Utah and the West.

Acknowledgments

We express thanks to Noel H. Holmgren for his examination of the type materials, and for his comments regarding relationships of this taxon. Kaye Thorne provided the illustrations, and for this we are grateful.

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A COMPARATIVE STUDY OF COYOTE FOOD HABITS ON TWO UTAH DEER HERDS

Jordan C. Pederson[1] and R. Cary Tuckfield[2]

ABSTRACT.— Coyote (*Canis latrans*) scats from two southern Utah deer herd units were collected and analyzed to establish diet selection. The category showing the most consistent frequency of occurrence was mule deer *Odocoileus hemionus*; lagomorphs were next. Formal statistical analysis revealed that the only significant difference in coyote food habits between herd units was in the frequency of rabbits eaten. These data suggest that coyotes in this region of southern Utah show a comparatively higher preference for mule deer but, at the same time, do not eat deer in proportion to the frequency of their occurrence.

Documented reductions in deer populations in most southern Utah mule deer (*Odocoileus hemionus*) herds have led to speculation concerning the cause or causes for these declines (Workman and Low 1976). This paper investigates the hypothesis that coyote (*Canis latrans*) predation may reflect differential selection for deer. This was done by assessing coyote food habits in two adjacent deer herd units in southern Utah's San Juan County. Areas studied included the Blue Mountain (31A) and Elk Ridge (31B) herd units. Since the deer population is known to be larger within the Blue Mountain unit (Jense 1981), an examination of coyote scats from both areas could indicate whether deer occur in coyote diets in relationship to herd size. If this relationship was positive at a high level of significance, it would lend some credence to the coyote predation hypothesis.

Study Area

The San Juan-Blue Mountain deer herd unit (31A) is, for the most part, that portion of San Juan County east of the North and

TABLE 1. Relative frequency of occurrence of food items in coyote diets as determined from 460 scats collected from September 1977 to December 1979.

		Blue Mountain						
Period[a]	(n)	Vegetation	Rodent	Deer	Lagomorph	Cattle	Bird	Carrion
1	(18)	11.1	11.1	44.4	48.9	0.0	5.6	0.0
2	(15)	26.7	20.0	46.7	33.3	0.0	0.0	0.0
3	(105)	23.8	3.8	61.0	15.2	1.0	1.0	6.7
4	(41)	4.9	0.0	14.6	87.8	0.0	2.4	0.0
5	(12)	16.7	16.7	16.7	91.7	0.0	0.0	0.0
6	(62)	21.0	16.1	58.1	33.9	1.6	1.6	30.6
7	(37)	59.5	40.5	37.8	13.5	10.8	10.8	21.6
8	(12)	14.3	50.0	46.4	25.0	17.0	10.7	0.0
Total[b]	(318)							
mean[c]		26.8	19.8	40.7	42.4	3.9	4.0	7.4
Standard deviation[c]		16.60	17.27	17.17	30.56	4.81	4.52	12.04

[a]*Period*	*Dates*
1	Sep–Dec 1977
2	Jan–Jun 1978
3	Jul–Sep 1978
4	Oct–Dec 1978
5	Jan–Mar 1979
6	Apr–Jun 1979
7	Jul–Sep 1979
8	Oct–Dec 1979

[1]Utah Wildlife Resources, 115 North Main Street, Springville, Utah 84663.

[2]Department of Statistics, Brigham Young University, Provo, Utah 84602. Present address: Department of Biology Indiana University, Bloomington, Indiana 47405.

South Cottonwood drainages. Its highest point is Abajo Peak at 11,360 ft (3,463 m), and it ranges to a low elevation at Bluff City of 4,473 ft (1,363 m). The summer range area of this unit is 153 mi^2 (396 km^2), and the area of the winter range is 1,394 mi^2 (3,610 km^2). Major vegetational types within this unit are conifer, aspen, mountain brush, sagebrush, pinyon-juniper, and blackbrush (Coles and Pederson 1968, 1969).

The San Juan-Elk Ridge deer herd unit (31B) is that area of San Juan County west of the North and South Cottonwood Wash drainages. Horse Mountain, at 9,320 ft (2,840 m) elevation, is the highest point; and the lowest is also at Bluff City, which divides these two herd units. The area of the summer range is 195 mi^2 (505 km^2), and that of the winter range is 1,132 mi^2 (2,932 km^2). Major vegetational complexes include conifer, aspen, mountain brush, sagebrush, pinyon-juniper, and salt desert shrub (Coles and Pedersen 1968, 1969).

During the period from 1976 to 1979, the number of deer harvested per 1000 ha of summer range was 2.9 for the Blue Mountain unit and 1.10 for the Elk Ridge unit. The number of deer harvested per hunter day (effort) for the same time period was 0.061 and 0.049, respectively.

Materials and Methods

Data on dietary selection were obtained from analyses of coyote scats collected along established roads. Scat analysis was chosen over stomach content analysis because a larger sample size could be collected during specific time periods and at specified localities without diminishing the predator population (Knowlton 1964, Meinzer et al. 1975). Scats were collected every three months during a 27-month period from 1 September 1977 to 31 December 1979, with the exception of a 6-month lapse during period 2. Scats were air dried for a minimum of 30 days and then analyzed after thoroughly crumbling. All remains were identified with the aid of a binocular dissecting microscope, hair (Moore et al. 1974), and feather keys, as well as a reference collection of skeletons and vegetation.

Table 1 continued.

	Elk Ridge						
(n)	Vegetation	Rodent	Deer	Lagomorph	Cattle	Bird	Carrion
(0)	–	–	–	–	–	–	–
(4)	0.0	0.0	50.0	25.0	50.0	0.0	0.0
(26)	19.2	15.4	57.7	19.2	3.8	0.0	3.8
(5)	0.0	0.0	80.0	20.0	0.0	0.0	0.0
(22)	9.1	0.0	18.2	81.8	4.5	0.0	0.0
(18)	16.7	16.7	72.2	33.3	0.0	5.6	5.6
(31)	77.4	58.1	25.8	9.7	6.5	0.0	3.2
(36)	8.3	9.3	27.8	86.1	5.6	2.8	0.0
(142)	18.7	14.1	47.4	39.3	10.1	1.2	1.8
	26.92	20.71	24.13	31.33	17.80	2.20	2.36

[b]63.2 and 74.6 percent of all scats contained unidentifiable material from the Blue Mountain and Elk Ridge herd units, respectively.
[c]Computed as the average overtime periods

Food habits are reported as relative frequency of occurrence.

Comparisons between the two coyote populations were made using three statistical procedures, viz., normal approximation to two sample binomial data (Snedecor and Cochran 1967), stepwise logistic regression (Fienberg 1980), and stepwise discriminant analysis (Morrison 1976). The statistical computing programs P1F, PLR, and P7M, respectively, were employed from the BMDP series (Brown 1977).

In the first statistical procedure, each scat was considered to represent a bernoulli trial for each category of remains identified. Hence the total number of scats from each herd unit was treated as a binomial random sample, of which a certain proportion contained remains but the complement did not.

In the second procedure, we treated the location (herd unit) category as a "response" variable and all other dichotomous categories of identified remains as "design" or explanatory variables. The logic of the response variable was then regressed on the explanatory variables.

In the final procedure, each scat was considered to be a multivariate observation, i.e., a vector of remains categories. Discriminant analysis was then used to determine which variables (categories) best discriminated between the two groups (herd units).

Results and Discussion

We collected and analyzed 460 coyote scats: 318 from the Blue Mountain unit and 142 from the Elk Ridge unit. Equal search effort was not expended on both areas, and scat numbers are not indicative of coyote numbers. The major food items found in the scats from both areas were mule deer, birds, carrion, lagomorphs (black-tailed jackrabbit [*Lepus californicus*], mountain cottontail

Table 2. Summary of coyote dietary studies

Authority		Study area	Sample size	Source
Bond	1939	California	282	S and S
Murie	1940	Yellowstone National Park	5,086	Scats
Sperry	1941		8,339	Stomachs
Murie	1945	British Columbia	311	Scats
	1945	Montana	286	Scats
	1945	Montana	67	Scats
Fitch	1948	California	1,173	Scats
Ferrel et al.	1953	California	2,222	Scats
Fichter et al.	1955	Nebraska	747	Stomachs
	1955	Nebraska	2,500	Scats
Korschgen	1957	Missouri	770	Stomachs
Korschgen	1957	Missouri	326	Scats
Ozoga[b] et al.	1966	Michigan	92	Scats
Gier	1968	Kansas	1,451	Stomachs
Clark	1972	Utah and Idaho	186	Stomachs
Hawthorne	1972	California	384	Scat
Mathwig	1973	Iowa	151	Stomachs
Richens et al.	1974	Maine	51	Stomachs
Gipson	1974	Arkansas	168	Stomachs
Meinzer et al.	1975	Texas	514	Scats
	1975	Texas	55	Stomachs
Niebauer et al.	1975	Wisconsin	3,353	S and S
Nellis et al.	1976	Alberta, Canada	344	Stomachs
Johnson et al.	1977	Arizona	224	Scats
Ribic[c]	1978	Colorado	54	Scats
Neff et al.	1979	Arizona	65	Scats
			102	Scats
Litvaitis et al.	1980	Oklahoma	361	Scats
Springer and Smith[c]	1981	Wyoming	404	Scats

[a]Percent could not be determined from data presented.
[b]Winter study only.
[c]Summer study only.
[d]Largely carrion; innards, heads, and feet.

[*Sylvilagus nuttallii*]), rodents (rock squirrel [*Spermophilus variegatus*], least chipmunk [*Eutamius minimus*], Apache pocket mouse [*Perognathus apache*], and deer mouse [*Peromyscus maniculatus*]), and vegetation (Table 1).

When results of our study are compared to data collected in 23 previous studies of coyote diets (Table 2) dating from 1939 through 1981, only two show deer occurring in the diets with greater relative frequency (Ozoga and Harger 1966, Hawthorne 1972). Coyote diets from both our study areas also showed a higher relative frequency of carrion than most other studies reported (Table 2). However, since it was difficult to postively identify carrion during the winter months, this category was not included in the statistical analyses reported hereafter. The greatest amount of fluctuation from one time period to another occurred in the category of lagomorph remains. Mule deer were the dietary item showing the most consistent use (highest relative frequency) across collection periods occurring in four out of eight and four out of seven collection periods for the Blue Mountain and Elk Ridge herd units, respectively. Lagomorphs were the second most consistently used food item identified in scats, occurring in two of eight and two of seven collection periods, respectively. Analysis suggests coyotes could be a factor in the fluctuations of deer populations in these southeastern Utah herd units. These results do not constitute evidence for a cause and effect relationship. Mule deer may be killed and eaten by coyotes or they may be eaten as carrion. Deer carrion could occur as a result of winter stress, other predators, disease, parasites, or other factors, but the reason for these mortality factors warrants further investigation.

Table 3 contains the single category comparisons of binomial proportions between

Table 2 continued.

Percentage of specimens in which item occurred						
Lagomorphs	Rodents	Carrion	Livestock	Birds	Deer	Vegetation
38.8	62.5	4.2	8.8	2.5	26.1	16.9
4.0	59.9	0.0[a]	0.1	3.1	1.0	2.0
43.0	32.0	25.0	20.0	13.0	6.0	4.0
69.4	6.1	9.2	6.6	7.4	4.6	1.8
31.8	40.1	12.6	0.0	3.5	1.1	2.4
52.7	1.7	8.9	6.4	12.9	1.1	3.2
45.4	43.7	1.0	1.0	2.0	0.0	3.0
29.3	49.1	0.0[a]	23.2	18.1	18.5	0.0[a]
58.2	0.0[a]	0.0[a]	26.1	44.1	0.4	3.6
23.0	0.0[a]	0.0[a]	30.5	33.7	7.6	16.0
55.3	36.3	8.6	13.8	22.0	2.9	7.9
80.4	33.3	0.0[a]	2.8	14.7	0.0	23.5
17.0	69.8	83.0	2.1	5.1	91.4	19.8
54.3	41.5	37.7	0.0[a]	24.8	0.0[a]	3.1
84.0	15.0	0.0[a]	10.3	2.1	2.0	1.6
5.7	74.2	0.0[a]	1.5	3.7	35.2	45.3
61.0	37.7	0.0[a]	31.1	21.2	0.0	64.2
19.6	19.6	0.0[a]	11.8	19.6	15.9	78.4
7.0	9.0	30.0	13.0	44.0	5.0	36.0
10.5	24.5	6.0	0.0	1.1	0.0	48.5
10.8	20.2	21.1	0.0	4.5	0.3	20.5
28.0	21.0	0.0[a]	0.0	12.1	26.9	36.2
3.0	22.0	0.0[a]	44.0[d]	11.0	0.0[a]	7.0
27.0	19.4	0.0[a]	0.0	18.6	0.0	4.5
24.0	45.0	0.0	0.0	30.0	13.0	78.0
26.2	43.0	0.0	15.4	1.5	12.3	32.8
0.0	38.2	0.0	6.9	34.3	2.0	39.5
11.0	53.0	0.0	6.0	19.0	20.0	32.0
63.0	45.0	0.0[a]	0.0[a]	0.0[a]	5.0	42.0

herd units. Normally we would conclude a significantly higher ($p = 0.27$) proportion of coyote scats from the Elk Ridge herd unit contained lagomorph remains than did that of the Blue Mountain unit, but such a conclusion would be somewhat misleading. All tests reported in Table 3 are not independent of one another since the information in each came from the same sample of coyote scats. One generally acknowledged and conservative interpretation of these kinds of results uses a Bonferroni procedure (Neter and Wasserman 1974) in which the level of acceptable Type I error is divided by the number of simultaneous tests (six in this investigation). Hence, the "appropriate" significance level for the results in Table 3 (assuming $P = .05$) is .008, in which case none of the test results are significant. It is interesting to note that the only other category approaching the point of demonstrating even weak evidence in favor of a difference in coyote diets between herd units was deer. The results of the stepwise discriminant analysis indicated the most important variable (category) to significantly discriminate between groups was lagomorphs (approx. F-statistic at 1st step = 4.941, $p = .027$). Similarly, the results of the stepwise logistic regression analysis indicated lagomorph remains were the only variable to account for a significant ($x^2 = 4.859$ at 1st step, $p = .028$) amount of variability in the logit (response) variable.

These results suggest coyotes do not include deer in their diets based on the potential frequency of occurrence of this food item. However, we did not conduct any simultaneous census of deer numbers in either of the areas where scats were collected. Further investigation is warranted.

ACKNOWLEDGMENTS

We thank Marlene and Robert Hasenyager, A. Ray Johnson, John C. Kimball, and Aurelia, Mary Ann, and Linda Pederson for

TABLE 3. Cell frequencies and statistical test results when each category of coyote scat material is considered to be a normal approximation to a two-sample binomial problem.

		Lagomorphs			Deer		
		Present	Absent	Total	Present	Absent	Total
Deer herd	1	111	207	318	151	167	318
	2	65	77	142	56	86	142
Total		176	284	460	207	253	460
		$P_1^a = .349$		$P_2^b = .458$	$P_1^a = .475$		$P_2^b = .394$
		$z = 2.216$		Prob. = .027	$z = 1.603$		Prob. = .109

		Birds			Cattle		
		Present	Absent	Total	Present	Absent	Total
Deer herd	1	10	308	318	12	306	318
	2	2	140	142	8	134	142
Total		12	448	460	20	440	460
		$P_1^a = .031$		$P_2^b = .014$	$P_1^a = .038$		$P_2^b = .056$
		$z = 1.079$		Prob. = .280	$z = .904$		Prob. = .366

		Rodents			Vegetation		
		Present	Absent	Total	Present	Absent	Total
Deer herd	1	52	266	318	77	241	318
	2	28	114	142	36	106	142
Total		80	380	460	113	347	460
		$P_1^a = .164$		$P_2^b = .197$	$P_1^a = .242$		$P_2^b = .254$
		$z = .880$		Prob. = .379	$z = .263$		Prob. = .793

1 = Blue Mountain
2 = Elk Ridge

[a]Proportion of scats collected from the Blue Mountain Range containing the indicated remains
[b]Proportion of scats collected from the Elk Ridge Mountain Range containing the indicated remains

their help with this study. We also acknowledge the help of Leonard Newlin, Albert W. Heggen and Norman V. Hancock of the Utah Division of Wildlife Resources. This study was supported by the Utah Division of Wildlife Resources and the Brigham Young University Department of Statistics. Critical review of this manuscript was provided by Dwight Bunnell, Jerran T. Flinders, K. T. Harper, Clyde L. Pritchett, Alvin C. Rencher, and Bruce L. Welsh.

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A SMALL CARNIVORE SURVEY TECHNIQUE

Tim W. Clark[1] and Thomas M. Campbell III[2]

Abstract.— A track station survey method for small, nocturnal mammalian carnivores is described. The method has been field tested under a wide variety of conditions. Stations were visited by rodents, mustelids, and canids, as well as insects and birds.

Small carnivores, because they often range relatively widely, occur at low densities, and tend to be solitary and nocturnal, are one of the more difficult mammal groups to study. Five basic categories of carnivore survey and census methods were described by Linhart and Knowlton (1975): (1) direct counts or capture-recapture, (2) counts of sign (dens, tracks, or droppings), (3) questionnaires and bounty payments, (4) catch per unit of effort (trap-nights), and (5) elicited responses to man-made stimuli (frequency of visitations to scent stations, howl responses to sirens). These methods vary in their effectiveness by species and habitat type.

We used a track recording method employing two varieties of lures (olfactory and acoustic) to elicit small carnivore responses between 1978 and 1982. Field-use determined: (1) efficacy, (2) ease and thrift of construction and setup, and (3) durability and amount of maintenance required. Elicited responses sought included: (1) deposition of tracks and scats at stations and (2) drawing animals to these stations to make them more visible during spotlight surveys. Our track-recording technique was a combination and modification of methods used by Mayer (1957) and Justice (1961) to determine small mammal presence and by Linhart and Knowlton (1975) to index coyote populations. We also compared our track stations according to the above objectives with Linhart and Knowlton's (1975) station design. We were particularly interested in small carnivores on prairie dog colonies, and therefore placed track stations of both types on white-tailed (*Cynomys leucurus*), Gunnison's (*C. gunnisoni*), and black-tailed prairie dog (*C. ludovicianus*) colonies, although they could be placed anywhere.

Track Stations

Our track station consisted of track-sensitive smoked kymograph paper covering a base of 4 mm thick plywood (0.6 m^2) (Fig. 1). The kymograph paper was smoked in the field by burning kerosene-soaked cotton inside an aluminum can which had a long, 1 cm wide slit cut in one side. Track impressions were preserved by spraying with quick drying shellac.

Scent and bait attractants were placed on a stake in the center of each track station (Fig. 1). Scents consisted of a variety of commercial mustelid and other lures (i.e., weasels *Mustela frenata*, mink *M. vison*, marten *Martes americana*, fisher *M. pennanti*, badger *Taxidea taxus*, wolverine *Gulo gulo*, and black bear *Ursus americanus*. Baits consisted of an aged liver and sardine mixture.

The acoustic attractant, a modified electronic bird call producing a "chirping" sound, was used in association with track stations. This call was developed by the U.S. Fish and Wildlife Service (electronic schematic available from the authors). The call was capable of functioning for a couple of weeks on a single 6-volt battery. The call was placed inside a camouflaged paint can (one-pint, 0.5 liters) with holes in the lid to emit the sounds.

Location of track stations was determined in the field to minimize wind damage and to

[1]Department of Biology, Idaho State University, Pocatello, Idaho 83201 and Biota Research and Consulting, Inc., Box 2705, Jackson, Wyoming 83001.
[2]Biota Research and Consulting, Inc., Box 2705, Jackson, Wyoming 83001.

Fig. 1. Photograph of kymograph-smoked track station used by a prairie dog. Scent stake is coated with liver/sardines.

maximize dispersal of odors and sounds. Each station was checked early each morning for nocturnal tracks and again in evenings for diurnal tracks for several consecutive days. Baits, scents, and kymograph paper were replaced and soil resifted as needed.

Linhart and Knowlton's (1975) track stations consisted of a 1-m diameter circle of freshly sifted fine dirt 1 cm deep and scented and baited with specially prepared tabs or our lures.

Results

We accumulated 264 kymograph and 112 sifted dirt track stations days (1 track station day was 1 track station in operation for 24 hrs) on 24 different prairie dog colonies. A variety of animals left track impressions on both kinds of stations; they were: long-tailed weasels, skunks (*Mephitis mephitis*), kit foxes (*Vulpes velox*), coyotes (*Canis latrans*), badgers, mice (*Peromyscus* sp., *Dipodomys* sp., *Onychomys* sp.), ground squirrels (*Spermophilus* sp.), prairie dogs, unidentified passerine birds, and numerous insects.

As a substitute for the rarest carnivore on prairie dog towns, the black-footed ferret (*Mustela nigripes*), we presented kymograph track stations to Steppe ferrets (*M. eversmanni*) in laboratory conditions and they locomoted on them.

Discussion

The utility of the kymograph and sifted dirt track stations depended on the target species sampled, the quality and permanence of visitation record sought, and field conditions encountered. Kymograph stations required about 4 minutes each to prepare, in a sheltered location, and about 5 minutes to set out. This type of station was most effective in low humidity and low to moderate winds—where stations might be effective 3–5 days before needing new smoked paper. Concerns that the kerosene odor and unfamiliar substrate texture might deter all wild species was not substantiated.

The sifted dirt stations required less time and equipment to establish and were easier to replace, but tracks were sometimes indefinite and harder to positively identify than with kymograph tracks. Photography was the only method to permanently record these tracks.

No scats or urinations were found within the track station areas. We never observed a carnivore at a track station during nearly continuous nighttime surveys, even though tracks indicated their visitations.

We think our track station method has utility in surveying site-specific areas, especially if camera monitoring of animal visits as described by Dodge and Synder (1960) and Loveless et al. (1963) were added to our system. Our technique, as suggested by Clark (1977, 1978) and Clark and Campbell (1980), may offer a valuable addition to traditional survey methods for some rare species like the black-footed ferret. Since its efficacy has been demonstrated, needed now are follow-up quantitative experimental studies on the value of the kymograph track station.

Acknowledgments

We thank those organizations who supported our field studies during which our track station method was tried—National Audubon Society, National Geographic Society, Defenders of Wildlife, U.S. Bureau of Reclamation, Cleveland Cliffs Iron Co., and Mid-American Pipeline Co. Denise Casey and John Weaver provided critical advice on the manuscript. Wildlife Preservation Trust International and the New York Zoological Society Animal Research and Conservation Center provided support for manuscript preparation.

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EVALUATION OF *DRABA OLIGOSPERMA*, *D. PECTINIPILA*, AND *D. JUNIPERINA* COMPLEX (CRUCIFERAE)

Robert W. Lichvar[1]

Abstract.— Since *Draba pectinipila* Rollins was described in 1953, it has been assigned to several different taxonomic categories. It has been recognized at the species and variety level and has also been placed in synonymy under *D. oligosperma* Hook. Then Dorn (1978) described *D. juniperina* and contrasted it to *D. pectinipila* and *D. oligosperma*. To clarify the status of these three taxa, the evaluation included field and herbarium observations and scanning electron microscope studies.

A proposal to give *Draba pectinipila* Rollins protection under the Endangered Species Act prompted extensive field studies on this and two closely related taxa. Rollins (1953) described *D. pectinipila* from the alpine habitat of Clay Butte, Park County, Wyoming. It is now known from two other alpine locations in British Columbia and Colorado. Since this taxon was described, it has been assigned to several different taxonomic categories. Before further action could be taken to protect the plants, the taxonomic status had to be reevaluated.

Hitchcock (1964) gave *Draba pectinipila* varietal status under *D. oligosperma* Hook. His only comment was that this variety was the only fairly distinct variant for the species. Mulligan (1972) placed it in synonomy under *D. oligosperma* without making field observations. Then Dorn (1978) described plants from the low elevation areas near the Utah-Wyoming border, mentioned by Rollins (1953) under *D. pectinipila*, as *D. juniperina*. To clarify the taxonomy of this species complex, *D. pectinipila* and *D. juniperina* are compared to one another and to *D. oligosperma*.

Methods

This analysis of *Draba oligosperma*, *D. pectinipila*, and *D. juniperina* included field and herbarium observations and scanning electron microscope (SEM) studies. Field observations included habitat, plant aspects, and flowering dates. Herbarium specimens were studied for shape, and scape characteristics. The herbarium analysis was done at the

Table 1. Character differences between the three *Draba* species.

Character	D. oligosperma	D. pectinipila	D. juniperina
Habitat	exposed rocky slopes and ridges	alpine slopes	pinyon-juniper woodlands
Scape pubescence	glabrous	pubescent	pubescent
Scape height	1–4 (9) cm	(4) 5–9 (11) cm	(5) 7–15 cm
Mature fruit pedicel length	0.1–0.5 (1.0) cm	0.5–1.2 (1.4) cm	0.5–1.0 cm
Petal color	yellow	yellow	yellow
Silique tip	mostly rounded	tapered	tapered
Silique base	rounded	rounded	tapered
Style length	0.1–1 mm	0.3–0.8 mm	0.6–1.5 mm
Flowering dates	May–July	July–August	April–May
Basal leaf trichomes	fine	medium	coarse
Valve trichomes	simple (90% +)	doubly pectinate (90% +)	doubly pectinate (90% +)
Distribution	Western U.S. and Canada	British Columbia, Wyoming, Colorado	Wyoming, Colorado, Utah

[1]Wyoming Natural Heritage Program, Nature Conservancy, 1603 Capitol Avenue, Room 325, Cheyenne, Wyoming 82001.

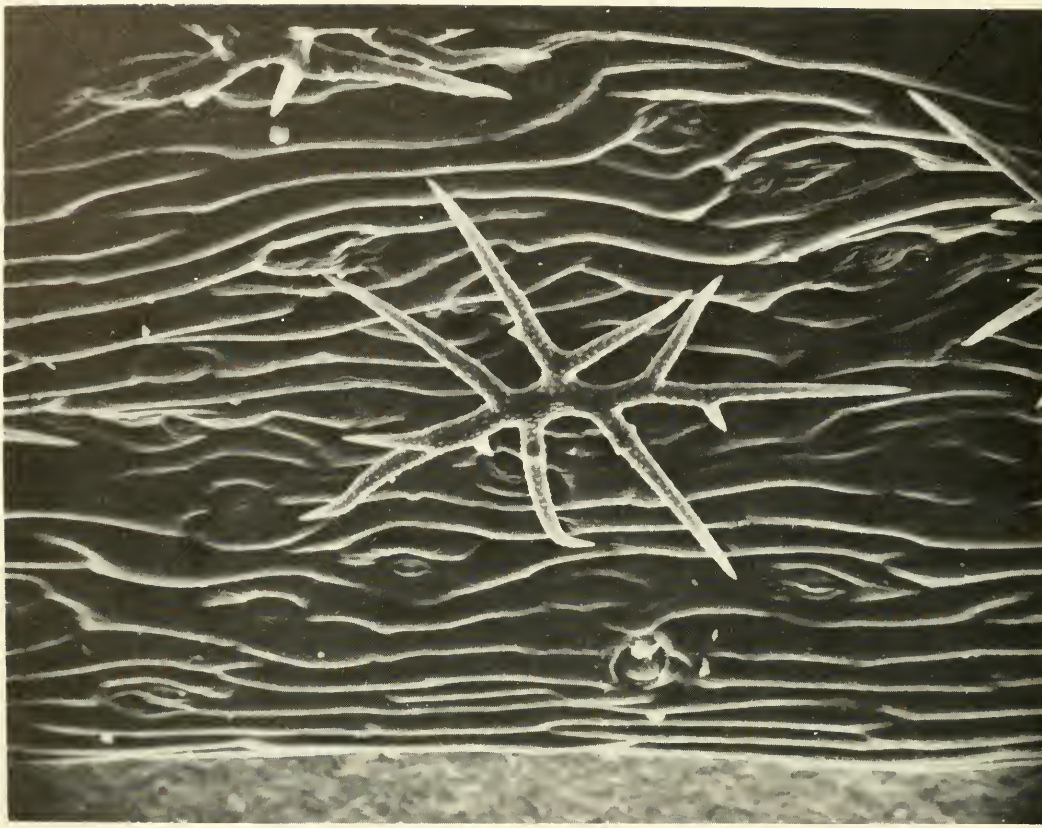

Fig. 1. Leaf trichome of *Draba pectinipila* X200 (*Lichvar 2066*).

Rocky Mountain Herbarium, Laramie, Wyoming; the Gray Herbarium, Cambridge, Massachusetts; and the University of Colorado Museum, Boulder, Colorado. The following specimens were most pertinent to this study: At RM: Dawson, s.n.; McCoun, s.n.; Dorn, 897; Nelson, 1223; Lichvar, 2066; Johnston, 1424, 1442A, 1434; at GH: Rollins and Porter 51269; Williams, 476; at COLO: Beaman and Erbisch, 1208, 1276; Johnston, 1273, 2314; Calder, Savile, and Ferguson, 13780.

Results and Discussion

Comparison of field observations, herbarium, and SEM analysis showed considerable differences between taxa in this complex. These taxa have overlapping ranges with areas of sympatry. Of the three taxa, *Draba oligosperma* has the widest range and is the most variable in habitat specificity. *Draba oligosperma* occurs from lower basin areas to high alpine ridges on either sandstone or limestone formations. *Draba pectinipila* is always found on limestone in an alpine habitat, and *D. juniperina* is found on sandstone formations in association with a pinyon-juniper woodland at lower elevations. When *D. oligosperma* and *D. pectinipila* are sympatric, *D. pectinipila* is readily identifiable in the field by its taller, more erect stature and the high percentage of pectinate hairs on the fruit valves. Near the Flaming Gorge area of Wyoming, Utah, and Colorado, *D. juniperina* is not found in the same habitat as *D. oligosperma*. *Draba oligosperma* occurs on sandstone or gravelly outwash ridges and outcrops, but *D. juniperina* is almost always found in association with pinyon-juniper woodlands or adjacent sagebrush that overlies a sandstone formation.

Certain characteristics separate *Draba pectinipila* and *D. juniperina* from *D. oligosperma* (Table 1). The correlation of characters that are similar between *D. pectinipila*

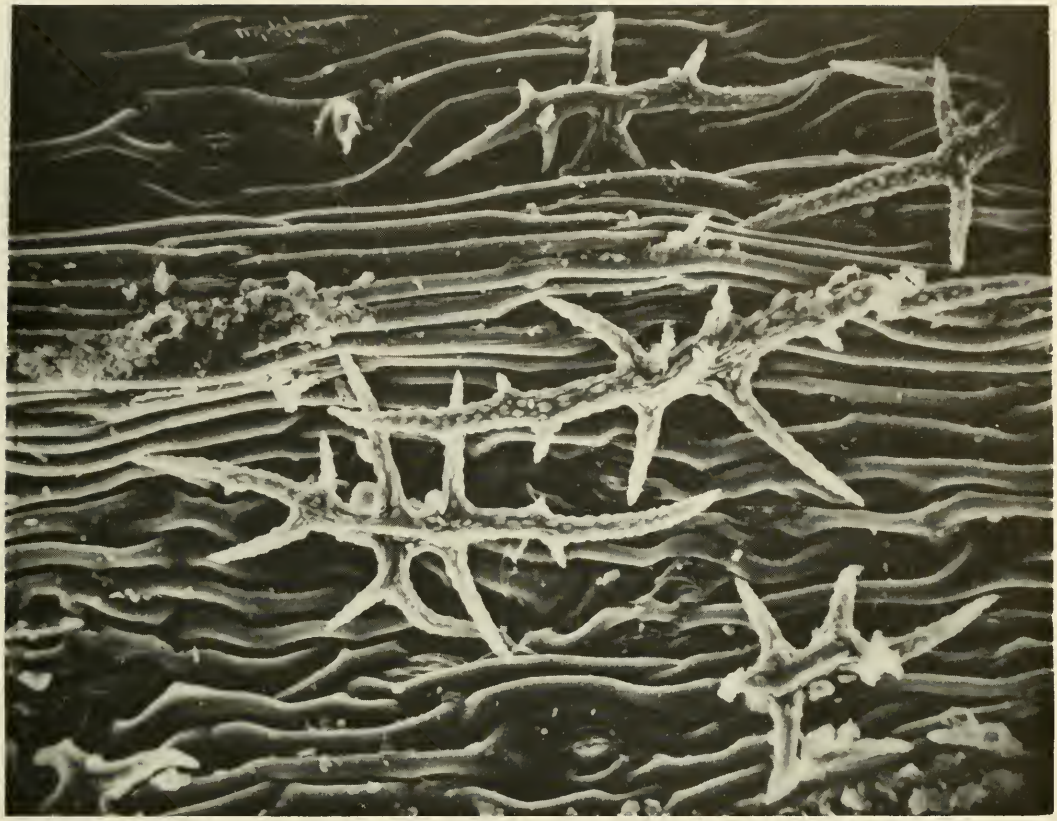

Fig. 2. Leaf trichome of *Draba oligosperma* X200 (*Lichvar 1981*).

and *D. juniperina* are the tapered fruit tips with doubly pectinate hairs on the valves of the fruits and the taller scapes that are pubescent. *Draba oligosperma* has rounded fruit tips with mostly simple hairs and shorter scapes that are glabrous. To distinguish between the two taxa with a more limited distribution, *D. pectinipila* and *D. juniperina*, habitat, style length, and leaf trichomes may be used. *Draba pectinipila* is an alpine taxon found on limestone and has tapered fruits above with styles 0.3–0.8 mm long, but *D. juniperina* is found at lower elevations in the basins on sandstone in a pinyon-juniper woodland and has tapered fruits above and below, and styles 0.6–1.5 mm long.

Rollins (1953) noted that the lower elevation taxon, *Draba juniperina*, had not only tapered fruits above and below but also coarse hairs on the basal leaves. Scanning electron micrographs (Figs. 1, 2, 3) show that *D. juniperina* (Fig. 3) has doubly pectinate leaf hairs twice the diameter of *D. pectinipila* (Fig. 1). *Draba oligosperma* (Fig. 2) is intermediate in leaf trichome diameter.

Recognition of each of these species can be justified at the species level for three reasons. First, specimens or plants of each of these taxa can consistently be separated in either the field or herbarium. Second, when any combination of these species occurs sympatrically in the field they are easily and consistently identifiable. Finally, based upon trichome characters, those used to distinguish these species are consistent with those used throughout the genus of *Draba*.

Key to the Species

1. Scapes glabrous; 1–4 (9) cm long; fruits with 90 percent or more simple hairs ... . *D. oligosperma*

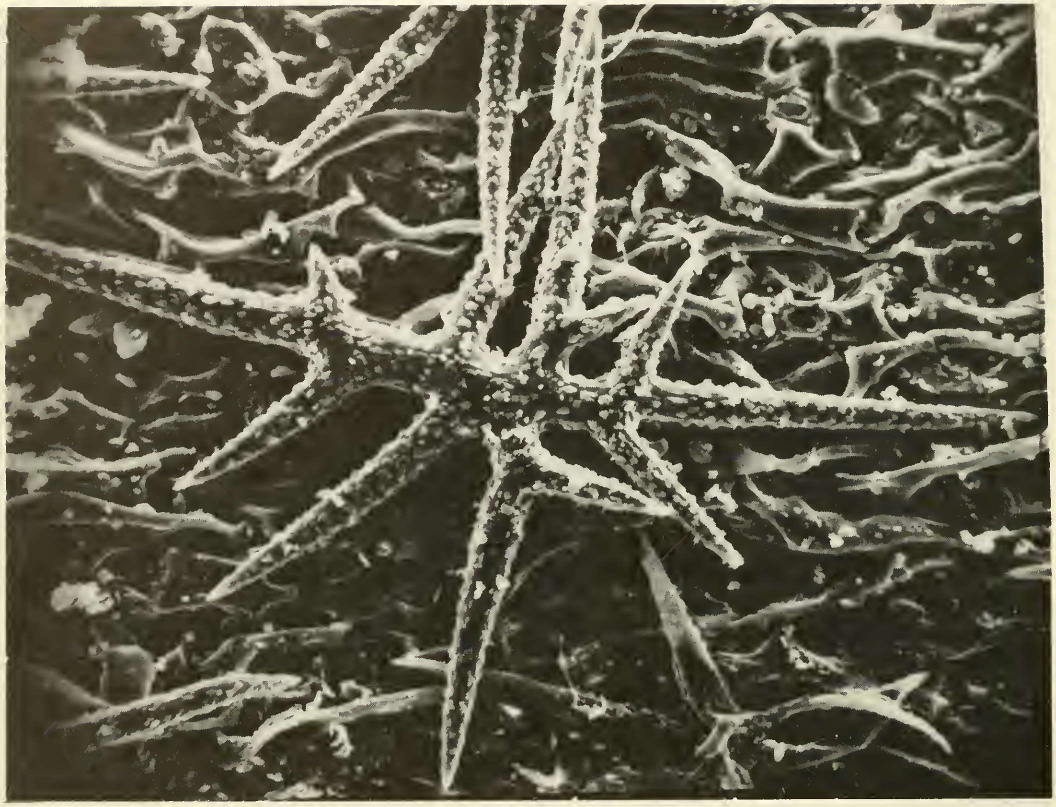

Fig. 3. Leaf trichome of *Draba juniperina* X200 (*Lichvar 2821*).

— Scapes pubescent, 4–12 cm long; fruits with 90 percent or more doubly pectinate hairs 2

2(1). Plants alpine with fine hairs on basal leaves; siliques tapered above, rounded below; styles 0.3–0.8 mm long .... *D. pectinipila*

— Plants of pinyon-juniper woodlands with coarse hairs on basal leaves; siliques tapered above and below; styles 0.6–1.5 mm long .... *D. juniperina*

Acknowledgments

Thanks are extended to Robert Dorn for reviewing the manuscript, to Robert Bowmen for doing the SEM work, and to the curators of the collections mentioned above for allowing me to study specimens in their herbaria.

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PRESENCE OF MAXILLARY CANINE TEETH IN MULE DEER IN UTAH

Jordan C. Pederson[1]

Abstract.— A hunter-harvested adult female mule deer (*Odocoileus hemionus*) was found to have canine teeth present along both rows of teeth of the maxillae.

The reported occurrence of erupted canine teeth in mule deer (*Odocoileus hemionus*) has been observed in California (Nordquist 1941), Utah (Robinette 1958), and Colorado (Robinette et al. 1977). The Utah incident occurred in a three-year-old male having a single erupted canine in the right maxilla (Robinette 1958).

On 27 November 1982, a hunter-harvested 4-year-old female mule deer was checked and collected by me. She was killed near Indianola in the Little Clear Creek drainage in Utah County. The presence of upper maxillary canine teeth on both sides was observed when the jaw was cut for field aging (Fig. 1). The head was removed from the carcass and, after cleaning and photographing, donated to the Brigham Young University Life Science Museum, Provo, Utah, Catalog no. 7225.

The following skull measurements were taken: total length 291 mm, condylobasal length 272 mm, zygomatic breadth 128 mm. Both maxillary canines are found posterior to the nasomaxillary suture identical to the position of canines found in elk (*Cervus canadensis*). Further measurements showed each

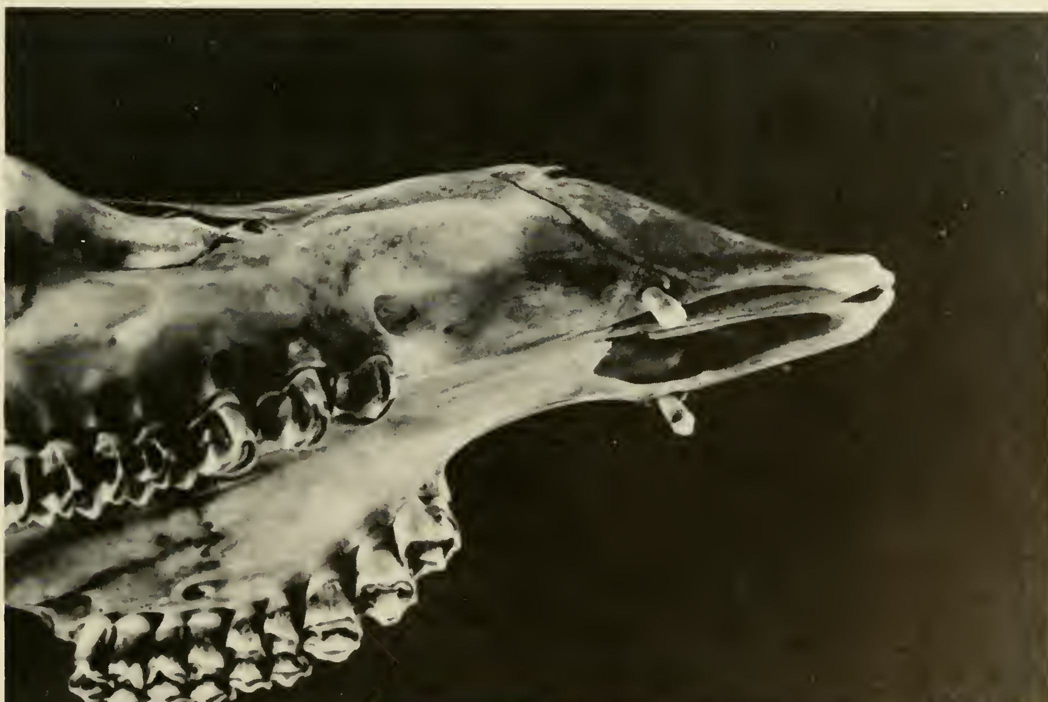

Fig. 1. Palatal view of a mule deer skull showing canine teeth on maxillae.

[1]Utah Division of Wildlife Resources, 1115 North Main, Springville, Utah 84663.

canine is positioned 46 mm posterior of the anterior point of the premaxilla and 43 mm anterior of the premolar. Measurements of the left and right canine, respectively, are: length of outside (labial), exposed part, 9.2, 9.9 mm; anteroposterior diameter of crown, 4.9, 5.1 mm; labial lingual diameter of crown, 3.8, 4.0 mm.

ACKNOWLEDGMENTS

Thanks are extended to Dr. Jerran T. Flinders, Dr. Kent M. Van De Graaff, Dennis L. Shirley, and Laura John for their help in the preparation of this manuscript.

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COMPARATIVE SUCCESSIONAL ROLES OF TREMBLING ASPEN AND LODGEPOLE PINE IN THE SOUTHERN ROCKY MOUNTAINS

Albert J. Parker[1] and Kathleen C. Parker[1]

Abstract.— A review of the ecological distribution and successional roles of lodgepole pine and trembling aspen in the Southern Rocky Mountains suggests that the two species have different strategies for occupying disturbed sites. Lodgepole pine's easily dispersed seeds and faster growth from seed in unsuppressed conditions allows it to colonize severe burns, even from remote seed sources. Aspen appears to compensate for ineffective development from seed by vegetative reproduction from durable root stocks, which promotes geographic persistence. Such persistence is achieved by the maintenance of a forest structure conducive to light surface fires, which stimulate suckering and retard conifer invasion, and by the accumulation of soil organic matter, which improves site nutrient retention and water availability.

Empirical studies of the dynamics of trembling aspen (*Populus tremuloides*) and lodgepole pine (*Pinus contorta* ssp. *latifolia*) forests show that both tree species commonly colonize open sites following disturbance (Clements 1910, Ives 1941, Stahelin 1943, Marr 1961, Langenheim 1962). In portions of the upper montane and subalpine zone (2,400–3,000 m) of the Southern Rocky Mountain region, the geographic and habitat ranges of these two important colonizers overlap, so that either species (or both) might be encountered on a disturbed site. Within this zone of cooccurrence, neither the site preferences of nor the successional relationship between these two species is satisfactorily detailed (Marr 1961, Peet 1981). Regarding habitat range, early workers thought that aspen more frequently occurred on mesic sites, and lodgepole more commonly occupied drier settings (Bates 1924, Daubenmire 1943). More recently, Marr (1961) and Peet (1978) have questioned the simplicity of this arrangement. Peet (1978) asserts that both species possess a comparable ecological optimum on mesic sites in the lower/middle subalpine zone, as evidenced by the distribution of aspen in mountainous regions where lodgepole is absent. He observed that, in regions where both species occur, lodgepole is a better competitor than aspen on prime sites and therefore tends to preempt aspen from optimal settings. Aspen maintains populations in this region of cooccurrence by possessing a broader environmental tolerance range, often being restricted to a variety of both wetter and drier sites at higher and lower elevations than lodgepole.

The successional relationship of the two species in this region of cooccurrence is complex (Moir 1969, Reed 1971, 1976, Whipple and Dix 1979, Peet 1981). Differences in their respective patterns of colonization are likely related to a number of factors, chief among which is the fundamental dissimilarity in their reproductive strategies. Lodgepole is a prolific seeder, depending on widespread wind dispersal of its light seeds to facilitate invasion of disturbed sites. Aspen, although it is capable of reproduction by seed, more often reproduces by vegetative suckering. Marr (1961) observed that aspen roots often survive fire, thus providing a stock for vegetative propagation on burned sites. Furthermore, both Marr (1961) and Peet (1981) noted that aspen is often found in the understory of a variety of different forest covers, including dense, mature conifer forests. Thus, aspen is able to maintain a suppressed but viable population on a site through long periods of time, and is capable of colonizing burned sites by the release of the persistent rock stock. Horton and Hopkins (1965), in an examination of fire ecology in aspen groves, found that light burns (i.e., low temperatures) stimulate aspen suckering (probably through

[1]Department of Geography, University of Georgia, Athens, Georgia 30602.

both the reduction of competition with the thick ground layer and mobilization of the nutrient supply tied up in the ground layer vegetation), but heavy burns (i.e., high temperatures) inhibit aspen suckering (presumably through damage to perennating organs in the root stock). Heavy burns are likely to enhance the establishment of lodgepole pine on disturbed sites, because they create a mineral seedbed and eliminate much of the ground layer vegetation that might normally inhibit development from seed of lodgepole pine. Hence, postburn colonization of sites by either aspen or lodgepole in their zone of cooccurrence is influenced by their respective reproductive modes and ecological tolerances of environmental factors, by burn intensity, and by a chance element (Marr 1961) associated with the probability/proximity of a lodgepole seed source or an aspen rootstock.

The present study presents a review and interpretation of both the habitat ranges and successional relationship of lodgepole pine and trembling aspen in the Colorado Front Range. This discussion is accompanied by a data set examining the age/size structure and community characteristics of an abrupt aspen/lodgepole ecotone on the south flank of Bierstadt Moraine in Rocky Mountain National Park, Colorado.

Bierstadt Moraine is a lateral moraine of approximately 200 m relief, deposited by alpine glaciers during the late Wisconsin glacial maximum (Pinedale stage, Richmond 1960). Bierstadt Moraine trends slightly north of east, extending for approximately 6 km along the northern margin of the Glacier Creek valley from Bear Lake to near Glacier Basin Campground. The dominant particle size in the till is sand (exceeding 70 percent of the total fine earth fraction); soils developed under both aspen and lodgepole forests are immature (typic Cryorthents), although there are distinct differences in the A-horizon under each cover type. A transect down the south-facing slope of Bierstadt Moraine from top to bottom reveals the following sequence of plant communities: lodgepole pine forest on the gently rolling upland, sagebrush (*Artemisia* ssp.) scrub on the steep upper slope, aspen forest on the middle slope, and lodgepole pine forest on the lower slope and throughout the adjacent valley bottom. The ecotone studied is between the aspen forest and the lower lodgepole forest, at an elevation of 2,700 m.

The study area is located within a much larger region (perhaps 10 km^2) which was burned by the Bear Lake fire of 1900 (Peet 1981). None of the trees cored on the study site is older than this burn, so that the modern forest is representative of postburn recovery dating three-quarters of a century from this extensive fire.

METHODS

Seven 4 × 60 m belt transects were placed with their long-axis oriented normal to elevation contours and the aspen/lodgepole ecotone. Each transect was subdivided into six 4 × 10 m quadrats and placed so that three of these quadrats were under aspen cover and three were under lodgepole cover. Although precise location of the "boundary" between types is subjective, in this case abrupt differ ences in both litter type and ground cover were used to determine the midpoint of the belt transect. Belt transects were spaced along the flank of the moraine at intervals of 60 m. In each quadrat, all living trees (stem DBH $>$ 6.25 cm) were identified to species and their diameter recorded. All saplings (0 $<$ stem DBH $<$ 6.25 cm) and seedlings (stems less than breast height) in each quadrat were counted by species. All standing dead stems in each quadrat were counted by species. Along the central long axis of each belt transect, the coverage of all herbs and shrubs was determined in 10-m intervals by the line-intercept method (Canfield 1941). In two of the seven belt transects a radial core was extracted from each tree (at 0.3 m height) with an increment borer, and the tree's age determined. Measurements of slope aspect, steepness, and configuration were taken for each 4 × 10 m quadrat. In two of the belt transects, the type and depth of litter was measured, using a point-frame, at the center of each 4 × 10 m quadrat. The point-frame was 1 m wide, with a 5 cm recording interval; hence, there are 21 litter measurements per quadrat. In addition, two soil pits were dug, one under each cover type, and the soil profiles were described.

TABLE 1. Vegetation data by forest type.

Characteristic	Lodgepole cover		Aspen cover	
	Lodgepole	Aspen	Lodgepole	Aspen
Tree density (stems•ha^{-1})	2420	430	100	2800
Stand basal area dm^2•ha^{-1})	2280	170	140	1910
Mean diameter (cm•stem^{-1})	15.5	10.2	19.5	13.2
Sapling density (st•ha^{-1})	290	190	80	540
Seedling density (st•ha^{-1})	10	210	20	3870
Standing dead density (st•ha^{-1})	250	920	10	2510

RESULTS

The aspen forest on the south flank of Bierstadt Moraine is on a slightly steeper slope than the lodgepole forest (15° vs. 12°), fingering to lower elevations along local convexities of the slope face.

The principal difference in the soil profiles under each cover type is the presence of a dark brown (10 YR 3/2) surface mineral horizon, approximately 10 cm thick, under the aspen forest. This darker topsoil, which is absent under lodgepole, is indicative of higher organic matter content associated with humification of the deciduous aspen leaves and litterfall from the thick ground layer vegetation (cf Hoff 1957, Tew 1968). Hydrometer analysis (Bouyoucos 1962) of soil material collected from varying depths in both profiles revealed no meaningful differences in texture with depth or between profiles, all samples being coarse sandy loams. This texture, which normally would permit only low water retention and rapid leaching of cations, imparts increased significance to the organic buildup in the A-horizon under aspen (Morgan 1969), in that organic colloids increase the water retention capacity and the cation (or nutrient) exchange capacity of the aspen soil relative to the lodgepole soil.

The ground layer of the lodgepole forest was poorly developed, with 3 percent ground coverage divided evenly between herbs and woody shrubs. The aspen forest ground layer was well developed (58 percent ground cover) and almost exclusively herbaceous. Such differences between aspen and conifer ground layer development have been reported elsewhere (Hoff 1957, Marr 1961, Peet 1981) and apparently result from a combination of the high acidity of conifer litter (Daubenmire 1953) and increased light penetration to the forest floor under aspen (particularly in the spring prior to aspen leaf flush).

Under the lodgepole cover, tree density was 2,850 stems•ha^{-1}; lodgepole pine accounted for 84.9 percent of this total (Table 1). Under the aspen cover, tree density was 2,900 stems•ha^{-1}; aspen accounted for 96.6 percent of this total. Similarly, under lodgepole cover, stand basal area was 2,450 dm^2•ha^{-1} (93.1 percent lodgepole); under aspen cover, stand basal area was 2,050dm^2•ha^{-1} (93.2 percent aspen).

Little evidence of invasion by more tolerant tree species over the last 75 years exists. The only other tree species encountered were

TABLE 2. Cross transect patterns of mean tree basal area and understory representation by species.

Cover	Quadrat	Species	Mean tree Basal area (dm^2•stem^{-1})	Number of saplings and seedlings	Number of standing dead
Lodgepole cover	1	Lodgepole	1.74	10	9
		Aspen	*0.47*	9	*12*
	2	Lodgepole	1.68	5	5
		Aspen	*0.37*	*10*	9
	3	Lodgepole	2.34	10	7
		Aspen	*0.89*	*15*	*56*
--Ecotone--					
Aspen cover	4	Lodgepole	2.52	3	0
		Aspen	*1.21*	*121*	92
	5	Lodgepole	1.47	2	0
		Aspen	*1.45*	*125*	*60*
	6	Lodgepole	4.91	4	1
		Aspen	*1.47*	*124*	59

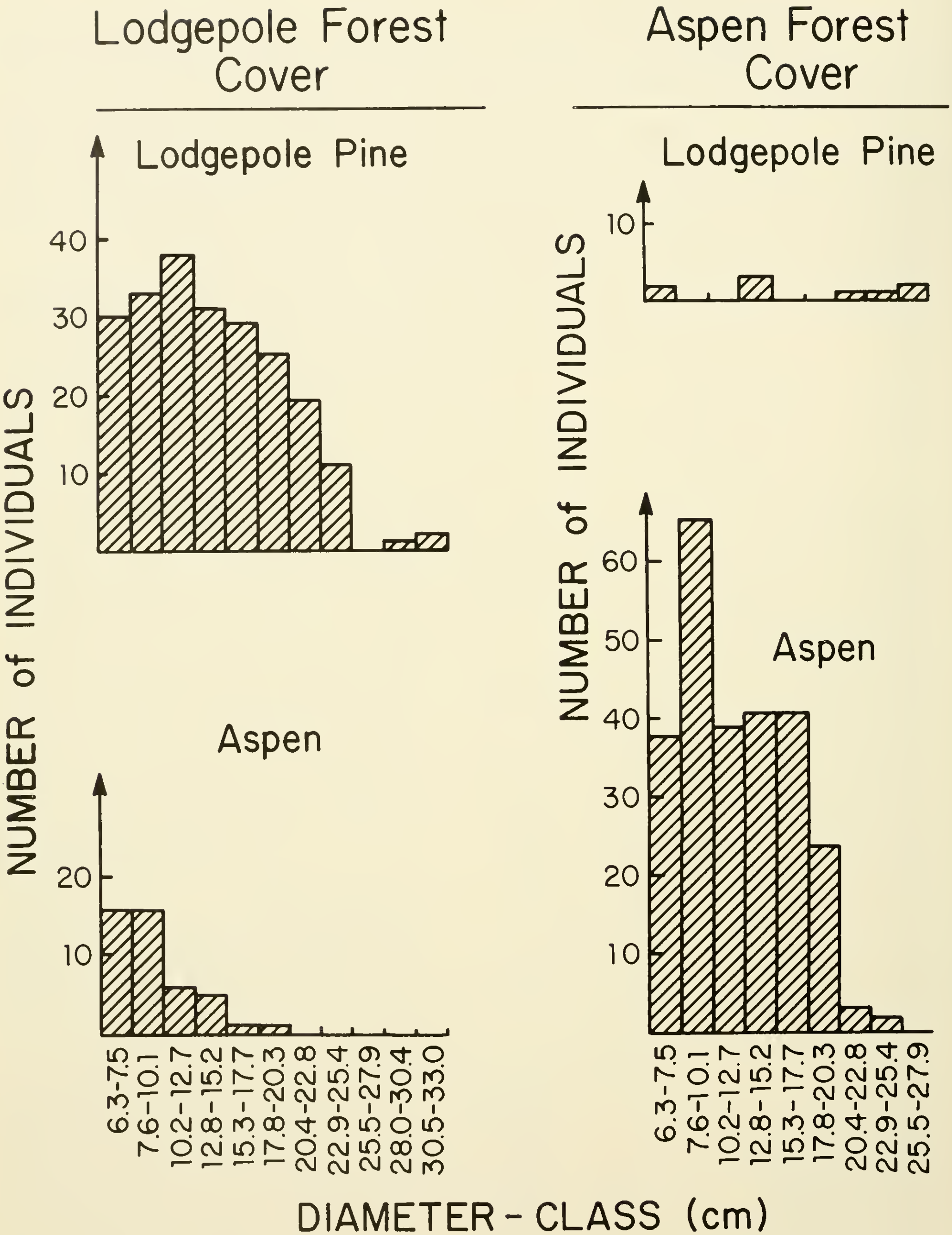

Fig. 1. Diameter-class distribution by forest cover. Histograms of stem number by diameter class for both lodgepole pine and aspen under each forest cover are depicted (diameter class interval = 2.54 cm). The number of stems in the smallest diameter class (6.3–7.5 cm) has been doubled to adjust for its half-interval width.

willow (*Salix* spp.), with two saplings present in a quadrat adjacent to the valley bottom, and Douglas-fir (*Pseudotsuga menziesii*), with a single seedling found under aspen.

Cross transect trends in the number and size of aspen and lodgepole (Table 2) demonstrate that lodgepole pine is infrequently encountered under aspen cover, but, where

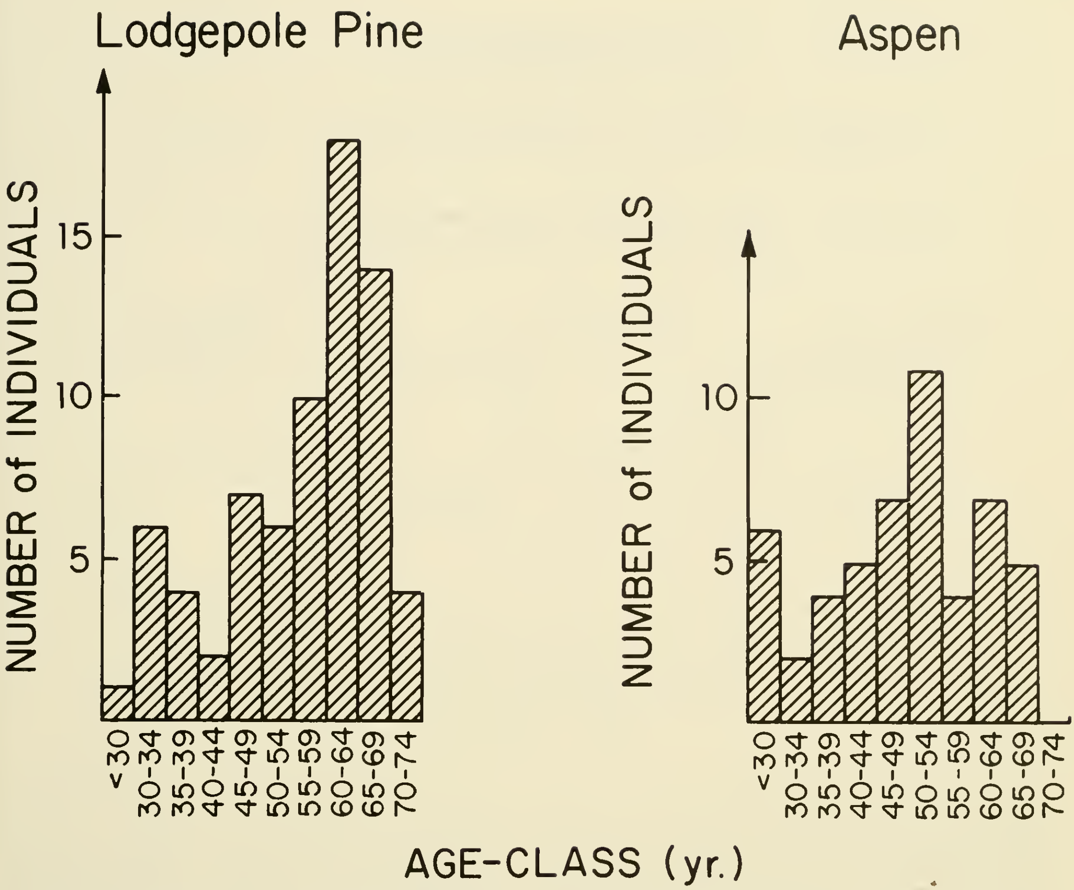

Fig. 2. Age-class distribution of lodgepole pine and aspen in cored transects. Histograms of the stem number by five-year age class intervals are shown for each species.

present, trees are generally large. Conversely, aspen is commonly encountered beneath lodgepole, although these trees are generally small. This pattern is more emphatically expressed in the understory; aspen saplings, seedlings, and standing dead stems (chiefly aborted suckers) are much more common under lodgepole cover than lodgepole is under aspen cover. The high number of aspen seedlings and standing dead stems under lodgepole cover is indicative of a successional strategy that relies on maintenance and gradual spread of the aspen root stock into the understory of adjacent conifer forests. The trend in mean tree diameter and in the number of both understory and dead stems across the transect clearly demonstrates the progressive spread of aspen across the ecotone (Table 2). The mean tree diameter of aspen and the total number of understory and dead aspen stems steadily decline away from the aspen grove.

The collection of 72 lodgepole pine and 51 aspen tree cores was used to correlate age with stem diameter. Both species exhibited a comparable age-diameter relationship, the coefficient of variation of age (lodgepole = 0.22, aspen = 0.25) being less than the coefficient of variation of diameter (lodgepole = 0.38, aspen = 0.41) in each case. Furthermore, age was significantly correlated with diameter for each species (for aspen $r = 0.654$, $p < 0.001$; for lodgepole $r = 0.665$, $p < 0.001$). Lodgepole pine displayed a somewhat stronger tendency toward even-agedness than aspen, although both species exhibited unbroken representation in age ranges between 30 and 75 years. Fifty percent of the lodgepole stems were in the 60-to 75-year age range, suggesting colonization

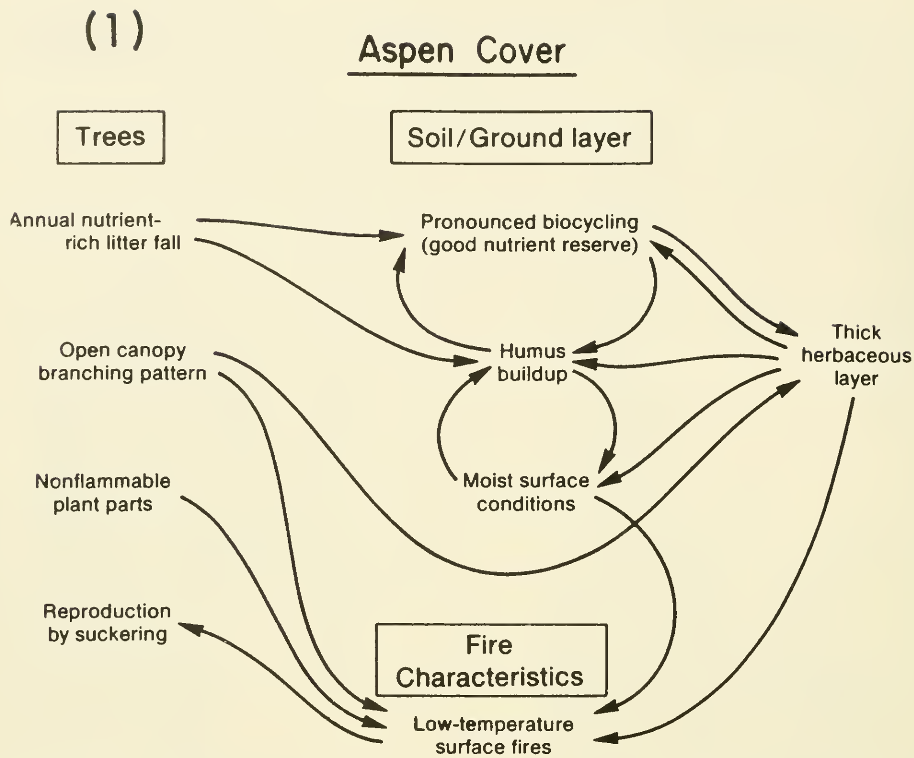

Fig. 3. Diagrammatic representation of the interactions among the dominant tree species, soil, ground layer vegetation, and fire characteristics under aspen and lodgepole pine forest cover.

immediately following the Bear Lake burn, and the maximum concentration of aspen stems (42 percent) occurred in the 45- to 60-year range (Fig. 1). The unsuppressed diameter growth rate of each species was determined using the 10 largest lodgepole and aspen trees cored. Our data reveal that following successful establishment unsuppressed lodgepole pine grows more rapidly than aspen (0.37 cm yr^{-1} vs. 0.32 cm yr^{-1}) on the study site. It should be cautioned that the period of establishment is generally several years longer for lodgepole pine produced from seed, which may require from 3 to 20 years to reach 0.2 m height (Romme and Knight 1981), than for aspen suckers, which may reach 3 m or greater height in 6 to 8 years (Jones and Trujillo 1975).

The composite diameter class diagram (Fig. 2), which is based on all seven belt transects and presented by cover type, does not show a tendency for concentration of lodgepole pine in larger size-classes even though many lodgepole trees are relatively old, suggesting that older lodgepole stems may persist as suppressed individuals following postburn colonization for a lengthy period. Examination of these diameter-class diagrams reiterates that aspen is a fairly common understory tree beneath lodgepole forests, but only a few generally large-sized lodgepole individuals are scattered throughout the aspen canopy.

Discussion

The soil profile and age structure differences between aspen and lodgepole pine stands suggest that each species, where dominant, reinforces a distinct group of vegetation-soil-fire interactions (Fig. 3). Furthermore, the persistence of these cover types appears to be more closely tied to stand history than to direct environmental gradients.

Under aspen cover, the deciduous, nutrient-rich foliage of aspen (Daubenmire 1953) and the dense herbaceous understory combine to enhance nutrient cycling and humifi-

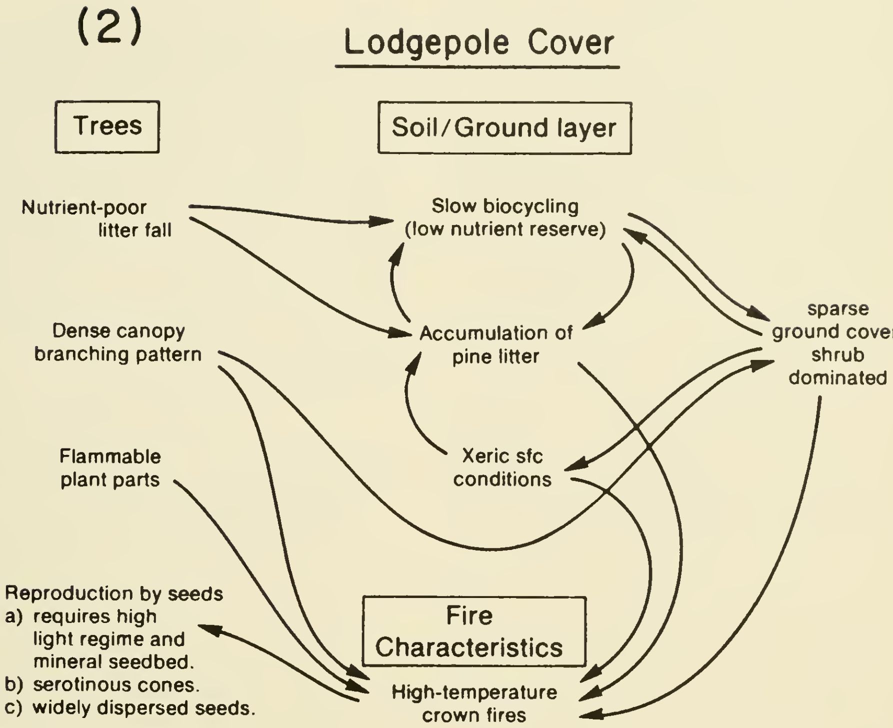

Fig. 3 continued.

cation, resulting in an increased cation exchange capacity and nutrient concentration in surface mineral horizons (Hoff 1957). The increased soil water retention conferred by the humus accumulation acts in concert with the ground cover (which buffers soil surface temperature and decreases windspeed, thus reducing evaporation) to increase the availability and effective use of soil moisture. Hence, aspen maintains a broad habitat range by direct enhancement of soil nutrient and moisture status (Lutz and Chandler 1946). On the contrary, the acidic lodgepole pine needles promote leaching, and the paucity of ground cover under lodgepole pine limits biocycling of nutrients; consequently, soils under lodgepole pine are often impoverished relative to adjacent aspen substrates (Hoff 1957). In addition, the mechanical resistance of pine needles to decomposition results in a decrease in humification and the buildup of pine needle litter.

Fire plays a prominent role in the perpetuation of discrete populations of both aspen and lodgepole pine (Fig. 3). Aspen dominance is maintained on a site through stimulation of vegetative propagation following low-temperature surface fires, presumably through reduction of apical dominance (Daniel 1980). The buildup of surface fuels by the thick herbaceous layer, the mesicness of the ground layer, and the relative openness of the aspen canopy favor light-burning surface over crown fires (Horton and Hopkins 1965). Because of its suckering habit, aspen can sus tain and is capable of slowly expanding local populations vegetatively into adjacent favorable sites. The ability of aspen to sucker in relatively dense shade facilitates this spread. Continued aspen dominance on a site requires the perpetuation of a surface fire regime that releases advance regeneration (Marks 1974, Oliver 1981) and stimulates vigorous reestablishment of aspen suckers. In the absence of fire, eventual ascendance of more tolerant conifer species often does not preclude the persistence of the aspen root stock in a suppressed condition (Marr 1961). Dependence on the maintenance of a "parental" aspen root stock is necessary to offset the competitive superiority of lodgepole pine (and other conifers) when both species are established from seed, and favors persistent recolonization by aspen following light surface fires.

In lodgepole forests a denser canopy branching network, greater leaf area index, and a high resin production combine with a paucity of undergrowth to favor hot crown fires. By creating high surface light levels and mineralizing the litter layer, crown fires create a favorable seedbed for lodgepole pine establishment and trigger a wave of lodgepole pine regeneration that manifests itself in a tendency toward even-agedness in Rocky Mountain lodgepole forests. This contagious postburn colonization pattern is facilitated by lodgepole pine's lightweight, easily wind-dispersed seeds and rapid growth rate following seedling establishment on disturbed sites (allowing colonization from a remote seed source). Furthermore, colonization of severely burned sites by lodgepole pine is reinforced locally by partial core serotiny (Fowells 1965). In addition to favoring lodgepole establishment, severe burns inhibit aspen suckering, because most suckers develop from roots which are within 5 cm of the soil surface, and hence are easily killed in a hot fire (Daniel 1980).

The persistence of both aspen and lodgepole pine populations on sites with little evidence of successional alteration suggests that both species can be expected to maintain dominance for extended periods, in accordance with Egler's (1954) view of vegetation development. Only with prolonged fire exclusion are stands likely to be invaded and replaced by more tolerant conifers. Moreover, changes in dominance on a site appear to be related to the character of initiating disturbances (Henry and Swan 1974, Anderson and Holte 1981) and the differential reproductive habits of each species. A low-temperature surface fire regime favors the maintenance and gradual spread of aspen dominance by aggressive suckering. Stand-destroying crown fires open sites to rapid colonization by lodgepole pine, and repeated crown fires reinforce lodgepole pine dominance.

In summary, both trembling aspen and lodgepole pine are successful colonizer species in the southern Rocky Mountain region, although they accomplish colonization and persistence in different ways. Aspen perpetuates itself through time on suboptimal sites by its suckering habit that rapidly recolonizes lightly burned sites, by promotion of a favorable surface fire regime, and by enhancement of site quality through improved soil water and nutrient retention capacity. Lodgepole pine, which develops more rapidly from seed than aspen and has easily dispersed seeds, is able to preempt aspen on optimal sites, and exhibits a relatively even-aged, contagious colonization pattern following stand-destroying crown fires.

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DIFFERENTIAL UTILIZATION OF BAT BOXES BY HOUSE WRENS (*TROGLODYTES AEDON*)

Hal L. Black[1]

Abstract.— Pine boxes nailed to trees in four habitat types in southeastern Utah as roosting sites for bats proved ineffective for bats but were utilized by house wrens in all but one habitat. Boxes were most often utilized in the aspen habitat. Hypotheses to account for differential utilization are presented.

In late Fall of 1977, 35 rough-sawn, pinewood, day-roosting boxes for bats, constructed after the design of Stebbings (Quarterly J. Deven Trust for Nature 6:114–119, 1974) were placed in each of four habitat types on the Abajo Mountains of southeastern Utah in the hope of attracting several montane species of vespertilionid bats. The aspen forest habitat was within a watershed relatively ungrazed by livestock and had a rich understory of low-growing shrubs, forbs, and grasses. The oak-pine habitat, which is grazed annually by cattle, had, relative to the aspen, a poor understory and more heterogeneous structure. The cottonwood habitat was within a rather broad stream bed and was not grazed by livestock. The spruce-fir forest was also ungrazed and consisted of large mature trees, which formed a fairly closed canopy with essentially no understory vegetation. Permanent water was available within each habitat. Boxes were attached to tree trunks with nails at heights of 3–4 m and arranged in a zig-zag fashion within each habitat at 12–15 m intervals. Unlike traditional bird boxes, these had a slit entrance on the ventral side that measured about 25 × 175 mm.

As roosting sites for insectivorous bats the boxes were disappointing, but as nesting sites for house wrens (*Troglodytes aedon*) the boxes were immediately successful. Table 1 indicates by habitat and year the number of boxes from which young wrens were fledged. Hypotheses to explain the differential utilization of these boxes include: (1) differences in productivity of the understory vegetation and, therefore, insect biomass on which wrens feed and (2) differences in the availability of natural cavities for nesting. The aspen habitat appears to have the most productive understory and the most homogeneous forest structure. The importance of nest boxes in the aspen habitat suggests that removal of understory vegetation by grazing or through competitive processes may have a rather severe effect on the abundance and distribution of foliage gleaning species like the house wren. These data suggest that the addition of nest boxes to habitats may selectively enhance population densities.

Table 1. Summary of patterns of utilization of bat-roosting boxes by house wrens. The open number under each habitat indicates the number of boxes out of 35 that were used. The number in parenthesis represents percent of total.

	Habitat Type			
Year	Aspen (El. 2700m)	Oak-Pine (El. 2400m)	Cottonwood (El. 2400m)	Spruce-Fir (El. 3200m)
1977	10 (29)	2 (6)	0	0
1978	12 (34)	2 (6)	1 (3)	0

[1]Department of Multicultural Education and Department of Zoology, Brigham Young University, Provo, Utah 84602.

PLANT AND SOIL RELATIONSHIPS IN TWO HYDROTHERMALLY ALTERED AREAS OF THE GREAT BASIN

N. M. Milton[1] and T. L. Purdy[1]

Abstract.— In two areas of hydrothermally altered rocks in the Great Basin, the native vegetation differs in composition and areal cover from unaltered to altered sites on the same geologic formations. Analysis suggests that physical rather than chemical factors may be the cause of the vegetation differences, especially permeability of bedrock, depth and texture of soils, and, possibly, amounts and types of clay minerals present. These characteristics influence the ability of soils to absorb and retain water.

In the East Tintic Mountains, Utah, the soils from argillized or mixed argillized and silicified parent materials have more characteristics associated with dryness and support sparser vegetation and more species especially adapted to dry conditions than do soils from unaltered or silicified parent materials.

In Battle Mountain, Nevada, unaltered areas have greater vegetation cover and have soil depth and texture that are more favorable for plants than do altered areas. Soil pH is higher in altered areas than in unaltered areas.

Where geology is obscured by vegetation, as in the humid regions of the world, vegetation can be used as a clue to the underlying rocks and minerals. Changes in the vegetation along zones of mineralization have been recognized since ancient times and have been well documented in several recent reviews (Malyuga 1964, Rommel 1968, Nesvetailova 1970, Cannon 1971, Brooks 1972). The reasons for the vegetation differences should be found in the physical and chemical properties of the soils that develop on hydrothermally altered, locally mineralized rocks which differ from those of soils that develop on unaltered rocks.

Two previous workers have studied the vegetation in hydrothermally altered areas in the Great Basin of the western United States. Billings (1950) concluded from greenhouse experiments that acid conditions and deficiencies in nitrogen and phosphorus were responsible for the lack of sagebrush on altered sites in the Virginia Range near Virginia City, Nevada. Salisbury (1954, 1964) performed similar experiments at Big Rock Candy Mountain, Utah, and concluded that nutrients in acid soils (pH 3.3) were chemically bound by iron and aluminum and therefore were unavailable to plants. These studies describe extreme states, in which the soil pH is very low and the vegetation is drastically different from that on nearby unaltered rocks. In many other hydrothermally altered areas, altered soils have pH ranges comparable with those of unaltered soils, and vegetation differences are more subtle.

The most striking vegetation differences in the study areas described in this report are on sites of intermediate alteration intensity, whereas the unaltered and the most intensely altered sites have more similar vegetation. Since intensely altered sites have been subjected to more leaching than intermediate sites, nutrient deficiencies and toxicities would seem to be ruled out as likely causes of the vegetation differences. The most common limiting factor of plant growth in arid and semiarid areas is water. Infiltration and water retention are closely related to soil depth, soil texture, i.e., the distribution of different-sized particles in the soil, and the type of clay minerals in the soil (Black 1968, Foth and Turk 1972). For the present study, the hypothesis of drier soil conditions in areas of intermediate alteration intensity was tested by examining soil characteristics on altered and unaltered sites and by comparing the vegetation distribution with that found by other workers in similar terrain.

Study Areas

Two study areas in Utah and Nevada were chosen to coincide with areas of ongoing re-

[1]Mailstop 927, U.S. Geological Survey, Reston, Virginia 22092.

search in the use of remote sensing techniques to identify hydrothermally altered rocks. The Utah study area has been used as a test site for mapping hydrothermally altered rocks from high altitude and satellite imagery (Rowan and Abrams 1978a, b, Rowan and Kahle 1982). Krohn et al. (1978) used Landsat imagery to detect hydrothermally altered rocks at the Nevada study area. Both areas were found to be at the limit beyond which limonitic hydrothermally altered rocks could not be detected through the plant cover by the remote sensing techniques used. For this reason they were considered ideal sites for devising a method to detect altered rocks by using differences in vegetation.

Emplacement of intrusive bodies during the Tertiary resulted in alteration of host rocks to form several types of altered rocks. Argillic and silicic alteration are the most common types in the study areas, and are the only types included in this study. In general, the acidic hydrothermal fluids followed faults and fractures in the rocks. The mineralizing fluids changed in composition away from the source, which resulted in a gradual decrease in alteration along the path of the fluid. Another change that took place outward from the path resulted in a gradation of alteration away from the conduit. These changes produced a zonation of altered rocks. Silicified rocks are closest to the conduit and the source and are surrounded by argillized rocks, beyond which is an area of gradual transition to unaltered rock. Widths of zones vary and can range from a few meters to several hundred meters (Lovering 1949, 1960, Lovering and Shepard 1959).

Degrees of alteration are reflected in the different clay minerals produced. Moderate alteration and supergene weathering under mild conditions favored the formation of montmorillonite. More intense alteration and a more acidic weathering environment resulted in the formation of kaolinite. In addition, supergene weathering resulted in the conversion of ferrous iron to limonite, causing the weathering environment to be more acidic in altered areas than in unaltered areas (Lovering 1949).

The study includes unaltered, argillized, and silicified sites. The argillized rocks are bleached, limonite stained, and friable. They are formed by cation leaching, addition of water, and formation of clays. Kaolinite, mixed-layer clays, and montmorillonite are present. Kaolinite decreases away from the conduit. Initial porosity is greater in the altered rock than in the host rock. In the Utah study area, however, gravity compacts the argillized rocks, causing the pores to close, and a nearly impermeable rock results (H. T. Morris, oral comm. 1979). Silicified rocks are limonite stained and very hard, composed largely of silica, and containing some kaolinite and mixed-layer clays. Porosity remains higher than in the fresh and argillized rock because of the rigidity of the matrix surrounding the pores (H. T. Morris, oral comm., 1979). The SiO_2 content of silicified rocks can be as high as 90–95 percent, making the original texture of the rock difficult or impossible to determine.

East Tintic Mountains, Utah

The East Tintic Mountains are located in Juab and Utah counties, west central Utah, near the eastern edge of the Great Basin (Fig. 1). The area is classified as semiarid desert, having an average annual precipitation of about 30 cm. The range is made up of Paleozoic sedimentary rocks partly overlain by Tertiary volcanic rocks. The Tertiary rocks include quartz latite and latite tuffs and flows. Intrusive bodies associated with the tuffs and flows are numerous, though not large, and range from monzonite to quartz monzonite. The Paleozoic rocks were extensively folded and faulted prior to the Tertiary volcanism (Morris 1957, 1964a, Morris and Lovering 1961, 1979, Lovering 1960).

The study was confined to two Tertiary units, the Packard Quartz Latite and the overlying Laguna Springs Volcanic Group. The Packard Quartz Latite consists of quartz latite tuffs and flows that contain phenocrysts of andesine, sanidine, quartz, and biotite in a fine-grained to glassy groundmass (Morris and Lovering 1961).

The Laguna Springs Volcanic Group consists of latite tuffs and flows. The tuffaceous member ranges from fine to coarse grained and in some areas is agglomeratic. The flow is a medium- to coarse-grained latite that contains phenocrysts of orthoclase, plagio-

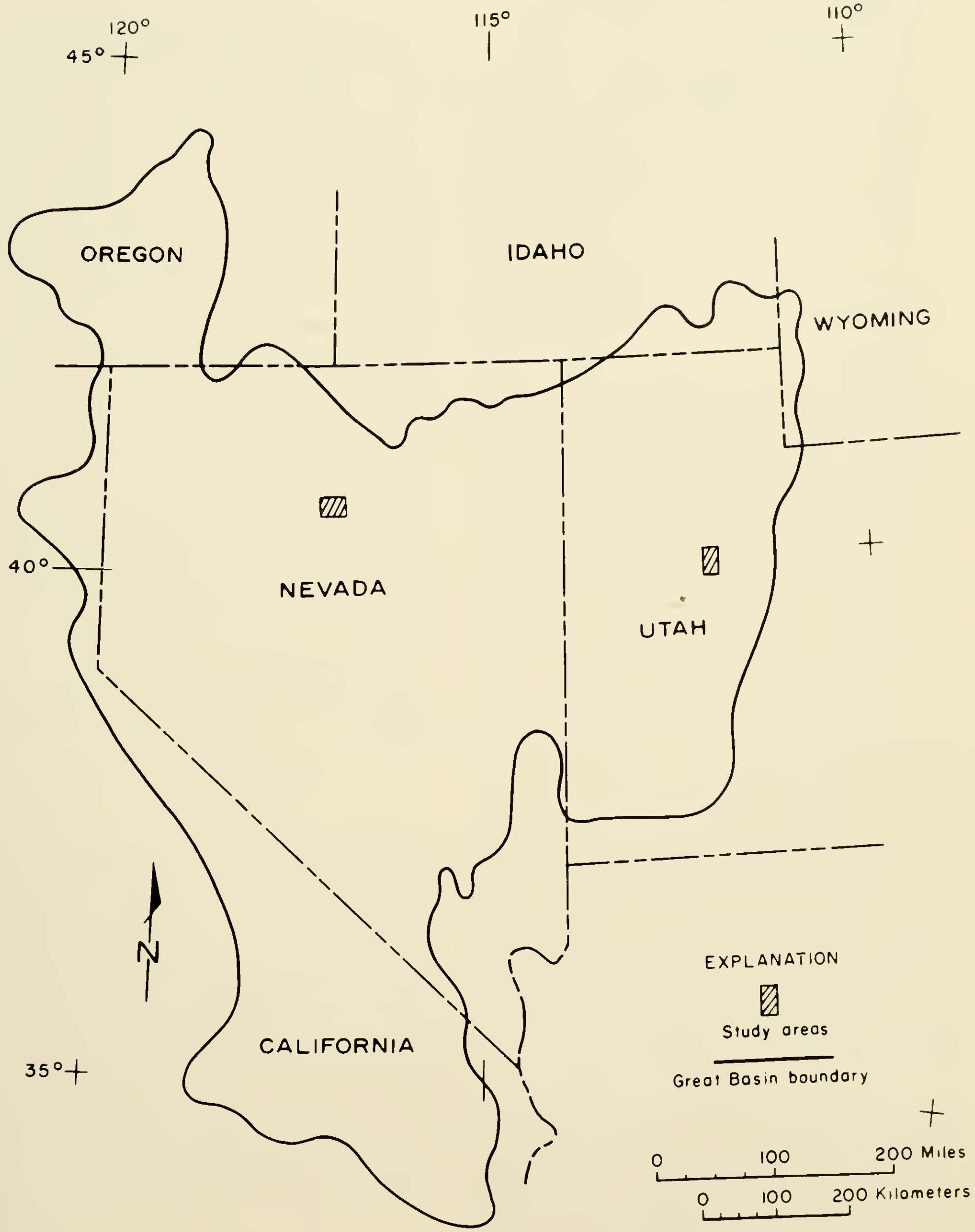

Fig. 1. Location of study areas in the Great Basin.

clase, hornblende, biotite, augite, magnetite, and quartz (Morris and Lovering 1961).

Battle Mountain, Nevada

Battle Mountain is located in Humboldt and Lander counties, north central Nevada (Fig. 1). The climate is arid, having about 15 cm average annual precipitation. The area is made up of Cambrian to Tertiary sedimentary and volcanic rocks. The pre-Tertiary rocks have been intruded by early Tertiary stocks, sills, and dikes. The geology of Battle Mountain is further complicated by its position along the Roberts Mountain and Golconda thrust zones.

Alteration at Battle Mountain took place at various times throughout the Paleozoic and Mesozoic, and most recently during the Tertiary. Potassic, argillic, and silicic alteration are present but are difficult to distinguish from each other in the field; for this report, rocks are categorized only as unaltered or altered (Roberts and Arnold 1965, Roberts et al. 1971, Theodore and Roberts 1971, Shawe and Stewart 1976, Silberman et al. 1976).

Three formations were chosen for the study. The Devonian Scott Canyon Formation is composed predominantly of chert, argillite, and greenstone with minor shale, limestone, and orthoquartzite. As the clastic content increases, the chert grades into argillite. Recrystallization of Scott Canyon chert by hydrothermal alteration resulted in an altered chert difficult to distinguish in the field from unaltered chert except for the presence of small amounts of altered argillite (Theodore and Blake 1975).

The Late Cambrian Harmony Formation is composed of feldspathic sandstone interbedded with shale and limestone. The sandstone is medium grained, subangular to subrounded, and poorly sorted. The formation is highly susceptible to alteration due to its texture and fine fracture patterns. Many of the mineralized areas were also enriched by supergene alteration (Theodore and Blake 1975, Suczek 1977).

The Pumpernickel Formation is Early Pennsylvanian to Early Permian in age. It consists of chert and argillite with minor shale, greenstone, limestone, sandstone, and conglomerate. Alteration resulted in recrystallization to quartzose hornfels. In addition, some silica was added and most oxides were decreased (Roberts 1964, Theodore and Blake 1975).

Vegetation

The vegetation of the study areas is included in the sagebrush and pinyon-juniper zones described by Billings (1951), Blackburn et al. (1968, 1969), Cronquist et al. (1972), Tueller (1975), Young et al. (1976, 1977), and MacMahon (1979). *Artemisia tridentata* (big sagebrush), commonly with *Chrysothamnus nauseosus* (rabbitbrush), *Purshia tridentata* (antelopebrush), grasses, and forbs, inhabits wide valleys and lower slopes, and occurs more sparsely within the pinyon-juniper woodland. *Juniperus osteosperma* (Utah juniper) is the most prevalent tree, found in stands having little undergrowth or scattered among the shrub communities. *Pinus monophylla* (single-leaf pinyon pine) is a common associate. Stream valleys and moist north-facing slopes contain a dense growth of *Acer grandidentatum* (bigtooth maple), *Prunus virginiana* (choke cherry), *Symphoricarpos oreophilus* (snowberry), and *Amelanchier utahensis* (shadbush). Many altered areas support a sparse and low flora, often including *Artemisia nova* (black sagebrush), *Petradoria pumila* (rock goldenrod), and other low matted shrubs and herbs. In addition, several halophytic species from the surrounding bajada slopes are found in altered areas in Battle Mountain.

Nomenclature for Utah follows Welsh and Moore (1973); that for Nevada follows Munz (1968).

Methods

Sites for sampling of vegetation and soils were chosen from geologic and alteration maps. To minimize variables, slopes chosen ranged from 1,500 to 2,100 m in altitude, were south facing (azimuth 135° to 225°), and inclined between 12° and 20°. Side slopes and spurs were chosen rather than coves to minimize drainage-catchment differences, and slopes containing springs were avoided. In the field, the sampling sites were further limited to those near roads and relatively undisturbed (e.g., not recently chained or burned).

Vegetation Sampling

A floristic list for each site was made, including forbs and grasses. Unfortunately, the lists are not complete, because each study area could not be visited during each part of the growing season, and the vegetation data presented here do not include forbs. However, shrubs and trees can be used to indicate soil and water conditions, as well as lithologic variations (e.g., Chikishev 1965).

Areal cover of vegetation was measured by using a modification of the line-interception method (Canfield 1941). Two 15 m tapes were stretched at right angles, one along the contour. The intercept of each species along the tapes was measured to the nearest centimeter, and the percent cover was calculated. Dead organic matter (standing dead and litter) was measured as "mulch." For each slope, fifteen 30-meter transects were measured and averaged to give a representative vegetation sample for each site. Total vegetation cover is the percentage of ground covered by trees, shrubs, grasses, or mulch.

Soil Sampling

Soil samples were taken from the same slopes on which vegetation was measured. Four sites on each alteration type in each geologic formation were sampled at depths of 20 to 60 cm. Rocks larger than about 1.0 cm were removed from samples at the time of collection. Because of the difficulty of augering such dry, rocky soils, holes were dug with a small shovel as deeply as possible. As a result, measurements of pore space or bulk density were not possible.

Silicification of flow and tuff units obscures the original texture so that these units are difficult to distinguish from one another in the field; also they would be expected to form identical soils because of their similar initial chemical composition. For this reason, the silicified Laguna Springs latite soil samples used in the summaries are the same for flow and tuff examples.

Soil pH was measured by a glass electrode pH meter on a 1:1 soil-water suspension. Cation exchange capacity (CEC) was measured by the modified barium chloride-triethanolamine procedure (Chapman and Pratt 1961), using a flame photometer.

Clay minerals were identified by X-ray diffraction analysis. Oriented slides were run untreated, after heating to 350 C and 500 C, and after treatment with ethylene glycol. Minerals having (001) peaks at 7.1 Å that disappeared after hearing to 500 C were identified as kaolinite-group. Illite-group minerals were identified as those having (001) peaks at 10.2 Å. Minerals having (001) reflections that expanded from 14 Å on untreated samples to 15 Å to 17 Å on samples treated with ethylene glycol were called mixed-layer illite-montmorillonites, and the percentage of expandable layers was estimated from the relative peak intensities. In the absence of other important peaks, relative proportions of the three clay groups could be estimated from the peak intensities (M. Hess, oral comm., 1977).

Particle size analysis was done by the hydrometer method and a series of sieves, using methods adapted from ASTM (1978) and Lambe (1951). Organic matter was not removed. Weighed samples were soaked overnight in sodium metaphosphate and sonified to aid dispersion. Soils were separated into the following fractions: clay ($<2\ \mu$), silt (2–50 μ), fine sand (50–250 μ) and coarse sand (250–1,000 μ).

Statistical Analysis

The Kruskal-Wallis test for central tendency (Gibbons 1976) was used to test the null hypothesis that there were no significant differences in the areal cover of vegetation in the East Tintic Mountains. Areal cover data for Battle Mountain were analyzed by using the Mann-Whitney-Wilcoxon test (Gibbons 1976). Different tests were used because of the different numbers of independent variables in the two study areas. Vegetation and soil differences were tested only within, and not between, the two study areas. Nonparametric tests were chosen in preference to the corresponding parametric tests because of small sample sizes and unknown distributions.

A binary discriminant analysis (Strahler 1978a, b) was used to compare affinity of plant species for rock formation and alteration type, resulting in a list of plant species for each type that best describes its difference from the other types. This is not a floristic list nor a list of dominant species; only those species strongly correlated with rock and alteration type ($p = 0.01$) are listed. In this test, each vegetation sample is entered separately rather than averaged to give a composite sample for each rock and alteration type. Frequency, rather than areal cover, is the variable used in this analysis.

Results

East Tintic Mountains, Utah

The two most common species on the Packard Quartz Latite areas, *Artemisia tridentata* and *Purshia tridentata,* have higher areal cover measurements on unaltered and silicified sites than on argillized sites (Table 1). *Chrysothamnus nauseosus* and *Ephedra viridis* are found only in unaltered and silicified areas. Grasses and mulch also have higher areal cover on unaltered and silicified sites than on argillized sites. In contrast, the cover of *Juniperus osteosperma* is higher on the argillized sites. This results in a high total vegetation measurement, even though there is actually substantial bare ground under and between the trees in argillized areas. With the exception of *J. osteosperma*, each species has lower areal cover on argillized than on unaltered and silicified sites.

The samples from the latite flow sites of the Laguna Springs Volcanic Group also show that samples from unaltered and silicified areas have higher shrub and nontree subtotals than do the samples from argillized sites (Table 1). Grasses and mulch have lower areal cover in argillized areas. An important difference is the presence of *Artemisia nova* only on the argillized sites.

The argillized samples from the Laguna Springs latite tuff (Table 1) have the lowest shrub and nontree subtotals and the lowest *Artemisia tridentata, Purshia tridentata,* grasses, and mulch. *Artemisia nova* occurs only on argillized sites. A greater variety of herbaceous species was observed in argillized areas than in unaltered and silicified areas on both tuff and flow, although forbs, as stated above, are not included in the vegetation summaries.

The statistically significant differences in shrub cover, nontree cover, and tree cover in

TABLE 1. Vegetation cover (in percent) for the East Tintic Mountains study areas. U, Unaltered. A, Argillized. S, Silicified.

	Packard Quartz Latite			Laguna Springs Volcanic Group				
				Flows		Tuffs		Tuffs and flows undifferentiated
	U	A	S	U	A	U	A	S
Artemisia tridentata	8.23	.81	14.68	16.20	9.19	12.86	7.09	9.28
A. nova					1.42		1.71	
Purshia tridentata	1.61	.49	6.22	.21	.26	5.74	.63	2.64
Chrysothamnus nauseosus	.08		.11		.78	.98		.17
C. viscidiflorus				.17			.05	
Ephedra viridis	1.50		.14					
Opuntia sp.			.08	.12			.03	
Gutierrezia sarothrae		.08	.01		.07			.50
Tetradymia sp.							.04	.02
Arenaria kingii			.02				1.18	.10
Petradoria pumila		.07	1.01				1.25	.05
Cercocarpus montanus			.31					
Subtotal	11.42	1.45	22.58	16.70	11.72	19.58	11.98	12.76
Grasses	1.96	.06	1.17	2.02	1.28	4.03	1.60	3.71
Mulch	8.18	3.30	9.58	11.74	7.85	14.62	6.85	10.85
Subtotal	10.14	3.36	10.75	13.76	9.13	18.65	8.45	14.56
Nontree subtotal	21.56	4.81	33.33	30.46	20.85	38.23	20.43	27.32
Juniperus osteosperma	6.90	29.34	5.18	5.76	6.25		4.32	1.64
Pinus monophylla	2.47	.29	2.99	2.75	1.53		1.99	
Tree subtotal	9.37	29.63	8.17	8.51	7.78		6.31	1.64
Total vegetation	30.93	34.44	41.50	38.97	28.63	38.23	26.74	28.96
Standard deviation	± 10.5	± 15.9	± 12.7	± 9.1	± 13.5	± 8.4	± 11.5	± 11.6
Number of samples	15	15	15	15	15	15	15	30

TABLE 2. Significant differences in vegetation on different alteration types using the Kruskal-Wallis test on the East Tintic Mountains data.

	Total vegetation	Shrub cover	Shrubs grasses mulch	Tree cover
Packard Quartz Latite				
Unaltered vs. argillized	–	°	°	°
Unaltered vs. silicified	°	–	–	–
Argillized vs. silicified	–	°	°	°
Laguna Springs Volcanic Group: Flows				
Unaltered vs. argillized	°	°	°	–
Unaltered vs. silicified	°	–	–	–
Argillized vs. silicified	–	–	°	–
Laguna Springs Volcanic Group: Tuffs				
Unaltered vs. argillized	°	°	°	–
Unaltered vs. silicified	–	°	°	°
Argillized vs. silicified	–	–	°	–

°Significantly different at $p < 0.15$

samples from the Packard Quartz Latite sites occur between unaltered and argillized samples and between silicified and argillized samples (Table 2). That is, the argillized samples are significantly different from both unaltered and silicified samples, whereas unaltered and silicified samples differ from each other only in total vegetation cover.

The Laguna Springs flow data show significant differences between unaltered and argillized samples in total vegetation, shrub cover, and nontree cover (Table 2). The argillized and silicified samples are significantly different only in the nontree measurements.

In the Laguna Springs tuff results, the unaltered and argillized samples differ significantly in total cover, shrub cover, and nontree cover, and the argillized and silicified samples differ in nontree cover (Table 2). In addition unaltered and silicified samples differ significantly in all but total vegetation cover.

Thus, the vegetation is similar in unaltered and silicified areas but different in argillized areas; on the Laguna Springs Volcanic Group, silicified areas are more like argillized than like unaltered areas.

The binary discriminant analysis results for the Packard Quartz Latite data (Table 3) show that unaltered areas are characterized by *Artemisia tridentata* and *Ephedra viridis*, argillized areas by *Juniperus osteosperma*, and silicified areas by *Purshia tridentata*. The correlation of *A. nova* with argillized flow and tuff is notable in the Laguna Springs data.

Soils in unaltered areas were dug to depths of 25–35 cm. A thin organic layer alternates with pebble- to cobble-sized angular float.

TABLE 3. Binary discriminant analysis results for East Tintic Mountains. Species listed are significantly correlated with rock and alteration type at $p = 0.01$. U, Unaltered. A, Argillized. S, Silicified. +, $d \geq 2.0$. –, $d \leq -2.0$.

	Packard Quartz Latite			Laguna Springs Volcanic Group				
	U	A	S	U	A	U	A	S
Artemisia tridentata	+	–						
Ephedra viridis	+	–						
Juniperus osteosperma		+	–	+		–		+
A. nova					+		+	
Purshia tridentata		–	+	–	–	+	–	+
Chrysothamnus nauseosus						+	–	
C. viscidiflorus								–
Gutierrezia sarothrae				–		–	–	+
Arenaria kingii						–	+	+
Petradoria pumila								+
Haplopappus acaulis							+	

The rock fragments increase in size as depth increases. The soil is light brown (Munsell color 7.5YR5/4) (Munsell Color Company 1969) to grayish brown (7.5YR4/2). Roots decrease in frequency as depth increases and penetrate crevices in the rock beyond the depth possible to dig by hand.

Soils in argillized areas are shallower (about 15 cm) and range in color from moderate brown (7 5YR4/4) to light yellowish or rusty brown (10YR7/4). The organic layer is absent or thinner than in unaltered areas. Pebble- to boulder-sized bleached and limonite coated rock fragments cover the top layer of soil and are profuse at all levels. At the deepest level dug, rocks are friable and roots are few.

Soils in silicified areas are nearly as deep as those in unaltered areas, and color is similar. Bleached rock fragments occur at the surface. Finer particles are found deeper than in soils on unaltered areas, and roots are profuse in lower parts of the soil profile.

Soil pH ranges from 6.6 to 7.7 (Table 4). No significant differences were found between soils on different rock or alteration type. Cation exchange capacity (CEC) ranged from 17 to 43 Me/100g (Table 4). In general, soils on Packard Quartz Latite areas have higher CEC than soils on the Laguna Springs Volcanic Group, except in silicified areas. Using the Spearman coefficient of correlation (Gibbons 1976), the CEC was found to be weakly positively correlated with the total clay content ($r = 0.413$). CEC is strongly negatively correlated ($r = -0.780$) with the amount of kaolinite in the soil and positively correlated ($r = 0.630$) with the amount of montmorillonite. However, the lack of significant differences between soils of different alteration types seems to indicate that, although the tests were done with reasonable accuracy, the CEC and clay content are too variable within soils of a single alteration type to be diagnostic of it.

Physical analysis of the soil samples includes particle size analysis for texture and X-ray diffraction analysis for identification of clay minerals. In the Packard Quartz Latite samples, clay content is about the same on all three alteration types (Table 4). Silt content, however, is higher and coarse sand content is lower in silicified areas than in unaltered and argillized areas.

In the samples from the latite flow in the Laguna Springs Volcanic Group, the unaltered soils have the most silt and the least coarse sand, argillized soils have the least silt and the most coarse sand, and silicified soils have intermediate amounts of each. In the sites on the tuffs, the argillized and silicified samples are similar, and the unaltered soils have less silt and more coarse sand.

Because clay is formed in the alteration process, a higher clay content would be expected in altered, particularly in argillized, areas. The small clay differences recorded in the samples suggest that dispersion was not complete in all tests.

The predominant types of clay minerals in the samples vary (Table 4). The standard de-

TABLE 4. pH, cation exchange capacity (CEC), particle size distribution and relative clay content for East Tintic Mountains soils. U, Unaltered. A, Argillized. S, Silicified.

	Packard Quartz Latite			Laguna Springs Volcanic Group		
	U	A	S	U	A	S
pH	6.8–7.7	6.9–7.6	6.7–7.6	6.7–7.2	6.6–7.5	6.7–7.4
CEC (Me/100g)	36 ±5	37 ±6	25 ±8	28 ±4	27 ±3	31 ±3

				Flows		Tuffs		
Particle size (percent)				U	A	U	A	S
Coarse sand	30 ±12	29 ±3	8 ±6	9 ±1	18 ±3	23 ±3	12 ±4	11 ±6
Fine sand	27 ±5	24 ±3	28 ±5	31 ±5	27 ±8	27 ±3	31 ±6	30 ±4
Silt	16 ±5	19 ±6	36 ±5	35 ±3	27 ±3	23 ±7	31 ±3	30 ±6
Clay	27 ±5	28 ±3	28 ±2	25 ±3	28 ±7	27 ±2	26 ±4	29 ±5
Relative clay content (percent)								
Kaolinite	14	25	40	27	21	42	41	33
Illite	47	49	44	44	67	55	56	61
Mixed-layer	50	33	24	24	24	9	7	11
Montmorillonite	39	26	16	14	12	4	3	6

viations of the X-ray data averages are large, so that these data can only be used to make rough comparisons from one alteration type to another. In the samples from the Packard Quartz Latite, the unaltered samples have the least kaolinite and the most mixed-layer clay and montmorillonite. Soils of silicified areas have the most kaolinite and the least mixed-layer clay and montmorillonite. Soils of argillized areas are intermediate between the two but have the greatest amount of illite.

The Laguna Springs latite samples show fewer differences in clay type (Table 4). All the soils contain large amounts of illite, less kaolinite, and small amounts of montmorillonite.

The soil characteristics of silicified areas resemble those of argillized latite areas in the Laguna Springs Volcanic Group. Following a suggestion of R. P. Ashley (oral comm., 1978), the silicified areas were examined and found to contain large amounts of argillized float around the silicified outcrops. This indicates that the soils from silicified areas are mixed with argillized material, resulting in smaller differences in soils and vegetation on the two alteration types than would be expected. The amount of argillized float on silicified areas of the Packard Quartz Latite is small, so that soils and vegetation differences are large.

Battle Mountain, Nevada

The vegetation patterns in the Battle Mountain study area show differences in composition and areal cover from unaltered to altered sites (Table 5). The altered areas have lower total vegetation cover on all three formations, and, except on the Harmony Formation, more variety of species is found in altered areas. Shrub cover is lower on altered sites of the Pumpernickel and Scott Canyon formations than on unaltered sites but remains nearly the same on the Harmony Formation; areal cover of grasses and mulch is higher on unaltered than on altered sites. Areal cover of *Artemisia tridentata* is higher on unaltered than on altered sites on all three formations and is absent on altered Harmony Formation. *Chrysothamnus nauseosus* is more likely to be found on unaltered sites, and *C. viscidiflorus* on altered sites. *Artemisia nova* rather than *A. tridentata* is found on the altered Harmony Formation.

Shrub cover and total vegetation cover are significantly different on unaltered and altered areas of the Pumpernickel and Scott Canyon formations (Table 6). On the Harmony Formation, the shrub cover is similar on unaltered and altered sites, but the greater amount of mulch on unaltered sites makes the total vegetation cover significantly different. Differences in vegetation cover between

Table 5. Vegetation cover (in percent) for the Battle Mountain study areas. U, Unaltered. A, Altered.

	Pumpernickel Formation		Scott Canyon Formation		Harmony Formation	
	U	A	U	A	U	A
Artemisia tridentata	15.9	3.5	15.2	11.1	19.1	
A. nova						18.8
Purshia tridentata	4.4					
Chrysothamnus nauseosus	.4		.2		.5	1.0
C. viscidiflorus		1.9	.2	.5		
Tetradymia sp.		1.8	1.5	1.4	.3	
Atriplex confertifolia		1.6	trace	.4		.1
Ephedra nevadensis		.3		0.9		
Peucephyllum schottii		trace		.3		
Subtotal	20.7	9.1	17.1	14.6	19.9	19.9
Grasses	2.6	4.5	2.0	1.7	2.2	1.1
Mulch	10.9	3.8	9.1	9.1	10.0	2.6
Subtotal	13.5	8.3	11.1	10.8	12.2	3.7
Total Vegetation	34.2	17.4	28.2	25.4	32.1	23.6
Standard deviation	±7.8	±4.4	±6.9	±4.3	±4.6	±6.7
Number of samples	15	15	15	15	15	15

TABLE 6. Significant differences in vegetation on different alteration types using the Mann-Whitney-Wilcoxon test on the Battle Mountain data.

	Total vegetation	Shrub cover
PUMPERNICKEL FORMATION		
Unaltered vs. altered	°	°
SCOTT CANYON FORMATION		
Unaltered vs. altered	°	°
HARMONY FORMATION		
Unaltered vs. altered	°	—

°Significantly different at $p < 0.15$

unaltered and altered sites are greater than those on different rock types.

Binary discriminant analysis results (Table 7) show that unaltered Pumpernickel Formation sites are characterized by *Artemisia tridentata* and *Purshia tridentata*, altered sites by *Atriplex confertifolia*, *Chrysothamnus viscidiflorus*, and *Tetradymia* sp. (Table 3). The altered Scott Canyon Formation sites contain *Peucephyllum schottii*, *Chrysothamnus viscidiflorus*, and *Ephedra nevadensis*, whereas only *Artemisia tridentata* is significantly correlated with the unaltered sites. *Artemisia tridentata* is characteristic of unaltered Harmony Formation and *A. nova*, of altered sites.

The pH of unaltered Battle Mountain soils was lower than that of altered soils in all three formations (Table 8). Soil depths were greatest (35 cm) in unaltered Pumpernickel chert and Scott Canyon chert soils. Depths of altered soils and unaltered Harmony sandstone soil averaged 20–25 cm.

The particle size distribution analysis results show similar patterns for all three formations (Table 8). Soils of unaltered areas are coarser than those of altered areas. The silt difference is greatest in the Harmony Formation, and the coarse sand difference is greatest in the Scott Canyon Formation. As in the Utah study area, the absence of the expected higher clay content in altered areas suggests that the clays may not have dispersed completely.

The soils in altered areas of all three formations have more kaolinite and less illite than those of unaltered areas (Table 8). In addition, the unaltered Scott Canyon soils contain montmorillonite. Again, differences are not large, particularly in the Pumpernickel soils, and the standard deviations are high. Consequently, only general comparisons can be made between soils of unaltered and altered areas.

The altered sites on all three formations are lower in altitude than the corresponding unaltered sites. This factor, plus the presence of *Atriplex confertifolia* and the higher pH on the altered sites, suggests that the vegetation may be influenced by increased salinity as well as by a factor in the alteration process.

DISCUSSION

In the East Tintic Mountains study area, total vegetation cover is lower in argillized areas than in unaltered and silicified areas, except on the argillized Packard Quartz Latite, where large numbers of *Juniperus osteosperma* are found. All other species have lower areal cover on the argillized Packard areas, and the ground is relatively bare under and around the trees. In addition, the composition of the plant communities varies with rock type and alteration history. On unaltered and silicified areas are large amounts of mulch, *Artemisia tridentata*, *Purshia tridentata*, and *Ephedra viridis*. Argillized areas, in contrast, contain mostly *Juniperus osteosperma* and a very few shrubs.

TABLE 7. Binary discriminant analysis results for Battle Mountain vegetation data. Species listed are significantly correlated with rock and alteration type at $p = 0.01$. U, Unaltered. A, Altered. +, $d \geq 2.0$. –, $d \leq -2.0$.

	Pumpernickel		Scott Canyon		Harmony	
	U	A	U	A	U	A
Artemisia tridentata	+		+	+	+	–
A. nova						+
Purshia tridentata	+					
Chrysothamnus nauseosus		–		–		+
C. viscidiflorus	–	+		+	–	–
Atriplex confertifolia		+				
Tetradymia sp.	–	+		+		–
Peucephyllum schottii				+		
Ephedra nevadensis				+		

TABLE 8. pH, particle size distribution and relative clay content for Battle Mountain soils. U, Unaltered. A, Altered.

	Pumpernickel Formation		Scott Canyon Formation		Harmony Formation	
	U	A	U	A	U	A
pH	6.8–7.3	7.6–7.9	6.8–7.3	7.2–7.9	6.7–7.3	6.9–7.8
Particle size (percent)						
Coarse sand	7 ± 1	4 ± 2	15 ± 2	5 ± 3	11 ± 3	8 ± 2
Fine sand	17 ± 2	18 ± 1	24 ± 2	24 ± 4	23 ± 4	23 ± 4
Silt	51 ± 2	54 ± 3	34 ± 2	38 ± 6	38 ± 5	49 ± 3
Clay	25 ± 3	24 ± 3	27 ± 6	31 ± 1	28 ± 6	20 ± 6
Relative clay content (percent)						
Kaolinite	23	28	20	49	17	29
Illite	77	72	70	51	83	71
Montmorillonite			5	0		

On the latite of the Laguna Springs Volcanic Group, vegetation differences are large between unaltered and argillized sites, but small between silicified sites and argillized sites. The vegetation on unaltered sites is composed largely of *Artemisia tridentata* and *Purshia tridentata*, whereas the argillized areas contain *A. nova* and a wide variety of minor shrubs.

In areal cover and in composition of vegetation the silicified areas of the Laguna Springs Volcanic Group fall between argillized areas and unaltered areas. The areas labeled 'silicified' contain a mixture of silicified and argillized float, which accounts for the similarity of soils and vegetation on argillized and silicified sites.

In the Battle Mountain study area, shrub cover and total vegetation cover are greater in unaltered areas than in altered areas; *Artemisia tridentata* is the most common shrub in all areas except on altered Harmony Formation, where it is replaced by *A. nova*. *Atriplex confertifolia* occurs on altered sites.

Several soil parameters were measured in an attempt to explain the causes of the vegetation patterns. The hypothesis of low nutrient levels to explain the low vegetation cover in some altered areas was discarded because of high vegetation cover measurements in the most highly altered, leached areas. Physical and chemical analyses of the soils include measurements of pH, cation exchange capacity, particle size distribution, and X-ray diffraction for identification of clay minerals. Although not quantitatively significant, some relationships seem to exist between areal cover of vegetation and soil characteristics. The hypothesis that water is the most important limiting factor in plant growth is supported by the following reasons and comparisons:

1. *Juniperus osteosperma* and *Artemisia nova*, which are found on argillized Packard Quartz Latite and on the argillized Laguna Springs Volcanic Group and altered Harmony Formation, respectively, are known to occur in the drier habitats in the Great Basin (Blackburn et al. 1968, 1969, Cronquist et al. 1972, Zamora and Tueller 1973, Vasek and Thorne 1977).

2. The high percentage of bare ground, around and under the trees on the argillized Packard Quartz Latite and between the low shrubs on the argillized Laguna Springs Volcanic Group and altered Scott Canyon and Pumpernickel Formations, results in high runoff and low infiltration of rainfall.

3. Although soil was not dug to bedrock due to the difficulty of digging, the soil appeared to be shallower in argillized areas and mixed argillized and silicified areas than in unaltered and silicified areas in the East Tintic Mountains, and shallower in the altered Battle Mountain areas than in the unaltered areas, except on the Harmony Formation.

4. Fractured unaltered and silicified bedrock allows greater infiltration of rainfall than does the highly compacted argillized bedrock in the East Tintic Mountains.

5. The argillized areas are low in mixed-layer clays and montmorillonite, which would retain more moisture. The presence of montmorillonite on the unaltered Scott Canyon Formation, Packard Quartz Latite, and Laguna Springs Volcanic Group may in-

crease water capacity. However, total clay content is probably more important than type of clay in areas that have a mixture of clay types.

6. The other major difference between unaltered and altered soils in Battle Mountain, the higher pH of altered soils, can account for the presence of salt-loving plants such as *Atriplex confertifolia* but does not explain the decrease in vegetation cover on altered sites, because nearby areas that contain halophytic communities have quite dense vegetation.

Conclusions

Vegetation patterns of areal cover and distribution of species are related to the distribution of hydrothermally altered and unaltered rocks in two areas within the Great Basin. Several factors, including bare ground, shallow soil, impermeable rock, soil texture, and, possibly, clay composition in some areas appear related to low vegetation cover in argillized areas, and suggest that water may be limiting in these areas. The results are consistent with those of other workers in the Great Basin. This type of information is needed for the development of techniques for using vegetation as an aid to prospecting in vegetated regions.

Acknowledgments

The authors are grateful to Drs. J. T. Hack and F. A. Branson of the U.S. Geological Survey for critical reviews of the manuscript.

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PLASTICITY AND POLYMORPHISM IN SEED GERMINATION OF *MIMULUS GUTTATUS* (SCROPHULARIACEAE)

Robert K. Vickery, Jr.[1]

Abstract.— Seeds of 12 populations of *Mimulus guttatus* representative of the Wasatch Mountain ecotype were incubated for 17 months (one natural season plus a year) in five artificial climates found in phytotron studies to be important to the growth of the plants of that form of monkey flower. In all but the coldest climate, germination occurred promptly (3–8 days, on average), peaked during the first three weeks, and then tapered off gradually well into the second season. Generally, the amount and timing of germination was plastic, showing much the same range of responses in widely different climates both overall and for individual populations. However, in some cases, there were significant differences between populations indicative of polymorphism within the species. For example, germination was significantly slower, more variable, and less in amount the higher the elevation of origin of the populations. The responses of the population suggest the presence of both much plasticity and much polymorphism for germination characteristics in this form of *M. guttatus*.

The purpose of this investigation is to study seed germination in the yellow Monkey flower, *Mimulus guttatus* Fischer ex DC., in greater depth than was possible in the earlier surveys (Vickery 1963, 1967). In those surveys small samples of a series of species and varieties of *Mimulus* were studied in a broad range of artificial climates. The present study concentrates on the Wasatch ecotype of *Mimulus guttatus* (Vickery 1978) and on five artificial climates found in phytotron studies to be important for the growth of *M. guttatus* (Vickery 1972, 1974).

Materials and Methods

Seeds from 12 populations of *M. guttatus* were collected for the study from the Wasatch mountain area of northern Utah and southern Idaho (Table 1). The experiments were carried out in four laboratory artificial climates and one greenhouse climate (Table 2). The seeds were germinated on moist blotters in petri dishes. Samples of 500 seeds, 125 per petri dish, were used for each population in each climate. The climates included extremes of the earlier studies (1 and 5), optimal and suboptimal growth conditions (3 and 4, respectively), and the contrasts of fluctuating and steady temperatures (1 and 2 vs. 3, 4, and 5). Germination was scored for 17 months, that is, through the 5-month germination season normal for *M. guttatus* in the Wasatch Mountains plus an additional year.

Results and Discussion

Overall, germination in the four warmer climates (2–5), started as early as the third

Table 1. Origins of the populations of *Mimulus guttatus* studied, arranged by culture number, locality, and elevation.

M. guttatus Fischer ex DC., n = 14	
5839	Spruces, Big Cottonwood Canyon, Salt Lake Co., Utah, 2350 m.
7273	Draper, Salt Lake Valley, Salt Lake Co., Utah, 1390 m.
7274	Gorgoza Ranch, Parley's Summit, Summit Co., Utah, 1910 m.
7311	Fish Haven, Bear Lake, Bear Lake Co., Idaho, 2030 m.
7312	Rick's Springs, Logan Canyon, Cache Co., Utah, 2000 m.
7314	East Canyon, Salt Lake Co., Utah, 2060 m.
7315	Thousand Springs, Mill Creek Canyon, Salt Lake Co., Utah, 2215 m.
7316	Mill F East, Big Cottonwood Canyon, Salt Lake Co., Utah, 2670 m.
7317	Brighton, Big Cottonwood Canyon, Salt Lake Co., Utah, 2645 m.
7318	Homestead, Heber Valley, Wasatch Co., Utah, 1570 m.
7319	Snow Pine, Alta, Little Cottonwood Canyon, Salt Lake Co., Utah, 2710 m.
11157	Mill D North, Big Cottonwood Canyon, Salt Lake Co., Utah, 2520 m.

Note: The experiments were carried out at the University of Utah, elev. 1500 m, near the center of the study area.

[1]Department of Biology, University of Utah, Salt Lake City, Utah 84112.

TABLE 2. Experimental climates used for the seed germination study.

1	Steady 4 C day and night, no photoperiod
2	Steady 25 C day and night, no photoperiod
3	Gradually changing from 4 C night to 17 C day, 16-hour photoperiod
4	Gradually changing from 14 C night to 17C day, 16-hour photoperiod
5	Standard greenhouse, changing from 10 C nights on average to 30 C days on average, 16-hour photoperiod.

NOTE: Artificial climates 1 and 2 employed incubators, whereas climates 3 and 4 employed growth chambers programmed to rise and fall like natural July climates in the Wasatch Mountains (Dept. of Commerce, Climatological Data, 1971–1980).

day, peaked during the following week, tapered off to a low level by the end of the third week, but continued to occur occasionally well into the next year, forming a typical (Went 1957, Vegis 1963) leptokurtic curve (Fig. 1). Despite the overall pattern, germination varied noticeably from climate to climate in both speed and amount (Table 3) as Stakanov (1976) observed in similar studies on beans. For example, in the 17/14 C climate (4), the monkey flower seeds were significantly slower than in the other cliamtes both in starting to germinate and in achieving 50 percent of the ultimate, total germination for the 17-month trial period (Table 4). The slowing effect on germination of the suboptimal, 17/14 C climate parallels the striking reduction in plant growth observed in that climate in the phytotron (Vickery 1972, 1974) and suggests that the posited cause, too similar day and night temperatures, acts on speed of germination as well as plant growth. In fact, if the temperature is constant as in climate 2, total germination is significantly less than in the fluctuating climates, 3, 4, 5 (Table 4). Overall, the variable, but generally similar ranges of germination results in the four diverse, warmer climates suggest wide plasticity of response in *M. guttatus*.

In the cold, steady 4 C climate (1), in sharp contrast to the pattern of early germination in the four warmer climates, no germination occurred at all during the first four weeks (Fig. 1). After that, apparently the cumulative effect of the time spent at room temperature while the seeds were being watered and scored triggered a little germination—2 or 3 seedlings per petri dish—followed by a spurt of germination when the watering and scoring time was inadvertently prolonged. Thus,

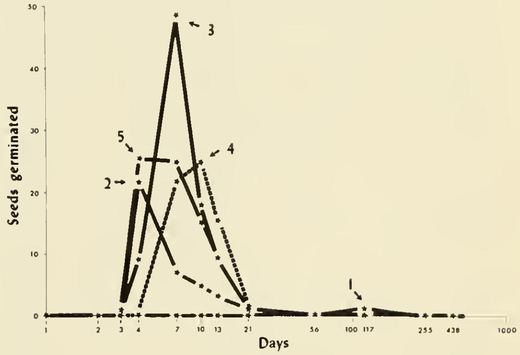

Fig. 1. The average number of seeds of all 12 populations of *M. guttatus* that germinated per day (Table 3) for each of the five climates studied (full data available on request). Peak germination occurred on day 7 in climate 3 with an average of close to 50 of the 500 seeds studied per population per climate germinating that day. The germination rate dropped off to approximately one seed germinating per 25,000 seeds per day by day 255 and to one-tenth of that rate by day 512, the end of the experiment.

the latter data for climate 1 are ambiguous and were not analyzed. However, the early results are clear and are consonant with the extremely slow growth of the young plants in the steady 4 C climate of the phytotron (Vickery 1972, 1974).

In general, the 12 individual populations of *M. guttatus* exhibit statistically similar ranges of germination responses to the test climates (Table 5) with some apparent differences (Table 2, 5), much as Wright (1978, 1980) observed in *Panicum*. The differences range from slight and insignificant to moderate to three cases in which they are so pronounced as to be statistically significant (Table 5). On one hand, the overall similarities suggest a wide plasticity of the populations of response. On the other hand, the differences appear to reflect underlying genetic differences—polymorphisms—of the populations.

The germination results of the 12 populations correlate with the elevation of origin of the populations (Table 6). The populations show significantly longer times to first germination and to 50 percent germination as well as less total germination with increasing elevation. This is true not only overall but in most of the individual climates as well (Table 6). The variances of the overall times to first germination are also significantly greater the higher the elevation of origin (Table 6). The

TABLE 3. Germination results for four replicates of each of the 12 populations of *M. guttatus* in each of the four warmer climates (Table 2). Climate 1, steady 4 C, was omitted due to the ambiguity of the later results.

Population	Climate	Days to first germination	Days to 50% germination	Total germination
5839	2	5.25 ± 2.50	15.00 ± 9.90	34.75 ± 16.38
Spruces	3	5.00 ± 1.41	8.00 ± 1.83	81.50 ± 51.45
	4	8.00 ± 1.41	13.50 ± 2.08	73.25 ± 11.38
	5	5.00 ± 1.82	11.00 ± 0.82	52.25 ± 15.84
	Average	5.81 ± 2.10	11.90 ± 5.37	60.44 ± 31.86
7273	2	4.00 ± 0.00	5.75 ± 0.96	56.25 ± 13.77
Draper	3	5.00 ± 0.00	6.50 ± 0.58	63.50 ± 16.09
	4	6.00 ± 0.82	8.50 ± 0.58	68.00 ± 41.29
	5	4.50 ± 0.58	6.50 ± 1.00	86.25 ± 34.60
	Average	4.88 ± 0.89	6.81 ± 1.28	68.50 ± 28.30
7274	2	4.00 ± 0.00	14.75 ± 13.10	24.75 ± 6.95
Gorgoza	3	4.25 ± 0.50	6.50 ± 1.00	109.00 ± 36.21
	4	5.75 ± 0.96	10.25 ± 2.50	98.75 ± 20.37
	5	4.00 ± 0.00	6.00 ± 1.15	95.75 ± 23.16
	Average	4.50 ± 0.89	9.38 ± 7.03	82.06 ± 40.69
7311	2	6.33 ± 0.00	6.25 ± 0.50	65.50 ± 15.20
Bear Lake	3	5.25 ± 0.00	6.25 ± 0.50	102.75 ± 22.88
	4	7.75 ± 0.58	8.75 ± 1.26	78.00 ± 23.85
	5	5.00 ± 0.50	6.50 ± 1.00	90.25 ± 9.18
	Average	6.08 ± 0.73	6.94 ± 1.34	84.13 ± 22.06
7312	2	6.33 ± 2.31	6.50 ± 3.69	2.67 ± 1.41
Logan Canyon	3	5.25 ± 0.50	10.00 ± 0.82	79.25 ± 6.45
	4	7.75 ± 0.96	12.75 ± 0.50	21.25 ± 16.19
	5	5.00 ± 1.41	14.00 ± 4.24	67.25 ± 6.85
	Average	6.08 ± 1.67	10.81 ± 4.47	55.11 ± 32.97
7314	2	4.00 ± 0.00	10.50 ± 2.65	31.50 ± 7.85
East Canyon	3	6.00 ± 1.41	8.00 ± 2.71	88.75 ± 35.88
	4	5.25 ± 0.50	9.50 ± 1.29	98.00 ± 10.86
	5	4.75 ± 0.50	8.00 ± 2.16	97.75 ± 11.35
	Average	5.00 ± 1.03	9.00 ± 2.31	79.00 ± 33.21
7315	2	4.25 ± 0.50	8.25 ± 2.22	15.25 ± 2.36
1000 Springs	3	6.00 ± 0.00	9.50 ± 0.58	68.72 ± 7.50
	4	7.00 ± 0.82	16.50 ± 7.59	77.75 ± 23.21
	5	5.00 ± 0.00	10.50 ± 1.00	59.00 ± 17.15
	Average	5.56 ± 1.15	11.19 ± 4.85	55.19 ± 28.24
7316	2	8.00 ± 2.16	17.25 ± 8.34	17.50 ± 9.61
Mill Creek	3	6.00 ± 0.82	22.50 ± 12.40	60.50 ± 28.18
East	4	9.50 ± 1.73	32.00 ± 4.32	49.25 ± 7.89
	5	8.50 ± 2.52	13.50 ± 2.38	34.00 ± 10.95
	Average	8.00 ± 2.16	21.31 ± 10.10	40.31 ± 22.19
7317	2	7.25 ± 2.63	10.50 ± 2.38	8.75 ± 7.59
Brighton	3	5.25 ± 0.50	10.50 ± 1.73	47.75 ± 8.66
	4	7.50 ± 0.58	12.50 ± 1.00	61.50 ± 6.66
	5	6.50 ± 1.00	9.25 ± 2.06	35.75 ± 9.54
	Average	6.63 ± 1.59	10.69 ± 2.06	38.43 ± 21.34
7318	2	3.25 ± 0.50	5.00 ± 0.00	65.25 ± 9.43
Homestead	3	4.25 ± 0.50	6.25 ± 0.50	85.00 ± 7.44
	4	6.75 ± 0.50	9.75 ± 0.50	74.50 ± 19.16
	5	5.00 ± 0.00	5.50 ± 1.00	80.25 ± 14.22
	Average	4.81 ± 1.38	6.63 ± 2.00	76.25 ± 14.16
7319	2	16.00 ± 10.74	16.75 ± 10.20	3.25 ± 1.21
Alta	3	7.25 ± 0.96	15.75 ± 12.30	8.50 ± 4.65
	4	11.75 ± 1.26	15.00 ± 5.35	8.50 ± 3.70
	5	8.50 ± 1.91	11.50 ± 0.58	9.00 ± 3.74
	Average	10.88 ± 6.04	14.75 ± 7.82	7.31 ± 4.05
11,157	2	3.75 ± 0.50	5.00 ± 0.00	82.00 ± 26.99
Mill D	3	5.25 ± 0.50	6.00 ± 0.00	97.25 ± 10.34
North	4	7.50 ± 1.73	11.75 ± 1.71	75.25 ± 9.00
	5	4.75 ± 0.50	5.00 ± 0.00	77.00 ± 22.69
	Average	5.31 ± 1.66	6.94 ± 3.00	83.00 ± 19.09
All	2	5.71 ± 4.60	9.98 ± 7.25	33.90 ± 28.32
populations	3	5.29 ± 1.11	9.65 ± 6.56	74.38 ± 34.14
	4	7.35 ± 2.02	13.40 ± 6.77	69.54 ± 28.18
	5	5.52 ± 1.80	8.94 ± 3.42	65.38 ± 30.94

TABLE 4. Comparison of germination in the different artificial climates. Climates that are underlined together are statistically inseparable according to the Student, Newman, Keuls Multiple Range Test (Woolf 1968). average values are given below the lines.

Days to 1st germination	3	5	2	4
	5.3	5.5	5.8	7.4
Days to 50% germination	5	3	2	4
	8.9	9.6	10.2	13.4
Total germination (Av. per petri dish)	2	5	4	3
	34.6	65.4	69.5	74.4

slower and more varied germination responses seem a reasonable adaptation to the increasing unpredictability of the climate with increasing elevation in the Wasatch area (Department of Commerce, Climatological Data, 1971–1980). This finding of decreased germination is compatible, also, with my field observations that the populations appear to rely more on rhizomes than on seeds at higher elevations, i.e., there appears to be a cline of decreasing r-selection and increasing K-selection with increasing elevation.

Although the great majority of seeds germinated promptly during the first season in the four warmer artificial climates, a few, about 1 percent on average, in each of the populations did not germinate until the following season (Fig. 1). This result parallels the germination response of *M. guttatus* in the Wasatch Mountains. There, most of the seeds germinate soon after shedding, i.e., during the later part of the summer. They do not require an after-ripening period as many species do (Mayer and Poljakoff-Mayber 1975). They continue to germinate in decreasing numbers well into the fall. The seedlings overwinter as small (1–2 cm) rosette stage plants. A few new seedlings appear in the spring along the streams as new habitats are exposed with receding water levels. The late germinating seeds appear to constitute small but important seed banks (Harper 1977), both for springtime germination and for the survival of the populations in unfavorable years.

TABLE 5. Comparison of germination of the various populations. Populations within underlined groups are statistically inseparable, whereas populations in nonoverlapping groups are statistically distinct according to the Student, Newman, Keuls Multiple Range Test (Woolf 1968). Population culture numbers (Table 1) are given above the lines and average values for each population below the line.

Days to first germination	7274	7311	7318	7273	7314	11157	7315	5839	7312	7317		
	4.5	4.6	4.8	4.9	5.0	5.3	5.6	5.8	6.1	6.6		
										7317	7316	
										6.6	8.0	
												7319
												10.9
Days to 50% germination	7318	7273	7311	11157	7314	7274	7317	7312	7315			
	6.6	6.8	6.9	6.9	9.0	9.4	10.7	10.8	11.2			
						7274	7317	7312	7315	5839	7319	
						9.4	10.7	10.8	11.2	11.9	14.8	
												7316
												21.3
Average total germination	7319											
	7.3											
		7317	7316	7315	7312	5839						
		38.4	40.3	55.2	58.6	60.4						
				7315	7312	5839	7273	7318	7314	7274	11157	7311
				55.2	58.6	60.4	68.5	76.3	79.0	82.1	83.0	84.1

TABLE 6. Regression analysis of seed germination in the artificial climates versus elevation of origin of the population, given as F-ratio and p value. Significant values are underlined.

Climates	First germination F = p =	50% germination F = p =	Total germination F = p =
2	11.462, .007	5.520, .041	2.444, .149
3	7.667, .019	7.942, .018	4.946, .050
4	16.586, .002	4.434, .061	6.894, .025
5	16.599, .002	2.767, .127	19.650, .001
All together	11.096, .007	7.649, .019	7.112, .024
Standard deviation (all)	6.168, .032	4.265, .066	2.578, .139

The Wasatch ecotype of *Mimulus guttatus* exhibits both much plasticity in the overall similarity of its range of seed germination responses to widely different climates and some apparent genetic polymorphisms for speed and amount of germination during the first season, for the speed and amount of germination in populations with different elevations of origin and for the ability to delay germination until the second season. Thus, the ecotype appear to be well adapted for survival in its climatically unpredictable area.

ACKNOWLEDGMENTS

I thank Michael Nellestein for his technical assistance with the seeds and Harold Hurst and Dennis Phillips for their assistance with the statistical checks.

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PREDATORY BEHAVIOR OF LARVAL *AMBYSTOMA TIGRINUM NEBULOSUM* ON *LIMNEPHILUS* (TRICHOPTERA) LARVAE

Joseph R. Holomuzki[1]

ABSTRACT.— Examination of stomach contents indicated that second-year *Ambystoma tigrinum nebulosum* larvae consumed *Limnephilus* sp. larvae but rarely ingested the case. Feeding observations of captive salamanders on caddisfly larvae supported this finding. Extraction of caddisfly larvae from their case was accomplished only when larval salamanders quickly seized the anterior portion of ambulatory *Limnephilus* sp. extended from their case and vigorously shook the trichopteran from side to side.

Interest in the predatory behavior of *Ambystoma tigrinum nebulosum* on *Limnephilus* sp. was prompted by the examination of stomach contents of 29 second-year larvae (~13 mos. old) from east central Arizona. Fourteen salamanders had eaten a total of 71 *Limnephilus* sp. larvae, yet remains of only 7 cases were evident. This indicated that *A. tigrinum* were extracting caddisfly larvae from their case. Such feeding behavior apparently contrasts with some *A. tigrinum* in Utah where individuals ingested caddisfly larvae with cases (Tanner 1931). Moreover, extraction of larva from the case is discordant with the notion that larval *A. tigrinum* exploit aquatic resources in a manner nearly identical to freshwater fish (Zaret 1980), since fish typically consume both caddisfly case and larva (Elliot 1967, Tippets and Moyle 1978, W. L. Minckley, pers. comm.). This paper describes the ability of captive *A. tigrinum nebulosum* larvae to extract *Limnephilus* sp. larvae from their cases.

Salamanders used for feeding observations and stomach analyses were collected in June 1981 from Big Meadows Tank 1, a permanent pond located 1.0 km NNW of the western edge of Sunrise Lake, Apache Co., Arizona (elev. 2,774 m). Eight second-year larvae varying from 78 to 98 mm from tip of snout to posterior margin of vent were individually kept in 36 × 22 × 26 cm aquaria partially filled with 50 percent Holtfreter's solution. Animals were acclimated for 24 hours before feeding observations were initiated. *Limnephilus* sp. collected from Big Meadows Tank 1 also were kept in 50 percent Holtfreter's solution. Each salamander was provided six caddisflies during feeding runs. The number of strikes and successful captures were counted in each 1–3 hour run. Salamanders were not fed between observations.

Movement by *Limnephilus* sp. seemed to provide a visual stimulus for a strike response by these salamanders. Previous studies also noted *A. tigrinum* larvae typically striking moving prey (Dodson and Dodson 1971, Rose and Armentrout 1976). My observations, however, suggest tactility may also play a role in stimulating an attack on prey. Attraction of a salamander to a caddisfly case was apparently frequently caused by any movement of the case. The salamander usually halted and placed its snout or chin against a case that had moved. Further movement by the caddisfly stimulated a strike. Salamanders withdrew from the case if cessation of movement was protracted.

During 26 hours of observations, only 2 (3.4 percent) *Limnephilus* sp. larvae were eaten in 58 strikes. Unsuccessful attempts at prey capture consisted of a salamander taking the entire case into its mouth. The animal then manipulated the case and discarded it after about 14 seconds (N = 12, range: 3–85 seconds). On no occasion was the case consumed. Caddisfly larvae were successfully attacked and eaten only when a salamander slowly approached an ambulatory *Limnephilus* sp. extended from its case and quickly seized the anterior portion of the larva. The salamander then vigorously shook the trichopteran from side to side until extracted.

[1]Department of Zoology, Arizona State University, Tempe, Arizona 85287.

Similar head-whipping behavior by metamorphosed *A. trigrinum* on elongate prey was described by Larsen and Guthrie (1975) and Lindquist and Bachmann (1980). This method of *Limnephilus* sp. capture seemed to be supported by the stomach analyses, in which 10 of 71 consumed larvae were severed 0–2 mm behind the metanotum.

The relatively poor capture success by salamanders in the laboratory may also be characteristic of the natural habitat. For example, Dodson and Dodson (1971) found relatively few tichopteran larvae in the diet of *A. tigrinum* larvae from Colorado, even though the insects were abundant in the samled pond. *Limnephilus* sp., however, comprised about 16 percent of the total volume of prey in the diet of larvae in June from Big Meadows Tank 1. This suggests salamander larvae of this population frequently attacked trichopterans.

In sum, stomach contents showed that *A. tigrinum* larvae from this population infrequently ingested caddisfly cases. Absence of case consumption in the laboratory supported the finding. Successful attacks on *Limnephilus* sp. were few and occurred only when *A. tigrinum* quickly seized the anterior portion of a caddisfly extended from its case. These observations suggest caddisfly cases are an effective means of deterring predation by larval salamanders of this population.

Acknowledgments

Thanks are extended to J. P. Collins and W. L. Minckley for commenting on an earlier draft of the manuscript.

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NOTES ON REPRODUCTION OF THE SIDE-BLOTCHED LIZARD *UTA STANSBURIANA STANSBURIANA* IN SOUTHWEST IDAHO

George Bakewell[1], Joseph M. Chopek[1], and Gary L. Burkholder[1]

Abstract.— In 1968 and 1973 in southwestern Idaho, 275 *Uta stansburiana* were collected. *Uta* occupies low hills with rocky outcrops and flat sparse vegetation consisting of the following shrubs: *Artemisia tridentata*, *Grayia spinosa*, *Atriplex confertifolia*, *Chrysothamnus nauseosus*, and *Atriplex canescens*. Emergence from hibernation occurs from mid-March to early April and the first yolked follicles appear in early April, with oviducal eggs present in late April. Testicular cycle begins with the emergence of males, and spermatozoa are produced from April through July. *Uta* reaches sexual maturity in one year at a SVL of 40.0 mm in males and 43 mm in females. Overall clutch size is 3.75 eggs (1–2 clutches per year). Fat body size at emergence is not known, but what is present shows a decline in males and females until July, when a substantial increase occurs. Sex ratios are about 1:1 in all months and seasons except June 1968, according to chi-square analysis.

This study has limited scope for two reasons: (1) the years of study are five years apart; (2) in 1968 there were only six trips to the field (which was about 10 miles from the 1973 area) in May and June, whereas in 1973 field trips were made once each week from 4 April through 25 July. In view of this, the 1968 data are minimized to some extent in drawing our conclusion and emphasis is on the 1973 data. Despite these limitations, the study sheds some light on the reproductive cycle of *Uta stansburiana* in the northern portion of its range.

Uta has been studied in considerable detail in Texas (Tinkle 1961, 1967a, Hahn and Tinkle 1965), Colorado (Tinkle 1967b), southern Nevada (Hoddenbach and Turner 1968, Turner, Hoddenbach, Medica, and Lannom 1970, Medica and Turner 1976, Tanner 1972), and Oregon (Nussbaum and Diller 1976). Our results show that latitudinal (and therefore climatic) differences exert observable modifications of the reproductive cycle as compared to that of southern populations in Colorado, Nevada, and Texas, which are 800–1200 km south of our study, respectively. In the case of the northern population studied by Nussbaum and Diller (1976), our results are similar in some aspects, as would be expected, since their study area is only 225 km further north.

Physical and Biotic Environment

These counties included in the study area are part of the Snake River Valley (Fig. 1). Elevations of study sites and collection areas range from 530 to 750 m. Dominant topographical features consist of small canyons, which are a part of the Snake River Drainage, low rolling hills, boulder-strewn areas, rocky outcroppings, and intermittent streams that form sandy washes and/or alluvial fans

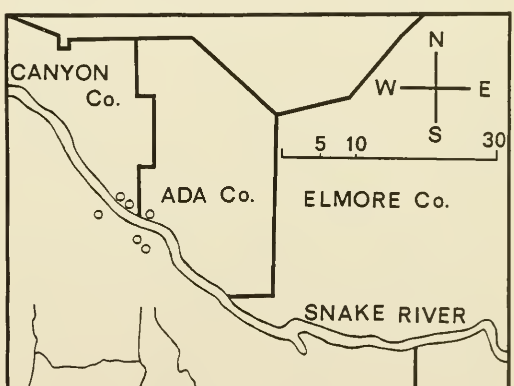

Fig. 1. Geographic location for capture sites (hollow circles) of *Uta stansburiana* in southwestern Idaho. Insert shows the portion of Idaho where collections were made.

[1]Mount Vernon Nazarene College, Martinsburg Road, Mount Vernon, Ohio 43050.

where they reach the desert floor. Annual rainfall varies from 10.1 to 30.4 mm; most of this occurs as snow in winter (Shreve 1942). Summers are typically hot and dry, with few overcast days. Frost free days average 150 per year from April to September.

The dominant floral description for the study areas is that of "cold desert formation" (Shreve 1942). The dominant floral associations consist of several different combinations of the following desert shrubs: *Grayia spinosa* (Hook.), *Atriplex canescens* (Pursh, Ex. Nutt.), *Atriplex confertifolia* (Torr.), *Artemisia tridentata* (Nutt.), and *Chrysothamnus nauseosus* (Poll.). These shrubs reach heights of 1 to 1.8 m and grow in a clumped pattern that creates open areas (Burkholder and Walker 1973). Many species of annuals are present in the open areas between the shrubs, the majority of which flower during the early and midspring rainy period. Others flower during the occasional rainy periods of late spring and summer.

Methods and Materials

Specimens for this study were collected in 1968 and 1973 in Canyon, Ada, and Owyhee counties of southwestern Idaho. All lizards were weighed, measured (SVL), and autopsied (except hatchlings). The ovaries and oviducts of the females were removed and counts were made of yolked ovarian follicles, oviducal eggs, and corpora lutea. Yolked follicles and oviducal eggs were measured to the nearest 0.1 mm and weighed to the nearest .01 g. In males, one testis was removed and used to determine sexual maturity by a squash preparation using aceto-orcein stain. Clutch size data followed the procedure outlined by Tinkle (1961). Fat bodies were also removed and weighed to the nearest .01 g.

Table 1. Sex ratios for six samples of *Uta stansburiana* in 1968 and 1973. Each year total was tested for goodness of fit by the chi-square statistic as well as the month of June, where the largest differences occurred. All fit the 95 percent confidence limit except June 1968.

Month	Year	Females	Males
May	1968	14	13
June	1968	20	37
Total		34	50
Chi-square test .95 = 5.06 for June			
Chi-square test .95 = 3.04 overall			
April	1973	20	16
May	1973	29	33
June	1973	23	32
July	1973	18	20
Total		90	101
Chi-square test .95 = 1.472 for June			
Chi-square test .95 = .632 overall			

Results

Sex ratio.— Sex was determined in 275 specimens by the examination of gonads. In May and June 1968, 34 females and 50 males were collected. The April through July 1973 sample consisted of 90 females and 101 males. Both years combined resulted in 124 (45.1 percent) females and 151 (54.9 percent) males. Data for sex ratios are summarized in Table 1. Statistical analysis for fitting the expected ratio of 1:1 are also included in Table 1.

Size at maturity and at hatching.— Size of individuals when reaching sexual maturity was determined by analyzing the gonads. In females, yolked ovarian follicles, oviducal eggs, and corpora lutea were used as criteria for maturity. From this analysis, it was determined that the smallest sexually mature female was 43 mm SVL for the 1973 sample and 44 mm SVL for the 1968 sample.

Size at sexual maturity in males was determined by analysis of a single testis removed from each male. An aceto-orcein squash preparation was performed to check for the presence of mature spermatozoa. All male specimens, even the smallest at 40 mm SVL, yielded a positive test for spermatozoa. The

Table 2. Data for hatchling *Uta stansburiana* captured in July 1973. Two lizards not listed were observed on 26 June but not captured.

SVL (mm)	Date Captured
26.0	3 July
25.5	18 July
25.0	23 July
25.0	23 July
26.0	23 July
31.0	23 July
31.0	23 July
31.5	23 July
36.0	23 July
28.0	25 July
29.0	25 July
31.0	25 July
33.0	25 July

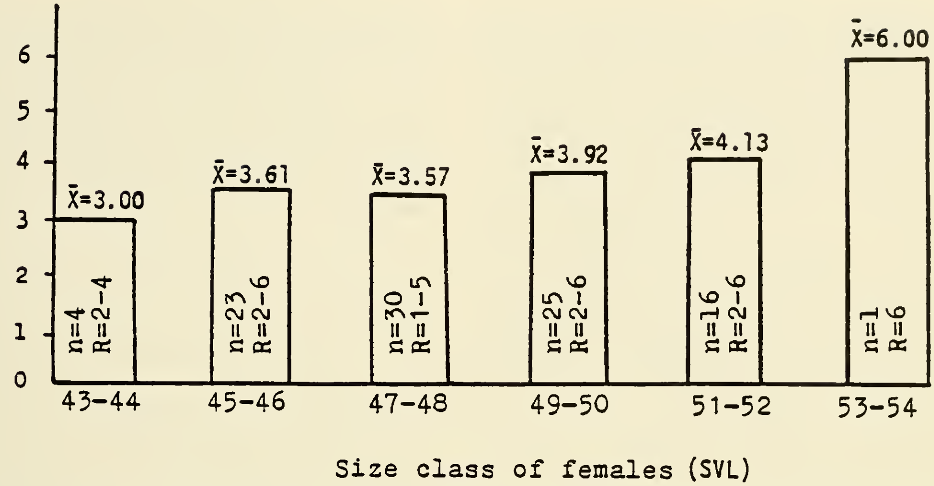

Fig. 2. The mean number of yolked ovarian follicles, oviducal eggs, and corpora lutea for six arbitrarily sized classes of females. N = number of individuals, R = range, and X = mean 1968 and 1973 females combined.

12 hatchlings were not sexed but were assumed not to be reproductively mature.

The first hatchlings were observed, but not collected, on 26 June 1973. Twelve specimens were collected from 3 July 1973 to 25 July 1973. The data for hatchlings is presented in Table 2.

Mean size of mature individuals.— The largest male specimen was 57.5 mm SVL and the smallest 40.0 mm SVL. The largest female was 53.0 mm SVL and the smallest was 43 mm SVL. Table 3 summarizes the remaining data related to mean size of mature individuals.

Reproduction in females.— Counts were made of oviducal eggs, corpora lutea, and yolked ovarian follicles in the ovaries of 124 females. Figure 2 shows a comparison of six arbitrary size classes that indicates that clutch size increases with size of the female, with the two smallest categories (43–44 and 45–46 SVL) presumably being first-year reproducive females, and those 47 and over second-year females. Using 1973 female data alone, because it covers the entire reproductive season, there was an attempt to determine the number of clutches per year, which is difficult in multiple clutch species.

The 1973 data appears to indicate a two-clutch ability by some individuals. The first clutch group is clustered between 23 April and 22 May (based on shelled oviducal eggs). The second clutch group is clustered between 2 June and 10 July. Between the period of 22 May and 2 June, there are females with oviducal eggs but these are late individuals reproductively, which will probably produce only one clutch because of time constraints. To substantiate the double clutch, we began with the correlation of the first appearance of hatchlings, assuming a 45–50 day incubation period, which is based on Burkholder and Tanner's (1974) work on *Sceloporus graciosus*, which has a mean incubation period of 49 days (from laboratory and field incubation data). If the females of the first group laid eggs from 23 April through 22 May, with a 50-day incubation period, the hatchlings would appear as early as 11 June and as late as 10 July. The first hatchlings

Table 3. The mean SVL in millimeters of sexually mature males and females for 1968 and 1973, based on spermatozoa in testis and epididymus and yolked ovarian follicles, oviducal eggs, or corpora lutea, respectively.

	Males			Females		
Year	x̄	N	R	x̄	N	R
1968	49.27	51	44–57	47.70	34	44.5–52
1973	49.66	100	40–55	48.06	99	43–53

were observed on 26 June and 3 July (Table 2), which falls within the predicted time. The second clutch hatchlings would appear 21 July through 28 August. The smallest hatchlings captured between 23 July and 25 July (Table 2) fit into this category.

The second point that supports two clutches is that of the time span between the first and second onset of vitellogenesis. Turner, et al. (1970) state that 31 days are sufficient for production of a second clutch. If the days are counted between the proposed first and second clutch (clustering of females with shelled oviducal eggs), there are 42 days, which would appear to be ample time.

The only nonsupportive evidence is the absence of corpora lutea when the second production of yolked ovarian follicles occurs. However, it is our opinion, based on observations of autopsied individuals, that corpora lutea in *Uta* disappear very quickly (1–5 days), which would explain the lack of overlap.

Along with the double clutch phenomena is the feature of clutch size fluctuation. The mean size of the first clutch (based on oviducal eggs only) was 4.40 (N = 14) and the second was 3.81 (N = 16). This corresponds to that reported by Tinkle (1967b) for Texas populations, Turner et al. (1970), and Medica and Turner (1976) for Nevada, and Nussbaum and Diller (1976) for Oregon, though the difference is not as significant.

The earliest onset of vitellogenesis is 14 April (1973). This is based on yolked ovarian follicles of 2 mm diameter or larger and a definite yellow color. Table 4 summarizes the numbers of yolked ovarian follicles, oviducal eggs, and corpora lutea for the determination of clutch size (1968 and 1973 data were pooled). Reproductive potential was not calculated; the actual numbers of females laying a second clutch was not determined.

FAT BODIES.— The fat bodies decrease in weight from the time of emergence of adults through the end of the reproductive period in both males and females (Table 5)

TABLE 4. Data for yolked ovarian follicles, oviducal eggs, corpora lutea, and mean clutch size per female for the years 1968 and 1973.

Year	Ovarian yolked follicles	Oviducal eggs	Corpora lutea	Mean clutch size
1968	45(N = 12)	65(N = 17)	0	3.79
1973	112(N = 33)	135(N = 33)	7(N = 2)	3.74
Total	157(N = 45)	200(N = 50)	7(N = 2)	3.64
Mean	3.49	4.00	3.50	3.75
	Clutch size		3.75	
	Clutches per year		1–2	

DISCUSSION

Although the volume of data and length of time are much less than studies which we will use for comparison and contrast, this study provides some additional information concerning the total knowledge of natural history of *Uta stansburiana*. In essence, the comparisons made with regard to *Uta* concern that of northern vs. southern populations and the changes that occur along that continuum.

The first feature is that of sex-ratio. On a yearly basis, all (1968 and 1973) fit the

TABLE 5. Fat body weight changes in 1973 male and female *Uta stansburiana* April–July in grams. Single asterisk means that all had yolked follicles or oviducal eggs. Double asterisk means the two at < .01 still had oviducal eggs and corpora lutea and the one at .08 corpora lutea only, and the rest had no reproductive activity. Triple asterisk means the .25 specimen had just begun vitellogenesis; the two at < .01, two at .02, and two at .03 had not started vitellogenesis, whereas all others had.

	April	May	June	July
Males	16 = < .01	32 = < .01	26 = < .01	3 = < .01
		1 = .08	1 = .01	2 = .01
				1 = .03
				2 = .04
				1 = .05
				2 = .06
				2 = .07
				1 = .08
				2 = .09
				1 = .10
				1 = .15
N	16	33	32	18
Females	11 = < .01	18 = < .01	14 = < .01	1 = < .01
	4 = .03	2 = .04	1 = .05	1 = .02
	1 = .05	2 = .03	2 = .03	2 = .05
	3 = .02	2 = .02	1 = .02	1 = .06
	1 = .04			1 = .07
	1 = .25			1 = .08
				1 = .09
				2 = .10
				2 = .11
				1 = .12
				1 = .15
N	21***	24*	18*	15**

expected ratio of 1:1. Monthly fluctuations are not as consistent, especially in June for both years. These data indicate a 3:2 ratio of males to females, which is similar to what Tinkle (1961) recorded in Texas. Tinkle (1961) attributed this to territorial vigilance in males, and this appears to be true for those in Idaho. In addition to this, the difference may be further enhanced by female oviposition in June. By July these activities (male and female) cease, and the ratio returns to 1:1.

Idaho *Uta* attain sexual maturity in one year; they hatch, over winter, and emerge as adults (Tinkle 1961, Tanner 1972, Medica and Turner 1976). Nussbaum and Diller (1976), however, observed that in north central Oregon some *Uta* that hatched late in the year (late August) would not have sufficient time for growth and therefore would not be sexually mature by the time the next reproductive season arrived. We think that this is rare in Idaho, based on size of earliest individuals collected, because they had yolked ovarian follicles, spermatozoa, and larger SVL than the minimum SVL as determined for sexual maturity of Oregon Uta. The longer growth period of Idaho vs. Oregon is most likely the basis for the differences in the two populations.

The remainder of our findings concerning Idaho *Uta* have been added to Table 6, which is a modification from Nussbaum and Diller (1976). Table 6 calls attention to several areas of interest. The elevation is as low or lower than all the previous studies, though further north than all but the one in Oregon. Length of growing season and therefore length of reproductive season are longer than that found in Oregon but less than the four southern studies. These physical aspects put the Idaho population in a somewhat intermediate position between that of Oregon and

Table 6. Comparison of data for six *Uta* populations.

	Texas	Colorado	Nevada (Rock Valley)	Nevada (Rainier Mesa)	Oregon	Idaho (1973)
Elevation (ft)	2900	≅4250	3400	7840	2400	1722–2437
Length of growing season (days)	215	175	225	200	110–140	150–180
Length of reproductive season (days)	121–141	120	135	–	70	90–100
Habit	arenicolous	saxicolous	–	–	saxicolous	saxicolous
Sexual dichromatism	high	103	–	–	high	high
Aggressiveness	high	103	–	–	low	–
Social structure	territorial	dominance	–	–	dominance (?)	dominance (?)
Density (individuals/acre)	36.109	17.5	24	10	71	–
Male home range (acres)	0.50	0.27	–	–	0.54	–
Female home range (acres)	0.17	0.23	–	–	0.43	–
Hatchling size (mm(SVL)	22	≅22	≅22	≅22	22	26°
Size range mature males (mm)	40–60	42–	–	40–56	40–53	40–55
Size range mature females (mm)	40–60	37–	40+	–	41–49	43–53
Average size adult males (mm)	–	–	–	49	48.4	49.6
Average size adult females (mm)	48.9	42.8	–	–	45.4	48.0
Clutch size	≅4.0	3.20	.6–.4	4.85	3.33	3.75
Clutch frequency	3.5	3	3–5	–	1–2	1–2
Percent males fail to breed first season	0.0	<25	–	–	= 19.0	–
Percent females fail to breed first season	0.0	<25	–	–	= 47.0	A
Percent males two years old and older	7	33	18–28	36–65	57.6	–
Percent females two years old and older	7	33	18–28	36–65	69.4	–
Date hatchlings appear	20 June	25 June	25 June	17 July	17 July	26 June

Texas and Colorado (Tinkle 1961, 1967a, b, 1969a, Tinkle and Woodward 1967)
Oregon (Nussbaum and Diller 1976)
Nevada—Rock Valley (Turner et al., 1970, Medica and Turner 1976)
Nevada—Rainier Mesa (Tanner 1972)
Idaho—(this study)
°Smallest individual caught 3 July 1973

the four southern populations, even though it is not located halfway between from the standpoint of miles. Because of these factors and others (i.e., precipitation and primary production), there should be some influence on reproductive cycle, average adult size, date of hatching, appearance, etc.

In reference to the above-mentioned parameters and the information in Table 6, it becomes apparent that Idaho *Uta* do lay more than one clutch per year. This is based on the broad period of time when females have oviducal eggs present (the same is true for yolked ovarian follicles) and the appearance and size (SVL) of hatchlings from 26 June through late July. The percentage of females laying a second clutch is speculative because of incomplete data, but it would appear to occur in the majority of the population as compared to a small percentage in the Oregon population as reported by Nussbaum and Diller (1976). It is doubtful if any could produce a third clutch, as is the case in Colorado *Uta* (Tinkle 1976), due to length of reproductive season, though the possibility does exist if favorable conditions prevail.

Coupled with this is the fairly high overall clutch size of 3.75 or, if based on oviducal eggs only (first and second clutch), 4.40 and 3.81/female, which approaches the size if not equals that of the Texas, Colorado, and Nevada (Rock Valley) populations. The only difference is the number of clutches per year. The size is significantly higher than that of Oregon. The explanation for the similarity to populations much farther south and the difference from the more northern Oregon population is complicated but again probably is within the realm of the response of *Uta* to changes in the elevation and/or latitude, length of growing and reproductive seasons, annual precipitation as it affects primary production, and general habitat. Because of the limitation of this study, we feel inadequate to speculate on these interrelationships at this time.

Average size of males and females (SVL), as well as size range for mature males and females, does not appear to deviate dramatically from other populations. Fat body cycle follows that reported first by Hahn and Tinkle (1965) and by many subsequent authors with regard to various lizard species.

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OBSERVATIONS ON ALPINE VEGETATION NEAR SCHOOLROOM GLACIER, TETON RANGE, WYOMING

John R. Spence[1] and Richard J. Shaw[1]

Abstract.— Quadrat and propagule trapping studies were made on the moraine of the Schoolroom Glacier and in adjacent dry alpine meadow vegetation in the Teton Range in 1978–1979. Forty-six species of vascular plants were collected. Distributionally, three groups of species exist. One of these is concentrated primarily on the moraine, a second in the meadow, and the third in a narrow ecotonal band at the base of the distal slope of the moraine. The moraine slopes are steep and unstable, with vegetation cover ranging from 1 to 9 percent, dominated by *Cirsium tweedyi* (Rydb.) Petr. Along the more stable moraine crest the vegetation cover is heavier, and is similar to that in the meadow. The meadow vegetation cover is about 50 percent, dominated by *Astragalus kentrophyta* Gray. Using a combination of cover and frequency as a measure of importance, dominance-diversity curves were constructed for the moraine and meadow. Both approach geometric series, which are suggested as indicating harsh environments. Abiotically pollinated species are more successful on the moraine than biotically pollinated species, but the reverse is true for the meadow. Propagule trapping studies suggest that dispersal of anemochorous propagules onto the moraine is very low compared with dispersal in the meadow.

Relatively little is known about the structure and dynamics of alpine vegetation in the Teton Range, Grand Teton National Park, Wyoming. In this paper we report some preliminary quadrat and propagule trapping studies from alpine vegetation in the southern fork of Cascade Canyon in the center of the range.

The selected study area is a complex of alpine meadow and morainal deposits at the head of the south fork of Cascade Canyon, about 4 km southwest of the Grand Teton (Fig. 1). An east-facing cliff called The Wall bounds the study area on the west; this formation forms part of the hydrographic divide of the Teton Range. A shallow cirque has been carved into this cliff by the Schoolroom Glacier, so called because of the almost perfect end moraine fronting it (Fig. 2). The age of this moraine is unknown, but similar deposits elsewhere in the range are of Neoglacial age, which places the moraine age from about 100 to 3,000 years (Mahaney 1975, Mahaney and Spence 1983). Between this moraine and the glacier lies a small meltwater lake about 50 m across, which is drained by a stream that has cut through the center of the moraine. The two ends of the moraine merge into extensive talus derived from The Wall to either side of the glacier. Northeast of the glacier is a large outcrop of gneiss and schist of Precambrian age, which is vegetated by a mosaic of fen and timberline krummholz stands. To the east and southeast lies an extensive, slightly undulating dry alpine meadow underlaid by glacial and talus deposits of Pinedale or older age. The Wall and Schoolroom Glacier moraine are composed primarily of Death Canyon Limestone of the Gros Ventre Formation (Cambrian), with some debris of the Wolsey Shale member of the Gros Ventre Formation, in addition to Flathead Sandstone (Cambrian, Love, and Reed 1968, Reed 1973).

Climate data from the Teton Range and park are summarized elsewhere (Spence 1981). Mean annual temperature from Jackson Hole to the east of the range, at an elevation of 2,040 m, is about 1.3 C. Using the elevation of the study area, 3,060 m, and the adiabatic lapse rate (Cole 1975), average annual temperature in front of the Schoolroom Glacier would be about −4.8 C. Snow depth during the winter is unknown, but it is usually gone from the area by late June to early July during an average year. Common animals at the site include marmots (*Marmota flaviventris*), pikas (*Ochotona princeps*), and Rosy Finches (*Leucosticte atrata*).

The purposes of this paper are (1) to characterize and contrast the vegetation on the

[1]Department of Botany, University of British Columbia, Vancouver, B.C., Canada V6T 1W5.
[2]Department of Biology, Utah State University, UMC45, Logan, Utah 84322.

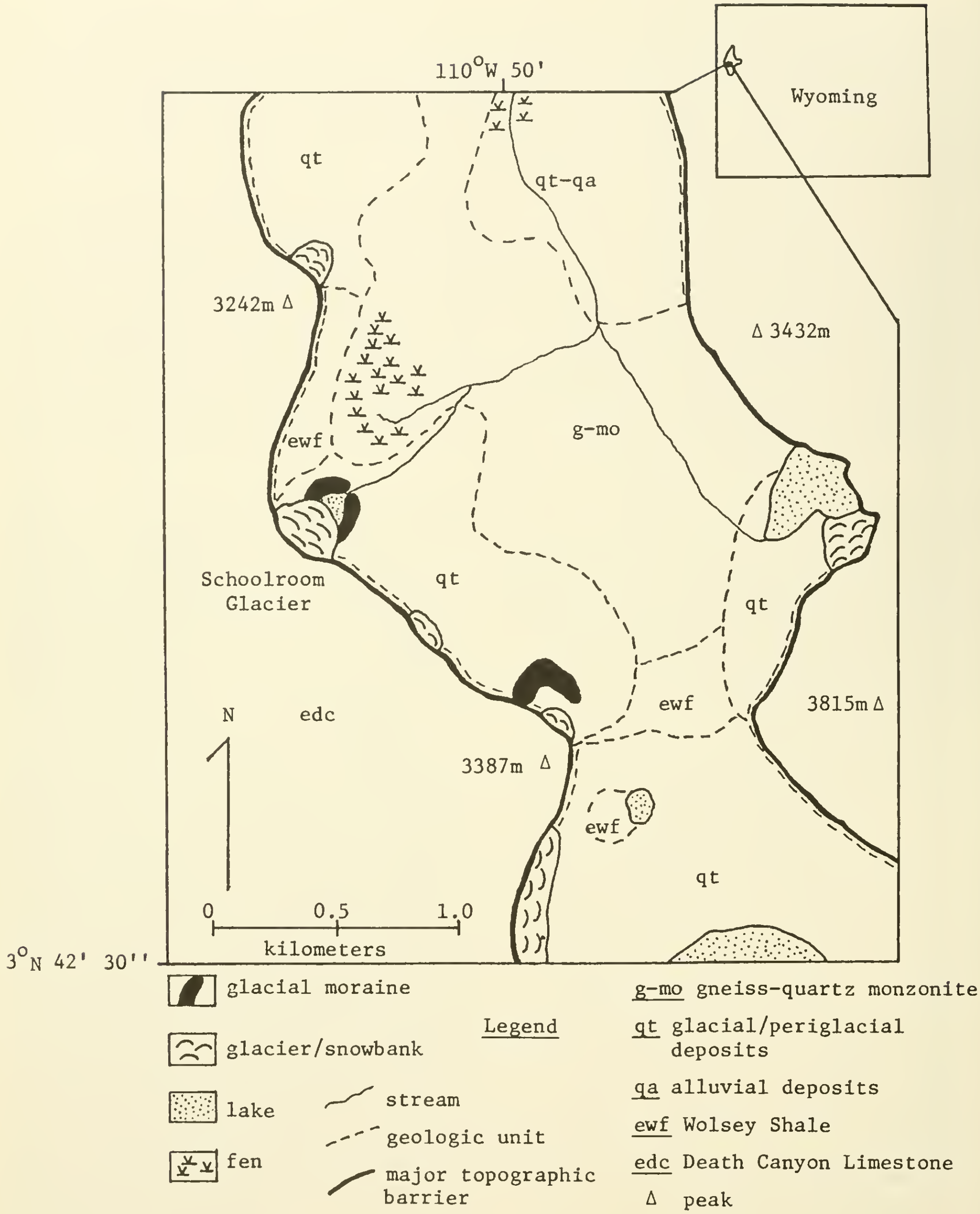

Fig. 1. A sketch map of the study area at the head of the south fork of Cascade Canyon. Only major features are shown on the map. The boundaries for the geologic units are only approximate. The map is derived from 7.5 minute USGS topographic maps, Love and Reed (1968), Reed (1973), and personal observations of the senior author (JRS). See the legend for map details.

Schoolroom Glacier moraine and in the dry alpine meadow adjacent to it, and (2) to suggest possible dynamics between the two communities.

Methods and Materials

Initial site observations and collections were made in the summer of 1978. In 1979,

Fig. 2. Schoolroom Glacier at the head of the south fork of Cascade Canyon, Grand Teton National Park, Wyoming.

the quadrat data were gathered on 19 September. Two transects, each 90 m long, were run from the base of the proximal slope of the moraine adjacent to the meltwater lake, up to and over the moraine crest, down the distal slope, and out into the meadow. At 3 m intervals, a 0.5 × 0.5 m quadrat was placed down on alternating sides of the transect line. Cover and presence of all species was noted visually, using a modified Braun-Blanquet scale, as follows: + = 0–1 percent, 1 = 1–5 percent, 2 = 5–25 percent, 3 = 25–50 percent, 4 = 50–75 percent, 5 = 75–100 percent. For calculating the total and average cover values, the midpoints of the ranges were used. Prominence Values (PV) were calculated using the formula PV = percent cover × the square root of percent frequency. Along the transect lines, slope was measured using an Abney level.

Propagule trapping was studied in two ways, by water-filled plastic trays 40 × 15 × 5 cm in size, and 15 × 15 cm wooden plates coated with petroleum jelly. The water trays were used in 1978, with six of them placed in a line from the edge of the meltwater lake up and over the moraine to the meadow. In 1979, nine wooden plates were used, and were placed in a line 10 m apart from the edge of the lake up and over the moraine and out into the meadow. Once in July and once in September the wooden plates were in operation, for a total of 38 hours in July and 24 hours in September. This amounts to a total of 558 trap-hours in operation. Trapped propagules were placed in glass vials for later identification. A reference set of propagules from species at the site was made to aid in identification. Specimens collected are on deposit at the Moose Herbarium in Grand Teton National Park and the Intermountain Herbarium at Utah State University (UTC). Nomenclature follows Shaw (1976).

Results and Discussion

Forty-six species of vascular plants were collected from the moraine and adjacent meadow in 1978 and 1979. Details on the floristics and comparisons with other glacial moraine sites in the Tetons will be published elsewhere (Spence 1983). One species, *Taraxacum lyratum* Ledeb., is a new report for the park. The distribution of life forms of the species is: 1 shrub, 1 fern ally, 1 annual dicot, 11 graminoids, and 32 biennial/perennial forbs. Of these species, 31 were encountered along the two transects (Table 1). The remaining species are quite rare at the site, many of them consisting of only a few individual plants.

Along the first transect, average cover was 0.6 percent for the moraine proximal slope, 8.9 percent for the distal slope, and 47.4 percent for the meadow. For the second transect, the respective values were 2.8 percent, 9.2 percent, and 63.3 percent. Cover values per quadrat ranged from 0 percent (7 times; 6 on the moraine proximal slope, 1 on the moraine distal slope, and 0 in the meadow) to 106.5 percent (once, in the meadow). Pooling the results of the two transects, total cover on the moraine is 1.7 percent for the proximal slope and 9.1 percent for the distal slope. Average cover for the meadow is 54.6 percent. These values are all significantly different from one another at $\alpha = 0.05$. Data from the two transects are summarized in Table 1 for the moraine and the meadow.

Although most of the species encountered in the transects are found on both the moraine and in the meadow, they tend to be much more common on one or the other (see Table 1). General observations elsewhere on the moraine and in the meadow tend to sup-

TABLE 1. The quadrat data from the two line transects in summarized form. Each transect was 90 m long, with a 0.5 × 0.5 m quadrat placed at every 3 m interval, for a total of 60 quadrats and 15 m^2. The species are arranged alphabetically, and three numbers are listed for each species; percent frequency, average percent cover, and prominence value, which is calculated as average percent cover × square root of percent frequency. For details on transect placement and method of measuring species, see Methods and Materials.

	Moraine (N = 38)	Meadow (N = 22)
Species	(percent frequency/average percent cover/prominence value)	
Achillea millefolium	–	4.5/0.68/1.44
Agropyron caninum	10.5/0.54/1.75	22.7/4.25/20.25
A. scribneri	2.6/0.07/0.11	–
Antennaria umbrinella	7.9/0.09/0.25	45.5/4.82/32.51
Arabis lyallii	–	13.6/0.07/0.26
Arenaria nuttallii	–	13.6/0.07/0.26
Arnica longifolia	2.6/0.01/0.02	–
Astragalus kentrophyta	2.6/0.45/0.73	68.2/28.20/232.88
Carex species	–	9.1/0.14/0.42
Cirsium tweedyi	26.3/0.92/4.72	–
Cymopterus hendersonii	7.9/0.04/0.11	4.5/0.68/1.44
Epilobium alpinum	18.4/0.63/2.70	4.5/0.02/0.04
Erigeron compositus	7.9/0.14/0.39	13.6/0.34/1.25
E. leiomerus	–	4.5/0.68/1.44
Erysimum asperum	–	18.2/0.09/0.38
Festuca ovina	–	4.5/0.02/0.04
Hymenoxys grandiflora	2.6/0.01/0.02	72.7/4.20/35.81
Oxyria digyna	2.6/0.01/0.02	–
Phacelia sericea	–	9.1/0.14/0.42
Poa alpina	7.9/0.14/0.39	–
P. pattersonii	15.8/0.24/0.95	40.9/3.59/22.96
Polemonium viscosum	18.4/0.58/2.49	4.5/0.68/1.44
Salix arctica	–	9.1/1.82/5.49
Selaginella densa	–	4.5/0.68/1.44
Senecio fremontii	23.7/0.12/0.58	–
Silene acaulis	2.6/0.39/0.63	4.5/1.70/3.61
Solidago multiradiata	5.3/0.08/0.18	31.8/0.43/2.42
Taraxacum lyratum	5.3/0.03/0.07	–
T. officinale	10.5/0.05/0.16	22.7/0.11/0.52
Townsendia montana	7.9/0.14/0.39	–
Trisetum spicatum	7.9/0.14/0.39	9.1/0.14/0.42
Unknown grasses	42.1/0.70/4.54	27.3/1.64/8.57
Unknown herbs	18.4/0.09/0.39	50.0/4.36/30.83

port the conclusions drawn from the transect data. Only a few species, such as *Poa pattersonii, Agropyron caninum,* and *Taraxacum officinale,* appear to be equally common in both areas. Furthermore, a group of species appears to be restricted to an area at the base of the distal moraine slope. They are found in a band ranging from 1 m up to 10 m wide between the moraine slope and the meadow proper. This band is formed primarily of debris derived from slumping and sliding off the distal moraine slope. Some of the species that were found in this ecotonal region include *Anemone multifida, Draba lonchocarpa, Oxytropis deflexa, Taraxacum lyratum, Androsace septentrionalis, Castilleja sulphurea,* and *Eritrichium nanum.* Few of these species were found on the moraine, and they were all either rare or absent from the meadow. The transect data show that this ecotonal region is richer in species than either the moraine or meadow. Average number of species per quadrat ranged from 4 on the moraine, to 5.1 in the meadow, to 7.3 in the ecotone between the two.

Using prominence values (PV), the most important species on the moraine are *Cirsium tweedyi, Epilobium alpinum, Polemonium viscosum, Agropyron caninum,* and *Poa pattersonii.* In the meadow the most important species are *Astragalus kentrophyta, Hymenoxys grandiflora, Antennaria umbrinella, Poa pattersonii,* and *Agropyron caninum.* Using the contribution of each species PV to the total summed PV for the moraine and the meadow, dominance diversity curves can be constructed (Fig. 3). Both curves approach geometric series, which have been suggested to indicate harsh environments in which dominance by one or a few species is strong (Whittaker 1975). On the moraine, several species share dominance; these are *Cirsium tweedyi* (28 percent of the total summed PV's), *Epilobium alpinum* (16 percent), *Polemonium viscosum* (15 percent), and *Agropyron caninum* (10 percent). In the meadow, *Astragalus kentrophyta* dominates (63 percent). Other species include *Hymenoxys grandiflora* (10 percent), *Antennaria umbrinella* (9 percent), and *Poa pattersonii* (6 percent). Of the eight species listed above, the majority are either western North American alpine species (*P. viscosum, A. kentrophyta,*

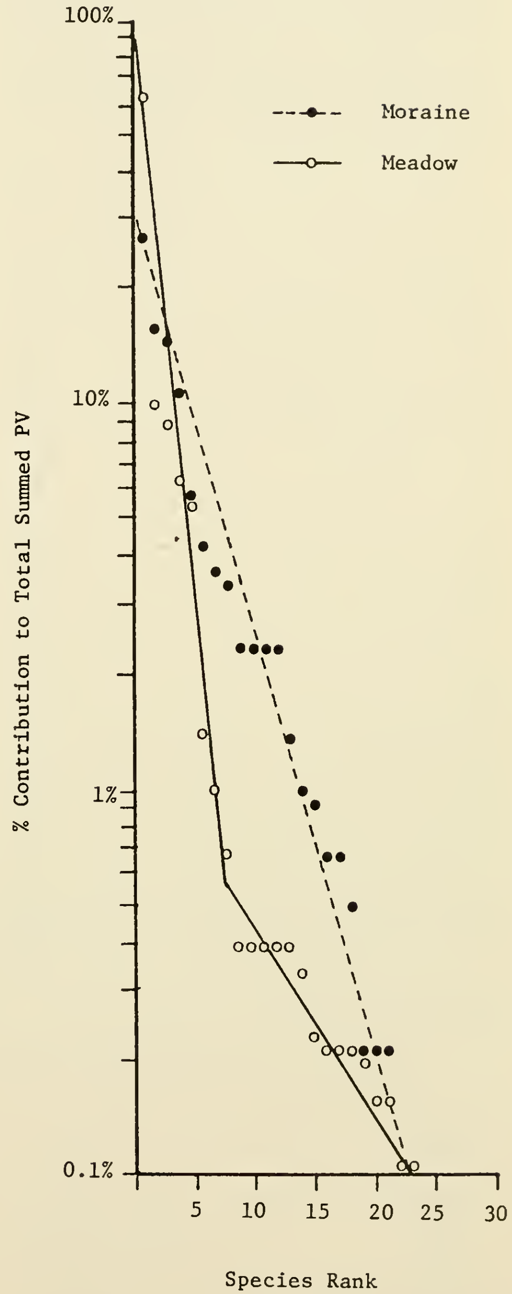

Fig. 3. Dominance-diversity curves for the moraine and the meadow. The measure of importance used was each species contribution to the total summed prominence values in percent. There are 21 species in the moraine curve and 23 species in the meadow curve. All species with values less than 0.1 percent had 0.1 percent added to their value to include them on the graph. This tended to slightly flatten the two curves at the bottom.

P. pattersonii, and *A. umbrinella*) or south/central Rocky Mountain alpine species (*C. tweedyi* and *H. grandiflora*). Of the other two, *Epilobium alpinum* (sensu lato) is a widespread circumpolar arctic-alpine species and *Agropyron caninum* is a North American boreal-montane species.

Using information derived from Fryxell (1957), Swales (1979), and Ostler and Harper (1978), the species from the transects can be divided into two groups, biotically and abiotically pollinated species. Wind-pollinated, suspected autogamous and apomictic species (i.e., *Arabis lyallii*, *Taraxacum officinale*, and *Epilobium alpinum*), and the fern ally *Selaginella densa*, which requires water for fertilization, are included in the abiotically pollinated group. Biotically pollinated (primarily entomophilous) dicot species comprise the biotically pollinated group. Average number of abiotically pollinated species per quadrat on the moraine is 1.0, in the meadow 1.4. These are not significantly different at $\alpha = 0.05$. Average number of biotically pollinated species per quadrat on the moraine is 1.2, in the meadow 3.1. These are significantly different at $\alpha = 0.05$ (using a t-test for unequal sample sizes). These and other comparisons between these two groups of species are summarized in Table 2. The total

TABLE 2. Comparisons between the moraine and the meadow using the quadrat data derived from the line transects. Two groups of species, abiotically pollinated (the abiotic group) and biotically pollinated (biotic group) are compared for the two areas. See the text for details on the two groups of species. The sample size (N) is the number of quadrats.

	Moraine (N = 38)	Meadow (N = 22)
Average percent cover		
Abiotic	2.5	10.7
Biotic	3.0	44.5
Average number of species per quadrat		
Abiotic	1.0	1.4
Biotic	1.2	3.1
Σ Prominance values (PV)		
Abiotic	11.0	54.9
Biotic	6.4	343.1
Number of species		
Abiotic	8	9
Biotic	13	14
Total number of species		
Abiotic	12	
Biotic	19	

summed PV for all the moraine species in the abiotically and biotically pollinated groups are 11.0 and 6.4, respectively. For the meadow they are 54.9 and 343.9, respectively. The ratio of PV for the abiotically pollinated species in the meadow and the moraine is 5:1, and that for the biotically pollinated species is 53:1. The total number of species on the moraine and in the meadow for the abiotically pollinated group are 8 and 9, respectively. For the biotically pollinated group the values for the moraine and meadow are 13 and 14, respectively. All these comparisons suggest that the species in the abiotically pollinated group are relatively more succesful at colonizing and establishing on the moraine deposits than the species in the biotically pollinated group. The reverse is true for the meadow, where the biotically pollinated species dominate. There could be several reasons for these differences. Perhaps the open nature of the vegetation on the moraine makes it more difficult for biotically pollinated species to attract pollinators. Thus species that are autogamous, apomictic, or anemophilous may be at a reproductive advantage. It is also possible that such breeding systems are linked with other traits that confer greater colonizing abilities than is found in the biotically pollinated species (Jain 1976). Differential dispersion of propagules onto the moraine by species in the two categories does not appear to be the reason (see below).

Turning to the propagule trapping results, the water trays caught only five propagules during several weeks of operation. The water in the trays tended to evaporate quickly, and many propagules were probably blown out of the trays once they had dried out. These five propagules and those trapped by the petroleum-jelly-coated wooden plates used in 1979 are listed in Table 3. No propagules were trapped by the wooden plates in July, presumably because the plants were still flowering and had yet to set seed. In September, the trap furthest out into the meadow (30 m) trapped 23 propagules over a 24-hour period. The only other trap that caught anything was placed on the distal moraine slope in about midslope position. This trap caught a single unidentifiable composite achene with a pappus. Extrapolating from the data on number of propagules trapped and the size of the plates, the 23 propagules trapped in the meadow represent about 1022 propagules dispersing into and through every 1 m^2 every 24 hours, at a time in September when most species had finished flowering and were dispersing propagules. The calculated value for the trap on the moraine is 45 propagules per 1 m^2 per 24 hours, assuming that the single propagule trapped is representative of the propagule rain on the deposits. Most of the propagules (90 percent) have some morphological feature that might aid in more efficient wind dispersal. Such features include the coma of the Salix and Epilobium seeds and the pappus of the composite achenes. Two propagules, the Carex achene and the *Astragalus kentrophyta* legume, have no apparent features that could enhance wind dispersal ability. The propagule of *Geum rossii* represents a special case. This species is the only one that did not occur in the vicinity of the moraine or meadow. The propagule consists of a persistent calyx with numerous stiff hairs, enclosing many small achene fruits. It was found in one of the water trays in 1978, which raises the possibility that the propagule could have accidently dropped into the water from the fur of an investigating pika. Pikas are known to collect plants of *Geum rossii* for their hay piles (Johnson 1967). All the propagules trapped consist of dicot species except for the achene of the Carex species.

The moraine deposits appear to be in an active state of collapse. Fresh slumps and old slump scars can be found on both slopes, and are especially common on the proximal slope. The deposits are very loose and tend to shift easily underfoot. Numerous small erosion channels (rills) exist, attesting to the effects of snow meltwater erosion. The steepness of the slopes, which are from 36° to 38° on the distal slope and 35° to 41° on the proximal, contributes to the instability of the moraine. The combination of continual disturbance and apparently low rates of dispersal of propagules from the meadow is the probable explanation for the low average vegetation cover on the moraine slopes. The only portions of the moraine where the plant cover is as dense as in the meadow is along the crest, which in places is flat and presumably more stable than the steep slopes. The patches of vegetation on the flat portions of the crest are very similar to the meadow vegetation, including the presence of the three most common meadow species, *Astragalus kentrophyta, Hymenoxys grandiflora,* and *Antennaria umbrinella.* This suggests that, as the moraine deposits stabilize, they will become vegetated by the species that dominate and characterize the meadow.

A perusal of alpine vegetation literature from the south central Rocky Mountains failed to reveal any reports of vegetation similar to that found in the meadow (Rydberg 1914, Cox 1933, Cain 1943, Hayward 1952, Ellison 1954, Langenheim 1962, Johnson and Billings 1962, Bamberg and Major 1968, Habeck 1969, Bonham and Ward 1970, Lewis 1970, Anderson et al. 1979, Komarkova 1979), although many of the species in the meadow are common and widespread in the Rocky Mountains. On the other hand, several reports list vegetation that is strongly similar to that of the moraine (Buttars 1914, Mahaney 1974, Given and Soper 1975). In a detailed study from the Colorado Front Range, Komarkova (1979) listed several species that are characteristic of scree, talus, and glacial deposits (her Order Aquilegio-Cirsietalia scopulorum). Many of these species are also found at the Schoolroom Glacier moraine. These include *Senecio fremontii, Poa pattersonii, Oxyria digyna, Draba lonchocarpa, Epilobium alpinum, Taraxacum officinale,* and *Trisetum spicatum.* The thistle *Cirsium*

TABLE 3. The identity of the propagules trapped during 1978 and 1979 are listed, along with the number caught, and the presence of any morphological feature that might aid in more efficient wind dispersal.

Species	Number trapped	Morphological feature
Epilobium alpinum (seeds)	8	coma
Salix arctica (seeds)	9	coma
Arnica longifolia (achenes)	3	pappus
Geum rossii (achenes enclosed in calyx)	1	hairy calyx
Solidago multiradiata (achene)	1	pappus
Astragalus kentrophyta (legume)	1	–
Carex species (achene)	1	–
Unknown composites (achenes)	5	pappus

scopulorum appears to play an ecological role similar to *Cirsium tweedyi* in the Tetons.

In summary, the vegetation on the Schoolroom Glacier moraine is very open, with average cover ranging from less than 1 percent up to 9 percent, compared with over 50 percent in the alpine dry meadow adjacent to it. Dominance-diversity curves using prominence values as the measure of importance were constructed for the meadow and the moraine. Both curves approach geometric series, suggesting harsh environments in which dominance by one or a few species is strong. The legume *Astragalus kentrophyta* dominates the meadow, and the thistle *Cirsium tweedyi* dominates the moraine. Using cover and frequency data, abiotically pollinated species are relatively much more successful on the moraine than biotically pollinated species. The reverse is true in the meadow. Propagule trapping studies suggest that wind dispersal onto the moraine is very low compared with wind dispersal within the meadow. Distributionally, three groups of species can be discerned. One group is concentrated primarily on the moraine, only rarely straying into the meadow. The second group is found primarily in the meadow. The third group consists of species that are found in a narrow band between the base of the distal moraine slope and the meadow. This band of vegetation has many of the characteristic of an ecotone. The moraine deposits are highly unstable, and, in the few places along the crest of the moraine that tend to be the most stable, the vegetation is strongly similar to the vegetation in the meadow.

Acknowledgments

This paper represents partial requirements for a M.Sc. thesis by JRS, under the supervision of RJS. We thank the National Park Service, particularly Linda Olson and Bob Wood, for collecting permits and for other help.

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WINTER STOMACH CONTENTS OF SOUTH DAKOTA BADGERS

E. Blake Hart[1] and Michael Trumbo[2]

Abstract.— Stomach contents of 33 hunter and trapper killed badgers, *Taxidea taxus*, from northeastern South Dakota were examined during the 1980–81 fur season. Mammal prey species made up the bulk of the ingested food, followed by plant materials. Approximately 40 percent of stomach contents were mammals, 35 percent were of plant origin, 10 percent were birds, 10 percent were insects, while the remainder was mostly inorganic materials. Little significant difference was found in variety of food items consumed by each sex. South Dakota badgers are opportunistic foragers in the wintertime when food is scarce. Individual food items are usually taken in quantity when encountered by badgers.

The severity of typical northern plains winters fixes food as a priority item in the lives of nonhibernating carnivorous mammals. Answers to the question as to varieties of prey consumed was sought by examination of a ubiquitous carnivore, the American badger, *Taxidea taxus*.

Stomachs of 33 badgers (15 male, 18 female) from the northeastern South Dakota counties of Faulk, Brown, Spink, and Edmunds were obtained from a local fur broker during the 1980–1981 season. Several keys were used to identify prey animal hairs, particularly Moore, Spence, and Dugnole (1974). Cuticular scale patterns of hairs were pressed into a film of nail polish and observed (Weingart 1973).

A variety of materials were found in stomachs, including plants, inorganic materials (soil, stones), insects, and prey animals. Stomachs contained an average of 98 grams of food materials each. From the standpoint of relative volume and variety of identifiable remains, 40 percent were mammal prey animals, 35 percent were of plant origin, 10 percent were birds, 10 percent were insects, and the remainder were mostly undigested inorganic materials. Similar foods were found in stomachs of both sexes with the exception that straw and small stones were not found in female stomachs.

At least one-half of all badger carcasses purchased by the fur dealer had empty stomachs. This suggests that either stomach contents had largely been digested during long trap stays or that many badgers spend considerable time with empty stomachs.

Most of the food matter contained within the stomachs had been thoroughly crushed and mascerated; the largest bone fragment was 1.7 × 0.8 cm. In fact, skull remnants of mammal prey were difficult to identify. In several instances portions of hair-covered epidermis of larger prey were present; these were the largest pieces of food material seen, although occasional intact mouse viscera and other assorted prey extremities were observed.

Sunflower seeds, corn, and millet were present in several stomachs in considerable quantities, though these too had mostly been chewed into a paste, with few kernels intact. We observed what possibly may have been several masses of feces. The majority of stomachs contained from 5 to 20 *Ascaris*-like parasites.

We found, as did Jense (1968), who studied badger food habits and energy utilization in east central South Dakota, that badgers are opportunistic foragers of edible plant and animal materials. Inasmuch as they feed on whatever is at hand, variety is often lacking, especially if the prey is a large animal or is plant material. One markedly distended stomach contained 375 grams of plant and animal materials. Full stomachs contained little variety; rather, they were often replete with a single food type.

[1]Department of Mathematics, Natural Sciences and Health Professions, Northern State College, Aberdeen, South Dakota 57401.
[2]Tulare, South Dakota 57476.

Jense (1968) suggested that grains were important fall foods, that birds and eggs were eaten only during the spring and summer. We found that squirrels, mice, rabbits, and other small mammals formed much of the typical winter badger diet, but also evidence was found of birds, insects, and grains. Snead and Hendrickson (1942) found many of the same food items in diets of Iowa badgers; they found that percentages of kinds of foods taken changed as availability changed with the seasons.

Hibernating prey animals appear to be attractive food sources throughout the winter, especially ground squirrels. During the midwinter 1978–1979 fur season, 17 toads were found in a single badger stomach. Rosenweig's (1966) statement that there is a clear trend for larger predators to seek larger prey appears true enough, although, judging from the quantities of mice in stomachs, badgers obviously do not ignore such small mammals as important auxiliary food sources.

In summary, winter diets of South Dakota badgers vary with the prey species, which represent most nonaquatic vertebrate groups, as well as insects. Opportunistic feeding appears to be common among badgers, which is not unexpected considering sparse food resources during the severe cold of typical northern plains winters.

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A LIST OF UTAH SPIDERS, WITH THEIR LOCALITIES

Dorald M. Allred[1] and B. J. Kaston[2]

Abstract. — The 621 species of spiders known to occur in Utah as recorded in the literature or Utah universities' collections are listed with their junior synonyms and collection localities. Two-fifths (265 species) are known from only one locality each, and only one-fifth (123 species) from five or more localities in the state.

Little is known of the distribution or ecological relationships of Utah spiders. Each of 265 species of the 621 recorded for the State is known from only one locality. Even the ubiquitous black widow, *Latrodectus hesperus,* has been recorded from only 24 sites in Utah. Most collections from the 249 localities, listed primarily from the literature and some unpublished data, are from a few places that seem to have been favorite or convenient collecting areas for early naturalists and students of arachnology. For example, 166 species are recorded from Box Elder County in the northwest corner of Utah, principally in the Raft River Mountains, which apparently was a favorite place of Wilton Ivie, a contemporary and associate of Ralph Chamberlin and Willis Gertsch. All three men were associated with the University of Utah in Salt Lake City, and 166 species are listed from that environs. Two naturalists and avid collectors who were contemporaries and associates of Chamberlin were Vasco Tanner and Angus Woodbury. Both had family ties in St. George in Washington County in the southwest corner of the state and lived and frequently revisited there for many years. One hundred species are listed for St. George, and 80 from nearby Zion National Park, where Woodbury was employed as a naturalist for several years. Chamberlin frequently visited Tanner in St. George, and collected in that area. Such large numbers of species recorded from these localities is indicative of the lack of study done in other areas of the state, further exemplified by the fact that each of only 123 species is known from five or more localities.

Much of our knowledge of Utah spiders was contributed by Ralph Chamberlin, who authored or coauthored the naming of 220 of the species listed for Utah. Wilton Ivie and Willis Gertsch authored 106 and 73 species, respectively, some in coauthorship with Chamberlin. Stanley Mulaik, arthropodologist, naturalist, and avid collector, was also contemporary with these men and coauthored several species with Gertsch.

We are indebted to Willis Gertsch, who provided some unpublished records and valuable criticism of the manuscript. James MacMahon of Utah State University also provided unpublished records of specimens collected by him and his students. Anne Bond, research assistant, initially helped with much of the literature search.

Sources of collection records are designated by initials and dates in parentheses immediately following specific, or a group of, localities. A key to these is given below. Where more than one publication is represented by an author's initials, the specific source is indicated by a date.

Key to Locality Sources

(Published articles except as indicated)

A	= Allred
Ac	= Archer
AG	= Allred & Gertsch
AU	= Allred (unpublished)
BU	= Beck (unpublished)
BA	= Beedlow & Abraham
Br	= Brady
BS	= Bowling & Sauer
C	= Chamberlin
CG	= Chamberlin & Gertsch
CI	= Chamberlin & Ivie

[1]Life Science Museum and Department of Zoology, Brigham Young University, Provo, Utah 84602.
[2]Department of Zoology, San Diego State University, San Diego, California 92182.

CW = Chamberlin & Woodbury
D = Dondale
DR = Dondale & Redner
E = Exline
G = Gertsch
GI = Gertsch & Ivie
GR = Gertsch & Russell
GU = Gertsch (unpublished)
GW = Gertsch & Wallace
H = Hatley
I = Ivie
IU = Ivie (unpublished)
K = Knowlton
Ks = Kaston
KsU = Kaston (unpublished)
Ky = Keyserling
L = Levi
LD = Lowrie & Dondale
Le = Leech
LL = Levi & Levi
LR = Levi & Randolph
M = Millidge
McU = MacMahon (unpublished)
MG = Muma & Gertsch
P = Platnick
PS = Platnick & Shadab
R = Roewer
S = Schick
SP = Sauer & Platnick
V = Van Helsdingen
W = Waagen
WE = Wallace & Exline

List of Utah Collection Localities with County Designation

Allen Cyn (Rich)
Alta (Salt Lake)
American Fork Cyn (Utah)
Aquarius Plateau (Garfield)
Aspen Grove (Utah)
Bear Lake (Rich)
Beaver (Beaver)
Beaver Crk (in 12 counties)
Beaver Cyn (Beaver)
Beaver Dam Mts (Washington)
Beaver Dam Wash (Washington)
Benson (Cache)
Bicknell (Wayne)
Big Cottonwood Cyn (Salt Lake)
Big Indian Rock (San Juan)
Bills Cyn (Salt Lake)
Black Rock (Salt Lake)
Blanding (San Juan)
Blue Spruce Cyn (Garfield)
Bluff (San Juan)
Boulder Mt (Garfield)
Bountiful (Davis)
Brigham (Box Elder)
Brigham Cyn (Box Elder)
Brigham Plains Flat (Kane)
Bryce Cyn Nat Park (Garfield)
Butterfield Cyn (Salt Lake)
Caineville (Wayne)
Calf Crk (Garfield)
Carter Crk (Daggett)
Carter & Deep Crk Jct (Daggett)
Castle Cliffs (Washington)
Castle Dale (Emery)
Castle Park (?)
Cedar Cyn (Iron)
Cedar Hills (Box Elder)
Cedar Jct (Box Elder)
Cedar Mt (Juab)
Cedar Mts (in Uinta Mts — Summit?)
Chalk Crk (Summit)
City Crk Cyn (Salt Lake)
Clarkston (Cache)
Clear Crk (Box Elder)
Clear Crk Cyn (Box Elder)
Clear Lake (Millard)
Cobble Rest (Wasatch)
Cove Fort (Millard)
Coyote Gulch (Garfield)
Curlew Valley (Box Elder)
Cyclone Lake (Garfield)
Daniels (Wasatch)
Deep Crk (Daggett)
Delta (Millard)
Devils Cyn (San Juan)
Diamond Valley (Washington)
Dinosaur Nat Mon (Uintah)
Dixie Nat Forest (Iron)
Dove Crk (Box Elder)
Dry Cyn (Salt Lake)
Duchesne (Duchesne)
East Cyn (Salt Lake)
Egg Island (Tooele)
Elk Ridge (San Juan)
Elsinore (Sevier)
Emery (Emery)
Emigration Cyn (Salt Lake)
Emory (Summit)
Ensign Peak (Salt Lake)
Escalante (Garfield)
Eureka Cyn (Utah)
Farmington (Davis)
Farmington Cyn (Davis)
Ferron (Emery)
Ferron Res (Sanpete)
Fillmore (Millard)
Fillmore Cyn (Millard)
Fish Lake (Sevier)
Fisher Pass (Tooele)
Four-mile Bench (Kane)
Franklin Basin (Cache)
Fremont River (Wayne)
Fruita (Wayne)
Ft Douglas (Salt Lake)
Garden City (Rich)
Glen Cyn City (Kane)
Glenwood (Sevier)
Government Crk (Tooele)
Grand Gulch (San Juan)
Grandaddy Lake (Duchesne)
Granite (Salt Lake)
Grantsville (Tooele)
Green Cyn (Cache)
Green Lake (Daggett)

Greenriver (Emery)
Grouse Crk (Box Elder)
Gunnison Butte (Emery)
Hanksville (Wayne)
Hat Island (Tooele)
Hatch (Garfield)
Heber (Wasatch)
Helper (Carbon)
Henry Mts (Garfield)
Hidden Lake (Kane & Summit)
Holliday (Salt Lake)
Horse Valley (Wayne)
Hughes Cyn (Salt Lake)
Hurricane (Washington)
Junction (Piute)
Kaibab Forest (Kane)
Kanab (Kane)
Kerns (Salt Lake)
Kelton (Box Elder)
Lake Powell (Kane)
Laketown (Rich)
Lambs Cyn (Salt Lake)
La Sal Jct (San Juan)
La Sal Mts (Grand)
La Sal Pass (San Juan)
Layton (Davis)
Lehi (Utah)
Leidy Peak (Uintah)
Levan (Juab)
Liberty (Weber)
Little Cottonwood Cyn (Salt Lake)
Loa (Wayne)
Locomotive Spngs (Box Elder)
Logan (Cache)
Logan Cyn (Cache)
Lynn (Box Elder)
Lynndyl (Millard)
Manila (Daggett)
Marysvale (Piute)
Marysvale Cyn (Piute)
Mill Crk (Summit)
Mill Crk Cyn (Salt Lake)
Mirror Lake (Duchesne)
Moab (Grand)
Monroe Cyn (Sevier)
Monticello (San Juan)
Moroni (Sanpete)
Motauqua (Washington)
Mounds (Emery)
Mt Agassiz (Summit)
Mt Ellen (Garfield)
Mt Nebo (Juab)
Mud Spngs (Emery)
Navajo Mt (San Juan)
Nipple Bench (Kane)
Noton (Wayne)
Ogden (Weber)
Ogden Cyn (Weber)
Ophir (Tooele)
Oquirrh Mts (Tooele)
Orton (Garfield)
Ouray (Uintah)
Panguitch (Garfield)
Paradise (Cache)
Park Valley (Box Elder)
Parleys Cyn (Salt Lake)
Parowan (Iron)
Payson (Utah)
Pickleville (Rich)
Pinecrest (Salt Lake)
Pine Cyn (Millard)
Pine Spngs (Garfield)
Pine Valley (Washington)
Pine Valley Mts (Washington)
Pink Sand Dunes (Kane)
Pintura (Washington)
Plain City (Weber)
Posey Lake (Garfield)
Price (Carbon)
Promontory Point (Box Elder)
Provo (Utah)
Provo River, Upper (Duchesne)
Puffer Lake (Beaver)
Raft River (Box Elder)
Raft River Mts (Box Elder)
Red Butte Cyn (Salt lake)
Red Cyn Camp (Garfield)
Richardson (Grand)
Richfield (Sevier)
Rock Island (Utah)
Rotary Park (Salt Lake)
Salina (Sevier)
Saltair Beach (Salt Lake)
Salt Lake Airport (Salt Lake)
Salt Lake City (Salt Lake)
San Rafael (Emery)
San Rafael River (Emery)
Santa Clara (Washington)
Santaquin (Utah)
Santaquin Res (Utah)
Scipio (Millard)
Silver Lake (Salt Lake & Utah)
Smith & Morehouse Cyn (Summit)
Smokey Mt (Kane)
Snow Crk (Sevier)
Snow Crk Cyn (Sevier)
Snowville (Box Elder)
Spring Crk (Carbon)
Spring Cyn (Carbon)
Spring Lake (Utah)
St John (Tooele)
St George (Washington)
Standardville (Carbon)
Steep Crk (?)
Straight Wash (Emery)
Stockton (Tooele)
Strawberry (Wasatch)
Swan Lake (Rich)
Table Cliff Pass (Garfield)
Table Cliff Plateau (Garfield)
Teapot Lake (Summit)
Terrys Ranch (Washington)
Thompsons (Grand)
Three Lakes (Garfield & Kane)
Tibbet Spng (Kane)
Timpanogos Cave Nat Mon (Utah)
Timpanogos Park (Utah)
Tooele Cyn (Tooele)
Torrey (Wayne)
Tremonton (Box Elder)

Tropic (Garfield)
Tropic Res (Garfield)
Trout Crk City (Juab)
Uinta Mts (in 5 counties)
Utah Lake (Utah)
Utah State Univ School Forest (Rich)
Valley City (San Juan)
Verdure (San Juan)
Vermillion Castle (Iron)
Vernal (Uintah)
Vernon (Tooele)
Wah Wah Mts (Beaver)
Wanship (Summit)
Wasatch (Salt Lake & Summit)
Wasatch Mts (Salt Lake)
Wasatch Plateau (in 6 counties)
White River (Uintah)
Widtsoe (Garfield)
Willard (Box Elder)
Willow Crk (Tooele)
Willow Tank Spngs (Kane)
Yost (Box Elder)
Zion Nat Park (Washington)

Species and Localities

If the name associated with a specimen in a collection or a record in the literature is not found in this list of species, consult the list of "Synonymies of Utah Records" in the latter part of this report.

Achaearanea ambera Levi 1963 (Bull. Mus. Comp. Zool. 128:204). Mill Crk Cyn (L63).

Achaearanea canionis (Chamberlin & Gertsch) 1928 (J. Ent. Zool. Pomona Coll. 21:103). American Fk Cyn, Pinecrest (IU), Beaver Cyn, Cobble Rest, Dinosaur Nat Mon, Dry Cyn, Richfield, Salt Lake City, St George (L55), Zion Nat Park (CG28).

Achaearanea tepidariorum (C.L. Koch) 1841 (Die Arachn. 8:75). Holliday, Provo, Salt Lake City (L55).

Actinoxia sp. Glen Cyn City (AU).

Aculepeira carbonaria (L. Koch) 1869 (Zeits. Ferd. Tirol. Voral. 15:58). St George (CW).

Aculepeira packardi (Thorell) 1875 (Kongl. Svenska Vet. Akad. Handl. 13:3–203). Green Cyn (H), Kelton Pass (K), USU School Forest (W).

Agelenopsis aperta (Gertsch) 1934 (Amer. Mus. Novitates 726:24). Aspen Grove (BU), Motauqua (CI41), Salt Lake City, Trout Crk, Zion Nat Park (G34c), St George (CW).

Agelenopsis californica (Banks) 1896 (J. New York Ent. Soc. 4:88). Dove Crk, Grouse Crk (City), Lynn, Raft River S fk, Yost (CI33), St George (CW).

Agelenopsis oklahoma (Gertsch) 1936 (Amer. Mus. Novitates 852:12). Duchesne (CI41).

Agelenopsis utahana (Chamberlin & Ivie) 1933 (Bull. Univ. Utah Biol. Ser. 2(2):43). Clear Crk (CI33a), Fish Lake, La Sal Mts, Wasatch Mts (CI41).

Agelenopsis sp. Nipple Bench (AU).

Agroeca ornata Banks 1892 (Proc. Acad. Nat. Sci. Philadelphia 44:23). Clear Crk, Raft River S fk (CI33).

Agroeca pratensis Emerton 1890 (Trans. Conn. Acad. Sci. 8:155). Raft River S fk(CI33).

Agroeca trivittata (Keyserling) 1887 (Verh. zool. bot. Ges. Wien 37:444). Fillmore (C19), Moab (CG28), St George (CW).

Alopecosa gulosa (Walckenaer) 1837 (Hist. Nat. Ins. Apt., 1:38). Clear Crk, Yost (CI33), La Sal Jct (CG28), St George, Zion Nat Park (CW).

Alopecosa kochi (Keyserling) 1877 (Verh. zool. bot. Ges. Wien 26:636). Green Cyn (H), Posey Lake, Steep Crk, Table Cliff Pass, Three Lakes (N Kanab) (BU), USU School Forest (W).

Amaurobius americanus (Emerton) 1888 (Trans. Conn. Acad. Sci. 7:443). Bluff, Fruita, Moab, Monticello, Mounds, San Rafael River, Verdure (CI28), Clear Crk (in Raft River Mts), Dove Crk, Grouse Crk, Lynn (CI33), Lake Powell (CW).

Anacornia microps Chamberlin & Ivie 1933 (Bull. Univ. Utah Biol. Ser. 2(2):29). Clear Crk, Raft River S fk, Uinta Mts (CI33).

Anacornia proceps Chamberlin 1948 (Ann. Ent. Soc. Amer. 41:483). Chalk Crk, Cobble Rest, Mirror Lake (C48a), USU School Forest (W).

Antrodiaetus hageni (Chamberlin) 1917 (Bull. Mus. Comp. Zool. 61:74). Raft River S fk (CI33).

Antrodiaetus montanus (Chamberlin & Ivie) 1935 (Bull. Univ. Utah Biol. Ser. 2(8):4). Green Cyn (H), USU School Forest (W).

Anyphaena californica (Banks) 1904 (Proc. Calif. Acad. Sci. 3:338). Mill Crk (C20b).

Anyphaena pacifica (Banks) 1896 (Trans. Amer. Ent. Soc. 23:63). Green Cyn (H), Verdure (CG28).

Anyphaena sp. Clear Crk, Dove Crk, Raft River S fk (CI33), Escalante, Three Lakes (N Kanab) (BU).

Aphonopelma angusi Chamberlin 1940 (Bull. Univ. Utah Biol. Ser. 5(8):21). W of Beaver Dam Mts (C40).

Aphonopelma simulatum (Chamberlin & Ivie) 1939 (Bull. Univ. Utah Biol. Ser. 5(1):8). Fruita (CI39a).

Aphonopelma zionis Chamberlin 1940 (Bull. Univ. Utah Biol. Ser. 5(8):24). Zion Nat Park (C40).

Apollophanes texanus Banks 1904 (J. New York Ent. Soc. 12:113). Blanding, Bluff, Moab, Verdure (CG28), Glen Cyn City 5 km W (AG).

Araneus gemma (MacCook) 1888 (Proc. Acad. Nat. Sci. Philadelphia 50:193). Clear Crk, Lynn, Park Valley (in Raft River Mts) (CI33), Ferron, Salt Lake City (CI35b), Green Cyn (H), Locomotive Spngs (K), Provo, Three Lakes (nr Escalante) (BU), Zion Nat Park (CW).

Araneus mammatus (Archer) 1951 (Amer. Mus. Novitates 1487:17). Mill Crk Cyn (L81a).

Araneus marmoreus Clerck 1757 (Aranei Suecici, p. 29). Chalk Crk (in Uinta Mts) (C19).

Araneus nordmanni (Thorell) 1870 (Rem. Syn. Europ. Spid., p. 4). USU School Forest (W).

Araneus pima Levi 1971 (Bull. Mus. Comp. Zool. 141:176). "Utah" (L71).

Araneus saevus (L. Koch) 1872 (Zeits. Ferd. Tirol Voralberg (3) 17:323). Salt Lake City (Ac).

Araneus trifolium (Hentz) 1847 (J. Boston Soc. Nat. Hist. 5:471). Provo (BU).

Araneus varians Thorell 1899 (Bih. Svenska Vet. Akad. Handl. 25:49). Zion Nat Park (CW).

Araneus sp. Coyote Gulch (BU).

Araniella displicata (Hentz) 1847 (J. Boston Soc. Nat. Hist. 5:476). Aspen Grove (BU), Clear Crk (CI33), Green Cyn (H), USU School Forest (W).

Araniella octopunctata Chamberlin & Ivie 1942 (Bull. Univ. Utah Biol. Ser. 7(1):76). Emigration Cyn, Pine Valley, Zion Nat Park (CI42a), Steep Crk (BU).

Arctosa alpigena (Doleschall) 1852 (Sitz.-ber. Akad. Wiss. Wien, 9:643). USU School Forest (W).

Arctosa chamberlini Gertsch 1934 (Amer. Mus. Novitates 693:4). Vernal (G34).

Arctosa littoralis (Hentz) 1844 (J. Boston Soc. Nat. Hist. 4:388). Calf Crk, Coyote Gulch (in Escalante Basin), La Sal Mts, Rock Island (in Utah Lake), Steep Crk, Three Lakes (nr Kanab), Willow Tank Spngs (BU), Grand Gulch, Utah Lake (G34), Greenriver, Moab (CG28), St George (CW).

Arctosa parva (Banks) 1894 (J. New York Ent. Soc. 2:52). "Utah" (C8).

Arctosa rubicunda (Keyserling) 1877 (Verh. zool. bot. Ges. Wien 26:663). Raft River S fk (CI33).

Arcuphantes decoratus Chamberlin & Ivie 1943 (Bull. Univ. Utah Biol. Ser. 7(6):17). Zion Cyn (Nat Park) (CI43).

Arcuphantes fragilis Chamberlin & Ivie 1943 (Bull. Univ. Utah Biol. Ser. 7(6):17). American Fork Cyn, Timpanogos Nat Mon (CI43).

Argenna obesa Emerton 1911 (Trans. Conn. Acad. Sci. 16:399). Utah Lake W shore (CI35b), Zion Nat Park (CG58).

Argenna saphes Chamberlin 1948 (Bull. Univ. Utah Biol. Ser. 10(6):6). Mirror Lake (C48).

Argenna sp. Raft River S fk (CI33).

Argennina reclusa Gertsch & Ivie 1936 (Amer. Mus. Novitates 858:1). Cove Fort 10 mi N (GI36).

Argiope trifasciata (Forskal) 1775 (Descr. Anim., p. 86). Green Cyn (H), Kelton, Kelton Pass, Snowville (K), Salt Lake City (BU), St George (CW).

Ariadna bicolor (Hentz) 1842 (J. Boston Soc. Nat. Hist. 4:225). Lake Powell (CW), Verdure (CG28).

Aysha gracilis (Hentz) 1847 (J. Boston Soc. Nat. Hist. 5:452). Zion Nat Park (CW).

Aysha incursa (Chamberlin) 1919 (Ann. Ent. Soc. Amer. 12:239). St. George (CW).

Bathyphantes concolor (Wider) 1834 (In: Reuss, Zool. Misc. Mus. Senck. 1:267). Provo, Salt Lake City (I69).

Bathyphantes latescens (Chamberlin) 1919 (Ann. Ent. Soc. Amer. 12:248). Aspen Grove, Logan Cyn, Mill Crk Cyn, Ogden River Cyn (I69), Chalk Crk (in Uinta Mts) (C19), Clear Crk, Grouse Crk, Raft River S fk (CI33).

Bathyphantes pullatus (O. Pick.-Cambridge) 1863 (Zoologist 21:8580) Cobble Rest Camp, Uinta Mts, Salt Lake City (I69).

Bathyphantes sp. USU School Forest (W).

Batroceps sp. Kelton (K).

Brachybothrium montanum Chamberlin & Ivie 1935 (Bull. Univ. Utah Biol. Ser. 2(8):4). Provo River N fk (in Uinta Mts), Raft River Mts, Salt Lake City (CI35).

Calilena gertschi Chamberlin & Ivie 1941 (Ann. Ent. Soc. Amer. 34:612). Monticello (CI41).

Calilena multiformis dixiana Chamberlin & Ivie 1941 (Ann. Ent. Soc. Amer. 34:608). Diamond Valley, Pintura, St George (CI41).

Calilena restricta Chamberlin & Ivie 1941 (Ann. Ent. Soc. Amer. 34:606). Aquarius Plateau, Cedar Mt, Escalante, Eureka Cyn, Ferron, Loa, Mt Ellen, Noton, Panguitch, Price, Raft River Mts, Richfield, Standardville, Utah Lake W side, Zion Nat Park (CI41), Locomotive Spngs (K), Tibbet Spng 2 km NE (AG), Widtsoe (BU).

Calilena sp. Calf Crk, Cyclone Lake (nr Escalante), Steep Crk, Three Lakes (nr Kanab) (BU), Smokey Mt (AU).

Callilepis eremellus Chamberlin 1928 (Proc. Biol. Soc. Washington 41:77). Caineville (CG28).

Callilepis zionis Chamberlin & Woodbury 1929 (Proc. Biol. Soc. Washington 43:133). Zion Nat Park (CW).

Callilepis sp. Kelton, Kelton Pass (K), Fourmile Bench, Smokey Mt, Tibbet Spng 2 km NE (AU).

Callobius nevadensis (Simon) 1884 (Bull. Soc. Zool. France 9:318). American Fk Cyn, City Crk Cyn, Dry Cyn, Logan, Logan Cyn, Mill Crk Cyn, Timpanogos Park (Le), Fillmore (C19), Green Cyn (McU), Hughes Cyn, Ogden, Ogden Cyn, Wasatch Mts (C47).

Callobius nomeus (Chamberlin) 1919 (Ann. Ent. Soc. Amer. 12:240). Cedar Mts, Chalk Crk (in Uinta Mts), Ferron Res, Mirror Lake, Upper Provo River (C47), Cobble Rest, Grand Daddy Lake, La Sal Pass, Mill Crk Cyn, Ouray (Le), USU School Forest (W), Wasatch Plateau (CI47a).

Castianeira aurata (Hentz) 1847 (J. Boston Soc. Nat. Hist. 5:459). Raft River S fk (CI33).

Castianeira descripta (Hentz) 1847 (J. Boston Soc. Nat. Hist. 5:456). Zion Nat Park (CW).

Castianeira longipalpa (Hentz) 1847 (J. Boston Soc. Nat. Hist. 5:457). "Utah"(DR82).

Castianeira occidens Reiskind 1969 (Bull. Mus. Comp. Zool. 138:211). Brigham Plains Flat, Four-mile Bench (8 km SE cow camp at head Wesses Cyn) (AG), Green Cyn (H), USU School Forest (W).

Castianeira zionis Chamberlin & Woodbury 1929 (Proc. Biol. Soc. Washington 42:139). Zion Nat Park (CW).

Catabrithorax clypiellus Chamberlin 1920 (Canad. Ent. 52:199). Bear Lake, Logan Cyn (C20), Clear Crk, Dove Crk, Raft River S fk, Raft River Mts (CI33).

Catabrithorax plumosus (Emerton) 1882 (Trans. Conn. Acad. Sci. 6:53). Fish Lake, Moab, Price (C48).

Catabrithorax stylifer Chamberlin 1948 (Ann. Ent. Soc. Amer. 41:486). Clear Crk, Dove Crk, Lynn 8 mi S, Raft River S fk (C48).

Catabrithorax utus (Chamberlin) 1919 (Ann. Ent. Soc. Amer. 12:253). Clear Lake (C19), Cyclone Lake (nr Escalante), Posey Lake (BU), Dove Crk, Raft River S fk, Yost (CI33).

Ceraticelus crassiceps Chamberlin & Ivie 1939 (Verh. 7 intern. Kongr. Ent. 1:68). Mirror Lake (CI39).

Ceraticelus subniger Chamberlin 1948 (Ann. Ent. Soc. Amer. 41:491). Salt Lake City 10 mi W (C48).

Ceraticelus sp. Curlew Valley (K).

Ceratinella acerea Chamberlin & Ivie 1933 (Bull. Univ. Utah Biol. Ser. 2(2):26). Raft River S fk, Wasatch Mts (CI33).

Ceratinella brunnea Emerton 1882 (Trans. Conn. Acad. Sci. 6:36). Clear Crk, Dove Crk (CI33).

Ceratinops uintana Chamberlin 1948 (Ann. Ent. Soc. Amer. 41:508). Cobble Rest, Mirror Lake (C48).

Ceratinops watsinga Chamberlin 1948 (Ann. Ent. Soc. Amer. 41:516). Salt Lake City (C48).

Ceratinops sp. Clear Crk (CI33).

Cesonia gertschi Platnick & Shadab 1980 (Bull. Amer. Mus. Nat. Hist. 165:352). Zion Nat Park (PS80).

Cesonia sincera Gertsch & Mulaik 1936 (Amer. Mus. Novitates 851:10). Smokey Mt (AG).

Cheiracanthium inclusum (Hentz) 1847 (J. Boston Soc. Nat. Hist. 5:451). Calf Crk, Kanab, Kanab Cyn, Three Lakes (N Kanab) (BU), Green Cyn (H), St George, Zion Nat Park (CW).

Cheiracanthium mildei L. Koch 1864 (Abh. naturh. Ges. Nurnberg 1864:144). Provo (A80), Brigham (McU).

Chrosiothes chirica (Levi) 1954 (Trans. Amer. Microscop. Soc. 73:184). Utah (LR).

Chrysso nordica (Chamberlin & Ivie) 1947 (Ann. Ent. Soc. Amer. 40:29). Utah (LR).

Chrysso pelyx (Levi) 1958 (Psyche 64:104). Salt Lake City (L58).

Cicurina deserticola Chamberlin & Ivie 1940 (Bull. Univ. Utah Biol. Ser. 5(8):65). Bicknell, Bluff, Ferron, Henry Mts, Pintura, S Price, Santa Clara, Thompsons, Tropic (CI40), Glen Cyn City 5 km SW, Nipple Bench, Smokey Mt (14 km from Last Chance Jct) (AG).

Cicurina intermedia Chamberlin & Ivie 1933 (Bull. Univ. Utah Biol. Ser. 2(2):46). Clear Crk, Henry Mts, Raft River S fk, Uinta Mts, Wasatch Mts (CI33), Fish Lake, Salt Lake City (E), Green Cyn (H).

Cicurina parma Chamberlin & Ivie 1940 (Bull. Univ. Utah Biol. Ser. 5(9):67). Bryce Cyn Nat Park (CI40).

Cicurina robusta Simon 1886 (Ann. Ent. Soc. Belg. 30:40). Bluff (CG28), Chalk Crk (in Uinta Mts) (C19), Clear Crk, Henry Mts, Raft River S fk (CI33), Ferron, Fish Lake, La Sal Mts, Liberty, Mirror Lake, Provo River N fk, Raft River Mts, Smith & Morehouse Cyn, Verdure, Wasatch Mts (CI40), Pine Cyn (C13), Steep Crk, Widtsoe (BU), USU School Forest (W).

Clubiona abbottii Koch 1866 (Arach. Fam. Drassiden., p. 303). City Crk Cyn, Utah Lake W side (G41), Clear Crk (CI33), Moab (CG28).

Clubiona canadensis Emerton 1890 (Trans. Conn. Acad. Sci. 8:181). Logan (McU).

Clubiona mimula Chamberlin 1928 (Proc. Biol. Soc. Washington 41:184). Clear Crk (CI33), Fruita (CG28).

Clubiona maesta Banks 1896 (Trans. Amer. Ent. Soc. 23:64). Chalk Crk (in Uinta Mts) (C19), Clear Crk, Dove Crk, Park Valley (City), Raft River S fk, Raft River Mts (CI33).

Clubiona mutata Gertsch 1941 (Amer. Mus. Novitates 1184:14). Salt Lake City (G41).

Clubiona norvegica Strand 1900 (Kong. Norske Vidensk. Selsk. Skr., p. 30). "Utah" (DR82).

Clubiona pacifica Banks 1896 (Trans. Amer. Ent. Soc. 23:65). Zion Nat Park (CW).

Cochlembolus provo Chamberlin 1948 (Ann. Ent. Soc. Amer. 41:522). Cobble Rest (C48).

Coreogonal bicornis (Emerton) 1923 (Canad. Ent. 55:242). USU School Forest (W).

Coriarachne brunneipes Banks 1893 (J. New York Ent. Soc. 1:133). Raft River S fk (CI33), NE Utah (BS).

Coriarachne versicolor Keyserling 1880 (Spinn. Amer. Lat. 1:53). Benson (G53), Bluff, Salt Lake City, Zion Nat Park (G32), Clear Crk (CI33), Greenriver, Moab (CG28), Heber (McU).

Crustulina sticta (O. Pick.-Cambridge) 1861 (Ann. Mag. Nat. Hist., ser. 3, 7:432). Moab, Price, San Rafael River (CG28), Salt Lake City, St George (IU), Uinta Mts (L57).

Ctenium eremophilus (Chamberlin) 1928 (Proc. Biol. Soc. Washington 41:180). Devils Cyn (CG28), Verdure (Ks46).

Ctenium fusca (Emerton) 1894 (Trans. Conn. Acad. Sci. 9:407). Locomotive Spngs (K).

Ctenium vigerens (Chamberlin & Ivie) 1933 (Bull. Univ. Utah Biol. Ser. 2(2):9). Dove Crk, Raft River S fk, Yost (CI33), Raft River Mts, Salt Lake City, Verdure (Ks46).

Cybaeota concolor Chamberlin & Ivie 1937 (Ann. Ent. Soc. Amer. 30:211). Mill Crk Cyn (CI37).

Cybaeota wasatchensis Chamberlin & Ivie 1937 (Ann. Ent. Soc. Amer. 30:211). Hughes Cyn, Mill Crk Cyn (CI37).

Cyclosa conica (Pallas) 1772 (Spicil. Zool. 1(9):48). Clear Crk (CI33), Logan SE (McU), Zion Nat Park (CW).

Delopelma iodius Chamberlin & Ivie 1939 (Bull. Univ. Utah Biol. Ser. 5(1):6). Castle Cliffs 2 mi W, Zion Nat Park (CI39a).

Delopelma marxi (Simon) 1891 (Acta Bull. Soc. Linn. Bordeaux 44:321). Fruita (G35).

Delopelma melanius Chamberlin & Ivie 1939 (Bull. Univ. Utah Biol. Ser. 5(1):5). Brigham, Salt Lake City, Stockton, and Davis and Utah counties (CI38a).

Delopelma steindachneri (Ausserer) 1875 (Verh. zool. bot. Ges. Wien 25:199). St George (C21).

Dendryphantes (prob is *Metaphidippus*) *mylothrus* Chamberlin 1925 (Proc. Calif. Acad. Sci. (4)14:134). Mill Crk Cyn (C25).

Dendryphantes (prob is *Metaphidippus*) *uteanus* Chamberlin & Gertsch 1929 (J. Ent. Zool. Pomona Coll. 21:110). Clear Crk, Raft River S fk (CI33), Lambs Cyn, Zion Nat Park (CG29).

Dictyna abundans Chamberlin & Ivie 1941 (Bull. Univ. Utah Biol. Ser. 6(3):5). St George (CI41a), Zion Nat Park (CG58).

Dictyna apacheca Chamberlin & Ivie 1935 (Bull. Univ. Utah Biol. Ser. 2(8):28). American Fk Cyn (CG58).

Dictyna artemisia Ivie 1947 (New York: priv. publ.). Provo River N fk, Scipio, Wasatch Mts (nr Salt Lake City) (CG58).

Dictyna bellans Chamberlin 1919 (Ann. Ent. Soc. Amer. 12:242). Moab (CG58).

Dictyna bicornis Emerton 1915 (Trans. Conn. Acad. Sci. 20:141). Salt Lake City (G46).

Dictyna borealis cavernosa Jones 1947 (Field & Lab. 15:12). Salt Lake City (CG58).

Dictyna brevitarsus Emerton 1915 (Trans. Conn. Acad. Sci. 20:140). USU School Forest (W).

Dictyna calcarata Banks 1904 (Proc. Calif. Acad. Sci. 3:342). Calf Crk (BU), St George, Zion Nat Park (CG58).

Dictyna cholla Gertsch & Davis 1942 (Amer. Mus. Novitates 1158:12). Salt Lake City (CG58).

Dictyna completa Chamberlin & Gertsch 1929 (J. Ent. Zool. Pomona Coll. 21:101). Green Cyn (H), Moab (CG28).

Dictyna coloradensis Chamberlin 1919 (Ann. Ent. Soc. Amer. 12:241). Utah (C58).

Dictyna cornupeta Bishop & Ruderman 1946 (Proc. Biol. Soc. Washington 59:1). Salt Lake City (CG58).

Dictyna horta Gertsch & Ivie 1936 (Amer. Mus. Novitates 858:4). City Crk Cyn, Layton (CG58).

Dictyna idahoana Chamberlin & Ivie 1933 (Bull. Univ. Utah Biol. Ser. 2(2):4). Cedar Hills, Kelton, Kelton Pass, Snowville (K), Green Cyn (H), Grouse Crk (CI33), Mt Nebo (CG58).

Dictyna littoricolens Chamberlin & Ivie 1935 (Bull. Univ. Utah Biol. Ser. 2(8):30). Black Rock, Salt Lake City (CG58), Locomotive Spngs 3 mi E (K), Utah Lake W side (CI35).

Dictyna major Menge 1869 (Schr. naturf. Ges. Danzig 2:247). Farmington Cyn (LL).

Dictyna minuta Emerton 1888 (Trans. Conn. Acad. Sci. 7:447). Price (CG58), Salt Lake City (GI36).

Dictyna moaba Ivie 1947 (New York, priv. publ.). Moab (C48).

Dictyna pallida Keyserling 1887 (Verh. zool. bot. Ges. Wien 37:472). Richfield (CG58).

Dictyna personata Gertsch & Mulaik 1936 (Amer. Mus. Novitates 851:9). East Cyn, Hurricane (CG58), Glen Cyn City (AG), Glenwood 2 mi E (G46).

Dictyna pictella Chamberlin & Gertsch 1958 (Bull. Amer. Mus. Nat. Hist. 116:97). Pintura, Scipio (CG58).

Dictyna piratica Ivie 1947 (New York, priv. publ.). Dry Cyn (CG58), East Cyn, Provo River N fk, Wanship (C48).

Dictyna reticulata Gertsch & Ivie 1936 (Amer. Mus. Novitates 858:7). Curlew Valley (K), Richfield, Santa Clara 4 mi SW (GI36).

Dictyna secuta Chamberlin 1924 (Proc. Calif. Adad. Sci. 12:583). St George (CG58).

Dictyna stulta Gertsch & Mulaik 1936 (Amer. Mus. Novitates 851:7). Aspen Grove, Ogden Cyn (G46).

Dictyna terrestris Emerton 1911 (Trans. Conn. Acad. Sci. 16:399). Bill's Cyn, Delta, Dry Cyn, Mill Crk Cyn (CG58).

Dictyna tertanea Ivie 1947 (New York, priv. publ.). American Fork Cyn, Bluff, Castle Park, Dinosaur Nat Mon, Greenriver, Henry Mts, Richfield, Salt Lake City (CG58).

Dictyna tridentata Bishop & Ruderman 1946 (Proc. Biol. Soc. Washington 58:2). Elk Ridge (CG58).

Dictyna tucsona Chamberlin 1948 (Bull. Univ. Utah Biol. Ser. 10(6):8). Kanab (CG58).

Dictyna uintana Chamberlin 1919 (Ann. Ent. Soc. Amer. 12:240). Bluff (CG28), Chalk Crk (in Uinta Mts) (C19), City Crk Cyn (C48), Clear Crk, Grouse Crk, Raft River Mts, Raft River S fk, Yost (CI33), Elsinore, Fish Lake, Richfield, Salt Lake City (G46).

Dictyna variana Chamberlin & Gertsch 1958 (Bull. Amer. Mus. Nat. Hist. 116:57). St George (CG58).

Dictyna vincens Chamberlin 1919 (Ann. Ent. Soc. Amer. 12:243). Clear Crk, Raft River S fk, Raft River Mts (CI33).

Dictyna volucripes Keyserling 1882 (Verh. zool. bot. Ges. Wien 31:286). Central & northern Utah, St George (C21), La Sal Mts (C28).

Dictyna zaba Barrows & Ivie 1942 (Ohio J. Sci. 42:21). City Crk Cyn, Layton, Richfield (CG58).

Dictyna sp. Coyote Gulch, Posey Lake, Steep Crk, Table Cliff Plateau, Willow Tank Spngs (BU).

Dictynina eutypa (Chamberlin & Ivie) 1929 (J. Ent. Zool. Pomona Coll. 21:101). Bluff (CG28).

Dictynoides sp. Zion Nat Park (CW).

Diguetia canities (McCook) 1890 (Amer. Spiders 2:136). St George (G35), Zion Nat Park (CW).

Dipoena atopa (Chamberlin) 1948 (Ann. Ent. Soc. Amer. 41:541). City Crk Cyn, Dry Cyn, Timpanogos Nat Mon (L53), Grantsville (L63), Red Butte Cyn (C48a).

Dipoena malkini Levi 1953 (Amer. Mus. Novitates 1647:33). Government Crk, Mill Crk Cyn (L53).

Dipoena nigra (Emerton) 1882 (Trans. Conn. Acad. Sci. 6:21). Beaver Cyn, City Crk Cyn, Government Crk, Wanship (L53), Pickleville (W).

Dipoena prona Menge 1868 (Schr. naturf. Ges. Danzig 2:177). Moab (L53).

Dipoena provalis Levi 1953 (Amer. Mus. Novitates 1639:34). Cobble Rest, Hughes Cyn (L53), Provo River N fk (GU).

Dipoena tibialis Banks 1906 (Proc. Ent. Soc. Washington 7:96). Green Cyn (H), USU School Forest (W).

Dipoena sp. Clear Crk, Raft River Mts (CI53).

Disembolus alpha (Chamberlin) 1948 (Ann. Ent. Soc. Amer. 41:550). Dry Crk Cyn (C48a).

Disembolus anguineus Millidge 1981 (J. Arach. 9:276). Utah (M81a).

Disembolus beta Millidge 1981 (J. Arach. 9:274). Dry Cyn (M81a).

Disembolus galeatus Millidge 1981 (J. Arach. 9:268). Utah (M81a).

Disembolus implexus Millidge 1981 (J. Arach. 9:279). Fish Lake (M81a).

Disembolus implicatus Millidge 1981 (J. Arach. 9:277). Cobble Rest, Upper Provo River (M81a).

Disembolus kesimbus (Chamberlin) 1948 (Ann. Ent. Soc. Amer. 41:552). Fish Lake, Henry Mts, Strawberry Res (C48a).

Disembolus stridulans Chamberlin & Ivie 1933 (Bull. Univ. Utah Biol. Ser. 2(2):20). Fillmore Cyn, Lynn 8 mi S, Mirror lake, Snow Crk Cyn, Wasatch Mts (nr Salt Lake City) (CI45), Henry Mts, Raft River S fk, (CI33).

Disembolus vicinus Millidge 1981 (J. Arach. 9:281). Grantsville (M81a).

Dolomedes triton (Walckenaer) 1837 (Hist. Nat. Ins. Apt. 1:340). Raft River Mts (CI33).

Drassodes gosiutus Chamberlin 1919 (Ann. Ent. Soc. Amer. 12:245). City Crk Cyn, Dry Cyn, Ensign Peak, Greenriver, Helper, E Monticello, Mud Spngs, Rotary Park, Salt Lake Airport 5 mi SW, Spring Crk, Utah Lake W side, Willow Crk (PS76), Fillmore (C19), Nipple Bench (AG), Zion Nat Park (CW).

Drassodes neglectus (Keyserling) 1887 (Verh. zool. bot. Ges. Wien 37:434). Bluff, Marysvale, Verdure (CG28), Fish Lake (C36), La Sal Mts (C28), also counties of Garfield, Iron, Salt Lake, Summit, Tooele, and Utah (PS76).

Drassodes saccatus (Emerton) 1890 (Trans. Conn. Acad. Sci. 8:178). Fillmore (C19), Glen Cyn City 5 km SW, Nipple Bench (AG), Green Cyn (H), Raft River Mts (CI33), also counties of Carbon, Emery, Garfield, Grand, Salt Lake, San Juan, Sevier, and Washington (PS76).

Drassodes sp. Curlew Valley (K), Glen Cyn City (AU), Steep Crk, Widtsoe (BU).

Drassyllus conformans Chamberlin 1936 (Amer. Mus. Novitates 841:22). Richfield, Salt Lake City (C36).

Drassyllus dromeus Chamberlin 1922 (Proc. Biol. Soc. Washington 35:169). Dry Cyn, Pinecrest (C36).

Drasyllus inanus Chamberlin & Gertsch 1940 (Amer. Mus. Novitates 1068:17). Bluff (CG40).

Drassyllus insularis (Banks) 1900 (Canad. Ent. 32:97). Bluff, Salt Lake County, Straight Wash, Valley City (CG28), Green Cyn (H), Grouse Crk (CI33), Lake Powell (C58), St George (CW).

Drassyllus lamprus (Chamberlin) 1920 (Canad. Ent. 52:193). Mill Crk (C22), USU School Forest (W).

Drassyllus lepidus (Banks) 1899 (Proc. Ent. Soc. Washington 4:190). Pine Valley Mts (C36).

Drassyllus mexicanus (Banks) 1898 (Proc. Calif. Acad. Sci (3)1:217). La Sal Mts (CG40).

Drassyllus mormon Chamberlin 1936 (Amer. Mus. Novitates 841:27). St George (C36).

Drassyllus nannellus Chamberlin & Gertsch 1940 (Amer. Mus. Novitates 1068:11). Tremonton 10 mi W (CG40), Green Cyn (H).

Drassyllus notonus Chamberlin 1928 (Proc. Biol. Soc. Washington 41:179). Noton (CG28).

Drassyllus tonaquintus Chamberlin & Gertsch 1940 (Amer. Mus. Novitates 1068:1). Farmington, St George (CG40).

Drassyllus sp. Curlew Valley (K).

Ebo evansae Sauer & Platnick 1972 (Canad. Ent. 104:41). Butler, Logan, Salt Lake City (SP72), Green Cyn (H).

Ebo sp. Locomotive Spngs (K), Raft River S fk (CI33).

Enoplognatha joshua Chamberlin & Ivie 1942 (Bull. Univ. Utah Biol. Ser. 7(1):44). Brigham Plains Flat (AG), Hurricane, Pintura, Helper, Spring Cyn (CI42a), counties of Emery, Grand, Salt Lake, and Sevier (L57).

Enoplognatha marmorata (Hentz) 1850 (J. Boston Soc. Nat. Hist. 6:273). Dry Cyn, Emigration Cyn (IU), Oquirrh Mts, Santaquin (CI42), Park Valley, Raft River Mts, Raft River S fk (CI33), Sevier County (L57).

Enoplognatha ovata (Clerck) 1757 (Aranei Suecici, p. 58). Green Cyn (H).

Enoplognatha wyuta Chamberlin & Ivie 1942 (Bull. Univ. Utah Biol. Ser. 7(1):43). American Fork Cyn, Hughes Cyn (CI42a), and Emery County (L57).

Erigone canthognatha Chamberlin & Ivie 1935 (Bull. Univ. Utah Biol. Ser. 2(8):13). Colorado River 5 mi up from Moab (CI35).

Erigone denticulata Chamberlin & lvie 1939 (Verh. 7 intern. Kongr. Ent. Berlin 1:57). Mirror Lake (CI39).

Erigone dentosa O. Pick.-Cambridge 1894 (Biol. Centr. Amer. Arach. Ar. 1:128). Clear Crk, Grouse Crk, Raft River Mts, Raft River S fk, Yost (CI33), Green Cyn (H), Posey Lake (BU), USU School Forest (W).

Erigone uintana Chamberlin & lvie 1935 (Bull. Univ. Utah Biol. Ser. 2(8):14). Mirror Lake (CI35).

Erigone viabilis Chamberlin & Ivie 1933 (Bull. Univ. Utah Biol. Ser. 2(2):11). Mirror Lake, Raft River S fk (CI33).

Eris marginata (Walckenaer) 1837 (Hist. Nat. Ins. Apt. 1:466) Mill Crk Cyn (C25), St George (CW).

Eris nigromaculatus (Keyserling) 1884 (Verh. zool. bot. Ges. Wein 34:500) Lambs Cyn (CG29).

Ero canionis Chamberlin & Ivie 1935 (Bull. Univ. Utah Biol. Ser. 2(8):23). City Crk Cyn (CI35).

Eularia chelata Chamberlin & Ivie 1939 (Verh. 7 intern. Kongr. Ent. Berlin 1:61). Mirror Lake (CI45).

Eularia dela Chamberlin & Ivie 1933 (Bull. Univ. Utah Biol. Ser. 2(2):15). Clear Crk, Raft River S fk, Raft River Mts (CI33), Lynn 8 mi S (CI45).

Eularia kaiba Chamberlin 1948 (Ann. Ent. Soc. Amer. 41:530). Mirror Lake (C48).

Eularia mana Chamberlin & Ivie 1935 (Bull. Univ. Utah Biol. Ser. 2(8):16). Mill Crk Cyn (C45).

Eularia schediana Chamberlin & Ivie 1933 (Bull. Univ. Utah Biol. Ser. 2(2):17). Cedar Mt, City Crk Cyn, Ferron, Fish lake, Henry Mts, Horse Valley, Kaibab Forest, Mirror Lake, Upper Provo River (CI45), Dove Crk (CI33), Raft River Mts (CI45).

Euryopis coki Levi 1954 (Amer. Mus. Novitates 1666:33). Salt Lake City (L54).

Euryopis formosa Banks 1908 (Canad. Ent. 40:206). American Fork, Salt Lake City (CI41), Dry Cyn, Smith & Morehouse Cyn (L54).

Euryopis scriptipes Banks 1908 (Canad. Ent. 40:206). Clear Crk, Grouse Crk, Raft River Mts (CI33), Glen Cyn City (AG), Mt Agassiz, Bryce Cyn Nat Park, Jct Deep Crk & Carter Crk (in Uinta Mts), Fish Lake, Fruita, Hughes Cyn, Mill Crk Cyn, Trout Crk, Vermillion Castle (nr Parowan), Zion Nat Park (L54), Green Cyn (H).

Euryopis spinigera O. Pick.-Cambridge 1895 (Biol. Centr. Amer. Arachn. Ar. 1:146). City Crk Cyn, Junction, Parleys Cyn, Pintura 10 mi N (L54).

Euryopis taczanowskii Keyserling 1886 (Spinn. Amer., Theridiidae 2:47). Orton (L54).

Euryopis texana Banks 1908 (Canad. Ent. 40:207). Hurricane (L54).

Euryopis sp. Brigham Plains (AU), Snowville (K), Coyote Gulch, Escalante, Steep Crk (BU).

Evarcha leucophaea (Koch) 1846 (Die Arachn. 13:216). Dove Crk, Raft River S fk (CI33).

Filistata hurca Chamberlin & Ivie 1942 (Bull. Univ. Utah Biol. Ser. 7(1):3). Hurricane (CI42a).

Filistata utahana Chamberlin & Ivie 1935 (Bull. Univ. Utah Biol. Ser. 2(8):5). Brigham Plains Flat, Glen Cyn City 7 km SW, Tibbit Spng 2 km NE (AG), Marysvale, St George (CI35b).

Floricomus littoralis Chamberlin & Ivie 1935 (Bull. Univ. Utah Biol. Ser. 2(8):16). Utah Lake W shore (CI35b).

Frontinella pyramitela (Walckenaer) 1841 (Hist. Nat. Ins. Apt. 2:261). Green Cyn (H), Washington County, Willow Tank Spngs (BU).

Gayenna dixiana Chamberlin & Woodbury 1929 (Proc. Biol. Soc. Washington 42:138). St George (CW).

Geolycosa fatifera (Hentz) 1842 (J. Boston Soc. Nat. His. 4:229). Utah (C9).

Geolycosa rafaelana (Chamberlin) 1928 (Proc. Biol. Soc. Washington 41:186). Big Indian Rock, San Rafael Desert (CG28), Glen Cyn City 5 km SW (AG).

Gnaphosa antipola Chamberlin 1933 (Amer. Mus. Novitates 631:4). Farmington, Moab, Salt Lake City (PS75), Utah Lake W shore (C33).

Gnaphosa brumalis Thorell 1875 (J. Boston Soc. Nat. Hist. 17:497). La Sal Mts, Verdure (CG28), Salt Lake City (PS75).

Gnaphosa californica Banks 1904 (Proc. Calif. Acad. Sci. (Zool.) 3:335). Four-mile Bench (5 km SW cow camp at head Wesses Cyn) (AG), Ft Douglas, Glenwood, Grantsville, Hat Island, Manilla, Pintura, Raft River Mts, Richfield, Salt Lake City, St George, Stockton, Straight Wash, Tooele Cyn, Tremonton (PS75), Grouse Crk (CI33).

Gnaphosa clara (Keyserling) 1887 (Verh. zool. bot. Ges. Wien 37:429). Bridger Basin (C22), Greenriver, Grouse Crk, Moab, Mud Spngs, Wah Wah Mts (PS75).

Gnaphosa dentata Platnick & Shadab 1975 (Bull. Amer. Mus. Nat. Hist. 155:18). Utah Lake and Washington County (PS75).

Gnaphosa gosoga Chamberlin 1928 (Proc. Biol. Soc. Washington 41:178). Marysvale, Straight Wash (CG28), Tooele Cyn (C36).

Gnaphosa hirsutipes Banks 1901 (Proc. Acad. Nat. Sci. Philadelphia 53:573). Fruita, Salt Lake City, San Rafael River, Verdure (CG28), Grouse Crk (CI33), St George (CW).

Gnaphosa muscorum (L. Koch) 1866 (Arachn. Fam. Drassiden., p. 14). Blue Spruce Camp, Castle Dale, Emigration Cyn, Fish Lake, Fillmore, Hatch, Leidy Peak, Mill Crk, Provo, Richfield, Salt Lake City (PS75), Clear Crk, Raft River Mts, Raft River S fk, Yost (CI33), Curlew Valley, Kosmo (K), La Sal Mts (C28a), Monroe Cyn (C36), Oquirrh Mts (CG28), Rock Island (in Utah Lake) (BU), St George (CW).

Gnaphosa salsa Platnick & Shadab 1975 (Bull. Amer. Mus. Nat. Hist. 155:22). Terrys Ranch (Beaver Dam Wash) (PS75).

Gnaphosa saxosa Platnick & Shadab 1975 (Bull. Amer. Mus. Nat. Hist. 155:17). Salt Lake City (PS75).

Gnaphosa sericata (L. Koch) 1866 (Arach. Fam. Drassiden., p. 31). Green Cyn (H), Locomotive Spngs (K), Moab, Price, Salt Lake City (PS75).

Gnaphosa synthetica Chamberlin 1924 (Proc. Calif. Acad. Sci. 12:620). St George (PS75).

Gnaphosa utahana Banks 1904 (J. New York Ent. Soc. 12:110). Egg Island, Farmington NW, Hat Island, Plain City, San Rafael River, Silver Lake (PS75).

Gnaphosa sp. Brigham Plains (AU), Posey Lake, Provo, Widtsoe (BU).

Gnathantes ferosa Chamberlin & Ivie 1943 (Bull. Univ. Utah Biol. Ser. 7(6):5). City Crk Cyn (CI43).

Gosiphrurus unicolor Chamberlin & Ivie 1935 (Bull. Univ. Utah Biol. Ser. 2(8):40). Ferron (CI35b).

Grammonota salicicola Chamberlin 1948 (Ann. Ent. Soc. Amer. 41:532). Salt Lake City (C48a).

Habrocestrum sp. Raft River S fk (CI33).

Habronattus sp. Calf Crk, Kanab, Steep Crk (BU).

Hahnia cinerea Emerton 1890 (Trans. Conn. Acad. Sci. 8:197). Butterfield Cyn, Mill Crk, Logan Cyn (G34b), Zion Nat Park (CW).

Hahnia ononidium Simon 1875 (Arach. de France 2:135). Fish Lake, La Sal Mts, Mt Ellen, Pine Spngs (in Henry Mts) (CI42a).

Haplodrassus bicornis (Emerton) 1909 (Trans. Conn. Acad. Sci. 14:218). Blanding, City Crk Cyn (CG28), Marysvale Cyn (C36a).

Haplodrassus dixiensis Chamberlin & Woodbury 1929 (Proc. Biol. Soc. Washington 42:134). St George (CW).

Haplodrassus eunis Chamberlin 1922 (Proc. Biol. Soc. Washington 35:162). Cedar Cyn, East Cyn, Emory, Provo River N fk, Smith & Morehouse Cyn, Tropic Res (CI46), Nipple Bench, Smokey Mt (14 & 23 km from Last Chance Jct) (AG), USU School Forest (W).

Haplodrassus signifer (Koch) 1839 (Die Arachn. 6:31). Blanding, Marysvale, Moab, Noton, Salt Lake County, Straight Wash (CG28), Cyclone Lake (nr Escalante) (BU), Green Cyn (H), Gunnison Butte (nr Greenriver), Moab, Richardson (CG40), La Sal Mts (C28a).

Haplodrassus sp. Posey Lake (BU).

Helophora orinoma (Chamberlin) 1920 (Canad. Ent. 52:195). Bear Lake (C20).

Helophora reducta (Keyserling) 1886 (Spinn. Amer. Theridiidae 2:54). Chalk Crk (in Uinta Mts), Clear Lake (C19), Clear Crk, Raft River S fk, Yost (CI33).

Helophora tunagyna Chamberlin & Ivie 1943 (Bull. Univ. Utah Biol. Ser. 7(6):6). USU School Forest (W).

Herpyllus cockerelli (Banks) 1901 (Proc. Acad. Nat. Sci. Philadelphia 53:571). Red Cyn Camp (11 mi SE Panguitch) (P).

Herpyllus convallis Chamberlin 1936 (Amer. Mus. Novitates 841:2). St George, Zion Nat Park (P).

Herpyllus ecclesiastica Hentz 1832 (Amer. J. Sci. 21:102). Bluff, Hanksville, San Rafael River, Valley City (CG28).

Herpyllus hesperolus Chamberlin 1928 (Proc. Biol. Soc. Washington 42:176). Big Indian Rock, Bluff, Fruita, Hanksville, Marysvale, Moab, San Rafael River, Valley City (CG28), Locomotive Spngs (K), Richfield (C36a), St George, Zion Nat Park (CW), and counties of Carbon, Davis, Duchesne, Morgan, Salt Lake, San Juan, Tooele, Utah, and Wayne (P).

Herpyllus propinquus (Keyserling) 1887 (Verh. zool. bot. Ges. Wien 37:430). Fourmile Bench (8 km SE cow camp at head Wesses Cyn) (AG), La Sal Mts (CG28), Lynn, Raft River Mts (CI33), St George (CW) and counties of Beaver, Carbon, Duchesne, Millard, Uintah, Utah, and Wayne (P) and San Juan (PS77).

Herpyllus sp. Curlew Valley, Kosmo (K), Glen Cyn City (AU), Green Cyn (H).

Hillhousia microtarsus (Emerton) 1882 (Trans. Conn. Acad. Sci. 6:57). Mirror Lake, upper Provo River (CI45).

Hololena hola (Chamberlin & Gertsch) 1928 (Proc. Biol. Soc. Washington 41:183). Blanding, Devils Cyn, Moab, Noton, Verdure (CG28), Monticello (CI42).

Hololena mimoides (Chamberlin) 1919 (Ann. Ent. Soc. Amer. 12:256). Devils Cyn, Moab, Pine Valley, Pintura, St George, Zion Nat Park (CI42), Fillmore Cyn (C19), Posey Lake (BU).

Hololena nevada (Chamberlin & Gertsch) 1929 (J. Ent. Zool. Pomona Coll. 21:107). Beaver Cyn, Moab 5 mi NE, Price, Richfield (CI42).

Hololena oquirrhensis (Chamberlin & Gertsch) 1930 (Proc. Biol. Soc. Washington 43:142). Butterfield Cyn (CG30), Oquirrh Mts, Wasatch Mts (CI42).

Hybocoptus dentipalpis (Emerton) 1915 (Trans. Conn. Acad. Sci. 20:149). Chalk Crk (in Uinta Mts) (C19).

Hypselistes florens (O. Pick.-Cambridge) 1875 (Proc. Zool. Soc. London, p. 403). Smith & Morehouse Cyn (CI35b).

Hypselistes reducens Chamberlin & Ivie 1935 (Bull. Univ. Utah Biol. Ser. 2(8):17). Mirror Lake (CI35b).

Hypsosinga funebris (Keyserling) 1893 (Spinn. Amer. Epeiridae 4:37). Alta (L75).

Hypsosinga groenlandica (Thorell) 1872 (Öfvers Kongl. Vet. Akad. Förh. 29:157). Franklin Basin (L75).

Hypsosinga pygmaea (Sundevall) 1831 (Kongl. Svenska Vet. Akad. Handl., p. 121). Kanab Cyn (BU), Salt Lake City (L75).

Hypsosinga singaeformis (Scheffer) 1904 (Ent. News 15:259). Green Cyn (H).

Hyptiotes gertschi Chamberlin & Ivie 1935 (Bull. Univ. Utah Biol. Ser. 2(8):12). Cedar Cyn (nr Cedar City), Henry Mts, Salt Lake City (CI35b).

Hyptiotes puebla Muma & Gertsch 1964 (Amer. Mus. Novitates 2196:14). N central Utah (MG).

Icius annectans Chamberlin & Gertsch 1929 (J. Ent. Zool. Pomona Coll. 21:110). Zion Nat Park (CG29).

Idionella anomala (Chamberlin & Ivie) 1939 (Verh. 7 intern. Kongr. Ent. Berlin 1:69). Dry Cyn (CI39).

Idionella tuganus (Chamberlin) 1948 (Ann. Ent. Soc. Amer. 41:494). Salt Lake City 10 mi W (C48).

Labuella prosaica Chamberlin & Ivie 1943 (Bull. Univ. Utah Biol. Ser. 7(6):10). Smith & Morehouse Cyn (CI43).

Larinia borealis Banks 1894 (Ent. News 5:8). Green Cyn (H), nr Salt Lake City (L75a).

Larinia famulatoria (Keyserling) 1883 (Ver. zool. bot. Ges. Wien 32:201). Central and southern Utah (L75a).

Latrodectus hesperus Chamberlin & Ivie 1935 (Bull. Univ. Utah Biol. Ser. 3(1):15). Ahlstrom Point, Glen Cyn City 6 km SW, Tibbet Spng 2 km NE (AG), Bluff, Moab, Price (CG28), Clear Crk, Grouse Crk, Raft River Mts (CI33), Curlew Valley, Kosmo (K), Dry Cyn, Mill Crk, Logan Cyn, Weber County, Millard County (GU), Green Cyn (H), Provo (A74), St George, Zion Nat Park (CW), Salt Lake City (CI35a), Tooele (L59), Utah Lake, Three Lakes (N Kanab) (BU).

Lathys deliculata Gertsch 1946 (Amer. Mus. Novitates 1319:3). Moab, Pintura (CG58).

Lathys hesperus Chamberlin 1948 (Bull. Univ. Utah Biol. Ser. 10(6):14). Utah (C48).

Lepthyphantes agressus Chamberlin & Ivie 1943 (Bull. Univ. Utah Biol. Ser. 7(6):15). Lambs Cyn head, Mirror Lake, Provo River (in Uinta Mts) (CI43).

Lepthyphantes arborea (Emerton) 1915 (Trans. Conn. Acad. Sci. 20:151). Posey Lake (BU), USU School Forest (W).

Lepthyphantes calcarata (Emerton) 1909 (Trans. Conn. Acad. Sci. 14:197). USU School Forest (W).

Lepthyphantes concolor (Wider) 1834 (In: Reuss, A. Zool. Misc. Arachn., Mus. Senck. 1:267). Provo, Salt Lake City (I69).

Lepthyphantes furcillifer Chamberlin & Ivie 1933 (Amer. Mus. Novitates 631:32). Clear Crk, Raft River S fk (CI33).

Lepthyphantes lamprus Chamberlin 1920 (Canad. Ent. 52:195). Clear Crk, Raft River S fk (CI33), Lake Powell (C58), La Sal Mts (C28), Logan Cyn (C20b), Posey Lake (BU).

Lepthyphantes nebulosus (Sundevall) 1829 (Kongl. Svenska Vet. Akad. Handl., p. 218). Lynn (CI33).

Lepthyphantes pollicaris Zorsch 1937 (Amer. Midl. Nat. 18:897). USU School Forest (W).

Lepthyphantes ranieri Emerton 1926 (Canad. Ent. 58:118). USU School Forest (W).

Lepthyphantes sp. Cyclone Lake (nr Escalante) (BU).

Linyphantes ephedrus (Chamberlin & Ivie) 1933 (Bull. Univ. Utah Biol. Ser. 2(2):31). Dry Cyn, Fish Lake, St George, Yost, Zion Nat Park (CI42a).

Linyphia tauphora Chamberlin 1928 (Proc. Biol. Soc. Washington 41:180). Bluff, Zion Nat Park (CG28).

Loxosceles deserta Gertsch 1975 (Toxicon 13:203). Southern Utah (GR).

Loxosceles rufipes (Lucas) 1834 (Mag. Zool. Guérin 4:354). Clear Crk, Raft River Mts (CI33), San Juan County (CG28), Zion Nat Park (CW).

Loxosceles sp. Lake Powell (C58).

Lycosa antelucana Montgomery 1904 (Proc. Acad. Nat. Sci. Philadelphia 56:282). St George (C21a).

Lycosa carolinensis Hentz 1842 (J. Boston Soc. Nat. Hist. 4:230). Utah (CO8).

Lycosa frondicola Emerton 1885 (Trans. Conn. Acad. Sci. 6:484). Clear Crk (CI33).

Lycosa helluo Walckenaer 1837 (Hist. Nat. Ins. Apt. 1:337). Utah (C8).

Lycosa uinticolens Chamberlin 1936 (Proc. Biol. Soc. Washington 49:15). Green Lake (in Uinta Mts) (C36).

Lycosa sp. Green Cyn (H), Provo (A78).

Mallos alpheus Chamberlin 1948 (Bull. Univ. Utah Biol. Ser. 10(6):14). American Fork Cyn (C48).

Mallos eutypus (Chamberlin & Gertsch) 1929 (J. Ent. Zool. Pomona Coll. 21:101). Bluff, Monroe Cyn, Richfield, St George (G46).

Mallos niveus O. Pick.-Cambridge 1902 (Biol. Centr. Amer., Arachn. Ar. 1:308). Calf Crk, Posey Lake, Three Lakes (nr Kanab), Willow Tank Spngs (BU), Hughes Cyn, Ophir, Richfield, Salt Lake City, Zion Nat Park (G46), Hurricane (C48).

Mallos trivittatus (Banks) 1901 (Proc. Acad. Nat. Sci. Philadelphia 53:577). Calf Crk, Kanab, Posey Lake, Steep Crk, Three Lakes (N Kanab) (BU), Richfield (G46), USU School Forest (W), Zion Nat Park (C48).

Marpissa californica (Peckham) 1888 (Trans. Wisconsin Acad. Sci. 7:81). San Rafael (CG28).

Maso perplexa Chamberlin & Ivie 1939 (Verh. 7 intern. Kongr. Ent. Berlin 1:64). Cobble Rest (CI45), Provo River N fk (in Uinta Mts) (CI39).

Meioneta fillmorana (Chamberlin) 1919 (Ann. Ent. Soc. Amer. 12:249). Fillmore Cyn (C19).

Meioneta sp. Green Cyn (H).

Metacyrba taeniola (Hentz) 1846 (J. Boston Soc. Nat. Hist. 5:353). Moab (CG28), Nipple Bench (AG).

Metaphidippus aeneolus (Curtis) 1892 (Zoe 3:332). Kelton Pass, Snowville (K), USU School Forest (W).

Metaphidippus diplacis Chamberlin 1924 (Proc. Calif. Acad. Sci. (4)12:616). Zion Nat Park (CW).

Metaphidippus galathea (Walckenaer) 1837 (Hist. Nat. Ins. Apt. 1:456). La Sal Mts (C28), Raft River S fk (CI33), Zion Nat Park (CW).

Metaphidippus helenae (Banks) 1921 (Proc. Calif. Acad. Sci. 11:101). Fish Lake, Richfield (G34c).

Metaphidippus paiutus Gertsch 1934 (Amer. Mus. Novitates 726:1). Richfield, St George (G34c).

Metaphidippus unicus (Chamberlin & Gertsch) 1930 (Proc. Biol. Soc. Washington 43:143). Uintah County (CG30).

Metaphidippus verecundus (Chamberlin & Gertsch) 1930 (Proc. Biol. Soc. Washington 43:144). Clear Crk, Raft River S fk (CI33), Dry Cyn (CG30), Green Cyn (H).

Metaphidippus vitis (Cockerell) 1894 (Entomologist 27:207). Kanab Cyn, Three Lakes (N Kanab) (BU).

Metaphidippus sp. Coyote Gulch, Escalante, Steep Crk, Table Cliff Plateau, Three Lakes (N Kanab), Widtsoe, Willow Tank Spngs (BU), Green Cyn (H), Nipple Bench (AU).

Metellina mimetoides Chamberlin & Ivie 1941 (Bull. Univ. Utah Biol. Ser. 6(3):15). Utah (L80).

Metepeira foxi Gertsch & Ivie 1936 (Amer. Mus. Novitates 858:20). Curlew Valley (K), Fish Lake, Richfield (GI36), Green Cyn (H).

Metepeira grandiosa alpina Chamberlin & Ivie 1942 (Bull. Univ. Utah Biol. Ser. 7(1):74). Fish Lake (CI42a).

Metepeira gosoga Chamerlin & Ivie 1935 (Bull. Univ. Utah Biol. Ser. 2(8):21). Escalante, Steep Crk (BU).

Metepeira labyrinthea (Hentz) 1847 (J. Boston Soc. Nat. Hist. 5:471). Clear Crk, Dove Crk, Raft River S fk (CI33).

Metepeira nanella Chamberlin & Ivie 1942 (Bull. Univ. Utah Biol. Ser. 7(1):71). Fillmore (CI42a).

Metepeira sp. Smokey Mt (AU).

Micaria altana Gertsch 1933 (Amer. Mus. Novitates 637:6). Utah (G35).

Micaria formicoides Chamberlin & Woodbury 1929 (Proc. Biol. Soc. Washington 42:139). St George (CW).

Micaria gosiuta Gertsch 1942 (Amer. Mus. Novitates 1195:1). City Crk Cyn (G42).

Micaria jeanae Gertsch 1942 (Amer. Mus. Novitates 1195:4). Glenwood (G42).

Micaria montana Emerton 1890 (Trans. Conn. Acad. Sci. 8:168). Clear Crk, Dove Crk, Lynn (CI33).

Micaria mormon Gertsch 1935 (Amer. Mus. Novitates 805:17). City Crk Cyn (G35).

Micaria salina Gertsch 1942 (Amer. Mus. Novitates 1195:5). Salina (G42).

Micaria sp. Ahlstrom Point, Four-mile Bench (AU), Green Cyn (H), Kelton, Locomotive Spngs (K), USU School Forest (W).

Microlinyphia mandibulata (Chamberlin & Ivie) 1943 (Bull. Univ. Utah Biol. Ser. 7(6):24). Emery, Fillmore, Provo River mth, Scipio, Verdure, Wasatch Mts, Zion Nat Park (CI43).

Microneta anopla Chamberlin & Ivie 1933 (Bull. Univ. Utah Biol. Ser. 2(2):35). Clear Crk, Dove Crk, Grouse Crk, Raft River S fk (CI33).

Microneta cornupalpis (O. Pick.-Cambridge) 1875 (Proc. Zool. Soc. London, p. 401). Clear Crk (CI33).

Microneta fratrella (Chamberlin) 1919 (Ann. Ent. Soc. Amer. 12:250). Clear Crk (CI33), Uinta Mts (C19).

Microneta lophophor Chamberlin & Ivie 1933 (Bull. Univ. Utah Biol. Ser. 2(2):35). Raft River S fk (CI33).

Microneta orines Chamberlin & Ivie 1933 (Bull. Univ. Utah Biol. Ser. 2(2):35). Clear Crk, Raft River S fk (CI33).

Microneta protrudens Chamberlin & Ivie 1933 (Bull. Univ. Utah Biol. Ser. 2(2):37). Clear Crk, Uinta Mts (CI33).

Microneta tumoa Chamberlin & Ivie 1933 (Bull. Univ. Utah Biol. Ser. 2(2):37). Clear Crk (CI33).

Microneta uta Chamberlin 1920 (Canad. Ent. 52:196). Logan Cyn (C20b).

Microneta viaria (Blackwall) 1841 (Trans. Linn. Soc. London 18:645). Chalk Crk (in Uinta Mts) (C19), Clear Crk, Dove Crk (CI33).

Microneta sp. Zion Nat Park (CW).

Mimetus aktius Chamberlin & Ivie 1935 (Bull. Univ. Utah Biol. Ser. 2(8):23). Green Cyn (H), Utah Lake W side (CI35b).

Mimetus hesperus Chamberlin 1923 (J. Ent. Zool. Pomona Coll. 15:5). Grouse Crk (CI33).

Minyriolus plesius Chamberlin 1948 (Ann. Ent. Soc. Amer. 41:538). Cobble Rest (C48a).

Misumena vatia (Clerck) 1757 (Aranei Suecici, p. 128). Aspen Grove (BU), Clear Crk (CI33), St George, Zion Nat Park (CW).

Misumenoides aleatoria (Hentz) 1847 (J. Boston Soc. Nat. Hist. 6:444). La Sal Mts (C28a).

Misumenops asperatus (Hentz) 1847 (J. Boston Soc. Nat. Hist. 5:447). Green Cyn (H).

Misumenops californicus (Banks) 1896 (J. New York Ent. Soc. 4:91). Coyote Gulch (BU).

Misumenops celer (Hentz) 1847 (J. Boston Soc. Nat. Hist. 5:446). Clear Crk, Raft River S fk (CI33), Curlew Valley (K), Green Cyn (H).

Misumenops coloradensis Gertsch 1933 (Amer. Mus. Novitates 635:17). Upper Escalante Basin at 10-mile Crk (BU).

Misumenops importunus (Keyserling) 1881 (Verh. zool. bot. Ges. Wien 31:307). Cedar Jct, Kelton Pass (K).

Misumenops oblongus (Keyserling) 1880 (Spinn. Amer. Lat. 1:79). Three Lakes (N Kanab) (BU).

Misumenops utanus Chamberlin 1929 (Proc. Biol. Soc. Washington 2:137). Zion Nat Park (CW).

Misumenops varia (Keyserling) 1880 (Spinn. Amer. Lat. 1:94). USU School Forest (W).

Misumenops sp. Calf Crk, Coyote Gulch, Escalante, Kanab Cyn, Steep Crk, 10-mile Crk (in Escalante Basin), Three Lakes (N Kanab), Widtsoe, Willow Tank Spngs (BU).

Nanavia monticola Chamberlin & Ivie 1933 (Bull. Univ. Utah Biol. Ser. 2(2):27). Clear Crk (CI33).

Neoanagraphis pearci Gertsch 1941 (Amer. Mus. Novitates 1147:19). Ahlstrom Point, Brigham Plains Flat, Four-Mile Bench (5 km SE cow camp head Wesses Cyn), Nipple Bench, Smokey Mt (14 & 23 km from Last Chance Jct) (AG).

Neoantistea gosiuta Gertsch 1934 (Amer. Mus. Novitates 712:24). Lynn 8 mi S, Raft River S fk, Yost (G34b), Table Cliff Pass (BU).

Neoantistea magna (Keyserling) 1887 (Verh. zool. bot. Ges. Wien 37:463). Raft River S fk, Yost (CI33a), Spring Lake (G34b).

Neoantistea sp. Glen Cyn City, Nipple Bench (AU), USU School Forest (W).

Neon nellii G. & E. Peckham 1888 (Trans. Wisconsin Acad. Sci. 7:88). City Crk, Jordan River (nr Salt Lake City) (GI55), Clear Crk (CI33), Verdure (CG28).

Neon pixii Gertsch & Ivie 1955 (Amer. Mus. Novitates 1743:15). Salt Lake City (GI55).

Neoscona arabesca (Walckenaer) 1841 (Hist. Nat. Ins. Apt. 2:74). Curlew Valley (K), Green Cyn (H), St George (CW).

Neoscona benjamina (Walckenaer) 1841 (Hist. Nat. Ins. Apt. 2:42). St George (CW).

Neoscona oaxacensis (Keyserling) 1864 (Sitz.-ber. naturw. Ges. Isis, Dresden., p. 121). Saltair Beach (C20a), Washington County (CW), West Mt (A73).

Neoscona utahana (Chamberlin) 1919 (Ann. Ent. Soc. Amer. 12:254). Fillmore (C19).

Neriene montana (Clerck) 1757 (Aranei Suecici, p. 64). Clear Crk (CI33), St George, Zion Nat Park (CW).

Nodocion eclecticus Chamberlin 1924 (Proc. Calif Acad. Sci. 12:613). Ophir (CG40), Price, Promontory Point, Utah Lake W side, Zion Nat Park (PS80a), Valley City (CG28).

Nodocion moronius Chamberlin 1936 (Amer. Mus. Novitates 853:5). Moroni (C36b).

Nodocion rufithoracicus Worley 1928 (Ann. Ent. Soc. Amer. 21:620). American Fork Cyn mth, Mill Crk Cyn, Willard (PS80a), Green Cyn (H).

Nodocion utus (Chamberlin) 1936 (Amer. Mus. Novitates 841:7). Glen Cyn City 7 km

SW (AG), Richfield (C36a), Santaquin 3 mi E, Utah Lake W side (PS80a).

Nodocion voluntarius (Chamberlin) 1919 (J. Ent. Zool. Pomona Coll. 12:5). Panguitch 11 mi SE, Red Cyn Camp (PS80a).

Novalena idahoana (Gertsch) 1934 (Amer. Mus. ovitates 726:25). Price, Wasatch (CI42).

Novalena lutzi (Gertsch) 1933 (Amer. Mus. Novitates 637:12). Cedar Cyn, Horse Valley (in Henry Mts) (CI42).

Nuctenea patagiata (Clerck) 1757 (Aranei Suecici, p. 38). Aspen Grove, St George (BU), Benson (McU), Dove Crk, Grouse Crk, Raft River S fk (CI33), Lake Powell (C58), La Sal Mts (C28a).

Oedothorax lasalanus Chamberlin & Ivie 1935 (Bull. Univ. Utah Biol. Ser. 2(8):18). La Sal Mts (CI35b).

Oedothorax sp. Dove Crk (CI33).

Olios fasiculatus Simon 1880 (Acta Soc. Linn. Bordeaux 34:307). St George (C21), Zion Nat Park (CW).

Orchestina moaba Chamberlin & Ivie 1935 (Bull. Univ. Utah Biol. Ser. 2(8):10). Bluff, Moab (CI35b).

Orchestina utahana Chamberlin & Ivie 1935 (Bull. Univ. Utah Biol. Ser. 2(8):10). Utah Lake W shore (CI35b).

Oreonetides vaginatus (Thorell) 1872 (Öfvers. Kongl. Vet. Akad. Förh. 29:153). Utah (V).

Orodrassus coloradensis (Emerton) 1877 (Bull. U.S. Geol. Surv. 3:528). Posey Lake, Steep Crk, Widtsoe (BU), Raft River S fk (CI33), USU School Forest (W), Uinta Mts (C19).

Orthonops gertschi Chamberlin 1928 (Psyche 35:235). Straight Wash (in San Rafael Desert) (C28).

Oxyopes rufipes Banks 1893 (J. New York Ent. Soc. 1:133). lear Crk, Raft River S fk (CI33), Kanab, Kanab Cyn, Escalante (BU), St George (CW).

Oxyopes salticus (Hentz) 1845 (J. Boston Soc. Nat. Hist. 5:196). St George (C21).

Oxyopes scalaris (Hentz) 1845 (J. Boston Soc. Nat. Hist. 5:196). Green Cyn (H), Locomotive Spngs (K).

Oxyopes tanneri Chamberlin 1928 (Canad. Ent. 60:95). La Sal Mts (C28a).

Oxyopes tridens Brady 1964 (Bull. Mus. Comp. Zool. 131:472). Glen Cyn City 5 km W (AG).

Oxyopes sp. Escalante (BU), USU School Forest (W).

Ozyptila beaufortensis Strand 1916 (Arch. Naturgesch. 81A(9):124). Smith & Morehouse Cyn (DR74).

Ozyptila conspurcata Thorell 1877 (Bull. U.S. Geol. Surv. 3:496). Dry Cyn, Fish Lake, Fruita, Salt Lake City, White River, Zion Nat Park (DR74).

Ozyptila sp. Cyclone Lake (nr Escalante) (BU).

Pachygnatha dorothea McCook 1894 (Amer. Spiders 3:270). nr Salt Lake City (L80).

Pachygnatha mccooki Banks 1916 (Proc. Acad. Nat. Sci. Philadelphia 68:79). Kanab (BU).

Pachygnatha xanthostoma C. L. Koch 1845 (Die Arachn. 12:148). Grouse Crk (CI33), & other localities not designated (L80).

Pagomys monticola (Gertsch & Mulaik) 1936 (Amer. Mus. Novitates 851:2). Mirror Lake (CG58).

Pagomys uinta Chamberlin 1948 (Bull. Univ. Utah Biol. Ser. 10(6):15). Mirror Lake (C48).

Paidisca camano Levi 1957 (Bull. Amer. Mus. Nat. Hist. 112:105). Mill Crk Cyn (L57).

Paidisca pallida (Emerton) 1913 (Trans. Conn. Acad. Sci. 18:213). Counties of Salt Lake & Utah (L57).

Pardosa altamontis Chamberlin & Ivie 1946 (Bull. Univ. Utah Biol. Ser. 9(5):7). East Cyn (CI46).

Pardosa atra Banks 1894 (J. New York Ent. Soc. 2:52). Blanding, Devils Cyn (CG28), Clear Crk (CI33), Salt Lake City, Zion Nat Park (G34), Green Cyn (H), Steep Crk (BU), USU School Forest (W).

Pardosa bellona Banks 1898 (Proc. Calif. Acad. Sci. 1:275). Monroe Cyn (G34).

Pardosa californica Keyserling 1887 (Verh. zool. bot. Ges. Wien 37:483). Utah (C8).

Pardosa coloradensis Banks 1894 (J. New York Ent. Soc. 2:51). Raft River S fk (CI33).

Pardosa concinna (Thorell) 1877 (Bull. U.S. Geol. Surv. 3:506). Sevier County (G34).

Pardosa distincta (Blackwall) 1846 (Ann. Mag. Nat. Hist. London (1)17:32). Aspen Grove (BU), Beaver Crk (G34), Clear Crk, Dove Crk, Lynn, Raft River S fk, Yost (CI33).

Pardosa dorsalis Banks 1894 (J. New York Ent. Soc. 2:51). Several localities not designated (LD81).

Pardosa dorsuncata Lowrie & Dondale 1981 (Bull. Amer. Mus. Nat. Hist. 170:130). Several localities not designated (LD81).

Pardosa falcifera F. Pick.-Cambridge 1902 (Biol. Centr. Amer., Arachn. Aran. 2:318). Hurricane, Salt Lake City, Zion Nat Park (G34).

Pardosa giebeli (Pavesi) 1873 (Atti Soc. Ital. Sci. Nat. 16:30). Navajo Mt (AG), Steep Crk (BU), Uinta Mts (G34).

Pardosa groenlandica (Thorell) 1872 (Öefv. Vet. Akad. Förh. 29:157). Devils Cyn, Greenriver, Moab, Monticello, Price, San Rafael River, Valley City, Verdure (CG28), Dove Crk, Grouse Crk, Raft River S fk, Yost (CI33).

Pardosa lapidicina Emerton 1885 (Trans. Conn. Acad. Sci. 6:494). Blanding, Bluff, Fruita, Greenriver, Hanksville, Moab, San Rafael River, Straight Wash (CG28), La Sal Mts (C28a), St George, Zion Nat Park (CW).

Pardosa mackenziana (Keyserling) 1877 (Verh. zool. bot. Ges. Wien 26:621). Aspen Grove, Washington County, Steep Crk (BU), Clear Crk, Raft River S fk (CI33), La Sal Mts (C28a).

Pardosa modica (Blackwall) 1846 (Ann. Mag. Nat. Hist. London (1)17:33). Fish Lake (G34), Utah Lake (C8).

Pardosa saxatilis (Hentz) 1844 (J. Boston Soc. Nat. Hist. 4:392). Marysvale Cyn (G34).

Pardosa sierra Banks 1898 (Proc. Calif. Acad. Sci. 1:274). Coyote Gulch (in Escalante Basin) (BU).

Pardosa solituda Levi & Levi 1951 (Zoologica 36:225). Hidden Lake, Mt Timpanogos (LL).

Pardosa sternalis (Thorell) 1877 (Bull. U.S. Geol. Surv. 3:504). Blanding, Fruita, Moab, Price, Valley City, Verdure (CW), Clear Crk, Dove Crk, Grouse Crk, Raft River S fk, Yost (CI33), Rock Island (in Utah Lake), Steep Crk, Three Lakes (N Kanab), Kanab (BU), St George (C21), USU School Forest (W).

Pardosa tristis (Thorell) 1877 (Bull. U.S. Geol. Surv. 3:510). Cyclone Lake (nr Escalante) (BU).

Pardosa uintana Gertsch 1933 (Amer. Mus. Novitates 636:27). Uinta Mts (G33), SW Utah (LD81).

Pardosa uncata (Thorell) 1877 (Bull. U.S. Geol. Surv. 3:508). Undesignated localities in Utah (LD).

Pardosa utahensis Chamberlin 1919 (Ann. Ent. Soc. Amer. 12:258). Chalk Crk (in Uinta Mts) (C19), Navajo Mt (AG), Steep Crk (BU).

Pardosa wasatchensis Gertsch 1933 (Amer. Mus. Novitates 636:25). Utah (R).

Pardosa xerampelina (Keyserling) 1876 (Verh. zool. bot. Ges. Wien 26:622). Utah (C8).

Pardosa yavapa Chamberlin 1925 (Bull. Mus. Comp. Zool. 68:231). Fish Lake, Henry Mts, Richfield, Weber Cyn (G34), La Sal Mts (C28a), Boulder Mt, Steep Crk, Table Cliff Pass (BU).

Pardosa zionis Chamberlin & Ivie 1942 (Bull. Univ. Utah Biol. Ser. 7(1):33). Coyote Gulch (BU), Zion Nat Park (CI42a).

Pardosa sp. Calf Crk Crossing (nr Escalante), Kanab Cyn, Steep Crk (BU), Fourmile Bench (AU).

Pelecopsis digna Chamberlin & Ivie 1939 (Verh. 7 Kongr. intern. Ent. Berlin, p. 70). Clear Crk, Uinta Mts (CI33), Provo River (in Uinta Mts), Raft River Mts (CI39).

Pelecopsis sculptum (Emerton) 1917 (Canad. Ent. 49:261). Clear Crk, Uinta Mts (CI33).

Pellenes americanus (Keyserling) 1884 (Verh. zool. bot. Ges. Wien 34:506). USU School Forest (W).

Pellenes candidus G. & E. Peckham 1901 (Bull. Wisconsin Nat. Hist Soc. (N.S.) 1:206). Rock Island (in Utah Lake) (BU), Verdure (CG28).

Pellenes clypeatus (Banks) 1895 (Canad. Ent. 27:102). Moab, Verdure (CG28).

Pellenes decorus (Blackwall) 1846 (Ann. Mag. Nat. Hist. (1)17:34). Utah (C58).

Pellenes griseus G. & E. Peckham 1901 (Bull. Wisconsin Nat. Hist. Soc. (N.S.) 1:206). Price (CG28).

Pellenes hirsutus (G. & E. Peckham) 1888 (Trans. Wisconsin Acad. Sci. 7:64). Green Cyn (H).

Pellenes laggani G. & E. Peckham 1909 (Trans. Wisconsin Acad. Sci. 16:532). USU School Forest (W).

Pellenes mimula Chamberlin & Gertsch 1929 (J. Ent. Zool. Pomona Coll. 21:111). St George (CG29).

Pellenes oregonense (G. & E. Peckham) 1888 (Trans. Wisconsin Acad. Sci. 7:66). Valley City CG28).

Pellenes viridipes (Hentz) 1846 (J. Boston Soc. Nat. Hist. 5:362). Verdure (CG28).

Pellenes sp. Curlew Valley (K), Four-mile Bench, Glen Cyn City, Nipple Bench (AU).

Phidippus apacheanus Chamberlin & Gertsch 1929 (J. Ent. Zool. Pomona Coll. 21:109). Black Rock (W Salt Lake City), City Crk Cyn, Fisher Pass, Strawberry (CG29), Green Cyn (McU), Locomotive Spngs (K).

Phidippus asotus Chamberlin & Ivie 1933 (Amer. Mus. Novitates 631:50). Grouse Crk (CI33).

Phidippus johnsoni (G. & E. Peckham) 1883 (Desc. Spiders Fam. Attidae, p. 22). Aspen Grove, Provo, Rock Island (in Utah Lake) (BU), Clear Crk, Dove Crk, Raft River S fk (CI33), Green Cyn (H), Mounds, San Rafael, Straight Wash (CG28), St George (C21).

Phidippus octopunctatus (G. & E. Peckham) 1883 (Descr. Spiders Fam. Attidae, p. 6). Green Cyn (H).

Phidippus pogonopus Chamberlin 1925 (Proc. Calif. Acad. Sci. 14:132). Greenriver (C25).

Phidippus pruinosus G. & E. Peckham 1909 (Trans. Wisconsin Acad. Sci. 16:388). Blanding, Bluff (CG38).

Phidippus purpuratus Keyserling 1884 (Verh. zool. bot. Ges. Wien 34:489). USU School Forest (W).

Phidippus workmanii (G. & E. Peckham) 1901 (Trans. Wisconsin Acad. Sci. 13:287). St George (C21).

Phidippus sp. Glen Cyn City (AU), Posey Lake, Provo (BU).

Philodromus alascensis Keyserling 1884 (Verh. zool. bot. Ges. Wien 33:674). Farmington Cyn (LL), Salina (CG28), USU School Forest (W).

Philodromus californicus Keyserling 1884 (Verh. zool. bot. Ges. Wien 33:676). Big Cottonwood Cyn, Fruita, Mill Crk, Ogden River Cyn, Payson, Salt Lake City (D), Bluff, Moab, San Rafael River, Zion Nat Park (CG28), Green Cyn (H), St George (CW).

Philodromus cespitum (Walckenaer) 1802 (Faune Parisienne, Insecta, 2:230). Curlew Valley (K), Richfield, W Utah Lake (D).

Philodromus histrio (Latreille) 1819 (N. Dic. hist. nat. Nouv. édit., Paris, p. 36). Green Cyn (H).

Philodromus imbecillus Keyserling 1880 (Spinn. Amer., Lat., p. 224). Paradise (DR).

Philodromus infuscatus Keyserling 1880 (Spinn. Amer., Lat., p. 222). St George (C21).

Philodromus insperatus Schick 1965 (Bull. Amer. Mus. Nat. Hist. 129:66). East Cyn, Salt Lake City, Silver Lake (DR68).

Philodromus pernix Blackwall 1846 (Ann. Mag. Nat. Hist (1)17:38). Clear Crk, Raft River S fk, Yost (CI33), Mill Crk (D).

Philodromus praelustris Keyserling 1880 (Spinn. Amer., Lat., p. 209). Allen Cyn (D).

Philodromus quercicola Schick 1965 (Bull. Amer. Mus. Nat. Hist. 129:56). Kelton Pass (K).

Philodromus rodecki Gertsch & Jellison 1939 (Amer. Mus. Novitates 1032:27). Red Cyn Camp (DR68).

Philodromus rufus Walckenaer 1826 (Faune française, Paris, p. 91). Green Cyn (H), USU School Forest (W).

Phildromus satullus Keyserling 1880 (Spinn. Amer., Lat., p. 211). Green Cyn (H), Little Cottonwood Cyn, Salt Lake City, Zion Nat Park (DR68).

Philodromus speciosus Gertsch 1934 (Amer. Mus. Novitates 707:22). Green Cyn (H), Salt Lake City (G34a), Vermillion Castle (nr Parowan) (LL).

Philodromus spectabilis Keyserling 1884 (Verh. zool. bot. Ges. Wien 33:676). SW Utah (DR76).

Philodromus sp. Escalante, Kanab Cyn, Posey Lake, Provo, Rock Island (in Utah Lake), Three Lakes (N Kanab), Widtsoe, Willow Tank Spngs (BU).

Pholcophora americana Banks 1893 (Trans. Amer. Ent. Soc. 23:57). Four-mile Bench (5 km SE cow camp at head Wesses Cyn) (AG), Lehi (G35), Lynn, Raft River Mts (CI33).

Phruronellus pictus Chamberlin & Gertsch 1930 (Proc. Biol. Soc. Washington 43:138). Bountiful (CG30).

Phruronellus similis (Banks) 1895 (J. New York Ent. Soc. 3:81). Utah (R).

Phrurotimpus alarius (Hentz) 1847 (J. Boston Soc. Nat. Hist. 5:461). Caineville, Moab, San Rafael River (CG28), Four-mile Bench (5 km SE cow camp at head Wesses Cyn) (AG), Green Cyn (H).

Phrurotimpus borealis (Emerton) 1911 (Trans. Conn. Acad. Sci. 16:404). Clear Crk (CI33).

Phrurotimpus mormon (Chamberlin & Gertsch) 1930 (Proc. Biol. Soc. Washington

43:140). Ferron (CI35b), Salt Lake City (CG30).

Phrurotimpus woodburyi (Chamberlin & Woodbury) 1929 (J. Ent. Zool. Pomona Coll. 21:18). Dry Cyn, Smith and Morehouse Cyn (CI35b).

Physocyclus tanneri Chamberlin 1921 (Canad. Ent. 53:245). Lake Powell (C58), St George (C21), Zion Nat Park (CW)

Piabuna nanna Chamberlin & Ivie 1933 (Bull. Univ. Utah Biol. Ser. 2(2):41). Dove Crk, Grouse Crk (CI33).

Piabuna xerophila Chamberlin & Ivie 1935 (Bull. Univ. Utah Biol. Ser. 2(8):38). Moab (CI35b).

Pimoa utahana (Gertsch & Ivie) 1936 (Amer. Mus. Novitates 858:16). Salt Lake City (CI43).

Pirata minutus Emerton 1885 (Trans. Conn. Acad. Sci. 6:493). Ferron, Logan 1 mi S (WE).

Pirata montanus Emerton 1885 (Trans. Conn. Acad. Sci. 6:493). Fruita (CG28).

Pirata piraticus (Clerck) 1757 (Aranei Suecici, p. 102). Coyote Gulch (in Escalante Basin), Rock Island (in Utah Lake) (BU), counties of Davis, Emery, Grand, Millard, Rich, and Salt Lake (WE).

Pirata sedentarius Montgomery 1904 (Proc. Acad. Nat. Sci. Philadelphia 56:312). Counties of Cache, Grand, Millard, Salt Lake, and Utah (WE).

Pirata sp. Kanab (BU).

Pityohyphantes costatus (Hentz) 1850 (J. Boston Soc. Nat. Hist. 6:31). Bear Lake, Chalk Crk (in Uinta Mts), Logan Cyn (C20b), Clear Crk, Raft river S fk (CI33).

Pityohyphantes cristatus Chamberlin & Ivie 1942 (Bull. Univ. Utah Biol. Ser. 7(1):38) USU School Forest (W).

Pityohypthantes navajo Chamberlin & Ivie 1942 (Bull. Univ. Utah Biol. Ser. 7(1):60). Henry Mts (CI42a).

Pityohyphantes sp. Posey Lake (BU).

Plectreurys tristis Simon 1893 (Ann. Ent. Soc. France 62:300). Blanding, Bluff, Devils Cyn, Straight Wash (CG28), Nipple Bench (AG), Zion Nat Park (CW).

Pocadicnemis pumila (Blackwall) 1841 (Trans. Linn. Soc. London 18:639). Dove Crk, Raft River S fk (CI33), St John, Verdure (CG28), Zion Nat Park (CW).

Poeciloneta bellona Chamberlin & Ivie 1943 (Bull. Univ. Utah Biol. Ser. 7(6):13). Mirror Lake (CI43).

Poeciloneta canionis Chamberlin & Ivie 1943 (Bull. Univ. Utah Biol. Ser. 7(6):13). Cobble Rest (CI43).

Porrhomma ocella Chamberlin & Ivie 1943 (Bull. Univ. Utah Biol. Ser. 7(6):4). City Crk Cyn, Smith & Morehouse Cyn (CI43).

Prolinyphia litigiosa (Keyserling) 1886 (Spinn. Amer., Theridiidae 2:62). Aspen Grove (BU), Clear Crk (CI33), Zion Nat Park (CW).

Psilochorus imitatus Gertsch & Mulaik 1940 (Bull. Amer. Mus. Nat. Hist. 77:321). Four-mile Bench (8 km SE cow camp at head Wesses Cyn), Nipple Bench (AG), Salt Lake City (GU).

Psilochorus utahensis Chamberlin 1919 (Ann. Ent. Soc. Amer. 12:247). Clear Crk, Fillmore, Fillmore Cyn, Pine Cyn (C19), Coyote Gulch, Cyclone Lake (nr Escalante), Steep Crk (BU), Devils Cyn, Moab, Straight Wash, Verdure (CG28), Ahlstrom Pt, Brigham Plains Flat, Four-mile Bench (5 km SE cow camp at head Wesses Cyn), Glen Cyn City 5 km W, Nipple Bench, Smokey Mt (14 and 23 km from Last Chance Jct), Tibbet Spng 2 km NE (AG), Green Cyn (H), Lake Powell (C58), Grouse Crk, Lynn, Raft River Mts (CI33), St George (C21).

Rhysodromus alascensis dondalei Schick 1965 (Bull. Amer. Mus. Nat. Hist. 129:73). Utah (S).

Rhysodromus virescens (Thorell) 1877 (Bull. U.S. Geol. Surv. 3:500). Calf Crk, Pink Dunes (N Kanab) (BU), Clear Crk, Raft River S fk (CI33), Curlew Valley (K), Lake Powell (C58), St George (C21).

Salticus austinensis Gertsch 1936 (Amer. Mus. Novitates 852:20). St George (C21).

Salticus scenicus (Clerck) 1757 (Aranei Suecici, p. 117). Benson (McU).

Salticus peckhamae (Cockerell) 1897 (Canad. Ent. 29:223). Lynn (CI33), Snowville (K).

Sassacus papenhoei G. & E. Peckham 1895 (Occ. Pap. Nat. Hist. Soc. Wisconsin 2:177). City Crk Cyn (CG29), Curlew Valley (K), Green Cyn (H), Steep Crk (BU).

Satilatlas gentilis Millidge 1981 (Bull. Amer. Mus. Nat. Hist. 170:251). Smith & Morehouse Cyn (M81b).

Schizocosa avida (Walckenaer) 1837 (Hist. Nat. Inst. Apt. 1:322). Bluff, Caineville, Fremont River, Fruita, Moab, Straight Wash, Valley City (CG28), Clear Crk, Raft River S fk (CI33), Four-mile Bench (8 km SE cow camp at head Wesses Cyn), Glen Cyn City 5 km W & 6.5 km S, Smokey Mt (23 km from Last Chance Jct) (AG), Widtsoe (BU).

Schizocosa (?) celerior Chamberlin 1910 (Ent. News 21:2). (Not a *Schizocosa* according to Dondale & Redner 1978). St. George (GW).

Schizocosa crassipalpata Roewer 1951(Abh. naturw. Ver. Bremen 32:440). nr Salt Lake City (DR78).

Schizocosa mccooki (Montgomery) 1904 (Proc. Acad. Nat. Sci. Philadelphia 56:283). Green Cyn (H), Hughes Cyn (CI42a), USU School Forest (W), other localities not designated (DR78).

Schizocosa mimula (Gertsch) 1934 (Amer. Mus. Novitates 726:5). Salt Lake City (DR78).

Schizocosa minnesotensis (Gertsch) 1934 (Amer. Mus. Novitates 726:4). Utah (DR78).

Schizocosa saltatrix (Hentz) 1844 (J. Boston Soc. Nat. Hist. 4:387). Fish Lake (GW).

Sciastes simplex (Chamberlin) 1919 (Ann. Ent. Soc. Amer. 12:250). Bear Lake, Logan Cyn, Mirror Lake, upper Provo River, Swan Crk Cyn, Teapot Lake (in Uinta Mts), Wasatch Mts (CI45), Chalk Crk (in Uinta Mts) (C19).

Scotinella formidabilis (Chamberlin & Gertsch) 1930 (Proc. Biol. Soc. Washington 43:137). Fish Lake (CG30), Posey Lake (BU), Raft River S fk (CI33).

Scotinella pelvicolens (Chamberlin & Gertsch) 1930 (Proc. Biol. Soc. Washington 43:138). Clear Crk (CI33), Mt Ellen (in Henry Mts) (CG30), USU School Forest (W).

Scotinella pugnata (Emerton) 1890 (Trans. Conn. Acad. Sci. 8:188). "Utah" (DR82).

Scotinotylus castorus (Chamberlin) 1948 (Ann. Ent. Soc. Amer. 41:520). Beaver Cyn (C48).

Scotinotylus dubiosus Millidge 1981 (J. Arach. 9:205). Logan (M81).

Scotinotylus kenus (Chamberlin) 1948 (Ann. Ent. Soc. Amer. 41:519). Ferron Res, Mirror Lake (C48).

Scotinotylus pallidus (Emerton) 1882 (Trans. Conn. Acad. Sci. 6:1). Utah (M81).

Scotinotylus sacratus Millidge 1981 (J. Arach. 9:181). Mirror Lake (M81).

Scotinotylus sanctus (Crosby) 1929 (Ent. News 40:81). Clear Crk, Raft River S fk (CI33).

Scotoussa bidentata (Emerton) 1882 (Trans. Conn. Acad. Sci. 6:56). Carter Crk & Deep Crk jct, Smith & Morehouse Cyn (CI45).

Scylaceus sp. Four-mile Bench (AU).

Sergiolus angustus (Banks) 1904 (Proc. Calif. Acad. Sci. 3:337). City Crk Cyn, Richfield (C36b), Clear Crk Cyn, Hughes Cyn, Salt Lake City (PS81), Fruita (CG28).

Sergiolus columbianus (Emerton) 1917 (Canad. Ent. 49:269). Salt Lake County (PS81).

Sergiolus iviei Platnick & Shadab 1981 (Amer. Mus. Novitates 2717:34). Lynn, Moab, Salt Lake City, West Jordan (PS81).

Sergiolus lowelli Chamberlin & Woodbury 1929 (Proc. Biol. Soc. Washington 41:177). Moab (PS81), St George (CW).

Sergiolus montanus (Emerton) 1890 (Trans. Conn. Acad. Sci. 8:175). Clear Crk, Lynn, Raft River Mts (CI33), Green Cyn (H), Richfield, Salt Lake City (C36b), Zion Nat Park (CW), and counties of Garfield, Rich, San Juan, Uintah, Utah, Wayne and Weber (PS81).

Sisicottus montanus (Emerton) 1882 (Trans. Conn. Acad. Sci. 6:55). Chalk Crk (in Uinta Mts) (C19), Clear Crk, Raft River S fk (CI33).

Sisicottus uintanus Chamberlin & Ivie 1939 (Verh. 7 intern. Kongr. Ent. Berlin 1:65). Mirror Lake (CI39).

Sitticus finschi (L. Koch) 1879 (Verh. zool bot. Ges. Wien 28:483). USU School Forest (W).

Sosticus loricatus (L. Koch) 1866 (Arach. Fam. Drassiden, p. 131). City Crk Cyn, Green River, Price (PS76a), Logan (CG40).

Spirembolus humilis Millidge 1980 (J. Arach. 8:12). Mirror Lake, Tooele County (M80).

Spirembolus monticolens (Chamberlin) 1919 (Ann. Ent. Soc. Amer. 12:251). Chalk Crk (in Uinta Mts) (C19), Grouse Crk, Raft River S fk (CI33), Logan Cyn, Lynn 8 mi S, Smith & Morehouse Cyn (CI45a).

Spirembolus mundus Chamberlin & Ivie 1933 (Bull. Univ. Utah Biol. Ser. 2(2):18). City Crk Cyn, Raft River Mts (CI45a), Clear Crk (CI33), Green Cyn (H).

Spirembolus pachygnathus Chamberlin & Ivie 1935 (Bull. Univ. Utah Biol. Ser. 2(8):18). City Crk Cyn, Fish Lake, Mill Crk Cyn, Smith & Morehouse Cyn (CI45a).

Spirembolus pallidus Chamberlin & Ivie 1935 (Bull. Univ. Utah Biol. Ser 2(8):19). Pine Spngs (on Mt Ellen in Henry Mts) (CI45a).

Spirembolus spirotubus (Banks) 1895 (Ann. New York Acad. Sci. 8:424). Mt Ellen (in Henry Mts), and other localities not designated (M80).

Spirembolus vallicolens (Chamberlin) 1920 (Canad. Ent. 52:198). Fillmore, Fish Lake, Mt Ellen (in Henry Mts), Provo River mth, Richfield, Salt Lake City 10 mi W, Santaquin Res (CI45a), Mill Crk (C20b), Verdure (CG28a). (Millidge 1980 states that many of Chamberlin and Ivie's 1945a records of this species actually are *S. spirotubus*.)

Steatoda albomaculata (DeGeer) 1778 (Mèm. pour. servir à l'hist. des Ins. 7:257). Clear Crk, Grouse Crk, Lynn, Raft River Mts, Raft River S fk (CI33), La Sal Mts (C28a), Boulder Mt, Cyclone Lake, Posey Lake, Steep Crk (BU), Bryce Cyn Nat Park, counties of Kane, Millard, San Juan (L57), and Wayne (IU).

Steatoda americana (Emerton) 1882 (Trans. Conn. Acad. Sci. 6:23). Fort Douglas, Salt Lake City, Washington County (C28), Fruita, Verdure (CG28), Green Cyn (H), Oquirrh Mts (IU).

Steatoda castanea (Clerck) 1757 (Aranei Suecici, p. 49). Logan (McU).

Steatoda fulva (Keyserling) 1882 (Spinn. Amer. Theridiidae 2:142). Dry Cyn, Fort Douglas, Great Salt Lake shore (IU), Ahlstrom Point, Brigham Plains, Glen Cyn City, Nipple Bench, Tibbet Spng 2 km NE (AG), Spring Lake (Ky), and counties of Carbon, Sevier, Tooele and Weber (L57).

Steatoda grandis Banks 1901 (Proc. Acad. Nat. Sci. Philadelphia 53:578). Beaver Dam Wash, Utah Lake W shore (IU), Cedar Cyn nr Cedar Breaks Nat Mon, Ferron, Henry Mts, Levan, Salt Lake City, Zion Nat Park (CI35b), Escalante, Fish Lake, Fruita, Helper, Noton, Parowan, Price, Red Cyn, Richfield, Scipio, Vernal, Watson, White River (nr Evacuation Crk) (L57), St George (CW), Steep Crk, Torrey 15 mi S (BU). (According to Gertsh (pers. comm.), this species and *S. mexicana* need clarification, and the records above are tentatively assigned to these two species. *Steatoda mexicana* actually is southern Mexico in distribution, and the Utah specimens need other names, possible only after revision of the group.)

Steatoda hespera Chamberlin & Ivie 1933 (Bull. Univ. Utah Biol. Ser. 2(2):9). Aspen Grove, Cyclone Lake (nr Escalante) (BU), Clear Crk, Raft River Mts, Raft River S fk (CI33), St George (CW), USU School Forest (W).

Steatoda medialis (Banks) 1898 (Proc. Calif. Acad. Sci. (3)1:239). Several localities not designated (L59).

Steatoda mexicana Levi 1957 (Bull. Mus. Comp. Zool. 117:415). Beaver Dam Wash, Boulder 15 mi N, Bryce Cyn Nat Park, Fish Lake, Henry Mts, Lehi, Panguitch 10 mi SE, Salt Lake City, St George, Utah Lake W shore (L57). (See comments under *S. grandis*).

Steatoda triangulosa (Walckenaer) 1802 (Faune parisienne, Paris 2:207). Utah (LR).

Steatoda variata Gertsch 1960 (Amer. Mus. Novitates 1982:24). Ferron, Fruita, Greenriver, Grouse Crk, Moab, Raft River Mts, Salt Lake City, White River (on Evacuation Crk) (G60), Glen Cyn City (AG).

Steatoda washona Gertsch 1960 (Amer. Mus. Novitates 1982:21). Ferron, Fish Lake, Glenwood, Loa, Moab, Richfield, Salt Lake City (G60).

Steatoda sp. Three Lakes (N Kanab) (BU).

Stemonyphantes blauveltae Gertsch 1951 (Amer. Mus. Novitates 1514:1). Strawberry Res (G51a).

Stylophora pullata (O. Pick.-Cambridge) 1863 (Zoologist 21:8580). Cobble Rest (I69).

Synagales sp. Green Cyn (H), Cedar Hills, Curlew Valley (K).

Tachygyna haydeni Chamberlin & Ivie 1939 (Verh. 7 intern. Kongr. Ent. Berlin, p. 63). Mirror Lake (CI39).

Tachygyna paita Chamberlin 1948 (Ann. Ent. Soc. Amer. 41:548). Mirror Lake (C48a).

Tachygyna pallida Chamberlin & Ivie 1939 (Verh. 7 intern. Kongr. Ent. Berlin, p. 63). Provo River N fk (in Uinta Mts) (CI39).

Tachygyna tuoba (Chamberlin & Ivie) 1933 (Bull. Univ. Utah Biol. Ser. 2(2):23). Raft River S fk (CI33), Raft River Mts (CI39).

Tachygyna watona Chamberlin 1948 (Ann. Ent. Soc. Amer. 41:549). Mirror Lake (C48a).

Talavera minuta (Banks) 1895 (Canad. Ent. 27:99). Green Cyn (H), USU School Forest (W).

Tapinocyba gamma Chamberlin 1948 (Ann. Ent. Soc. Amer. 41:550). Mirror Lake (C48a).

Tetragnatha extensa (Linnaeus) 1758 (Syst. Nat. 10th ed., p. 621). Aspen Grove, Calf Crk Crossing (nr Escalante), Boulder (BU), Clear Crk, Dove Crk, Raft River S fk (CI33), Curlew Valley (K), Zion Nat Park (CW).

Tetragnatha laboriosa Hentz 1850 (J. Boston Soc. Nat. Hist. 6:27). Curlew Valley (K), Dove Crk, Raft River S fk (CI33), Green Cyn (H), Moab (CG28), Calf Crk, Kanab Cyn, Posey Lake, Steep Crk, Three Lakes (N Kanab), Utah Lake (BU), Zion Nat Park (CW).

Tetragnatha marginata (Thorell) 1890 (Ann. Mus. Civ. Stor. Nat. Genova 28:230). Lake Powell (C58).

Tetragnatha pallescens F. Pick. — Cambridge 1903. (Biol. Centr. Amer., Arachn., Ar. 2:436). NE Utah (L81).

Tetragnatha shoshone Levi 1981 (Bull. Mus. Comp. Zool. 149:312). Bear Lake SE shore, Granite, Laketown, Provo River mth, Richfield, Salt Lake City, Utah Lake W side (L81).

Tetragnatha straminea Emerton 1884 (Trans. Conn. Acad. Sci. 6:335). N central Utah (L81).

Tetragnatha versicolor Walckenaer 1841 (Hist. Nat. Ins. Apt. 2:215). Many localities not designated (L81).

Tetragnatha sp. Willow Tank Spngs (BU).

Thanatus altimontis Gertsch 1933 (Amer. Mus. Novitates 636:6). Glen Cyn City (AG).

Thanatus coloradensis Keyserling 1880 (Spinn. Amer. Lat. 1:206). Clear Crk, Raft River S fk (CI33), St George (BU).

Thanatus formicinus (Clerck) 1757 (Aranei Suecici, p. 134). Green Cyn (H), USU School Forest (W).

Theridion albidum Banks 1895 (J. New York Ent. Soc. 3:84). Green Cyn (H).

Theridion australe Banks 1899 (Proc. Ent. Soc. Washington 4:191). Richfield (L57).

Theridion berkeleyi Emerton 1924 (Pan Pacif. Ent. 1:30). Counties of Salt Lake & Utah (L57).

Theridion denticulatum (Walckenaer) 1802 (Fauna parisienne, Paris 2:208). Utah (LR).

Theridion differens Emerton 1882 (Trans. Conn. Acad. Sci. 6:9). Counties of Box Elder, Grand, Rich, Salt Lake and Sevier (L57).

Theridion dilutum Levi 1957 (Bull. Amer. Mus. Nat. Hist. 112:37). Richfield, Washington County (L57).

Theridion goodnightorum Levi 1957 (Bull. Amer. Mus. Nat. Hist. 112:41). Counties of Sevier and Utah (L57).

Theridion kawea Levi 1957 (Bull. Amer. Mus. Nat. Hist. 112:48). Zion Nat Park (L57).

Theridion leechi Gertsch & Archer 1942 (Amer. Mus. Novitates 1171:8). Counties of Morgan, Salt Lake and Utah (L57).

Theridion montanum Emerton 1882 (Trans. Conn. Acad. Sci. 6:10). Pickleville (Wa), USU School Forest (W), and counties of Beaver, Emery (L47) and Rich (L57).

Theridion murarium Emerton 1882 (Trans. Conn. Acad. Sci. 6:11). Counties of Davis, Tooele and Utah (L57).

Theridion neomexicanum Banks 1901 (Proc. Acad. Nat. Sci. Philadelphia 53:577). Beaver, Bryce Cyn Nat Park, counties of Carbon, Grand, Juab, Kane, Sevier, Wayne and Weber (L57), Green Cyn (H), Hughes Cyn, Logan Cyn (IU), Pickleville (Wa), St George (CW), Straight Wash (CG28), USU School Forest (W).

Theridion ohlerti Thorell 1870 (Remarks Syn. European Spiders, p. 85). Pickleville (Wa), USU School Forest (W), counties of Tooele and Utah (L57).

Theridion ornatum Hahn 1831 (Monogr. der Spinnen, H.6, T.3, 7.c). Richfield, Salt Lake County (L57).

Theridion petraeum L. Koch 1872 (Zeits. Ferd. Tirol Voral. 17:246). Green Cyn (H), counties of Grand, Millard, Morgan, Salt Lake, Summit, Utah and Washington (L57).

Theridion pictum (Walckenaer) 1802 (Faune parisienne, Paris 2:207). Utah (LR).

Theridion rabuni Chamberlin & Ivie 1944 (Bull. Univ. Utah Biol. Ser. 8(5):53). Green Cyn (BA), Pickleville (Wa), USU School Forest (W), counties of Morgan, Salt Lake, San Juan and Utah (L57).

Theridion sexpunctatum Emerton 1882 (Trans. Conn. Acad. Sci. 6:12). Clear Crk, Raft River Mts (CI33), Zion Nat Park, counties of Salt Lake, Summit, Utah and Wasatch (L57).

Theridion timpanogos Levi 1957 (Bull. Amer. Mus. Nat. Hist. 112:31). American Fk Cyn, Mt Timpanogos (L57).

Theridion transgressum Petrunckevitch 1911 (Bull. Amer. Mus. Nat. Hist. 29:208). Ogden Cyn, Weber River, counties of Garfield, Washington and Utah (L57).

Theridion sp. Steep Crk (BU).

Theridula opulenta (Walckenaer) 1837 (Hist. Nat. Ins. Apt. 1:322). Utah (LR).

Thiodina sylvana (Hentz) 1846 (J. Boston Soc. Nat. Hist. 5:364). Utah (C58).

Thiodina sp. Willow Tank Spngs (BU).

Thomisus sp. La Sal Mts (C28a).

Thymoites camano Levi 1957 (Bull. Amer. Mus. Nat. Hist. 112:105). Mill Crk Cyn (L57).

Thymoites edinburgensis (Gertsch & Mulaik) 1936 (Amer. Mus. Novitates 863:9). Hughes Cyn (L57).

Thymoites pallidus (Emerton) 1913 (Bull. Amer. Mus. Nat. Hist. 32:255). Utah (LR).

Tibellus chamberlini Gertsch 1933 (Amer. Mus. Novitates 593:10). Elsinore, Monroe, Zion Nat Park (G33), Green Cyn (H), Kelton Pass (K).

Tibellus duttoni (Hentz) 1847 (J. Boston Soc. Nat. Hist. 5:448). Lake Powell (C58), St George (C21).

Tibellus gertschi Chamberlin & Ivie 1942 (Bull. Univ. Utah Biol. Ser. 7(1):81). Smith & Morehouse Cyn (CI42a).

Tibellus maritimus (Menge) 1875 (Schr. naturf. Ges., Danzig, N.F. 3:398). Zion Nat Park (G33).

Tibellus oblongus (Walckenaer) 1802 (Faune parisienne, Paris 2:228). Clear Crk, Raft River S fk (CI33), Curlew Valley (K), Green Cyn (H), USU School Forest (W), Utah Lake (BU).

Tibellus sp. Moab (CG28), Kanab Cyn, Three Lakes (N Kanab) (BU).

Titanebo magnificus Chamberlin & Ivie 1942 (Bull. Univ. Utah Biol. Ser. 7(1):81). Salt Lake City (CI42a).

Titanebo sp. Escalante, Posey Lakes, Three Lakes (N Kanab) (BU).

Titanoeca nigrella (Chamberlin) 1919 (J. Ent. Zool. Pomona Coll. 12:2). Beaver 10 mi E, Beaver Cyn, Beaver Mt, Bountiful, City Crk Cyn, Cobble Rest, Daniel, Dry Cyn, Eureka, Evacuation Crk, Farmington, Fruita, Garden City, Glenwood, Junction, Moab, Parleys Cyn, Richfield, Utah Lake (Le), Green Cyn (H).

Titanoeca silvicola Chamberlin & Ivie 1947 (Bull. Univ. Utah Biol. Ser. 10(3):15). City Crk Cyn (C47), Fish Lake, Glendale (at Virgin River), La Sal Forest, Snow Crk (Le).

Tmarus angulatus (Walckenaer) 1837 (Hist. Nat. Ins. Apt. 1:537). Zion Nat Park (CW).

Trachelas deceptus (Banks) 1895 (J. New York Ent. Soc. 3:81). Moab, Verdure, Wayne County (CG28), St George (CW).

Trachelas mexicanus Banks 1898 (Proc. Calif. Acad. Sci. 1:226). St George, Zion Nat Park (CI35b).

Trachelas tranquillus (Hentz) 1847 (J. Boston Soc. Nat. Hist 5:450). Bluff (CG28), St George, Zion Nat Park (CW).

Trachelas sp. Three Lakes (BU).

Tricholathys spiralis Chamberlin & Ivie 1935 (Bull. Univ. Utah Biol. Ser. 2(8):28). Kelton (K), Salt Lake City, Utah Lake W side (CI35b).

Trochosa avara (Keyserling) 1877 (Verh. zool. bot. Ges. Wien 27:661). La Sal Mts (BU).

Trochosa gosiuta (Chamberlin) 1908 (Proc. Acad. Nat. Sci. Philadelphia 60:281). Devils Cyn, Fruita, San Rafael, Verdure (CG28), St George, Zion Nat Park (CW), Utah Lake (BU), counties of Carbon, Duchesne, Grand, Salt Lake, Sevier, Tooele, and Wasatch (Br).

Trochosa terricola Thorell 1856 (Nova Acta Reg. Soc. Sci. Upsala (3)2:171). Aspen Grove (BU), City Crk Cyn, Lambs Cyn (CG29), Clear Crk, Dove Crk, Grouse Crk (CI33), Salt Lake City, Tooele (G34c), counties of Daggett, Rich, Sevier and Summit (Br).

Trogloneta paradoxum Gertsch 1960 (Amer. Mus. Novitates 1981:12). Timpanogos Cave Nat Mon (G60).

Tutelina similis (Banks) 1895 (Canad. Ent. 27:100). Clear Crk (CI33), Green Canyon (H).

Uloborus diversus Marx 1898 (Proc. Calif. Acad. Sci. 1:234). Fillmore (C19), N, S and central Utah (MG).

Usofila flava Chamberlin & Ivie 1942 (Bull. Univ. Utah Biol. Ser. 7(1):8). Provo River (in Uinta Mts), Raft River Mts, Wasatch Mts (CI42a).

Usofila gracilis Marx 1891 (Proc. Ent. Soc. Washington 2:9). Mill Crk (G35).

Walckenaeria communis (Emerton) 1882 (Trans. Conn. Acad. Sci. 6:41). Dove Crk (CI33), Steep Crk (BU).

Walckenaeria perditus (Chamberlin) 1948 (Ann. Ent. Soc. Amer. 41:555). Salt Lake City (C48a).

Walckenaeria spiralis (Emerton) 1882 (Trans. Conn. Acad. Sci. 6:39). Raft River S fk (CI33).

Walckenaeria thrinax (Chamberlin & Ivie) 1933 (Bull. Univ. Utah Biol. Ser. 2(2):24). Dove Crk (CI33).

Walckenaeria weber (Chamberlin) 1948 (Ann. Ent. Soc. Amer. 41:557). Smith & Morehouse Cyn (C48a).

Walckenaeria sp. Fruita (CG28).

Wubana drassoides (Emerton) 1882 (Trans. Conn. Acad. Sci. 6:72). Chalk Crk (in Uinta Mts), Fillmore, La Sal Mts (CI36).

Wubana reminescens Chamberlin 1948 (Ann. Ent. Soc. Amer. 41:560). USU School Forest (W).

Wubana utahana Chamberlin & Ivie 1936 (Ann. Ent. Soc. Amer. 29:89). Chalk Crk (in Uinta Mts), Fish Lake, Mirror Lake, Smith & Morehouse Cyn (CI36).

Xysticus apachecus Gertsch 1933 (Amer. Mus. Novitates 593:22). Blanding (G3), Glenwood (G53).

Xysticus benefactor Keyserling 1880 (Spinn. Amer., Lat. 1:22). Bridger Basin, Brigham Cyn, Logan (G53).

Xysticus californicus Keyserling 1880 (Spinn. Amer., Lat. 1:37). Brigham, Clarkston, Escalante 22 mi N, Fish Lake, Logan, Ogden, Parowan, Salina, Willard, Zion Nat Park (G53), Grouse Crk, Raft River S fk, Lynn (CI33), St George (CG29), Straight Wash, Verdure (CG28), Green Cyn (H), Utah Lake (BU).

Xysticus coloradensis Bryant 1930 (Psyche 37:133). Tooele County (G53).

Xysticus facetus O. Pick.-Cambridge 1896 (Biol. Centr. Amer., Arach. Ar. 1:179). Moab (G53).

Xysticus ferox (Hentz) 1847 (J. Boston Soc. Nat. Hist 5:445). Bluff, Fruita, Moab, Price, San Rafael River (CG28).

Xysticus gertschi Schick 1965 (Bull. Amer. Mus. Nat. Hist. 129:159). Clear Crk Cyn, Elsinore, Monroe Cyn (G34a).

Xysticus gosiutus Gertsch 1933 (Amer. Mus. Novitates 593:20). Little Cottonwood Cyn, Zion Nat Park (G33).

Xysticus gulosus Keyserling 1880 (Spinn. Amer., Lat. 1:43). Blanding (CG28), Glen Cyn City (AG), Kelton Pass (K), Lake Powell (C58), Provo (BU), St George (CW).

Xysticus imitarius Gertsch 1953 (Bull. Amer. Mus. Nat. Hist. 102:442). Little Cottonwood Cyn (G53).

Xysticus knowltoni Gertsch 1939 (Bull. Amer. Mus. Nat. Hist. 76:399). Vernon (G53).

Xysticus lassanus Chamberlin 1925 (Bull. Mus. Comp. Zool. 67:218). Glen Cyn City, Smokey Mt (AG), Hanksville, St George (G53).

Xysticus locuples Keyserling 1880 (Spinn. Amer., Lat. 1:24). Brigham (G53), Green Cyn (McU), Grouse Crk (CI33).

Xysticus lutulentus Gertsch 1939 (Bull. Amer. Mus. Nat. Hist. 76:396). Mill Crk Cyn (CI42a).

Xysticus lutzi Gertsch 1935 (Amer. Mus. Novitates 792:27). Glen Cyn City (AG).

Xysticus montanensis Keyserling 1887 (Verh. zool. bot. Ges. Wien 37:479). Clear Crk (CI33), Ferron, Salt Lake City (G34a), Green Cyn (H), Kelton (K), USU School Forest (W).

Xysticus orizaba Banks 1898 (Proc. Calif. Acad. Sci. 1:260). Beaver Dam Wash (G53), Little Cottonwood Cyn, St George (G33).

Xysticus pellax O. Pick.-Cambridge 1894 (Bio. Centr. Amer., Arach. Ar. 1:138). Kearns (G53).

Xysticus sp. Coyote Gulch, Steep Crk, Three Lakes (N Kanab), 10-mi Crk (in Escalante Basin) (BU), USU School Forest (W).

Zanomys kaiba Chamberlin 1948 (Bull. Univ. Utah Biol. Ser. 10(6):18). Dry Cyn (C48).

Zanomys ochra Leech 1972 (Mem. Canad. Ent. Soc. 84:90). Lynndyl 10 mi N (Le).

Zelotes fratris Chamberlin 1920 (Canad. Ent. 2:193). Blanding, Bluff, Grantsville, Verdure (CG28), Clear Crk, Raft River Mts, Raft River S fk, Yost (CI33), Curlew Valley (K), Fish Lake, Monroe Cyn, Richfield (C36a), Green Cyn (H), Logan Cyn (C20b), St George (CW).

Zelotes lampra Chamberlin 1920 (Canad. Ent. 52:193). Mill Crk (C20b).

Zelotes lasalanus Chamberlin 1928 (Canad. Ent. 60:93). La Sal Mts (C28a).

Zelotes nannodes Chamberlin 1936 (Amer. Mus. Novitates 853:10). Tremonton 10 mi W (C36b).

Zelotes nannus Chamberlin & Gertsch 1940 (Amer. Mus. Novitates 1068:18). Bluff, Richardson (CG40).

Zelotes puritanus Chamberlin 1922 (Proc. Biol. Soc. Washington 35:164). Puffer Lake, Tooele Cyn (C36a).

Zelotes tuobus Chamberlin 1919 (Ann. Ent. Soc. Amer. 12:247). Ahlstrom Point, Brigham Plains (AG), Dove Crk, Raft River Mts (CI33), Fillmore (C19), USU School Forest (W).

Zelotes sp. Brighams Plains, Glen Cyn City (AU), Kelton, Locomotive Spngs (K), St George, Three Lakes (N Kanab) (BU).

Zornella cultrigera (L. Koch) 1879 (Kongl. Svenska Vet. Akad. Handl. 16:11). USU School Forest (W).

Synonymies of Utah Records

In the list below, the names on the left are as recorded for some specimens in collections of Utah universities, or as listed in some published articles, and are considered as junior synonyms of the names on the right, which are the only ones included in the main body of this report.

Aculepeira verae = A. packardi
Agelena californica = Agelenopsis californica
Agelena hola = Hololena hola
Agelena mimoides = Hololena mimoides
Agelena oquirrhensis = Hololena oquirrhensis
Agelenopsis mimoides = Hololena mimoides
Agelenopsis naevia = A. aperta
Agroeca oaba = A. trivittata
Alopecosa helluo = Lycosa helluo
Amaurobius nevadensis = Callobius nevadensis
Amaurobius nomeus = Callobius nomeus
Amaurobius utahensis = Callobius nevadensis
Aranea carbonaria = Aculepeira carbonaria
Aranea cucurbitina = Araniella displicata
Aranea displicata = Araniella displicata
Aranea ocellatula = Nuctenea patagiata
Areanea ocellatus = Nuctenea patagiata
Aranea solitaria = Araneus saevus
Aranea tusigia = Araneus marmoreus
Aranea utahana = Neoscona utahana
Arctachaea pelyx = Chrysso pelyx
Arctosa cinerea = A. littoralis
Aysha nigrifrons = A. incursa
Bathyphantes fillmoranus = Meioneta fillmorana
Bathyphantes phylax = Helophora orinoma
Bathyphantes spatulifer = Leptyphantes lamprus
Ceraticelus guttatus = Idionella anomala
Ceraticelus tuganus = Idionella tugana
Cheraira castoris = Scotinotylus castoris
Cheraira kena = Scotinotylus kenus
Cicurina garrina = C. robusta
Clubiona orinoma = C. moesta
Cochembolus sanctus = Scotinotylus sanctus
Cornicularia communis = Walckenaeria communis
Cornicularia thrinax = Walckenaeria thrinax
Cylphosa gosoga = Gnaphosa gosoga
Cylphosa sericata = Gnaphosa sericata
Delopelma simulatum = Aphonopelma simulatum
Dendryphantes diplacis = Metaphidippus diplacis
Dendryphantes mylothrus = prob. Metaphidippus mylothrus
Dendryphantes nigromaculatus = Eris nigromaculatus
Dendryphantes pruinosus = Phidippus pruinosus
Dendryphantes unicus = Metaphidippus unicus
Dendryphantes uteanus = prob. Metaphidippus uteanus
Dendryphantes verecundus = Metaphidippus verecundus
Dendryphantes workmanii = Phidippus workmanii
Dictyna dactylata = D. calcarata
Dictyna eutypa = Mallos eutypus
Dictyna hoples = D. calcarata
Dictyna socarina = D. uintana
Diplocentria bidentata = Scotoussa bidentata
Diplocentria perplexa = Maso perplexus
Dipoena daltoni = D. atopa
Dipoena hamata = D. prona
Drassodes celes = D. saccatus
Drassodes robinsoni = D. saccatus
Drassyllus apacheus = D. insularis
Drassyllus devexus = D. dromeus
Drassyllus gertschi = D. conformans
Drassyllus lasalus = D. mexicanus
Drassyllus mephisto = D. lepidus
Emblyna completa = Dictyna completa

Emblyna rena = Dictyna completa
Emblyna reticulata = Dictyna reticulata
Emblyna urica = Mallos niveus
Emblyna utesca = Dictyna piratica
Epeira labyrinthea = Metapeira labyrinthea
Eperigone taibo = Tachygyna tuobo
Eularia simplex = Sciastes simplex
Euryopis nigripes = E. taczanowskii
Evarcha leucophaea = E. hoyi
Frontinella communis = F. pyramitela
Fuentes taeniola = Metacyrba taeniola
Garritus vigerens = Ctenium vigerens
Gayenna saniuana = Anyphaena pacifica
Geodrassus gosiutus = Drassodes gosiutus
Geolycosus carolinensis = Lycosa carolinensis
Gertschia sp. = Synagales sp.
Gnaphosa gigantea = G. muscorum
Hahnia inornata = H. ononidium
Haplodrassus dystactus = H. signifer
Haplodrassus uncifer = H. bicornis
Haplodrassus utus = H. eunis
Herpyllus atopophysis = Nodocion eclecticus
Herpyllus piedicus = H. propinquus
Herpyllus validus = H. hesperolus
Herpyllus vasifer = H. ecclesiasticus
Icius similis = Tutelina similis
Labuella utahana = Pimoa utahana
Lathys moabana = Dictyna moaba
Latrodectus curacaviensis = L. hesperus
Latrodectus geometricus = L. hesperus
Latrodectus mactans = L. hesperus
Latrodectus variolus = L. hesperus
Linyphia communis = Frontinella communis
Linyphia ephedra = Linyphantes ephedrus
Linyphia litigiosa = Prolinyphia litigiosa
Linyphia montana = Neriene montana
Linyphia phrygianus = Pityohyphantes costatus
Liodrassus metalleus = Nodocion eclecticus
Liodrassus utus = Nodocion utus
Lithyphantes albomaculatus = Steatoda albomaculata
Lycosa avara = Trochosa avara
Lycosa gosiuta = Trochosa gosiuta
Lycosa orophila = Trochosa terricola
Lycosa piraticus = Pirata piraticus
Lycosa pratensis = Trochosa terricola
Lycosa rafaelana = Geolycosa rafaelana
Meriola sp. = Trachelas sp.
Metaphidippus nigromaculatus = Eris nigromaculatus
Metaphidippus verecundus = M. diplacis
Metastinus oblongus = Tibellus oblongus
Metepeira alpina = M. grandiosa alpina
Misumenops lepidus = M. celer
Neoantistea riparia = N. magna
Neoscona naiba = N. arabesca
Paraphidippus marginatus = Eris marginatus
Pardosa atromedia = P. sierra
Pardosa wyuta = P. atra
Peocilochroa montana = Sergiolus montanus
Peponocranium pumila = Pocadicnemis pumila
Phidippus borealis = P. purpuratus
Phidippus capitatus = Metaphidippus galathea
Phidippus formosus = P. johnsoni
Philodromus cespiticolis = P. cespitum
Philodromus hoples = P. californicus
Philodromus virescens = Rhysodromus virescens
Pirata sylvestris = P. piraticus (part) & P. insularis (part)
Pityohyphantes phrygianus = P. costatus
Platyxysticus utahensis = Coriarachne versicolor (part) & C. utahensis (part)
Prosopotheca sp. = Walckenaeria sp.
Pselothorax atopus = Dipoena atopus
Pterotrichia clara = Gnaphosa clara
Pusillia mandibulata = Microlinyphia mandibulata
Robertus fuscus = Ctenium fusca
Robertus eremphilus = Ctenium eremophilus
Sassacus uteanus = S. papenhoei
Schizocosa wasatchensis = S. mccooki
Sergiolus clarus = S. angustus
Sergiolus fruitanus = S. angustus
Singa variabilis = Hyposinga pygmaea
Sostogeus zygethus = Sosticus loricatus
Spirembolus chera = Scotinotylus sanctus
Steatoda punctulata = S. medialis
Tapinocyba alpha = Disembolus alpha
Tapinocyba kesimba = Disembolus kesimbus
Teutana castanea = Steatoda castanea
Theridion placens = T. neomexicanum
Theridion pygmaea = Hyposinga pygmaea
Theridium canione = Achaearanea canione
Tigellinus weber = Walckenaeria weber
Tigellinus perditus = Walckenaeria perditus
Tosyna calcarata = Dictyna calcarata
Tosyna cholla = Dictyna cholla
Tosyna terrestris = Dictyna terrestris
Trachelas utahanus = T. mexicanus
Tricholathys reclusa = Argennina reclusa
Trochosa frondicola = Lycosa frondicola

Trochosa pratensis = T. terricola
Uloborus utahensis = U. diversus
Xysticus cunctator = X. californicus
Xysticus quinquepunctatus = X. gertschi
Zelotes pananus = Sergiolus angustus
Zelotes subterraneus = Z. fratris

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1-84 650 68551

ISSN 017-3614

The Great Basin Naturalist

Published at Provo, Utah, by
Brigham Young University

ISSN 0017-3614

Volume 43 | October 31, 1983 | No. 4

ALPINE AND SUBALPINE WETLAND PLANT COMMUNITIES OF THE UINTA MOUNTAINS, UTAH

George M. Briggs[1] and James A. MacMahon[2]

Abstract.— Seven wetland areas in the subalpine and alpine regions of the Uinta Mountains are described. Most areas have a mosaic vegetation structure, comprised of several patches that are usually sharply demarcated from one another. Each patch has a distinct species composition, usually with only one or two species. Water level is associated with some of the vegetation patterns found in these sites. Standing crop varied from 28 to 360 g/m^2. Sites show considerable variation in standing crop that could not be explained by elevation differences between sites. Sites with water flowing over them have substantially greater standing crops than sites where water stagnates. Seasonal patterns in shoot density and standing crop indicate one late summer peak in standing crop and little recruitment of shoots over the summer. On stagnant sites, the average stem weight shows a strong relationship to stem density. This pattern did not appear to be caused by thinning mortality and did not follow a "3/2 power law" pattern.

A conspicuous aspect of many of the western North American mountain ranges is their wetlands. The Uinta Mountains of northeastern Utah have an abundance of wetland areas, from the lower elevations (around streams in sagebrush slopes) to areas near springs at high elevations in the alpine zone. The majority of wetlands are found at the heads of glaciated valleys in a zone just above and below treeline. The vegetation in these areas is dominated by members of the Cyperaceae (sedges), as is much of the upland region in the alpine zone of the Uintas. Although both wetland and upland regions are dominated by *Carex* spp., the structure of the two regions is markedly different (Briggs and MacMahon 1982). In this study we describe a variety of sedge-dominated wetlands, detail some of their structural attributes, and discuss some of the factors that we think are important in determining their patterns of occurrence.

Study Sites and Methods

All sites are in the Uinta Mountains of northeastern Utah (40°45′N, 110°–111°W), the largest east-west trending mountain range in North America. Bedrock throughout the upper elevations of the range is quartzite. The range was heavily glaciated in Pleistocene time (Hansen 1975) and is dominated by numerous large U-shaped valleys ending abruptly in steep-walled cirques.

No attempt was made to describe or catalog all the wetland areas of the Uintas. Instead, we chose to study a variety of wetland regions that varied in their species composition and standing crop. Most of these regions had a patchwork appearance because they were composed of regions (2–100 m^2) of distinct species composition, often monotypic, which abruptly gave way to regions of a different species mixture. In sampling these areas, we first made a rough map that demarcated the "patches" found in them. Each

[1]University of Michigan Biological Station, Pellston, Michigan 49769.
[2]Department of Biology, Utah State University, Logan, Utah 84322.

patch was then sampled by the methods outlined below. We refer to each patch as a site and present figures representing the species composition and standing crop of each of these. The larger units of vegetation (the entire meadow composed of several patches) are not quantitatively described in this paper. Each site was given a two-letter code that represented the area from which it came and a number that indicated the specific patch sampled (e.g., SC-1 is patch 1 in area SC).

The boundaries to each site were subjectively demarcated and a point was picked within the stand. A 20 × 50 cm frame was placed at that point and all vegetation (except bryophytes) was clipped at ground level. Nine additional samples were taken at regular intervals from the first point. These samples were sorted to species in the field, returned to the lab, air dried for at least two months, and oven dried at 40 C for at least 24 h. Sorting to species was quite easy, even when based on vegetative characters, since there were rarely more than two species per sample. For larger species, the number of stems was directly counted and the average weight per stem calculated. For the smaller species, the average weight per stem was determined by weighing three replicates of 100 stems. The total number of stems was obtained by dividing the total weight of that species in the sample by the weight/stem. All sites were sampled in August, when the fruits of the dominant species were mature. Seasonal changes in aboveground standing crop, number of shoots, and number of fruiting shoots were determined in three of the sites by sampling three or four times during the summer. In addition, several individual plants were observed. The length of each leaf and the length and condition of the fruiting culm (if present) were measured at each sampling time.

At each site, soil samples were dug and pH of the soil was determined. All these sites were submerged at least part of the summer, and notes were made of both the length of time the site was submerged and the degree of water movement over the site.

Site Descriptions

Seven wetland areas were mapped and 21 sites were sampled within these areas. Each wetland area contains between one and five sites. Table 1 lists the dominant species, elevation, and standing crop of all 21 sites. Figure 1 maps the vegetational patterns found in the more complex areas.

The highest wetland found was at an elevation of 3,768 m, in an area adjacent to the steep, rocky talus pile that makes up the northeast side of King's Peak in the east central section of the Uinta range. Springs moisten the site all summer and feed a small stream that traverses the site. Large rocks are scattered throughout. The wetlands of this region consist of a series of small irregularly shaped pools containing 1–10 cm of water at the end of the summer. The emergent vegetation consists solely of *Eriophorum scheuchzeri* Hoppe. These pools were sampled as site ER-1.

To the north of King's Peak lies Henry's Fork Basin. The head of this basin has large expanses of sedge meadows and willow thickets interrupted by upland regions. In spite of a homogeneity in species composition (much of the area is dominated by *Carex aquatilis*), there is considerable variation in stature and standing crop of wet meadows within upper Henry's Fork Basin. We sampled two sites that represent extremes in *Carex aquatilis* meadows. HF-1 is a border to a small (20 m diameter) pond at an elevation of 3,278 m. Vegetation consisted of robust individuals of *Carex aquatilis* and *Caltha leptosepala*. Water stands at least 10 cm deep throughout the year, draining off the site to the north. HF-2 is a very different *Carex aquatilis* region, with a more dense stand of much smaller plants. There is no proximate open water and the ground surface was dry at the end of the summer although the ground was saturated with water at a depth of 2–5 cm.

The remaining five areas are within four miles of Mirror Lake on the west end of the Uintas. Area TL is part of a circular meadow approximately 200 m in diameter. The meadow has a small stream meandering through it and has numerous small "oxbow lakes" and "kettleholes." The vegetation displays a pattern commonly found in moist subalpine meadows of the Uintas: monotypic stands of *Carex aquatilis* and *Eleocharis pauciflora*, areas of *Carex aquatilis* and *Eleocharis pauciflora* mixed, and sections of bare ground, all surrounded by an upland that has soil with less organic matter and a vegetation of *Carex illota* L. H. Bailey, *Deschampsia cespitosa*, and *Ligusticum filicinum* var. *tenuifolium* (S. Wats.) Mathias & Constance. A large portion of this area has standing water year around. This area was sampled in five sites (Fig. 1).

Areas FT and SE are small meadows in *Picea engelmannii*-dominated forests. The vegetation in them is similar to that in TL and is mapped in Figure 1. Both areas were sampled as four sites. Area SC is a meadow in a *Picea engelmannii-Pinus contorta*-dominated forest. The meadow has a stream flowing through it and is kept moist by two large seepage areas. The vegetation presents a complex patterning, with part of the area exhibiting the mix described at the TL site.

TABLE 1. Elevation, standing crop, and species found on the sites.

Site	Elevation (m)	Standing crop (g/m^2)	Dominant species (> 10 percent standing crop)	Other species
ER	3,768	28	*Eriophorum scheuchzeri* Hoppe.	None
HF-1	3,278	360	*Carex aquatilis* Wahl. *Caltha leptosepala* DC.	None
HF-2	3,278	103	*Carex aquatilis*	*Eleocharis pauciflora* (Lightf.) Link, *Pedicularis groenlandica* Retz.
SE-1	3,260	172	*Carex aquatilis* *Carex canescens* L.	None
SE-2	3,260	234	*Carex aquatilis*	None
SE-3	3,260	264	*Carex aquatilis*	None
SE-4	3,260	106	*Eleocharis pauciflora* *Carex aquatilis*	*Pedicularis groenlandica*
FT-1	3,256	152	*Eleocharis pauciflora* *Carex aquatilis*	*Caltha leptosepala, Pedicularis groenlandica, Dodecatheon pulchellum* (Ref.) Merrill, *Epilobium alpinum* L., *Agrostis alba* L.
FT-2	3,256	104	*Carex aquatilis*	*Eleocharis pauciflora*
FT-3	3,256	78	*Eleocharis pauciflora*	*Carex aquatilis*
FT-4	3,256	114	*Carex illota* L. H. Bailey *Ligusticum filicinum* (S. Wats.) Mathias and Constance	*Carex aquatilis, Eleocharis pauciflora, Caltha leptosepala, Pedicularis groenlandica, Veronica wormskjoldii* Roem. and Schult.
TL-1	3,110	86	*Carex aquatilis*	*Deschampsia cespitosa* (L.) Beauv.
TL-2	3,110	96	*Carex illota* *Deschampsia cespitosa*	*Eleocharis pauciflora, Caltha leptosepala, Ligusticum filicinum, Pedicularis groenlandica, Veronica wormskjoldii*
TL-3	3,110	139	*Eleocharis pauciflora*	None
TL-4	3,110	97	*Carex aquatilis* *Eleocharis pauciflora*	None
TL-5	3,110	92	*Carex aquatilis*	None
AQ	3,085	141	*Carex aquatilis*	None
SC-1	3,073	194	*Scirpus cespitosus* L. *Caltha leptosepala*	*Carex nigricans* A. Meyer, *Pedicularis groenlandica, Veronica wormskjoldii*
SC-2	3,073	109	*Scirpus cespitosus* *Carex aquatilis* *Eleocharis pauciflora*	*Caltha leptosepala, Ligusticum filicinum, Pedicularis groenlandica, Veronica wormskjoldii*
SC-3	3,073	83	*Carex aquatilis* *Eleocharis pauciflora*	None
SC-4	3,073	251	*Carex illota* *Carex rostrata* Stokes *Carex aquatilis* *Caltha leptosepala*	*Agrostis alba, Carex canescens, Ligusticum filicinum*

Other parts of the meadow have a dense turf of *Scirpus cespitosus* L. associated with *Carex aquatilis, Eleocharis pauciflora,* and *Caltha leptosepala.* A final portion of the meadow contains a mix of *Carex illota* and *C. aquatilis.* The whole meadow has standing water throughout the year. SC was divided into four sites (Fig. 1).

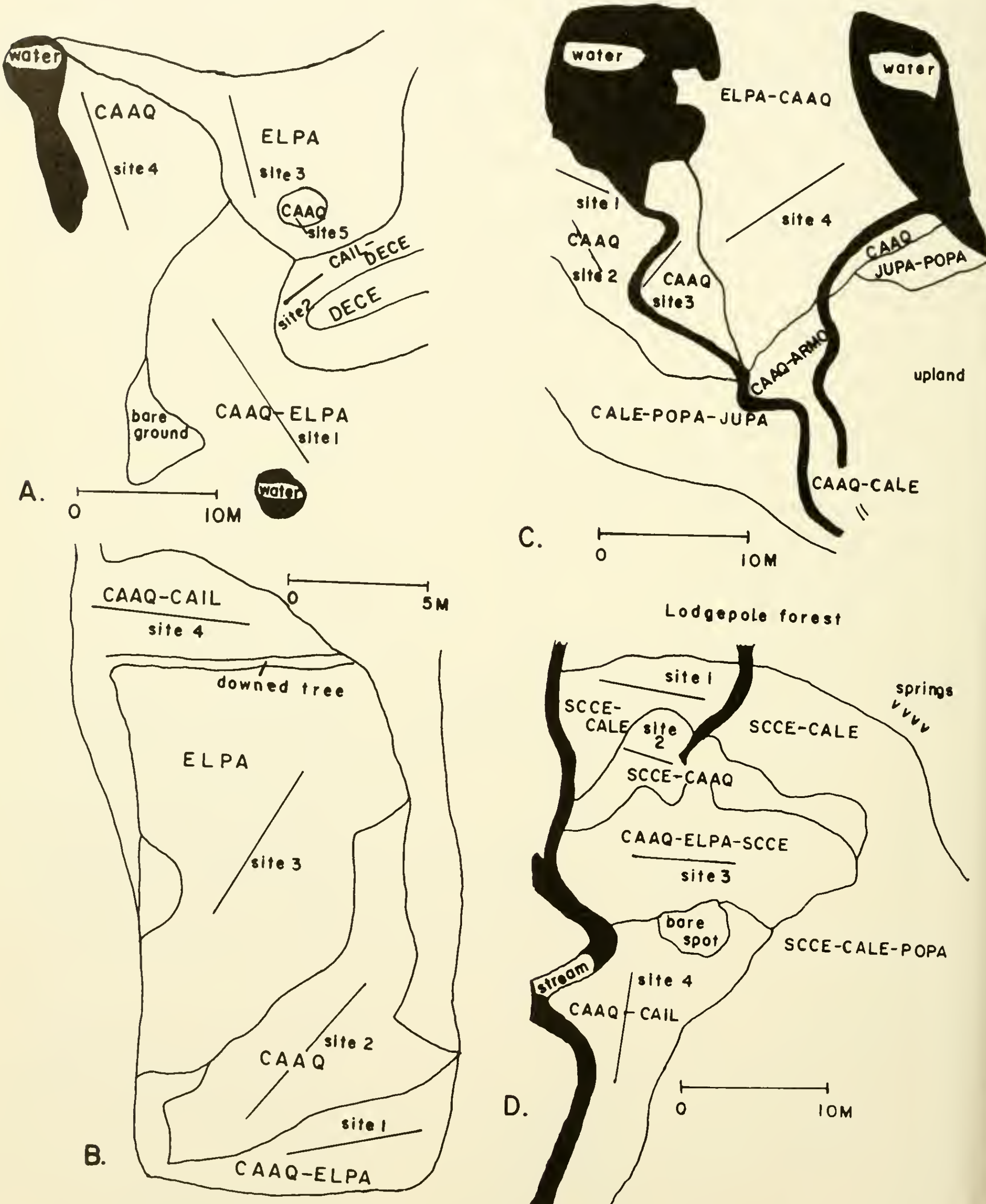

Fig. 1. Maps of four of the wetland areas: A, Area SE. B, Area TL. C, Area SC. D, Area FT. ARMO = *Arnica mollis,* CAAQ = *Carex aquatilis,* CAIL = *Carex illota,* CALE = *Caltha leptosepala,* DECE = *Deschampsia cespitosa,* ELPA = *Eleocharis pauciflora,* JUPA = *Juncus parryi,* POPA = *Poa pratensis,* SCCE = *Scirpus cespitosa.*

Area AQ is on the margin of a small pond that narrows into a stream at one end. It is surrounded by a *Picea engelmannii–Pinus contorta*-dominated forest. This area is at least 30 cm under water in the spring. Standing water is present to a depth of 10 cm in the fall. One site was sampled in this area, a region of nearly pure *Carex aquatilis*.

Results and Discussion

Vegetation

The number of species sampled on each of the 21 sites (Table 1) varied from one to seven. Most of the species present in the wetland sites are common species of the western United States. The *Carex* species collected can be separated, phytogeographically, into two groups: western cordilleran species (*Carex nigricans*, *C. illota*) and circumboreal species (*C. rostrata*, *C. aquatilis*, and *C. canescens*).

One of the striking features of these wetlands is the dominance by plants that are capable of extensive spread by rhizomes. The mosaic structure (Fig. 1) of these communities is a function of the strongly rhizomatous nature of the dominant plants and some, perhaps most, of the "patches" seen represent single plants (genets, Harper 1977) formed by growth from a single propagule. The patterns seen in these wetlands are probably dependent on both the history of propagule arrival and on variations in environmental conditions affecting the success of particular species. A complicating factor results from the "inertia" of these sites—a resistance to vegetational change resulting from both the harsh nature of the climate and the vigorous mode of wetland plant growth. Both these factors could make established vegetation patterns difficult to disrupt. Although seedling establishment is common in some wetlands (Lieffers and Shay 1982), both Costello (1936) and Bernard (1975) noted that seedling establishment was rare in some *Carex* wetlands. Our sites included areas where the dominant was in very poor condition (e.g., HF-2) or had died off completely, leaving areas of bare ground (e.g., part of TL). Both biotic and abiotic factors at these sites may change with time. These changes will sometimes be to the detriment of the species that has been dominant. But, because of the difficulty in establishing additional species, the dominant may continue to exist in a depauperate condition and may even die back completely before another species is able to invade the area. Thus, the species present today may not reflect present conditions but may represent conditions of an earlier time.

One environmental variable that we found associated with community structure is water level. In TL and FT the *Carex illota* section was always upland relative to the *Carex aquatilis-Eleocharis pauciflora* sections. In SC the part of the plot containing *Scirpus cespitosus* was on higher ground than those regions containing *C. aquatilis* and *Eleocharis pauciflora*. Some species distributions could not be associated consistently with water level. *Carex aquatilis* could be found in areas with both more and less standing water than the often adjacent *E. pauciflora* areas (areas TL, FT). *Carex illota*, although usually restricted to areas with no standing water (FT-4, TL-2), sometimes was found in areas 5 cm deep in running water (SC-4).

It is generally thought that the influence of water level in wetland regions is based on variations in waterlogging and aeration. Soil aeration may influence plants either by affecting root respiration (Mendelssohn et al. 1981), which could affect water and nutrient flow through roots, or by affecting soil nutrient status. The influence on soil nutrition can occur directly, by influencing the chemical forms available and their solubilities (Jones 1971, 1972), or indirectly, by affecting soil microbial activity.

The importance of aeration on species distribution is represented in our observations on *Carex illota*, which is intolerant of waterlogged soils if the water is stagnant (and presumably poorly aerated), yet grows quite well under 5 cm of water when it is flowing over the site (and probably better aerated). Further evidence for the importance of aeration in these sites is shown in standing crop data presented below. If aeration does influence the structure of these communities, the complex nature of some of these subalpine sites could be due to underground water flow patterns and resultant aeration patterns. These flow patterns may be due to

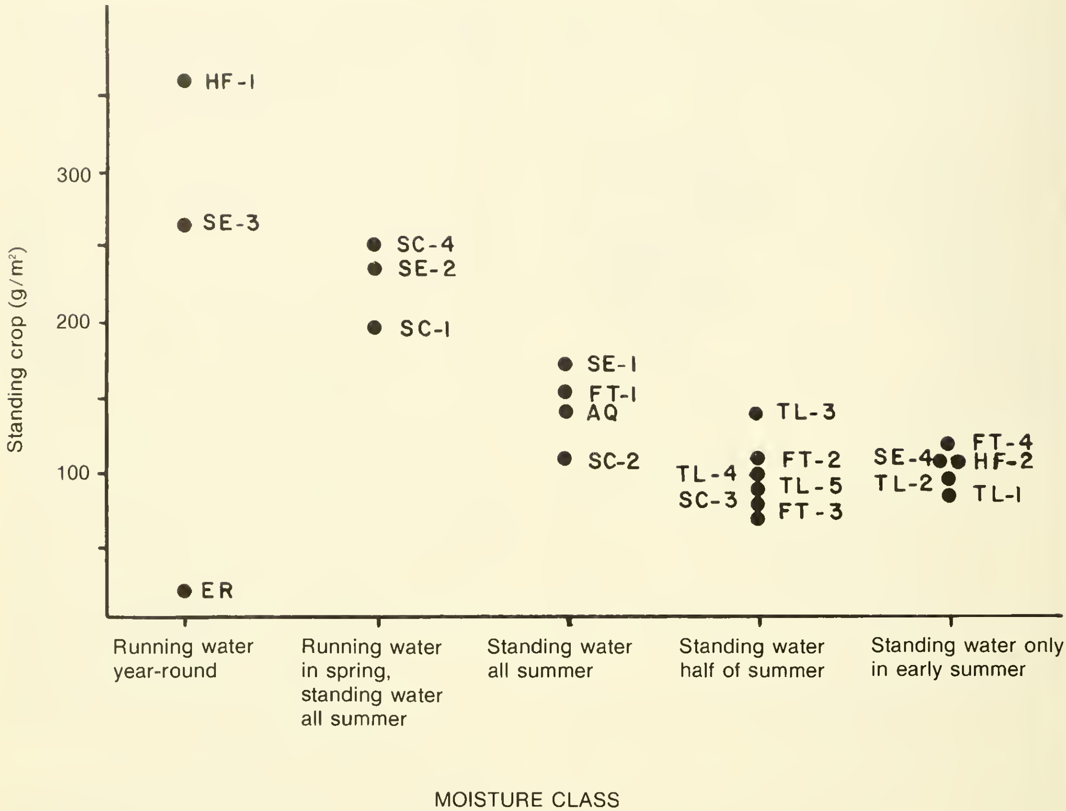

Fig. 2. Graph showing the relationship between standing crop on a site and a measure of water movement over that site.

springs and may not be readily discernable without measurement of soil conditions.

The peak aboveground standing crop values (Table 1) varied considerably, both between areas and also between adjacent sites in one area (e.g., area SC). The very low standing crop value for site ER was undoubtedly due to the short growing season and low temperatures associated with this, the highest site. However, aside from site ER, there is very little relationship between elevation and peak aboveground standing crop. Gorham (1974) derived a regression equation relating standing crop of *Carex* meadows to the highest monthly mean temperature of the year. His data on 11 pure *Carex* stands (on both rich and poor soils) fit the regression line well ($r = 0.84$). The data of Auclair et al. (1976) on wetland stands that were not pure *Carex* also fit this regression. Using weather data for areas in Colorado that are comparable to ours, Gorham's equation predicts a standing crop of 292 g/m^2 for a site at 3,109 m (10,200 ft) and 235 g/m^2 for a site at an elevation of 3,566 m (11,200 ft). The standing crop values that we found are both above and below these values, with most sites below. Gorham's equation is most appropriate for those sites where water is not stagnant (HF-1, SE-2, SE-3, SC-4). The sites with less water movement have less standing crop than predicted by Gorham. The reduced growth on sites where water stagnates is shown in Figure 2, where standing crop is plotted against a gradient in the amount of water movement through the site. Reduced growth on the stagnant sites is probably due to low oxygen levels that may be disturbing root respiration, mineral uptake, or soil nutrient status.

An oxygen-limited situation in *Carex* meadows might explain the timing of nutrient uptake in wetlands. Boyd (1970) and Bernard and Solsky (1977) note considerable

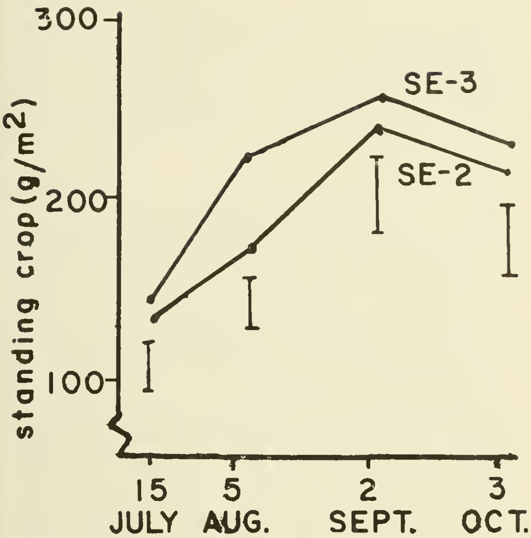

Fig. 3. Seasonal trends in aboveground standing crop for two of the pure *Carex aquatilis* sites, SE-2 and SE-3.

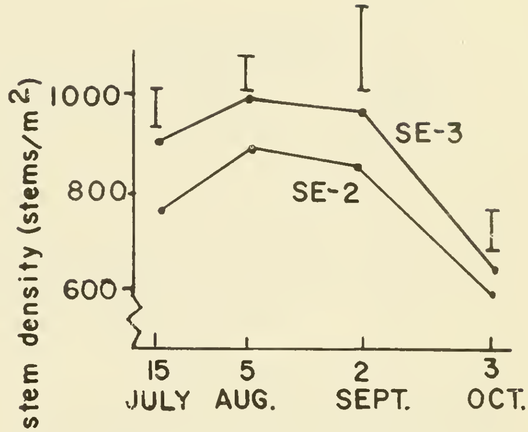

Fig. 4. Seasonal trends in stem density (stems/m^2) for *Carex aquatilis* on SE-2 and SE-3.

mineral uptake by wetland plants in the early spring. Boyd hypothesized that this early mineral uptake (preceding the growth period) was an adaptation to allow certain species to procure nutrients before other species. Another possible reason for mineral uptake early in the spring could be related to oxygen concentrations. In the early spring, oxygen in wetland soils may be at its highest levels because of well-oxygenated runoff waters and because low temperatures increase the amount of oxygen that water can hold. Thus, plants may take up nutrients in the early spring because that is the most favorable time for root respiration.

In several of the *Carex aquatilis*-dominated sites, we observed the variation in standing crop during the summer. The typical pattern in these subalpine meadows (Fig. 3) includes a single peak in aboveground standing crop which occurs in late summer. Gorham and Somers (1973) and Bernard and MacDonald (1974) also found such a pattern for wetlands composed of *C. aquatilis* and *C. lacustris*, respectively. On our sites there was relatively little new shoot production over the course of the summer (Fig. 4), and the changes in aboveground standing crop were being caused by the growth of individual shoots. Some *Carex* species (e.g., *C. rostrata*) have biannual periods of shoot production and these may be responsible for bimodal patterns in biomass (Gorham and Somers 1973), although other factors may cause bimodal patterns. The pattern in shoot production that we observed for *C. aquatilis* had been found previously for this species (Gorham and Somers 1973), as well as for *C. lacustris* (Bernard and MacDonald 1974), and would be expected in regions with short growing seasons such as the one we studied.

Based on our observations, the life history of *C. aquatilis* is initiated by growth of a new shoot sometime during the winter or spring. The shoots grow throughout the summer and then overwinter. The following spring the old shoots are distinguishable from shoots of the current year by their large size and old leaves. One or two of these old leaves may undergo additional growth in the spring. At least some and possibly all of the shoots undergo two or possibly more seasons of growth before they flower or die. Many shoots may not flower. Floral initiation is evident very early in the spring; floral parts are visible less than two weeks after growth initiation. During the growing season leaves are initiated, grow quickly to a maximum length, and remain green until early September.

There was considerable variation in plant density in the *C. aquatilis* stands. On the stagnant sites (those where water was not flowing), the variation in density was related to stem weight. If a plot is made of the natural logarithm of plant density vs. the natural logarithm of plant weight (Fig. 5), it can be seen that the stagnant sites fall on a line

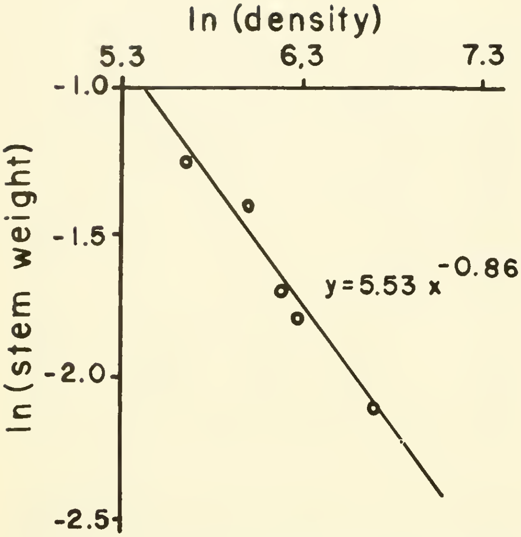

Fig. 5. Graph showing the relationship between stem density and average stem weight for five *Carex aquatilis* stands where water was stagnant.

(r^2 = 0.98). Sites with flowing water do not fall on this line and have substantially greater plant weights at a particular density than those on stagnant sites. The regression line of Figure 5 describes the following equation:

[1] $$w = 5.53\rho^{-0.86}$$

where w = individual plant weight; ρ = plant density

The form of this equation is characteristic of monotypic stands and an exponential value of -3/2 has been found for a wide variety of species of differing life forms and habitats (Gorham 1979, White 1981). The equation has been labeled the "3/2's thinning law" because it describes the changes in density and plant weight that occur in stands during self-thinning. On our plots it is likely that the pattern of density and plant weight is not being caused by mortality (thinning) but rather by recruitment (see Fig. 4). Gorham (1979) cites studies with uncrowded conditions, and therefore little self-thinning, where the exponent value in equation (1) is closer to -1. Our stagnant sites appear to be similar areas. With an exponent of -1, standing crop ($w \circ \rho$) remains constant regardless of density. Such sites may represent areas where standing crop is limited by factors (such as fertility?) that prevent densities to reach levels where self-thinning in the typical 3/2's fashion can occur. The precise factors that dictate the 3/2's thinning law are still not elucidated (White 1981). Perhaps studies on such areas as these, where the "law" does not hold, may help to clear up the problem.

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UTAH FLORA: SALICACEAE

Sherel Goodrich[1]

Abstract.— A revision of the willow family, Salicaceae, is presented for the state of Utah. Included are 31 species and 5 subspecific taxa of indigenous and introduced plants. Keys to genera and species are provided, along with detailed descriptions, distributional data, and comments. No new taxa or combinations are proposed.

This paper is another in a series of works leading to a definitive treatment of the flora of Utah. The willow family as represented in Utah is rather small when compared to several other families, but its taxa cover the state, and it is complex. Herbarium specimens are frequently misidentified. Unisexual plants, extreme variation in leaves of fertile and vegetative or short and long twigs, and early deciduous flowers all contribute to the difficulty in identification of taxa. Hybridization especially in *Populus* further complicates identification.

Several members of the family are cultivated for ornamental plants or shade trees. Not all of these are included in this treatment. Among those not treated are *Populus candicans* Ait. (Balm of Gilead), *P. simonii* Carr., and *Salix viminalis* L. (Golden Osier).

Members of the family are important to many kinds of wildlife. For example, in Utah, beaver are almost totally dependent on the family. They utilize aspen, cottonwoods, and willows and avoid most other woody plants. Among the very few exceptions are probably *Alnus* and *Betula*.

The arabic numerals following the discussion of each taxon indicate the number of specimens examined in the preparation of this treatment. The roman numerals indicate the number of specimens collected by me.

Acknowledgments

Appreciation is expressed to Dr. Arthur Cronquist for permitting me to preview his *Salix* manuscript of the intermountain flora. Appreciation is also expressed to the directors and curators of the following herbaria of Utah: Brigham Young University, Provo; Forest Service Herbarium, Ogden; Garret Herbarium, University of Utah, Salt Lake City; Intermountain Herbarium, Utah State University, Logan. I appreciate the loan of specimens from each of these herbaria. These specimens are the basis of this work.

Salicaceae Mirbel.

Willow Family

Dioecious dwarf shrubs to large trees; leaves alternate, simple, entire, serrate, crenate, rarely lobed, usually stipulate, but the stipules often readily deciduous; flowers borne in aments (catkins), without a perianth, each subtended by a small, scalelike bract (commonly referred to as a scale); staminate flowers of (1)2–many stamens; pistillate flowers of a single pistil with 2–4 carpels and as many stigmas; placentation parietal or basal; fruit a sessile or stipitate capsule with 2–4 valves; seeds numerous, small, covered with long white hairs, dispersed easily by wind.

1. Trees with pendulous aments; leaf buds covered by several, usually resinous scales; each flower subtended by a cup-shaped disk, without obvious glands; stamens 6 to many; scalelike bracts subtending the flowers laciniate or fimbriate (except in *P. alba*), otherwise glabrous or ciliate .... *Populus*

[1]Forest Service, U. S. Department of Agriculture, Intermountain Forest and Range Experiment Station, Ogden, Utah 84401, stationed in Provo, Utah, at the Shrub Sciences Laboratory.

— Trees, shrubs, or dwarf shrubs with mostly ascending to erect aments; leaf buds covered by a single nonresinous scale; each flower subtended by 1 or 2 basal glands, but without a disk; stamens (1)2–8, rarely more; scalelike bracts subtending the flowers entire or occasionally shallowly toothed, usually densely pubescent .... *Salix*

POPULUS L.

Small to large trees; leaf buds covered by several overlapping scales, resinous in most taxa; aments pendulous, mostly appearing before the leaves, and often soon deciduous, the scalelike bracts very quickly deciduous, deeply lobed to laciniate, often dilated (entire or nearly so and not dilated in *P. alba)*; each flower subtended by a cuplike disk; stamens 6–60 or more, the filaments free; inserted on the disk; capsules pedicellate, with 2–4 valves, glabrous in our taxa except in *P. balsamifera*.

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1\. At least some of the mature leaves deeply 3–5 lobed and aceriform, often densely tomentose beneath; bracts of flowers entire or shallowly toothed, long pilose-ciliate; twigs of the season and winter buds often white-woolly; stigma lobes slender; plants introduced, cultivated, and escaping .... *P. alba*

— Leaves not deeply lobed, not aceriform, merely toothed, glabrous or nearly so; scales of flowers deeply lobed to lacerate 2

2(1). Bark white and smooth except blackened and rough where scarred, covered with a whitish powdery bloom; bracts of flowers more or less persistent, deeply lobed or cleft, ciliate with long white hairs; leaves orbicular to reniform-cordate; bud scales shiny but hardy resinous; stamens 6–14; capsules 4–6 mm long, with 2 carpels; stigmas slenderly lobed; plants not confined to water courses .... *P. tremuloides*

— Bark turning gray or brown and roughly furrowed on older trunks; bracts of flowers laciniate-fringed, otherwise glabrous or inconspicuously short hairy; stamens 12–60 or more; capsules mostly longer, with 2–4 carpels; stigmas broadly dilated; plants mostly cultivated or growing along water courses or edges of lakes 3

3(2). Leaves 0.67–1.3 times longer than wide, deltoid to rhombic or ovate; petioles compressed laterally 4

— Leaves (1)1.2–7(10) times longer than wide, ovate to lanceolate; petioles terete or dorsiventrally compressed 6

4(3). Bud scales and twigs of the season pubescent; leaf blades commonly with 4–10(15) fine to coarse teeth on each side; branches widely spreading and the crown often as broad or broader than the tree is tall; plants native, sometimes cultivated, most common along the drainages of the Colorado River system, but sporadic along the Wasatch Front and elsewhere .... *P. fremontii*

— Bud scales and twigs mostly glabrous; leaf blades commonly with 15–25(30) fine teeth on each side; branches ascending to erect and the crown mostly longer than wide; plants introduced, cultivated, sometimes persisting 5

5(4). Leaf blades rhombic-ovate, cuneate at the base, seldom over 7 cm long, capsules 2 valved; branches often comparatively small, strongly ascending to erect and the crown narrow and columnar (in the trees planted in our area) .... *P. nigra*

— Leaf blades more or less deltoid or broadly ovate, broadly cuneate at the base, some regularly over 7 cm long; capsules 2 or more valved; branches large, spreading-ascending, the crown not columnar .... *P. canadensis*

6(3). Leaf blades distinctly darker above than beneath, very strongly resinous especially when young, the petiole terete or nearly so; ovary and young fruit hairy or glabrous; stamens 30–60 .... *P. balsamifera*

— Leaf blades about equally yellow-green on both sides; ovary and young fruit glabrous; stamens mostly 12–30 7

7(6). Leaf blades (1.8) 2.5–6 (9.5) times longer than wide; petioles 1/5–1/3 (2/5) as long as the blades, dorsiventrally compressed; carpels 2 .... *P. angustifolia*

— Leaf blades 1–2.4 times as long as wide; petioles 1/5–3/4 as long as the blades, subterete or somewhat flattened; carpels 2 or 3; plants hybrids, intergrading into *P. angustifolia* on one hand and into *P. fremontii* and other broad-leaved poplars on the other .... *P. acuminata*

Populus acuminata **Rydb.** Lanceleaf cottonwood. A series of hybrids between *P. angustifolia* and *P. fremontii* and other taxa with broad leaves, with features intermediate between the parents and intergrading into *P. angustifolia* on one hand and into the broad-leaved parent on the other; petioles commonly (1.5) 2.5–5.5 (6.5) cm long, 1/5–3/4 as long as the blade; leaf blades 1–2.4 times longer than wide. Along streams and rivers, edges of ponds and lakes, often in mouths of canyons where the parental types come together, probably cultivated, from (1370) 1525–1920 m, in Box Elder, Cache, Duchesne, Emery, Garfield, Iron, Kane, Salt Lake, San Juan, Sevier, Uintah, Utah, Wasatch, Washington, Wayne counties; throughout the range of *P. angustifolia*. The name *P. acuminata* in the strict sense is applied to crosses of *P. angustifolia* and *P. deltoides* Marsh. var. *occidentalis* Rydb. It is used here in a broad sense to include crosses with other broad-leaved taxa, including *P. balsamifera* and *P. fremontii*; 29(0).

Populus alba **L.** White poplar. Trees spreading by root sprouts, to about 30 m tall, the trunk to 1 m or more in diameter, the branches usually spreading, the crown more or less rounded; bark gray-green to whitish and smooth on upper parts of the trunk and branches, rough and furrowed and turning blackish on lower parts of old trunks; twigs tomentose or glabrous; buds tomentose; petioles terete 1–5 cm long, 0.2–0.6 times as long as the blade; leaf blades longer than wide, deltoid-ovate in outline, undulate toothed to deeply palmately 3–5 lobed and aceriform, the lobes serrate or crenate, the two primary lateral lobes sometimes hastately lobed, dark green above, silvery white-tomentose beneath or glabrous; aments appearing before or with the leaves, the rachis pilose-tomentose, the bracts entire to toothed, not laciniate, ciliate-fringed with long-pilose hairs, very quickly deciduous; staminate aments 8 cm long or more, the flowers with 6–10 stamens; pistillate aments 4–9 cm long; capsules 2–5 mm long, glabrous, 2–3 valved, the pedicels about 1(2) mm long; stigmas 2, each 2 lobed, the lobes linear, not dilated. Introduced from Eurasia, cultivated, escaping, and more or less naturalized, in populated areas, along fencelines, ditchbanks, and abandoned homesteads and fields, up to about 1980 m, to be expected in all counties of the state. Trees with leaves densely white-tomentose beneath are referable to **var. *alba*.** Those with leaves and twigs glabrous or glabrate and fastigiate crowns are referable to **var. *bolleana* Lauche.** These may be hybrids between *P. alba* and some other species; 21 (ii).

Populus angustifolia **James** Narrowleaf cottonwood. Trees about 7–15(20) m tall, the trunk 30–60(80) cm in diameter, the branches erect-ascending, the crown more or less pyramidal; bark pale green to whitish when young, furrowed and grayish on old trunks, twigs glabrous or pubescent; buds ovoid-conic, pointed, strongly resinous, reddish brown, glabrous or pubescent; petioles semiterete or horizontally flattened and channeled above, especially near the blade, 3–25 mm long, up to 0.3 (rarely 0.4) times as long as the blade; leaf blades 4–14 cm long, 0.7–2.5 (4.0) cm wide, (1.8) 2.5–6 (9.5) times longer than wide, lanceolate or occasionally narrow elliptical or ovate, glabrous or nearly so, usually acute at the apex, rounded at the base, the margins finely to coarsely serrate; aments often developing with the leaves, the rachis glabrous or nearly so, the bracts broadly obovate, deeply and irregularly lacrate; staminate aments 2–6 cm long, the flowers with 12–20 stamens; pistillate aments 6–10 cm long; capsules 3–6(7) mm long, 2 valved, glabrous, the pedicels about 2–10 mm long; stigmas 2, dilated, irregularly lobed. Along water courses, often in canyons, from about 1525–2135 (2440) m, in all counties of the state. Rather freely crossing with the broad-leaved species of the genus; 79 (i).

Populus balsamifera **L.** Balsam poplar, Black cottonwood. [*P. trichocarpa* T. & G.]. Tree 15–30(50) m tall; the trunk mostly 0.6–1 (1.5) m in diameter, bark furrowed and grayish on older trunks; buds large, the scales very resinous, glabrous or inconspicuously puberulent; petioles more or less terete, 2–6.2 cm long, 1/4–3/4 as long as the blade; leaf blades 4.3–11 cm long, 3.2–8 cm wide, 1.3–2.6 times longer than wide, ovate-accuminate, cuneate to cordate at the base, the margins crenulate, sometimes short ciliate, strongly resinous, glabrous at maturity on both sides, the upper side dark green, the lower side distinctly paler and often rufous tinged in dried specimens; bracts of aments lacerate-fringed, otherwise glabrous or sometimes with minute hairs, these not over 0.5 mm long; staminate aments 2–3(5) cm long, readily deciduous; stamens commonly 30–60; pistillate aments 8–20 cm long; capsules 5–8 mm long, glabrous or pubescent, subsessile; stigmas broadly dilated. Along streams, mostly in canyons and cultivated, 1370–2350 m, in Cache, Juab, Salt Lake, Sevier, Utah, Wasatch, and Wayne counties; widespread in North America from Newfoundland south to New York and west to Alaska (ssp. *balsamifera*), and from Alaska south to Baja California in the western part of the continent (ssp. *trichocarpa*). The native trees of our area are expected to be **ssp. *trichocarpa* (T. & G.) Brayshaw** with mostly pubescent and 3 (rarely 2–4) carpellate capsules. Some of the cultivated trees might be ssp. *balsamifera* with mostly glabrous and 2 (rarely 3–4) carpellate capsules; 9 (0).

Populus x canadensis **Moench.** Carolina poplar, Gray poplar. Cultivated and persisting, rarely escaping, to 40(50) m tall, the trunk 0.75–1.5(2) m in diameter; bark deeply furrowed and grayish on old trunks; buds large, the scales glabrous, but resinous; petioles laterally flattened 3.5–8.5 cm long, 1/3 to as long as the blade; leaf blades mostly 3.5–11.5 cm long, 3.5–11 cm wide, or much larger on stump sprouts, 0.9–1.3 (rarely to 1.5) times as long as wide, deltoid-ovate, acuminate at the apex, mostly broadly cuneate or truncate at the base, the margin crenate-serrate; glabrous and equally green on both sides; staminate aments about 7 cm long; stamens 15–25; pistillate aments unknown. Cultivated for shade trees, probably originated in France as a cross between *P. deltoides* Marsh. and *P. nigra* (Rehder, 1951), to be expected in nearly all counties of the state. *Populus deltoides* might also be expected in the state as an introduced tree from the Plains and eastward, but no specimens were seen that were clearly assignable to that taxon. The original Carolina poplar was *P. deltoides*, but for many years the nursery stock distributed under that name has been *P. x canadensis* (Hitchcock and Cronquist, 1964); 15 (ii).

Populus fremontii **Wats.** Fremont cottonwood. Trees 10–25 m tall with broad rounded crowns, the crown often as broad or broader than the tree is high, the trunk 0.5–1 (1.5) m in diameter; bark smooth and whitish on young trees and on twigs and young branches, deeply furrowed and grayish or brownish on old trunks; petioles (0.8) 3–9.5 cm long, one half to as long as the blade, flattened; rarely with two glands at the summit; leaf blades (2) 4–10 cm long, (15) 4.5–12.5 cm wide, or much larger on sterile sprouts, 0.67–1.2 times as long as wide, deltoid, ovate, rarely nearly rhombic, with truncate, cuneate, or occasionally cordate base, acuminate at the apex, coarsely to finely crenate or serrate with about 8–11 (15) glandular teeth, glabrous, greenish or yellow-green on both sides, turning yellow in autumn; staminate aments 4–10 cm long, the flowers with a broad oblique disk and 50–80 stamens with dark red anthers; pistillate aments 5–15 cm long, the flowers with a cup-shaped disk, this to 5 mm wide in fruit; capsules 7–10 (12) mm long, to 8 mm wide, ovoid to subglobose, 3 to 4 valved, glabrous, the stipes 2–6 (10) mm long; stigmas strongly dilated and irregularly lobed. Along flood plains of rivers and along washes, irrigation ditches, and occasionally cultivated, from 762 to about 1860 m, in Cache, Duchesne, Garfield, Grand, Iron, Kane, Salt Lake, San Juan, Sevier, Tooele, Uintah, Utah, Washington, Wayne, and Weber counties. The Fremont cottonwood is abundant along the Colorado, Green, San Juan, and Virgin rivers and their tributaries within the Colorado Drainage, to be expected anywhere in the state as it has been cultivated for a shade tree. This tree is part of a transcontinental complex, of which *P. arizonica* Sarg., *P. deltoides*, *P. sargentii* Dode, and *P. wislizeni* (Wats.) Sarg. are a part. *Populus arizonica* and *P. wislizeni* have generally been considered closely allied to *P. fremontii* and they have by some authors been included as varieties of or as synonymous with *P. fremontii*. Specimens that have capsules with stipes up to 6 or even 10 mm long are found in Emery County and other points along the Colorado River system. These trees have been referred to as *P. fremontii* var. *wislizeni* Wats. Based on the long stipes, these trees have recently been assigned to *P. deltoides* var. *wislizenii* (Wats.) Eckenwalder (Eckenwalder, 1977). However, these trees are like *P. fremontii* in the lack of glands at the junction of petiole and blade and with few, broad, and coarse teeth on leaf margins. Based on my provincial study, I am not well prepared to make a judgment as to the specific assignment of these trees, but I prefer the traditional approach. If *P. fremontii* is to be kept separate at all from *P. deltoides*, I feel these plants are best kept as a part of *P. fremontii*; 98 (ii).

Populus nigra **L.** Black poplar. Tree to 30 m tall; bark deeply furrowed and grayish on old trunks; bud scales glabrous, resinous; petioles flattened laterally, slender 1–4.5 cm long, 0.4–0.8 times as long as the blade; leaf blades 2.2–6.5 cm long, 1.8–8 cm wide, occasionally larger 0.8–1.2 (rarely 1.4) times as long as wide, very often as wide or wider than long, rhombic ovate, or orbicular, usually strongly accuminate at the apex, cuneate at the base, glabrous, equally green on both sides or a little darker above, the margin crenate-serrate, not ciliate; bracts of aments laciniate; staminate aments 4–6 cm long; stamens 20–30; pistillate aments not seen. Introduced, cultivated for shade and wind breaks, specimens seen from Beaver, Salt Lake, and Utah counties, but to be expected throughout the state. Most of the trees in our area are from a staminate clone with strongly ascending branches that produced a narrow, often nearly cylindrical crown. Trees of this clone have been assigned to **var. *italica* Duroi**, Lombardy poplar; 6 (0).

Populus tremuloides **Michx.** Aspen, quaking aspen, quakey. Colonial tree 10–15 (20) m tall, seldom taller; the trunk seldom over 40 cm in diameter; bark white and smooth, covered with a powdery white bloom, turning black and rough where scarred and at the base of very old trunks; branches usually spreading, the crown usually rounded; bud scales shiny but hardly resinous; petioles laterally flattened, 2–5.5 cm long (1/2) 3/4 to nearly as long as the blade; leaf blades 2–6.5 cm long, 1.8–6.5 cm wide, or much larger on stump sprouts, 3/4–1 1/3 times longer than wide, ovate to reniform-cordate, the margin subentire to serrate or undulate, ciliate, glabrous on the surfaces at maturity; bracts of the aments more or less persistent, especially the staminate ones, 3–7 lobed or cleft, silky-pilose ciliate, the hairs up to 2 mm long; staminate aments 2–4 cm long, readily deciduous; stamens 6–14; pistillate aments 4–12 cm long, to 13 mm wide; capsules 4–6 mm long, the stipes 1–2 mm long, subtended by a cuplike disk about 2 mm across; carpels 2; stigmas 2, each deeply cleft into 2 or more slender lobes. Along water courses and forming clones and aggregates of clones on canyon walls and mountain sides, from (1400) 1830–3050 (3200) m, in all counties of the state; widespread in North America from Labrador to Alaska and south to Tennessee and northern Mexico. Aspen is cultivated as a shade or ornamental tree. In recent years, nursery stock has become readily available from commercial nurseries; 96 (i).

SALIX L.

Depressed, mat-forming dwarf shrubs to large trees; buds covered with one non-resinous scale; aments erect to spreading, rarely drooping, developing before (precocious), with (coetaneous) or after (serotinous) the leaves, the bracts mostly entire, occasionally with a slightly toothed apex; flowers with 1, occasionally 2 minute glands near the base; stamens (1) 2–8 (12), the filaments free or united toward the base, inserted on the base of the bract; capsules sessile or stipitate, glabrous or pubescent.

A large genus of about 300 species, mostly of the Northern Hemisphere, most common in arctic and temperate regions.

Identification of the willows is compounded by unisexual plants, aments that are sometimes precocious and mostly early deciduous, and variation among the usually smaller leaves of the flowering branches which often lack or have inconspicuous stipules and the usually much larger leaves and stipules of vegetative branches and particularly of vigorous young shoots. Thus, herbarium specimens of each species present specimens of 3 or 4 phases (pistillate, staminate, flowering twigs with or without the deciduous aments, and vegetative twigs). Vigorous young shoots sometimes add a fifth dimension. At times whole plants in the field present only one or two of the various phases.

To facilitate identification of plants of the different phases, pistillate, staminate, and vegetative features have been included in many of the leads in the key. Thus, some of the leads are rather long, and features not applicable to a particular specimen will need to be skipped. An alternative approach to lengthy leads is separate keys for the different sexual and vegetative phases. Many such keys have been written, but these sometimes also contain a mixing of vegetative and sexual features. To establish an adequate basis for a staminate key, I feel that many more staminate specimens are needed in the herbaria of the state.

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1. Plants shrubs or dwarf shrubs not over 1 (1.5) m tall, subalpine to alpine 2

— Plants shrubs or trees, mostly over 1.5 m tall, of valleys to montane 3

2(1). Plants depressed dwarf shrubs 1–10 (20) cm tall mostly alpine, often forming mats, the stems creeping on or below the ground surface .... **KEY I**

— Plants (10) 20–100 cm tall or taller, subalpine or alpine, not forming mats on the ground, the stems ascending to erect .... **KEY II**

3(1). Leaves (8) 10–20 (32) times longer than wide; plants often strongly colonial, spreading underground and forming patches and occasionally thickets, our most common and widespread lowland willow .... *S. exigua*

— Leaves less than 8 times as long as wide 4

4(3). Bracts persistent, dark brown to blackish or if pale green or pale brown in age then silky pilose with the hairs exceeding the bract by 1–2 mm and the capsules pubescent (rarely glabrous in unusual specimens); stamens 2 per flower, the filaments glabrous or pilose in a few species; plants shrubs or occasionally treelike, mostly native .... KEY III

— Bracts of at least the pistillate aments quickly deciduous, pale green or yellowish tan in age, short pubescent, the hairs hardly if at all exceeding the bract by more than 1 mm; capsules glabrous; stamens more than 2 per flower, or if only 2 then plants introduced trees, the filaments pilose; plants mostly trees or treelike except in S. *lasiandra,* mostly of valleys and lower montane 5

5(4). Plants native; stamens 3–9 per flower; stipes of capsules mostly 1–2 mm long, obviously longer than the gland .... KEY IV

— Plants introduced trees; stamens 2 except in S. *pentandra;* capsules sessile or the stipes mostly less than 1 mm long and hardly longer than the gland .... KEY V

KEY I.

Depressed, mat-forming dwarf shrubs, 1–10 (20) cm tall, at or above timberline

1. Bracts of aments pale green or yellowish, glabrous dorsally; filaments 1.5–2 mm long; style obsolete or to 0.2 mm long, shorter than the stigma; leaves elliptic to orbicular, 1.4–2.6 times longer than wide, glaucous and strongly reticulate-veined beneath, the tips mostly rounded or obtuse ..... S. *reticulata*

— Bracts of aments blackish, pilose dorsally; filaments over 2 mm long; styles 0.5 mm long or longer, longer than the stigmas; leaves elliptic or narrow elliptic, (1.25)2.3–4.7 times longer than wide, glaucous or not, not strongly reticulate veined beneath, the tips mostly pointed 2

2(1). Leaves 2–5 (7) mm wide, 2–4.7 times longer than wide, sessile or the petiole to 3 mm long; plants seldom over 3 cm tall, aments 0.5–2.2 cm long .... S. *cascadensis*

— Leaves 5–20 mm wide, mostly 2–3 times longer than wide, with petiole 3–13 mm long; plants mostly 5–10 (20) cm tall; aments (1) 2–4 cm long ...... S. *arctica*

KEY II.

Low shrubs (10) 20–100 (300) cm tall, mat forming, subalpine or alpine

1. Capsules glabrous, the style and stigma together less than 1 mm long; leaves permanently pubescent on both sides, the lower surface not glaucous but often more densely pubescent and thus lighter than the upper surface; twigs of the season glabrous or thinly villous-puberulent .... S. *wolfii*

— Capsules pubescent at least until mature or style and stigma together over 1 mm long; leaves often glaucous beneath, glabrous or pubescent 2

2(1). Mature leaves glabrous, dark green and shiny above, strongly glaucous and glabrous or with a few hairs beneath; twigs of the season glabrous or very scattered pubescent, dark chestnut to lustrous purplish black; aments precocious or coetaneous, sessile or nearly so or rarely on a stalk to 0.5(1) cm long, this neither bearing nor subtended by bractlike leaves; style and stigmas collectively 1.5 mm long or longer; filaments of stamens glabrous .... S. *planifolia*

— Mature leaves pubescent on both sides, but sometimes glabrate or glabrous in age; twigs of the current season densely pubescent; aments coetaneous or subserotinous, born on stalks to 2 (4) cm long, these usually bearing and subtended by bractlike leaves; style and stigmas collectively up to 1.5 mm long; filaments of stamens sometimes pilose 3

3(2). Bracts of aments pale green when young, tan in age; capsules 3–5 mm long, pubescent even in age, crowded and nearly sessile so as to mostly conceal the rachis at the center of the aments, the stipes seldom over 0.5 mm long; pistillate aments 0.8–2 (2.5) cm long, 8–10 mm wide; staminate aments about 0.8–1 (1.2) cm long, 5–6 mm wide, the filaments densely pilose at the base and for 1/2 to 3/4 their length, the pilose portion often equaling or exceeding the scale, the anthers usually less than 0.5 mm long; petioles 1–4 mm long, seldom exceeding the bud even on vegetative twigs .... S. *brachycarpa*

— Bracts of aments brown to blackish, sometimes light brown to whitish tan but not green even when young; capsules (4) 5–7 (8) mm long, sometimes glabrate in age, dense but often not so crowded as to conceal the rachis at the center of the ament, the stipes 0.5–2 mm long; pistillate aments (1.8) 2.5–5 cm long, 11–15 mm wide; staminate aments 0.8–2(4) cm long, sometimes over 6 mm wide, the filaments glabrous or pilose but usually not so conspicuously pilose as above, the anthers mostly over 0.5 mm long; petioles (1) 2–6 (10) mm long, equaling or often exceeding the bud, especially on vegetative twigs .... S. *glauca*

KEY III.

Mostly native shrubs or small trees; aments mostly with dark bracts; stamens 2; capsules glabrous or pubescent

1. Capsules glabrous; leaves not both glaucous and pubescent on the lower surface when fully expanded; hairs of aments mostly crisped-villous and more or less tangled except in S. *wolfii* with aments 0.8–2(3) cm long or in S. *planifolia* and then plants keyed both ways 2

— Capsules mostly pubescent except in S. *lasiolepis*; leaves glaucous and pubescent on the lower surface when fully expanded; hairs of aments straight or slightly wavy but hardly crisped-villous or tangled; aments sometimes longer than in S. *wolfii* 6

2(1). Leaves glaucous beneath, not or scarcely pubescent when fully expanded 3

— Leaves not glaucous beneath, although sometimes lighter colored from pubescence; pubescent at least in part on both sides when fully expanded, but sometimes glabrate in age 5

3(2). Aments sessile or on a stalk, the stalk to 0.5(1) cm long neither bearing nor subtended by bractlike leaves; pubescence of aments straight or nearly so; leaves mostly entire, often slightly revolute; twigs dark chestnut to lustrous purplish black, essentially glabrous; plants often less than 1.5 m tall and keyed also in Key II .... S. *planifolia*

— Aments usually stalked, the stalk usually subtended by or bearing 1–4 bractlike leaves; pubescence of aments crisped-villous; leaves serrate, serrulate, or entire, not at all revolute; twigs variously colored, glabrous or those of the current season more often pubescent; plants often over 1.5 m tall 4

4(3). Styles 0.7–1.5(1.8) mm long; leaves of fertile and vegetative twigs often less than 3 times longer than wide, evidently crenulate-serrate or subentire; bark of older twigs not ashy gray or whitish; plants apparently uncommon, in the eastern and central part of the state, mostly montane .... S. *monticola*

— Styles 0.2–0.7 mm long; leaves of vegetative twigs 2–5 times longer than wide, serrulate or entire; bark of older twigs usually ashy gray or white; plants widespread, mostly of valleys and lower montane .... S. *lutea*

5(2). Aments precocious or coetaneous (1.5) 2–5 cm long, with dense crisped-villous, tangled hairs; leaves subglabrate in age, with inconspicuous hairs, entire or sometimes serrulate; plants sometimes over 2 m tall .... *S. boothii*

— Aments coetaneous, 0.8–1.5 (3) cm long, with hairs straight or nearly so; leaves permanently pubescent throughout on both sides even in age, the hairs readily conspicuous with a 10-power lens, entire; plants 0.6–1.5(2)m tall, also keyed in Key II .... *S. wolfii*

6(1). Twigs strongly blue glaucous, the bloom sometimes deciduous, but then the twigs glabrous or sometimes puberulent; larger leaves mostly 3–5 times longer than wide, sericeous beneath; capsules densely pubescent 7

— Twigs not glaucous or those of the current season often pubescent, or leaves not sericeous; the larger leaves various but sometimes wider than above; capsules pubescent or glabrous 8

7(6). Pistillate aments 2–5 cm long; capsules sessile or the stipes to 1 mm long, the style and stigmas together 0.8–1.3 mm long; staminate aments about 2 cm long, the filaments glabrous; aments sessile or nearly so with or more often without subtending bractlike leaves, precocious or subcoetaneous; bracts of the aments blackish; leaves permanently silvery, silky-sericeous to subtomentose beneath, dark green and glabrous above in age .... *S. drummondiana*

— Pistillate aments 1–2 cm long; capsules stipitate, the stipes 2–3 mm long, the style and stigmas together about 0.5 mm long; staminate aments 8–15 mm long, the filaments pilose on the lower 1/2; aments borne on 2–10 mm long, bracteate-leafy stalks; coetaneous or subprecocious; bracts of the aments dark at the tip and pale below; leaves sericeous when unfolding, sparsely or moderately sericeous, especially beneath when fully expanded, glabrate in age especially above .... *S. geyeriana*

8(6). Plants shrubs 0.6–3 m tall, midmontane to above timberline, the stems less than 4 cm thick; leaves mostly less than 2 cm wide, occasionally wider on vegetative twigs, elliptic to narrowly lanceolate .... **KEY II**

— Plants shrubs or small trees, commonly 3–4 m tall or taller, but sometimes shorter, of valleys or montane, the stems of mature plants often 4–10 cm thick or thicker; leaves sometimes over 2 cm wide, oblong, obovate, oblanceolate, or elliptic 9

9(8). Capsules glabrous; filaments about 3–5 mm long, bracts of aments blackish or purplish black, about as wide as long and rounded at the apex, densely pilose-tomentose, the hairs exceeding the bracts by about 1 mm; leaves oblong to oblanceolate, less than 15 mm wide except on vigorous young shoots; plants of Great Basin and Virgin River drainages .... *S. lasiolepis*

— Capsules pubescent; filaments longer or bracts not as dark; bracts of aments of lighter color or if blackish then with hairs exceeding the bracts by about 2 mm, pointed or somewhat rounded; leaves elliptic, obovate, to oblanceolate, sometimes over 15 mm wide; plants of various distribution 10

10(9). Twigs of the second and current year and the dark red bud scales velvety villous; lower surface of leaves densely velvety villous throughout the season, twigs with longitudinal ridges beneath the bark; aments precocious; plants introduced, cultivated .... *S. cinerea L.*

— Twigs of the second year glabrous, those of the current season villous or with appressed hairs; lower surface of leaves villous at first but usually rather scattered-villous to glabrate in age; aments various; plants native 11

11(10). Bracts of aments pale green or tan to very light brown in age, silky pilose, the hairs exceeding the bract by about 1 mm; aments coetaneous; capsules long beaked, loosely arranged so as to expose much of the rachis; filaments of stamens 3–6 mm long; leaves mostly elliptic, occasionally lanceolate or obovate; twigs of the season with mostly appressed or ascending hairs or occasionally glabrous .... *S. bebbiana*

— Bracts of aments black or purplish black, reddish or pale only at the very base, pilose, the hairs exceeding the bract by about 2 mm; pistillate aments precocious, or subprecocious, the capsules not long beaked, densely arranged and mostly concealing the rachis; staminate aments strictly precocious, the filaments about 10 mm long; leaves obovate or oblanceolate; twigs of the season with mostly widely spreading hairs .... *S. scouleriana*

KEY IV.

Plants native, tall shrubs or small trees; bracts of aments pale green or yellow, at least the pistillate ones, deciduous; stamens 3–8(12); capsules glabrous with a 1–2 mm long stipe

1. Bracts of aments 3–4 mm long; bud scales fused, without free overlapping margins, blunt to rounded at the tip; staminate aments 2–3.5 times longer than wide, 1–3.5 cm long; styles 0.5–1 mm long; petioles of larger leaves often with wartlike glands near the base of the blade; plants mostly multistemmed, large shrubs from large root crowns, rarely trees, widespread in the northern half of the state .... *S. lasiandra*

— Bracts of aments 1–2 mm long; bud scales with free overlapping margins, usually pointed at the tip; staminate aments often narrower and longer than above; styles 0.1–0.2 mm long; petioles without wartlike glands or occasionally with glands in *S. nigra*; plants mostly trees with solitary or few trunks, of various distribution 2

2(1). Leaf blades not glaucous beneath, (2.5)4–7 times longer than wide; twigs whitish or grayish yellow; plants of the southern half of the state .... *S. nigra*

— Leaf blades glaucous beneath 3

3(2). Twigs reddish or reddish brown, often pubescent at least near the nodes, horizontal or spreading; some of the leaf blades usually 4–5 times longer than wide, shiny dark green above; plants of San Juan and Washington counties .... *S. laevigata*

— Twigs ashy gray or yellowish when fresh, glabrous, tending to droop; leaf blades usually not over 3 times longer than wide, not shiny dark green above; plants widespread in the state, mostly north of the counties listed above .... *S. amygdalioides*

KEY V.

Plants small or rather large trees, introduced, cultivated, sometimes escaping and persisting; bracts of aments pale green or yellowish, at least the pistillate ones deciduous; capsules glabrous, sessile or nearly so

(Note: The cultivated species of this key, except *S. fragilis*, are not described due to lack of adequate specimens in herbaria.)

1. Stamens 3–12; leaves with wartlike glands on upper part of petiole and lower margins of blade, the blade seldom over 3 times longer than wide, usually glabrous except above along the midrib, lighter beneath than above but not glaucous (bay willow) .... *S. pentandra* L.

— Stamens 2; leaf blades 3–5 times longer than wide, usually glaucous beneath, glabrous or variously pubescent 2

2(1). Pistillate aments 1–2.5 (3) cm long, the capsules 1–2.5 mm long; staminate aments to 4 cm long; petioles glandless; trees weeping, with very slender, greatly elongate, pendulous branches, or if not weeping then the twigs more or less contorted 3

— Pistillate aments mostly over 3 cm long, the capsules 3–6 mm long; petioles sometimes with small glands near the base of the blade; trees not weeping, with upright branches; twigs spreading, not contorted 5

3(2). Trees not weeping; twigs not pendulous, more or less contorted, aments 1–1.5 cm long; (all specimens seen from the state were referrable to f. *tortuosa* Rehd. with the branches twisted and contorted — corkscrew willow) .... *S. matsudana Koidz.*

— Trees weeping; twigs pendulous, very straight; aments sometimes longer than above 4

4(3). Leaves mostly 3–15 mm wide, mostly deciduous in October; twigs often bright yellow; capsules sessile (weeping willow) .... *S. babylonica L.*

— Leaves 15–22 mm wide, often persisting into December; twigs greenish or yellow-green; capsules with stipe exceeding the gland; plants hybrids of *S. babylonica* x *S. fragilis* (Niobe or Wisconsin weeping willow) .... *S. x blanda* Anderss.

5(2). Leaves glabrous when unfolded, the margin of mature leaves usually serrate with 4–8 teeth per cm; twigs glabrous, or nearly so; stipe of capsules 0.5–0.8(1) mm long; plants common, cultivated, and escaping .... *S. fragilis*

— Leaves sericeous, or glabrous when unfolded, the margin of mature leaves finely serrulate with 9–10 teeth per cm; twigs sometimes pubescent; capsules sessile or subsessile; plants not known outside of cultivation (white willow) *S. alba L.*

Salix amygdaloides **Anderss.** Peach-leaf willow. Plants mostly small trees, rarely shrublike, mostly 4–10 (12) m tall, often with 2–4 leaning trunks; twigs whitish, yellowish, or ashy gray, rarely reddish, glabrous except when very young; stipules usually minute and soon deciduous; petioles (3) 5–15 (25) mm long; leaf blades, (1.8) 2.3–6 (7.5) cm long, (7) 12–19 (23) mm wide, or up to 10.5 cm and 3.2 cm wide on vigorous young shoots, elliptical to lanceolate, entire or serrulate, glabrous except when very young, glaucous beneath, green above; aments coetaneous, rarely subprecocious, on leafy or bracteate twigs of the season, 1.5–4 cm long; bracts of the aments 1–2 mm long, at least the pistillate ones soon deciduous, pale green, orbicular, the dorsal side woolly-pilose below and along the margins, but mostly glabrous toward the apex, the ventral surface woolly-villous throughout, the hairs seldom exceeding the bract by more than 0.5 mm; staminate aments 2–10 cm long, 7–11 mm wide; stamens 4–7, the filaments pilose on the lower half; pistillate aments (1.5) 2.5–8 cm long, 13–20 mm wide; capsules 4–7 mm long, glabrous, the stipe 1.2–3 mm long, the style about 0.2 mm long, not longer than the stigmas. Lake and pond margins and along ditches, streams, and rivers, and in neglected fields and pastures, from about 1070–1710 m in Box Elder, Davis, Duchesne, Emery, Juab, Salt Lake, Tooele, Uintah, Utah, and Washington counties; southern Canada and widespread in the United States except the southern part; 63 (vi).

Salix arctica **Pall.** Arctic willow. [*S. anglorum* Cham. var. *antiplasta* Schneid.]. Depressed shrubs with stems creeping on or under the ground, seldom rising more than 10 (20) cm above ground level, tending to form mats, but not so much as in *S. cascadensis* or *S. reticulata*; stipules minute or lacking; petioles 2–12 mm long; leaf blades (5) 11–47 mm long, (4) 6–16 mm wide, elliptical, narrow elliptical, obovate, or oblanceolate, entire, slightly paler beneath than above but not strongly glaucous; pilose-sericeous when young, sparingly pubescent or glabrous when mature; aments coetaneous, borne on glabrous or pubescent 7–35 mm long leafy-bracteate or barren twigs of the season; bracts of the aments persistent, dark brown, pinkish purple at the base, pilose-sericeus on both sides, sometimes less so dorsally than ventrally, the hairs exceeding the bract by about 1 mm; staminate aments 15–25 mm long, about 7–9 mm wide; stamens 2, the filaments glabrous, to about 7 mm long; pistillate aments 1.5–7 cm long, about 10–12 mm wide, with 25–75 fruits; capsules 4–7 mm long, pubescent, the stipe about 1 mm long, the style and stigmas together about 1–2 mm long. About snowbanks, meadows, shores of lakes, and rocky slopes near or a little above timberline, 2775–3600 m on the Bear River (Mt. Naomi), Tushar (Delano Peak), western Uinta, and the Wasatch mountains in Cache, Piute, Salt Lake, Summit, and Utah counties; circumboreal and south in mountains of western North America to California and New Mexico. Our plants are **var. *petraea* Anderss.** They more or less intergrade into S. *cascadensis* in the Uinta Mountains; 14 (0).

***Salix bebbiana* Sarg.** Bebb willow. Plants shrubs, occasionally treelike, (2) 4–6 (8) m tall, with 1 to several stems, young twigs glabrous, puberulent or densely pubescent; stipules usually inconspicuous and soon deciduous; petioles (2) 3–8 (10) mm long, reddish or pale; leaf blades 1–4 cm long, 1.2–2 cm wide or to 7 cm long and 3 cm wide on vigorous young shoots, 2.2–2.8 times longer than wide, mostly elliptical, occasionally obovate or oblanceolate, entire to slightly undulate-crenate, dark green above, glaucous beneath, pubescent when young on both sides; fully expanded leaves glabrous above, usually with a few hairs beneath near the midrib; aments coetaneous, on a bracteate 3–15 mm long peduncle; bracts of the aments persistent, pale green to very light brown in age, sometimes reddish at the apex, particularly in staminate aments, silky pubescent, the hairs exceeding the bract by about 1 mm; staminate aments 1.5–2 cm long, to 13 mm wide; stamens 2, the filaments 3–6 mm long, glabrous or sparingly pilose at the base; pistillate aments 1.5–4(5) cm long, to 2 cm wide; capsules 6–8(10) mm long, rostrate with a rounded basal portion 1–2 mm wide and a long slender beak, pubescent, rather loosely arranged and not concealing the rachis, the stipe 2–3.5 mm long, the style about 0.1–0.2 mm long; stigmas 0.3–0.5 mm long, bilobed to the base. Riparian communities on canyon bottoms and along streams in mountains, occasionally along irrigation ditches, from (1370) 1830–2710 m in Box Elder, Cache, Daggett, Davis, Garfield, Grand, Juab, Kane, Rich, Salt Lake, San Juan, Sevier, Summit, Uintah, Utah, Wasatch, Washington, and Wayne counties; across much of Canada and northern United States. Our plants with leaves sparsely appressed pubescent and soon glabrous beneath and rather weakly raised reticulate-veiny are often referred to as var. *perrostrata* (Rydb.) Schneid., but the separation probably merits no recognition. 77(x).

***Salix boothii* Dorn** Booths willow. [S. *pseudocordata* (Anderss.) Rydb., misapplied]. Shrubs (1.5) 2–4 m tall; young twigs finely hairy, stipules small, inconspicuous and soon deciduous or larger and leaflike on vigorous young shoots; petioles mostly 2–5 mm long; leaf blades (0.8) 2.5–6 cm long, (4) 8–22 mm wide, or to 11.2 cm long and 4 cm wide, with petiole to 2 cm long on vigorous shoots, elliptical, lanceolate, occasionally nearly linear, rarely oval, entire or serrulate, not glaucous beneath, sparingly to moderately pubescent at least in part on both sides, or glabrate toward the end of the season, about as pubescent at the apex as at the base, coriaceous in age; aments subprecocious or coetaneous, sessile or on a barren or 1–3 bracteate peduncle to 8 mm long; bracts of the aments persistent, dark brown to purplish black at the apex, often with a lighter base; pubescence of aments sericeus-pilose at first but soon becoming crisped-villous and somewhat entangled, the hairs usually exceeding the bracts by 1–2 mm, sometimes deciduous; staminate aments 1–2.5 cm long; stamens 2, the filaments about 5 mm long, glabrous; pistillate aments (1) 2–4 (6) cm long; capsules 3–6 mm long, glabrous, the stipe 1.5–2 mm long; styles 0.3–1 (1.5) mm long. Riparian and wet meadow communities from about 2075–3050 m, particularly common on the plateaus of central Utah, but from all counties of the state except Millard, Morgan, Rich, Tooele, Washington, Wayne, and Weber and to be expected in some of these; Colorado Rockies west to northern California and north to southern Alberta and British Columbia. Our plants are closely related to S. *myrtillifolia* Anderss. of Alaska and Canada. They vary from those of Alaska and Canada by either taller stature or pubescent leaves or both, and they have longer stipules that are more sharply acute at the apex. They might be treated as a variety of S. *myrtillifolia*, but no new combination is proposed here. Sometimes referred to as S. *pseudocordata*, but this name is synonymous with S. *myrtillifolia* (Dorn 1975). Occasionally grading toward S. *wolfii* in pubescence of leaves and sometimes difficult to distinquish from that species vegetatively. Like S. *lutea* in color and pubescence of scales and rachis of aments, and sometimes confused with that species, but with leaves coriaceous in age and more and persistently pubescent and not glaucous beneath, and generally of higher elevations, but sometimes nearly impossible to distinguish from S. *lutea* in leafless or very young-leaved specimens with precocious aments. However, older twigs of S. *boothii* are not whitish as they often are in S. *lutea*, and specimens with older twigs are more easily distinguished; 139 (xli).

Salix brachycarpa **Nutt.** Barrenground willow, Short-fruited willow. Shrubs (0.25) 0.6–1.5 m tall, rarely taller; twigs below the leaves with epidermis breaking in translucent flakes, twigs of the season dark or reddish under the dense pubescence; stipules inconspicuous, deciduous; petioles 1–4 mm long, usually not longer than the bud, often reddish, the reddish color sometimes extending up the midrib of the blade; leaf blades (0.6) 1.5–4 cm long, (3) 5–18 mm wide, or to 7 cm long and 3 cm wide on sterile branches, 2–4 (5) times longer than wide, elliptical, broadly lanceolate, occasionally nearly linear, entire, thinly to moderately sericeous to nearly glabrous on both sides, strongly glaucous beneath; aments coetaneous or serotinous, nearly sessile or more often on bracteate peduncles at the ends of leafy twigs; bracts of the aments pale green, tan, or light brown in age, rarely pink or pale reddish at apex, scattered to densely pilose on both sides, the hairs exceeding the bract by about 1 mm or less; staminate aments (6) 8–10 (12) mm long, 5–6 mm wide; stamens 2, the filaments 2.5–5 mm long, densely pilose at base and scattered pilose to 1/3 to 3/4 the entire length, the pubescent portion sometimes exceeding the scale, anthers 0.3–0.5 (0.6) mm long, orbicular, yellowish; pistillate aments 8–25 mm long, 3–10 mm wide; capsules 3–5 mm long, densely arranged and mostly concealing the rachis, sessile or on stipes up to 0.5 (1) mm long, sometimes persisting over winter, pubescent, the hairs persistent even on over-wintering capsules, the style 0.5–1 mm long, the stigmas about 0.5 mm long, bilobed to the base. Along streams, in wet meadows, dry rocky and talus slopes, and rocky, open ground in mountains from 2070–3230 m, mostly on ground with basic substrate in Cache, Duchesne, Emery, Grand, Iron, Juab, Kane, Salt Lake, Sanpete, Sevier, Summit, Utah, and Wasatch counties; widespread in Alaska, Canada, and south in western United States from Oregon south and east to Colorado. Our plants are assignable to var. ***brachycarpa*** with bracts greenish at anthesis and subspherical or short cylindrical, densely flowered pistillate aments, leaves coarsely pubescent on both sides and with comparatively tall stature. Closely related to and often confused with S. *glauca*, but distinct in the state by small but numerous features. In addition to the features given in the key, S. *brachycarpa* more or less differs from S. *glauca* in having twigs with more numerous aments, distal leaves of fertile twigs often considerably larger than the 3 or 4 proximal ones, and reddish as well as yellowish petioles with the reddish color sometimes extending up the midrib of the leaf blade. Although most of our plants seem quite distinct, apparently there is widespread introgression with S. *glauca* in the Rocky Mountain Region and particularly southward in Colorado (Argus 1965); see discussion under S. *glauca*; 74 (xviii).

Salix cascadensis **Cockerell.** Cascades willow. Depressed, mat-forming subshrubs, 1–3 cm tall, from tap root and rhizomatously much-branched caudex; petiole lacking or to 3 mm long; leaf blades 6–18 mm long, 1.5–4 mm wide, 2–4.7 times longer than wide, linear or narrow elliptical, entire, pilose-sericeous when young, soon glabrous and green on both sides or slightly paler below, some marcescent for 1 or more years; aments coetaneous, terminal on short leafy lateral branches, these about 8–22 mm long; bracts of the aments persistent, black or purplish black, reddish-purplish at the very base, about 1–2 mm long, 1 mm wide, pilose on both sides, but less so to nearly glabrous at the base ventrally, the hairs about 1 mm long; staminate aments 3–12 mm long, 5–8 mm wide; stamens 2, separate to the base, the filaments about 3–4 mm long, glabrous, the anthers reddish or purplish; pistillate aments 5–22 mm long, 5–11 mm wide; capsules 3–4 mm long, pubescent, sessile or the stipe less than 1 mm long, the style and stigmas together about 1.5 mm long. Alpine tundra on the Uinta Mountains, 3350–3932 m, in Daggett, Duchesne, Summit, and Uintah counties; southwestern British Columbia, east to Montana south through Wyoming to Colorado and Utah; 15 (iv).

Salix drummondiana **Barratt in Hook.** Drummond willow. [S. *subcoerulea* Piper]. Shrubs (1) 2–3(4) m tall; twigs glabrous or puberulent when very young, heavily glaucous, the bloom persisting into the second year, yellow-brown to blackish purple beneath the bloom; stipules narrow, small and deciduous, or larger and more persistent on vigorous young shoots; petioles 4–12 mm long; leaf blades 2.2–8 cm long, (5) 13–20 mm wide, or to 14 cm long and 3 cm wide on vigorous young shoots, lanceolate or narrowly elliptical, rarely oblanceolate, entire, sometimes with slightly revolute margins, dark green and glabrous or thinly pubescent above, densely silvery white pubescence beneath with short appressed or spreading and slighty tangled hairs, pale glaucous beneath the pubescence; aments precocious or sub-coetaneous; bracts of the aments persistent, purplish black or purplish brown, pilose on both sides, the longest hairs exceeding the bract by 1.5–2 mm; staminate aments 19–22 mm long, 3–10 mm wide, sessile or on a peduncle to 3 mm long; stamens 2, the filaments, 4–9 mm long, glabrous; pistillate aments 2–4.5 cm long, 3–12 mm wide; capsules 3–6 mm long, pubescent, sessile or the stipe to 1 mm long, the style 0.5–0.7 mm long, the stigmas 0.3–0.6 mm long. Along streams and rivers, wet meadows, and other wet places from 2135–3140 (3290) m in Beaver, Box Elder, Cache, Daggett, Davis, Duchesne, Emery, Grand, Piute, Salt Lake, Sanpete, Sevier, Summit, Uintah, Utah, and Wasatch counties; British Columbia and Alberta south to California and New Mexico; 84 (xxv).

Salix exigua **Nutt.** Coyote willow, Dusky willow, Narrow-leaf willow. Colonial shrub (1) 2–3 m tall or rarely treelike and to 8 m tall; stems ashy gray, branches often reddish, twigs of the season greenish, pubescent; leaves (1) 2–11 cm long, (0.1) 0.2–1 cm wide, sessile or with 1–3 mm long petiole, or to 17.5 cm long and 1.6 cm wide with petiole up to 12 mm long on vigorous young shoots, linear, entire or serrulate-dentate with glandular teeth, glabrate to densely white sericeous; aments coetaneous or serotinous on slender leafy peduncles or twigs of the season, these 0.5–14 cm long; bracts of the aments about 2 mm long, about 1 mm wide, pale green or yellowish, deciduous, pubescent on both sides but often glabrate or glabrous dorsally especially toward the apex, occasionally only ciliate ventrally; staminate aments 1.5–4.5 cm long, 0.5–1 cm wide; stamens 2, the filaments pilose on the lower half; pistillate aments 1.5–6 cm long, 8–16 mm wide; capsules 4–7 mm long, mostly glabrous, sometimes pubescent, sessile or the stipe up to 0.8 mm long, the style obsolete. Along rivers and streams, irrigation ditches, washes, in neglected fields and pastures, around ponds and reservoirs, tolerant of alkaline soils, from 825–2315 (2590) m in all counties of the state. Our plants are part of a complex that extends from the Atlantic to the Pacific in the northern United States and southern Canada and extends from Alaska to northern Mexico in the western part of North America. Most of our specimens of ssp. *exigua* have glabrous capsules and can be assigned to var. *stenophylla* (Rydb.) Schneid. Some specimens from the northern part of the state have somewhat pubescent capsules and these may be var. *exigua*. The closely related S. *melanopsis* Nutt. has been reported for the area, but I have not seen any specimen that clearly belongs to that taxon. 170 (ii).

Salix fragilis **L.** Crack willow. Large trees to 20 m tall, the trunks to 1.3 m in diameter, solitary or few, erect or strongly leaning, with thick furrowed gray or blackish gray bark; branches ascending, often large; twigs spreading, not pendulous, very brittle and easily broken at the base; leaf blades lanceolate to narrow elliptic, (2.5)3–17 cm long, (7)10–32 mm wide, acute or accuminate, serrate, glaucous or glaucescent beneath, glabrous or sericeous when young, glabrous when mature; aments coetaneous, on twigs of the current season, these twigs about 1–2.5 cm long, with (1)2–3(4) reduced leaves, the leaves like the larger leaves of the nonfloriferous twigs but sometimes oblanceolate; bracts of the aments pale green, pale yellow-green, or greenish white, tan or very pale brown upon drying, the pistillate ones deciduous by the time the capsules mature, sericeous with the hairs exceeding the bract by about 1–1.5 mm; staminate aments 3.5–7(9) cm long, 9–12 mm wide; stamens 2; filaments about 3–6 mm long, yellow, pilose toward the base, the pilose portion about equal or shorter than the subtending bract; pistillate aments (2.5)4–7 cm long, 10–13 mm wide; capsules 4–6 mm long, crowded but usually not so dense as to conceal the rachis, glabrous, the stipes about 1 mm long, the styles 0.5–1 mm long, the stigmas 0.2–0.3 mm long. Introduced from Eurasia, cultivated at homes and along streets, persisting, escaping, and naturalized along irrigation and natural waterways and lake margins, solitary to forming groves, from 1370–2075 m, in Beaver, Box Elder, Cache, Duchesne, Juab, Rich, Salt Lake, Sanpete, Sevier, Summit, Tooele, Uintah, Utah, Wasatch, and probably most other counties of the state. Hybrids of S. *fragilis* x S. *alba* (S. x *rubens* Schrank.) have been developed (Rehder 1951). If such hybrids have been cultivated in the state, they could add considerable complication to the taxonomic separation of the two species; 30 (xiv).

Salix geyeriana **Anderss.** Geyer willow. Shrubs 1.5–4.5 m tall, twigs glabrous or scattered puberulent, strongly glaucous, the bloom sometimes deciduous; stipules minute and deciduous; petioles 3–10 mm long; leaves (1) 2–4.5 cm long (4) 8–12 mm wide, elliptical, narrow elliptical to narrow lanceolate, entire or nearly so, glaucus beneath, sericeous when unfolding, sparsely to moderately sericeous at maturity, especially below, the hairs white or a few pale reddish; aments subprecocious to coetaneous; peduncles of aments leafy or bracteate, the staminate 2–5 mm long, the pistillate 3–10 mm long; bracts of the aments persistent, sericeous-pilose on both sides, or glabrate or glabrous ventrally especially in age, the hairs exceeding the bract by 0.5–1 mm, the staminate ones light brown when very young, turning reddish to purplish black at the tips, those at the tips of aments turning first, the pistillate ones greenish brown to brown; staminate aments 7–15 mm long, 5–9 mm wide; stamens 2, the filaments about 4 mm long, pilose to about midlength, the pilose portion about equaling or exceeding the bract; pistillate aments 1–2 cm long, 6–15 mm wide; capsules 4–7 mm long, pubescent, the stipe (1) 2–3 mm long, the style 0.2–0.3 mm long; stigmas about 0.2 mm long. Along streams and rivers and in other wet places from 2195–2895 m, most common in the Uinta Mountains to Strawberry Valley, occasional elsewhere in the state, in Beaver, Cache, Daggett, Duchesne, Emery, Kane, Rich, Salt Lake, Sevier, Summit, Uintah, Utah, Wasatch, Washington, and Wayne counties; southern British Columbia south to California and east to Montana and Colorado. With glaucous twigs and whitish pubescence, our plants are assignable to **var. *geyeriana***; 67 (xix).

Salix glauca **L.** Glaucous willow, Grayleaf willow. [S. *pseudolapponum* Seem. in Engler]. Plants mostly low shrubs (0.1) 0.3–1 (3) m tall; twigs sometimes glaucous but mostly not, those below the leaves with epidermis exfoliating in translucent flakes, those of the season reddish under whitish pubescence, occasionally glabrate, often with a tuft of pilose hairs at the node; stipules mostly small and soon deciduous; petioles (1) 2–6 (18) mm long, mostly yellowish or greenish, the color often extending up the midrib of the blade; leaf blades 2–55 mm long, 7–22 mm wide, or to 9 cm long and to 5 cm wide on ends of vegetative twigs, elliptical, pubescent when young to glabrate or glabrous in age, mostly entire or rarely serrate; aments coetaneous, nearly sessile on old twigs or more often on bracteate peduncles or leafy, current twigs; bracts of the aments persistent, pale brown to blackish, pilose; staminate aments 1.5–4 cm long; stamens 2, the filaments free or united in unusual specimens, glabrous or sparsely pilose at the base, the anthers 0.5–0.8 mm long; pistillate aments 1.5–5 cm long, 11–15 mm wide; capsules (4) 5–7 (9) mm long, densely pubescent to glabrate or glabrous in age, crowded but usually not so dense as to conceal the rachis, the stipes 0.5–2 mm long, the style 0.6–1 mm long, the stigmas about 0.5 mm long. Along streams, around springs, on talus slopes, snowflush areas, and dry alpine tundra but then usually in or near krummholz, from 2775–3660 m, on the Bear River, Uinta, and Wasatch mountains and Wasatch Plateau in Cache, Daggett, Duchesne, Salt Lake, Sanpete, Summit, Uintah and Wasatch counties; circumboreal, south in western North America in the Rocky Mountains to New Mexico. Highly variable plants with geographic phases. The Uinta Mountain plants from high elevations are more or less comparable to plants that have passed under the name of S. *pseudolapponum*, and they generally represent a rather low-statured phase. On windswept alpine summits, these plants approach the stature of S. *arctica*, but the stems are still ascending to erect. These Uinta Mountain plants tend more toward glabrescence in the capsules and have darker scales than is typical of those in the Bear River Range. The twigs are quite persistently pubescent. Leaves are seldom over 5 cm long or over 2 cm wide. Plants from the Bear River and Wasatch ranges have densely and persistently pubescent capsules, pale brown to dark brown to occasionally pinkish tan or rarely whitish tan scales, the twigs are sometimes early glabrate and some of the leaves are frequently over 5 cm long and over 2 cm wide. Specimens from Horseshoe Flat area of the Wasatch Plateau have glabrous or pubescent capsules, mostly dark scales, and glabrate and unusual, distinctly serrate leaves. The variability in S. *glauca* nearly encompasses S. *brachycarpa*. However, I prefer to follow Argus (1965) and keep the two separate; 57 (xii).

***Salix laevigata* Bebb.** Red willow. Shrub or tree 2–15 m tall; twigs reddish brown or dull brown, ashy red or ashy gray during exfoliation, stipules inconspicuous or to 6 mm long on vigorous vegetative twigs; usually deciduous, petioles stout, 4–14 mm long; leaf blades (1) 1.8–4 (6) cm long, 5–20 cm wide, or to 19 cm long and 4 cm wide on vigorous young shoots, narrowly to broadly lanceolate, glandular-serrulate, somewhat revolute, usually thick and firm, dark green and glabrous above, glaucous, and glabrous or pubescent toward the base and along the midrib; aments subprecocious to coetaneous, on leafy or bracteate twigs of the season; bracts of aments 1–2 mm long, at least the pistillate ones deciduous, pale yellow, crinkly pilose on both sides or often glabrous dorsally, entire or erose to dentate at apex; staminate aments 3–6 cm long, about 1 cm wide; stamens 3–7, pilose on lower half; pistillate aments 4–8 (11) cm long, to 1.5 mm wide; capsules 4–5 (6) mm long, glabrous, the stipes 1.5–2.5 mm long, styles 0.1–0.2 mm long, equaling the bilobed stigmas. Along drainages from 701–1370 m, in Washington, San Juan, and probably Kane counties; Arizona, California, Nevada, Utah, and northern Baja California. Perhaps not distinct from S. *bonplandiana* H.B.K., and treated as synonymous with that taxon by Dorn (1977); 16 (0).

***Salix lasiandra* Benth.** Whiplash willow; Caudate willow. Shrub or small tree (2) 3–6 (12) m tall; twigs glabrous or finely hairy when young; stipules often well developed, broadly rounded, gland toothed, 2–10 mm long, eventually deciduous; petioles 3–15 (25) mm long, often bearing 2 or more wart-like glands on the upper side at or near the base of the blade; leaf blades (2.2) 5.5–11.5 cm long, (5) 12–21 mm wide, or to 26 cm long and 5.5 cm wide on vigorous young shoots, lanceolate, elliptical or narrow elliptical, gradually long accuminate, closely serrulate, glabrous except when very young; aments coetaneous, on 1–3.5 cm long leafy-bracteate twigs, the leaves or bracts of the ament-bearing twigs 3–5 in number to 6.5 cm long and 1.2 mm wide, deciduous after the fruit matures; bracts of the aments deciduous (at least the pistillate ones) by the time the capsules start to open, 3–4 mm long, glabrous or nearly on the upper half, pubescent toward the base usually more so ventrally than dorsally, entire or minutely toothed at the apex with a few rounded teeth, the staminate yellow, the pistillate pale greenish; staminate aments 1.8–4.5 cm long, 3–12 mm wide; stamens 3–8, usually 5, the filaments pilose; pistillate aments 2–7 cm long, 11–18 mm wide; capsules 4–8 mm long, glabrous, the stipe 1–2 mm long, the style 0.5–1 mm long, the stigmas to 0.5 mm long. Along streams and rivers, on flood plains, occasionally along irrigation canals, or around ponds, and reservoirs, from 1525–2440 (2621)m in Beaver, Box Elder, Cache, Carbon, Daggett, Davis, Duchesne, Emery, Garfield, Juab, Piute, Rich, Salt Lake, Sanpete, Sevier, Summit, Uintah, Utah, and Wasatch counties; to be expected elsewhere; Alaska and Yukon to California and New Mexico. Our plants are **var. *caudata* (Nutt.) Sudw.** with leaves about equally colored on both sides. Var. *lasiandra* with leaves glaucous beneath has been reported for the state, but I have seen no specimen; 98 (xxi).

***Salix lasiolepis* Benth.** Arroyo willow. Shrubs or small trees mostly 4–6 m tall in our range; twigs yellowish olive to reddish, usually soft puberulent when young; stipules minute, soon deciduous or lacking, occasionally well developed on vigorous young shoots; petioles 3–15 mm long; leaf blades 1.5–4.2 cm long, 6–13 mm wide, or to 11 cm long and 2.5 cm wide on vigorous young shoots, usually oblanceolate or oblong, occasionally elliptical, entire, rarely minutely toothed, somewhat revolute margined, dark green and glabrous above, at maturity glaucous beneath, more or less coriaceous, rather densely soft pubescent on both sides when unfolding, less so above than beneath, few to many of the hairs persisting beneath at maturity; aments precocious to subcoetaneous on 3–6 mm long bracteate or bare peduncles; bracts of the aments persistent purple-black, obovate with broad rounded apex, densely villous, almost hidden in the hairs; staminate aments 2.2–4.5 cm long; stamens 2, the filaments glabrous; pistillate aments (1.8) 2.2–4.5 cm long (to 7 cm long outside of our area), 10–12 mm wide; capsules 3–4 (5) mm long, glabrous, the stipe 1–2 cm long, the style about 0.5 mm long, the stigmas 0.2–0.3 mm long. Along streams, ditches, and washes from about 1463–2328 m, in western Utah, Great Basin and Virgin River drainages, in Beaver, Iron, Juab, Millard, Sevier, Tooele, Utah, and Washington counties; southern British Columbia south to Baja California and east to Idaho, Utah, Texas and northern Mexico; 32 (xvii).

***Salix lutea* Nutt.** Yellow willow. [S. *l.* var. *platyphylla* Ball; S. *l.* var. *watsonii* (Bebb) Jeps.]. Shrubs or rarely small trees but then still generally several stemmed at the base; (2) 3–5 (9) m tall; young twigs slender, yellowish to reddish at first, often pale on one side and red-purple on the other, glabrous; older twigs and smaller branches often grayish white; stipules small and inconspicuous or to 1 cm long or more and leaflike in texture on vigorous young shoots, usually deciduous; petioles 1–11 (20) mm long; leaf blades (1) 2–5.5 cm long, (4) 9–21 mm wide or to 10.7 cm long and 3 cm wide on vigorous young shoots, elliptical or lanceolate, rarely linear, entire or occasionally serrulate, glaucous beneath but hardly so when very young, usually glabrous at maturity, the lower surface glabrous from the first or less pubescent than above, the upper surface sometimes pubescent toward the base while the leaves are unfolding; aments precocious or subprecocious, on 1–7 mm long barren or 1–3 bracteate stalks; rachis and usually the stalk of the aments covered with a tangle of crisped-villous white hairs; bracts of the aments persistent, pubescent with crisped-villous, soon-entangled hairs, sometimes only moderately pilose-woolly toward the base or near the apex ventrally, the dorsal side usually glabrous toward the apex and often throughout as the crinkly hairs are readily deciduous; staminate aments 2–5 cm long, about 1 cm wide; stamens 2, the filaments glabrous, the anthers yellowish or turning purple; pistillate aments 2–7 cm long, to 2 cm wide; capsules 3–6 mm long, glabrous, mostly densely arranged on the rachis, occasionally a little scattered, the stipe (1) 1.3–3 (4) mm long, the style 0.2–0.7 mm long, the stigmas often scarcely bilobed. Along streams and ditches in valleys and canyons and occasionally on mountains from 1340–2255 (2350) m, in all counties of the state except Beaver, Carbon, Davis, Iron, Morgan, and Rich, and to be expected in some or all of these; New Mexico to California and north to Alberta. Our plants are closely related to and possibly a part of the S. *eriocephala* Michx. complex. They have been referred to as S. *rigida* Muhl., but Argus (1980) has placed S. *rigida* in synonymy under S. *eriocephala*. He did not place S. *lutea* in synonomy, but suggested that more study is needed. Until such a study is made, I believe it best to retain the traditional name of S. *lutea* for our plants. *Salix ligulifolia* Ball has been reported for southern Utah. This has been separated from *S. lutea* by pedicels of capsules 1–2 mm long versus (1)2–4.5 mm long in *S. lutea*, and by having mostly entire rather than mostly serrulate leaves. At the varietal level such plants are referrable to *S. lutea* var. *ligulifolia* Ball. See discussion under *S. boothii*; 144 (xxv).

***Salix monticola* Bebb ex Coult.** Shrubs 1.5–4 m tall; twigs yellowish when fresh, drying blackish, puberulent at first; stipules small and inconspicuous or leaflike on vigorous young shoots; petioles 5–10 (15) mm long; leaf blades 2–5 cm long, 0.7–1.5 mm wide or up to 11 cm long and 4 cm wide on vigorous young shoots, mostly elliptical or elliptic-obovate, crenate-serrate or subentire, slighty pubescent when very young, more so above than beneath, usually glabrous when fully expanded, glaucous beneath when mature; aments precocious or coetaneous, subsessile or on short stalks to 1 cm long, often subtended by bractlike leaves; bracts of the aments persistent, dark brown to blackish, pilose, or soon crisped-villous, the hairs exceeding the bract by about 2 mm, more or less tangled; staminate aments 2–3.5 cm long, about 1–1.5 cm wide; filaments 2, glabrous; pistillate aments 2–6 cm long, 1–1.5 cm wide; capsules 4–7 mm long, glabrous, subsessile, the stipe less than 1 mm long; style 0.7–1.8 mm long, longer than the stigmas. Along streams and other wet places from 2195–3200 m, on mountains of eastern and central Utah in Beaver, Garfield, Piute, San Juan, Sanpete, Sevier, Uintah, and Wasatch counties, and to be expected elsewhere in eastern Utah, but apparently uncommon in the state; Rocky Mountains of southern Wyoming, Colorado, Utah, Arizona, and New Mexico. Closely allied to *S. boothii* and *S. lutea* and rather easily confused with them. Separation from *S. boothii* is often compounded by the lack of glaucescence on young leaves; I am indebted to Dr. Robert Dorn for his annotations of specimens of this taxon. More specimens are needed to gain a better understanding of this plant in the state; 12 (0).

***Salix nigra* Marsh.** Black willow. [*S. gooddingii* Ball]. Trees or occasionally shrubs (2) 6–10 (24) m tall; twigs of the season yellowish, glabrous, or finely pubescent at first; stipules to 8 mm long, more or less glandular, usually quickly deciduous; petioles 3–7 mm long; leaf blades 2–7.5 cm long, 6–16 mm wide or to 10.2 cm long and 18 mm wide with petiole to 15 mm long on vigorous vegetative twigs, narrowly to broadly lanceolate, apex short to long acuminate, entire or more often glandular-serrulate, greenish on both sides, pubescent when unfolding but becoming glabrous or glabrate; aments coetaneous, on lateral 1–6 cm long twigs of the season with 3–6 leaves or bracts; bracts of aments pale green or pale yellow, soon fading to tan, and at least the pistillate ones deciduous, pubescent on both sides or glabrous toward the apex, entire or with 1–3 minute, rounded teeth; staminate aments 2.5–6.5 cm long, 5–10 mm wide; stamens 3–6, the filaments pilose to about midlength; pistillate aments 1.5–6 cm long, 10–17 mm wide; capsules 4–7 mm long, glabrous, not so densely arranged as to conceal the rachis, the stipe 1–2 mm long, the style 0.1–0.3 mm long. Along the Virgin and San Juan rivers and other drainages in southern Utah, and up the Green River to near Moab from 825–1585 m, in Garfield, Grand, Kane, San Juan, and Washington counties; widespread in the continental United States, southern New Brunswick, and southern Quebec and Ontario, and northeastern Mexico. Utah specimens quite consistently have light-colored twigs and have been called *S. gooddingii*. I feel as did Archer (1965) that *S. gooddingii* is not clearly distinct from *S. nigra*. Arthur Cronquist (unpubl. ms.) has placed *S. gooddingii* in synonomy under *S. nigra* var. *venulosa* (Anderss.) Bebb, and he recognized our plants as being different in having smaller stature and usually having some pubescence on the capsules or stipes, or both, as well as having light-colored twigs. However, he further states that these features are not consistent. I prefer to follow Cronquist's approach and recognize the differences in our plants at the varietal rather than at the specific level. *Salix nigra* and *S. amygaloides* come together near Moab on the Green River, and notes on specimens from that area by Arthur Cronquist indicate that the two hybridize at that location; 23 (0).

Salix planifolia **Pursh.** Plainleaf willow. [*S. phylicifolia* L. ssp. *planifolia* (Pursh) Hiitonen]. Shrubs 0.5–1.5 (4) m tall; twigs below the leaves often with epidermis exfoliating in translucent flakes or strips, younger twigs typically glabrous and lustrous black or purplish black, rarely glaucous in part; stipules small and usually deciduous; petioles 2–10 mm long; leaf blades 1.2–3.8 (8) cm long, 4–13 (30) mm wide, or to 5 (13) cm long and 2 (5) cm wide on vigorous sterile twigs, elliptical or narrow elliptical, soon glabrous and dark green above, glaucous and glabrous to sparingly pubescent below, entire or rarely with minute teeth; aments precocious (at least the staminate) to coetaneous, nearly sessile or rarely on a short, mostly barren peduncle to 0.5–1 cm long; bracts of the aments persistent, blackish, scattered to densely villose to pilose, the hairs usually exceeding the bract by about 2 mm; staminate aments 10–25 mm long; stamens 2, the filaments glabrous, about 6 mm long; pistillate aments 2–4 cm long, 1–1.5 cm wide; capsules 3–7 mm long, typically pubescent at least near the base, occasionally glabrous or nearly so in age, the stipe mostly less than 1 mm long, the style and stigmas together mostly over 1.5 mm long. Streamside meadows, around lakes and ponds and other wet places, most abundant and sometimes forming willow fields in the Uinta Mountains, scattered on high points of the plateaus and mountains of the central and southern part of the state, from (2255) 2895–3660 m in Daggett, Duchesne, Garfield, Iron, Salt Lake, Sanpete, Sevier, Summit, and Uintah counties; circumboreal, south to California and New England. I have followed Argus (1973) in listing our plants under S. *planifolia* rather than S. *phylicifolia*. Our plants mostly fall well within the concept of var. *monica* (Bebb) Jeps., though a few taller plants with larger leaves from moderate elevations of the major drainages in the Uinta Mountains are apparently var. *planifolia*. However, the differences are merely of stature and of leaf size and the two varieties are hardly worthy of separation; 39 (ix).

Salix reticulata **L.** [S. *nivalis* Hook.; S. *n.* var. *saximontana* (Rydb.) Schneid.]. Caespitose dwarf shrubs, stems creeping at or just below the ground surface, the slender aerial twigs rarely more than 2–3 cm long, usually prostrate; stipules minute and deciduous or none; petioles 1–8 (15) mm long; leaf blades 0.5–3 cm long, 0.3–2 cm wide, ovate, obovate, orbicular or occasionally broadly elliptical, entire, glabrous, green above, glaucous beneath, strongly reticulate veined; aments subcoetaneous, but mostly serotinous on the ends of shoots of the season; bracts of the aments persistent, pale green or yellowish, sometimes with reddish tops, spatulate or obovate, glabrous or sparsely pubescent ventrally, especially toward the margin, with short hairs that extend less than 1 mm beyond the bract; staminate aments 0.5–2 cm long, slender, the flowers loose and not concealing the puberulent rachis, on a slender glabrous peduncle about 10–12 mm long; stamens 2; filaments 1.5–2 mm long, glabrous or pilose toward the base; anthers soon reddish or purple; pistillate aments 5–15 mm long, 5–8 mm wide, on a slender 1–2 mm long peduncle; capsules 1.5–3 mm long, pubescent or glabrous in age, sessile or the stipe to 0.5 mm long, the style obsolete or to 0.2 mm long, the stigmas about 0.1–0.2 mm long. Open rocky slopes and ridges and alpine tundra from 2987–3965 m, on the LaSal, Uinta, and Wasatch Mountains in Duchesne, Grand, Salt Lake, San Juan, Summit, and Utah counties; circumboreal, south in the mountains of western North America to California, New Mexico, Utah, and Colorado. Most of our plants are referable to **var. *saximontana* (L.) Kelso**, which may not be distinct from var. *reticulata*. A few specimens seem to be like var. *nivalis* (Hook.) Anderss. The features used for separation seem to be poorly correlated in our plants. Some plants with pistillate aments less than 1 cm long (that should be var. *nivalis*) have leaves well over 15 mm long, which is indicative of the other variety; 32 (0).

Salix scouleriana **Barratt in Hook.** Scouler willow. Shrubs or small trees 3–7 m tall; stipules small and inconspicuous or large and leaflike on vigorous young shoots, eventually deciduous; petioles 2–11 mm long; leaf blades 2–6 cm long, (0.8) 1–3 cm wide or to 11.5 cm long and 4 cm wide on vigorous young shoots, obovate to oblanceolate, rounded to acute or occasionally accuminate at the apex, entire or finely serrate, or occasionally coarsely crenate or serrate on larger leaves of vegetative twigs, densely crisp-hairy or sericeous, especially beneath as they unfold, the mature ones dark green and glabrous above except sometimes puberulent along the midrib, the lower side strongly glaucous, sparsely puberulent with translucent whitish or rusty minute hairs, or occasionally densely felty-villous; bracts of aments blackish or purplish black nearly throughout, reddish or pale at the very base, sericeous-pilose on both sides, the hairs at the apex usually exceeding the bract by 1.5–2 mm; staminate aments 15–35 mm long, nearly as wide as long, strictly precocious, nearly sessile or on thickened bracteate peduncles to 7 mm long, the bracts 3–4 mm long, about 2 mm wide, pale green to whitish, sericeous; stamens 2, the filaments to 11 mm long at maturity, glabrous; pistillate aments 2–6 cm long, 13–17 mm wide, precocious or subcoetaneous, nearly sessile or on thickened bracteate peduncles to 17 mm long, the bracts to 7 mm long and 2 mm wide, not at all leaflike; capsules (5) 6–9 mm long, pubescent, rarely nearly sessile, usually on a 1–3 mm long stipe, the style 0.3–0.4 mm long, rarely shorter, the stigmas 0.5–1 mm long. Around springs, along streams, and on well-drained slopes in aspen and conifer woods, from (1400) 2377–2835 (3355) m, in Box Elder, Cache, Carbon, Daggett, Davis, Duchesne, Garfield, Grand, Juab, Millard, Rich, Salt Lake, Sanpete, San Juan, Sevier, Summit, Tooele, Uintah, Utah, Wasatch, Washington, and Weber counties; Alaska and Yukon to California, Arizona, and New Mexico. *Salix scouleriana* is most closely allied to *S. humilus* Marshall and to *S. discolor* Muhl. of eastern United States and Canada. *Salix discolor* (pussy willow) may be cultivated in our area. It is generally distinguished from *S. scouleriana* by: looser aments with longer stipes (1.5–3 mm), more elliptic, pointed, and toothed leaves that are usually more quickly and fully glabrate, but none of these features is wholly consistent (Hitchcock and Cronquist, 1964). Occasionally specimens have leaves densely pubescent beneath. Arnow et al. (1980) attributed this to hybridization with *S. drummondiana*; 69 (xi).

Salix wolfii **Bebb in Rothr.** Wolf's willow. Shrubs 0.6–1.5 (2) m tall; twigs yellow to orange when young, chestnut brown in age, those of the season thinly villous-puberulent; stipules 1–5 mm long, often glandular-serrulate, eventually deciduous; petioles 2–10 mm long; leaf blades 1.2–4.2 cm long, 5–13 mm wide or to 5.3 cm long and 16 mm wide toward the ends of vigorous vegetative twigs, narrow elliptical, linear-lanceolate, or occasionally oblanceolate, entire, sparsely to densely sericeous-tomentose on both sides even in age or glabrate beneath very late in the season; aments coetaneous or subserotinous, nearly sessile or on bracteate peduncles to 1 cm long; bracts of the aments persistent, blackish or pale at the very base, pilose-sericeous on both sides, the hairs exceeding the bract by about 1 mm; staminate catkins 10–15 mm long, about 8–10 mm wide; stamens 2, the filaments about 3–4 mm long, glabrous; pistillate aments 8–20 (30) mm long, 6–10 mm wide; capsules 3–5 mm long, glabrous or rarely pubescent, the stipe less than 1 mm long, the style about 0.5 mm long, the stigmas about 0.2 mm long. Along streams and around the margins of lakes and ponds, occasionally forming willow fields, in the Bear River and Uinta mountains and West Tavaputs and Wasatch plateaus from 2470–3290 m, in Cache, Daggett, Duchesne, Emery, Summit, Uintah, and Wasatch counties. Oregon to Montana, south to Nevada, Utah, and Colorado. Our plants are **var. *wolfii*** with mostly glabrous capsules. One specimen (B. Maguire, D. Hobson, & R. Maguire 14104) from White Pine Lake, Cache County, has pubescent capsules and leaves that are larger than others from the state. This specimen is like *S. wolfii* var. *idahoensis* Ball, which is known from well north and west of Utah. Other specimens from the vicinity of White Pine Lake and other points in the Bear River Range have glabrous capsules, and I prefer not to list var. *idahoensis* for the state based on this one specimen. The plants from the Bear River Range with pistillate aments 15–30 mm long do, however, seem intermediate toward var. *idahoensis* when compared to those of the Uinta Mountains with pistillate aments 8–15 mm long. The specimen with pubescent capsules and somewhat large leaves is probably the basis of reports of *S. commutata* Bebb for Utah; 44 (ix).

A MAMMALIAN HUMERUS FROM THE UPPER JURASSIC OF COLORADO

Donald R. Prothero[1] and James A. Jensen[2]

Abstract.— The first reported mammal fossil from Dry Mesa Quarry (Upper Jurassic Morrison Formation, Mesa County, Colorado) is the distal end of a right humerus. It is very similar to humeri described by Jenkins (1973) from the Morrison Formation at Como Bluff, Wyoming. It has a distinct ulnar condyle and a spiral humero-ulnar joint, both features found in prototherian mammals but not in therians.

Postcranial remains of Jurassic mammals are extremely rare. An articulated skeleton of a dryolestid therian mammal has been reported from the Jurassic of Portugal (Henkel and Krebs 1977), but is still undescribed. Early Jurassic mammalian postcranial fossils are also known from India (Datta et al. 1978), but are undescribed. A few fragmentary postcranial remains of mammals have been described from the Upper Jurassic of England (Seeley 1879, Simpson 1928, Haines 1946) and from the Upper Jurassic Morrison Formation of Wyoming (Jenkins 1973). Of the five important mammal-producing localities in the Morrison Formation (listed in Clemens et al. 1979:23–26), two have produced mammalian postcranial fossils prior to this paper: Como Bluff, Wyoming (Jenkins 1973), and the Fruita Paleontological Area, Mesa County, Colorado (Rasmussen and Callison 1981).

In 1977, the distal portion of a right humerus of a mammal was found in Dry Mesa Quarry, Mesa County, Colorado. This specimen (BYU 2026) was first mentioned by Clemens et al. (1979:24), and is described below.

Locality and Associated Fauna

Dry Mesa Quarry is located in the lower section of the Brushy Basin Member of the Upper Jurassic Morrison Formation, 135 feet below its contact with the overlying Cretaceous Cedar Mountain Formation. The quarry sediments include very fine to coarse sands, grits, and fine gravels containing angular to well-rounded clay and bone pebbles. Stream gradient was sufficient to move very large bones, with the long axes of all large bones usually oriented at right angles to the stream flow. Sorting was biased by shape rather than by size.

Sediments overlying the bone layer are predominantly light-colored, cross-bedded sands with occasional lenses of clay and fine gravel, the latter often containing clay pebbles. Sediments underlying the bone layer are principally a light, blue-green clay with occasional traces of bright yellow zones of oxidation.

The bone layer consists of an unusual variety of disarticulated bones of all sizes, including specimens representing crocodilians, fish, turtles, pterosaurs, four new theropods, an unknown variety of sauropods, some ornithopods, and the mammal described herein. Due to the great variety of disarticulated bones in the deposit, and the generic novelty of the fauna, descriptive work has been postponed until enough material is available. Field work has been carried out for the last 10 years. The following have been identified so far:

Lungfish tooth plate (probably *Ceratodus*—K. Thomson, pers. comm.)
Pterodactyloid phalanx (Jensen and Ostrom 1977)
Torvosaurus tanneri, a megalosaur (Galton and Jensen 1979)
Prototherian mammal humerus (this paper)

Description

BYU 2026 (Fig. 1) is the distal portion of a right humerus of a mammal. It has been broken at midshaft, but is otherwise well preserved. There is relatively little evidence of crushing or distortion. The shaft cross-section

[1]Department of Geology, Knox College, Galesburg, Illinois 61401.
[2]Earth Science Museum, Brigham Young University, Provo, Utah 84602.

is a mediolaterally compressed triangle with the apex pointing anteriorly. Distally the shaft expands transversely to form the large medial and lateral epicondyles. The distal end of the humerus is naturally flattened anteroposteriorly. The long axis of the distal end is not perpendicular to the major axis of the shaft cross-section, but is rotated about 20 degrees clockwise (viewed from the distal end). The shaft of the humerus has a strong anterior crest that is deflected anterolaterally. This crest is probably the distal end of the deltopectoral crest. A faint posterolateral crest merges with the lateral epicondyle.

The medial epicondyle is considerably more prominent than the lateral epicondyle. It flares medially and is anteroposteriorly compressed. The entepicondylar foramen is visible in anterior view. It is broken at the anterior end, where it passes anteromedially. The lateral epicondyle merges with the radial condyle. It is connected to the shaft of the humerus by a thin posterolaterally arched crest. The radial and olecranon fossae are interconnected, forming an apparent supratrochlear foramen. This feature may be an artifact of breakage, however.

In anterior view, the main body of the shaft bifurcates to form crests joining the radial and ulnar condyles. These crests surround the radial fossa. In posterior view, the olecranon fossa is broadly concave and extends partially up the shaft. From this view the apparent supratrochlear foramen has an irregular margin that is clearly enlarged by breakage.

In distal view, three main features are seen: the medial epicondyle, the ulnar condyle, and the radial condyle-lateral epicondyle. The latter two features are confluent and separated only by a shallow groove. The ulnar and radial condyles, on the other hand, are separated by a narrow, deep intercondylar groove. The radial condyle is broad and bulbous in anterior view. The spiral ulnar condyle is very similar to that shown by Jenkins (1973, Fig. 13). It is wrapped around the distal end of the humerus, with a proximolaterally oriented extensor surface and a proximodistally oriented flexor surface. However, the anterior portion of the ulnar condyle is more bulbous than the same feature in the humerus figured by Jenkins (1973, Fig. 18). The axis of the ulnar condyle as it crosses over the distal end of the humerus is at an approximately 60 degree angle to the transverse (interepicondylar) axis of the humerus (seen in distal view). This compares with angles of 58–65 degrees reported by Jenkins (1973:286) for several humeri from Como Bluff, Wyoming.

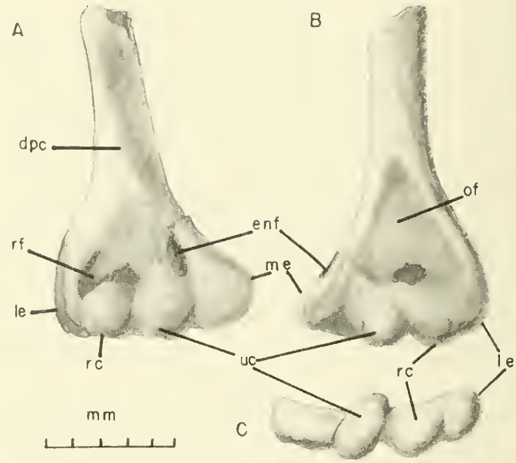

Fig. 1. BYU 2026, distal end of a right humerus. A, Anterior view. B, Posterior view. C, Distal view. Abbreviations: dpc, deltopectoral crest; enf, entepicondylar foramen; le, lateral epicondyle; me, medial epicondyle; of, olecranon fossa; rc, radial condyle; rf, radial fossa; uc, ulnar condyle.

Discussion

The Dry Mesa Quarry mammal very closely resembles the Como Bluff humeri described by Jenkins (1973). It differs from them in having a more bulbous and broader ulnar condyle. In this respect, it is more like the humeri referred to the multituberculate *Catopsalis* by Jenkins (1973, Fig. 19). The multituberculates *Tugribataar* (Kielan-Jaworowska and Dashzeveg 1978) and *Ptilodus* (Gidley 1909), the triconodont *Eozostrodon* (Jenkins and Parrington 1976), and the monotremes (Howell 1937, Haines 1946) also have prominent bulbous ulnar condyles. BYU 2026 clearly does not have a trochlear condyle, which Jenkins (1973) considers characteristic of therian mammals.

The only other feature that distinguishes the Dry Mesa Quarry mammal from the Como Bluff humeri is the apparent supratrochlear foramen. As noted above, this feature may be an artifact of breakage.

The affinities of BYU 2026 are difficult to assess based on such limited evidence. The presence of a distinct ulnar condyle with a spiral humero-ulnar joint is characteristic of prototherian mammals (Jenkins 1973). The advanced therian trochlear condyle is known from rocks as old as the Lower Cretaceous (Jenkins 1973, footnote 3). The Dry Mesa Quarry mammal humerus could have belonged to a number of prototherian mammal taxa presently known from the Morrison Formation (Prothero 1981, Clemens et al. 1979). It could also have come from some of the primitive Morrison therian mammals that may or may not have had a trochlear condyle. Until the Portuguese dryolestid therian skeleton (Henkel and Krebs 1977) is fully described, we cannot rule out the possibility that the Dry Mesa Quarry humerus belonged to a very primitive therian mammal. Of the possible candidates among nontherian mammals, BYU 2026 resembles the known humeri of multituberculates and triconodonts. The skeleton of docodonts is presently unknown. The systematic affinities of the Dry Mesa Quarry mammal cannot be determined more precisely at present than Mammalia *incertae sedis*.

Acknowledgments

The Dry Mesa Quarry has been worked for 10 years by the Earth Science Museum of the Brigham Young University under permits from the U.S. Forest Service, as authorized by the Antiquities Act of 1906. Funds for this work have been provided by research support grants from Brigham Young University, with additional support from the National Geographic Society, Kenneth R. Thomson, and several other private donors.

Measurements of angles were made with an E.P.O.I. Shopscope. D.R. Prothero was supported by a Columbia Faculty Fellowship during preparation of this paper. We thank Henry Galiano for advice on the illustration.

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BATS OF THE COLORADO OIL SHALE REGION

Robert B. Finley, Jr.,[1] William Caire,[2] and Dallas E. Wilhelm[3]

ABSTRACT.— New records for *Myotis californicus, M. evotis, M. leibii, M. lucifugus, M. thysanodes, M. volans, M. yumanensis, Lasionycteris noctivagans, Pipistrellus hesperus, Eptesicus fuscus, Lasiurus cinereus, Plecotus townsendii,* and *Antrozous pallidus* and their habitat occurrence in northwestern Colorado are reported. Mortality of 27 bats of six species trapped in an oil sludge pit is described.

In 1974 the National Fish and Wildlife Laboratory began field work in the Piceance Basin as part of a survey of the vertebrates of the coal and oil shale regions of northwestern Colorado. The information was needed as baseline data in preparation for energy development and to better define the poorly known distribution of mammals in this area.

From the oil shale region of Colorado, roughly defined as Rio Blanco and Garfield counties west of a line between Meeker and Rifle, records of eight species of bats were summarized by Armstrong (1972), seven of which had been reported only from the vicinities of Meeker or Rifle. Since then specimens of five additional species have been collected and numerous locality and habitat records obtained. This information is reported herein to make it available for management decisions, and to facilitate and stimulate further work on the bats of northwestern Colorado.

Study Area and Methods

The elevation of the Oil Shale Region ranges approximately from 1,585 to 2,805 m, falling within the Upper Sonoran, Transition, and Canadian life zones of Cary (1911). The Roan Plateau extends east-west, roughly along the Rio Blanco-Garfield county line, dividing the two main drainages, the Colorado River to the south and the White River to the north. The region is semiarid with predominantly shaly alkaline soils and has only a few long permanent creeks, with many short intermittent tributaries. The few permanent creek bottoms are occupied by ranches and irrigated hay meadows. Low cliffs and rock ledges border some of the creeks, and high cliffs mark the southern rim of the Roan Plateau and the western rim of the Cathedral Bluffs east of Douglas Creek.

Specimens were obtained primarily by mist-netting and were preserved as study skins and skulls or in liquid. All specimens examined are in the Biological Surveys/Fort Collins collection (BS/FC) of the U.S. Fish and Wildlife Service, unless otherwise indicated: (CU) Colorado University Museum or (KU) Kansas University Museum of Natural History.

Results

The known kinds of bats from the Colorado oil shale region include seven species of *Myotis* and one species in each of six other genera (*Lasionycteris, Pipistrellus, Eptesicus, Lasiurus, Plecotus,* and *Antrozous*). Species found to be most common were the hoary bat (*Lasiurus cinereus cinereus*), long-legged myotis (*Myotis volans interior*), long-eared myotis (*Myotis evotis evotis*), and small-footed myotis (*Myotis leibii melanorhinus*). The spotted bat (*Euderma maculatum*) has been reported in some environmental impact reports as "potentially" or "possibly" present; yet to our knowledge no specimen has been taken in the oil shale region. One was picked up in Browns Park, 65 km north of the oil shale region, in 1981 by J. Creasy (Finley and Creasy 1982).

[1]U.S. Fish and Wildlife Service, 1300 Blue Spruce Drive, Fort Collins, Colorado 80524-2098.
[2]Department of Biology, Central State University, 100 North University Drive, Edmond, Oklahoma 73034.
[3]Department of Biology, Hastings College, P.O. Box 269, Hastings, Nebraska 68901.

Accounts of Species

Myotis californicus stephensi Dalquest
California Myotis

Specimens examined (5).— Garfield Co.: 5½ mi N, 2 mi W Rifle, 5,900 ft, 5.

Five California myotis, four unsexed and one female, were found partially decomposed in an oil sludge pit on the east side of the valley of Government Creek north of Rifle. Four specimens were picked up on 17 September 1974 and one on 17 May 1975. They are referred to *stephensi* on geographic grounds. The circumstances of these and 22 other bat casualties at the same sludge pit are described in this paper under "Effects of Energy Development on Bats."

The National Museum of Natural History has a specimen taken 14 August 1907 by Merritt Cary (1911) in a house 7 mi W Rifle, 5,300 feet.

Myotis evotis evotis (H. Allen)
Long-eared Myotis

Specimens examined (31).— Garfield Co.: 5½ mi N, 2 mi W Rifle, 5,900 ft, 7; Rio Blanco Co.: Cascade Gulch, T3S, R95W, Sec 8, 1; Duck Cr tank, T1S, R98W, Sec 7, 1; Little Duck Cr, T1S, R98W, Sec 10, 6,200 ft, 10; Ryan Gulch, 24 mi W, 10 mi S Meeker, 6,500 ft, 5; 25 mi W, 10 mi S Meeker, 6,400 ft, 2; 1 mi N, 4 mi W Rio Blanco, 6,900 ft, 5.

Seven long-eared myotis carcasses (1 male, 3 females, and 3 unsexed) were picked up on the bank of the sludge pit north of Rifle on 17 September 1974. This species was the most abundant bat taken at pools adjacent to big sage (*Artemisia tridentata*), greasewood (*Sarcobatus vermiculatus*), and pinyon-juniper habitats. Sandstone ledges or low cliffs were also present within a few hundred yards at all localities.

The most productive mist netting site was on Little Duck Creek, at 2,000 m elevation. There on 7 August 1975 Caire and Finley collected 10 *M. evotis*, 2 *M. leibii*, 4 *M. volans*, 3 *Eptesicus fuscus*, and 2 *Lasiurus cinerus*. The valley bottom was covered with tall, dense big sagebrush and greasewood on deep alluvial soil. Little Duck Creek was entrenched in an arroyo about 3–4½ m deep. The steep upper slopes of the valley were of nearly bare shaly soil. Higher rock outcrops along the rim supported old mature junipers (*Juniperus osteosperma*).

The water in the arroyo was barely enough to provide a flow, but a deposit of silt at the mouth of a side gully had dammed the flow and formed a long pool about 4 m wide and 20 cm deep. Nets were set over this pool and another about 40 m downstream, where we dammed the stream with a shovel, creating a pool.

One long-eared myotis caught at Little Duck Creek had a large laceration in the left wing membrane, which had fully healed. The study skin (BS/FC 2119), pinned with wings fully extended, has the posterior margin of the membrane between the tibia and the 5th metacarpal deeply concave so that the width (chord) of the left wing measures only 22 mm, compared with 37 mm at the same place on the right wing. A lobe of smooth scar tissue extends anteriorly from the deformed posterior margin, leaving only an 8 mm band of normal membrane between the scar tissue and the radius.

In Ryan Gulch Wilhelm netted bats at a steel stock tank by a windmill on 15 August 1974. He took 5 *M. evotis*, 5 *M. volans*, and 2 *M. leibii*. The terrain and habitat there were almost the same as on Little Duck Creek, except that Ryan Gulch was dry at the time and not so deeply gullied. Less than a mile away in June two macerated skeletons of *M. evotis* that had apparently drowned in a small watering trough were found.

Three of four female *M. evotis* taken on 4 August 1977 on Piceance Creek, 1 mi N, 4 mi W Rio Blanco, were lactating or recently lactating. The habitat there is described in the *M. lucifugus* account. Of the 26 total specimens of long-eared myotis that were sexed, 14 were females and 12 were males.

Myotis leibii melanorhinus (Merriam)
Small-footed Myotis

Specimens examined (14).— Garfield Co.: 3 mi N Douglas Pass, 7,000 ft, 1; 4.6 mi W Rifle (by rd), T6S, R94W, Sec 14, 1; 5½ mi N, 2 mi W Rifle, 5,900 ft, 5; Rio Blanco Co.: Cascade Gulch, T3S, R95W, Sec 8, 2; Little Duck Cr, T1S, R98W, Sec 10, 2; Ryan Gulch stock tank, 24 mi W, 10 mi S Meeker, 6,500 ft, 2; Ryan Gulch, 25 mi W, 10 mi S Meeker, 1.

Five *M. leibii* were picked up (4 on 17 September 1974 and 1 on 29 April 1975) on the bank of the same oil sludge pit north of Rifle where 5 *M. californicus* and 7 *M. evotis* were found. There were 2 females, 1 male, and 2 unsexed carcasses.

This species seems to be found mainly at lower and intermediate elevations in sagebrush, greasewood, and pinyon-juniper habitats, but is less abundant there than *M. evotis*. Our highest record of occurrence was at 2,130 m, 3 mi N Douglas Pass, where one was netted along with *Lasiurus cinereus* on 2 August 1977 over an earthen stock pond. The adjacent hillsides supported mixed chaparral, sagebrush, and grassland with scattered Douglas-fir (*Pseudotsuga menziesii*) and junipers (*Juniperus*).

A female taken on 22 July 1975 at a sheep stock tank 4.6 mi W Rifle contained an embryo 20 mm long. Of the 12 individuals collected that were sexed, half were females. The eight skins at hand show a wide variation in color of the back and sides, from light buffy or reddish brown to dull medium brown, but have uniformly blackish ears and wings.

Myotis lucifugus carissima Thomas
Little Brown Bat

Specimens examined (3).— Garfield Co.: 4 mi W, 1 mi S Rifle, 5,300 ft, 1; 1 mi N, 4 mi W Rio Blanco, 6,900 ft 2.

A female was taken on 28 August 1975 over a sheep watering pond in the Colorado River valley west of Rifle. The pond had been bulldozed in alkali soil on a greasewood flat south of cliffs and a steep rock slope with pinyon-juniper.

Two males were taken in a net across upper Piceance Creek west of Rio Blanco on 4 August 1977. At that point the valley is narrow between steep canyon sides covered with pinyon-juniper and mountain shrub, with Douglas-fir in the tributary gulches. The valley bottom was grazed by sheep, and the creek was barely flowing between long shallow pools. Other bats taken there were four *M. evotis* and one *Lasionycteris*.

Cary (1911:206) collected two *M. lucifugus* on the White River meadows a few miles east of Meeker in August 1905.

Myotis thysanodes thysanodes Miller
Fringed Myotis

Specimens examined (1).— Rio Blanco Co.: 11 mi W Meeker, ½ mi S Hwy 64, Hay Gulch Rd, 1 (CU).

A male fringed myotis was netted by Jerry Freeman on 17 August 1978 at a stock tank where Hay Gulch opens into the White River Valley.

Myotis volans interior Miller
Long-legged Myotis

Specimens examined (14).— Garfield Co.: 2 mi E Rio Blanco, 1; Rio Blanco Co.: Little Duck Cr, T1S, R98W, Sec 10, 4; Little Hills Game Research Station, 15 mi W, 1.9 mi S Meeker, 4 (CU); Ryan Gulch, 24 mi W, 10 mi S Meeker, 5,600 ft, 5.

Myotis volans occurs in the sagebrush, greasewood, and pinyon-juniper habitats along with *M. evotis* and *M. leibii*. Specimens were taken at sites described under the accounts of these species, and also at a more wooded site described under *Lasiurus cinereus*.

Two males and two females were taken in the barn at the headquarters of the Little Hills Game Research Station by Bissell, Olivas, and Webb of the Colorado Division of Wildlife on 29 June and 7 July 1977. The barn is in a gulch flanked by rocky slopes with pinyon-juniper. One *M. yumanensis* and one *Eptesicus fuscus* were also obtained there.

Eight of the 14 *M. volans* examined were males and 6 were females.

Myotis yumanensis yumanensis (H. Allen)
Yuma Myotis

Specimens examined (4).— Rio Blanco Co.: Little Hills Game Research Station, 15 mi W, 1.9 mi S Meeker, 1 (CU); Rio Blanco Lake, 3 (CU).

Three female Yuma myotis were taken on 6 and 7 July 1977 by Ribic and Olivas in the attic of a deserted house by Rio Blanco Lake, a small reservoir on the White River near the mouth of Piceance Creek. One contained three embryos 4 mm in length.

Lasionycteris noctivagans (Le Conte)
Silver-haired Bat

Specimens examined (8).— Garfield Co.: 5½ mi N, 2 mi W Rifle, 5,900 ft, 6; Rio Blanco Co.: 3½ mi W Rio Blanco, 1; 1 mi N, 4 mi W Rio Blanco, 6,900 ft, 1.

Six silver-haired bats (5 males and 1 female) were found at the sludge pit north of Rifle. One each day was picked up in a fairly good state of preservation on 29 April, 14 May, and 17 May, two on 4 June 1975, and one still alive on 17 September 1974.

Only two *Lasionycteris* were taken in mist nets, one each at two sites on Piceance Creek west of Rio Blanco, where they were associated with *M. lucifugus* at one site and *Lasiurus cinereus* at the other. The sites are described under those accounts.

Pipistrellus hesperus hesperus (H. Allen)
Western Pipistrelle

Specimens examined (2).— Garfield Co.: 5½ mi N, 2 mi W Rifle, 5,900 ft, 1; 4 mi W, 1 mi S Rifle, 5,300 ft, 1.

One *P. hesperus* was picked up on 17 September 1974 at the sludge pit north of Rifle. The only pipistrelle netted was in the Colorado River valley at the locality described under *M. lucifugus*. These records and the absence of specimens from our other sites at higher elevations bear out Cary's (1911:209) statement that pipistrelles "inhabit the Upper Sonoran zone in the western and southwestern valleys . . . [and] live only about cliffs and in rock-walled canyons."

Eptesicus fuscus pallidus Young
Big Brown Bat

Specimens examined (4).— Rio Blanco Co.: Little Duck Cr, T1S, R98W, Sec 10, 6,200 ft, 3; Little Hills Game Research Station, 15 mi W, 1.9 mi S Meeker, 1 (CU).

One big brown bat was shot flying over tall sagebrush and two were netted over a pool in a gully at Little Duck Creek on 7 August 1975. The habitat and other captures are described under the account of *Myotis evotis*. Cary (1911:209) obtained a big-brown bat from the White River, a few kilometers east of Meeker in August 1905.

The four skins vary in color, as discussed by Armstrong (1972:70), and fall within the range of a series of nine *pallidus* in the BS/FC collection from 5 mi E, 1 mi N Fort Collins, except that one is more light reddish than any in the Fort Collins series.

Lasiurus cinereus cinereus Palisot de Beauvois
Hoary Bat

Specimens examined (16).— Garfield Co.: 3 mi N Douglas Pass, 7,000 ft, 1; 3.4 mi N Rifle, on Government Creek, 1; 5½ mi N, 2 mi W Rifle, 5,900 ft, 3; 2 mi E Rio Blanco, 7,500 ft, 3; Rio Blanco Co.: Little Duck Cr, T1S, R98W, Sec 10, 2; T1N, R102W, Sec 4, W of Rangely [5,300 ft], 1; 3½ mi W Rio Blanco, 5.

The hoary bat was the most abundant species in mist nets set over pools of Piceance Creek adjacent to cottonwood (*Populus*) and Douglas-fir stands between 2,000 and 2,300 m elevation. One was also netted over an ephemeral pond a few miles west of Rangely in salt desert shrub at 1,615 m elevation. Three hoary bats were picked up at the sludge pit north of Rifle. A female was found on 15 July 1974 and a male and a female on 17 September 1979. Two male hoary bats were netted on Little Duck Creek on 7 August 1975 at the site described under the account of *Myotis evotis*.

Five male hoary bats were caught in two nets over Piceance Creek, 3½ mi W Rio Blanco, on the night of 10–11 July 1975. One net was set over a narrow beaver pond in a grove of cottonwoods and the other in a grassy area just below the junction of Cow Creek and Piceance Creek. The Piceance valley was narrow between steep hillsides wooded with small Douglas-fir and mixed mountain shrubs on the shady side and mostly pinyon-juniper on the sunny slope.

One female and two male hoary bats, as well as one female *M. volans*, were netted on 10–11 July 1975 over a beaver pond on upper Piceance Creek, 2 mi E Rio Blanco, 7,300 ft. The site was more wooded than the one just described (3½ mi W Rio Blanco). The north-facing slope above the beaver pond was covered with Douglas-fir, and the opposite slope had a heavy stand of pinyon-juniper and mountain mahogany (*Cercocarpus montanus*). Other localities where hoary bats were taken are described under the accounts of *Myotis leibii* and *Antrozous pallidus*.

A pregnant female (BSC/FC 5109, alcoholic) was taken on 11 July 1975, 2 mi E Rio Blanco. She weighed 30 grams and carried two embryos, 22 mm. All 11 of the other hoary bats taken by mist nets were males. The 11 skins available vary considerably in appearance. The three taken the latest in the summer (7 August) have longer dorsal fur with a heavier overlay of silver tips. Some taken in July have short pelage and some are moulting.

Plecotus townsendii pallescens (Miller)
Townsend's Big-eared Bat

Specimens examined (5).— Rio Blanco Co.: Spring Cave, 7,850 ft, 9 mi S, 4 mi E Buford, 4; 5 mi N, 10 mi W Rangely, 5,800 ft, 1 (KU).

On 19 February 1977 Finley visited Spring Cave to investigate reports of two kinds of bats there in winter, one with "long" ears and one with "short" ears. This limestone cave is located high on a forested mountainside in the White River National Forest. A detailed description, photos, and maps of Spring Cave were published by Parris (1973:221). The mountainside was snow covered, but temperatures were mild. There were a few scattered dormant bats on the wall of the entry passage between the two main entrances, some even in the twilight zone. There were about 90 bats in all high on the wall of the "Long Room" extending southwest from the entry passage. About 25 were hanging singly and about 65 in 3 clusters, mostly 2 to 3.7 m above the floor. All appeared to be *Plecotus*, some with ears extended and some with ears folded, giving a first impression of two kinds of bats present. No bats were seen beyond the bend in the Long Room or on the walls of the "Tunnel" or "Pirates' Den." Wilhelm visited Spring Cave on 15 August 1974 and explored it without finding any bats or guano deposits. Armstrong (1972) reported one specimen at the University of Colorado Museum from Spring Cave.

A single male big-eared bat was taken by Finley on 29 August 1948 in a sandstone cave 5 mi N, 10 mi W Rangely, 5,800 ft., Rio Blanco County. It was found in an overhead vertical cleft through the roof of an arched rock shelter that was also occupied by a bushy-tailed wood rat (*Neotoma cinerea arizonae*).

Antrozous pallidus pallidus (Le Conte)
Pallid Bat

Specimens examined (4).— Garfield Co.: 3.4 mi N Rifle, on Government Cr, 3; Rio Blanco Co.: T1N, R102W, Sec 4, W of Rangely, 1.

Three pallid bats, lactating females, were taken by Caire on 25 July 1975 in a net set under cottonwoods over a trickle of water in Government Creek north of Rifle. The creek was nearly dry and lined with large cottonwoods and a few tamarisks (*Tamarix gallica*). On 7 August 1975 another lactating female was taken west of Rangely on the dry, low sage–saltbush bench south of the White River. The net was set across the lower end of a shallow, mud-flat pool in a small arroyo. A single hoary bat was the only bat taken in the evening, and the pallid bat was found in the net the following morning.

Cary (1911:206) reported seeing a pallid bat "among the cliffs along the Grand [Colorado] River, 7 miles west of Rifle, August 14, 1907."

Effects of Energy Development on Bats

Man's increasing activities for development of energy resources in western Colorado can entail several kinds of adverse effects on bat populations, such as disturbance of hibernating bats in caves, mine tunnels, and other sites; destruction of daytime roost sites; loss or contamination of watering sites; and contamination of the food chain by insecticides and pollutants.

Bats are extremely vulnerable because of their specializations as volant, nocturnal insectivores. For protection against ground predators they require secure daytime roosts such as cave walls, cliff crevices, or hollow tree snags. Suitable shelters in the oil shale region are usually located in narrow canyons and ravines or on juniper-covered rimrock. Such terrain features occupy a low percentage of total land area and should be avoided as waste disposal sites for spent shale from retorts.

Both natural and man-made water surfaces are widely available to bats for drinking in northwestern Colorado. The main permanent streams such as the White River and Piceance Creek are important and likely to remain dependable drinking sites. But the small intermittent streams and springs are very susceptible to loss by lowering water tables when wells are drilled, and may become contaminated by waste dumping or spillage. Loss of springs and small stream pools on the upland areas may be compensated for by presence or addition of stock-watering tanks. As long as cattle raising is maintained as a viable industry in the areas of energy development, the adverse effects on bats of spring and creek flow loss can be at least partially mitigated. However, production of aquatic insect food would still be reduced.

Drilling for oil and gas in Colorado results in a certain amount of drilling fluids and oil at well sites being spilled and impounded in pools or sludge pits. These are recognized hazards to birds and other wildlife, but bats have not previously been reported as casualties. A source of bat mortality was called to our attention by Richard E. Pillmore, who picked up a mummified hoary bat carcass on 15 July 1974 on the bank of a sludge pit 5½ mi N, 2 mi W Rifle at 1,800 m elevation. Pioneer Drilling, Inc., had drilled a test well and dug two pits for impounding spilled oil. The sludge pool was situated in the bottom of a pit with steep banks rising about 3 m above the surface, which was about 23 by 30 m in size. Oil in the pool formed a thin slick over the water, which was a few feet deep. This lower pool was formed by drainage from an adjacent higher pit that contained much heavier oil sludge and was nearly dried up. The oil well and pits were on a bulldozed pad of alkaline clay soil on the east side of the valley. The pad was surrounded by a gentle slope covered with greasewood. To the east was a steep rocky slope of pinyon-juniper, leading up to high cliffs bounding the east side of the valley of Government Creek.

The lower of the two sludge pits proved to be a lucrative source of bats. They were found 3 to 8 m from the edge of the lower pool, but none were found around the upper, nearly dry pit. In the following 16 months repeated visits to this site by Finley and others yielded 27 poor-quality but identifiable specimens. The kinds and numbers of individuals collected are as follows: hoary bat (3), long-eared myotis (7), small-footed myotis (5), California myotis (5), western pipistrelle (1), silver-haired bat (6).

A live, oil-soaked *Lasionycteris* was seen on 17 September 1974 hanging on the side of a rock about 1 m from the oil-slick surface of the pond. It responded to touch but did not seem to be much affected by the oil.

In comparison with collections from other localities, there were relatively high numbers of silver-haired bats, only two of which have been taken by mist net in the region, and of California myotis, none of which has been mist-netted; but the pallid bat, three of which were netted only 5 km away, is absent from the sludge pit sample. A more common species not far away, *Myotis volans*, was also absent from the sludge pit. Perhaps various species of bats differ in their vulnerability to entrapment.

On 19 September 1974 Finley visited the Rangely oil field and inspected sludge pits without finding any bats. The six pits that contained oil were all much smaller than the pit north of Rifle and had heavy oil, apparently without water, in the bottom. They had wires with colored streamers stretched over them, apparently to keep out birds. It does not seem likely that bats would mistake such pits for water ponds. Four sludge pits containing oil on water were inspected on 1 May 1981 between Craig, Colorado, and Rock Springs, Wyoming, without finding any bats.

Three instances of entrapment of bats in oil are known to us in the literature: Krutzsch (1948) described finding 3 bats as well as insects, lizards, and birds in three small pools of oil formed by drainage into a gully from a recently oiled road in the Borego Desert, California. Barbour and Davis (1969) cited a report by E. J. Koestner of 15 red bats (*Lasiurus borealis*) entrapped in oil on a 500-foot stretch of road in Illinois. Gillette and Kimbrough (1970) reported a bat seen in a "tar pit" of undescribed origin at Fort Sill, Lawton, Oklahoma.

We thank Jerry Freeman for permission to report a specimen of *Myotis thysanodes* taken by him, Michael Bogan for identifying several bats, and the Colorado Division of Wildlife for generous information and assistance.

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NEW GENERIC CONCEPTS IN THE TRITICEAE OF THE INTERMOUNTAIN REGION: KEY AND COMMENTS

Mary E. Barkworth[1], Douglas R. Dewey[2], and Riley J. Atkins[1]

Abstract.— Revision of the perennial genera of North American Triticeae requires recognition of seven new genera in the Intermountain Region: *Elytrigia, Leymus, Psathyrostachys, Pseudoroegneria, Thinopyrum*, and the hybrid genera × *Elyleymus* and × *Pseudelymus*. One previously recognized genus, *Sitanion*, is included in *Elymus*. Several new combinations are presented to accommodate the taxonomic changes. *Elymus trachycaulus* is treated as a widespread, polymorphic species with three subspecies in the region: subsp. *trachycaulus, subsecundus*, and *latiglumis*. *Agropyron dasystachyum* and *A. albicans* are treated as conspecific subspecies of *Elymus lanceolatus*. A key to the genera of the Triticeae occurring in the Intermountain Region is presented as well as keys and brief descriptions for those genera not included in, or substantially modified from, other regional treatments.

Agrostologists have been aware for a long time that traditional North American treatments of the Triticeae (e.g., A. Hitchcock 1951, Gould 1968, C. Hitchcock 1969, Holmgren and Holmgren 1977) do not reflect the evolutionary relationships within the tribe. Nevertheless, in the absence of any well-documented revision that included a high proportion of the North American species, most North American taxonomists have adopted A. Hitchcock's (1951) treatment, with relatively minor modifications, as the best available. Recently, however, Dewey (1982, 1983a, 1983b) has published a revision of the perennial genera that better reflects the genomic and ecological data available and is consistent with the morphological data. Although written in terms of North American taxa, Dewey's treatment is based on data from the full geographic and taxonomic range of the tribe.

This paper is designed to assist those who wish to use Dewey's generic concepts for plants from the Intermountain Region. It includes a key to the genera of the tribe in the region and, for those genera not included in, or substantially modified from Holmgren and Holmgren (1977), brief generic descriptions and keys to the infrageneric taxa that we recognize. Readers are referred to the Holmgrens' article for illustrations, detailed descriptions of the species, and the complete synonymy. Table 1 summarizes the differences between the treatment presented here and that found in their article.

Taxonomic Treatment

The genera that are most affected by the revised generic boundaries are *Agropyron* Gaertn., *Elymus* L., and *Sitanion* Raf. *Agropyron* has been restricted to the crested wheatgrasses, the remaining species being assigned to *Elymus, Elytrigia, Pseudoroegneria*, or *Thinopyrum*. Several species of *Elymus* have been placed in the segregate genus *Leymus* Hochst., but all species of *Sitanion* are now included in *Elymus*. The reasons for these and other changes are given in the discussion of individual genera. To assist those not familiar with the subtribal classification of the Triticeae, the genera and species within genera are treated alphabetically after the generic key.

The intergeneric hybrids are treated after the nonhybrid genera. Readers are advised that such hybrids are relatively rare in nature. We include them because they do exist but, in our experience, most plants thought to be hybrids are aberrant forms of good species. Interspecific hybrids are more common, particularly in disturbed areas. Part of the problem in identifying hybrids in the Triticeae, particularly interspecific hybrids, is that most can backcross to their parents,

[1]Department of Biology, UMC 45, Utah State University, Logan, Utah 84322.
[2]Crops Research Laboratory, UMC 63, U.S. Department of Agriculture, Logan, Utah 84322.

Table 1. Synopsis of our revised treatment of the Triticeae occurring in the Intermountain Region compared with that presented in the *Intermountain Flora* (Holmgren and Holmgren 1977).

Revised treatment	Intermountain Flora
Aegilops cylindrica L.	*Aegilops cylindrica* L.
Agropyron cristatum L.	*Agropyron cristatum* L.
Agropyron desertorum J. A. Shultes	included in *A. cristatum* L.
Agrpyron fragile Roth	included in *A. cristatum* L.
× *Elyhordeum macounii* (Vasey) Barkworth & D. R. Dewey	× *Agrohordeum macounii* (Vasey) Lepage
× *Elyleymus aristatus* (Merrill) Barkworth & D. R. Dewey	× *Elysitanion aristatum* (Merril) Bowden
Elymus canadensis L.	*Elymus canadensis* L.
Elymus elymoides (Raf.) Sweezy	*Sitanion hystrix* (Nutt.) J. G. Smith
Elymus glaucus Buckley	*Elymus glaucus* Buckley
Elymus × *hansenii* Scribner, pro sp.	× *Elysitanion hansenii* (Scribner) Bowden
Elymus lanceolatus (Scribner & J. G. Smith) Gould	
subsp. *lanceolatus*	*Agropyron dasystachyum* (Hooker) Scribner
	var. *dasystachyum*
	Var. *riparium* (Scribner & J. G. Smith) Bowden
subsp. *albicans* (Scribner & J. G. Smith) Barkworth & D. R. Dewey	*Agropyron albicans* Scribner & J. G. Smith
	var. *albicans*
	var. *griffithsii* (Scribner & J. G. Smith) A. A. Beetle
Elymus multisetus (J. G. Smith) M. E. Jones	*Sitanion jubatum* J. G. Smith
Elymus × *pseudorepens* (Scribner & J. G. Smith) Barkworth & D. R. Dewey	*Agropyron* × *pseudorepens* Scribner & J. G. Smith
Elymus × *saundersii* Vasey	× *Agrositanion saundersii* (Vasey) Bowden
Elymus trachycaulus (Link) Gould ex Shinners	*Agropyron trachycaulum* (Link) Malte
subsp. *trachycaulus*	var. *trachycaulum*
subsp. *subsecundus* (Link) Barkworth & D. R. Dewey, pro parte	var. *glaucum* (Pease & Moore) Malte
subsp. *latiglumis* (Scribner & J. G. Smith) Barkworth & D. R. Dewey	var. *latiglumis* (Scribner & J. G. Smith) A. A. Beetle
subsp. *subsecundus* (Link) Barkworth & D. R. Dewey, pro parte	var. *unilaterale* (Cassidy) Malte
Elymus virginicus var. *submuticus* Hooker	*Elymus virginicus* var. *submuticus* Hooker
Elytrigia intermedia (Host) Nevski	*Agropyron intermedium* (Host) Beauv.
subsp. *intermedia*	var. *intermedium*
subsp. *barbulata* (Schur) A. Löve	var. *trichophora* (Link) Halac
Elytrigia repens (L.) Nevski	*Agropyron repens* (L.) Beauv.
Elytrigia spicata (Pursh) D. R. Dewey	*Agropyron spicatum* Pursh
Eremopyrum triticeum (Gaertner) Nevski	*Eremopyrum triticeum* (Gaertner) Nevski
Hordeum brachyantherum Nevski	*Hordeum brachyantherum* Nevski
Hordeum depressum (Scribner & Smith) Rydb.	*Hordeum depressum* (Scribner & Smith) Rydb.
Hordeum marinum Hudson	
subsp. *gussonianum* (Parl.) Thell.	*Hordeum geniculatum* All.
Hordeum murinum L.	
subsp. *murinum*	*Hordeum murinum* L.
subsp. *glaucum* (Steudel) Tsvelev	*Hordeum glaucum* Steudel
subsp. *leporinum* (Link) Arcang.	*Hordeum leporinum* Link
Hordeum pusillum Nutt.	*Hordeum pusillum* Nutt.
Hordeum vulgare L.	*Hordeum vulgare* L.
Leymus cinereus (Scribner & Merrill) A. Löve	*Elymus cinereus* (Scribner & Merrill)
Leymus flavescens (Scribner & Smith) Pilge	*Elymus flavescens* Scribner & Smith
Leymus salinus (M. E. Jones) A. Löve	
subsp. *salinus*	*Elymus salina* M. E. Jones
subsp. *salmonis* (C. L. Hitchc.) R. J. Atkins	*Elymus ambiguus* var. *salmonis* C. L. Hitchc.
Leymus simplex (Scribner & Williams) D. R. Dewey	*Elymus simplex* Scribner & Williams
Leymus triticoides (Buckley) Pilger	*Elymus triticoides* Buckley
Pascopyrum smithii (Rydb.) A. Löve	*Agropyron smithii* Rydb.

Table 1 continued.

REVISED TREATMENT	INTERMOUNTAIN FLORA
Pseudoroegneria spicata (Pursh) A. Löve	*Agropyron spicatum* Pursh
× *Pseudelymus saxicolus* (Scribner & J. G. Smith) Barkworth & D. R. Dewey	× *Agrositanion saxicola* (Scribner & J. G. Smith) Bowden
Psathyrostachys juncea (Fischer) Nevski	*Elymus junceus* Fischer
Secale cereale L.	*Secale cereale* L.
Taeniatherum caput-medusae (L.) Nevski	*Taeniatherum caput-medusae* (L.) Nevski
Thinopyrum ponticum (Podp.) Barkworth & D. R. Dewey	*Agropyron elongatum* (Host) Beauv.
Triticum aestivum L.	*Triticum aestivum* L.

resulting in a morphological continuum as well as partial restoration of fertility. This problem is not unique to the Triticeae but it is exacerbated by the relatively small number of diagnostic characters available for these grasses.

Key to the Genera

1. Spikelets three at a node, each with only one floret; only the central floret fertile (exc. in *Hordeum vulgare* in which all three florets are fertile) .... *Hordeum*

— Spikelets not three at a node OR with more than one floret per spikelet (n.b watch out for some forms of *Elymus elymoides* [= *Sitanion hystrix*] in which the second floret of the central spikelet is reduced and the lateral spikelets have only a single, sterile, floret) 2

2(1). Annual or biennial, introduced cereals or weeds 3

— Perennial; native or introduced 7

3(2). Glumes ovate, with three or more (often many) nerves at midlength 4

— Glumes subulate to lanceolate, only one vein evident at midlength 5

4(3). Spikelets sunk in the rachis, the spike therefore very slender, less than 5 mm in diameter; rachis disarticulating at maturity .... *Aegilops*

— Spikelets not sunk in the rachis, the spike therefore with a larger diameter; rachis not disarticulating at maturity .... *Triticum*

5(4). Spikes less than 2.5 cm long; lemmas 5–7.5 mm long .... *Eremopyrum*

— Spikes more than 4 cm long; lemmas more than 8 mm long 6

6(5). Glumes more than 15 mm long, subulate, united at the base and tapering into a long slender awn; spikelets with only one fertile floret; lemmas glabrous .... *Taeniatherum*

— Glumes 6–15 mm long, narrowly lanceolate to linear, free to the base, gradually acuminate but not awned; spikelets with two fertile florets; lemmas conspicuously scabrous on the keel .... *Secale*

7(2). Spikelets solitary at each node, closely imbricate, often pectinate; internodes short, less than one third the length of the spikelets .... *Agropyron*

— Spikelets two or more at some nodes OR, if single at all nodes, neither closely imbricate nor pectinate and with internodes about half as long as the spikelets or longer 8

8(7). Glumes 3–10 mm long, very narrow, 1-nerved at midbody length, their keels lying over the sides of the lowest lemmas rather than the midvein; lemmas awnless or with awns up to 7 mm long 9

— Glumes 5–90 mm long, with 2–5 nerves evident at midbody length; keels of the glumes lying opposite the midveins of the lowest lemmas; lemmas often truncate or with awns more than 10 mm long 10

9(8). Rachis disarticulating at maturity; truly cespitose, branching intravaginal, rhizomes never present; old leaf sheaths becoming fibrous .... *Psathyrostachys*

— Rachis not disarticulating at maturity; often rhizomatous, sometimes shortly so, branching extravaginal; old leaf sheaths not fibrous .... *Leymus*

10(8). Plants fertile; anthers well-filled prior to anthesis, dehiscent, usually bleached and falling off after anthesis 11

— Plants sterile; anthers poorly filled prior to anthesis, nondehiscent, retaining their color and usually retained on the plant 13

11(10). Glumes 6–12 mm long; linear-lanceolate to lanceolate, tapering from below midlength into an awn-tip; only one spikelet at most nodes .... *Pascopyrum*

— Glumes varied but if 6–12 mm long either obtuse or tapering only in the distal third; number of spikelets per node 1–4, varying between species 12

12(11). Glumes acute to long awned, never truncate or obtuse; anthers 2–3.5 mm long and plants cespitose *or* anthers more than 3.5 mm long, plants rhizomatous, *and* leaf blades with subequal ribs .... *Elymus*

— Glumes varied, often truncate or obtuse; anthers 4–7 mm long, plants rhizomatous or cespitose, if both long anthered and rhizomatous [*E. repens*], leaf blades with 2–3 minor ribs alternating with the major ribs 13

13(12). Plants cespitose; glumes acute-tipped; spikelets only slightly longer than the internodes .... *Pseudoroegneria*

— Plants rhizomatous or cespitose, if cespitose the glumes truncate to obtuse; spikelets almost twice as long as the internodes 14

14(13). Plants cespitose .... *Thinopyrum*

— Plants rhizomatous .... *Elytrigia*

15(10). Lemmas with divergent awns more than 15 mm long; nodes with only one spikelet .... × *Pseudelymus*

— Lemmas awnless or with nondiverging awns; nodes with one or two spikelets 15

16(15). Internodes less than 3 mm long; lowest lemmas usually less than 8.5 mm long ... . × *Elyhordeum*

— Internodes more than 3 mm long; lowest lemmas usually 9 mm or longer 16

17(16). Glumes 12–24 mm long .... × *Elyleymus*

— Glumes awnless or 25–85 mm long .... *Elymus* hybrids

Aegilops L.

Bowden (1959) argued that *Aegilops* should be included in *Triticum*, primarily because species of both genera have been involved in the evolution of many of such polyploid wheat species at *T. durum* Desf. and *T. aestivum* L. He noted also that the International Code of Botanical Nomenclature requires that intergeneric hybrids must have a different generic name from their parents. By including *Aegilops* in *Triticum* he obviated the need for a new generic name for the polyploid wheats. His treatment has since been adopted by Morris and Sears (1967) and Gould (1968).

The difficulty with this approach is that, if applied consistently, the tribe has to be reduced to a single genus because its members are connected by a network of introgressants and hybrids. Krause (1898) advocated recognition of a single genus, but most taxonomists have rejected his position because it ignores the differentiation, both morphological and physiological, that has occurred within the tribe. MacKey (1975) pointed out that the combination of annual growth habit and self-fertilization, such as occurs in *Aegilops* and *Triticum*, "stimulates morphological and physiological discontinuity in connection with ecological specialization without the necessity for a simultaneous construction of sterility barriers based on karyological differentiation." Of the two genera in question, *Aegilops* has remained a weedy genus with a relatively narrow ecological amplitude and is generally restricted to poor soils. *Triticum*, on the other hand, has a much wider ecological amplitude and greater ability to occupy fertile land. This, combined with its tendency to produce a larger grain, has led to rapid evolution in response to selection pressures exerted in part by human cultivation. Thus, we prefer to treat the two as separate genera both because of their morphological discontinuity and their different evolutionary potentials.

The nomenclatural code requires that a hybrid genus be given a different name from any of its parents, but it does not state what groups of species are to be treated as hybrid genera. A group that has become sufficiently well established that its origins are "ancient history" can be treated as a "normal" genus even if it is known to have originated through hybridization. The species of *Triticum* are such a group.

Agropyron Gaertner

This genus is now restricted to members of the crested wheatgrass group. Its members can be recognized by the very short internodes of the inflorescence and, in most instances, the pectinate arrangement of the spikelets. All our species are more or less cespitose, although forms that produce short rhizomes exist. Only one genome, the C genome, has been found in *Agropyron* s.str. Both diploids and polyploids are known.

Agropyron s.str. includes about 10 species, all of which are native to Eurasia. Considerable controversy exists concerning the appropriate taxonomic treatment for the plants found in North America (cf, e.g., Hitchcock 1951, Sarkar 1956, Schulz-Schaeffer et al. 1963, Dewey 1969a, Taylor and McCoy 1973). The species exhibit considerable morphological intergradation (cf. Tsvelev 1976), and the problems of identification are exacerbated by their ability to hybridize when brought into contact (Knowles 1955, Dewey 1969a), as has happened in North America. The genus needs detailed biosystematic study, based on wild populations, a project beyond the scope of this paper. The treatment presented here is based in part on Dewey's examination of specimens in the Komarov Institute (the National Herbarium of the Soviet Union) and discussions with Tsvelev.

Key to the Species of *Agropyron*

1. Spikelets diverging from the rachis at an angle of more than 40 degrees; glumes widespread, forming an angle of more than 120 degrees, giving the spike a bristly appearance; spikes at least 8 mm wide .... *A. cristatum*

— Spikelets diverging from the rachis at an angle of less than 350 degrees; glumes appressed; spikes 5–10 mm wide 2

2(1). Lemma with an awn 1–2(4) mm long; glumes forming an angle of approximately 60 degrees .... *A. desertorum*

— Lemma without an awn, sometimes mucronate; glumes forming an angle of approximately 45 degrees (not common) .... *A. fragile* (= *A. sibiricum*)

Elymus L.

Elymus is the largest genus in the Triticeae, but genomically it is very uniform. All of its members are allopolyploids in which two genomes are present, one derived from *Pseudoroegneria spicata* or a relative thereof, and the other from *Hordeum*. Almost all plants examined, including all those from the Intermountain Region, are tetraploids ($2n = 28$).

Despite their genomic similarity, species of *Elymus* fall into two distinct morphological groups. The largest group consists of selffertilizing, cespitose species with small anthers; the other of rhizomatous, outcrossing species, with long anthers. Dewey (1983a) earlier included the latter group in *Elytrigia* with other rhizomatous, long-anthered, but genomically distinct species; but he now (1983b) includes them in *Elymus*, a treatment that better reflects their phylogenetic affinities. These rhizomatous species of *Elymus* differ from those of *Elytrigia* in having glumes that are acute or shortly awned, rather than truncate or long-awned, and leaf blades with no evident alteration of major and minor ribs on the adaxial surface. As interpreted here, there is only one such species in the Intermountain Region, *Elymus lanceolatus* [= *Agropyron dasystachyum* and *Agropyron albicans*, cf. Table 1.]. The change in epithet is necessary because the combination *Elymus dasystachys* has been used for a European species.

Elymus includes two other species that used to be included in *Agropyron* (*E. scribneri* and *E. trachycaulus*), because they have only one spikelet per node. We maintain that the morphological, reproductive, and genomic similarity of these two species to others with a similar genomic composition is more significant than the number of spikelets per node.

Elymus elymoides [= *Sitanion hystrix*] and *E. multisetus* [= *S. jubatum*] have previously been included in *Sitanion* (A. Hitchcock 1951, C. Hitchcock 1969, Holmgren and Holmgren 1977), a genus characterized by a readily disarticulating rachis and subulate, long-awned glumes. Genomic studies have shown, however, that the species included in *Sitanion* are just as closely related to the SH species previously included in *Elymus* or *Agropyron* as these species are to each other (Stebbins and Snyder 1956, Stebbins et al. 1946, Stebbins and Vaarama 1954, Brown and Pratt 1960, Dewey 1967, 1969b, Church 1967a, b).

The disarticulating rachis, long subulate glumes, and reduced sterile florets constitute a set of adaptations for dispersal in open environments because the segments of the spike are easily blown over the ground. Similar features are found in one of the forms of the dimorphic species *Aegilops speltoides*. The other form consists of plants with a non-disarticulating rachis, short glumes, and more fertile florets. Zohary and Imber (1963) showed that the differences between the two forms are determined by a group of closely linked genes that are normally inherited as a block. No studies have been conducted to determine whether the same is true of the characteristics used to delimit *Sitanion*, but Zohary and Imber's study lends credence to our conviction that *Sitanion* does not merit recognition at the generic level.

Three hybrid species are included in our interpretation of *Elymus*, *E.* × *hansenii*, *E.* × *pseudorepens*, and *E.* × *saundersii*. These were previously referred to × *Elysitanion*, *Agropyron*, and *Agrositanion*, respectively. The change in their generic position results from changes in the treatment of their parental taxa.

Our treatment of *Elymus trachycaulus* differs somewhat from that endorsed by Holmgren and Holmgren (1977). The taxonomy of the slender wheatgrass complex, of which *Elymus trachycaulus* is a part, is extremely difficult to elucidate. Jozwik (1966) recognized four groups in North America, primarily on the basis of field, hybridization, and herbarium studies. He suggested that many of the members of two of his groups may have been derived by hybridization, one of them comprising plants derived from a variety of different hybrid combinations. He described the largest of the other two groups (which corresponds to subsp. *trachycaulus* in our treatment) as morphologically diverse, probably as a result both of innate genetic plasticity and introgression from other taxa. It has a wide ecological amplitude, growing along stream banks and in forests, meadows, and moist prairies. Geographically it is extremely widespread, extending from Mexico to Alaska and to both the west and east coasts of North America.

Subspecies *latiglumis* corresponds to Jozwik's other, primarily nonhybrid, group. Its members are more or less restricted to subalpine, alpine, and far northern locations, but at lower elevations they tend to intergrade with subsp. *trachycaulus*, probably in part because of hybridization.

Our third subspecies, subsp. *subsecundus*, corresponds to Jozwik's second group. This is the group that he believed consisted almost entirely of hybrids. His data indicated that the second parent could be one of several taxa, e.g. *E. elymoides*, *E. multisetus*, *E. glaucus*, and *H. jubatum*. Intermediates between the members of this subspecies and subsp. *trachycaulus* were numerous. He also found intermediates with subsp. *latiglumis*, but these were much less frequent.

We admit that our treatment of this complex is not altogether satisfying, but it seems the most appropriate treatment considering the data available. Even if more data were available, it would be impossible to design a completely satisfying treatment for such a group because the formal requirements of the nomenclatural code cannot perfectly reflect the dynamic interactions occurring in a group such as the slender wheatgrass complex.

Our treatment of *E. elymoides* also differs from that in Holmgren and Holmgren (1977) in that we are not recognizing any infraspecific taxa.

Key to Species and Hybrids of Elymus

1. Spikelets 2–7 at a node 2
— Spikelets solitary at each node 7

2(1). Glumes subulate, 1–2-nerved at midlength and with awns more than 20 mm long; rachis disarticulating at maturity 3
— Glumes lanceolate, 2–5-nerved at midlength, if 2-nerved the awns less than 5 mm long; rachis not disarticulating at maturity 5

3(2). Awns not diverging, even at maturity .... *E.* × *hansenii*
— Awns widely divergent at maturity 4

4(3). Glumes longitudinally divided into 3 or more narrow sections .... *E. multisetus*
— Glumes entire or bifid .... *E. elymoides*

5(2). Rachis flexible, spike nodding; glumes with an awn 10–30 mm long ..... *E. canadensis*
— Rachis stiff, spike erect; glumes unawned or short awned 6

6(5). Glumes bowed outward and indurate at the base, the nerves not evident in the indurate portion .... *E. virginicus* var. *submuticus*
— Glumes not bowed out, membranous at the base, nerves evident throughout .... *E. glaucus*

7(1). Plants rhizomatous; anthers 3–5 mm long 8
— Plants cespitose; anthers 1–3 mm long 10

8(7). Plants sterile, anthers not well filled at anthesis, not dehiscent ..... *E.* × *pseudorepens*
— Plants fertile, anthers well filled at anthesis, dehiscent (*E. lanceolatus*) 9

9(8). Lemmas awnless or with an awn-tip less than 5 mm long .... *E. lanceolatus* subsp. *lanceolatus*
— Lemmas with a divergent awn 5–12 mm long .... *E. lanceolatus* subsp. *albicans*

10(7). Lemmas awned, the awns widely divergent; culms decumbent, usually less than 35 cm tall .... *E. scribneri*
— Lemmas unawned or, if awned, then erect or only slightly divergent; culms erect, usually more than 50 cm tall 11

11(10). Glumes 1–2(3)-nerved; rachis tending to disarticulate at maturity; plants sterile .... *E.* × *saundersii*
— Glumes (3) 5-nerved; rachis not disarticulating at maturity; plants fertile (*E. trachycaulus*) 12

12(11). Lemma awns 8–24 mm long, erect to divergent . *E. trachycaulus* subsp. *subsecundus*
— Lemmas awnless or with short, erect, awns less than 5 mm long 13

13(12). Culms erect, 30–130 cm tall; glumes with a narrow hyaline margin .... *E. trachycaulus* subsp. *trachycaulus*
— Culms often geniculate or decumbent, less than 55 cm tall; glumes with a broad hyaline margin .... *E. trachycaulus* subsp. *latiglumis*

Elymus lanceolatus **subsp.** ***albicans*** (Scribner & J. G. Smith) Barkworth & D. R. Dewey, *comb. nov.*— Basionym: *Agropyron albicans* Scribner & J. G. Smith, USDA Div. Agrost. Bull. 4:32, 1897.

Elymus × pseudorepens (Scribner & J. G. Smith) Barkworth & D. R. Dewey, *comb. nov.*— Basionym: *Agropyron pseudorepens* Scribner & J. G. Smith, USDA Div. Agrost. Bull. 4:34, 1897, pro sp.

Elytrigia Desv.

All species of *Elytrigia* are outcrossing, but in their other characteristics, including their genomic composition, they are very diverse. It is undoubtedly the least satisfactory genus as presently constituted and the one that most needs further study. There are only two species in the Intermountain Region, both of which are introduced.

Key to the Species of *Elytrigia*

1. Glumes acute to awn tipped, membranous; rachis only slightly concave adjacent to spikelet .... *E. repens*
— Glumes truncate or mucronate, thick; rachis markedly concave adjacent to the spikelet (*E. intermedia*) 2

2(1). Lemmas glabrous; spikelets 3–8-flowered .... *E. intermedia* subsp. *intermedia*
— Lemmas hirsute; spikelets 2–3(-6)-flowered .... *E. intermedia* subsp. *barbulata*

Hordeum L.

The limits of this genus have not been changed but we have adopted the infrageneric treatment recommended by von Bothmer (pers. comm.), since he has studied the genus in both North and South America as well as Europe. This seems particularly appropriate since the taxa for which von Bothmer's treatment differs from that in Holmgren and Holmgren (1977) are all introduced Mediterranean weeds. Moreover, although Holmgren and Holmgren treated the subspecies of *H. murinum* at the specific level, they noted that the taxa were very closely related and often difficult to distinguish. Thus, the differences between the two treatments are not as great as it may appear. No key is presented since the Holmgren's key can be used, the only changes needed being nomenclatural. These are indicated in Table 1.

Leymus Hochst.

In our region, the species of this genus can be recognized by their short, subulate glumes that lie over the sides rather than the midveins of the lemmas, and by the absence of long awns. The genus includes both rhizomatous and cespitose, but extravaginally branching, species.

Species of *Leymus*, both here and elsewhere, tend to grow in alkaline or saline soils. Some are coastal in distribution; others are inland species. The two groups are morphologically distinct. Our species, not surprisingly, belong to the inland group.

Despite the morphological discontinuity between its coastal and inland members, species of *Leymus* are genomically similar. They are all allopolyploids based on the J genome, from *Psathyrostachys*, and the X genome whose origin is unknown. Tetraploids ($2n$ = 28), hexaploids ($2n$ = 42), and octoploids ($2n$ = 56) are known. Thus species of *Leymus* differ from species of *Elymus* both in their genomic composition and their tendency to form higher polyploids.

In traditional treatments of the tribe, *Leymus* is included in *Elymus* since most of its members have more than one spikelet at a node. As indicated above, however, the two genera differ from each other in a number of other morphological characteristics. Moreover, *L. salinus* and *L. simplex* usually have only one spikelet at most, if not all, nodes. The treatment of *L. salinus* presented here is based on work by Atkins (1983; Atkins et al., in press).

Key to Species of *Leymus*

1.	Plants strongly rhizomatous, the rhizomes long and slender	2
—	Plants cespitose, sometimes with short rhizomes	5
2(1).	Lemmas conspicuously hirsute, the hairs 1–2 mm long, not closely appressed to the lemma	*L. flavescens*
—	Lemmas glabrous to, at most, inconspicuously hirsute with hairs less than 1 mm long	3
3(2).	Leaf blades with more than 7 veins, not densely hirsute above the ligule; most nodes with two or more spikelets	*L. triticoides*
—	Leaf blades with 5–7 prominent veins, densely short-hirsute above the ligule; most nodes with only one spikelet	*L. simplex*
5(1).	Leaf blades 4–15 mm wide, flat, many nerved; ligules 2–5 mm long; culms more than 1 m tall	*L. cinereus*
—	Leaf blades 2–4 mm wide when flat, strongly involute, 5–7-nerved; ligules less than 2 mm long; culms less than 1 m tall (*L. salinus*)	6
6(5).	Basal leaf sheaths glabrous; most nodes with only one spikelet	*L. salinus* subsp. *salinus*
—	Basal leaf sheaths conspicuously hirsute; most nodes with two or more spikelets	*L. salinus* subsp. *salmonis*

Leymus salinus* subsp. *salmonis (C. Hitchc.) Atkins, *comb. nov.*— Basionym: *Elymus ambiguus* var. *salmonis* C. Hitchc. Univ. Wash. Publ. Biol. 17(1):558, 1969. Holotype: WTU!

Pascopyrum A. Löve

Pascopyrum is a monotypic genus comprising only *P. smithii*. This species is an octoploid, its probable parents being *Elymus lanceolatus* and *Leymus triticoides* (Dewey 1975). Morphologically it is intermediate between its parents. This is particularly evident in the glumes, which are membranous and flat at the base, as it typical for *Elymus*, but then taper gradually into an acuminate tip resembling the linear lanceolate glumes characteristic of *Leymus*. Holmgren and Holmgren (1977) recognized two varieties within the species, but we do not consider either merits formal recognition.

Psathyrostachys Nevski

This genus is comprised of eight species that are native to the steppes and arid regions of southeastern Europe. They are all strictly cespitose and have disarticulating rachises and two spikelets at a node. All the species studied so far are diploids based on the J genome. *Psathrostachys juncea* (Russian wild rye) is the only species to have become established in North America.

Pseudoreogneria A. Löve

All species of *Pseudoroegneria* are based on a single genome, the S genome. The genus consists of several Eurasian species but only one North American species, *P. spicata*. Most of its members can be recognized by their rather slender habit and the single spikelets that are only slightly longer than the internodes.

In previous discussions of the tribe, Dewey (1982, 1983a, b) has included these species in *Elytrigia* in conformity with Tsvelev's (1976) treatment. It is clear, however, that they are genomically distinct and consequently, in keeping with the philosophy guiding this revised treatment, should be recognized at the generic level. No new combinations are necessary for the Intermountain Region.

Thinopyrum A. Löve

This is a Eurasian genus but one of its members, *T. ponticum*, has been introduced into North America and occurs along highways in the Intermountain Region. We have followed Holub (1973) and Melderis (1980) in adopting the epithet *pontica* for the plants that Holmgren and Holmgren (1977) referred to *Agropyron elongatum*. The epithet *elongata* is now interpreted as referring to a western Mediterranean species of relatively small, slender plants, all of which are diploids. *Thinopyrum ponticum* (Tall Wheatgrass) consists of robust decaploid plants that are widespread in Eurasia. It has been seeded at scattered locations in the Intermountain Region. The new combination is presented here:

Thinopyrum ponticum (Podp.) Barkworth & D. R. Dewey, *comb. nov.*— Basionym: *Triticum elongatum* (Host), Gram. Austr. 2:18, 1802).

× *Elyhordeum* Mansf. ex Zizin & Petr.

One hybrid between *Elymus* and *Hordeum* is established in the Intermountain Region, × *E. macounii*. Its parents are *Elymus trachycaulus* and *Hordeum jubatum* (Boyle and Holmgren 1955). In previous treatments it was included in × *Agrohordeum macounii*. The transfer to × *Elyhordeum* is made necessary by the transfer of *Agropyron trachycaulum* to *Elymus*.

× ***Elyhordeum macounii*** (Vasey) Barkworth & D. R. Dewey, *comb. nov.*— *Elymus trachycaulus* (Link) Gould ex Shinners × *Hordeum jubatum* L.— Basionym: *Elymus macounii* Vasey, Grasses U.S. 46, 1883. *Macoun*, Great Plains of B.C.

× *Elyleymus* Baum

One hybrid between *Elymus* and *Leymus* occurs in the Intermountain Region, × *Elyleymus aristatus*. Dewey and Holmgren (1962) have shown that its parents are probably *Elymus elymoides* and *L. triticoides*. Holmgren and Holmgren (1977) referred it to × *Elysitanion aristatum*.

× ***Elyleymus aristatus*** (Merrill) Barkworth & D. R. Dewey, *comb. nov.*— *Elymus elymoides* (Raf.) Barkworth & Dewey × *Leymus triticoides* (Buckley) Pilger.— Basionym: *Elymus aristatus* Merrill, Rhodora 4:147, 1902. *Cusick 2712*, "in large clumps, Silver Creek, Harney Co., Oregon."

× *Pseudelymus* Barkworth & D. R. Dewey, gen. hybr. nov.

× ***Pseudelymus*** Barkworth & D. R. Dewey, *gen. hybr. nov.*— *Pseudoroegneria* A. Löve × *Elymus* L.

One hybrid between *Pseudoroegneria* and *Elymus* has become established in western North America, × *P. saxicola*. The generic name × *Pseudelymus* is presented here to accommodate it and other such hybrids that may occur elsewhere.

The parents of × *P. saxicola* are *Pseudoroegneria spicata* and *Elymus elymoides* (Dewey 1964). The plants are usually completely sterile but, being perennial, once they are established at a location, they will persist there. The change in generic name is made necessary by changes in generic boundaries affecting its parents.

× ***Pseudelymus saxicola*** (Scribner & J. G. Smith) Barkworth & D. R. Dewey, *comb. nov.*— *Pseudoroegneria spicata* (Pursh) A. Löve × *Elymus elymoides* (Raf.) Sweezy.— Basionym: *Elymus saxicolus* Scribner & J. G. Smith, USDA Div. Agrostol. Bull. 18:20, 1899, pro. sp.

DISCUSSION

Selection of the most appropriate taxonomic treatment of a polyploid complex is always difficult. This is particularly true when the members of the complex hybridize as readily as do members of the Triticeae. The problem is compounded by the great morphological reduction that characterizes all grasses and the prevalence of convergent evolution. The treatment presented here seeks to reflect as completely as possible all available data. It is therefore a compromise between a strictly genomic interpretation and one based entirely on morphological data.

The main advantage of this treatment is that it reflects a higher proportion of the genomic and morphological information available than does the traditional treatment. It is also in closer accord with the systems adopted by Tsvelev (1976) and Tutin et al. (1980). Since both the Soviet Union and Europe have more species of Triticeae than the United States and Canada combined, it is appropriate to consider seriously the treatments advocated by taxonomists in those regions.

Some of the new genera are not, perhaps, as easy to recognize as the old interpretation of *Agropyron* and *Elymus.* On the other hand, numerous herbarium specimens indicate that *Leymus salinus* and *Leymus simplex,* which have only one spikelet at most of their nodes, have often been misidentified as species of *Agropyron* rather than *Elymus.* Thus, even the traditional treatment was sometimes difficult to apply. The revised genera can be recognized on the basis of their gross morphological characters, although not the same characters as before. We hope that this treatment will assist those wishing to become familiar with the new generic concepts.

Acknowledgments

We thank Drs. A. Löve and J. McNeill for their careful review and criticism of the initial draft of this manuscript and for the numerous discussions concerning the taxonomy of the Triticeae in general.

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REPRODUCTIVE ATTRIBUTES OF SOME ROCKY MOUNTAIN SUBALPINE HERBS IN SUCCESSIONAL CONTEXT

David J. Schimpf[1,2] and Robert L. Bayn, Jr.[1,3]

Abstract.— Selected reproductive attributes of herbaceous plant species were compared among three stages of a sere in the subalpine zone of Utah's Wasatch Mountains: herbaceous meadow, aspen grove, spruce-fir forest. No successional trends in seed size or inferred mode of seed dispersal were detected. We ascribe the deviation of these findings from those of most other studies to differences in climate, life-form composition, or community age between our sere and those of other studies. A variety of flower colors were found in the meadow stage, grading into a predominance of white flowers under conifers. Animal vectors of pollen, capable of effecting plant outcrossing, were most abundant in the meadows and an order of magnitude less abundant under aspen.

Attempts to develop inductive generalizations about ecological succession have included studies of reproductive characteristics of plants. Among the earliest were those of Salisbury (1942), who found British woodland species to have heavier seeds than those of species in open vegetation. This was largely due to woody species having heavier seeds than herbs, but forest herbs were also heavier seeded than meadow herbs. Salisbury suggested that low light intensity on forest floors favored individuals with stored materials in the seed sufficient to fabricate a greater light-intercepting surface. These results have been generally corroborated for grassland (Hayashi 1976, Werner and Platt 1976) as well as forest (Opler et al. 1977, Abrahamson 1979) seres. The statistical significance of these increases in seed size during succession has not been established. Marino (1980) found no significant difference in seed size of foredune herbs and shrubs from those under dune forest, but those of the intermediate slack dune stage were significantly smaller.

The mode of seed dispersal, as inferred from diaspore morphology, has been suggested to change toward a greater frequency of animal dispersal as forest succession proceeds (Dansereau 1957, Dansereau and Lems 1957, Harper et al. 1970, Johnston and Odum 1956, Pijl 1972, Opler et al. 1977). Hayashi (1976) did not detect this trend in a grassland sere. Several of these authors, as well as others, suggest that animal dispersal adaptations may be more common among woody species than among herbaceous species. If so, the successional changes in dispersal mode may be due to changes in the proportions of various life forms. Statistical tests of these trends are lacking.

Most of the above studies were conducted in temperate deciduous forest or tropical moist forest biomes. Our study examined some plant reproductive attributes in stands along a sere terminating in subalpine coniferous evergreen forest. Seed sizes, dispersal modes, flower color frequencies, and abundance of animal pollen vectors most likely to effect floral outcrossing were compared among the stages of this sere.

Study Area and Methods

Field work was conducted in the subalpine zone of the Wasatch Mountains in extreme northern Utah. The presumed sere involves vegetative colonization of well-drained, herb-dominated meadows by clones of quaking aspen, *Populus tremuloides* Michx. The climax forest is dominated by subalpine fir, *Abies lasiocarpa* (Hook.) Nutt., and Engelmann spruce, *Picea engelmannii* Parry. No other

[1]Department of Biology and Ecology Center, Utah State University, Logan, Utah 84322.
[2]Present address: Department of Biology, University of Minnesota, Duluth, Minnesota 55812.
[3]Present address: Bio-Resources, Inc., P.O. Box 3447, Logan, Utah 84321.

woody species are significant community components. For further discussion of community dynamics and a site description, see Schimpf et al. (1980).

For each stage of succession, we selected abundant herbaceous species producing substantial numbers of seed, thus excluding vegetative remnants of earlier stages. Species were included if they produced at least 100 seeds from a total of 10 or more mother plants within a 0.2-ha rectangular plot during the summers of 1976, 1977, or 1978. There was one such plot for each stage in the example of the sere known as Big Meadow (Schimpf et al. 1980): meadow, aspen, fir, spruce-fir. The species inclusion criteria proved unworkable for the fir and spruce-fir plots, owing to lower population densities and seed production per plant; these plots were treated as a single 0.4-ha conifer plot to determine species inclusion and for all data analyses. Species which qualified for inclusion were all counted equally in the analyses of reproductive attributes, rather than being weighted by abundance.

Total weight was determined for a sample of 100 seeds (or caryopses or achenes) for each species in a stage. Samples had been heated overnight at 100 C after collection to stop respiration. All seeds and caryopses were inspected microscopically, and all achenes sectioned transversely to confirm seed development before being weighed to the nearest 0.1 mg, in equilibrium with atmospheric humidity. Size was expressed as mean mg per seed. Baker (1972) reported that mean seed sizes of a group of plant species are often not normally distributed. The distribution of mean sizes in each stage was tested for normality with the Kolmogorov-Smirnov method (Sokal and Rohlf 1969), using both untransformed and log-transformed variates. Transformed mean seed sizes were compared among stages by analysis of variance. Pairs of stages were compared for their intrinsic variation in mean sizes by the F-ratio of variances (log-transformed data) (Lewontin 1966).

Flower color was recorded in the field for each species. The presumed mode of dispersal was classified as animal, wind, or other from inspection of diaspore structure. The frequency distributions of flower color and dispersal mode categories were compared among stages by chi-square tests. Chi-square was also employed to test for differences in frequency of animal dispersal modes among different plant life forms.

Insects suspected to be capable of effecting floral outcrossing were sorted from the general collections of insects associated with the herbaceous layer. Suspected pollinators included all adults in the following families: Syrphidae, Bombyliidae, Colletidae, Halictidae, Andrenidae, Megachilidae, Apidae, Sphingidae, Nymphalidae, Lycaenidae. These collections were obtained by D-Vac sampling of from 130 to 310 randomly chosen 0.50-m^2 or 0.25-m^2 plots that had been quickly covered with an insect-tight cage (Southwood 1978). Samples were taken at regular intervals throughout the 1977 and 1978 growing seasons in nearby examples of the successional stages similar to those at Big Meadow. Results were expressed as m^2 sampled per pollinator caught.

RESULTS

The 46 herbaceous taxa studied included 26 species in the meadow plot, 22 taxa in the aspen plot (including two varieties of one species), and 23 species in the conifer plot (Table 1). Mean seed sizes fail to exhibit a normal distribution within a stage, based on the Kolmogorov-Smirnov test. Following log transformation, all three stages show a normal distribution. The mean and standard deviation of transformed variates is depicted for each stage in Figure 1. None of the F values are significant at the .05 level; the means and variances of seed sizes in the three stages are statistically indistinguishable. No successional trends in community seed size are apparent. There are also no discernible patterns of size change within the set of those species that occupy two or more stages (Table 1), based on sign tests (Sokal and Rohlf 1969). White-flowered species become increasingly frequent and the red- and blue-flowered species less frequent through successional time, although this trend was not significant at the 0.05 level (Table 2). Modes of dispersal have similar frequencies in all three successional stages (Table 3), suggesting that there is no trend in this attribute.

Pollen vector abundance was notably lower during 1977 than during 1978 (Table 4). In both summers, abundance is an order of magnitude greater in the meadows than in the aspen understory, with intermediate values in conifer understory. The most abundant pollinator families in the meadows were Halictidae, Apidae, and Syrphidae, each about

TABLE 1. Reproductive attributes of the herbaceous taxa.

Taxon	Mean seed size, mg			Flower color	Dispersal mode
	Meadow	Aspen	Conifer		
Achillea millefolium L. ssp. *lanulosa* (Nutt.) Piper	0.166	0.157	0.197	White	Other
Agoseris aurantiaca (Hook.) Greene var. *aurantiaca*	3.017	2.513		Orange	Wind
Agropyron trachycaulum (Link) Malte var. *glaucum* (Pease & Moore) Malte		3.359	3.324	Green	Animal
Agropyron trachycaulum (Link) Malte var. *latiglume* (Scribn. & Smith) A. A. Beetle	2.807	3.125		Green	Other
Androsace filiformis Retz.			0.359	White	Other
Aquilegia coerulea James var. *ochroleuca* Hook.			1.318	White	Other
Arabis drummondii Gray	0.255			Pink	Wind
Arnica cordifolia Hook. var. *cordifolia*			1.080	Yellow	Wind
Arnica parryi Gray			1.462	Yellow	Wind
Aster engelmannii (Eat.) Gray			3.091	White	Wind
Aster integrifolius Nutt.	1.932			Blue	Wind
Bromus carinatus Hook. & Arn.	6.905			Green	Animal
Castilleja miniata Dougl. var. *miniata*		0.383		Red	Wind
Claytonia lanceolata Pursh var. *lanceolata*	0.740	0.823	0.782	White	Other
Collomia linearis Nutt.	2.141			Pink	Other
Delphinium nuttallianum Pritz. var. *nuttallianum*	0.601			Purple	Other
Descurainia richardsonii (Sweet) Schulz var. *sonnei* (Robins.) C.L. Hitchc.		0.206	0.205	Yellow	Other
Draba stenoloba Ledeb. var. *nana* (Schulz) C.L. Hitchc.			0.084	Yellow	Other
Epilobium brachycarpum Presl	0.115		0.125	White	Wind
Epilobium lactiflorum Haussln.	0.802			Pink	Wind
Erigeron speciosus (Lindl.) D.C. var. *macranthus* (Nutt.) Cronq.		0.263	0.294	Blue	Wind
Eriogonum heracleoides Nutt.	2.786			Yellow	Other
Erysimum asperum (Nutt.) D.C. var. *purshii* Durand		0.719		Yellow	Other
Erythronium grandiflorum Pursh	5.125	5.992	6.660	Yellow	Other
Galium bifolium Wats.	2.427	3.260	3.338	White	Animal
Geranium viscosissimum Fisch. & C.A. Meyer var. *nervosum* C.L. Hitchc.	11.065			Pink	Other
Gilia aggregata (Pursh) Spreng.	1.369			Red	Other
Hackelia micrantha (Eastw.) J.L. Gentry	3.621	4.058		Blue	Animal
Hieracium albiflorum Hook.			0.430	White	Wind
Hieracium scouleri Hook.	0.814	0.926		Yellow	Wind
Hydrophyllum capitatum Dougl. var. *capitatum*			4.752	White	Other
Ligusticum filicinum Wats.		6.501	5.932	White	Other
Lupinus argenteus Pursh var. *rubricaulis* (Greene) Welsh	27.706	26.478		Blue	Other
Madia glomerata Hook.	2.664			Yellow	Other
Osmorhiza chilensis Hook. & Arn.		7.746	4.673	White	Animal
Osmorhiza occidentalis (Nutt.) Torr.	12.666	13.953		White	Other
Pedicularis racemosa Dougl. var. *alba* (Pennell) Cronq.			1.976	White	Other
Poa nervosa (Hook.) Vasey var. *wheeleri* (Vasey) C.L. Hitchc.		0.470	0.580	Green	Other
Polygonum douglasii Green var. *douglasii*	2.039			White	Other
Potentilla arguta Pursh var. *convallaria* (Rydb.) Th. Wolf	0.276			Yellow	Other
Rudbeckia occidentalis Nutt. var. *occidentalis*	2.070	1.657		Yellow	Other
Senecio crassulus Gray		2.633	2.855	Yellow	Wind
Senecio serra Hook.	0.745			Yellow	Wind
Stipa lettermanii Vasey	1.105			Green	Animal
Trisetum spicatum (L.) Richter		0.165	0.172	Green	Animal
Viola nuttallii Pursh var. *major* Hook.		3.944	3.478	Yellow	Animal

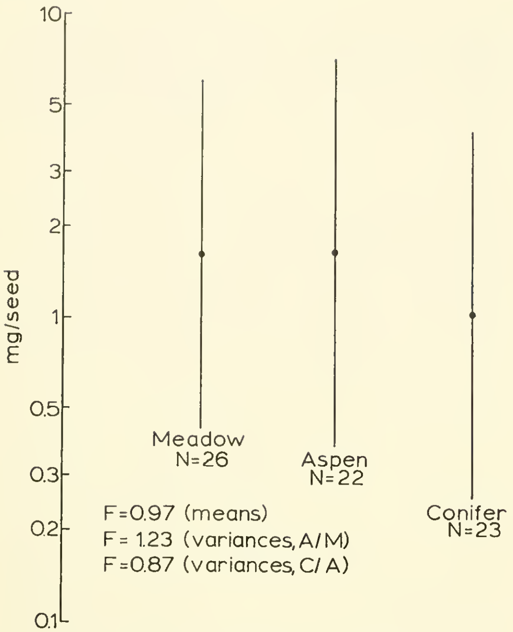

Fig. 1. Seed sizes of species in each stage of succession, depicted on log-scale. Dots represent means of log-transformed species means for each stage, with bars extending one standard deviation above and below these. N is the number of species in a stage. None of the F values are statistically significant.

12–15 m^2 per individual averaged over the two years. So few pollinators were caught in the forest understories that we cannot recognize their numerically dominant families with confidence.

Discussion

Several explanations can be offered for the lack of a successional increase in seed size (Fig. 1). Unlike almost all seres for which seed size has been studied, ours does not include a pioneer stage. The meadows we studied have apparently been unforested for centuries and are being slowly invaded vegetatively by forests due to climatic change (Schimpf et al. 1980). Thus, we do not expect the meadows to be dominated by species with light, highly vagile diaspores to the extent that recently deforested sites often are.

Likewise, our study site differs considerably from the deciduous forest and tropical moist forest sites of other studies with respect to environmental conditions. Soil at our site dries quickly after snowmelt, and summer rain is far less than potential evaporation. This is especially marked in the meadows, where evaporative potential is more than twice that under the conifer canopy (Schimpf et al. 1980). Because low moisture availability has been correlated with greater seed size, both interspecifically (Baker 1972) and intraspecifically (Schimpf 1977), the dryness of the meadows may offset the dim illumination of the spruce-fir understory as a force selecting for larger seeds. Marion (1980) found equally large seeds in the most xeric and most shaded stages of a sere.

Some reports of increases in seed size with succession appear to be equivocal. Werner and Platt (1976) found greater seed sizes of herbaceous *Solidago* species in climax than in seral ecosystems, but this is confounded by the location of the climax stand in a drier climate than that of the seral stand. The significance of an interspecific successional increase in herb seed size (Abrahamson 1979) is due to the presence of a single large-seeded climax species; no significant increase can be shown if the sizes are first normalized by log transformation. Perhaps the most noteworthy seed size increases during succession are those associated with shifts in life form composition.

A number of recent community-level studies of flower color in western North America concur that white flowers are relatively more

TABLE 2. Number of species in each flower color category in each successional stage.

Color category	Meadow	Aspen	Conifer
Red, orange, or pink	6	2	0
Blue or purple	4	3	1
Yellow	7	7	7
White	6	6	12
X^2 = 10.70, .05<P<.10			

TABLE 3. Number of species in each dispersal mode category in each successional stage.

Type of dispersal	Meadow	Aspen	Conifer
Animal	4	6	5
Wind	7	5	7
Other	15	11	11
X^2 = 1.46, P>.25			

Table 4. Abundance of pollinators capable of effecting floral outcrossing. Total area D-Vac sampled over the course of the summer and area sampled per pollinator caught is expressed for each successional stage.

	Meadow		Aspen		Conifer	
Year	m^2 sampled	m^2 per pollinator	m^2 sampled	m^2 per pollinator	m^2 sampled	m^2 per pollinator
1977	155	5	59	59	33.5	8
1978	97	2	36.5	19	32.5	6

frequent under dense forest canopies than in better illuminated layers of vegetation (Baker and Hurd 1968, Daubenmire 1975, Moldenke 1976, Ostler and Harper 1978, del Moral and Standley 1979), but do not take a successional perspective. The similar pattern in our stands (Table 2) leads us to believe that a shift toward white-flowered species may be a widespread successional trend, but this also needs to be tested with seres including pioneer stages. We resist the temptation to propose functional interpretations of this pattern on the basis of human visual perceptions, which differ from those of pollen vectors, especially in the ultraviolet region (Kevan 1978, Goldsmith 1980). A spruce canopy acts as a neutral filter in the visible range, even when sun flecks are not considered (Federer and Tanner 1966). Therefore, the potential visibility of various colors (on a relative scale) probably changes minimally along our sere. Though we might expect the conifer understory to be bathed in radiation somewhat enriched in ultraviolet relative to visible (Vézina and Boulter 1966), white flowers may be the least UV-reflective (Guldberg and Atsatt 1975); thus the importance of signals in the ultraviolet may not change much during succession.

The similar frequencies of dispersal modes in all stages (Table 3) perhaps simply reflects the lack of change in life form composition in the lower strata of the sere. Shrubs and woody vines, surmised to have high proportions of species possessing adaptation for animal dispersal, are commonly thought to be most important in intermediate stages of seres, though we are not aware of any rigorous tests of this hypothesis. It is interesting that Thompson and Willson (1978) demonstrated more rapid vertebrate removal of fleshy fruits when experimentally provided at a forest edge than when placed beneath a closed forest canopy, implying that temperate frugivores frequent intermediate seral stages, perhaps in response to vegetation physiognomy.

The differences among successional stages in abundance of pollinators reported in Table 4 are large, but nonetheless underestimated. Several strong-flying vectors were not sampled by the D-Vac technique, but were common to abundant nectar feeders in meadows. These were the sphinx moth *Hyles lineata* (Fabricius) and the hummingbirds *Selasphorus platycercus* (Swainson) and *S. rufus* (Gmelin), which visited primarily *Gilia*, *Delphinium*, and *Geranium* flowers. We casually observed essentially no moth activity in the forests, but expect some associated with the bloom of *Aquilegia* there. Smith (1982) quantitatively recorded hummingbird feeding in aspen understory but only transient flights through spruce-fir stands.

The level of herbaceous productivity undoubtedly affects the abundance of associated vectors. Lower pollinator densities in 1977 (Table 4) are associated with reduced herb aboveground productivity following an exceptionally dry winter (Schimpf et al. 1980). Within years, differences among stages in vector abundance do not correlate well with differences in herbaceous aboveground phytomass; meadow standing crop is four times that of herbs under conifers, and two to three times that of aspen understory (Reese 1981). Vectors respond, of course, to pollen and nectar rather than to total primary production, but we lack the requisite data to evaluate floral resource levels. The apparent low density of pollinators in aspen understory awaits elucidation.

Acknowledgments

We thank James A. MacMahon and Ivan G. Palmblad for comments on an earlier draft, and Linda Finchum, Karin Cowper, and Avis Hedin for typing the manuscript. This work was supported by NSF Grant DEB 78-05328 to James A. MacMahon.

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APPLICABILITY OF THE UNIVERSAL SOIL LOSS EQUATION FOR SOUTHEASTERN IDAHO WILDLANDS[1]

Mark E. Jensen[2]

Abstract.— In 1981, 20 sediment-collecting tanks and troughs were installed on range and timbered sites of the Caribou National Forest. Measured erosion losses from the first year of study were contrasted to Universal Soil Loss Equation (USLE) estimates utilizing three different vegetative factors. State of Idaho C factors, National Rangeland C factors, and the Vegetative Management (VM) factors were studied. The erosion estimates of all three USLE tests were significantly different than measured soil losses. All equations overestimated the measured mean soil loss, 0.52 megagrams/ha/yr (0.23 tons/ac/yr), by 33, 3,000, and 2,000 percent, respectively. The soil erodibility factor (K), Rangeland C, and VM showed significant relationships to soil loss. The K and VM factors accounted for 88 percent of the variability in sediment loss in multiple regression models. Erosion equations suitable for use on this study area are presented.

Soil scientists are frequently required to provide land managers with estimates of soil erosion rates on specific sites. The ongoing preparation of Land Use Plans for forests managed by the U.S. Forest Service, Intermountain Region, has increased the need for realistic approaches to estimating erosion rates. The Universal Soil Loss Equation (USLE) is the dominant method used in making soil erosion estimates within the region (Wischmeier 1968). However, questions have been raised as to the validity of this equation when applied to wildlands (U.S. Department of Agriculture 1982). The USLE was developed for agricultural lands where overland flow and erosion processes comparable to those described by Horton (1933) are operable. Such erosion processes are usually not encountered on wildlands with good vegetative cover and snowmelt runoff. Accordingly, it seems likely that the USLE parameters will require modification for use on wildlands to insure that they will give reasonable erosion estimates. A description of the USLE factors used in this study is presented in Table 1. The primary objective of this study was to contrast the actual surface erosion rates of some southeastern Idaho wildlands to estimates derived by the USLE. A further objective was to determine which of the USLE parameters showed the strongest relationships to measured soil loss. Such information will improve the usefulness of the USLE on wildlands.

Study Area

The Caribou National Forest is in southeastern Idaho, covering an elevational range of 1,490 to 2,930 m. (Fig. 1). The forest lies primarily within the Middle Rocky Mountain physiographic province, with some inclusion of the Basin Range physiographic province (Fenneman 1931). The geology is rather complex, ranging from Precambrian metamorphics in the Bannock and Portneuf Ranges,

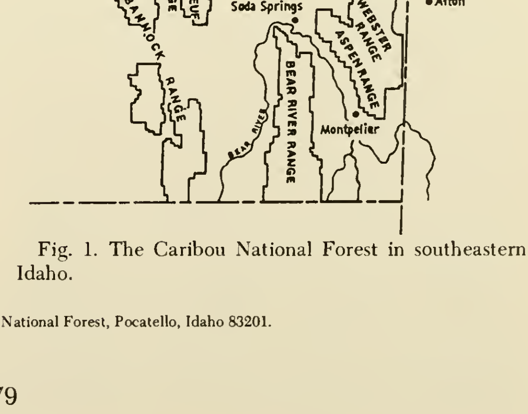

Fig. 1. The Caribou National Forest in southeastern Idaho.

[1]Contributed from U.S. Department of Agriculture, Forest Service, Caribou National Forest, Pocatello, Idaho 83201.
[2]Soil Scientist, Humboldt National Forest, Elko, Nevada 89801.

TABLE 1. A description of the Universal Soil Loss Equation factors used in this study.

The Universal Soil Loss Equation Model is

$$A = Rt\ K\ L\ S\ C\ P$$

Where:

A = The estimated average soil loss per unit area in tons/acre for the time period selected for Rt, usually 1 year.

Rt = The rainfall factor, usually expressed in units of the rainfall-erosivity index, EI, and evaluated from an iso-erodent map.

K = The soil-erodibility factor, usually expressed in tons/acre/EI units for a specific soil in cultivated continuous fallow tilled up and down slope. Values for K in this study were determined from the soil erodibility nomograph.

L = The slope length factor, the ratio of soil loss from the field slope length to that from a 22.1 m length on the same soil, gradient, cover, and management.

S = The slope gradient factor, the ratio of soil loss from a given field gradient to that from a 9 percent slope with the same soil, cover, and management. In this study, the L and S factors were computed together, using the topographic factor (LS) nomograph.

C = The vegetative factor, the ratio of soil loss from land managed under specified conditions to that from the fallow condition on which the factor K is evaluated. Three methods for determining this factor were studied. They are: (1) State C factors that are determined by the Rt values for a site; (2) National Rangeland C factors determined by the canopy cover, vegetation type, and ground cover on a site, and (3) Vegetative Management factors determined by the canopy cover, ground cover, and percent of bare ground with fine roots on a site.

P = The erosion control factor, not usually applied to wildlands.

NOTES (a) These factors take on dimensionless values when computing A.
(b) Source = Warrington, 1980.

Jurassic-Triassic sedimentaries in the Bear River and Webster Ranges, to Cretaceous sedimentaries in the Caribou Range.

Bailey (1980) has classified the vegetation of the forest as belonging to the Rocky Mountain Forest Province—Douglas Fir Forest section and the Intermountain Sagebrush Province—Sagebrush-Wheatgrass section. The climate is a semiarid steppe regime with a wide range in mean annual precipitation. The lower elevations receive 330 mm of precipitation per year, and higher elevations commonly experience 1,524 mm annual precipitation. Approximately 60 percent of the precipitation is in the form of snow. Most soil erosion is observed to occur during the spring snowmelt period.

METHODS

In the summer of 1981, 20 erosion plots were installed on the Caribou National Forest. Plots were equipped with erosion tanks and troughs to catch surface erosion losses induced by soil creep and sheet erosion. The data presented is from the 1981–1982 erosion year. The erosion plot construction techniques used were comparable to those employed in Montana by Packer and Williams (1976). Erosion plots were .015 hectare in size, with dimensions of 2.4 by 10.1 m. The long axis of each plot was oriented up and down slope. Plots were constructed from 2.5 by 15.2 cm cedar boards on the top and sides. A metal trough, 15.2 cm deep by 25.4 cm wide, was placed on the downhill side to catch sediment. Water and sediment collected from the plots were stored in sealed 907 liter tanks. Tanks were connected to the troughs by 15.2 cm diameter, steel reinforced hose. Sediment was removed from the troughs in early summer after the spring snowmelt. Minimal soil erosion occurred during the summer months. The accumulated sediment was oven dried to determine erosion loss weights.

The USLE factors were computed using the procedures outlined in the WRENS doctrine (Warrington 1980). Rainfall factor values (Rt) were taken from an iso-erodent map developed for Idaho by the Soil Conservation Service (1977). This factor is a water drop impact indicator, with only a small component for runoff. The dominant erosion agent operable on the study sites, however, is snowmelt runoff. Adequate factors for this erosion parameter have not been developed, which necessitated the use of the Rt factor in this study. Length and percent slope at each site were used to determine the LS factors. Soil profile descriptions and lab analyses of the A horizon were made for each site. Soil organic matter was determined by the Walkley-Black Method, and particle size analysis was determined by the Hydrometer Method (Black 1965). Soil erodibility factors (K) were determined by the soil erodibility nomograph

(Warrington 1980). Soil classification followed procedures outlined in *Soil Taxonomy* (Soil Conservation Service 1975).

The cropping management factor (C) is important in estimating erosion on wildlands (Dissmeyer 1980). Three different methods for determining the vegetative factor were tested in this study. They are: (1) the Vegetative Management factor—VM (Warrington 1980), (2) the National C factor for rangelands—Range C (USDA 1977), and (3) state-developed C factors for Idaho—State C (Soil Conservation Service 1977). The vegetative information collected to compute these factors utilized the Range Site Analysis procedures of the Forest Service, Intermountain Region (U.S. Department of Agriculture 1969). The statistical methods employed followed Zar (1974). Sites were selected to sample over a wide range in vegetative and soil conditions.

Results

Site descriptions for the erosion plots are presented in Table 2. Soils of the order Mollisols and sage-grass vegetative types (i.e., *Artemisia vaseyana–Agropyron spicatum*, *A. vaseyana–Stipa comata*, and *A. vaseyana–Symphoricarpos oreophilus–Agropyron spicatum* habitat types) were dominant (Hironaka 1981).

Table 2. Site descriptions of the erosion plots.

Site number	Soil classification	Vegetative type	Elevation (m)	Aspect	Percent slope
1	Loamy skeletal, mixed family of the Typic Cryoborolls	Sage-Grass	2,620	W	15
2	Fine loamy, mixed family of the Argic Cryoborolls	Mountainbrush	1,950	E	50
3	Fine loamy, mixed family of the Argic Cryoborolls	Sage-Grass	1,980	W	60
4	Loamy skeletal, mixed family of the Argic Cryoborolls	Sage-Grass	1,950	S	60
5	Fine loamy, mixed family of the Cryic Pachic Paleborolls	Sage-Grass	1,830	NW	30
6	Fine loamy, mixed family of the Argic Cryoborolls	Sage-Grass	1,800	NW	21
7	Loamy skeletal, mixed family of the Argic Cryoborolls	Sage-Grass	2,620	S	35
8	Loamy skeletal, mixed, mesic family of the Typic Argixerolls	Sage-Grass	1,830	W	25
9	Fine loamy, mixed family of the Argic Pachic Cryoborolls	Aspen	2,100	E	20
10	Fine loamy, mixed, mesic family of the Typic Argixerolls	Sage-Grass	1,650	W	45
11	Coarse loamy, mixed, mesic family of the Typic Xerorthents	Juniper-Forb	1,610	S	23
12	Fine loamy, mixed family of the Argic Cryoborolls	Sage-Grass	2,130	SE	40
13	Loamy skeletal, mixed family of the Typic Cryoborolls	Mountainbrush	2,070	S	50
14	Loamy skeletal, mixed family of the Typic Cryorthents	Fir-Pinegrass	2,350	W	30
15	Fine loamy, mixed family of the Typic Cryorthents	Fir-Pinegrass	2,200	N	35
16	Loamy skeletal, mixed family of the Argic Cryoborolls	Sage-Grass	1,950	SE	56
17	Fine loamy, mixed family of the Typic Cryoboralfs	Sage-Grass	2,130	SE	42
18	Loamy skeletal, mixed family of the Argic Cryoborolls	Sage-Grass	1,650	SW	60
19	Fine loamy, mixed family of the Mollic Cryoboralfs	Pine-Pinegrass	2,040	N	35
20	Fine, mixed family of the Argic Cryoborolls	Sage-Grass	1,950	S	30

TABLE 3. The Universal Soil Equation predictions for the study plots*.

C Factor used	Mean	Standard deviation	Minimum	Maximum	n
State C	0.72 (0.32)	0.54 (0.24)	0.02 (0.01)	1.86 (0.83)	20
Range C	16.02 (7.15)	35.39 (15.8)	0.76 (0.34)	153.6 (68.6)	20
VM	11.51 (5.14)	31.81 (14.2)	0.20 (0.09)	138.4 (61.8)	20
Measured rate	0.52 (0.23)	1.37 (0.61)	0.02 (0.01)	5.8 (2.6)	20

*The first number provided is in units of megagrams/ha/yr. The second number provided is in units of tons/ac/yr.
NOTE: The erosion predictions derived by all three C factor methods were found to be significantly different than the measured erosion losses by use of a Wilcoxon Paired Sample Test at the 95 percent confidence level.

The USLE was tested for each site using the three vegetative factors (Table 3). Erosion loss estimates from all three USLE tests were significantly different from measured losses as determined by the Wilcoxon paired sample test. The USLE that utilized the State C factor provided the most reasonable estimates; it overestimated the mean erosion loss of the sites by 33 percent. USLE predictions that utilized the VM and Range C factors overestimated the mean loss by 2,135 and 3,010 percent, respectively. These factors also yielded high standard deviations for mean losses and large ranges in predicted erosion rates.

To determine how an improvement in the accuracy of the USLE might be made, simple linear regression analysis was performed on the data (Table 4). The percent variability in measured soil loss explained by the USLE factors were 80 percent for VM, 51 percent for Range C, 27 percent for K, 12 percent for LS, and 0 for Rt. The K, VM, and Range C factors showed significant linear relationships to the measured soil loss on the erosion plots. Of the site factors studied, percent canopy cover and percent vegetation plus litter gave significant negative correlation to soil loss. Percent pavement (i.e., rocks less than 1.9 cm in diameter) had a positive correlation to soil loss. Production, percent bare ground, and percent rock on the sites did not show significant linear relationships to measured soil loss.

Table 5 shows Pearson Correlation Coefficients for two soil variables and the USLE factors. Percent clay has a strong positive correlation to soil loss (A) and soil erodibility (K). The organic matter content in the soil showed a strong negative correlation to these factors. Since certain factors of the USLE were not found to have significant relationships to soil loss, equations using correlated variables were developed (Table 6). Stepwise multiple regression analyses indicate that 80 percent of the variability in soil erosion loss is attributable to the VM factor of a site. Considering the K factor with VM accounts for 88 percent of the variability in soil erosion loss. Adding the Rt and LS factors does little toward improving predictions. This relationship is important since the VM

TABLE 4. Linear regression relationships between soil loss (A) and the USLE and site variables.

	Line equation	r^2
USLE variables		
Rt	A = 0.01 + 0.0033 Rt	0.002
K	A* = −0.48 + 4.12 K	0. 27
LS	A = −0.19 + 0.05 LS	0. 12
State C	A = 0.37 + 18.85 S-C	0. 02
Range C	A* = −0.21 + 4.02 R-C	0. 51
VM	A* = −0.19 + 6.38 VM	0. 80
Site variables		
% Canopy cover	A* = 0.67 − 0.0096 C	0. 17
% Vegetation & litter	A* = 0.83 − 0.0105 VL	0. 23
% Bare ground	A = −0.06 + 0.0114 BG	0. 09
% Pavement	A* = 0.04 + 0.0146 P	0. 17
% Rock	A = 0.06 + 0.0351 R	0. 08
Production	A = 0.58 − 0.00018 Prod.(kg/ha/yr)	0. 12

NOTES: (1) * Slopes of these equations found to be significantly different than 0 by use of a T test at the 95% confidence level.
(2) Sample size = 20 in all cases.
(3) A is in units of tons/ac/yr. The product A may be multiplied by 2.24 to obtain units of megagrams/ha/yr.

TABLE 5. Pearson correlation coefficients between the USLE factors and soil clay content and organic matter.

USLE factor	% Clay in the A horizon	% Organic matter in the A horizon
Rt	0.15	0.03
K	0.65	−0.57
LS	0.39	−0.32
State C	−0.45	0.14
Range C	0.74	−0.66
VM	0.88	−0.73
Soil loss (A)	0.88	−0.70

Sample size = 20 in all cases.

and K factors can be easily determined through soil profile description and relatively simple vegetative analyses. The Rt factor is variable over wildlands of the Intermountain Region and will probably never be quantified for snowmelt situations. The LS factor also presents a problem for field determinations. An absence of uniformity and the benchy nature of slopes within the region make it difficult to determine a site's contributing slope length and steepness. An accurate assessment of these variables is needed to derive the LS factor.

Actual values for soil loss from plots were used to test the accuracy of different USLE formulations (Table 7). USLE estimates that utilized the State C factor showed a poor correlation with measured soil loss. However, USLE estimates that used the VM and Range C factors showed a high correlation with measured losses; yet they overestimated actual rates. The new equations derived in this paper can be used to scale down USLE estimates when the designated vegetative factors are used to predict erosion on western wildlands.

DISCUSSION

Erosion estimates generated by the USLE were not representative of actual soil losses on erosion plots. The three equations tested significantly overestimated erosion as shown by actual field measurements. This is consistent with the findings of Patric (1982) in his review of erosion research on forested lands. Patric suggests that the USLE tended to overestimate erosion losses on forested sites if limitations of the equation on such lands are not considered. Patric also points out that sediment yields of no more than 0.56 megagrams per ha per year provide an index of soil loss from relatively undisturbed forest watersheds. The mean erosion loss on plots considered in this study (i.e., 0.52 megagrams per ha per year) suggests that erosion rates on the Caribou National Forest are comparable to those on other wildlands.

The Rt and LS factors present problems when using the USLE to estimate soil losses. These factors showed no significant relationship to measured soil losses in this study. This suggests that Rt and LS factors contribute little when the USLE is applied to western wildlands. More information is needed concerning the relationships these factors have to determining soil erosion losses on wildlands with snowmelt runoff.

The K factor showed a significant linear relationship to measured soil losses in this study. Laflen (1982) raised questions about the quality of the estimate that the K factor provides for use on wildlands, because the soils of such areas differ from agricultural soils. Steep slopes, high rock fragment content, and high organic matter content of wildland soils contributed to differences in soil erodibility not addressed by Wischmeir (1969) in his early efforts to develop the K factor concept. The correlation between soil loss and the K factor can be improved with a thorough understanding of soil variables. Percent clay and organic matter in the A horizon were correlated with soil losses and most of the USLE factors considered in this study. Future applications of the USLE to intermountain wildlands should address these soil factors.

USLE predictions, using the three different vegetative factors, gave erosion estimates higher than observed rates. Equations presented in Table 7 offer a means of reducing estimates to more reasonable levels. Equations that utilize the VM and the K factors (Table 6) provide the land manager with a

TABLE 6. Stepwise multiple regression relationships between soil erosion loss (A) and the VM and K factors.

$$A \text{ (tons/ac/yr)} = -0.19 + 6.4 \times \text{VM factor}; \quad r^2 = 0.80, \text{ standard error} = 0.28, n = 20$$

$$A \text{ (tons/ac/yr)} = -0.55 + 5.8 \times \text{VM factor} + 2.4 \times \text{K factor}; \quad r^2 = 0.88, \text{ standard error} = 0.23, n = 20$$

NOTE: (1) The inclusion of the Rt and LS factor increase the r^2 value to 0.89.
(2) The product A may be multiplied by 2.24 to obtain units of megagrams/ha/yr.

TABLE 7. Regression equations correlating USLE estimates with measured soil losses when three different vegetative factors are used.

Vegetative factor used	Correction equation
State C	$y = 0.02 + 0.62x$; $r^2 = 0.06$, $n = 20$
Range C	$y = -0.05 + 0.04x$; $r^2 = 0.97$, $n = 20$
VM	$y = 0.002 + 0.04x$; $r^2 = 0.99$, $n = 20$

NOTE: (1) y = measured soil loss (tons/ac/yr).
(2) x = USLE estimated soil loss (tons/ac/yr).

simple approach for predicting erosion loss. These equations are effective because the two USLE factors that showed the greatest sensitivity in predicting soil loss are used in the construction.

Conclusions

The information collected during the first year of this study will assist those who use the USLE for predicting soil erosion on wildlands. The results presented will be refined as the study continues. Further research is needed to quantify the relationships between USLE factors and soil erosion on wildlands in the Intermountain Region. Specifically, more work should be directed toward developing Rt factors for snowmelt runoff situations. The VM factor offers an effective means for predicting soil erosion. It is particularly useful to the land manager since it allows for the testing of different management objectives against their effects on soil loss.

Acknowledgments

I thank Norm Bare for his assistance in this work. I also wish to thank the U.S. Department of Agriculture Intermountain Forest Experiment Station, Logan, Utah, for the erosion tanks and troughs used in this study.

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WINTER STONEFLIES (PLECOPTERA) OF NEW MEXICO

Gerald Z. Jacobi[1] and Richard W. Baumann[2]

Abstract.— Twenty-two species of winter emerging Plecoptera were collected in New Mexico from 1979 to 1982. Distributional records are given for 13 that are new state records, including 2 new species, and 9 previously reported species.

Winter stoneflies, usually defined, mean species in the families Capniidae (Nebeker and Gaufin 1968) and Nemouridae (Baumann et al. 1977). For this study, we have expanded the list to include additional cold lotic species (Baumann 1979) in the Taeniopterygidae and Perlodidae. These emerged on snow or ice, or prior to peak spring runoff when air and water temperatures were below 12 C and 8 C, respectively.

New state records, including two previously undescribed species, follow: *Capnia barbata* Frison, *C. coloradensis* Claassen, *C. vernalis* Newport, *C. wanica* Frison, *Isocapnia vedderensis* (Ricker), *Mesocapnia arizonensis* (Baumann & Gaufin), *M. werneri* (Baumann & Gaufin), *Utacapnia logana* (Nebeker & Gaufin), *Utacapnia poda* (Nebeker & Gaufin), *Doddsia occidentalis* (Banks), *Taenionema pacificum* (Banks), *Taenionema* sp. A, and *Taeniopteryx* sp. A.

Previously recorded species (Stewart et al. 1974, Stark et al. 1975, and Baumann et al. 1977) are: *Capnia confusa* Claassen, *C. gracilaria* Claassen, *C. fibula* Claassen, *Eucapnopsis brevicauda* (Claassen), *Mesocapnia frisoni* (Baumann and Gaufin), *Prostoia besametsa* (Ricker), *Zapada cinctipes* (Banks), *Z. haysi* (Ricker), and *Skwala parallela* (Frison).

In addition to distributional data for new state records, recent distributional data are given for previously reported species. All specimens were collected by G. Z. Jacobi unless otherwise noted.

Capnia barbata Frison

Capnia barbata Frison, 1944.

This species was listed as being restricted to the Southern Rocky Mountain Zone (Nebeker and Gaufin 1967). It had been collected in Arizona and Colorado but not in New Mexico (Baumann et al. 1977). Here it is reported from seven counties in New Mexico, which include the northern Sangre de Cristo, central Manzano, south central Sacramento, and southwestern Black and Mogollon mountain ranges. Grant Co., Cherry Creek, Pinos Altos, 2,012 m, 6–XI–80, 3 ♀ (dried); Little Cherry Creek, Hwy 255, 2,012 m, 25–III–81, 3 ♀; Sapello River, Hwy 15, 1,767 m, 25–III–81, G. Z. J. and L. R. Smolka, 50 ♀. Lincoln Co., Rio Bonito, Mill Creek Picnic Area, 2,164 m, 14–III–80, 2 ♂ 29 ♀; Rio Ruidoso, 2,188 m, 14–III–80, 1 ♀; Eagle Creek, Hwy 127, 2,179 m, 14–III–80, 2 ♀; Eagle Creek, Hwy 117, 2,164 m, 14–III–80, 1 ♂ 8 ♀; Nogal Creek, Nogal, 1,975 m, 14–III–80, 1 ♀. Three Rivers, Three Rivers Cmpgd., 1,859 m, 7–III–82, 1 ♂ 1 ♀. Rio Arriba Co., Canjilon Creek, north of Ghost Ranch, 2,102 m, 22–III–82, 1 ♂; Brazos River, Hwy 84–64 bridge, 2,256 m, 22–III–82, G. Z. J. and L. R. Smolka, 6 ♂ 4 ♀. San Miguel Co., Dalton Creek Canyon, 2,195 m, 28–II–79 reared to 2–IV–79, 1 ♂ 2 ♀; 28–II–79, 3 ♂ 11 ♀ 5n; 3–III–80, 26 ♂ 29 ♀; Pecos River, Hwy 63, 2,115 m, 30–III–80, 1 ♂; Macho Creek Canyon, 2,225 m, 30–III–80, 3 ♀. Santa Fe Co., Little Tesuque Creek, 2,377 m, 17–II–79, 4 ♂ 12n; La Cueva Creek, 2,256 m, 6–IV–80, G. Z. and C. L. Jacobi, 6 ♂ 3 ♀. Sierra Co., Percha Creek, 1,905 m, 6–IV–79, R. Gordon, 1 ♀ (NMSU). Socorro Co., Water Canyon, 1,981 m, 23–III–81, 8 ♀. Taos Co., Rio Hondo, Twining, 2,862 m, 17–III–80, 1 ♀; Red River, West Fork, 2,804 m, 18–III–80, 5 ♀; Red River, Middle Fork, 2,865 m, 5–V–80,

[1]State of New Mexico, Health and Environment Department, P.O. Box 968, Santa Fe, New Mexico 87503.
[2]Bean Life Science Museum and Department of Zoology, Brigham Young University, Provo, Utah 84602.

2 ♀. TORRANCE Co., Canon de Tajique, 1.5 km above 4th of July Picnic Area, 2,331 m, 9–VI–80, 24 ♀; 11–IV–80, 2 ♀; 2.4 km above 4th of July Picnic Area, 2,377 m, 9–IV–80, 3 ♀.

Capnia coloradensis Claassen

Capnia coloradensis Claassen, 1937.
Capnia coloradensis, Ricker, 1965.

Capnia coloradensis had not been reported previously from New Mexico. The records from Taos County extend the distribution southward from the Sangre de Cristo Mountains in southern Colorado into northern New Mexico. All New Mexico locations are within a 25 km radius of each other. TAOS Co., Arroyo Seco, 2,426 m, 16–III–79, 4 ♂ 3 ♀; 19–III–80, 1 ♂; Red River, jct East and West forks, 2,865 m, 18–III–79, 1 ♂ 3 ♀; Red River, Red River, 2,651 m, 18–III–79, 3 ♀; Red River, USGS gage, 2,706 m, 18–III–80, S. J. Oppenheimer and A. M. Young, 5 ♂ 4 ♀; 31–III–80, 2 ♂ 5 ♀; Cabresto Creek, 2,401 m, 19–III–80, 1 ♀.

Capnia confusa Claassen

Capnia nivalis Neave, 1929.
Capnia confusa Claassen, 1936.
Capnia ligulata Hanson, 1943.

This species has a wide distribution in the Central Rocky Mountains (Nebeker and Gaufin 1967) and has been recorded from counties in northern New Mexico. Collections in Lincoln County are new records and extend the southern distribution limit approximately 250 km. Recent New Mexico records include: COLFAX Co., small trib. Cieneguilla Creek, Rd. B 5, 2,520 m, 24–IV–82, 1 ♂ 2 ♀. LINCOLN Co., Rio Ruidoso, 2,164 m, 14–III–80, 1 ♂ 1 ♀; 2,188 m, 14–III–80, 4 ♀. SAN MIGUEL Co., Dalton Creek Canyon, 2,195 m, 30–III–80, 1 ♂ 1 ♀; Holy Ghost Creek, 2,335 m, 30–III–80, 5 ♂ 1 ♀; Macho Creek Canyon, 2,225 m, 30–III–80, 1 ♂ 1 ♀; Pecos River, The Box, 2,438 m, 30–III–80, 22 ♂ 33 ♀; Pecos River, below Rio Mora, 2,405 m, 30–III–80, 24 ♂ 26 ♀; Pecos River, Hwy 63, 2,115 m, 30–III–80, 1 ♂ 5 ♀; 6–IV–80, 2 ♂ 6 ♀; Pecos River, Windy Bridge Picnic Area, 2,286 m, 30–III–80, 24 ♂ 14 ♀; Pecos River, Willow Creek Picnic Area, 2,377 m, 30–III–80, 15 ♂ 7 ♀ 1n; Pecos River, above Dalton Creek Canyon, 2,195 m, 20–IV–80, 2 ♂; Rio Mora, USGS gage, 2,408 m, 30–III–80, 1 ♂; 8–V–80, 11 ♂ 6 ♀. TAOS Co., Cabresto Creek, 2,401 m, 5–IV–80, 1 ♀; Rio Fernando de Taos, La Sombra Picnic Area, 2,377 m, 17–III–79, 1 ♀; Rio Hondo, Twining, 2,862 m, 17–III–79, 1 ♂; Rio Hondo, USGS gage, 2,331 m, 24–IV–79, 1 ♂; Red River, Hwy 3, 2,219 m, 19–III–80, 6 ♂ 11 ♀; 1–IV–80, 22 ♂; Red River, 2,621 m, 5–IV–80, 7 ♂ 2 ♀; Red River, Red River, 2,637 m, 5–IV–80, 2 ♂ 3 ♀.

Capnia fibula Claassen

Capnia fibula Claassen, 1924.

T. D. A. Cockerell first collected this species at the "Las Vegas Hot Springs" in 1902 (Claassen 1924). His collection site was probably the Gallinas River above the Hot Springs (Hanson 1946). The only other locality this species has been previously recorded from is in central Arizona, Coconino Co., West Fork of Oak Creek, approximately 700 km west of the New Mexico site (Baumann et al. 1977). Our recent New Mexico collections, 77 years later, are: SAN MIGUEL Co., Gallinas River, above Las Vegas Hot Springs, 2,073 m, 27–II–79, 14 ♂ 5 ♀ 14 n; Sapello River, Hwy 3, 2,102 m, 8–III–81, L. R. Smolka, 6 ♂ 2 ♀; 15–III–81, L. R. Smolka, 20 ♂ 22 ♀; Manuelitas Creek, Hwy 94, 2,164 m, 8–III–81, L. R. Smolka, 4 ♂.

Capnia gracilaria Claassen

Capnia gracilaria Claassen, 1924.

Capnia gracilaria was recorded by Nebeker and Gaufin (1967) as being common to four western mountain zones: the Pacific Northwest, Northern Rockies, Southern Rockies, and the Wasatch Range. It had been recorded previously from Taos and Santa Fe counties in New Mexico. Additional records are: COLFAX Co., small trib. Cieneguilla Creek, Rd B 5, 2,520 m, 12–III–82, 6 ♂, 1 ♀. GRANT Co., Little Cherry Creek, 2,001 m, 25–III–81, G. Z. J. and L. R. Smolka, 1 ♀. LINCOLN Co., Nogal Creek, 1,975 m, 14–III–80, 5 ♀. SANDOVAL Co., San Antonio Creek, Hwy. 125, 2,331 m, 25–III–79, 1 ♂. SANTA FE Co., Little Tesuque Creek, Hyde Park, 2,453 m, 29–III–81, 6 ♂ 8 ♀. TAOS Co., Arroyo Seco, 2,426 m, 16-III-79, 6♀; 19-III-80, 1♂, 1♀; Gavilan Canyon, 2,743 m, 16-III-79, 12♂; 24-IV-79, 1♂; Italianos Creek, 2,640 m, 23-II-79, 1♂ 1♀; 24-IV-79, 1♀; Rio del Medio, El Rito, 2,429 m, 8-III-80, 2♂ 1♀; Rio Hondo, Twining, 2,862 m, 16-III-79, 4♂ 3♀; 20-III-79, 3♂ 3♀; 23-III-79, 2♀; 17-III-80, 1♂ 1♀; Rio Hondo, 2,575 m, 16-III-79, 1♂ 1♀; 19-III-80, 1♂ 4♀; Rio Hondo, USGS gage, 2,331 m, 16-II-80, 4♂ 2♀; Rio Hondo, above Italianos Creek, 2,633 m, 19-III-80, 5♂ 4♀; Rio Hondo, Upper Chuchilla Picnic Area, 2,401 m, 19-III-80, 8♂ 10♀; Rito de La Olla, 2,286 m, 8-III-80, 2♀; South Fork Creek, 2,545 m, 16-III-79, 2♂.

Capnia vernalis Newport

Capnia vernalis Newport, 1848.
Capnia limata Frison, 1944.

This species is typically found in the northern United States and Canada (Nebeker and Gaufin 1967). Baumann et al. (1977) reported it from several western states, including Colorado and Utah. The following records are the first for New Mexico: COLFAX Co., Cienegulla Creek, above Eagle Nest Lake, 2,499 m, 16-III-81, 8♂ 13♀. RIO ARRIBA Co., Brazos River, Hwy 84-64 bridge, 2,256 m, 22-III-82, G. Z. J. and L. R. Smolka, 3♂ 6♀; Chamita River, 1.5 km above Chama, 2,431 m, 23-III-82, G. Z. J. and L. R. Smolka, 10♂ 12♀.

Capnia wanica Frison

Capnia wanica Frison, 1944.

Capnia wanica is said to be confined to the Southern Rockies and has been recorded from Colorado and Utah (Baumann et al. 1977). This single collecting locality in the Sangre de Cristo Mountains of New Mexico is a new record for the state: COLFAX Co., Vermejo River, above York Creek, 2,179 m, 7-III-79, 5♂, 3♀.

Eucapnopsis brevicauda (Claassen)

Capnia brevicauda Claassen, 1924.
Eucapnopsis brevicauda, Needham and Claassen, 1925.

Eucapnopsis brevicauda is one of the most common species of Capniidae in western North America (Nebeker and Gaufin 1967 and Baumann et al. 1977). Previous New Mexico records have been from Santa Fe and Taos counties: New records for New Mexico include: GRANT Co., Iron Creek, Hwy 90, 2,149 m, 25-III-81, 2♀. LINCOLN Co., Rio Ruidoso, 2,164 m, 14-III-80, 1♂; 2,188 m, 14-III-80, 2♂. SANDOVAL Co., Rio de Las Vacas, 2,499 m, 1-VI-80, 3♂ 2♀. SAN MIGUEL Co., Pecos River, Hwy 63, 2,115 m, 30-III-80, 1♂ 1♀; 20-IV-80, 3♀; Pecos River, above Dalton Canyon, 2,210 m, 20-IV-80, 1♀. TAOS Co., Cabresto Creek, 2,401 m, 5-V-80, 2♀; Gavilan Canyon, 2,743 m, 24-IV-79, 1♂; Rio Hondo, 2,545 m, 1-V-80, 9♂ 8♀; 7-V-80, 7♂ 1♀ 3n; 14-V-80, 1♂ 1♀; 2,499 m, 7-V-80, 7♂ 15♀; Rio Hondo, jct Italianos Creek, 2,640 m, 6-V-80, 1♂ 1♀; Rio Hondo, Twining, 2,862 m, 24-IV-79, 1♂; Rio Hondo, USGS gage, 2,331 m, 14-III-79, 1♂; 24-IV-79, 2♂ 1♀; 6-V-80, 6♂ 11♀; 14-V-80, 1♂; Red River, USGS gage, 2,706 m, 5-V-80, L. R. Smolka, 1♂ 1♀; Red River, jct East and Middle forks, 2,880 m, 5-V-80, 1♂ 1♀.

Isocapnia vedderensis (Ricker)

Eucapnopsis vedderensis Ricker, 1943.
Isocapnia vedderensis (Ricker), 1965.

This species is found in the Pacific Northwest, Northern Rockies, and Wasatch Mountains (Nebeker and Gaufin 1967). These New Mexico records, the first from the Southern Rockies, extend the range approximately 1000 km to the southeast: LINCOLN Co., Three Rivers, Three Rivers Cmpgd, 1,859 m, 7-III-82, 1♂. SAN MIGUEL Co., Pecos River, above jct Dalton Creek, 2,210 m, 20-IV-80, 1♀. TAOS Co., Red River, Hwy 3, 2,219 m, 5-V-80, 2♂.

Mesocapnia arizonensis (Baumann & Gaufin)

Capnia arizonensis Baumann & Gaufin, 1969.
Mesocapnia arizonensis, Zwick, 1973.

Mesocapnia arizonensis has been previously recorded only from three Arizona counties in the Southern Rockies. This New Mexico record in the Black Range (Gila National Forest) extends the distribution approximately 200 km eastward: SIERRA Co., Percha Creek, 1,905 m, 6-IV-79, J. R. Zimmerman, 1♂ 1♀ 7n (NMSU).

Mesocapnia frisoni (Baumann and Gaufin)

Capnia frisoni Baumann and Gaufin, 1970.
Mesocapnia frisoni, Zwick, 1973.

Mesocapnia frisoni is an infrequently collected species found in the Southern Rockies at low elevations near mountains (Baumann et al. 1977). Previous New Mexico records include two central counties: Guadalupe Co., (Middle Pecos River) and Lincoln Co., (Sacramento Mountains). Recent records are from: CATRON Co., East Fork Gila River, 1,620 m, 9–IV–79, J. Anderson, 8♂ 12♀ 4n (NMSU). GUADALUPE Co., Pecos River, Anton Chico, 1,585 m, 5–I–80, 5n. OTERO Co., Tularosa River, Hwy 70, below Bent, 1,676 m, 7–III–82, G. Z. J. and S. J. Cary, 7♂, 10♀. SAN MIGUEL Co., Pecos River, Villanueva, 1,798 m, 27–II–79, 1♂ (mature nymph) 1♀ 3n; Sapello River, Hwy 3, 2,102 m, 8–III–81, L. R. Smolka, 3♂ 6♀; 15–III–81, L. R. Smolka, 25♂ 15♀. SIERRA Co., Percha Creek, 6–IV–79, 1,605 m, J. R. Zimmerman, 1♂ 6♀ (NMSU).

Mesocapnia werneri (Baumann & Gaufin)

Capnia werneri Baumann & Gaufin, 1970.
Mesocapnia werneri, Zwick, 1973.

This species had been reported only from central Arizona (Baumann et al. 1977). These two new records from New Mexico extend the distribution approximately 250 km eastward: GRANT Co., Cherry Creek, Hwy 255, 2,012 m, 25–III–81, G. Z. J. and L. R. Smolka, 2♂ 10♀; Iron Creek, Hwy 90, 2,149 m, 25–III–81, 1♂ 1♀.

Utacapnia logana (Nebeker & Gaufin)

Capnia logana Nebeker & Gaufin, 1965.
Utacapnia logana, Zwick, 1973.

The following collections from New Mexico are new state records. This species is restricted in its distribution to mountain streams in the Rocky Mountains (Baumann et al. 1977). It was recorded previously from Colorado, Utah, and Wyoming (Nebeker and Gaufin 1967). New Mexico localities include: COLFAX Co., Cimarron River, jct Tolby Creek, 2,438 m, 18–III–79, 2♂. SAN MIGUEL Co., Pecos River, above jct Willow Creek, 2,377 m, 4–III–80, 2♂ 2♀; Holy Ghost Creek, 2,335 m, 4–III–80, 4♂; Rio Mora, 2,408 m, 30–III–80, 2♂; Pecos River, 1 km below Rio Mora, 2,405 m, 30–III–80, 1♂; Pecos River, The Box, 2,438 m, 30–III–80, 1♂. TAOS Co, Arroyo Seco, 2,426 m, 16–III–79, 5♂ 5♀; Cabresto Creek, 2,401 m, 17–II–80, G. Z. J. and D. F. Tague, 4♂ 2♀; Cerro Ditch, El Rito, 2,426 m, 8–III–80, 1♂; Rio Chiquito, 2,280 m, 8–III–80, 2♂; Rio Fernando de Taos, La Sombra Picnic Area, 2,377 m, 17–III–80, 5♂ 3♀; Rio Hondo, USGS gage, 2,331 m, 14–III–79, 1♂; 16–III–79, 1♂; 16–II–80, 1♂; Rio Hondo, Hwy 3, 2,115 m, 16–II–80, 1♂; Rio Pueblo, 2,721 m, 8–III–80, 1♀; Rito del Medio, El Rito, 2,429 m, 8–III–80, 5♂ ♂ 3♀; Rito de La Olla, 2,286 m, 8–III–80, 4♂.

Utacapnia poda (Nebeker & Gaufin)

Capnia poda Nebeker & Gaufin, 1965.
Utacapnia poda, Zwick, 1973.

Utacapnia poda is found in the Northern and Southern Rockies (Nebeker and Gaufin 1967). The following new state records are from northern New Mexico near the Colorado border: RIO ARRIBA Co., Chama River, below jct Chamita River, 2,342 m, 23–III–82, G. Z. J. and L. R. Smolka, 5♂; Chama River, Hwy 84–64 bridge, 2,370 m, 22–IV–82, 6♂ 11♀; Chamita River, near jct Chama River, 2,370 m, 22–IV–82, 11♂ 21♀.

Prostoia besametsa (Ricker)

Nemoura glabra Claassen, 1923.
Nemoura completa, Ricker, 1943.
Nemoura (Prostoia) besametsa Ricker, 1952.
Prostoia besametsa, Illies, 1966.

This species had been collected previously in some northern New Mexico counties (Baumann et al., 1977). Recent records include: RIO ARRIBA Co., Rio Puerco, Rio Puerco Cmpgd, 2,484 m, 11–IV–81, 1♂ 1♀. SANDOVAL Co., San Antonio Creek, Hwy 126, 2,780 m, 1–VI–80, 1♂ 2♀. SAN MIGUEL Co., Pecos River Hwy 63, 2,305 m, 30–III–80, 3♂ 4♀; 20–IV–80, 6♂ 12♀. TAOS Co., Rio Fernando de Taos, Capulin Picnic Area, 2,390 m, 9–V–82, 3♂ 1♀; Rio Hondo, 2,545 m, 1–V–80, 2♂; 7–V–80, 7♂ 4♀; 14–V–80, 2♂; Rio Hondo, Hwy 3, 2,219 m, 19–III–80, 5♂ 1♀; Rio Hondo, USGS gage, 2,331 m, 16–II–79, G. Z. J. and M. R. Snavely, 2n;

24-IV-79, 2♂ 1♀; 6-V-80, 3♂; 14-V-80, 1♂ 6♀ 7n; Rio Hondo, Hondo Cabin, 2,499 m, 7-V-80, 13♂ 11♀; Rio Hondo, above jct Italianos Creek, 2,640 m, 6-V-80, 22♂, 12♀; Red River, Middle Fork, 2,865 m, 5-V-80, 1♀; Red River, jct East and Middle forks, 2,880 m, 5-V-80, 1♂; Red River, USGS gage, 2,706 m, 5-V-80, 1♂.

Zapada cinctipes (Banks)

Nemoura cinctipes Banks, 1897.
Nemoura (Zapada) cinctipes, Castle, 1939.
Zapada cinctipes, Illies, 1966.

This is the most frequently collected winter stonefly. New records for New Mexico include: Colfax Co., Cimarron Creek, jct Tolby Creek, 2,438 m, 18-III-79, 2♂ 1♀; small trib Cimarron River, Hwy 64, 2,557 m, 18-III-79, 2♀. Rio Arriba Co., Rio Puerco, Rio Puerco Cmpgd, 2,184 m, 11-IV-81, 2♂ 2♀; Rio Embudo, Hwy 68, 1,787 m, 12-III-81, 3♂ 3♀. Sandoval Co., Las Huertas Creek, Sandia Mountains, 2,195 m, 23-II-80, 14♂ 5♀; Las Huertas Creek, Ellis Ranch, 2,438 m, 23-II-80, 1♂ 1♀; Las Huertas Creek, Las Huertas Picnic Area, 2,316 m, 23-II-80, 21♂ 24♀; 25-III-80, 2♂ 1♀; 9-IV-80, 1♂ 2♀; Las Huertas Creek, Sandia Man Cave Area, 2,079 m, 25-III-80, 9♂ 7♀; 9-IV-80, 1♂ 2♀; Redondo Creek, 2,362 m, 25-III-79, 3♂ 4♀; East Fork, Las Conchas Picnic Area, 2,578 m, 25-III-79, G. Z. and M. D. Jacobi, 22♂ 12♀; San Antonio Creek, 2,331 m, 25-III-79, 18♂ 16♀. San Miguel Co., Dalton Creek, 2,195 m, 28-II-79, 2♂ 2♀ 2n; 30-III-80, 7♂ 5♀; 2,210 m, 20-IV-80, 3♀; Holy Ghost Creek, 2,335 m, 3-III-80, 25♂ 15♀; Macho Creek, 2,225 m, 30-III-80, 6♂ 6♀; Pecos River, above Willow Creek, 2,377 m, 4-III-79, 1♂; Pecos River, 1 km below jct Rio Mora, 2,393 m, 30-III-80, 6♂ 4♀; Pecos River, The Box, 2,438 m, 30-III-80, 4♂; Pecos River, Windy Bridge Picnic Area, 2,286 m, 30-III-80, 1♂; Pecos River, Hwy 63 bridge, 2,115 m, 6-IV-80, 1♂; Pecos River, above jct Dalton Creek, 2,210 m, 20-IV-80, 1♀; Rio Mora, 2,408 m, 30-III-80, 7♂ 6♀; Willow Creek, 2,377 m, 30-III-80, 10♂ 10♀. Santa Fe Co., North Fork Tesuque Creek, USFS Exp Watershed, 2,947 m, 22-IV-79, 1♀. Taos Co., Arroyo Seco, 2,426 m, 16-III-79, 1♂ 2♀; 19-III-80, 2♂; Cabresto Creek, USGS gage, 2,401 m, 19-III-80, 2♀; Rio Chiquito, 2,280 m, 8-III-80, 3♂ 2♀; Rio Fernando de Taos, La Sombra Picnic Area, 2,401 m, 17-III-79, 7♀; Gavilan Creek, 2,743 m, 16-III-79, 3♂; 24-IV-79, 4♂ 2♀; 3-IV-80, 2♂ 1♀; Italianos Creek, 2,640 m, 16-III-79, 1♂; 23-III-79, 1♂ 4♀; 14-V-80, 2♂ 1♀; Rio Hondo, USGS gage, 2,331 m, 16-II-79, G. Z. J. and M. R. Snavely, 2n; 14-III-79, 6♂ 3♀; 16-III-79, 8♂ 3♀; 29-III-79, 8♂ 11♀; 24-IV-79, 1♀; Rio Hondo, Hondo Cabin, 2,499 m, 16-III-79, 2♂; 7-V-80, 2♂; Rio Hondo, 2,545 m, 19-III-80, 1♂ 2♀; Rio Hondo, above jct Italianos Creek, 2,640 m, 19-III-80, 1♀; Rio Hondo, Upper Chuchilla Picnic Area, 2,401 m, 19-III-80, 2♂ 1♀; Manzanita Creek, 2,560 m, 16-III-79, 9♂ 4♀; 7-V-80, 2♀; Rito de La Olla, 2,286 m, 8-III-80, 2♂ 1♀; Red River, Hwy 3, 2,219 m, 1-IV-80, 1♂; Red River, Middle Fork, 2,865 m, 5-V-80, 8♂ 3♀.

Zapada haysi (Ricker)

Nemoura (Zapada) haysi Ricker, 1952.
Zapada haysi, Illies, 1966.

This species has previously been confused with *Zapada oregonensis* (Claassen) (Stewart et al., 1974). It begins emerging in April and is often still present at higher elevations into the summer. It is known in New Mexico from three counties: Lincoln, Santa Fe, and Taos (Baumann et al. 1977). A recent collection is from: Taos Co., Rio Hondo, 2,862 m, 22-VII-80, 1♀.

Doddsia occidentalis (Banks)

Taeniopteryx occidentalis Banks, 1900.
Taeniopteryx (Doddsia) occidentalis, Needham and Claassen, 1925.
Brachyptera (Doddsia) occidentalis, Jewett, 1959.
Doddsia occidentalis, Illies, 1966.

The following records extend the distribution of this species to New Mexico: San Miguel Co., Pecos River, 1 km below jct Rio Mora, 2,393 m, 30-III-80, 4♂. Taos Co., Cabresto Creek, 2,401 m, 19-III-80, 3♂; Gavilan Canyon, 2,743 m, 24-IV-79, 1♂ 1♀; Rio Hondo, USGS gage, 2,331 m, 29-III-79, 1♂; 6-V-80, 1♀; 14-V-80, 1♂; Rio Hondo, Twining, 2,862 m, 18-III-80, 2 ♀; 1–V–80, 3 ♂ 1 ♀; 7–V–80, 2 ♀; Rio Hondo, Upper Chuchilla Cmpgd, 2,401 m, 19–III–80, 1 ♂; Rio Hondo, 2,545 m, 19–III–80, 3 ♂ 2n; 30–IV–80, 19 ♀; 1–V–80, 9 ♀; 7–V–80, 5 ♀; Rio Hondo, Hondo Cabin, 2,499 m, 7–V–80, 6 ♀; Rio Hondo, jct Italianos Creek, 2,640 m, 14–V–80, 2 ♂ 1 ♀; Red River, Hwy 3, 2,219 m, 19–III–80, 1 ♂; 31–III–80, 1 ♀; Red River, Middle Fork, 2,880 m, 5–V–80, 4 ♂ 2 ♀; Red River, jct East and Middle forks, 2,865 m, 5–V–80, 1 ♂.

Taenionema pacificum (Banks)

Taeniopteryx pacifica Banks, 1900.
Taenionema analis Banks, 1905.
Taeniopteryx pacifica, Needham and Claassen, 1925.
Brachyptera (Taenionema) pacifica, Jewett, 1959.
Taenionema pacifica, Illies, 1966.
Taenionema pacificum, Ricker and Ross, 1975.

This species has been recorded previously from New Mexico (Stewart et al. 1974) and (Baumann et al., 1977). New state records for *T. pacificum* include the northern Sangre de Cristo Mountains and the south central Sacramento Mountains: LINCOLN Co., Rio Bonito, Mills Creek Cmpgd 2,164 m, 14–III–80, 7 ♂ 6 ♀. RIO ARRIBA Co., Chama River, Hwy 84–64 bridge, 2,370 m, 23–III–82, G. Z. J. and L. R. Smolka, 6n; 22–IV–82, 3 ♂ 2 ♀ 3n; Chavez Creek, trib Brazos River, 22–IV–82, 1 ♂. SAN MIGUEL Co., Pecos River, Hwy 63, 2,115 m, 30–III–80, 6 ♂ 4 ♀; 7–IV–80, 7 ♂ 5 ♀; 20–IV–80, 1 ♂ 1 ♀. TAOS Co., Rio Hondo, USGS gage, 2,331 m, 16–II–79, 55n.

Taenionema sp. A.

This species is known from only two localities less than 2 km apart in the same drainage of the Gila National Forest in southwestern New Mexico: GRANT Co., Little Cherry Creek, Hwy 255, 2,100 m, 25–III–81, G. Z. J. and L. R. Smolka, 7 ♂ 5 ♀; Bear Creek, Ben Lilly Cmpgd 1,950 m, 25–III–81, 1 ♂ 1 ♀.

It was studied as part of a revision of the genus *Taenionema* by Jean A. Stanger and is described in a forthcoming publication (Stanger and Baumann, in press).

Taeniopteryx sp. A.

A single nymph collected in 1970 from the Pecos River near Santa Rosa was tentatively identified as *T. nivalis* (Baumann et al., 1977). Collections of adults and nymphs in 1979–80 upstream near Tecolotito and Anton Chico resulted in the discovery of a previously undescribed species of *Taeniopteryx* (Baumann and Jacobi, in press). The following sites are the lowest elevations, thus far, at which winter stoneflies have been collected in New Mexico: GUADALUPE Co., Pecos River, Hwy 119, Anton Chico, 1,585 m, 5–I–80, 3n. SAN MIGUEL Co., Pecos River, Hwy. 119, Tecolotito, 1,615 m, 27–II–79, 10 ♂ 5 ♀; 5–I–80, 5n.

Skwala parallela (Frison)

Perlodes americana, Needham and Claassen, 1925.
Hydroperla parallela Frison, 1936.
Arcynopteryx americana, Hanson, 1942.
Arcynopteryx (Skwala) parallela, Ricker, 1943.
Skwala parallela, Illies, 1966.

This large perlodid emerges from February through July (Baumann et al. 1977). In New Mexico, it was found in the Pecos River above the town of Pecos (Hwy 63 bridge), during ice-free conditions in March. One female with an egg mass was captured in April after crawling out of a crack in the 0.5 m thick ice covering Dalton Creek, a small tributary of the Pecos River. Recent New Mexico records include: COLFAX Co., Cienegulla Creek, above Eagle Nest Lake, 2,499 m, 16–II–81, 1n. RIO ARRIBA Co., Rio Em budo, Hwy 68, 1,790 m, 16–II–79, 2n. SAN MIGUEL Co., Pecos River, Hwy 63, 2,115 m, 30–III–80, 1 ♂ 8 ♀; 7–IV–80, 4 ♂ 14 ♀; 20–IV–80, 10 ♂ 12 ♀; Dalton Creek, 2,210 m, 20–IV–80, 1 ♀.

ACKNOWLEDGMENTS

We appreciate the assistance of L. R. Smolka in field collecting and the opportunity to study the winter stoneflies in the New Mexico State University (NMSU) collection provided by Dr. James R. Zimmerman.

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DAILY AND YEARLY MOVEMENT OF THE DEVIL'S HOLE PUPFISH *CYPRINODON DIABOLIS* WALES IN DEVIL'S HOLE, NEVADA

Thomas M. Baugh[1] and James E. Deacon[1]

Abstract.— Past observations and ongoing population surveys indicate daily and yearly vertical movement of the Devil's Hole pupfish, *Cyprinodon diabolis* Wales, within the upper 27 m of the water column in Devil's Hole, Nevada. This movement involves occupying and leaving a 5 by 3.5 m rock shelf during daily and yearly periods of maximum light intensity.

Devil's Hole, located in the southeast quadrant of R50E, T18S, Sec. 36, in Ash Meadows, Nevada, at an elevation of 730 m, is the only natural habitat of the Devil's Hole pupfish.

The surface pool at Devil's Hole lies about 15 m deep in a roughly conical depression in a ridge of Cambrian carbonate rock (Winograd and Doty 1980) (Fig. 1). The pool is about 3.5 by 22 m in surface area with a natural rock shelf 5 by 3.5 by .3 m (deep) at one end. Water depth increases abruptly at the end of the shelf into a large and only partially mapped cavern system that interrupts the groundwater of the carbonate aquifer (Winograd and Doty 1980). Devil's Hole has no surface outlet.

The spring-line in Ash Meadows (including Devil's Hole) is tectonically controlled, containing Quaternary faults, with Devil's Hole on the upthrown side of the fault zone (Winograd and Doty 1980). Because of its recessed position, the entire water column in Devil's Hole receives significantly less direct and indirect light than the surrounding area. This situation has existed for millenia.

The Ash Meadows Ground Water Basin, of which Devil's Hole is a part, receives its water from the area of the Nevada Test Site north of Las Vegas. This is fossil water, with the transport process taking about 10,000 years from precipitation to outflow at Devil's Hole (Winograd and Doty 1980). The water in Devil's Hole remains a relatively constant 32 C to a depth of at least 27 m.

According to Minckley and Deacon (1975), diatoms are the most important food items of *C. diabolis* in the winter and spring, with the algae *Spirogyra* and *Plectonema* becoming most important in summer and fall. Although a majority of the food used by *C. diabolis* is available only on or near the shallow shelf, divers have confirmed, as late as mid-October, that algae covers about 80 percent of the available substrate from the area adjacent to and just below the shelf to a depth of about 12 m (35 ft), 15–20 percent from 12–17 m (35–50 ft), with only trace amounts below 17 m.

Dissolved oxygen concentration is relatively uniform at 2.5–3.0 ppm throughout the water column to a depth of about 22 m. Photosynthetic activity increases dissolved oxygen concentrations on the shelf during midday as a function of light intensity and duration. Maximum values of 6.0–7.0 ppm DO have been recorded on the shelf in June and July.

It is unlikely that *C. diabolis* movement from the shelf to the depths during periods of peak sunlight is in response to availability of dissolved oxygen. Such a movement would imply oxygen avoidance on the part of this species. Work with *Crenichthys* sp. by Hubbs et al. (1967) indicates increased activity and greater numbers of fish in areas of higher dissolved oxygen in the natural habitats of these species.

Daily Movement

James (1969) noted that as light intensity increased during the day at Devil's Hole the number of fish present on the shelf decreased

[1]Department of Biological Sciences, University of Nevada, Las Vegas, Nevada 89154.

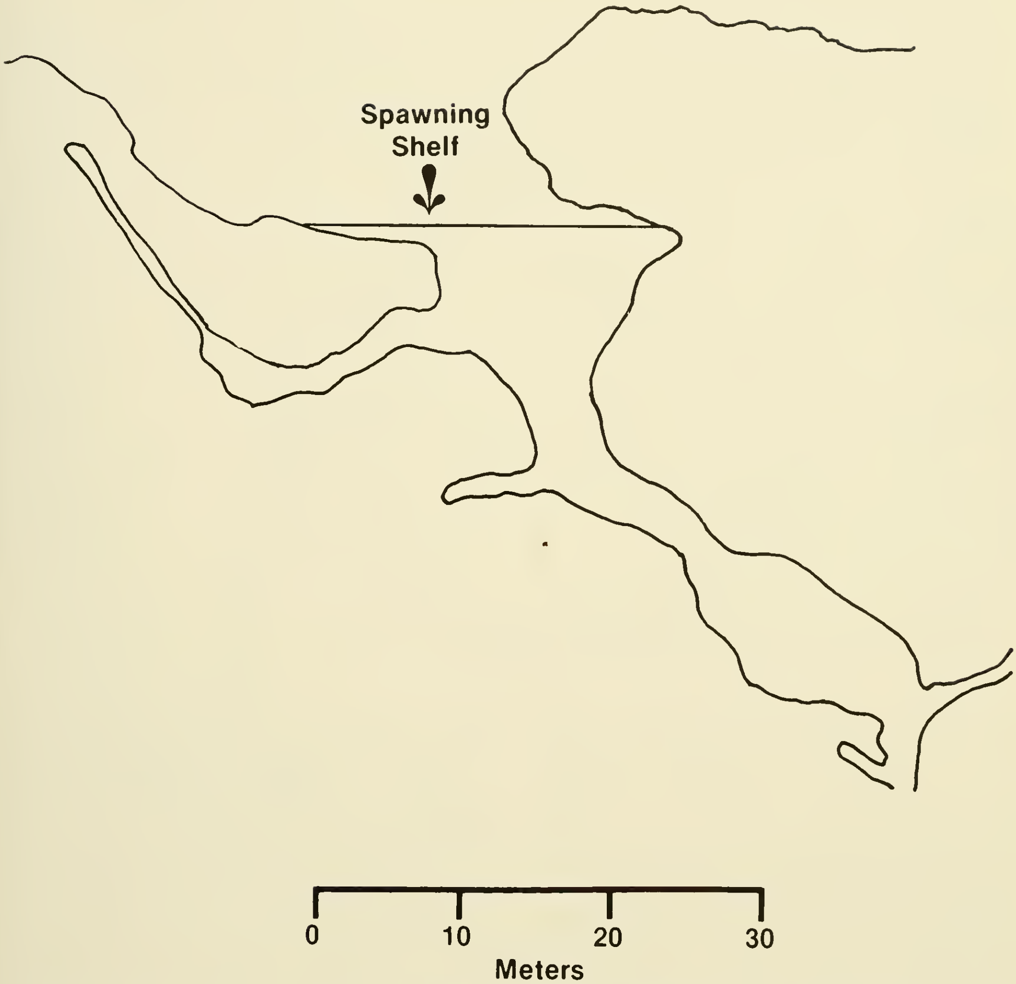

Fig. 1. Upper section of Devil's Hole, Ash Meadows, Nevada, showing shelf exposed to sunlight and upper portion of cavern system.

(Fig. 2). Since 1974, counts of fish in Devil's Hole have been made by both a surface team and a scuba dive team. From 1974 through 1978 counts were made in the morning around 0900 hr, near the period when maximum light falls on the shelf at about 1200 hr, and in the afternoon at about 1600 hr. Analysis of these population data (Fig. 3) tend to support the observations of James (1969) that the numbers of fish present on the shelf generally decrease around the noon period of maximum light intensity on the shelf. This tendency is most marked during the period of April through September, when light intensity and duration are the greatest. The lack of a sharply defined decrease in numbers on the shelf around noon in July is inconsistent. Whether it is real or an artifact is unknown. An increase in fish numbers on the shelf around noon usually does not occur during the period October through March, when sunlight reaches the water surface only briefly or not at all during midday. In fact, from December through March there is a regular increase in numbers of fish occupying the shelf as the day progresses.

Movement Within the Year

In addition to the diel rhythm noted by James (1969) and verified by ongoing population surveys, data were also analyzed to determine the relationship between duration and intensity of sunlight and fish numbers on

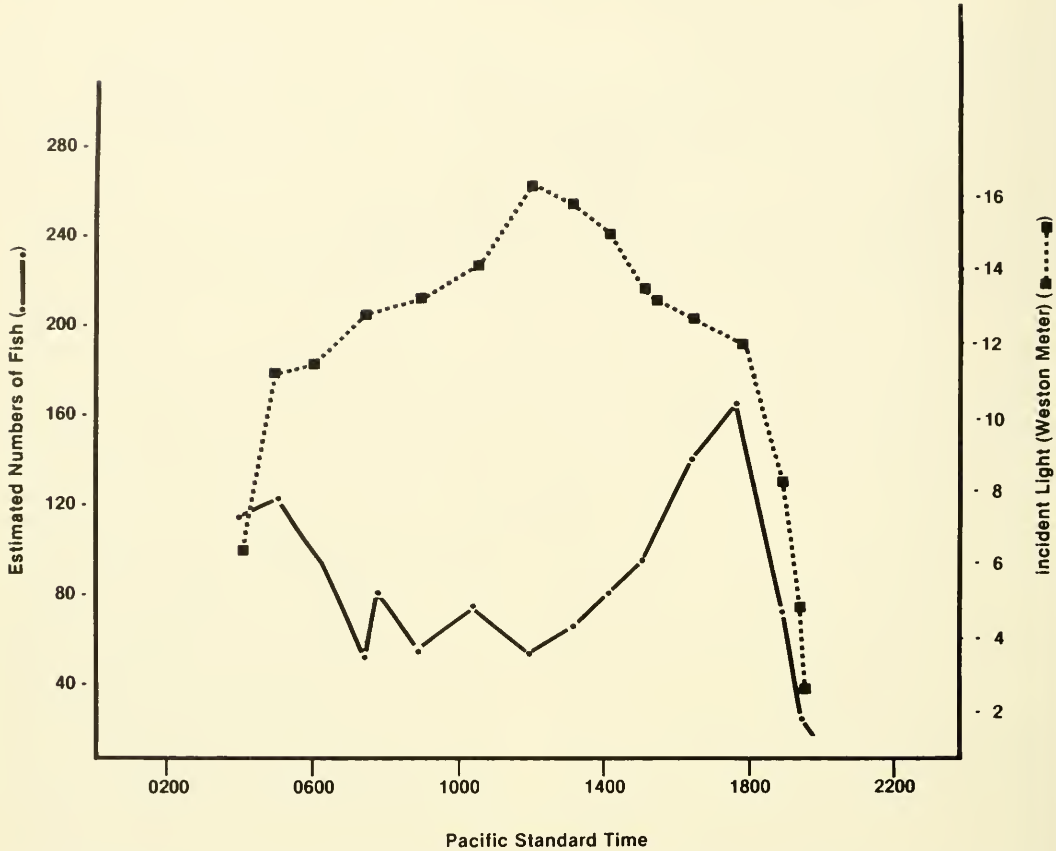

Fig. 2. Relationship of diel fluctuation in incident light with estimates of the fish population inhabiting the upper shelf (from James 1969).

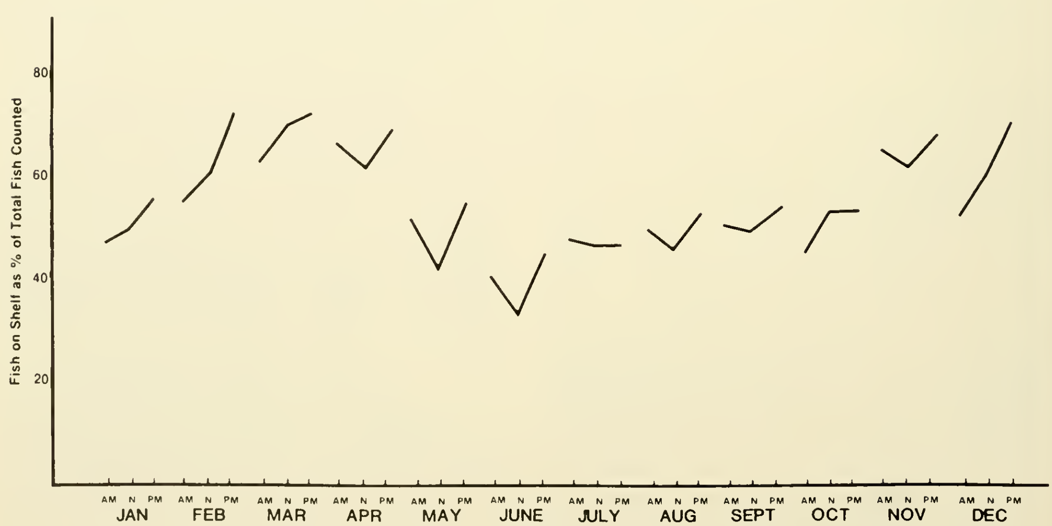

Fig. 3. Fish on shelf as a percentage of total fish counted by period in day.

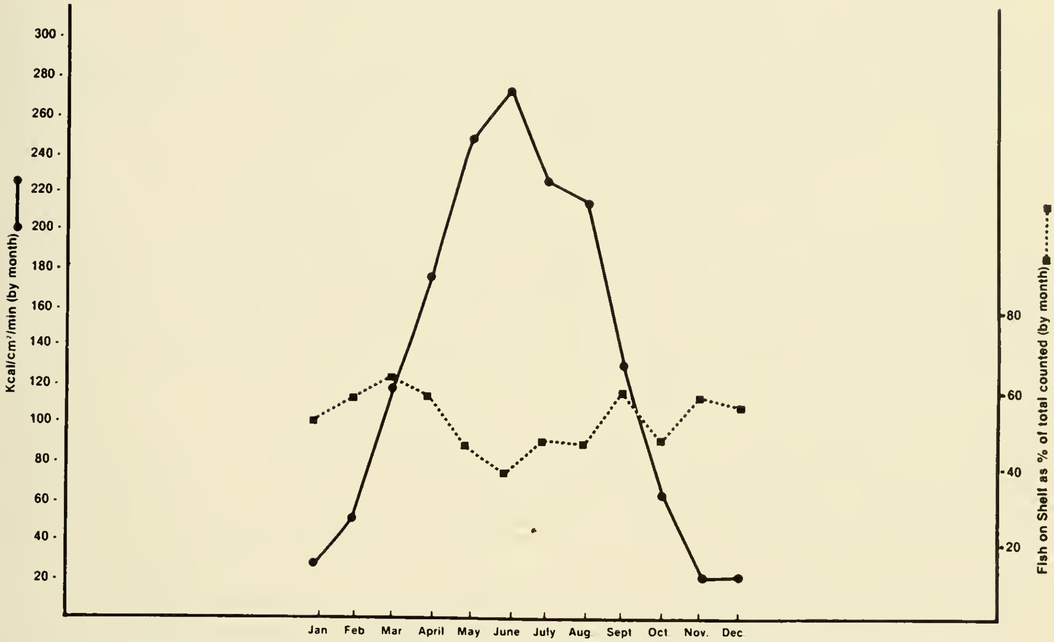

Fig. 4. Relationship of sunlight (kcal/cm²/min) to fish on shelf as percent of total fish counted.

the shelf through the year. The results of this analysis are presented in Figure 4 and indicate that the number of fish present on the shelf, as a percentage of the total fish counted, is inversely proportional to the intensity and duration of sunlight on the shelf over a twelve-month period. A one-way analysis of variance indicated that significant differences existed between monthly population counts presented in Figure 4.

While an inverse relationship between sunlight duration and intensity and percentage of the population occupying the shelf does exist, other factors may influence the relationship. For example, the increasing percentage of the population occupying the shelf from January through March may be related to spawning activities, which increase in intensity during this period and are concentrated on the shelf (James 1969, Minckley and Deacon 1975). The declining percentage of the population occupying the shelf from March to the annual minimum in June occurs during the time when fry and juveniles are increasing in abundance on the shelf. Although these events in the life cycle of *C. diabolis* may influence the pattern shown in Figure 4, with the exception of October, the relationship between sunlight and percentage of the population on the shelf is most striking and consistent.

Figure 5 profiles fish present at various levels in the water column as a percent of the total number of fish counted by month over the five-year study period. These data are consistent with those presented in Figure 4 and indicate a decrease in shelf population and an increase in population at depths with more sunlight.

With the exception of October, when population pressure on the shelf may contribute to recruitment to the next lowest level, the partial depopulation of the shelf does not appear to be a general function of population pressure. Analysis of population data for the period 1974–1978 indicates that the yearly population curve is essentially sinusoidal, reaching a low in March and April and a peak in August and September. Thus, the highest percentage of the population occurring on the shelf corresponds to both the maximum and minimum population densities.

Summary

The Devil's Hole pupfish, *Cyprinodon diabolis* Wales, engages in movement from and to a narrow rock shelf at the surface of the

Fig. 5. Relationship of sunlight to fish occupancy of upper 27 m of Devil's Hole by level.

Devil's Hole system. Movement occurs daily and yearly during periods of maximum sunlight intensity and duration.

Acknowledgments

We thank the U.S. Department of the Interior, Fish and Wildlife Service and National Park Service, and the Nevada Division of Wildlife for the permits which made this work possible. Numerous individuals assisted with the monthly population counts. The National Park Service provided partial financial assistance. The analysis was done and the manuscript completed while James E. Deacon was a Barrick Distinguished Scholar at the University of Nevada, Las Vegas, and an adjunct professor at the International College of the Cayman Islands.

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A REVISION OF THE GENUS *MICRORHOPALA* (COLEOPTERA: CHRYSOMELIDAE) IN AMERICA NORTH OF MEXICO

Shawn M. Clark[1]

Abstract.— The eight known North American species of *Microrhopala* infest *Solidago*, *Aster*, and other compositaceous plants. Descriptions and keys to species and subspecies are given. *Microrhopala rileyi* is named as a new species from Missouri, *M. hecate* (Newman) is removed from synonymy with *M. cyanea* (Say), and *M. cyanea* is reduced to a subspecies of *M. excavata* (Olivier). Lectotypes are designated for taxa described originally in the genus *Hispa*, i.e., *Hispa vittata*, *H. xerene*, and *H. erebus*, and neotypes are designated for *H. excavata* and *H. cyanea*. Phylogenetic relationships are discussed.

History.— The generic name *Microrhopala* was first published by Dejean (1837) and attributed to Chevrolat. This name has often been listed with Dejean as its author, because it was never actually described or listed by Chevrolat. However, following the nomenclatural interpretation of Barber and Bridwell (1940), authorship is again credited to Chevrolat in this study. Included in the genus were two valid species, *Hispa vittata* Fabricius, 1798, and *H. excavata* Olivier, 1808.

Melsheimer (1853) added *H. cyanea* Say, 1823, to the genus but referred *H. excavata* back to *Hispa*. Baly (1864) published the first generic description of *Microrhopala* and designated *H. vittata* as the type species. He also returned *H. excavata* to the genus and added *H. xerene* Newman, 1838. *Odontota rubrolineata* Mannerheim, 1843, was transferred to the genus by Crotch (1873), and, finally, Schwarz (1878) named *M. floridana* and also transferred *H. erebus* Newman, 1841, to the genus. Several other species are known from tropical America but do not extend north of Mexico; no Old World species are known.

In addition to the species cited above, several varieties and geographical races have been named in *Microrhopala*. LeConte (1859a) presented *M. signaticollis* as a distinct species, but it was reduced to a variety of *rubrolineata* by Crotch (1873). *Microrhopala xerene* var. *interrupta* was named by Couper (1865). Horn (1883) presented *M. vulnerata* as a distinct species, but this was reduced to a variety of *rubrolineata* by Weise (1911). Finally, *M. rubrolineata* var. *militaris* was named by Van Dyke (1925). Most of these varieties represent true subspecies, but *laetula* and *interrupta* are no longer recognized (Weise 1911, McCauley 1938).

Also, *H. hecate* Newman, 1841, was synonymized with *M. cyanea* by Gemminger and Harold (1876), and *M. bivitticollis* was described by Baly (1864) and later synonymized with *M. rubrolineata* var. *signaticollis* by Weise (1911).

In addition to the above species that actually belong to *Microrhopala*, various others have sometimes been assigned to the genus but do not belong here. These are *M. porcata* (Melsheimer, 1846) (now in *Glyphuroplata*), *M. collaris* (Say, 1823) (now in *Chalepus* and synonymized with *C. walshi*), *M. melsheimeri* Crotch, 1873 (now in *Brachycoryna* and synonymized with *B. hardyi*), *M. plicatula* (Fabricius, 1801) (now in *Octotoma*), *M. uniformis* Smith, 1885 (now in *Uroplata*), *M. dimidiata* Horn, 1883 (now in *Pentispa* and synonymized with *P. melanura*), *M. montana* Horn, 1883 (now in *Brachycoryna*), *M. suturalis* (Baly, 1885) (now in *Pentispa*), and *M. arizonica* Schaeffer, 1906 (now in *Pentispa* and synonymized with *P. suturalis*).

Relationship to Other Genera.— Within the family Chrysomelidae, *Microrhopala* is

[1]Department of Zoology, Brigham Young University, Provo, Utah 84602. Present address: Department of Entomology, Ohio State University, Columbus, Ohio 43210.

placed in the subfamily Hispinae and the tribe Uroplatini (Weise 1910). The tribe Uroplatini is best characterized by having the four terminal segments of the antenna very closely united and often appearing as a single segment.

In addition to *Microrhopala*, five other genera are included in this tribe. Four of these genera—*Octotoma*, *Brachycoryna*, *Stenopodius*, and *Glyphuroplata*—are easily distinguished from *Microrhopala* as follows. *Brachycoryna* and *Stenopodius* are distinguished from the others by their short antennae that are not longer than the pronotum, and *Octotoma* and *Glyphuroplata* are distinguished by having more than eight striae on the elytra. Apart from being members of the same tribe, these genera show no particularly close affinities to *Microrhopala*. However, the fifth genus, *Pentispa*, shares many characters with *Microrhopala* and is apparently closely related. It is distinguished by the flattened, more strongly costate elytra, but even this character does not eliminate all difficulties in separating the genera. In fact, a careful study of the species of *Pentispa* may eventually indicate that they are congeneric.

Biology

The life cycle and development of *Microrhopala* are well known for only *M. vittata* and *M. xerene* (Hendrickson 1930, McCauley 1938). During the summers of 1980 and 1981, I observed these two species in Provo Canyon, Utah, and confirmed previous reports about them, but also uncovered new information. These data summarize what is known about *vittata* and *xerene*, but much of it probably applies to the other species in this genus.

So far as is known, larvae of all species in the genus are internal leaf miners of compositaceous plants, and adults are external leaf feeders of the same host species. Host selection is very narrow, and each beetle species is restricted in its feeding activity to only a few plant species.

Oviposition occurs in the early summer and may be either on the upper or lower surface of the host leaf, usually near the apex. A female usually lays three to five disk-shaped eggs in a contiguous row. The eggs are positioned on their edges and are slightly tilted back on each other. After oviposition, the female covers the eggs with an anal secretion, likely feces, that soon hardens to a black, crusty material, which probably serves to protect the eggs. Often, several rows of eggs are laid alongside one another, in which case all rows are protected by a single covering. I observed a female of *M. vittata* laying eggs on 16 June 1981; these eggs hatched on 10 July 1981, thus indicating a period of 3.5 weeks (25 days) in this stage of development.

When the eggs hatch, the larvae enter directly into the leaves below the crusty covering without exposing themselves to the external environment and begin feeding on tissues between the upper and lower epidermal layers. Mining begins near the apex of the leaf and continues to the base. I have seen larvae of *M. xerene* emerge from one leaf and enter another, where mining activity continued. Eventually, the larvae dispersed themselves such that only one to four larvae were usually found in each leaf. In 1981 I noted that the first eggs of *M. vittata* hatched on 23 June, and pupae were first noted on 22 July, thus indicating a larval duration of approximately one month (30 days).

At the end of the larval stage many leaves contain large, inflated cavities where the larvae have mined. The beetles pupate in these cavities. According to my observations, the pupal period lasts for five to eight days.

The adults emerge and spend several days within the mines until their cuticle is sufficiently hardened. They then abandon the mines and begin to feed externally on the same host as did the larvae. Small areas of the leaf, usually not much larger than the size of a beetle, are skeletonized by this activity. After feeding, a few beetles mate. However, most mating activity is delayed until the next spring.

Toward the end of the summer, the beetles begin to wander, presumably in search of places to pass the winter. During this time they may be found on many plant species, but they do not feed on them, and this has likely led to several erroneous host plant records. Eventually, the beetles find areas under loose bark, crevices in the soil, accumulated debris, or leaf litter, and pass the winter in these situations.

When spring arrives, the beetles emerge from their overwintering sites, then resume feeding and mating activity. Males remain mounted atop females for several hours before copulation actually takes place. I have observed such pairs of *M. vittata* rapidly swaying from side to side in repeated motions that continue for up to one minute. The motions may be important in identifying a mate, and it is possible that comparable activities may exist for other species. Eventually, copulation occurs, and oviposition begins within a few days. In 1981, I observed that a population of *M. vittata* first laid eggs on 26 May and continued until 22 July, indicating an oviposition period of just less than two months. Soon after oviposition the adults died. Nearly all the beetles died before the next generation of adults emerged.

Generally, only one generation is produced each year, but there is some indication that there may be two generations at low altitudes in the southern United States. Also, adults can be found throughout the year but are most often collected only during the active summer months.

Discussion of Characters

Various characters have been used in the classification of *Microrhopala* (Baly 1864, Douglass 1929, McCauley 1938). These include the presence or absence of costae on the elytra, the size of serrations on interstriae 9, the size and depth of pronotal and elytral punctures, the color, the presence or absence of metallic lusters, and the size and conformation of colored markings when present.

McCauley (1938) attempted to find reliable genitalic characters but reported the following:

> The genitalia of *Microrhopala* in common with other genera of the subfamily Hispinae are of little taxonomic value. During the winter of 1935–1936 the male genital tubes of a large series of individuals from all of the species in the genus were carefully dissected out and mounted upon hairs. The results were very disappointing. At first, slight differences seemed to be apparent between species, but as the series were extended it was soon obvious that these differences were no greater than the differences existing between members of what were unquestionably the same species. In no instance was a character observed which was either constant, distinct, or describable enough to be used taxonomically. The female genitalia showed even less and in addition are difficult to preserve in a position undistorted as well as practical for observation.

In connection with the present study, all the characters mentioned above were again examined, and several others were also investigated (Table 1). These previously unused characters include the extent of minute reticulation, the size of the eye, the nature of the punctures behind the eye, the shape of the

TABLE 1. Ancestral and derived characters of *Microrhopala*.

Ancestral	Derived
1. Mesal impression of vertex not laterally margined by punctures	1. Mesal impression of vertex laterally margined by punctures
2. Elytra with more than eight striae	2. Elytra with eight striae
3. Eye large	3. Eye small
4. Thin strip of cuticle at anterior margin of pronotum well formed	4. Thin strip of cuticle at anterior margin of pronotum poorly formed
5. Ventral area of head not reticulate	5. Ventral area of head reticulate
6. Red markings present	6. Red markings absent
7. Femora broad	7. Femora narrow
8. Interstriae 9 strongly serrate	8. Interstriae 9 not strongly serrate
9. Frons angular	9. Frons not angular
10. Prothorax narrowed anteriorly	10. Prothorax not narrowed anteriorly
11. Anterolateral tubercle of pronotum not extending beyond anterior margin	11. Anterolateral tubercle of pronotum extending beyond anterior margin
12. Body broad	12. Body narrow
13. Elytral punctures of small or moderate size, not confused	13. Elytral punctures large, confused
14. Interstriae 9 strongly serrate	14. Interstriae 9 not strongly serrate

frons, the structure of the anterior margin of the pronotum, and the width of the hind femora. Genitalia structure was not found to be taxonomically helpful.

The findings of this study are that the physical appearance of most species of *Microrhopala* is extremely variable. Many clinal differences exist, some of which are usable in the characterization of geographical races. Also, tremendous variation often occurs among individuals in a local, interbreeding population. These variable characters include size, color, location and extent of colored markings, and, to a limited degree, density and coarseness of pronotal and elytral punctures. Because of this situation, it is difficult to select characters that are sufficiently reliable to separate taxa and, at the same time, constant within each taxon.

However, a few anatomical characters were found that not only allow for the identification of species but also suggest phylogenetic relationships.

One such character involves a thin, transparent piece of cuticle at the anterior margin of the pronotum. This structure is best seen in *M. vittata*, in which it forms the entire anterior margin of the pronotum. In other species this structure is obscure. However, it is always represented by either a small piece of cuticle that is present only mesally or by an indistinct, strongly scalloped piece of cuticle along the entire anterior margin of the pronotum. It is not reasonable to assume that this structure developed independently for each phylogenetic line of the genus. A more likely interpretation is that the well-formed structure of *M. vittata* is a primitive condition that has been variously reduced in other species.

Two other characters, a comparatively small eye and minute reticulation on the ventral area of the head, are also unique to *M. vittata*. These characters are not found in any other species of *Microrhopala* or in any other genera of the tribe Uroplatini.

Although most species of *Microrhopala* have distinct serrations on interstriae 9 of the elytra, these serrations have been greatly reduced or completely lost in several phylogenetic lines of the genus. Strong serrations are also prevalent in other genera of Uroplatini and are therefore considered to be ancestral. Also, the frons of most species is transversely, arcuately angulate or carinate. However, this apparently primitive character has been lost in a few species. Most species also have the hind femora slightly broadened. However, the hind femora of *M. xerene*, *M. rubrolineata*, and *M. rileyi* differ from the typical, apparently primitive condition in being more slender.

Another character involves the presence of red or orange vittae on the elytra. These vittae occur in *M. vittata*, *M. xerene*, *M. rubrolineata*, and *M. rileyi*, and also in the closely related genus *Pentispa*. They are here considered to be a primitive condition.

The elytral sculpture of *Microrhopala* differs tremendously from one species to another. However, the primitive condition apparently consists of regular strial rows that are separated by distinctly elevated interstriae. This condition exists for many of the species of this genus and is also prevalent throughout the tribe Uroplatini.

Microrhopala floridana is unusual in its very elongate form and in its parallel-sided prothorax. These characters are not found in any other species of the genus and are apparently derived from the more usual condition exhibited by other species.

PHYLOGENY

The morphological characters of *Microrhopala* suggest a major division in the phylogeny of the genus (Fig. 10). One branch includes a single species, *M. vittata*, which has several important characters. One such character is the anterior margin of the pronotum that is entirely formed by a slender, thin, transparent strip of cuticle. This strip is apparently a primitive structure that has been greatly reduced in other species. Also, the eye of *M. vittata*, in comparison to the size of the head, is much smaller, and interstriae 9 of the elytra is never serrate or conspicuously undulate. The second branch of the genus contains all other species.

This second branch can be divided into two species groups, the first of which includes *M. xerene*, *M. rubrolineata*, and *M. rileyi*. These species all have red or orange vittae on the pronotum or elytra or both, a character that they share with *M. vittata*. Also, the hind femora are distinctly broadened. Within the group, *M. xerene* is a distinctive species and is apparently only distantly related to *M. rubrolineata* and *M. rileyi*. It is distinct in having reduced serrations on interstriae 9 and in the angular frons. The two remaining species share many characters and appear to be closely related. Interestingly, some specimens of *M. rubrolineata* are remarkably similar to *M. excavata cyanea*. However, the characters listed above are sufficient to indicate that the species belongs with this group rather than with *M. excavata*.

The second species group includes *M. excavata, M. hecate, M. erebus*, and *M. floridana*. The distinctive species *M. floridana* exhibits a narrow body form and a parallel-sided prothorax. These substantial characters are unique in the genus and suggest significant phylogenetic distance between this species and others in the group. Two of the remaining species, *M. excavata* and *M. hecate*, show an interesting and slightly perplexing relationship. *Microrhopala hecate* is similar to *M. e. excavata* and differs from *M. e. cyanea* in having distinct elytral costae, but it is similar to *M. e. cyanea* and differs from *M. e. excavata* in having very regular strial rows and only slight serrations on interstriae 9 of the elytra. Although *M. hecate* is very distinctive in the structure of the frons, the above characters indicate a close affinity to *M. excavata*. The last species, *M. erebus*, is similar to *M. excavata* and *M. hecate* in its overall form but is very distinct in having extremely coarse, confused punctures on the elytra.

Systematic Treatment

Genus *Microrhopala* Chevrolat

Microrhopala Chevrolat, 1837, page 389 *in* Dejean, Catalogue des Coléoptères, 3d ed. (Type species: *Hispa vittata* Fabricius, designated by Baly, 1864, Ann. Mag. Nat. Hist. (3):14:268–269)

Diagnosis.— Within the tribe Uroplatini, *Microrhopala* differs from *Brachycoryna* and *Stenopodius* by the more elongate body, and by the antennae that exceed the length of the prothorax; from *Octotoma* and *Glyphuroplata* by having only eight elytral striae; and from the closely related *Pentispa* by having less strongly elevated elytral costae and by being more evenly convex dorsally.

Description.— Length 3.0–7.0 mm, 2.0–2.9 times as long as wide; color variable, either metallic blue, green, or bronze or nonmetallic red to black; pronotum and elytra sometimes marked with orange to red vittae.

Head subglobular, often with an arcuate, transverse carina below the antennae, a longitudinal carina between the antennae; surface minutely reticulate, at least dorsally; area surrounding eyes closely punctured; vertex mesally impressed, impression bordered on each side by a longitudinal row of punctures. Antennae distinctly longer than pronotum, segments 7–11 distinctly wider and more densely pubescent than preceding segments, segments 8–11 closely united and appearing as a single segment.

Pronotum 0.5–0.8 times as long as wide, widest posteriorly, often narrowed anteriorly, 0.6–0.9 times as wide as elytra at humeri; transverse profile convexly arched; in dorsal aspect, anterior margin appearing straight, lateral margins straight, arcuate, sinuate, or bisinuate, posterior margin bisinuate; anterolateral angles each armed by a bristle; surface usually minutely reticulate; punctation usually dense, of two or three sizes, smallest punctures equal in size to reticulations; a slender, usually slightly elevated strip lacking coarse punctures present in front of scutellum.

Elytra 1.6–2.2 times as long as wide, 0.7–0.8 times as long as body, usually slightly narrowed behind humeri, often minutely reticulate; eight striae and usually a scutellar striole present; striae 1 and 2 extending to apex of elytra, 8 and 9 separate or sometimes fused apically, extending to near suture where they join 1 and 2; interstriae 1 and 9 and also 3 and 7 meeting apically; interstriae 9 strongly elevated.

Venter, except mesal area of mesosternum, minutely reticulate; prosternum margined anteriorly by a row of short setae; abdomen sparsely punctate and pubescent, terminal segment more coarsely punctate and often more pubescent than preceding segments.

Key to the species and subspecies of *Microrhopala*

1. Eyes small, separated from oral fossa by a distance equal to or greater than width of antennal segment 3 (Fig. 9a); interstriae 9 of elytra never serrate, not or but slightly undulate; anterior margin of pronotum formed by a thin, transparent, slender strip of cuticle; frons prominent, acutely, transversely carinate; impressions margining rugae on vertex shallow; interstriae 3 at least as wide as striae 2 or 3; red markings present on pronotum and elytra; British Columbia and Maine to California and Georgia; 5.0–7.0 mm .... *vittata* (Fabricius)

— Eyes large, separated from oral fossa by a distance less than width of antennal segment 3 (Figs. 9b–i); interstriae 9 undulate to serrate; thin cuticle on anterior margin of pronotum largely obsolete or strongly scalloped laterally; frons not carinate, sometimes angular; impressions margining rugae on vertex deeper; interstriae 3 often narrower; red markings present or absent 2

2(1). Red markings nearly always present on pronotum and elytra; hind femora not or but slightly broader than middle femora; striae 5 and 6 with apical punctures usually similar in size to those near base; strial row 2 usually with more than 20 punctures 3

— Red markings never present on pronotum or elytra; hind femora conspicuously broader than middle femora; strial rows 5 and 6 with apical punctures usually larger than those near humerus; strial row 2 variable, often with less than 20 punctures 8

3(2). Interstriae 9 undulate to slightly serrate; lateral profile angled; tarsal segment 3 cleft ventrally to about half length of segment; eye margined behind by a double row of punctures (Fig. 9d); Alberta and Manitoba to Utah and Florida; 3.6–4.9 mm .... *xerene* (Newman)

— Serrations on interstriae 9 conspicuous; lateral profile of frons not prominent or angulate; tarsal segment 3 cleft ventrally to about two-thirds length of segment; punctures behind eye arranged in a single row, less often confused or arranged in a double row 4

4(3). Scutellum about half as long as wide; eye margined behind by a double or strongly confused row of punctures (Fig. 9c); striae 7 and 8 united apically; Arkansas to Illinois; 4.1–5.8 mm .... *rileyi* Clark

— Scutellum about two-thirds as long as wide; eye margined behind by a single or slightly confused row of punctures (Fig. 9b); striae 7 and 8 either fused or separate apically 5

5(4). Elytral vittae restricted to interstriae 5 or absent; dorsal surface usually minutely reticulate; striae 7 and 8 usually separate apically 6

— Elytral markings occupying more than one interstriae or, if rarely absent, elytral reticulation obsolete; striae 7 and 8 often fused apically 7

6(5). Elytral vittae present; California and Arizona to Sonora and Durango; 3.7–5.4 mm .... *rubrolineata rubrolineata* (Mannerheim)

— Elytral vittae absent; California to Baja California; 3.7–5.4 mm ....
.... *rubrolineata signaticollis* LeConte

7(5). Pronotal markings absent or greatly reduced; elytra distinctly reticulate; Arizona to New Mexico; 3.8–4.7 mm .... *rubrolineata vulnerata* Horn

— Pronotal markings present, usually covering most of pronotum; minute reticulation of elytra absent or indistinct; California to Texas; 3.7–4.7 mm ....
.... *rubrolineata militaris* Van Dyke

8(2). Prothorax strongly narrowed anteriorly; width across elytral humeri more than twice width across base of head; form usually stouter, 2.1–2.6 times as long as wide 9

— Prothorax parallel sided or only slightly narrowed anteriorly; width across elytral humeri about twice that across base of head; form slender, 2.3–2.9 times as long as broad; Florida to North Carolina; 3.0–4.9 mm .... *floridana* Schwarz

9(8). Striae 2 with 11–25 punctures; interstriae 5 and 7 not or but slightly sinuate; serrations on interstriae 9 weaker, less numerous, sometimes largely obsolete, usually with one or fewer serrations per adjacent puncture 10

— Striae 2 with 8–14 punctures; either interstriae 5 and 7 strongly sinuate, or punctures strongly confused and interstriae not evident; interstriae 9 strongly serrate, usually averaging more than one serration per adjacent puncture; Florida; 4.3–5.4 mm .... *erebus* (Newman)

10(9). Profile of frons prominently rounded, not angulate (Fig. 9g); interstriae not or only slightly sinuate; interstriae 5 distinctly elevated; striae 2 with 20–25 punctures; Ohio to South Carolina and Georgia; 4.1–5.5 mm .... hecate (Newman)

— Profile of frons either not prominent or distinctly angulate; if interstriae 5 elevated, striae 2 with less than 20 punctures and lateral interstriae usually sinuate 11

11(10). Frons angulate in lateral aspect (Fig. 9f); interstriae 3 usually narrower than striae 3 or 4; interstriae 9 distinctly serrate; Minnesota and Nova Scotia to Texas and Florida; 4.1–5.6 mm .... *excavata excavata* (Olivier)

— Lateral profile of frons not angulate or prominent (Fig. 9e); interstriae 3 usually wider than striae 3 or 4, at least posteriorly; interstriae 9 not or but slightly serrate; Alberta and Manitoba to Arizona, Texas, and Missouri; 4.0–6.0 mm .... *excavata cyanea* (Say)

Microrhopala vittata (Fabricius)

Hispa vittata Fabricius, 1798, Suppl. Ent. Syst., p. 117 (Lectotype, male; Carolina; Zoologisk Museum, Copenhagen, present designation)

Microrhopala vittata: Chevrolat, 1837, in Dejean, Catalogue des Coléoptères, 3d ed., p. 389.

Microrhopala laetula LeConte, 1859, Smithsonian Contribution to Knowledge 11:27–28 (Holotype, female?; "Kansas"; Mus. Comp. Zoology); Weise, 1911, Col. Cat. p. 38. *Synonymy*

DIAGNOSIS.— This distinctive species can easily be recognized by the comparatively small eye that is separated from the oral fossa by a distance about equal to the width of antennal segment 3 and by the presence of a thin, slender, transparent strip of cuticle along the entire anterior margin of the pronotum. It is similar to *M. xerene*, *M. rubrolineata*, and *M. rileyi* in having red markings but is distinguished from them by the above characters as well as by the comparatively smaller strial punctures on the elytra.

MALE.— Length 5.0–6.0 mm, 2.0–2.4 times as long as wide; mature color red to black, each elytron with a lighter colored vitta.

Head with minute reticulation of dorsal surface continuing behind eyes and to ventral area; antennae usually black, occasionally rufous; front arcuately, transversely carinate below antennae; eyes comparatively small, separated from oral fossa by a distance equal to antennal segment 3; punctures bordering mesal impression of vertex comparatively shallow, usually confused.

Pronotum 0.6–0.7 times as long as wide, 0.8 times as wide as elytra across humeri, narrowed anteriorly; lateral margins rounded to sinuate; color orange to red, often with a median dark vitta; most punctures separated from one another by distances equal to more than the diameter of a puncture; entire anterior margin formed by a slender transparent strip of cuticle.

Elytra 1.7–1.8 times as long as wide, widest posteriorly; color red to black, interstriae 5 more lightly colored; surface minutely reticulate; strial punctures comparatively small, mostly separated from each other by distances at least equal to the diameter of a

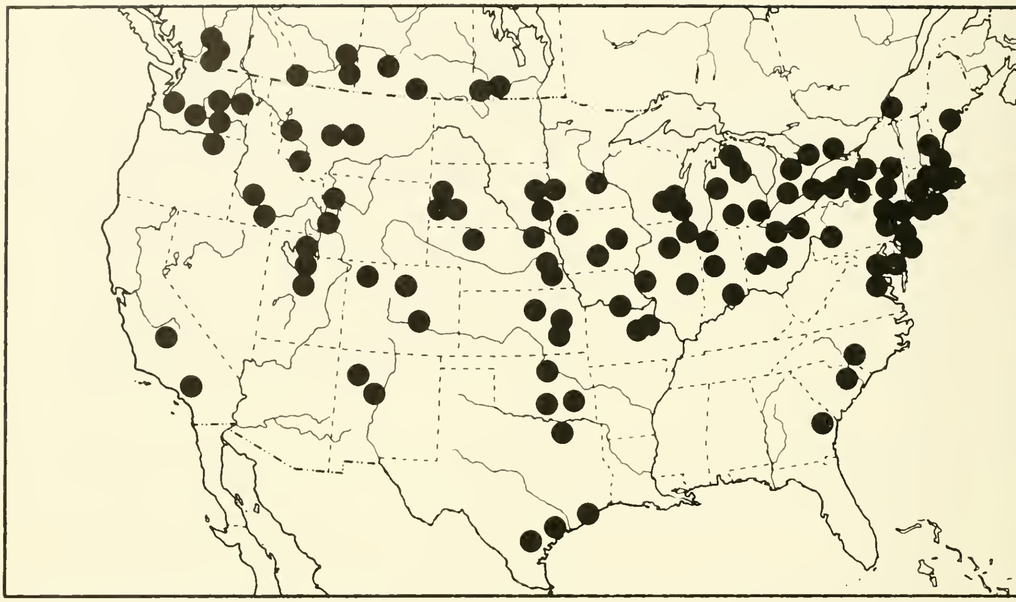

Fig. 1. Distribution of *Microrhopala vittata*.

puncture; interstriae 3 and 5 distinctly wider than others, slightly elevated; interstriae 9 never undulate or serrate.

FEMALE.— Externally similar to male except usually larger, 5.5–7.0 mm long.

VARIATION.— Specimens from Georgia and South Carolina north to Quebec and eastern Ontario tend to be colored red with orange vittae on the elytra and to have comparatively rounder strial punctures, while more western specimens are usually black with red vittae, and the elytral punctures are slightly smaller and more elongate. Throughout the range, but especially from Ohio to Illinois and north to the Great Lakes, occur specimens with short vittae that do not occupy all of interstriae 5, or vittae are rarely altogether lacking.

DISTRIBUTION.— British Columbia and Maine to California, Texas, and Georgia (Fig. 1).

CANADA: **Alberta:** Cypress Hills, Elkwater Park, Manyberries, Medicine Hat, Robinson, Spring Pt., Sweetgrass, Twin Butte, Waterton Park. **British Columbia:** Cawston, Kamloops, Keremeos, Oliver, 7 mi N of Oliver, Vernon. **Manitoba:** Aweme, Baldur, Melita, Ninette. **Ontario:** Ad & Lennox Co., Delhi, E. Moore L., Eramosa, Erieau, Fonthill, Grimsby, Guelph, Marmota, Niagara Falls, Ojibway, Penetanguishene, Port Dover, Prince Edward Co., St. Catharines, St. Thomas, Vineland, Windsor. **Quebec:** Beech Grove, Montreal. **Saskatchewan:** Aylesbury, Buffalo Pound, Swift Current, Kenosee, Minton, Rockglen, Val Marie, Wood Mountain. USA: **California:** Los Angeles Co., Tulare Co. **Colorado:** Boulder Co., Denver Co., Douglas Co., Larimer Co., Moffat Co., Pueblo Co., Routt Co., Yuma Co. **Connecticut:** Fairfield Co., Litchfield Co., Middlesex Co., New Haven Co. **District of Columbia:** Washington. **Georgia:** Chatham Co. **Idaho:** Ada Co., Bannock Co., Boise Co., Twin Falls Co. **Illinois:** Adams Co., Champaign Co., Cook Co., Knox Co., Lake Co., La Salle Co. **Indiana:** Clark Co., Lake Co., Lawrence Co., Tippecanoe Co., Warren Co. **Iowa:** Benton Co., Dickinson Co., Humboldt Co., Iowa Co., Lucas Co., Story Co. **Kansas:** Clay Co., Douglas Co., Greenwood Co., Shawnee Co. **Maine:** Lincoln Co. **Maryland:** Baltimore Co., Montgomery Co., Prince Georges Co., Baltimore. **Massachusetts:** Barnstable Co., Bristol Co., Essex Co., Hampden Co., Hampshire Co., Middlesex Co., Nantucket Co., Norfolk Co., Plymouth Co., Suffolk Co., Worcester Co. **Michigan:** Allegan Co., Cheboygan Co., Iosco Co., Jackson Co., Midland Co., Oakland Co., Oceana Co., Washtenaw Co., Wayne Co. **Minnesota:** Hennipin Co., Lincoln Co. **Missouri:** Boone Co., Callaway Co., Crawford Co., Gasconade Co., Hickory Co., Jefferson Co., Phelps Co., Pike Co., Randolph Co., Ste. Genevieve Co. **Montana:** Beaverhead Co., Cascade Co., Fergus Co., Judith Basin Co., Ravalli Co. **Nebraska:** Cherry Co., Douglas Co., Knox Co., Lancaster Co. **New Hampshire:** Belknap Co., Rockingham Co., Strafford Co. **New Jersey:** Bergen Co., Burlington Co., Camden Co., Cape May Co., Essex Co., Hudson Co., Monmouth Co., Ocean Co., Passaic Co., Union Co. **New Mexico:** Bernalillo Co., McKinley Co. **New York:** Albany Co., Allegheny Co., Bronx Co., Cattaraugus Co., Cayuga Co., Columbia Co., Dutchess Co., Erie Co., Genesee Co., Greene Co., Jefferson Co., Kings Co., Monroe Co., Nassau Co., Orange Co., Orleans Co., Oswego Co., Putnam Co., Queens Co., Rensselaer Co., Richmond Co., Rockland Co., Schuyler Co., Tompkins Co., Ulster Co., Wayne Co., Westchester Co., Wyoming Co. **North**

Carolina: Gaston Co. **Ohio:** Ashtabula Co., Butler Co., Champaign Co., Clinton Co., Cuyahoga Co., Erie Co., Franklin Co., Lorain Co., Summit Co. **Oklahoma:** Murray Co., Pawnee Co., Payne Co., Pittsburg Co. **Oregon:** Umatilla Co. **Pennsylvania:** Allegheny Co., Delaware Co., Northampton Co., Philadelphia Co. **Rhode Island:** Kent Co., Washington Co. **South Carolina:** Florence Co. **South Dakota:** Brookings Co., Custer Co., Lawrence Co., Minnehaha Co., Pennington Co. **Texas:** Collins Co., Galveston Co., Goliad Co., Jim Wells Co., Victoria Co. **Utah:** Box Elder Co., Cache Co., Davis Co., Utah Co. **Virginia:** Arlington Co., Fairfax Co., Alexandria, Falls Church. **Washington:** Franklin Co., Grant Co., Pierce Co., Spokane Co., Yakima Co. **Wisconsin:** Calumet Co., Dodge Co., Milwaukee Co. **Wyoming:** Lincoln Co., Teton Co.

BIOLOGY.— This species has been reported from *Solidago canadensis*, *S. graminifolia*, *S. juncea*, *S. missouriensis*, *S. mollis*, *S. sempervirens*, *Silphium laciniatum*, and *S. perfoliatum*. Species of *Solidago* are apparently the preferred host. Adults are active from May to September.

NOTES.— The above treatment was based on three syntypes of *H. vittata* in the Zoologisk Museum, Copenhagen, on the holotype of *M. laetula*, and on 2,275 other specimens. The three syntypes of *H. vittata* are mounted on the same pin; the top specimen, a male, is here designated as the lectotype for the species.

Microrhopala xerene (Newman)

Hispa xerene Newman, 1838, Ent. Mon. Mag. 5:390 (Lectotype, female; Trenton Falls, New York; British Mus. Nat. Hist., present designation)

Microrhopala xerene: Baly, 1864, Ann. Mag. Nat. Hist. (3)14:269

Microrhopala xerene var. *interrupta* Couper, 1865, Canad. Nat. and Geol. 2:63 (Holotype, male?; Hermitage, north of Quebec); Weise, 1911, Col. Cat. p. 38. *Synonymy*

DIAGNOSIS.— This species is similar to *M. vittata*, *M. rubrolineata*, and *M. rileyi* in having red markings. However, it is easily distinguished from *M. vittata* by having larger eyes that are separated from the oral fossa by less than the width of antennal segment 3 and by lacking a slender transparent strip of cuticle that is present along the entire anterior margin of the pronotum. It differs from *M. rubrolineata* in having interstriae 9 undulate or at most slightly serrate, in having the punctures behind the eye arranged in a strongly confused or double row, and in having the frons distinctly, transversely angled below the antennae. And it differs from *M. rileyi* by the smaller size, by lacking strong serrations on interstriae 9, and by the distinctly angled frons.

MALE.— Length 3.6–4.6 mm, 2.2–2.5 times as long as wide; color black, marked with orange to red vittae laterally on the pronotum and on each elytron.

Head black, minutely reticulate dorsally, not reticulate laterally and ventrally; antennae black, distinctly reticulate; frons prominent, appearing angular in lateral aspect; mesal impression of vertex bordered laterally by a row of deep, contiguous punctures; eyes separated from oral fossa by less than width of antennal segment 3; punctures behind eye arranged in a double row or strongly confused.

Pronotum 0.6–0.7 times as long as wide, 0.7 times as wide as elytra at humeri, narrowed anteriorly; sides sinuate; color black, usually with orange or red vittae extending forward from near the base of striae 5 of the elytra to the anterior margin of the pronotum; anterior margin with a small, transparent, mesal piece of cuticle that is not developed laterally; punctation dense, deep, with most punctures separated by less than the diameter of a puncture.

Elytra 1.7–1.9 times as long as wide, widest posteriorly; color black, with interstriae 5 and the distal end of interstriae 3 orange to red; reticulation distinct; discal punctures of moderate size, separated from other punctures of the same row by the diameter of a puncture or slightly less; lateral punctures slightly larger, more closely spaced; striae 5 and 6 with apical punctures usually similar in size to basal punctures; interstriae 3 and 5 wider than other interstriae, slightly elevated distally; interstriae 9 undulate or weakly serrate.

Hind femora not or but slightly wider than middle femora.

FEMALE.— Externally similar to male but averaging larger. 4.1–4.9 mm long.

VARIATION.— A few specimens, most commonly from Virginia to Florida, have the orange or red markings of the pronotum expanded and covering most of the dorsal surface. However, many western specimens, from Alberta and Saskatchewan south to Utah and Colorado, entirely lack pronotal

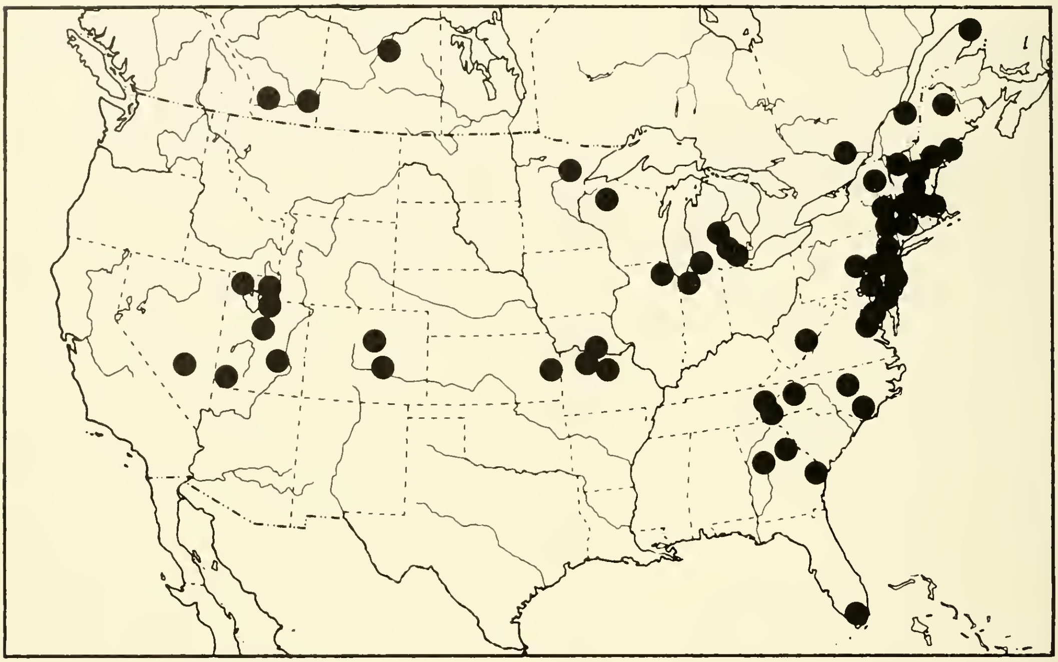

Fig. 2. Distribution of *Microrhopala xerene.*

markings. Throughout the range, but especially from Vermont to Maine and Quebec, specimens occur with interstriae 5 orange to red colored only in the basal half and at the distal end. And western specimens, from Alberta and Saskatchewan south to Utah and Colorado, have the elytral vittae expanded to include parts of interstriae 4 and 6, a condition that is occasionally found to a lesser degree in the eastern part of the range.

DISTRIBUTION.— Alberta and Maine to Utah and Florida (Fig. 2).

CANADA: **Alberta:** Elkwater Park, Lethbridge. **Manitoba:** Berens River. **Ontario:** Rainy R. Dist. **Quebec:** Cap Rouge, Duparquet, Gaspé, Gatineau Pk., Laniel, Ste-Foy, 25 mi W of Gaspé. **Saskatchewan:** 8 mi W of Paynton, Prince Albert. USA: **Colorado:** Denver Co., El Paso Co. **Connecticut:** Litchfield Co. **District of Columbia:** Washington. **Florida:** Monroe Co. **Georgia:** Chatham Co., Clarke Co., Fulton Co. **Illinois:** Cook Co. **Indiana:** La Porte Co., Porter Co. **Kansas:** Franklin Co. **Maine:** Lincoln Co., Oxford Co., Piscataquis Co. **Maryland:** Montgomery Co., Washington Co. **Massachusetts:** Berkshire Co., Hampden Co., Middlesex Co., Norfolk Co. **Michigan:** Berrien Co., Ingham Co., Jackson Co., Shiawassee Co., Washtenaw Co. **Minnesota:** Itasca Co. **Missouri:** Callaway Co., Pettis Co., Randolph Co. **Nevada:** Nye Co. **New Hampshire:** Cheshire Co., Grafton Co. **New Jersey:** Bergen Co., Burlington Co., Camden Co., Essey Co., Mercer Co., Morris Co., Warren Co. **New York:** Albany Co., Greene Co., Herkimer Co., Rockland Co., Sullivan Co., Ulster Co., Westchester Co. **North Carolina:** Brunswick Co., Buncombe Co., Guilford Co., Macon Co. **Pennsylvania:** Dauphin Co., Delaware Co., Lancaster Co., Montgomery Co., Philadelphia Co. **Tennessee:** Sevier Co. **Utah:** Box Elder Co., Cache Co., Utah Co., Washington Co., Wayne Co., Weber Co. **Vermont:** Lamoille Co. **Virginia:** Arlington Co., Fairfax Co., Stafford Co., Alexandria, Falls Church, Fredericksburg. **West Virginia:** Greenbrier Co. **Wisconsin:** Washburn Co.

BIOLOGY.— Reported host plants are *Aster chilensis, A. cordifolius, A. patens, A. paternus, A. puniceus, Boltonia asteroides, Solidago caesia, S. canadensis,* and *S. juncea.* Species of *Aster* are preferred to other hosts. In Provo Canyon, Utah, I have consistently encountered *M. xerene* feeding on *A. chilensis,* and, although *Solidago canadensis* is abundant in the same local area, the beetle does not utilize it. Adult beetles are most often collected from May to July.

NOTES.— The above treatment was based on a syntype of *Hispa xerene* from Trenton Falls, New York, that is now in the British Museum (Natural History) and on 566 other specimens. This syntype is here designated as the lectotype of the species.

Microrhopala rubrolineata (Mannerheim)

Odontota rubrolineata Mannerheim, 1843, Soc. Imp. Nat. Moscou (Moskov. Obshch. Isp. Prirody Otd.

Biol. Biul.) 2:307 (Holotype, male; Calif. bor.; Universitets Zoologiska Museum, Helsinki)

Microrhopala rubrolineata: Crotch, 1873, Proc. Acad. Nat. Sci. Philadelphia 25:82–83

DIAGNOSIS.— This species is similar to *M. rileyi,* from which it differs by having the punctures behind the eye arranged in a single row that is not or only slightly confused. It differs from *M. vittata* and *M. xerene,* which are similarly marked with red or orange, by the frons that does not appear prominent, angled, or carinate in profile.

MALE.— Length 3.7–5.3 mm, 2.3–2.6 times as long as wide; color black, often with a metallic blue or purple cast, often with orange markings on the pronotum or elytra or both.

Head distinctly, minutely reticulate dorsally, not or obsoletely reticulate laterally and ventrally; frons not angulate or prominent; mesal impression of vertex bordered laterally by a deep row of contiguous punctures; eye separated from oral fossa by less than the width of antennal segment 3; punctures posterior to eye arranged in a single, sometimes slightly sinuate row, never strongly confused. Antennae black sometimes with a metallic blue, purple, or green cast.

Pronotum 0.5–0.8 times as long as wide, 0.6–0.9 times as wide as elytra at humeri, narrowed anteriorly; lateral margins usually appearing straight or bisinuate in dorsal aspect, less commonly sinuate or arcuate; anterior margin with a small, thin, mesal piece of cuticle that does not extend laterally; punctures deep, usually separated by the diameter of a puncture or less; orange markings sometimes present in lateral areas.

Elytra 1.7–2.0 times as long as wide, usually widest posteriorly; punctures deep, mostly separated by less than the diameter of a puncture; striae 5 and 6 with apical punctures usually similar in size to those near base; striae 2 with 20–29 punctures; interstriae 7 costate, at least distally; interstriae 9 distinctly serrate; color wholly dark, or variously marked with orange.

Hind femora not or but slightly wider than middle femora.

FEMALE.— Externally similar to males from the same area but usually larger, 4.0–5.4 mm long.

NOTES.— Four subspecies are recognized within this species.

Microrhopala rubrolineata rubrolineata (Mannerheim)

Odontota rubrolineata Mannerheim, 1843, Soc. Imp. Nat. Moscou (Moskov. Obshch. Isp. Prirody Otd. Biol. Biul.) 2:307 (Holotype, male; Calif. bor.; Helsinki Museum)

Microrhopala rubrolineata: Crotch, 1873, Proc. Acad. Nat. Sci. Philadelphia 25:82–83.

DIAGNOSIS.— This subspecies can be distinguished from the others by the orange elytral vittae that occupy all or most of interstriae 5 but are not expanded to other interstriae.

MALE.— Length 3.9–5.2 mm, 2.3–2.6 times as long as wide, prothorax and elytra with orange vittae.

Head black, sometimes with a metallic blue cast.

Pronotum 0.6–0.8 times as long as wide, 0.7–0.8 times as wide as elytra at humeri; minute reticulation usually present, sometimes indistinct; lateral fourth orange except for narrow dark areas along the lateral margins and a slender dark area along the anterior margin; mesal area black, often with a metallic blue cast.

Elytra 1.7–2.0 times as long as wide; surface minutely reticulate; interstriae 3 and 5 usually wider than others; interstriae 5 and sometimes distal end of interstriae 3 orange, other areas black, sometimes with a metallic blue or purple cast.

FEMALE.— Similar to male but averaging larger, 4.3–5.3 mm long.

DISTRIBUTION.— Southern California and Arizona to Sonora and Durango (Fig. 3).

MEXICO: **Durango:** Durango. **Sonora:** 30 mi N Guayamas, 3 mi N Hermosillo. USA: **Arizona:** Cochise Co., Maricopa Co., Pima Co., Santa Cruz Co., Yuma Co. **California:** Almeda Co., Kern Co., Los Angeles Co., Madera Co., Orange Co., Riverside Co., San Bernardino Co., San Diego Co., Santa Clara Co., Ventura Co. **Texas:** Culberson Co.

BIOLOGY.— Reported host plants are *Encelia californica, E. farinosa, Franseria acanthicarpa, F. ambrosioides, F. confertiflora, Haplopappus squarrosus, H. venetus,* and *Heterotheca grandiflora.* Adults are active throughout the year but are most often collected during the summer.

NOTES.— This subspecies freely interbreeds with *M. r. militaris* wherever the two populations contact each other in southern Arizona and southern California, and it freely interbreeds with *M. r. signaticollis* in southern

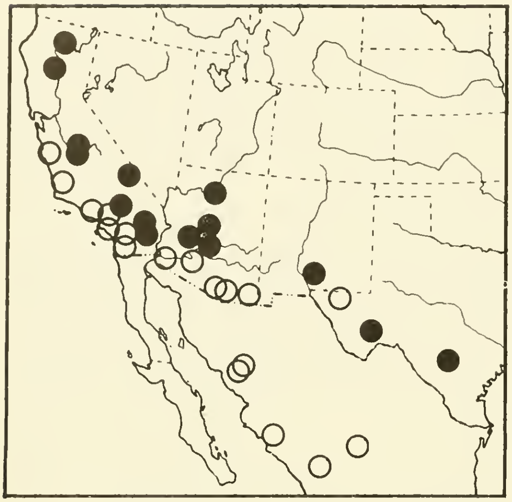

Fig. 3. Distribution of *Microrhopala rubrolineata rubrolineata* (open circles) and *M. r. militaris* (filled circles).

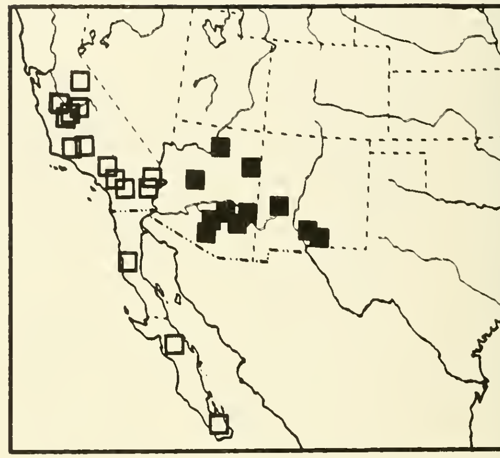

Fig. 4. Distribution of *Microrhopala rubrolineata signaticollis* (open squares) and *M. r. vulnerata* (filled squares).

California. The above treatment was based on the holotype of *Odontota rubrolineata* and on 730 other specimens.

Microrhopala rubrolineata signaticollis LeConte

Microrhopala signaticollis LeConte, 1859, Proc. Acad. Nat. Sci. Philadelphia 11:82 (Holotype, female?; Tejon, California; Mus. Comp. Zoology)

Microrhopala bivitticollis Baly, 1864, Ann. Mag. Nat. Hist. (3)14:268–271 (Holotype, female; probably California; British Museum); Weise, 1911, Col. Cat. p. 38. *Synonymy*

DIAGNOSIS.— This subspecies can usually be recognized by the absence of elytral vittae. However, a few unusual specimens of *M. r. militaris* also lack elytral vittae. This subspecies differs from such unusual specimens by having distinct elytral reticulation. Also, a few specimens of *M. r. signaticollis* lack pronotal markings in addition to elytral markings and therefore resemble *M. e. cyanea.* Such specimens are most easily distinguished by the single row of punctures posterior to the eye.

MALE.— Length 3.7–5.2 mm, 2.4–2.6 times as long as wide; color black, often with a metallic blue or purple tint, usually with orange markings on the pronotum.

Head black, sometimes with a metallic blue cast.

Pronotum 0.5–0.7 times as long as wide, 0.6–0.9 times as wide as elytra at humeri; surface minutely reticulate; color mostly black, often with a metallic blue tint; lateral fourth usually orange except a slender, dark area along the anterior margin and narrow dark areas along the lateral margins, or orange markings rarely absent.

Elytra 1.8–2.0 times as long as wide, distinctly, minutely reticulate; interstriae 3 slightly wider than others; colors black, often with a metallic blue or purple tint.

FEMALE.— Externally similar to male but averaging larger, 4.0–5.4 mm long.

DISTRIBUTION.— California to Baja California (Fig. 4).

MEXICO: **Baja California del Norte:** San Quintin, 10 mi S Catavina. **Baja California del Sur:** 5 mi W San Bartolo, Miraflores, 19 mi E Rosario, Sierra La Laguna, Todos Santos. USA: **California:** Fresno Co., Kern Co., Los Angeles Co., Madera Co., Monterey Co., Orange Co., Riverside Co., San Bernardino Co., San Diego Co., Santa Barbara Co., Tulare Co., Tuolumne Co.

BIOLOGY.— This subspecies has been reported from *Encelia californica, Haplopappus squarrosus, H. venetus,* and *Heterotheca grandiflora.* Adults are active from April to August.

NOTES.— This subspecies freely interbreeds with *M. r. rubrolineata* in areas of southern California where the populations contact each other. It also occasionally interbreeds with *M. r. militaris* in southeast California. The above treatment was based on the holotypes of *M. signaticollis* and *M. bivitticollis* and on 107 other specimens.

Microrhopala rubrolineata vulnerata Horn

Microrhopala vulnerata Horn, 1883, Trans. Amer. Ent. Soc. 10:291–292 (Holotype, female?; Arizona; Mus. Comp. Zoology)

Microrhopala rubrolineata var. *vulnerata:* Weise, 1911, Col. Cat. 35:38.

DIAGNOSIS.— The reduced or usually absent pronotal markings and the elytral markings that occupy more than a single interstriae distinguish this subspecies from others.

MALE.— Length 3.8–4.5 mm, 2.4–2.6 times as long as wide; color black or metallic blue, green, or purple, with orange markings on elytra.

Head black, often with a metallic blue or green cast.

Pronotum 0.6–0.8 times as long as wide, 0.7–0.8 times as wide as elytra at humeri; reticulation distinct; color metallic blue or purple, orange markings absent or confined to posterolateral corners.

Elytra 1.8–1.9 times as long as wide; minute reticulation usually distinct; color mostly black, usually with a metallic blue or purple cast; orange markings present, usually confined to interstriae 5 basally, expanded behind humeri to interstriae 4 and 8, narrowed distally and terminating between middle and distal fourth of elytra.

FEMALE.— Externally similar to male but averaging larger, 4.2–4.7 mm long.

DISTRIBUTION.— Arizona to New Mexico (Fig. 4).

USA: **Arizona:** Apache Co., Coconino Co., Gila Co., Graham Co., Greenlee Co., Pima Co., Pinal Co., Yavapai Co. **New Mexico:** Catron Co.

BIOLOGY.— This subspecies is known from *Solidago* sp. Adults are active from June to September.

NOTES.— The above treatment was based on the holotype of *M. vulnerata* and on 23 other specimens.

Microrhopala rubrolineata militaris Van Dyke

Microrhopala rubrolineata var. *militaris* Van Dyke, 1925, Pan-Pacific Ent. 1:173 (Holotype, male, Siskiyou Co., California; California Acad. Sci.)

DIAGNOSIS.— The well-developed pronotal markings in combination with the elytral markings that cover more than one interstriae usually distinguish this subspecies from others. However, a few unusual specimens are similar to *M. r. signaticollis* in lacking elytral markings. Such specimens are most easily recognized by the absence of distinct reticulation on the elytra.

MALE.— Length 3.7–4.6 mm, 2.3–2.4 times as long as wide; color black, sometimes with a slight metallic blue, green, or purple cast, with orange or sometimes red markings on the pronotum and elytra.

Head black, usually with a metallic blue or green tint.

Pronotum 0.6–0.7 times as long as wide, 0.7–0.8 times as wide as elytra at humeri; minute reticulation usually present, sometimes indistinct; mesal area and a slender area along the anterior margin black, often with a metallic blue or green tint; orange or sometimes red markings present in lateral areas, usually expanded to cover most of pronotum.

Elytra 1.7–1.8 times as long as wide; minute reticulation indistinct or lacking; color mostly black, often with a metallic blue or purple cast; orange or sometimes red markings present, usually confined to interstriae 5 basally, expanded to interstriae 8 and often to interstriae 4 behind humeri, narrowed distally, and terminating before middle of elytra.

FEMALE.— Externally similar to male but averaging larger, 4.2–4.7 mm long.

DISTRIBUTION.— California to Texas (Fig. 3).

USA: **Arizona:** Coconino Co., Maricopa Co., Pinal Co., Yavapai Co. **California:** Fresno Co., Imperial Co., Inyo Co., Los Angeles Co., Madera Co., Riverside Co., San Diego Co., Siskiyou Co. **New Mexico:** Otero Co. **Texas:** Brewster Co., Uvalde Co.

BIOLOGY.— *Encelia farinosa* and *Franseria* sp. are reported food plants. Adult beetles are active from March to September.

NOTES.— This subspecies freely interbreeds with *M. r. rubrolineata* wherever the two populations contact each other in southern Arizona and southern California. It also occasionally interbreeds with *M. r. signaticollis* in southeastern California. The above treatment was based on the holotype of *M. rubrolineata* var. *militaris* and on 211 other specimens.

Microrhopala rileyi, n. sp.

DIAGNOSIS.— This species is most similar to *M. rubrolineata,* from which it differs by hav-

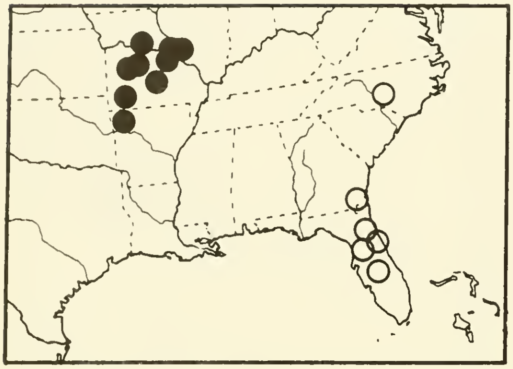

Fig. 5. Distribution of *Microrhopala rileyi* (filled circles) and *M. floridana* (open circles).

ing a double or strongly sinuate row of punctures behind the eye. It is also similar to *M. vittata* and *M. xerene* in having vittate elytra but differs from them by the frons that is not transversely carinate or angulate.

MALE.— Length 4.1–5.5 mm, 2.3–2.5 times as long as wide; mature color black, often with a metallic blue cast, with orange vittae on the prothorax and elytra.

Head distinctly reticulate dorsally, lacking reticulation laterally and ventrally; frons not appearing prominent or angulate in lateral aspect; mesal impression of vertex bordered laterally by a contiguous row of deep punctures; eye usually separated from oral fossa by less than width of antennal segment 3, bordered posteriorly by a double or strongly sinuate row of punctures. Antennae black, sometimes with a slight metallic cast.

Pronotum 0.7–0.8 times as long as wide, 0.7–0.8 times as wide as elytra at humeri, narrowed anteriorly; color in mesal area dark, in lateral fourths orange; lateral margins appearing bisinuate in dorsal aspect; anterior margin with a small, thin, mesal piece of cuticle that is obsolete laterally; reticulation indistinct; punctures deep, mostly separated by less than the diameter of a puncture.

Scutellum usually only about half as long as wide.

Elytra 1.7–2.0 times as long as wide; reticulation indistinct; interstriae 3 and 5 slightly wider than others; interstriae 7 distinctly elevated; interstriae 9 serrate; punctures deep, mostly separated by less than the diameter of a puncture; striae 5 and 6 with apical punctures usually similar in size to those near base; orange markings occupying area from interstriae 3 to 8 basally, sometimes slightly narrowed, sometimes expanded to suture, narrowed distally and occupying only interstriae 5, usually extending to apex of interstriae 5, sometimes extending only to middle of elytra; distal end of interstriae 3 sometimes orange.

Hind femora not or but slightly wider than middle femora.

FEMALE.— Externally similar to male but averaging larger, 5.2–5.8 mm long.

DISTRIBUTION.— Arkansas to Illinois (Fig. 5).

TYPE MATERIAL.— Holotype (male) U.S. National Museum number 100631, allotype (female), and one paratype: Randolph Bennett Wildlife Area, Randolph Co., Missouri, 31-V-1976, *Helianthus* sp., E. G. Riley, USNM. Paratypes: Springdale, Arkansas, 6-VI-1932, California Acad. Sci. (1); Cahokia, Illinois, 31-V-1898, Univ. Missouri-Columbia (2); 4 miles NW of Warsaw, Benton Co., Missouri, 30-V-1970, E. G. Riley Collection (1); ½ mi NE jct. J on U.S. 54, Camden Co., Missouri, 25-VII-1975, E. G. Riley, E. G. Riley Collection (2); Gasconade Co., Missouri, 17-VI-1971, D. D. Kopp, Univ. Missouri-Columbia (1); T37N, R26W, secs. 35 and 36, "Buzzards Roost," Doyal Township, St. Clair Co., Missouri, 12-V-1978, E. G. Riley, E. G. Riley Collection (2); Kimberling City, Stone Co., Missouri, 14-VI-1978, E. Riley, E. G. Riley Collection (1); Kimberling City, Stone Co., Missouri, 5-V-1979, E. G. Riley, E. G. Riley Collection (2); 3.5 mi N of Wappapello on Rt. 2, 11-VI-1975, E. G. Riley, E. G. Riley Collection (2); St. Louis, Missouri, 6-10-1932, Dr. Jass, USNM (1).

BIOLOGY.— This species has been found feeding on *Helianthus* sp. from May to July.

NOTES.— The above treatment was based on the type series of 21 specimens. This species is named in honor of Edward G. Riley, Louisiana State University, who collected most of the type series.

Microrhopala excavata (Olivier)

Hispa excavata Olivier, 1808, Entomologie, ou histoire naturelle des insectes, avec leurs caractères génériques et spécifiques, leur description, leur synonymie, et leur figure enluminée. Coleopteres, vol. 6, p. 775 (Neotype, male; Montreal, Quebec; Canadian National Collection, present designation)

Microrhopala excavata: Dejean, 1837, Cat. Col. p. 389

DIAGNOSIS.— This variable species can be distinguished from *M. hecate* by the lateral profile of the frons that is either distinctly angled (ssp. *excavata*) or arcuate and not prominent (ssp. *cyanea*), from *M. erebus* by the smaller elytral punctures that are not or only slightly confused, and from *M. floridana* by the stouter form and by the pronotum that is distinctly narrowed anteriorly.

MALE.— Length 4.0–5.6 mm, 2.2–2.4 times as long as wide; color black or metallic green, blue, or purple.

Head distinctly reticulate dorsally, not or indistinctly reticulate laterally and ventrally; mesal impression of vertex margined laterally by a distinct row of deep, contiguous punctures; eye separated from oral fossa by less than the width of antennal segment 3, bordered behind by contiguous punctures that are either strongly confused or arranged in a double row.

Pronotum 0.6–0.8 times as long as wide, 0.7–0.8 times as wide as elytra at humeri, narrowed anteriorly; lateral margins appearing arcuate, sinuate, bisinuate, or rarely straight; mesal area of anterior margin with a small, transparent piece of cuticle that does not extend laterally; surface usually minutely reticulate.

Elytra 1.6–1.9 times as long as wide, usually widest posteriorly; surface usually minutely reticulate; striae 2 with 11–25 punctures; striae 5 and 6 with apical punctures often slightly larger than basal punctures.

Hind femora usually broader than middle femora.

FEMALE.— Externally similar to male but averaging larger, 4.6–6.6 mm long.

NOTES.— This species can be divided into two subspecies.

Microrhopala excavata excavata (Olivier)

Hispa excavata Olivier, 1808, Entomologie, ou histoire naturelle des insectes, avec leurs caractères génériques et spécifiques, leur description, leur synonymie, et leur figure enluminée. Coleopteres, vol. 6, p. 775 (Neotype, male; Montreal, Quebec; Canadian National Collection, present designation)

Microrhopala excavata: Dejean, 1837, Cat. Col. p. 389

DIAGNOSIS.— This subspecies can be distinguished from *M. e. cyanea* by the more angular frons and by the distinctly elevated interstriae 5.

MALE.— Length 4.1–5.3 mm, 2.2–2.4 times as long as wide; color black. Frons transversely, arcuately angled below antennae; mesal impression of vertex margined laterally by a contiguous row of deep punctures. Antennae usually metallic blue, sometimes black.

Pronotum 0.5–0.7 times as long as wide; surface minutely reticulate; punctures deep, closely, often contiguously spaced.

Elytra 1.6–1.9 times as long as wide; interstriae 7, 5, and often 3 elevated or, if costae indistinct, punctures somewhat confused and interstriae sinuate; interstriae 3 not or but slightly wider than other interstriae, not wider than striae 2 or 3; interstriae 9 distinctly serrate; punctures within each stria closely, usually contiguously spaced.

FEMALE.— Externally similar to male but averaging larger, 4.8–5.6 mm long.

VARIATION.— Specimens from Pennsylvania and New Jersey to Maine and Quebec usually have slightly larger, more confused elytral punctures than do specimens from more southern areas.

DISTRIBUTION.— Minnesota and Nova Scotia to Texas and Florida (Fig. 6).

CANADA: **New Brunswick:** Kouchibouguac N.P. **Nova Scotia:** Ingramport, Waverley. **Ontario:** Blackburn, Go Home Bay, Honey Harbor, Kanata, Orrville, Ottawa. **Quebec:** Beech Grove, Gatineau Pk., Georgeville, Montreal, Knowlton, Lucerne, Perkins Mills, Rigaud, St. Hyacinthe. USA: **Alabama:** Mobile Co. **Connecticut:** Fairfield Co., Litchfield Co. **Florida:** Escambia Co. **Georgia:** Hall Co. **Illinois:** Knox Co., Lake Co. **Iowa:** Woodbury Co. **Kansas:** Douglas Co. **Louisiana:** Natchitoches Parish. **Maine:** Androscoggin Co., Cumberland Co., Franklin Co., Hancock Co., Kennebec Co., Lincoln Co., Oxford Co., Washington Co., York Co. **Maryland:** Montgomery Co., Prince Georges Co., Baltimore. **Massachusetts:** Berkshire Co., Bristol Co., Hampshire Co., Middlesex Co., Norfolk Co., Worcester Co. **Michigan:** Jackson Co. **Minnesota:** Hennepin Co., Kanabec Co. **Mississippi:** George Co., Perry Co., Tishomingo Co. **Missouri:** St. Francois Co., Vernon Co. **New Hampshire:** Carrol Co., Cheshire Co., Coos Co., Grafton Co., Hillsborough Co. **New Jersey:** Atlantic Co., Bergen Co., Burlington Co., Camden Co., Essex Co., Gloucester Co., Middlesex Co., Union Co. **New York:** Bronx Co., Columbia Co., Essex Co., Greene Co., Nassau Co., Orange Co., Oswego Co., St. Lawrence Co., Sullivan Co., Tompkins

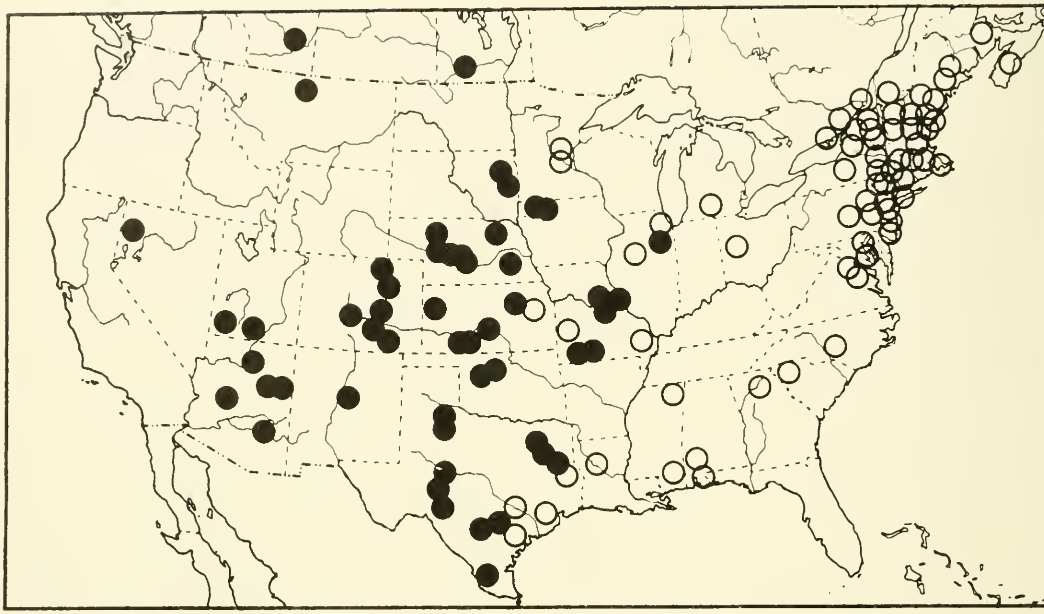

Fig. 6. Distribution of *Microrhopala excavata excavata* (open circles) and *M. e. cyanea* (filled circles).

Co., Ulster Co., Warren Co., Westchester Co. **North Carolina:** Moore Co. **Ohio:** Champaign Co. **Pennsylvania:** Berks Co., Dauphin Co., Monroe Co., Northampton Co., Pike Co. **South Carolina:** Oconee Co. **Texas:** Harris Co., Jasper Co., Lee Co., San Patricio Co. **Vermont:** Lamoille Co., Orleans Co., Washington Co. **Virginia:** Fairfax Co., Fredericksburg, Glencarlyn.

BIOLOGY.— This subspecies feeds on *Doellingeria umbellata* and *Solidago* sp. Most collections are made from May to September.

NOTES.— The type of *Hispa excavata* has been lost from the Museum National d'Histoire Naturelle, Paris. However, a specimen from the Canadian National Collection is here designated as a neotype. This specimen is labeled Montreal, Quebec, 15-V-1979, A. Smetana and E. C. Becker. The above treatment was based on this neotype and on 345 other specimens.

Microrhopala excavata cyanea (Say)

Hispa cyanea Say, 1823, J. Acad. Nat. Sci. Philadelphia 3:433 (Neotype, male; Colorado Springs, Colorado; Museum of Comparative Zoology, present designation)

Microrhopala cyanea: Melsheimer, 1853, Cat. Desc. Col. U.S. p. 119

DIAGNOSIS.— This subspecies differs from *M. e. excavata* by the frons that does not appear angular and by interstriae 5 that is not or but slightly elevated.

MALE.— Length 4.0–5.6 mm, 2.2–2.4 times as long as wide; color black or metallic green, blue, or purple.

Frons not prominent in lateral aspect, usually appearing arcuate; mesal impression of vertex margined laterally by a distinct row of deep, contiguous punctures. Antennae black.

Pronotum 0.6–0.8 times as long as wide; punctures deep, of three sizes, with coarse punctures mostly separated by less than the diameter of a puncture; surface usually minutely reticulate.

Elytra 1.7–1.9 times as long as wide; strial punctures in regular rows; interstriae straight or but slightly sinuate; interstriae 3 usually wider than striae 2 or 3, wider than other interstriae; punctures within striae small to moderate in size, mostly separated by less than the diameter of a puncture; interstriae 7 usually elevated, 5 not or but slightly elevated, 3 not elevated; interstriae 9 weakly serrate.

FEMALE.— Externally similar to male but usually larger than males from the same area, 4.6–6.0 mm long.

VARIATION.— Although color is not strictly correlated with locality, black, nonmetallic specimens tend to be collected from Nebraska and Kansas east to Illinois and from Manitoba, and metallic specimens tend to occur in other areas of the range. Metallic blue and purple colors are common in South Dakota and Iowa, and metallic green beetles are usually found from Utah and Arizona to Texas. Specimens south of central Colorado and Kansas usually have slightly larger elytral punctures that are round and gradually impressed, and more northern beetles have slightly smaller punctures that are abruptly impressed and often elongate. Specimens from Manitoba are small and have indistinct reticulation on the pronotum, and interstriae 7 is not elevated.

DISTRIBUTION.— Alberta and Manitoba to Arizona, Texas, and Missouri (Fig. 6).

CANADA: **Alberta:** Laggan, Medicine Hat, Mill Creek Road to Big Bear. **Manitoba:** Aweme, Treesbank. USA: **Arizona:** Apache Co., Coconino Co., Gila Co., Navajo Co., Yavapai Co. **Colorado:** Chaffee Co., El Paso Co., Huerfano Co., Las Animas Co., Morgan Co., Weld Co. **Illinois:** Cook Co. **Iowa:** Dickinson Co., Emmet Co. **Kansas:** Clark Co., Meade Co., Reno Co., Riley Co., Wallace Co. **Missouri:** Barry Co., Boone Co., Gasconade Co., Taney Co. **Montana:** Hill Co. **Nebraska:** Cherry Co., Custer Co., Knox Co., Lancaster Co. **Nevada:** Washoe Co. **New Mexico:** Santa Fe Co. **Oklahoma:** Alfalfa Co., Major Co. **South Dakota:** Brookings Co., Codington Co. **Texas:** Caldwell Co., Cherokee Co., Comal Co., Dickens Co., Gillespie Co., Hidalgo Co., Motley Co., Sabine Co., Tarrant Co., Uvalde Co., Val Verde Co. **Utah:** Kane Co., Washington Co.

BIOLOGY.— *Helianthus* sp. has been reported as the host plant. Adults are most often collected from May to September.

NOTES.— The appearance of these beetles is very different from that of *M. e. excavata*, and the two subspecies have traditionally been considered distinct species. However, the two populations freely interbreed wherever they contact each other and must be considered conspecific. A specimen in the Museum of Comparative Zoology is labeled Colo. Spr., Colorado, 6,000–7,000 ft, June 15–30, '96, H. F. Wickham. This specimen is here designated as the neotype of *Hispa cyanea*. The above treatment was based on this neotype, on 5 specimens from the LeConte collection, and on 302 other specimens.

Microrhopala hecate (Newman)

Hispa hecate Newman, 1841, Entomologist 1:77 (Holotype, male, Warm Springs, North Carolina; British Mus. Nat. Hist.)

DIAGNOSIS.— This species is similar to *M. excavata*. However, the very prominent but not angled frons, the regular strial rows, the distinctly elevated interstriae 5 and usually interstriae 3, and the undulate or but slightly serrate interstriae 9 are sufficient characters for correct identification.

MALE.— Length 4.1–4.9 mm, 2.2–2.6 times as long as wide; color black, usually with a slight metallic red cast on the elytra and pronotum, a metallic green cast often on the floor of the punctures.

Head minutely reticulate dorsally, lacking reticulation laterally and ventrally; frons very prominent in lateral aspect, not angulate; mesal impression of vertex margined laterally by a contiguous row of deep punctures; eye separated from oral fossa by a distance less than the width of antennal segment 3, bordered posteriorly by contiguous punctures that are not arranged in a single row. Antennae metallic green, blue, or purple.

Pronotum 0.6–0.8 times as long as wide, 0.7–0.8 times as wide as elytra; lateral margins usually appearing bisinuate in dorsal aspect; anterior margin with a small, thin, mesal piece of cuticle that is obsolete laterally; punctures deep, separated by less than the diameter of a puncture.

Elytra 1.7–1.8 times as long as wide, widest posteriorly; reticulation distinct; interstriae 9 undulate or but slightly serrate; interstriae 7, 5, and often 3 distinctly elevated, costate; interstriae 2 and 3 wider than others; punctures deep, mostly contiguously spaced within each row; striae 2 with 11–25 punctures; striae 5 and 6 with apical punctures often larger than basal punctures.

Hind femora usually wider than middle femora.

FEMALE.— Externally similar to male but larger, 4.2–5.5 mm long.

DISTRIBUTION.— Ohio to South Carolina and Georgia (Fig. 7).

USA: **Georgia:** Fulton Co., Rabun Co. **North Carolina:** Buncombe co., Macon Co., Moore Co., Transylvania Co. **Ohio:** Scioto Co. **South Carolina:** Oconee Co. **West Virginia:** Greenbrier Co.

BIOLOGY.— The food plant of this species is unknown. However, adults have been collected from April to August.

NOTES.— This species was placed in synonymy with *M. cyanea* by Gemminger and Harold (1876). The color, shape of the frons, and nature of the elytral punctation readily

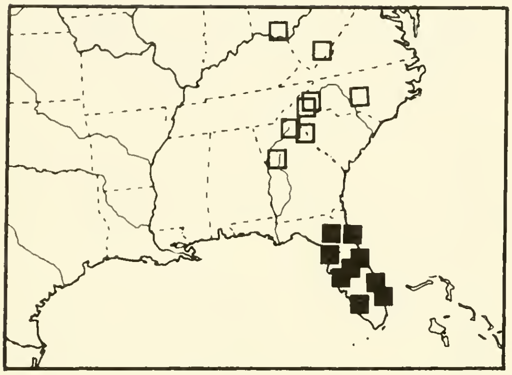

Fig. 7. Distribution of *Microrhopala hecate* (open squares) and *M. erebus* (filled squares).

distinguish the two species, however. The above treatment was based on the holotype of *Hispa hecate* and on 25 other specimens.

Microrhopala erebus (Newman)

Hispa erebus Newman, 1841, Entomologist 1:77 (Lectotype, female, St. Johns Bluff, Florida; British Mus. Nat. Hist., present designation)
Microrhopala erebus: Schwarz, 1878, Proc. Amer. Philos. Soc. Philadelphia 18:369

DIAGNOSIS.— This species differs from others in the genus by the very coarse sculpture of the elytra. The punctures are large and contiguous or often confluent, and the interstriae, especially laterally, are indistinguishable or at least strongly sinuate.

MALE.— Length 4.3–5.2 mm, 2.1–2.4 times as long as wide; mature color black; sculpture coarse.

Head minutely reticulate dorsally, not or indistinctly reticulate laterally and ventrally; frons prominent, transversely, arcuately angled; mesal impression of vertex margined laterally by a row of deep, contiguous punctures; eye separated from oral fossa by a distance less than the width of antennal segment 3, margined posteriorly by contiguous, confused punctures. Antennae black, sometimes with a metallic blue cast.

Pronotum 0.6–0.8 times as long as wide, 0.7–0.8 times as wide as elytra at humeri; anterior margin with a small, thin, mesal piece of cuticle that does not extend laterally; lateral margins usually appearing bisinuate in dorsal aspect, sometimes sinuate or arcuate; surface minutely reticulate; punctures deep, mostly large, contiguous.

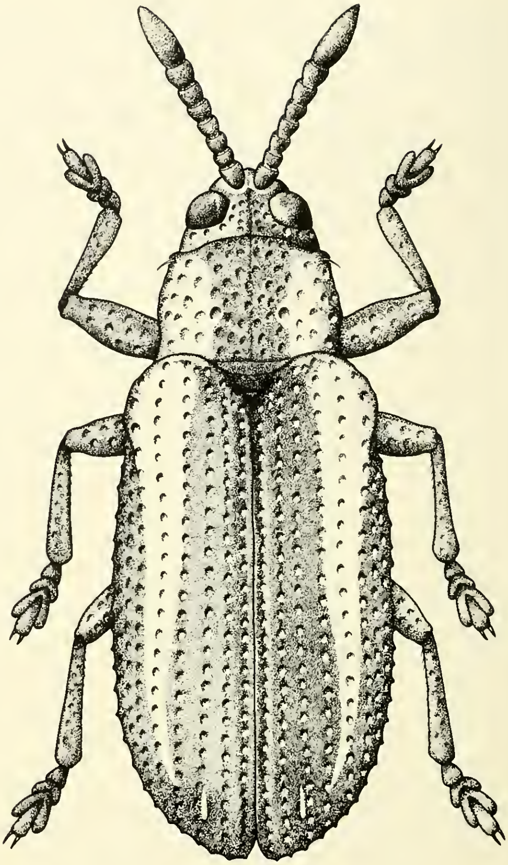

Fig. 8. *Microrhopala rileyi.*

Elytra 1.6–1.8 times as long as wide, usually slightly narrowed behind humeri, widest posteriorly; minute reticulation present, sometimes weak; punctures large, laterally and usually dorsally confused; striae 2 with 8–14 punctures; striae 5 and 6 with apical punctures often larger than basal punctures; most interstriae, especially in lateral areas, strongly sinuate or indistinguishable; interstriae 9 strongly serrate.

Hind femora usually wider than middle femora.

FEMALE.— Externally similar to male but averaging larger, 4.5–5.4 mm long.

DISTRIBUTION.— Florida (Fig. 7).

USA: **Florida:** Alachua Co., Lake Co., Lee Co., Levy Co., Manatee Co., Orange Co., Osceola Co., Palm Beach Co., Pinellas Co., Polk Co., Putnam Co., St. Johns Co., Seminole Co., Sumpter Co., Volusia Co.

BIOLOGY.— This species is known from *Solidago* sp. and is most abundantly collected from March to May.

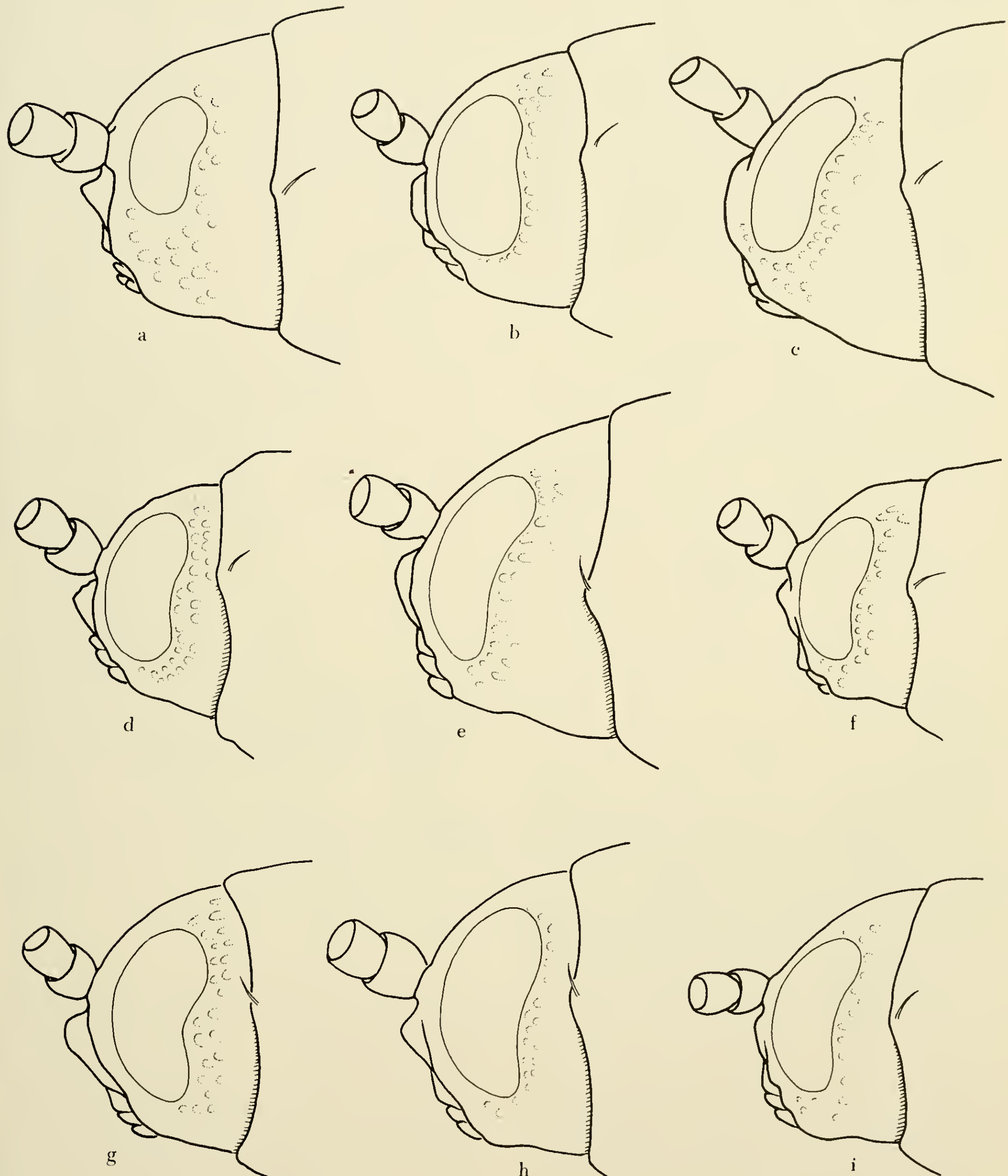

Fig. 9. Heads of *Microrhopala* spp.: (a) *M. vittata,* (b) *M. rubrolineata,* (c) *M. rileyi,* (d) *M. xerene,* (e) *M. excavata cyanea,* (f) *M. e. excavata,* (g) *M. hecate,* (h) *M. erebus,* (i) *M. floridana.*

Notes.— The above treatment was based on two syntypes of *Hispa erebus* from the British Museum and on 114 other specimens. The female syntype labeled Ent. Club 44-12 is here designated as the lectotype for the species.

Microrhopala floridana Schwarz

Microrhopala floridana Schwarz, 1878, Proc. Amer. Philos. Soc. Philadelphia 17:369 (Holotype, male, Sumpter Co., Florida; USNM)

Diagnosis.— This species superficially resembles members of the genus *Anisostena* in

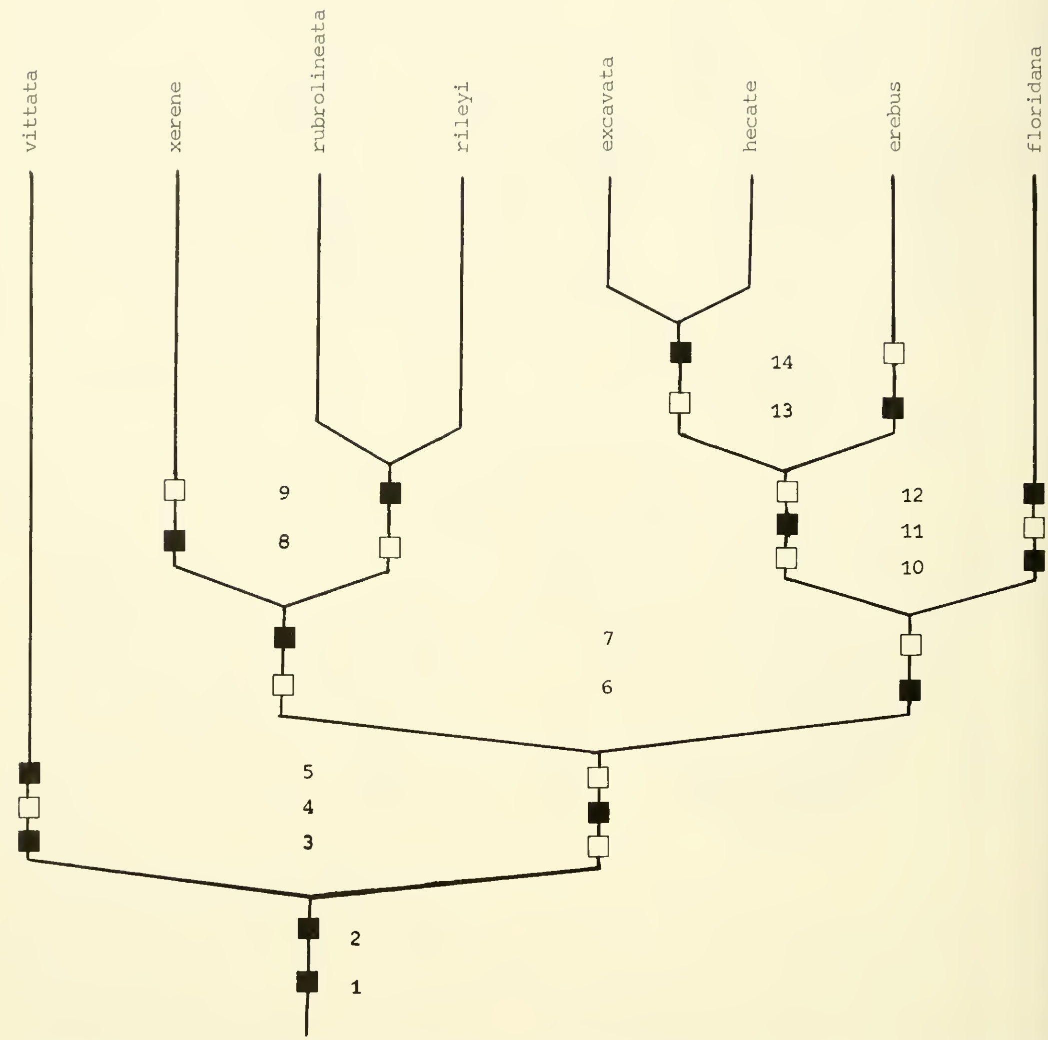

Fig. 10. A hypothetical phylogeny of the species of *Microrhopala*. Filled squares represent ancestral characters; open squares represent derived characters. Numbers refer to characters in Table 1.

its narrow form and in its parallel-sided prothorax. However, it is easily distinguished from that genus by antennal segments 8–11 that are fused, appearing as a single segment. Within the genus *Microrhopala* this species most closely resembles *M. excavata*, from which it differs by the more slender form and the parallel-sided prothorax.

MALE.— Length 3.4–4.5 mm, 2.3–2.9 times as long as wide; color black or less commonly metallic blue.

Head distinctly reticulate dorsally, not or indistinctly reticulate laterally and ventrally; frons arcuately, transversely angled or narrowly rounded below antennae; mesal impression of vertex margined laterally by a contiguous row of deep punctures; eye separated from oral fossa by a distance less than the width of antennal segment 3, margined behind by contiguous, confused punctures. Antennae black, sometimes with a metallic blue tint.

Pronotum 0.7–0.8 times as long as wide, 0.7–0.9 times as wide as elytra at humeri, not or but slightly narrowed anteriorly; lateral margins appearing arcuate, sinuate, or bisinuate in lateral aspect; anterior margin with a small, thin, mesal piece of cuticle that does not extend laterally; minute reticulation distinct; punctures deep, mostly separated by much less than the diameter of a puncture.

Elytra 1.7–2.2 times as long as wide, usually parallel sided; punctures separated by less than the diameter of a puncture, arranged in regular rows; striae 5 and 6 with apical punctures often larger than basal punctures; costae variable, well developed to completely absent; interstriae 9 undulate to slightly serrate.

Hind femora usually wider than middle femora.

Female.— Externally similar to male but averaging larger, 3.8–4.9 mm long.

Variation.— The slenderness of the body, the extent of metallic coloration, and the degree to which the interstriae are elevated are all variable. Although no geographic trends are apparent, they may be discovered after more specimens are collected.

Distribution.— Florida to North Carolina (Fig. 5).

USA: **Florida:** Marion Co., Polk Co., Putnam Co., Seminole Co., Sumpter Co., Volusia Co. **Georgia:** Chariton Co. **North Carolina:** Moore Co.

Biology.— This species feeds on *Pityopsis graminifolia* from April to August. It has also been reported from *Lupinus diffusus*, which is a very unusual and perhaps erroneous record.

Notes.— The above treatment was based on the holotype of *M. floridana* and on 25 other specimens.

Acknowledgments

Appreciation is extended to the following people and institutions for their kind assistance and loans of specimens: Donald Azuma, Academy of Natural Sciences of Philadelphia; Nicole Berti, Museum National d'Histoire Naturelle, Paris; Robert L. Blinn, University of Missouri–Columbia; Lee H. Herman, American Museum of Natural History; Charles L. Hogue, Los Angeles County Museum of Natural History; David H. Kavanaugh, California Academy of Sciences; L. L. Pechuman, Cornell University; Laurent LeSage, Canadian National Collection; Ole Martin, Zoologisk Museum, Copenhagen; Alfred F. Newton, Jr., Museum of Comparative Zoology; Carl A. Olson, University of Arizona; R. D. Pope, British Museum (Natural History); Edward G. Riley, Louisiana State University; Hans Silfverberg, Universitets Zoologiska Museum, Helsinki; Charles A. Triplehorn, Ohio State University; J. Reese Voshell, Jr., Virginia Polytechnic Institute and State University; Larry E. Watrous, Field Museum of Natural History; and Richard E. White, Systematic Entomology Laboratory, USDA. Special thanks is given to the Department of Zoology, Brigham Young University, and particularly to Dr. Stephen L. Wood, for their support and encouragement.

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FLORA OF THE STANSBURY MOUNTAINS, UTAH

Alan C. Taye[1]

Abstract.— The Stansbury Mountains of north central Utah rise over 2000 m above surrounding desert valleys to a maximum elevation of 3362 m on Deseret Peak. Because of the great variety of environmental conditions that can be found in the Stansburys, a wide range of plant species and vegetation types (from shadscale desert to alpine meadow) exist there. This paper presents an annotated list of 594 vascular plant species in 315 genera and 78 families. The largest families are Asteraceae (98 species), Poaceae (71), Brassicaceae (33), Fabaceae (27), and Rosaceae (26). *Elymus flavescens* was previously unreported from Utah. Statistical comparison of the Stansbury flora with neighboring mountain floras indicates that the Wasatch Mountains lying 65 km to the east have probably been the primary source area for development of the Stansbury flora. Many lowland species, especially those inhabiting sandy areas, apparently have migrated to the area from the south.

The high mountain ranges of the Great Basin are botanically interesting for their isolated montane floras. Surrounded by desert, these islandlike ranges have characteristics in common with oceanic islands (Harper et al. 1978). One of these ranges, the Stansbury Mountains of north central Utah, is particularly interesting in supporting a vegetational zonation and flora that are transitional between the Great Basin ranges and the Wasatch Mountains.

Geography and Geology

The Stansbury Mountains of Tooele County, Utah, situated near the eastern edge of the Great Basin about 65 km west of Salt Lake City and the Wasatch Front, are located between 40° 20′ and 40° 45′ N latitude and 112° 29′ and 112° 44′ W longitude. The range is bounded on the west by Skull Valley, on the east by Tooele and Rush valleys, on the north by the Great Salt Lake and Stansbury Island, and on the south by the Onaqui Mountains. The range has a length of 45 km and a width of 21 km at its widest point, and occupies an area of about 909 km^2. The elevation ranges from 1280 m (4200 ft) in the valleys to 3362 m (11,031 ft) at the summit of Deseret Peak.

Structurally, the Stansbury Mountains are a "gigantic eastward tilted fault block" (Rigby 1958). The western escarpment rises abruptly from the floor of Skull Valley and is dissected by steep-walled canyons. The eastern side of the range is generally less rugged except in the vicinity of Deseret Peak, where Pleistocene glacial activity has produced sheer canyon walls and several well-defined horns formed from coalescing glacial cirques. At least 17 cirque basins, two of which contain small lakes, occur in the range. Skirting the base of the range are terraces, wave-cut cliffs, spits, and other features produced by Lake Bonneville. Pediment surfaces, bajadas, and alluvial fans are present on the western and eastern edges of the range (Rigby 1958).

The core of the range is composed of the Cambrian Tintic Quartzite. Younger Paleozoic sedimentary strata, which overlay and flank the quartzite throughout the range where not eroded away, compose the bulk of the northern and southern portions of the range. Lesser amounts of sedimentary and igneous formations of Tertiary age are also present as are Quaternary glacial, aeolian, and lacustrine deposits (Rigby 1958).

Climate and Soils

The climate for the area is classified as cold semiarid or steppe by Trewartha (1968). The city of Tooele, located 16 km to the east of the Stansburys at an elevation of 1545 m (5070 ft), has average January and July temperatures of −1.7 C and 24.7 C, respectively, with an average annual temperature of 10.6 C. The high and low temperatures at Tooele

[1]U.S. Army Intelligence Center and School, Fort Huachuca, Arizona 85613.

for 1979 were 35.6 C and -22.2 C (U.S. Department of Commerce 1980). Temperature data are not available for the higher portions of the range.

Precipitation in the Great Basin is strongly influenced by the orographic effect, with mountains receiving greater amounts than the valleys (Houghton 1969). Tooele receives an average annual precipitation of 41.43 cm, with the largest amounts falling in the months of March (4.67 cm), April (5.59 cm), and May (4.16 cm). The driest months are July (1.78 cm), August (2.36 cm), and September (1.83 cm) (U.S. Department of Commerce 1980). A precipitation station located at 2820 m (9250 ft) on the lee side of Deseret Peak received an average of 140.28 cm (more than three times the valley station average) over the three-year period from 1974 to 1976 (Soil Conservation Service 1979).

Soils are diverse in the study area. The Entisol, Aridisol, and Mollisol soil orders and six soil associations have been mapped in the Stansburys by the Soil Conservation Service (1973). Types of soils range from the strongly alkaline, light-colored soil typical of the valley greasewood community to the strongly acidic, dark-colored soil of the montane spruce-fir community (Wilson et al. 1975).

Vegetation

Eight somewhat distinct vegetation zones or communities, discussed by Billings (1951) and N. Holmgren (1972), are present in the Stansbury Mountains. In order of increasing elevation, they are the shadscale, sagebrush–grass, juniper–pinyon, Douglas fir–white fir, upper sagebrush–grass, Engelmann spruce–subalpine fir, limber pine–bristlecone pine, and alpine zone.

The vegetational zonation in the Stansbury Mountains is transitional between the Wasatch type and the Basin Range type (Billings 1951). Gambel oak (*Quercus gambelii*), a dominant species in the central and southern Wasatch Mountains, and common on the opposite side of Tooele Valley in the Oquirrh Mountains, is conspicuously absent from the Stansburys. The oak habitat is dominated instead by a well-developed Utah juniper (*Juniperus osteosperma*) woodland. Blue spruce (*Picea pungens*), a component of the Douglas fir–white fir–blue spruce zone in the Wasatch range (N. Holmgren 1972), is also apparently absent from the Stansburys. Bristlecone pine (*Pinus longaeva*) is a major component of the Great Basin subalpine conifer community (Billings 1951, N. Holmgren 1972), and its presence in the Stansburys marks its northern and eastern limits of distribution in the Bonneville Basin.

Botanical Exploration

Captain Howard Stansbury, for whom the mountains and island are named, collected the types of *Cowania mexicana* var. *stansburiana*, *Heuchera rubescens*, and *Perityle stansburii* from nearby Stansbury Island in 1850 (Stansbury 1852). Marcus E. Jones made the first known collections from the Stansbury Mountains in 1891 and 1903 (Jones 1965) and collected the type for *Phacelia incana* from nearby Dugway Valley (Welsh 1982). T. H. Kearney et al. (1914) prepared extensive species lists for the plant communities of Tooele Valley in their study on the relationship of vegetation to soil moisture and salt content. One new species, *Eriogonum kearneyi*, was discovered (Tidestrom 1913). S. Flowers collected in the range in 1928 and 1930, and B. Maguire visited there in 1943. M. E. Lewis (pers. comm. 1979) prepared a preliminary species list (with 150 species) for the Stansburys in 1957.

In the past two decades a number of botanists have collected in the Stansbury Mountains, including B. Albee, L. C. Anderson, M. E. Barkworth, E. M. Christensen, W. P. Cottam, K. T. Harper, A. H. Holmgren, R. Kass, R. M. Lanner, E. Neese, K. H. Thorne, R. K. Vickory, Jr., and S. L. Welsh. Their collections have contributed to this checklist. For this study, I visited the range from 1978 to 1981 and made over 1400 collections.

Discussion of the Flora

The diversity of climatic and edaphic habitats in the Stansbury Mountains is reflected in the large number of plant species occurring in this range. A total of 594 species from 315 genera and 78 families are listed following this discussion. Of this number, 494 species from 264 genera and 71 families are presumably native to the range. Though occupying only 0.43 percent of Utah's land area, the Stansbury range has 19.2 percent of the state's 2575 native species (from Welsh et al. 1981). A statistical summary of the flora is presented in Table 1.

The number of montane species expected to occur above 2286 m (7500 ft) in elevation on Great Basin mountain ranges can be predicted from the species-area equation in Harper et al. (1978). With an area of 140 km^2 above 2286 m (Behle 1978), the Stansbury Mountains would be expected to have 225 montane species. The number I found was 385. The unexpectedly high number of species is probably due to the presence of an alpine zone on this relatively narrow mountain range. Environmental heterogeneity and favorability are more important than area in the determination of floral diversity (Harper et al. 1978).

Statistical comparison of 11 mountain floras (listed in Table 2) in the eastern Great Basin (Taye 1981) shows the Stansbury flora to be most similar to the floras of Mount Timpanogos, northern Wasatch, and central Wasatch—62.0, 61.2, and 60.8 percent similarity, respectively, using Sørensen's index of similarity (Fig. 1). Thus the Wasatch range is perhaps the primary source area for development of the Stansbury flora. This might be expected because of the close proximity (65 km) of the Stansbury Mountains to the floristically rich Wasatch Mountains and of the finding by Harper et al. (1978) that Great Basin mountains are dominated by species from the Rocky Mountain floristic element. The floristic relationship between the Wasatch and Stansbury ranges is also evident from the several montane species found in both ranges but not known to occur west of the Stansburys (Table 3).

Though the Stansbury Mountains and central Wasatch Mountains rise to comparable heights (Table 2), the Stansbury flora has considerably fewer alpine species. Apparently missing are *Polygonum viviparum*, *Salix arctica*, *Silene acaulis*, *Smelowskia calycina*, and many others. Persistent snowdrifts, conducive

TABLE 1. Statistical summary of the vascular plants of the Stansbury Mountains.

	Indigenous			Introduced		
	Families	Genera	Species	Families	Genera	Species
Lycopodiophyta	1	1	1	0	0	0
Equisetophyta	1	1	3	0	0	0
Polypodiophyta	1	4	4	0	0	0
Pinophyta	2	5	10	0	0	3
Magnoliophyta						
Magnoliopsida	56	204	382	7	43	70
Liliopsida	10	49	94	0	8	27
Totals:	71	264	494	7	51	100

Grand totals:

Families	78
Genera	315
Species	594

Largest families (native + introduced species)

Asteraceae	87 + 11	Scrophulariaceae	19 + 3
Poaceae	44 + 27	Boraginaceae	17 + 2
Rosaceae	24 + 2	Polygonaceae	16 + 1
Cyperaceae	22 + 0	Apiaceae	15 + 1
Fabaceae	21 + 6	Chenopodiaceae	15 + 9
Brassicaceae	20 + 13	Onagraceae	15 + 0

Largest genera (native + introduced species)

Carex	17 + 0	*Artemisia*	7 + 0
Astragalus	12 + 0	*Cryptantha*	7 + 0
Eriogonum	10 + 0	*Poa*	7 + 4
Erigeron	8 + 0	*Ribes*	7 + 0

to the growth of many alpine species (Billings 1978), are present throughout the summer but they are few and small in size. Altithermal extinctions (Billings 1978), limited alpine habitat, or failure to reach the Stansburys are possible explanations for their absence there. A list of species occurring above 3050 m (10,000 ft) in elevation is presented in Table 4. Timberline is generally located from 3200 m (10,500 ft) to 3290 m (10,800 ft), but the south slope of Deseret Peak is nearly treeless to an elevation of 2865 m (9400 ft).

The influence of the Great Basin floristic division (N. Holmgren 1972) on the Stansbury flora is seen in the presence of many of the valley and foothill species. Most of these desert species have apparently migrated northward from the Mojave Desert during the warmer postglacial period of the last 10,000 years (Reveal 1979, Wells 1980), and many of them apparently reach their northern or eastern limit of distribution in the study area (Table 3). The Stansbury flora, in comparison with the flora of the more mesic Wasatch Mountains, has a greater number of species from many characteristically desert genera including *Astragalus, Camissonia, Cryptantha, Eriogonum, Phacelia,* and *Tetradymia.* A number of species from these and other genera are partially or wholly restricted to sandy areas at the base of the range (Table 5).

Plant migration to the Stansbury Mountains from northern and western routes has probably been extremely limited because of past and present barriers in the Bonneville Basin. Lake Bonneville, a large freshwater lake which occupied most of northwestern Utah during the Pleistocene (Morrison 1965), and the present Great Salt Lake–Great Salt Lake Desert have undoubtedly restricted the migration of most plant species. One species that appears to have reached the Stansburys from the north is *Elymus flavescens,* a species disjunct from the Snake River Plains of Idaho (Cronquist et al. 1977) and previously unreported from the state of Utah.

The impact of humans on the Stansbury flora can be seen by the large number (100) of cultivated or adventive species. Most of these species are limited to low elevations where even the vegetation has been markedly altered in some areas. Especially common are *Agropyron cristatum, Bromus tectorum, Halogeton glomeratus,* and *Salsola iberica.* Only a few introduced species such as *Dactylis glomerata, Poa pratensis,* and *Taraxacum officinale* are present at elevations greater than 2400 m (7874 ft).

None of the species are endemic to the study area, though several are restricted to somewhat larger areas. *Astragalus eurekensis* is endemic to central Utah (Welsh 1978b); *Astragalus lentiginosus* var. *pohlii* is a very narrow endemic of Rush Valley and Skull Valley (Welsh and Barneby 1981); *Eriogonum grayi* is endemic to alpine areas of north central Utah (Reveal 1973); and *Sphaeromeria diversifolia* is apparently restricted to the central and southern Wasatch Mountains and west to the Quinn Canyon Range of Nevada (Holmgren et al. 1976).

TABLE 2. Floras of the eastern Great Basin (after Harper et al. 1978).

	Native + introduced species	Maximum elevation (m)	Source of information
MOUNTAIN ISLANDS			
1 Stansbury Mountains	494 + 100	3362	This report
2 East Tintic Mountains	162 + 48	2505	Nebeker 1975
3 Raft River Mountains	303 + 23	3015	Preece 1950
4 Deep Creek Mountains	569 + 47	3688	McMillan 1948, Welsh 1978a
5 Jarbidge Mountains	478 + 22	3288	Lewis 1975
6 Ruby Mountains	524 + 24	3471	Lewis 1971
7 Wheeler Peak	389 + 23	3981	Lewis 1973
MAINLAND AREAS			
8 Northern Wasatch Mountains	767 + 528	3042	A. Holmgren 1972
9 Central Wasatch Mountains	911 + 228	3502	Arnow et al. 1980
10 Mount Timpanogos	538 + 90	3581	Allred 1975
11 Wasatch Plateau	826 + 86	3440	Lewis 1980

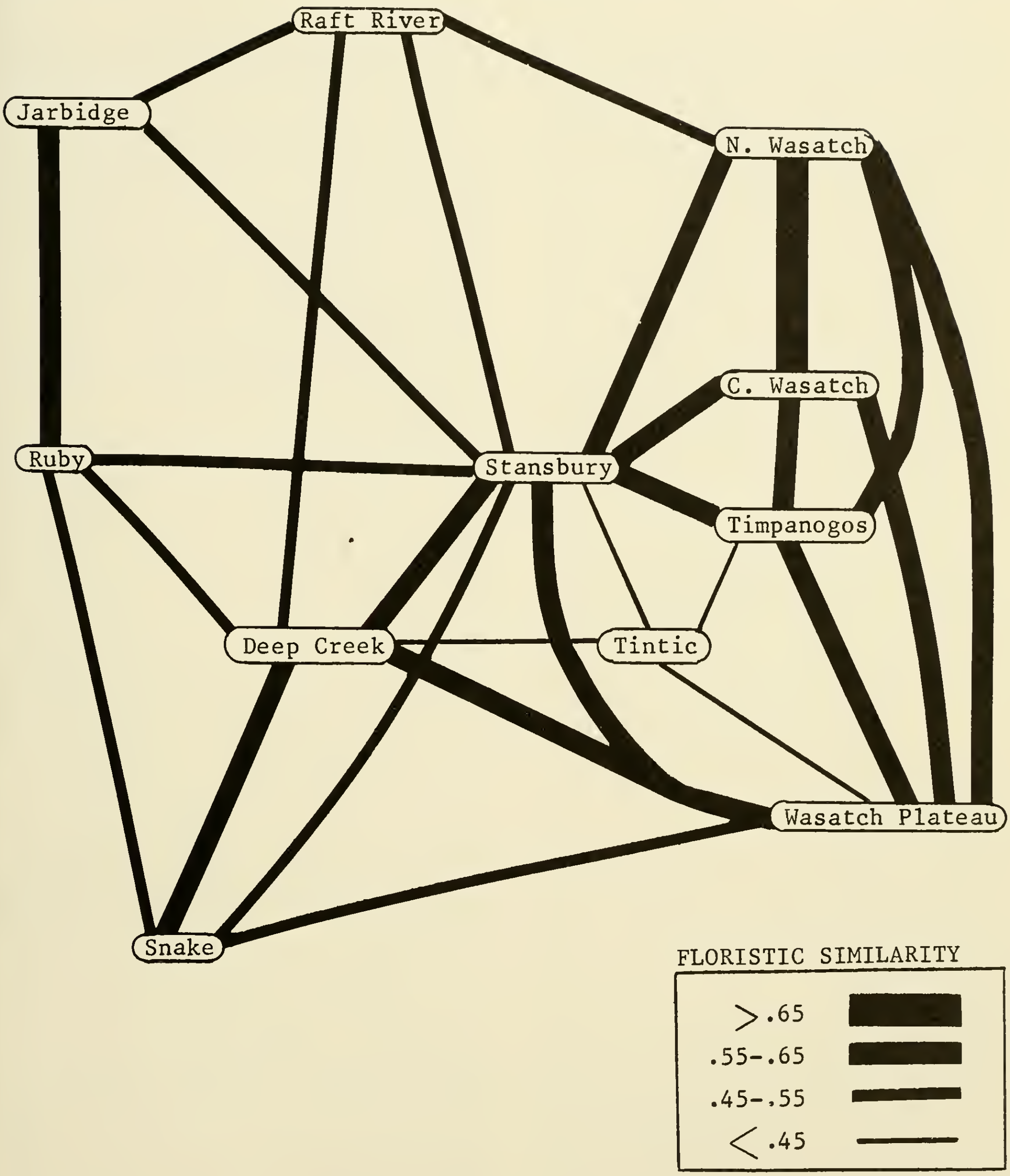

Fig. 1. Plexus diagram of floristic similarities among mountain ranges in the eastern Great Basin. High values correspond to high similarity. Comparisons were made using Sørensen's index of similarity. Data are from Taye (1981).

Acknowledgments

Many individuals kindly offered assistance during the preparation of this checklist. I am especially grateful to Dr. Stanley L. Welsh, curator of the herbarium of Brigham Young University, for guiding and encouraging the completion of this study. Drs. Kimball T. Harper, Elizabeth Neese, and Samuel R. Rushforth of Brigham Young University kindly reviewed and commented upon a portion of the manuscript. Assistance with plant identifications and herbarium research was given by Kaye H. Thorne, assistant curator of the Brigham Young University herbarium; Dr. Mary E. Barkworth and Dr. Leila Shultz, director and curator, respectively, of the Intermountain Herbarium at Utah State University; Lois Arnow and Beverly Albee, curator and assistant curator, respectively, of the Garrett Herbarium at the University of Utah; and Sherel Goodrich and Mont E. Lewis of the U.S. Forest Service. Bill Wall of the U.S. Forest Service graciously shared the Stansbury Guard Station with me for three summers and helped collect many of the plant specimens. Special thanks are expressed to Professor Arthur H. Holmgren, retired curator of the Intermountain Herbarium, for his sustained assistance and interest in this study. I also thank Dee Applegate for faithfully typing the manuscript and Mathew Chatterly for preparing the figure. Finally, deep appreciation is expressed to my parents for their love and support throughout the course of this study.

Annotated List of Vascular Plants

The following list of families, genera, and species is arranged in alphabetical order within the divisions of Cronquist et al. (1972). Nomenclature generally follows that of Welsh et al. (1981). Volumes 1 and 6 of the

TABLE 3. Plants with distributional limits in the Stansbury Mountains and vicinity.

Northern limit of distribution

Astragalus ceramicus (Puddle Valley)
Astragalus eurekensis
Astragalus mollissimus
Ceanothus martinii
Cymopterus fendleri
Echinocereus triglochidiatus var. *melanacanthus* (Stansbury Island)
Eriogonum kearneyi
Eriogonum umbellatum var. *subaridum*
Flaveria campestris
Geranium parryi
Lycium andersonii (Puddle Valley)
Pinus longaeva
Stephanomeria pauciflora

Eastern limit of distribution

Chamaebatiaria millefolium (Oquirrh Mtns.)
Erigeron argentatus
Euphorbia ocellata var. *arenicola*
Ribes velutinum var. *velutinum* (Oquirrh Mtns.)

Southern limit of distribution

Elymus flavescens

Western limit of distribution

Castilleja applegatei var. *viscida*
Eriogonum grayi
Geranium parryi
Mertensia arizonica var. *leonardii*
Mertensia brevistyla

TABLE 4. Nonarboreal species occurring above 3050 m in elevation in the Stansbury Mountains.

Achillea millefolium
Agropyron trachycaulum
Androsace septentrionalis
Antennaria corymbosa
Arabis holboellii var. *secunda*
Arenaria kingii
Artemisia tridentata var. *vaseyana*
Astragalus kentrophyta var. *implexus*
Astragalus tenellus
Carex atrata var. *erecta*
Carex haydeniana
Castilleja applegatei var. *viscida*
Castilleja rhexifolia
Cirsium eatonii
Cymopterus hendersonii
Cymopterus longipes
Cystopteris fragilis
Draba stenoloba
Erigeron compositus
Erigeron eatonii
Erigeron leiomerus
Eriogonum grayi
Eriogonum umbellatum var. *desereticum*
Festuca ovina var. *brevifolia*
Geum rossii var. *turbinatum*
Haplopappus macronema
Heuchera rubescens
Ivesia gordonii
Juniperus communis var. *depressa*
Lathyrus lanzwertii
Lesquerella occidentalis var. *cinerascens*
Leucopoa kingii
Lewisia pygmaea
Linum perenne
Lupinus argenteus
Luzula spicata
Oxyria digyna
Penstemon humilis
Phlox pulvinata
Poa fendleriana
Poa secunda
Potentilla ovina
Ribes montigenum
Saxifraga rhomboidea
Sedum lanceolatum
Selaginella watsonii
Senecio fremontii
Senecio streptanthifolius
Sitanion hystrix
Solidago parryi
Swertia radiata
Symphoricarpos oreophilus
Synthyris pinnatifida
Thlaspi montanum
Trisetum spicatum
Valeriana acutiloba var. *pubicarpa*
Zigadenus elegans

Intermountain Flora (Cronquist et al. 1972, 1977) were used for the nomenclature of the vascular cryptogams, gymnosperms, and monocots. Other helpful sources were Arnow et al. (1980), Hitchcock and Cronquist (1973), Welsh (1978b), Welsh and Moore (1973), and Welsh and Reveal (1977). Synonyms are not listed unless in recent use. Introduced species are preceded by an asterisk (*). A representative collection number (my own unless otherwise noted) is cited for each species, and all specimens cited are deposited in the herbarium at Brigham Young University (BRY) unless otherwise indicated. A number of specimens are deposited in the Garrett Herbarium at the University of Utah (UT) and/or the Intermountain Herbarium at Utah State University (UTC). Frequency of most species is estimated based on the following scale from Thorne (1967): rare, 1 to 3 collections or observation stations; infrequent, 4 to 7 stations; frequent, 8 to 12 stations; common, more than 12 stations. This list should not be considered complete since many additional species remain to be discovered.

Division Lycopodiophyta

Selaginellaceae

Selaginella watsonii Underw. Watson Spikemoss. Frequent; open rocky slopes at high elevations. 507.

Division Equisetophyta

Equisetaceae

Equisetum arvense L. Field Horsetail. Rare; streamside in North Willow Canyon. 437.

Equisetum hyemale L. Common Scouring Rush. Frequent; streamside at low and middle elevations. 311 (UT).

Equisetum laevigatum A. Br. Smooth Scouring Rush. Frequent; streamside at low elevations. 850.

Division Polypodiophyta

Polypodiaceae

Cystopteris fragilis (L.) Bernh. Brittle Bladder Fern. Common; shaded and open mesic sites from middle elevations to alpine. 943.

Pellaea breweri D. C. Eat. Brewer Cliff-brake. Rare; limestone outcrops at middle elevations. 649.

Polystichum lonchitis (L.) Roth. Mountain Holly Fern. Rare; base of quartzite cliff in Douglas fir community. Taye & Herrick 1441.

Woodsia oregana D. C. Eat. Oregon Woodsia. Rare; dry, rocky slopes in juniper zone. Taye & Herrick 1430.

TABLE 5. Species restricted (or most common) to sandy areas in the Stansbury Mountains and vicinity.

Abronia fragrans
Agropyron dasystachyum
Amaranthus blitoides
Astragalus ceramicus
Astragalus geyeri
Astragalus mollissimus
Camissonia parvula
Camissonia scapoidea ssp. *brachycarpa*
Chenopodium leptophyllum
Cryptantha circumscissa
Cryptantha fendleri
Cryptantha kelseyana
Cryptantha pterocarya
Cymopterus fendleri
Elymus flavescens
Erigeron argentatus
Eriogonum cernuum
Eriogonum hookeri
Eriogonum kearneyi
Eriogonum microthecum var. *laxiflorum*
Eriogonum umbellatum var. *subaridum*
Euphorbia ocellata var. *arenicola*
Gilia inconspicua
Gilia leptomeria
Gilia polycladon
Layia glandulosa
Leptodactylon pungens
Lupinus pusillus var. *intermontanus*
Lygodesmia dianthopsis
Malacothrix sonchioides
Mentzelia albicaulis
Nama densum
Nicotiana attenuata
Oenothera pallida
Orobanche corymbosa
Phacelia ivesiana
Psoralea lanceolata
Rumex venosus
Sporobolus cryptandrus
Stephanomeria exigua
Stipa comata
Streptanthella longirostris
Tiquilia nuttallii
Townsendia florifer
Tripterocalyx micranthus
Vulpia octoflora

DIVISION PINOPHYTA

Cupressaceae

Juniperus communis L. var. *depressa* Pursh. Common Mountain Juniper. Frequent; meadows and open slopes at high elevations. 983.

Juniperus osteosperma (Torr.) Little. Utah Juniper. Common; a dominant on dry slopes at low and middle elevations. 1006.

Juniperus scopulorum Sarg. Rocky Mountain Juniper. Common; near streams and on mesic slopes from low to middle elevations. 863.

Pinaceae

Abies concolor (Gord. & Glend.) Lindl. White Fir. Common; a dominant along streams and on mesic slopes at low and middle elevations. 356 (UT and UTC).

Abies lasiocarpa (Hook.) Nutt. Subalpine Fir. Common; a dominant at moderately high elevations. 347 (UT and UTC).

Picea engelmannii Parry. Engelmann Spruce. Common; a dominant at moderately high elevations. 350 (UT and UTC).

°*Picea pungens* Engelm. Blue Spruce. Rare; apparently planted in South Willow Canyon. 578 (UTC).

°*Pinus contorta* Dougl. Lodgepole Pine. Rare; apparently planted in South Willow Canyon. 1183.

Pinus flexilis James. Limber Pine. Common; a dominant on dry slopes from middle elevations to timberline. 355 (UT and UTC).

Pinus longaeva D. K. Bailey. Bristlecone Pine. Infrequent; locally a dominant on limestone slopes at moderately high elevations. 589.

Pinus monophylla Torr. & Frem. Singleleaf Pinyon. Infrequent; locally a dominant from low to middle elevations. 1031.

°*Pinus ponderosa* Laws. Ponderosa Pine. Rare; apparently planted in South Willow Canyon. 688 (UTC).

Pseudotsuga menziesii (Mirb.) Franco var. *glauca* (Beissn.) Franco. Douglas Fir. Common; a dominant along streams and on dry to mesic slopes from low to high elevations. 574.

DIVISION MAGNOLIOPHYTA

CLASS MAGNOLIOPSIDA

Aceraceae

Acer glabrum Torr. Rocky Mountain Maple. Common; streamside and mesic slopes at middle elevations. 1105.

Acer grandidentatum Nutt. Bigtooth Maple. Infrequent; canyon bottoms at low elevations. 99 (UT and UTC).

Acer negundo L. Boxelder. Common; streamside from low to middle elevations. 862.

Amaranthaceae

Amaranthus blitoides Wats. Prostrate Pigweed. [*A. graecizans* L.] Collected only from sandy site in juniper zone. 1301.

Anacardiaceae

Rhus trilobata Nutt. var. *trilobata*. Squawbush. Frequent; dry slopes of foothills. 859.

Apiaceae

Angelica pinnata Wats. Small-leaf Angelica. Infrequent; streamside at middle elevations. 1179.

Berula erecta (Huds.) Cov. Cutleaf Waterparsnip. Infrequent; along streams in the foothills. 1095.

°*Conium maculatum* L. Poison Hemlock. Infrequent; mesic, sometimes disturbed sites at low elevations. 498.

Cymopterus fendleri Gray. Chimaya. Rare; locally frequent in sandy areas of Skull Valley. 777.

Cymopterus hendersonii (Coult. & Rose) Cronq. [*Pteryxia hendersonii* (Coult. & Rose) Math. & Const.] Infrequent; meadows and open slopes above 3000 m. 501.

Cymopterus longipes Wats. Longfoot Springparsley. Frequent; open slopes from the foothills to near timberline. 982.

Cymopterus purpurascens (Gray) Jones. Purple Springparsley. Infrequent; dry foothills. 766 (UTC).

Heracleum spondylium L. ssp. *montanum* (Schleich.) Briq. Cow Parsnip. [*H. lanatum*

Michx.] Common; streamside at middle elevations. 1116.

Ligusticum filicinum Wats. Fernleaf Lovage. Infrequent; open slopes at middle elevations. Taye & Wall 1217.

Lomatium dissectum (Nutt.) Math. & Const. Fernleaf Lomatium. Open slopes from low to middle elevations. 874.

Lomatium grayi Coult. & Rose. Common; rocky slopes in juniper zone. 772.

Lomatium nuttallii (Gray) Macbr. Threadleaf Lomatium. Frequent; open slopes at middle elevations. Mill Fork, 135 (UT and UTC).

Orogenia linearifolia Wats. Indian Potato. Frequent; foothills in springtime. 369.

Osmorhiza chilensis H. & A. Sweetroot. Frequent; streamside and forest understory at middle elevations. 1103.

Osmorhiza depauperata Phil. Sweetroot. Frequent; streamside and forest understory at middle elevations. 1104.

Osmorhiza occidentalis (Nutt.) Torr. Sweetanise. Frequent; streamside and forest understory at middle elevations. 221 (UT and UTC).

Apocynaceae

Apocynum androsaemifolium L. Spreading Dogbane. Infrequent; open slopes at middle elevations. 1184.

Apocynum cannabinum L. Indian Hemp. Rare; on road embankment in South Willow Canyon. 572 (UTC).

Asclepiadaceae

Asclepias asperula (Dcne.) Woodson. Milkweed. Rare; dry slopes in juniper zone. 1121.

Asclepias speciosa Torr. Showy Milkweed. Infrequent; disturbed sites at low elevations. 593 (UTC).

Asteraceae

Achillea millefolium L. ssp. *lanulosa* (Nutt.) Piper. Common Yarrow. Common; meadows and mostly open slopes from the foothills to timberline. 1292.

Agoseris aurantiaca (Hook.) Greene. Orange Dandelion. Frequent; open slopes from the foothills to subalpine. 417 (UTC).

Agoseris glauca (Pursh) Raf. Mountain Dandelion. Open slopes from the foothills to subalpine. 693.

Ambrosia acanthicarpa Hook. Burweed. Common; sandy areas at low elevations. 686.

Ambrosia psilostachya DC. Western Ragweed. Collected only from streamside in the foothills near Delle Ranch. Taye & Dillman 1417.

Antennaria corymbosa E. Nels. Flattop Pussytoes. Frequent; meadows and open slopes near timberline. 969.

Antennaria dimorpha (Nutt.) T. & G. Low Pussytoes. Infrequent; juniper zone. 771.

Antennaria microphylla Rydb. Rosy Pussytoes. [*A. rosea* Greene] Infrequent; locally common on open slopes from middle elevations to subalpine. 931.

°*Arctium minus* (Hill) Bernh. Common Burdock. Infrequent; streamside and shaded mesic sites from the valleys to middle elevations. 1187.

Arnica cordifolia Hook. Heartleaf Arnica. Common; meadows and forest understory from middle elevations to subalpine. 223 (UT and UTC).

Arnica longifolia D. C. Eat. Longleaf Arnica. Infrequent; locally common in mesic meadows at middle elevations. Taye & Wall 1172.

Arnica mollis Hook. Hairy Arnica. Infrequent; meadows and streamside at middle elevations. 624.

Artemisia arbuscula Nutt. Low Sagebrush. Open rocky slopes at middle elevations. 658.

Artemisia dracunculus L. Tarragon. Frequent; open slopes from the foothills to middle elevations. 1266.

Artemisia ludoviciana Nutt. var. *incompta* (Nutt.) Cronq. Louisiana Sagebrush. Locally common in subalpine meadows. 661.

Artemisia ludoviciana Nutt. var. *ludoviciana*. Common; open slopes from the foothills to middle elevations. 1227.

Artemisia nova A. Nels. Black Sagebrush. [*A. arbuscula* Nutt. var. *nova* (A. Nels.) Cronq.] Rocky slopes at low elevations. 1015.

Artemisia spiciformis Osterhout. Locally common on open slopes just below timberline. 1259.

Artemisia spinescens D. C. Eat. Bud Sagebrush. Infrequent; dry valley sites. 891.

Artemisia tridentata Nutt. ssp. *tridentata*. Big Sagebrush. Common; open slopes from the valleys to middle elevations. 1016.

Artemisia tridentata Nutt. ssp. *vaseyana* (Rydb.) Beetle. Open slopes at middle elevations. 1241.

Aster chilensis Nees ssp. *adscendens* (Lindl.) Cronq. Everywhere Aster. Common; dry to mesic sites from the foothills to subalpine. 718.

Aster engelmannii (D. C. Eat.) Gray. Engelmann Aster. Infrequent; open forest understory at middle elevations. 692.

Aster glaucodes Blake. Infrequent; dry slopes at middle elevations. 727.

Balsamorhiza hookeri Nutt. var. *hispidula* (Sharp) Cronq. Hooker's Balsamroot. Seen only in the foothills near South Willow Canyon. 411 (UTC).

Balsamorhiza sagittata (Pursh) Nutt. Arrowleaf Balsamroot. Common; open slopes in the foothills. 378.

Brickellia grandiflora (Hook.) Nutt. Tasselflower. Rocky sites in juniper zone. Taye & Herrick 1427.

Brickellia microphylla (Nutt.) Gray. Littleleaf Brickellia. Rocky slopes at low elevations. 750.

°*Centaurea cyanus* L. Bachelor's Buttons. Rare; near guard station in South Willow Canyon. 171 (UT).

°*Centaurea maculosa* Lam. Rare; roadside near mouth of South Willow Canyon. 670.

°*Centaurea repens* L. Russian Knapweed. Rare; streamside near mouth of Box Canyon. 1148.

Chaenactis douglasii (Hook.) H. & A. Hoary Chaenactis. Frequent; juniper zone. 842.

Chrysothamnus nauseosus (Pallas) Britt. var. *albicaulis* (Nutt.) Rydb. Rubber Rabbitbrush. Frequent; valleys and foothills. 752.

Chrysothamnus nauseosus (Pallas) Britt. var. *consimilis* (Greene) Hall. Collected only from the foothills. 1019.

Chrysothamnus nauseosus (Pallas) Britt. var. *gnaphaloides* (Greene) Hall. [*C.nauseosus* ssp. *hololeucus* (Gray) H. & C.] Collected only from the foothills. 1265.

Chrysothamnus nauseosus (Pallas) Britt. var. *turbinatus* (Jones) Blake. Locally common in sandy soil of Skull Valley. Anderson 5118.

Chrysothamnus viscidiflorus (Hook.) Nutt. var. *puberulus* (D. C. Eat.) Jeps. Douglas Rabbitbrush. Locally common in clay soil in Skull Valley. Anderson 5116.

Chrysothamnus viscidiflorus (Hook.) Nutt. var. *viscidiflorus*. Common; open slopes from the foothills to middle elevations. 307.

°*Cichorium intybus* L. Common Chicory. Rare; streamside in the foothills. 1146.

Cirsium eatonii (Gray) Robins. Eaton Thistle. Frequent; open and wooded slopes from middle elevations to subalpine. Taye & Wall 1443.

Cirsium scariosum Nutt. Elk Thistle. Locally frequent in Skull Valley. 1274.

Cirsium undulatum (Nutt.) Spreng. Wavyleaf Thistle. Frequent; dry foothills. 1001.

°*Cirsium vulgare* (Savi) Ten. Bull Thistle. Disturbed sites at low to middle elevations. 259 (UTC).

Conyza canadensis (L.) Cronq. Horseweed. Infrequent; streamside at low elevations. 682.

Crepis acuminata Nutt. Tapertip Hawksbeard. Open slopes from the foothills to middle elevations. 435.

Crepis atrabarba Heller. Slender Hawksbeard. Open slopes at middle elevations. 605.

Crepis modocensis Greene. Low Hawksbeard. Infrequent; juniper zone. 527 (UTC).

Crepis occidentalis Nutt. Western Hawksbeard. Open slopes from the foothills to middle elevations. 867.

Crepis runcinata T. & G. var. *glauca* (Nutt.) Babc. & Stebbins. Meadow Hawksbeard. Rare; near spring in Skull Valley. 1376.

Erigeron argentatus Greene. Fleabane. Infrequent; sandy areas in foothills. 495.

Erigeron compositus Pursh. Fernleaf Fleabane. Infrequent; locally common in meadows and on open rocky slopes above 2800 m. 964.

Erigeron divergens T. & G. Spreading Fleabane. Rare; streamside near mouth of Spring Canyon. 1132.

Erigeron eatonii Gray. Eaton Fleabane. Common; open slopes and meadows from the foothills to alpine. 430.

Erigeron engelmannii A. Nels. Engelmann Fleabane. Valleys and foothills. 419.

Erigeron leiomerus Gray. Smooth Daisy. Infrequent; rocky slopes above 2800 m. 665.

Erigeron lonchophyllus Hook. Spearleaf Fleabane. Rare; near spring in Skull Valley. 1377.

Erigeron speciosus (Lindl.) DC. Showy Fleabane. Common; open and wooded slopes from middle elevations to subalpine. 650.

Eupatorium occidentale Hook. Western Eupatorium. Rare; base of quartzite cliff in Douglas fir community in Muskrat Canyon. Taye & Herrick 1440.

Flaveria campestris J. R. Johnst. Rare; locally common near springs in Skull Valley. Anderson & Thorne 5114.

Gnaphalium palustre Nutt. Lowland Cudweed. Rare; streamside near mouth of Spring Canyon. 1131.

°*Grindelia squarrosa* (Pursh) Dun. Gumweed. Common; disturbed sites at low elevations. 258 (UT and UTC).

Haplopappus acaulis (Nutt.) Gray. Cushion Goldenweed. Infrequent; open rocky slopes from the foothills to middle elevations. 532a.

Haplopappus lanceolatus (Hook.) T. & G. Lanceleaf Goldenweed. Locally frequent in moist soil near spring in Skull Valley. Anderson & Thorne 5115.

Haplopappus macronema Gray. Whitestem Goldenweed. Frequent; meadows and open slopes from middle elevations to alpine. Taye & Wall 1212.

Haplopappus rydbergii Blake. Rydberg Goldenweed. Frequent; foothills to middle elevations, mostly on limestone outcrops. 999.

Helianthella uniflora (Nutt.) T. & G. Oneflower Helianthella. Locally common on open slopes at middle elevations. 513.

Helianthus annuus L. Common Sunflower. Common; valleys and foothills, often in disturbed areas. 1161.

Heliomeris multiflora Nutt. Showy Goldeneye. [*Viguiera multiflora* (Nutt.) Blake] Frequent; meadows and wooded slopes at middle elevations. 729.

Heterotheca villosa (Pursh) Shinners. Hairy Golden Aster. [*Chrysopsis villosa* (Pursh) Nutt.] Dry rocky slopes in juniper zone. Taye & Herrick 1429.

Iva axillaris Pursh. Poverty Sumpweed. Infrequent; valleys and foothills near drainages. 1048.

Lactuca pulchella (Pursh) DC. Blue Lettuce. Infrequent; dry to mesic sites from the foothills to middle elevations. 602.

Layia glandulosa (Hook.) H. & A. Whitedaisy Tidytips. Infrequent; sandy areas of the valleys and foothills. 778.

Leucelene ericoides (Torr.) Greene. Rare; locally common on south-facing road embankment near Clover Creek in juniper zone. 457.

Lygodesmia dianthopsis (D. C. Eat.) Tomb. Skeletonweed. [*L. grandiflora* (Nutt.) T. & G.] Frequent; foothills, mostly in sandy areas. 481.

Machaeranthera canescens (Pursh) Gray. Hoary Aster. Frequent; dry slopes of juniper zone. 305.

Madia glomerata Hook. Cluster Tarweed. Rare; near little-used road above Hickman Pass in Douglas fir community. 659.

Malocothrix sonchioides (Nutt.) T. & G. Desert Dandelion. Infrequent; sandy areas in valleys and foothills. 796.

Microseris nutans (Geyer) Schultz-Bip. Nodding Microseris. Open slopes at middle elevations. 462.

°*Onopardum acanthium* L. Scotch Cotton Thistle. Rare; roadside in Skull Valley. 1422.

Perityle stansburii (Gray) Macbr. [*Laphamia stansburii* Gray] Frequent; on rock outcrops in foothills. 545.

Petradoria pumila (Nutt.) Greene. Rock Goldenrod. Frequent; open slopes from the foothills to subalpine. 618.

Rudbeckia occidentalis Nutt. Western Coneflower. Frequent; moist sites at middle elevations. 1180.

Senecio eremophilus Rich. Desert Groundsel. Frequent; open and wooded slopes from middle elevations to subalpine. 699.

Senecio fremontii T. & G. var. *blitoides* (Greene) Cronq. Dwarf Mountain Butterweed. Wooded and open slopes near timberline. Neese 9666.

Senecio integerrimus Nutt. var. *exaltatus* (Nutt.) Cronq. Columbia Groundsel. Frequent; open and wooded slopes from the foothills to middle elevations. 392.

Senecio multilobatus T. & G. Lobeleaf Groundsel. Common; juniper zone. 551.

Senecio streptanthifolius Greene. Cleftleaf Groundsel. Frequent; open and wooded slopes from middle elevations to timberline. 526.

Solidago canadensis L. Canada Goldenrod. Mesic sites at middle elevations. 310 (UT and UTC).

Solidago parryi (Gray) Greene. Parry Goldenweed. [*Haplopappus parryi* Gray] Infrequent; open slopes near timberline. 704.

Solidago sparsiflora Gray. Slender Goldenrod. Open, rocky slopes from the foothills to middle elevations. 691.

°*Sonchus asper* (L.) Hill. Prickly Sowthistle. Collected only from moist sandy soil in the foothills at Sand Spring. 683 (UTC).

Sphaeromeria diversifolia (D. C. Eat.) Rydb. [*Tanacetum diversifolium* D. C. Eat.] Frequent; on rock outcrops from middle elevations to subalpine. 719.

Stephanomeria exigua Nutt. Small Wirelettuce. Infrequent; sandy areas in the valleys and foothills. 1190.

Stephanomeria pauciflora (Torr.) A. Nels. Wirelettuce. Rare; dry foothills of Salt Mountain. 1155.

°*Taraxacum officinale* Weber. Common Dandelion. Frequent; dry to mesic, mostly disturbed sites from low to middle elevations. 879.

Tetradymia canescens DC. Gray Horsebrush. Locally common in juniper zone. 214 (UT and UTC).

Tetradymia glabrata Gray. Littleleaf Horsebrush. Frequent; valleys and foothills. 895.

Tetradymia nuttallii T. & G. Nuttall Horsebrush. Frequent; valleys and foothills. 405.

Tetradymia spinosa H. & A. Cottonthorn Horsebrush. Rare; valleys. 893.

Townsendia florifer (Hook.) Gray. Showy Townsendia. Frequent; sandy areas of valleys and foothills. 480.

°*Tragopogon dubius* Scop. Yellow Salsify. Rare; disturbed sites at low elevations. 436.

Wyethia amplexicaulis Nutt. Mulesear Wyethia. Locally common on open slopes from the foothills to middle elevations. 882.

Xanthium strumarium L. Common Cocklebur. Rare; valleys and foothills in disturbed sites. 1269.

Xanthocephalum sarothrae (Pursh) Shinners. Broom Snakeweed. [*Gutierrezia sarothrae* (Pursh) Britt. & Rusby] Common; dry slopes from the valleys to middle elevations. 306.

Berberidaceae

Mahonia repens (Lindl.) G. Don. Oregon Grape [*Berberis repens* Lindl.] Common; from dry slopes in the foothills to dense conifer forest at higher elevations. 963.

Betulaceae

Alnus incana (L.) Moench. Mountain Alder [*A. tenuifolia* Nutt.] Rare; locally frequent in North Willow Canyon near stream. 215 (UT and UTC).

Boraginaceae

Amsinkia retrorsa Suksd. Rigid Fiddleneck. Known from one collection from South Willow Canyon. Maguire 21807a (UTC).

Amsinkia tessellata Gray. Tessellate Fiddleneck. Infrequent; dry slopes at low elevations. 781.

Cryptantha circumscissa (H. & A.) Johnst. Matted Cryptantha. Infrequent; locally common in sandy areas of valleys and foothills. 775.

Cryptantha fendleri (Gray) Greene. Sandy areas of valleys and foothills. 809.

Cryptantha flavoculata (A. Nels.) Payson. Dry slopes of valleys and foothills. 795.

Cryptantha humilis (Gray) Payson. Dwarf Catseye. Common; rocky slopes below 2200 m. 794.

Cryptantha kelseyana Greene. Collected only from a sandy area in the foothills near Condie Meadows. 915.

Cryptantha pterocarya (Torr.) Greene. Winged Cryptantha. Collected only from a sandy area in Blue Canyon. 790.

Cryptantha torreyana (Gray) Greene. Dry slopes in the foothills. 471.

°*Cynoglossum officinale* L. Hound's Tongue. Frequent; disturbed sites at low elevations. 118 (UTC).

Hackelia floribunda (Lehm.) Johnst. Many-flowered Stickseed. Frequent; meadows and open slopes from middle elevations to subalpine. 1205.

Hackelia patens (Nutt.) Johnst. Spreading Stickseed. Frequent; dry slopes from low to middle elevations. 92 (UT and UTC).

°*Lappula echinata* Gilib. European Stickseed. Infrequent; disturbed sites in valleys and foothills. 784.

Lappula occidentalis (Wats.) Greene. Western Stickseed. [*L. redowskii* (Hornem.) Greene] Frequent; dry slopes of valleys and foothills. 888.

Lithospermum ruderale Dougl. Wayside Gromwell. Infrequent; dry foothills. 428.

Mertensia arizonica Greene var. *leonardii* (Rydb.) Johnst. Arizona Bluebells. Infrequent; streamside and in open forest understory at middle elevations. 1057.

Mertensia brevistyla Wats. Shortstyle Bluebells. Infrequent; dry foothills. 461 (UTC).

Mertensia oblongifolia (Nutt.) G. Don var. *nevadensis* (A. Nels.) L. O. Williams. Oblongleaf Bluebells. Frequent; open slopes from the foothills to middle elevations. 13 (UT).

Tiquilia nuttallii (Hook.) A. Richards. [*Coldenia nuttallii* Hook.] Rare; locally frequent in sandy areas of Skull Valley. 954.

Brassicaceae

°*Alyssum alyssoides* L. Pale Alyssum. Locally common in juniper zone. 1388.

°*Alyssum desertorum* Stapf. Desert Alyssum. Locally common in disturbed areas at low elevations. 398 (UTC).

Arabis drummondii Gray. Drummond's Rockcress. Infrequent; open forest and meadows from middle elevations to subalpine. 576.

Arabis glabra (L.) Bernh. Tower Mustard. Infrequent; open forest and meadows at middle elevations. 872.

Arabis holboellii Hornem. var. *secunda* (Howell) Jeps. Holboell's Rockcress. Common; open slopes from the foothills to timberline. 944.

Arabis lignifera A. Nels. Rockcress. Collected only from the foothills near Blue Canyon. 807.

°*Barbarea vulgaris* R. Br. Yellowrocket Wintercress. Rare; streamside in East Hickman Canyon. 1294.

°*Camelina microcarpa* Andrz. False Flax. Infrequent; juniper zone. 805.

°*Capsella bursa-pastoris* (L.) Medicus. Shepherd's Purse. Rare; streamside in North Willow Canyon. 374.

°*Cardaria draba* (L.) Desv. Whitetop. Common; disturbed sites at low elevations. 1309.

Chlorocrambe hastata (Wats.) Rydb. Rare; subalpine conifer community on Deseret Peak. Neese 9709.

°*Chorispora tenella* (Pallas) DC. Locally common in disturbed sites at low elevations. 764.

Descurainia pinnata (Walt.) Britt. Western Tansymustard. Frequent; beneath juniper and on open slopes of foothills. 887.

°*Descurainia sophia* (L.) Webb. Flixweed. Frequent; disturbed sites at low elevations. 396.

Draba cuneifolia Nutt. Wedgeleaf Draba. Infrequent; dry slopes from low to middle elevations. 803.

Draba stenoloba Ledeb. Slender Draba. Infrequent; open slopes and moist meadows from middle elevations to timberline. 506.

Erysimum asperum (Nutt.) DC. Wallflowr. Frequent; open slopes from the foothills to timberline. 885.

Hutchinsia procumbens (L.) Desv. Locally common in the valleys near springs. 1303.

Lepidium montanum Nutt. var. *montanum*. Mountain Pepperweed. Infrequent; sandy areas of Skull Valley. 951.

°*Lepidium perfoliatum* L. Clasping Pepperweed. Frequent; disturbed sites at low elevations. 892.

Lesquerella occidentalis Wats. var. *cinerascens* Maguire & Holmgren. Western Bladderpod. Infrequent; rocky slopes, usually near timberline and above. 453.

°*Malcolmia africana* (L.) R. Br. Frequent; disturbed sites at low elevations. 595 (UTC).

°*Nasturtium officinale* R. Br. Watercress. [*Rorippa nasturtium-aquaticum* (L.) Schinz & R. Keller] Frequent; along streams at low elevations. 849.

Physaria chambersii Rollins. Twinpod. Infrequent; dry slopes in juniper zone. 763.

Rorippa curvipes Greene. Yellowcress. Collected only from edge of South Willow Lake in moist soil. Taye & Wall 725 (UTC).

°*Sisymbrium altissimum* L. Tumbling Mustard. Infrequent; disturbed sites at low elevations. 925.

Stanleya pinnata (Pursh) Britt. Prince's Plume. Frequent; valleys and on dry slopes in the foothills. 998.

Streptanthella longirostris (Wats.) Rydb. Frequent; sandy areas of valleys and foothills. 793.

Streptanthus cordatus Nutt. Collected only from a juniper community near Johnson Pass. 770.

Thelypodium integrifolium (Nutt.) Endl. var. *integrifolium*. Rare; locally frequent in Skull Valley in greasewood community. 1194.

Thelypodium sagittatum (Nutt.) Endl. var. *vermicularis* Welsh & Reveal. Rare; greasewood community in Skull Valley. 1333.

°*Thlaspi arvense* L. Field Pennycress. Locally common in disturbed sites. 633 (UTC).

Thlaspi montanum L. var. *montanum*. Wild Candytuft. Frequent; meadows and open slopes from middle elevations to timberline. 962.

Cactaceae

Echinocereus triglochidiatus Engelm. var. *melanacanthus* (Engelm.) L. Benson. Hedgehog Cactus. Frequent; dry slopes in juniper zone, often growing from limestone or quartzite outcrops. 361.

Opuntia polyacantha Haw. Prickly Pear. Common; valleys to middle elevations on dry slopes. 897.

Campanulaceae

°*Campanula rapunculoides* L. Creeping Bellflower. Rare; abandoned ranch at mouth of Big Hollow. 744.

Capparidaceae

Cleome serrulata Pursh. Rocky Mountain Beeplant. Frequent; valleys and foothills in generally disturbed sites. 958.

Caprifoliaceae

Sambucus caerulea Raf. Blue Elderberry. Frequent; near streams, in mesic forest, and on dry open slopes from the foothills to middle elevations. 1122.

Sambucus racemosa L. Red Elderberry. Infrequent; meadows and open slopes from middle elevations to subalpine. 988.

Symphoricarpos oreophilus Gray. Mountain Snowberry. Common; forest understory and open slopes from the foothills to subalpine. 858.

Caryophyllaceae

Arenaria kingii (Wats.) Jones. King's Sandwort. Common; open slopes from the foothills to alpine. 425.

°*Cerastium fontanum* Baumg. Mouse-ear Chickweed. [*C. vulgatum* L.] Collected only from streamside in Davenport Canyon. 56 (UT and UTC).

°*Holosteum umbellatum* L. Jagged Chickweed. Infrequent; locally common in rocky foothills. 1315.

Lychnis drummondii (Hook.) Wats. Drummond Campion. [*Silene drummondii* Hook.] Infrequent; forest understory and open slopes from middle elevations to subalpine. 1238.

Sagina saginoides (L.) Britt. Arctic Pearlwort. Rare; moist subalpine sites. 555.

Silene douglasii Hook. Douglas Campion. Frequent; open forest understory and open slopes from middle elevations to subalpine. 1244.

Stellaria jamesiana Torr. Sticky Chickweed. Frequent; forest understory and open slopes at middle elevations. 125 (UT and UTC).

Stellaria umbellata Turcz. Umbrella Starwort. Rare; moist sites at middle elevations. Taye & Wall 1168.

Celastraceae

Pachistima myrsinites (Pursh) Raf. Mountain Lover. Frequent; shaded sites from the foothills to subalpine. 880.

Chenopodiaceae

Allenrolfea occidentalis (Wats.) Kuntze. Iodinebush. Locally common in Skull Valley in saline soil. 1195.

Atriplex canescens (Pursh) Nutt. Fourwing Saltbush. Frequent; valleys and lower foothills. 714.

Atriplex confertifolia (Torr. & Frem.) Wats. Shadscale. Common; a dominant in the valleys and lower foothills. 1005.

°*Atriplex hortensis* L. Garden Orach. Rare; collected only from a roadside in Tooele Valley. 1278.

°*Atriplex rosea* L. Tumbling Orach. Rare; collected only from a roadside in Rush Valley. 749.

Atriplex tridentata Kuntze. Three-toothed Saltbush. [*A. nuttallii* Wats.] Locally common in Skull Valley in saline soil. 1198.

°*Bassia hyssopifolia* (Pallas) Kuntze. Fivehook Bassia. Locally common in Skull Valley in saline soil. 1197.

Ceratoides lanata (Pursh) J. T. Howell. Winterfat. [*Eurotia lanata* (Pursh) Moq.] Infrequent; valleys and lower foothills. 900.

°*Chenopodium album* L. Lambsquarters. Infrequent; disturbed sites at low elevations. 597 (UTC).

°*Chenopodium botrys* L. Jerusalem-oak. Rare; rocky sites at low elevations. 1160.

Chenopodium fremontii Wats. Fremont Goosefoot. Common; open and wooded slopes from the valleys to middle elevations. 492.

°*Chenopodium glaucum* L. Oakleaf Goosefoot. Rare; dry pond in Skull Valley. 1273.

Chenopodium hybridum L. Mapleleaf Goosefoot. Rare; beneath juniper in sandy soil. 1033.

Chenopodium leptophyllum Nutt. Slimleaf Goosefoot. Rare; collected only from a sandy area in Skull Valley. 1411.

Grayia spinosa (Hook.) Moq. Spiny Hopsage. Infrequent; valleys and foothills. 779.

°*Halogeton glomeratus* C. A. Mey. Halogeton. Common; disturbed sites in valleys. 959.

Kochia americana Wats. Graymolly. Infrequent; valleys. 890.

°*Kochia scoparia* (L.) Schrad. Belvedere Summer Cypress. Infrequent; disturbed sites at low elevations. 748.

Salicornia europaea L. Marshfire Pickleweed. [S. *rubra* A. Nels.] Locally common at Big Spring in saline soil. 1308.

Salicornia pacifica Standl. var. *utahensis* (Tidestr.) Munz. Utah Pickleweed. [S. *utahensis* Tidestr.] Locally common at Big Spring in saline soil. 1340.

°*Salsola iberica* Sennen & Pau. Russian Thistle. [S. *kali* L.] Common; disturbed sites at low elevations. 300 (UT).

Sarcobatus vermiculatus (Hook.) Torr. Greasewood. Common; a dominant in lower portions of valleys. 1276.

Suaeda occidentalis Wats. Western Seepweed. Locally common near Big Spring in Skull Valley. 1424.

Suaeda torreyana Wats. Bush Seepweed. Frequent; saline valleys. 1189.

Convolvulaceae

°*Convolvulus arvensis* L. Field Morningglory. Infrequent; disturbed sites at low elevations. 95 (UT and UTC).

Cressa truxillensis H. B. K. Locally common near Big Spring in saline soil. 1404.

Cornaceae

Cornus stolonifera Michx. Red-osier Dogwood. Frequent; along streams at middle elevations. 1046.

Crassulaceae

Sedum debile Wats. Stonecrop. Infrequent; shaded and open rocky sites from middle elevations to timberline. 1245.

Sedum lanceolatum Torr. Lanceleaf Stonecrop. Rocky sites from middle elevations to alpine. 323 (UTC).

Cuscutaceae

Cuscuta denticulata Engelm. Desert Dodder. Parasitic on *Artemisia tridentata* and *Chrysothamnus nauseosus* in Skull Valley. 1421.

Elaeagnaceae

°*Elaeagnus angustifolia* L. Russian Olive. Not collected but seen cultivated at Willow Springs and Delle Ranch.

Euphorbiaceae

Euphorbia glyptosperma Engelm. Ridgeseed Spurge. Dry slopes in the foothills. 679.

Euphorbia ocellata Dur. & Hilg. var. *arenicola* (Parish) Jeps. Spurge. Rare; locally common on sand dunes in Skull Valley. 1203.

Euphorbia serpyllifolia Pers. Thymeleaf Spurge. Dry slopes in the valleys and foothills. 997.

Fabaceae

Astragalus argophyllus Nutt. var. *martinii* Jones. Silver-leaved Milkvetch. Collected only from an open mid-elevation slope in East Hickman Canyon. 648.

Astragalus beckwithii T. & G. Beckwith Milkvetch. Common; dry slopes of valleys and foothills. 782.

Astragalus ceramicus Sheld. Painted Milkvetch. Rare; sandy foothills. 488.

Astragalus cibarius Sheld. Browse Milkvetch. Common; open slopes in the foothills. 886.

Astragalus convallarius Greene var. *convallarius.* Lesser Rushy Milkvetch. Frequent; open slopes from the foothills to medium elevations. 647.

Astragalus eurekensis Jones. Eureka Milkvetch. Common; valley benches and foothills. 767.

Astragalus geyeri Gray. Geyer Milkevetch. Infrequent; locally common in sandy areas. 814.

Astragalus kentrophyta Gray var. *implexus* (Canby) Barneby. Mountain Kentrophyta. Infrequent; locally common on open rocky slopes near timberline and above. 965.

Astragalus lentiginosus Dougl. var. *pohlii* Welsh & Barneby. Infrequent; greasewood communities in Skull Valley. 1332.

Astragalus mollissimus Torr. var. *thompsonae* (Wats.) Barneby. Woolly Locoweed. Infrequent; sandy foothills. 792.

Astragalus tenellus Pursh. Pulse Milkvetch. Infrequent; meadows and open rocky slopes from middle elevations to timberline. 586.

Astragalus utahensis (Torr.) T. & G. Utah Milkvetch. Frequent; open slopes at low elevations. 788.

Hedysarum boreale Nutt. var. *boreale.* Northern Sweetvetch. Open slopes from the foothills to middle elevations. 947.

Lathyrus brachycalyx Rydb. var. *brachycalyx.* Rydberg Sweetpea. Infrequent; rocky foothills. 774.

Lathyrus lanzwertii Kellogg var. *lanzwertii.* Lanzwert Sweetpea. Infrequent; open to wooded subalpine slopes. 1451.

Lathyrus pauciflorus Fern. var. *utahensis* (Jones) Peck. Utah Sweetpea. Open to wooded slopes from the foothills to middle elevations. 64 (UT and UTC).

Lupinus argenteus Pursh var. *rubricaulis* (Greene) Welsh. Silvery Lupine. frequent; meadows and open slopes from middle elevations to timberline. 184.

Lupinus pusillus Pursh var. *intermontanus* (Heller) C. P. Sm. Dwarf Lupine. Infrequent; locally common in sandy areas. 815.

Lupinus sericeus Pursh var. *sericeus.* Silky Lupine. Open to wooded slopes at middle elevations. 1284.

°*Medicago lupilina* L. Black Medick. Infrequent; disturbed sites at low elevations. 869.

°*Medicago sativa* L. Alfalfa. Disturbed sites (and cultivated) at low elevations. 257 (UT).

°*Melilotus alba* Medicus. White Sweetclover. Disturbed sites at low elevations. 669 (UTC).

°*Melilotus officinalis* (L.) Pallas. Yellow Sweetclover. Disturbed sites at low elevations. 98 (UT and UTC).

Psoralea lanceolata Pursh. var. *stenostachys* (Rydb.) Welsh. Dune Scurfpea. Frequent; sandy areas at low elevations. 479.

°*Trifolium fragiferum* L. Strawberry Clover. Collected only from streamside in South Willow Canyon. 1041b.

°*Trifolium repens* L. White Clover. Frequent; wet places from the foothills to subalpine. 853.

Vicia americana Muhl. var. *americana.* American Vetch. Infrequent; dry foothills. 460.

Fumariaceae

Dicentra uniflora Kellogg. Steer's Head. Rare; open woodland on mid-elevation slope in Mining Fork in early spring. 22 (UT and UTC).

Gentianaceae

Centaurium exaltatum (Griseb.) Wight. Western Centaury. Seen but not collected by K. Thorne at springs in Skull Valley.

Swertia radiata (Kell.) Kuntze. Green Gentian. [*Frasera speciosa* Dougl.] Frequent; mesic open and wooded slopes from middle elevations to alpine. 948.

Geraniaceae

°*Erodium cicutarium* (L.) L'Her. Heronsbill. Frequent; disturbed sites at low elevations. 27 (UT).

Geranium parryi (Engelm.) Heller. Parry Geranium. Infrequent; locally common on rocky (quartzite) slopes between 2200 m and 3000 m in elevation. Taye & Wall 1213. Jones and Jones (1943) state that the petal color for this species is pale to deep rose-purple. Plants collected from Stansburys, and also from the Canyon Range 80 km to the south (S. Goodrich, pers. comm. 1981), have white petals and thus are possibly worthy of taxonomic distinction.

Geranium richardsonii Fisch. & Trautv. Richardson Geranium. Frequent; near streams at middle elevations. 1204.

Geranium viscosissimum Fisch. & Mey. Sticky Geranium. Frequent; mesic, mostly open slopes at middle elevations. 936.

Grossulariaceae

Ribes aureum Pursh. Golden Currant. Infrequent; valleys and foothills in drainage bottoms. 818.

Ribes cereum Dougl. Wax Currant. Common; open slopes, near streams, and in forest understory from the foothills to subalpine. 877.

Ribes inerme Rydb. Whitestem Gooseberry. Rare; streamside in South Willow Canyon. 1234.

Ribes montigenum McClatchie. Alpine Prickly Currant. Common; forest understory, meadows, and open slopes from middle elevations to alpine. 960.

Ribes velutinum Greene var. *velutinum*. Desert Gooseberry. Infrequent; dry rocky foothills. 1003.

Ribes viscosissimum Pursh. Sticky Currant. Frequent; forest understory at middle elevations. 1030.

Ribes wolfii Rothr. Wolf's Currant. Frequent; forest understory at middle elevations. 991.

Hydrophyllaceae

Hydrophyllum occidentale (Wats.) Gray. Western Waterleaf. Frequent; mesic, shaded to open sites from the foothills to middle elevations. 531.

Nama densum Lemmon. Matted Nama. Rare; sandy area of Skull Valley. 837.

Phacelia crenulata Torr. Scorpionweed. Rare; juniper community on Salt Mountain. 1153.

Phacelia hastata Dougl. Infrequent; open rocky areas from middle elevations to subalpine. 575.

Phacelia incana Brand. Seen only in rocky foothills near Big Spring. 1014.

Phacelia ivesiana Torr. Infrequent; sandy areas at low elevations. 791.

Phacelia linearis (Pursh) Holz. Threadleaf Scorpionweed. Infrequent; dry slopes from low to middle elevations. 789.

Juglandaceae

°*Juglans nigra* L. Black Walnut. Rare; abandoned ranch in Big Hollow. 741.

Lamiaceae

Agastache urticifolia (Benth.) Kuntze. Giant Hyssop. Frequent; open and wooded slopes at middle elevations. 175 (UT and UTC).

°*Marrubium vulgare* L. Common Horehound. Infrequent; disturbed sites at low elevations. 302.

Mentha arvensis L. Field Mint. Collected only from streamside near mouth of Spring Canyon. 1137.

°*Mentha piperita* L. Peppermint. Collected only from streamside at mouth of South Willow Canyon. 1186.

°*Mentha spicata* L. Spearmint. Collected only from marshy area in the foothills. Hardy 130.

Monardella odoratissima Benth. Infrequent; open rocky slopes from middle elevations to subalpine. 228 (UT and UTC).

°*Nepeta cataria* L. Catnip. Infrequent; dry to moist, sometimes disturbed sites at low elevations. 735.

Linaceae

Linum perenne L. Wild Blux Flax. [*L. lewisii* Pursh] Frequent; open slopes from the foothills to near timberline. 937.

Loasaceae

Mentzelia albicaulis Dougl. White Blazing Star. Rare; sandy areas in foothills. 484.

Mentzelia laevicaulis (Dougl.) T. & G. Blazing Star. Infrequent; dry slopes in foothills. 1267.

Malvaceae

Iliamna rivularis (Dougl.) Greene. Mountain Hollyhock. Infrequent; open and wooded slopes at middle elevations. 1109.

°*Malva neglecta* Wallr. Cheeseweed. Disturbed sites at low elevation. 96 (UT and UTC).

Sidalcea neomexicana Gray. New Mexico Checkermallow. Rare; near spring in Skull Valley. 1378.

Sphaeralcea grossulariifolia (H. & A.) Rydb. Gooseberryleaf Globemallow. Common; dry slopes of valleys and lower foothills. 860.

Moraceae

°*Morus alba* L. White Mulberry. Infrequent; cultivated at ranches. Taye & Dillman 1416.

Nyctaginaceae

Abronia fragrans Nutt. Snowball Sand Verbena. Frequent; sandy areas at low elevations. 838.

Mirabilis linearis (Pursh) Heimerl. Narrowleaved Four-o'clock. [*Oxybaphus linearis* (Pursh) Robins.] Rare; dry valley benches. 1047.

Tripterocalyx micranthus (Torr.) Hook. Sandpuff. Rare; sand dunes in Skull Valley. 1391.

Oleaceae

°*Syringa vulgaris* L. Common Lilac. Rare; abandoned ranch in Big Hollow. 743.

Onagraceae

Camissonia boothii (Dougl.) Raven ssp. *alyssoides* (H. & A.) Raven. [*Oenothera alyssoides* H. & A.] Locally common in the foothills. 928.

Camissonia minor (A. Nels.) Raven. [*Oenothera minor* (A. Nels.) Munz] Known from one collection from the foothills. Flowers 1222 (UT). The lectotype was collected by S. Watson from Stansbury Island in 1869 (Raven 1969).

Camissonia parvula (Nutt.) Raven. [*Oenothera contorta* (Dougl.) Kearney var. *flexuosa* (A. Nels.) Munz] Infrequent; sandy areas of foothills. 810.

Camissonia scapoidea (T. & G.) Raven. [*Oenothera scapoidea* T. & G.] Infrequent; valleys and foothills. 957.

Circaea alpina L. Enchanter's Nightshade. Rare; understory of Douglas fir community in South Willow Canyon. 1106.

Epilobium alpinum L. Alpine Willowherb. [*E. hornemannii* Reichenb.] Rare; wet places at middle elevations. Taye & Wall 1164.

Epilobium angustifolium L. Fireweed. Common; streamside at middle elevations. 237 (UT).

Epilobium brachycarpum Presl. Autumn Willowherb. [*E. paniculatum* Nutt.] Frequent; dry slopes in the foothills. 304.

Epilobium canum (Greene) Raven. Garret Firechalice. [*Zauschneria garrettii* A. Nels.] Frequent; dry rocky slopes in juniper zone. 690.

Epilobium ciliatum Raf. Frequent; stream side from low to middle elevations. 261.

Gaura parviflora Dougl. Lizard Tail. Rare; roadside in Skull Valley. 1420.

Gayophytum ramosissimum Nutt. Hairstem Groundsmoke. Collected only from a sandy area in the foothills. 1035.

Oenothera caespitosa Nutt. Tufted Evening Primrose. Frequent; dry foothills. 866.

Oenothera hookeri T. & G. Hooker Evening Primrose. Rare; streamside near mouth of Spring Canyon. 1141.

Oenothera pallida Lindl. Pale Evening Primrose. Infrequent; dry, sometimes sandy areas in the foothills. 477.

Orobanchaceae

Orobanche corymbosa (Rydb.) Ferris. Flattopped Broomrape. Rare; apparently parasitic on *Artemisia spinescens* and *Artemisia tridentata* in Skull Valley. 950.

Orobanche fasiculata Nutt. Clustered Broomrape. Rare; apparently parasitic on *Artemisia tridentata* in juniper woodland. 1075.

Papaveraceae

Argemone munita Dur. & Hilg. Prickly Poppy. Frequent; valleys and foothills, usually in disturbed sites. 912.

°*Papaver orientale* L. Oriental Poppy. Rare; abandoned ranch in Big Hollow. 745.

Plantaginaceae

°*Plantago lanceolata* L. Buckhorn Plantain. Collected only from roadside in South Willow Canyon. 1110.

°*Plantago major* L. Common Plantain. Moist sites in the foothills. 626.

Polemoniaceae

Collomia grandiflora Dougl. Large-flowered Collomia. Collected only from juniper community in Whiterocks Canyon. 883.

Collomia linearis Nutt. Narrowleaf Collomia. Infrequent; dry open slopes at middle elevations. 868.

Gilia aggregata (Pursh) Spreng. Scarlet Gilia. Frequent; open and wooded slopes from the foothills to middle elevations. 932.

Gilia inconspicua (Smith) Sweet. Shy Gilia. [*G. sinuata* Dougl.] Frequent; dry slopes at low elevations. 483.

Gilia leptomeria Gray. Infrequent; sandy areas at low elevations. 845.

Gilia polycladon Torr. Rare; sandy area in Skull Valley. 956.

Leptodactylon pungens (Torr.) Nutt. Prickly Phlox. Frequent; dry foothills in rocky or sandy soil. 797.

Leptodactylon watsonii (Gray) Rydb. Prickly Gilia. Infrequent; limestone outcrops in the foothills. 546.

Microsteris gracilis (Hook.) Greene. Locally frequent on dry slopes from low to middle elevations. 802.

Phlox hoodii Rich. Hood's Phlox. Frequent; valley benches and foothills. 493.

Phlox longifolia Nutt. Longleaf Phlox. Common; dry foothills. 395.

Phlox pulvinata (Wherry) Cronq. Cushion Phlox. [*P. caespitosa* Nutt.] Infrequent; rocky slopes near timberline and above. 971.

Polemonium foliosissimum Gray. Leafy Jacob's Ladder. Meadows at middle elevations. 993.

Polemonium pulcherrimum Hook. var. *delicatum* (Rydb.) Cronq. Skunkleaf. [*P. delicatum* Rydb.] Infrequent; rocky subalpine slopes. 985.

Polygonaceae

Eriogonum brevicaule Nutt. var. *laxifolium* (T. & G.) Reveal. Shortstem Wild Buckwheat. Frequent; dry slopes from low to middle elevations, often growing from cracks in rock outcrops. 432.

Eriogonum cernuum Nutt. var. *cernuum*. Nodding Buckwheat. Frequent; valleys and foothills, usually in sandy areas. 672.

Eriogonum grayi Reveal. Frequent; rocky slopes near timberline and above. 534.

Eriogonum heracleoides Nutt. Wyeth Buckwheat. Frequent; open slopes from middle elevations to subalpine. 614.

Eriogonum hookeri Wats. Rare; sandy areas in the foothills. 1150.

Eriogonum kearneyi Tidestr. Infrequent; locally common in sandy areas at low elevations. 675.

Eriogonum microthecum Nutt. var. *laxiflorum* Hook. Slenderbush Buckwheat. Collected only from a sandy area in juniper zone. Taye et al. 565 (UTC).

Eriogonum ovalifolium Nutt. var. *ovalifolium*. Cushion Buckwheat. Frequent; valleys and foothills, often in sandy areas. 839.

Eriogonum racemosum Nutt. Redroot Buckwheat. Infrequent; open slopes at middle elevations. 1078.

Eriogonum umbellatum Torr. var. *desereticum* Reveal. Sulfurflower. Open slopes from middle elevations to timberline. 732.

Eriogonum umbellatum Torr. var. *subaridum* S. Stokes. Frequent; sandy areas of foothills. 1037.

Oxyria digyna (L.) Hill. Mountain Sorrel. Frequent; rocky, often moist sites above 2600 m. Taye & Wall 1446.

Polygonum aviculare L. Prostrate Knotweed. Collected only from roadside in Tooele Valley. 596 (UTC).

Polygonum douglasii Greene. Douglas Knotweed. Frequent; open and wooded slopes at middle elevations. 1084.

Polygonum sawatchense Small. Sawatch Knotweed. Collected only from a sandy area in juniper zone. 1036.

°*Rumex crispus* L. Curly Dock. Frequent; mesic, often disturbed sites from the foothills to middle elevations. 557.

Rumex salicifolius Weinm. Willow Dock. Streamside at middle elevations. 558.

Rumex venosus Pursh. Wild Begonia. Infrequent; locally common in sandy areas at low elevations. 832.

Portulacaceae

Claytonia lanceolata Pursh. Lanceleaf Springbeauty. Common; moist soil at middle elevations in springtime. 381.

Lewisia pygmaea (Gray) Robins. Least Lewisia. Infrequent; locally common in meadows near timberline. 966.

Montia perfoliata (Donn) Howell. Miner's Lettuce. [*Claytonia perfoliata* Donn] Infrequent; streamside at low to middle elevations. 864.

Primulaceae

Androsace septentrionalis L. Northern Rock Jasmine. Frequent; rocky slopes and meadows above 2600 m, usually in moist soil. 145 (UTC).

Glaux maritima L. Sea Milkwort. Infrequent; near springs and streams at low elevations. 829.

Primula parryi Gray. Parry's Primrose. Infrequent; moist subalpine sites. 207 (UT and UTC).

Pyrolaceae

Pyrola secunda L. Sidebells Wintergreen. Infrequent; conifer understory at middle elevations. Taye & Wall 1214.

Ranunculaceae

Aconitum columbianum Nutt. Columbia Monkshood. Frequent; streamside at middle elevations. Taye & Wall 1169.

Actaea rubra (Ait.) Willd. Western Baneberry. Frequent; meadows and forest understory from middle elevations to subalpine. 1074.

Aquilegia caerula James. Colorado Columbine. Infrequent; streamside, in meadows, and in open forest understory from middle elevations to subalpine. 992.

Aquilegia formosa Fisch. Red Columbine. Streamside at middle elevations. 559.

Delphinium nuttallianum Pritz. Nuttal Larkspur. [*D. nelsonii* Greene] Common; open slopes and forest understory from the valley benches to 2900 m. 394.

Delphinium occidentale Wats. Duncecap Larkspur. Meadows and open forest understory at middle elevations. 180 (UT and UTC).

Ranunculus cymbalaria Pursh. Shore Buttercup. Common; wet areas from the valleys to subalpine. 825.

Ranunculus glaberrimus Hook. Sagebrush Buttercup. Rare; sagebrush community in North Willow Canyon. Taye & Taye 387.

Ranunculus inamoenus Greene. Infrequent; moist meadows and streamside from middle elevations to subalpine. 190 (UTC).

Ranunculus juniperinus Jones. Locally common in the foothills in early spring. Taye & Kass 1323.

°*Ranunculus testiculatus* Crantz. Bur Buttercup. Common; disturbed sites at low elevations. 1314.

Thalictrum fendleri Engelm. Fendler Meadowrue. Common; meadows and forest understory at middle elevations. 986.

Rhamnaceae

Ceanothus martinii Jones. Rare; sagebrush community in juniper zone at southern end of range. 525.

Ceanothus velutinus Dougl. Snowbrush. Infrequent; open and wooded slopes at middle elevations. 940.

Rosaceae

Amelanchier alnifolia Nutt. Serviceberry. Common; mesic, open and wooded slopes from the foothills to middle elevations. 400.

Cercocarpus ledifolius Nutt. Curl-leaf Mountain Mahogany. Common; a dominant on dry slopes in upper juniper zone. 1386.

Cercocarpus ledifolius Nutt. × *C. montanus* Raf. Rare; seen only in juniper zone in Vickory Canyon. 464.

Cercocarpus montanus Raf. Birchleaf Mountain Mahogany. Rocky slopes at middle elevations. 463 (UTC).

Chamaebatiaria millefolium (Torr.) Maxim. Fern Bush. Infrequent; dry rocky slopes below 2300 m in elevation, often growing from limestone outcrops. 1114.

Cowania mexicana D. Don var. *stansburiana* (Torr.) Jeps. Stansbury Cliffrose. Common; dry slopes at low elevations. 911.

Crataegus douglasii Lindl. var. *rivularis* (Nutt.) Sarg. Douglas Hawthorn. [*C. rivularis* Nutt.] Rare; along Clover Creek at southern end of the range. 1384.

Fragaria vesca L. var. *bracteata* (Heller) Davis. Woods Strawberry. Infrequent; meadows and open forest understory at middle elevations. 541 (UTC).

Geum macrophyllum Willd. var. *perincisum* (Rydb.) Raup. Largeleaf Avens. Frequent; streamside at middle elevations. 497.

Geum rossii (R. Br.) Ser. var. *turbinatum* (Rydb.) Hitchc. Alpine Avens. Frequent; locally common in subalpine meadows and on rocky alpine slopes, often near persistent snow patches. 1067.

Geum triflorum Pursh var. *ciliatum* (Pursh) Fassett. Prairie Smoke. Rare; open, mesic north-facing slope at 1950 m in Davenport Canyon. 512.

Holodiscus dumosus (Nutt.) Heller. Bush Oceanspray. Frequent; dry rocky slopes from low to middle elevations. 1011.

Ivesia gordonii (Hook.) T. & G. Gordon Ivesia. Infrequent; open rocky slopes from middle elevations to alpine. Taye & Wall 1448.

Petrophytum caespitosum (Nutt.) Rydb. Tufted Rockmat. [*Spiraea caespitosa* Nutt.] Infrequent; locally common on limestone outcrops from low to middle elevations. 1185.

Physocarpus malvaceus (Greene) Kuntze. Mallow Ninebark. Frequent; open slopes and forest understory at middle elevations. 949.

Potentilla diversifolia Lehm. Varileaf Cinquefoil. Collected only from a cirque meadow in Antelope Canyon. 976.

Potentilla glandulosa Lindl. Gland Cinquefoil. Common; meadows, open forest understory, and on rocky slopes from middle elevations to subalpine. 990.

Potentilla gracilis Dougl. Soft Cinquefoil. Meadows and open slopes from middle elevations to subalpine. 625.

Potentilla ovina Macoun. Sheep Cinquefoil. [*P. wyomingensis* A. Nels.] Infrequent; meadows and open rocky slopes from subalpine to alpine. 970.

Prunus virginiana L. var. *melanocarpa* (A. Nels.) Sarg. Chokecherry. Common; streamside and on mesic slopes from the foothills to middle elevations. 994.

Purshia tridentata (Pursh) DC. Antelope Bitterbrush. Common; dry foothills. 811.

Purshia tridentata (Pursh) DC. × *Cowania mexicana* D. Don. Rare; rocky foothills near Big Spring. 1018.

Rosa nutkana Presl. Bristly Nootka Rose. Mesic, open and wooded slopes at middle elevations. 1285.

°*Rosa rubiginosa* L. Sweetbrier. Rare; streamside near abandoned power station at mouth of South Willow Canyon. 903.

Rosa woodsii Lindl. Wood's Rose. Common; drainage bottoms and other generally mesic sites at middle elevations. 147 (UT and UTC).

Rubus idaeus L. ssp. *melanolasius* (Dieck) Focke. Wild Red Raspberry. Frequent; forest understory and on rocky slopes from middle elevations to subalpine. 201.

Rubus parviflorus Nutt. Western Thimbleberry. Rare; one streamside collection from Dry Lake Fork. Neese 9662.

°*Sanguisorba minor* Scop. Burnet. Locally frequent in disturbed sites at low elevations. 1142.

Rubiaceae

Galium aparine L. Catchweed Bedstraw. Open forest understory and along streams from the foothills to middle elevations. 117 (UT and UTC).

Galium bifolium Wats. Twinleaf Bedstraw. Open forest understory at middle elevations. 509 (UTC).

Galium multiflorum Kellogg. Shrubby Bedstraw. Rare; dry rocky slopes in the foothills near Timpie. 1009.

Galium triflorum Michx. Sweetscented Bedstraw. Frequent; streamside and open forest understory at middle elevations. 1107.

Salicaceae

Populus angustifolia James. Narrowleaf Cottonwood. Common; a dominant along streams from the foothills to middle elevations. 401.

°*Populus fremontii* Wats. Fremont Cottonwood. Rare; abandoned ranch in Big Hollow. 739 (UTC).

°*Populus nigra* L. Lombardy Poplar. Cultivated at several ranches. 738 (UTC).

Populus tremuloides Michx. Quaking Aspen. Common; a dominant along streams at low elevations and on mesic slopes to moderately high elevations. 399.

Salix amygdaloides Anderss. Peachleaf Willow. Streamside in the foothills. 1335.

Salix exigua Nutt. Sandbar Willow. Common; streamside from low to middle elevations. 443.

Salix rigida Muhl. Yellow Willow. [*S. lutea* Nutt.] Common; streamside from low to middle elevations. 438.

Salix scouleriana Barratt. Scouler Willow. Locally frequent along streams at middle elevations. 444.

Santalaceae

Comandra umbellata (L.) Nutt. Bastard Toadflax. Locally frequent in dry, sometimes sandy areas in the foothills. 914.

Saxifragaceae

Heuchera parvifolia Nutt. Littleleaf Alumroot. Open forest understory and open rocky areas from middle elevations to subalpine. 533.

Heuchera rubescens Torr. Red Alumroot. Streamside, open forest understory, and in open rocky areas from middle elevations to subalpine. 1100.

Lithophragma glabra Nutt. Fringecup Woodland Star. [*L. bulbifera* Rydb.] Moist sites at middle elevatons. 385a.

Lithophragma parviflora (Hook.) Nutt. Smallflower Woodland Star. Locally frequent at middle elevations in open forest understory and other shaded sites. 870.

Mitella stauropetala Piper. Miterwort. Common; streamside and open forest understory at middle elevations. 878.

Saxifraga debilis Engelm. Pygmy Saxifrage. Rare; below melting snowpatch in cirque of Big Creek Canyon. Taye & Wall 1170.

Saxifraga odontoloma Piper. Brook Saxifrage. [*S. arguta* D. Don] Infrequent; streamside at middle elevations. 1206.

Saxifraga rhomboidea Greene. Diamondleaf Saxifrage. Infrequent; near melting snow on cirque walls and in subalpine-alpine meadows. 503.

Scrophulariaceae

Castilleja applegatei Fern. var. *viscida* (Rydb.) Owenby. Sticky Indian Paintbrush. [*C. viscida* Rydb.] Frequent; open rocky slopes from middle elevations to alpine. 529.

Castilleja chromosa A. Nels. Desert Indian Paintbrush. Common; open slopes from the valleys to middle elevations. 407.

Castilleja linariifolia Benth. Narrowleaf Indian Paintbrush. Locally frequent on open mesic slopes at lower elevations. 111 (UT and UTC).

Castilleja rhexifolia Rydb. Splitleaf Indian Paintbrush. Infrequent; open slopes from subalpine to alpine. 579.

Castilleja sulphurea Rydb. Sulphur Indian Paintbrush. Infrequent; openings in conifer forest at middle elevations. 1112.

Collinsia parviflora Dougl. Blue-eyed Mary. Mesic slopes from low to middle elevations. 30 (UT).

Mimulus breweri (Greene) Rydb. Brewer's Monkeyflower. Rare; near subalpine spring in Dry Lake Fork. 613.

Mimulus floribundus Dougl. Rare; near mid-elevation spring in Big Creek Canyon. Taye & Wall 1165.

Mimulus guttatus Fisch. Yellow Monkeyflower. Common; streamside from low to middle elevations. 857.

Mimulus lewisii Pursh. Lewis Monkeyflower. Frequent; streamside at middle elevations. 153 (UT and UTC).

Orthocarpus tolmiei H. & A. Tolmie Owl Clover. Locally frequent on open slopes at middle elevations. 206 (UT and UTC).

Penstemon cyananthus Hook. Wasatch Penstemon. Frequent; open and wooded slopes from middle elevations to subalpine. 606.

Penstemon humilis Nutt. Low Penstemon. Common; rocky slopes from middle elevations to alpine. 588.

Penstemon whippleanus Gray. Whipple Penstemon. Infrequent; moist sites and conifer understory from middle elevations to subalpine. 195 (UT and UTC).

Scrophularia lanceolata Pursh. Lanceleaf Figwort. Known from one roadside collection in drainage bottom of East Hickman Canyon. 635 (UTC).

Synthyris pinnatifida Wats. Featherleaf Kittentails. Infrequent; locally common on rocky subalpine and alpine slopes. 535.

°*Verbascum thapsus* L. Flannel Mullein. Frequent; disturbed sites at low elevations. 199 (UT and UTC).

°*Verbascum virgatum* Stokes. Wand Mullein. Rare; disturbed sites at low elevations. 713 (UTC).

Veronica americana Schwein. American Brooklime. Frequent; streamside at middle elevations. 1049.

°*Veronica biloba* L. Bilobed Speedwell. Disturbed sites at low elevations. 112b (UTC).

Veronica peregrina L. Purslane Speedwell. Rare; streamside near mouth of Spring Canyon. 1128.

Veronica serpyllifolia L. Thyme-leaved Speedwell. Collected only from streamside in North Willow Canyon. 439.

Solanaceae

Lycium andersonii Gray. Anderson Wolfberry. Infrequent; dry rocky foothills at northern end of the range. 1328.

Nicotiana attenuata Torr. Coyote Tobacco. Locally frequent in disturbed and sandy sites at low elevations. 1088.

Physalis virginiana Mill. Virginia Groundcherry. [*P. longifolia* Nutt.] Seen only at roadside near South Mountain. 600 (UTC).

Tamaricaceae

°*Tamarix ramosissima* Ledeb. Salt Cedar Tamarisk. Rare; wet valley sites. 1144.

Ulmaceae

Celtis reticulata Torr. Netleaf Hackberry. Rare; near streamchannels in the foothills. 1140.

°*Ulmus pumila* L. Siberian Elm. Rare; near abandoned power station at mouth of South Willow Canyon. 904.

Urticaceae

Urtica dioica L. ssp. *gracilis* (Ait.) Seland. Stinging Nettle. Common; streamside and open forest understory at middle elevations. 181 (UTC).

Valerianaceae

Valeriana acutiloba Rydb. var. *pubicarpa* (Rydb.) Cronq. Sharpleaf Valerian. Infrequent; rocky open slopes near timberline and above. 984.

Valeriana occidentalis Heller. Western Valerian. Infrequent; meadows at middle elevations. 446.

Verbenaceae

Verbena bracteata Lag. & Rodr. Bracted Vervain. Frequent; dry to moist, usually disturbed sites at low elevations. 301.

Violaceae

Viola adunca Sm. var. *adunca*. Mountain Blue Violet. Common; open forest understory and streamside at middle elevations. 590.

Viola adunca Sm. var. *bellidifolia* (Greene) Harr. Rare; rock ledges of cirque in Dry Lake Fork. 191 (UT).

Viola nephrophylla Greene. Bog Violet. Collected only from streamside at Condie Meadows. 826.

Viola nuttallii Pursh. Yellow Prairie Violet. Mesic forest openings at middle elevations. 447.

Viola purpurea Kellogg. Goosefoot Violet. Frequent; open slopes and open forest understory from the foothills to subalpine. 372.

Viscaceae

Phoradendron juniperinum Engelm. Juniper Mistletoe. Infrequent; parasitic on *Juniperus osteosperma* in the foothills. 360.

Class Liliopsida

Cyperaceae

Carex atrata L. var. *erecta* W. Boott. Black Sedge. Infrequent; subalpine meadows and open slopes near timberline. 702.

Carex aurea Nutt. Golden Sedge. Locally common near streams in the foothills. 820.

Carex douglasii F. Boott. Douglas Sedge. Collected only from streamside in Davenport Canyon. 61 (UT and UTC).

Carex geyeri F. Boott. Elk Sedge. Infrequent; forest understory and open mesic slopes at middle elevations. 516.

Carex haydeniana Olney. Cloud Sedge. Infrequent; locally common in subalpine meadows. 1246.

Carex hoodii F. Boott. Hood Sedge. Common; meadows and open slopes from middle elevations to subalpine. 511.

Carex lenticularis Michx. Locally common in wet areas at middle elevations. 412.

Carex microptera Mackenzie. Smallwing Sedge. Meadows and streamside at middle elevations. 413.

Carex nebrascensis Dewey. Nebraska Sedge. Common; streamside at low to middle elevatons. 440.

Carex nova Bailey. Collected only from edge of South Willow Lake. Taye & Wall 724.

Carex pachystachya Cham. Chamisso Sedge. Collected only from cirque in Dry Lake Fork. 288 (UT and UTC).

Carex petasata Dewey. Collected only from an open, mesic mid-elevation slope in Davenport Canyon. 517.

Carex phaeocephala Piper. Dunhead Sedge. Locally common in subalpine meadows. 703.

Carex praegracilis W. Boott. Collected only from streamside in Davenport Canyon. 424.

Carex raynoldsii Dewey. Raynold's Sedge. Locally common in meadows and along streams at middle elevations. 552.

Carex rossii F. Boott. Ross Sedge. Conifer understory and meadows from middle elevations to subalpine. 705.

Carex vallicola Dewey. Valley Sedge. Meadows and open forest understory from middle elevations to subalpine. 580.

Eleocharis palustris (L.) R. & S. Common Spikerush. [*E. macrostachya* Britt.] Locally common in wet places from the valleys to middle elevations. 906.

Eleocharis rostellata (Torr.) Torr. Beaked Spikerush. Locally common near streams in the foothills. 823.

Scirpus acutus Muhl. Hardstem Bulrush. Wet places at low elevations. 827.

Scirpus maritimus L. Alkali Bulrush. Rare; pond in Skull Valley. 1272.

Scirpus pungens Vahl. Common Three-square. Seen only near stream at Condie Meadows. 851.

Iridaceae

Iris missouriensis Nutt. Western Iris. Rare; near spring in Skull Valley. 1374.

Sisyrinchium idahoense Bickn. Idaho Blue-eyed Grass. Rare; near springs and streams at low elevations. 847.

Juncaceae

Juncus arcticus Willd. Wiregrass. [*J. balticus* Willd.] Common; wet places at low elevations. 423.

Juncus articulatus L. Jointed Rush. Rare; streamside at mouth of South Willow Canyon. 907.

Juncus bufonius L. Toad Rush. Infrequent; streamside at low to middle elevations. 1129.

Juncus ensifolius Wikstr. var. *brunnescens* (Rydb.) Cronq. Locally common along streams at low elevations. 416.

Juncus ensifolius Wikstr. var. *ensifolius.* Collected only from streamside in South Willow Canyon. 218 (UT and UTC).

Juncus ensifolius Wikstr. var. *montanus* (Engelm.) C. L. Hitchc. Streamside at middle elevations. 1045.

Juncus longistylis Torr. Longstyle Rush. Locally common in meadows and along streams in the foothills. 822.

Juncus torreyi Cov. Torrey Rush. Infrequent; locally abundant in wet places at low elevations. 684.

Luzula spicata (L.) DC. Spike Woodrush. Infrequent; locally common in meadows and on rocky slopes from subalpine to alpine. 967.

Juncaginaceae

Triglochin maritima L. Shore Arrowgrass. Rare; wet area in foothills at Condie Meadows. 819.

Liliaceae

Allium acuminatum Hook. Tapertip Onion. Common; dry slopes and open forest understory from the valleys to middle elevations. 603.

Allium nevadense Wats. Nevada Onion. Infrequent; valleys and foothills. Taye & Kass 1324.

Calochortus nuttallii T. & G. Sego Lily. Common; open slopes from the valleys to subalpine. 476. The state flower of Utah.

Disporum trachycarpum (Wats.) Benth. & Hook. Fairy Bells. Infrequent; forest understory at middle elevations. 1182.

Erythronium grandiflorum Pursh. Glacier Lily. Common; moist slopes from low to middle elevations in springtime. 873.

Fritillaria atropurpurea Nutt. Leopard Lily. Open slopes from middle elevations to near timberline. 961.

Fritillaria pudica (Pursh) Spreng. Yellow Bell. Locally common in springtime on moist slopes. 380.

Smilacina stellata (L.) Desf. Starry Solomon-plume. Low to middle elevations in open forest understory and along streams. 817.

Veratrum californicum Dur. False Hellebore. Infrequent; locally common in wet places from middle elevations to subalpine. 242 (UT and UTC).

Zigadenus elegans Pursh. Mountain Death Camas. Infrequent; subalpine meadows and open conifer understory near timberline. 654.

Zigadenus paniculatus (Nutt.) Wats. Foothill Death Camas. Common; dry, mostly open slopes from the valleys to middle elevations. 553.

Orchidaceae

Corallorhiza striata Lindl. Striped Coralroot. Infrequent; dense conifer forest at middle elevations. 1059.

Goodyera oblongifolia Raf. Rattlesnake Plantain. Rare; rich understory of conifer-deciduous forest in South Willow Canyon. 264 (UT).

Habenaria dilatata (Pursh) Hook. White Bog Orchid. Rare; wet area below South Willow Lake. Taye & Wall. 722.

Habenaria unalescensis (Spreng.) Wats. Alaska Rein Orchid. Rare; near springs and in aspen understory at middle elevations. 1060.

Poaceae

°*Agropyron cristatum* (L.) Gaertn. Crested Wheatgrass. Common; disturbed areas and a dominant in portions of the valleys. 97 (UT and UTC).

Agropyron dasystachyum (Hook.) Scribn. Thickspike Wheatgrass. Infrequent; sandy areas at low elevations. 831.

°*Agropyron elongatum* (Host) Beauv. Tall Wheatgrass. Locally common in disturbed areas at low elevations. 639.

°*Agropyron intermedium* (Host) Beauv. Intermediate Wheatgrass. Locally common in disturbed areas at low elevations. 629.

Agropyron smithii Rydb. Western Wheatgrass. Collected only from a sandy area in a juniper community. 638.

Agropyron spicatum (Pursh) Scribn. & Smith. Bluebunch Wheatgrass. Common; dry slopes from the foothills to middle elevations. 470.

Agropyron trachycaulum (Link) Malte. Slender Wheatgrass. Common; streamside, and on open and wooded slopes from middle elevations to alpine. 609.

Agrostis exarata Trin. Spike Redtop. Frequent; wet places from the foothills to subalpine. 1125a.

°*Agrostis stolonifera* L. Redtop Bentgrass. Common; streamside from low to middle elevations. 734.

°*Alopercurus pratensis* L. Meadow Foxtail. Rare; pasture near guard station in South Willow Canyon. 1063.

Aristida purpurea Nutt. Three-awn. [*A. longiseta* Steud.] Infrequent; valleys and foothills. 601.

°*Arrhenatherum elatius* (L.) Presl. Tall Oatgrass. Rare; pasture near guard station in South Willow Canyon. 640 (UTC).

°*Bromus brizaeformis* Fisch. & Mey. Rattlesnake Chess. Rare; pasture near guard station in South Willow Canyon. 94 (UT and UTC).

Bromus carinatus H. & A. California Brome. [*B. marginatus* Nees; *B. polyanthus* Scribn.] Common; streamside and open to wooded slopes from middle elevations to subalpine. 646.

Bromus ciliatus L. Fringed Brome. Infrequent; open woods and meadows at middle elevations. 709.

°*Bromus commutatus* Schrad. Hairy Chess. Seen only near streamside at mouth of South Willow Canyon. 1053.

°*Bromus inermis* Leys. Smooth Brome. Disturbed sites at low elevations. 103 (UT and UTC).

°*Bromus japonicus* Thunb. Japonese Chess. Disturbed sites at low elevations. 1398.

°*Bromus tectorum* L. Cheatgrass. Common; a dominant species in disturbed areas, also occurring in undisturbed areas. 434.

Catabrosa aquatica (L.) Beauv. Brookgrass. Frequent; wet places from the foothills to subalpine. 908.

Cinna latifolia (Trev.) Griseb. Drooping Woodreed. Common; streamside at middle elevations. 238.

°*Dactylis glomerata* L. Orchard Grass. Common; streamside and open forest understory from the foothills to middle elevations. 60 (UT and UTC).

Danthonia intermedia Vasey. Timber Oatgrass. Rare; locally common in a cirque meadow in Dry Lake Fork. 352 (UT and UTC).

Distichlis spicata (L.) Greene. Saltgrass. Locally common in the valleys. 1120.

Echinochloa crusgalli (L.) Beauv. Barnyard Grass. Rare; streamside at mouth of Spring Canyon. 1124.

Elymus cinereus Scribn. & Merr. Great Basin Wildrye. Common; valleys to middle elevations, often in dry drainage bottoms. 1223.

Elymus flavescens Scribn. & Smith. Yellow Wildrye. Infrequent; locally common in sandy areas of Skull Valley and nearby foothills. 637.

Elymus glaucus Buckl. Blue Wildrye. Streamside and open forest understory at middle elevations. 1260.

°*Elymus junceus* Fisch. Russian Wildrye. Infrequent; disturbed sites at low elevations. 861.

Elymus triticoides Buckl. Creeping Wildrye. Rare; near spring in Skull Valley. 1380.

°*Festuca arundinacea* Schreb. Reed Fescue. Seen only at streamside in Davenport Canyon. 518.

Festuca ovina L. var. *brevifolia* (R. Br.) Wats. Alpine Fescue. Frequent; meadows and rocky slopes above 2800 m. 581.

Glyceria striata (Lam.) Hitchc. Fowl Mannagrass. Frequent; wet places at middle elevations. 441.

Hilaria jamesii (Torr.) Benth. Galleta. Infrequent; dry slopes at low elevations. 910.

Hordeum brachyantherum Nevski. Meadow Barley. Infrequent; wet places at low to medium elevations. 340 (UT).

Hordeum jubatum L. Foxtail Barley. Frequent; mostly in disturbed sites at low elevations. 591.

°*Hordeum murinum* L. Infrequent; disturbed sites at low elevations. 905.

Leucopoa kingii (Wats.) W. A. Weber. Spikegrass. [*Hesperochloa kingii* (Wats.) Rydb.] Common; dry meadows and rocky slopes from middle elevations to alpine. 450.

°*Lolium multiflorum* Lam. Italian Ryegrass. Rare; pasture near guard station in South Willow Canyon. 112 (UT).

Melica bulbosa Geyer. Oniongrass. Locally frequent on open slopes at middle elevations. 607.

Muhlenbergia asperifolia (Nees & Meyen) Parodi. Scratchgrass Muhly. Rare; streamside at Condie Meadows. 1093.

Oryzopsis hymenoides (R. & S.) Ricker. Indian Ricegrass. Common; dry slopes from the foothills to middle elevations. 1032.

Phleum alpinum L. Alpine Timothy. Infrequent; moist subalpine sites. Taye & Wall 1178.

°*Phleum pratense* L. Timothy. Collected only from streamside in South Willow Canyon. 268 (UT).

Phragmites australis (Cav.) Trin. Common Reed. [*P. communis* Trin.] Infrequent; valleys and foothills near springs. 1134.

Poa ampla Merr. Big Bluegrass. Collected only from streamside in South Willow Canyon. 114 (UT and UTC).

°*Poa annua* L. Annual Bluegrass. Seen only at streamside in South Willow Canyon. 415 (UT and UTC).

°*Poa bulbosa* L. Bulbous Bluegrass. Infrequent; disturbed sites at low elevations. 397 (UTC).

Poa canbyi (Scribn.) Howell. Canby Bluegrass. Collected only from mouth of Davenport Canyon. 24 (UT).

°*Poa compressa* L. Canada Bluegrass. Rare; streamside in the foothills. 1127.

Poa fendleriana (Steud.) Vasey. Mutton Grass. Common; dry meadows and mostly open slopes from middle elevations to alpine. 451.

Poa leptocoma Trin. Bog Bluegrass. Mesic slopes and meadows from middle elevations to subalpine. Taye & Wall 1175.

Poa nervosa (Hook.) Vasey. Wheeler Bluegrass. Frequent; open forest understory and meadows from middle elevations to subalpine. 989.

°*Poa pratensis* L. Kentucky Bluegrass. Frequent; disturbed to pristine, generally mesic sites from the foothills to subalpine. 695 (UTC).

Poa reflexa Vasey & Scribn. Nodding Bluegrass. Locally common in subalpine meadows. 1253.

Poa secunda Presl. Sandberg Bluegrass. [*P. sandbergii* Vasey] Common; open slopes from the valleys to alpine. Arnow (1981) cites *P. secunda* as being the correct name for this species.

°*Polypogon monspeliensis* (L.) Desf. Rabbitfoot Grass. Frequent; streamside at low elevations. 685.

°*Puccinellia distans* (L.) Parl. European Alkaligrass. Rare; streamside at middle elevations. 643.

°*Puccinellia fasiculata* (Torr.) Bickn. Alkaligrass. Locally common at Big Spring in Skull Valley. 1373.

°*Secale cereale* L. Rye. Infrequent; valley benches (cultivated) and occasionally higher. 598.

Sitanion hystrix (Nutt.) Smith. Squirreltail. Common; dry, mostly open slopes from the foothills to alpine. 499.

Sphenopholis obtusata (Michx.) Scribn. Prairie Wedgescale. Rare; streamside near mouth of Spring Canyon. 1125b.

Sporobolus airoides (Torr.) Torr. Alkali Sacaton. Infrequent; valleys and foothills. 1023.

Sporobolus cryptandrus (Torr.) Gray. Sand Dropseed. Frequent; valleys and foothills, usually in sandy areas. 549.

Stipa comata Trin. & Rupr. Needle-and-Thread Grass. Frequent; valleys and foothills in sandy areas. 844.

Stipa lettermannii Vasey. Letterman Needlegrass. Rare; cirque meadow in Dry Lake Fork. 351 (UT and UTC).

Stipa nelsonii Scribn. Columbia Needlegrass. [*S. columbiana* Macoun] Frequent; meadows and mostly open slopes from middle elevations to subalpine. 1113.

Trisetum spicatum (L.) Richter. Spike Trisetum. Common; meadows, streamside, and open forest understory from middle elevations to alpine. 582.

°*Triticum aestivum* L. Wheat. Locally common (cultivated) at mouth of East Hickman Canyon. 599 (UTC).

°*Vulpia myuros* (L.) C. C. Gmelin. Foxtail Fescue. [*Festuca myuros* L.] Rare; streamside near mouth of Spring Canyon. 1138.

Vulpia octoflora (Walt.) Rydb. Six-weeks Fescue. [*Festuca octoflora* Walt.] Infrequent; valleys and foothills, usually in sandy areas. 808.

Ruppiaceae

Ruppia maritima L. Widgeongrass. Locally common in Big Spring in Skull Valley. 1401.

Typhaceae

Typha latifolia L. Common Cattail. Infrequent; streamside in the foothills. 1145.

Zannichelliaceae

Zannichellia palustris L. Horned Pondweed. Rare; in ponds and streams at low elevations. 1372.

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NEW SYNONYMY AND NEW SPECIES OF AMERICAN BARK BEETLES (COLEOPTERA: SCOLYTIDAE), PART IX

Stephen L. Wood[1]

ABSTRACT.— The following new synonymy in Scolytidae is proposed. *Acorthylus* Brèthes (= *Phacrylus* Schedl), *Amasa* Lea (= *Anaxyleborus* Wood), *Cryptocurus* Schedl (= *Hyloperus* Browne), *Hylesinopsis* Eggers (= *Trypographus* Schedl, *Chilodendron* Schedl), *Hypothenemus* Westwood (= *Stylotentus* Schedl), *Metahylesinus* Eggers (= *Glochicopterus* Schedl), *Phloeotribus* Latreille (= *Neophloeotribus* Eggers), *Pityophthorus* Eichhoff (= *Hypopityopthorus* Bright), *Scolytoplatypus* Schaufuss (= *Spongocerus Blandford*, *Taeniocerus* Blandford, *Strophionocerus* Sampson), *Scolytus* Geoffroy (= *Confusoscolytus* Tsai & Hwang), *Styracoptinus* Wood (= *Afrotrypetus* Bright), *Sueus* Murayama (= *Neohyorrhynchus* Schedl), *Taphrorychus* Eichhoff (= *Pseudopoecilips* Murayama), *Webbia* Hopkins (= *Pseudowebbia* Browne), *Webbia dipterocarpi* Hopkins (= *Webbia 18-spinatus* Sampson), *Xyleborus* Eichhoff (= *Anaeretus* Dugès). A neotype is designated for *Anaeretus guanaguatensis* Dugès; this name becomes a junior synonym of *Xyleborus volvulus* (Fabricius). Species new to science are named from Mexico as follows: *Cactopinus atkinsoni, burjosi, granulatus, setosus, Carphobius pilifer, Chaetophloeus confinis, Chramesus exilis, exul, securus, tibialis, Cnemonyx equihuai, evidens, Cnesinus cornutus, nebulosus, parvicornis, Dendrosinus mexicanus, Liparthrum mexicanum, pruni, Phloeotribus geminus, Pycnarthrum amersum, Scolytodes plumericolens, retifer.*

A review of the holotypes of the type-species of several obscure genera of Scolytidae has led to the detection of several previously unpublished or obscured synonyms. These are presented below in alphabetical order of the senior generic name. The synonymy of *Webbia dipterocarpi* Hopkins is included.

The continuing faunal survey of Mexico of Dr. T. H. Atkinson, Chapingo, Mexico, has resulted in the discovery of a number of species new to science. Twenty-two species found during that survey are presented below. They represent: *Cactopinus* (4), *Carphobius* (1), *Chaetophloeus* (1), *Chramesus* (4), *Cnemonyx* (2), *Cnesinus* (3), *Dendrosinus* (1), *Liparthrum* (2), *Phloeotribus* (1), *Pycnarthrum* (1), and *Scolytodes* (2).

New Synonymy

Acorthylus Brèthes

Acorthylus Brèthes, 1922, Ann. Soc. Cien. Argentina 94:304 (Type-species: *Acorthylus asperatus* Brèthes, monobasic)

Phacrylus Schedl, 1938, Rev. Soc. Ent. Argentina 10:24 (Type-species: *Phacrylus bosqui* Schedl). *New synonymy*

The Argentine species *Acorthylus asperatus* Brèthes has stood as an unidentifiable species since its description. However, the description clearly characterizes the 3-segmented antennal funicle with the middle segment enlarged and almost equal in length to the scape. Because no other genus shares this character and because the description of the type species matches in every detail those of Argentine species placed by Schedl in his *Phacrylus*, it must be concluded that *Phacrylus* is a junior synonym of *Acorthylus* as indicated above.

Amasa Lea

Amasa Lea, 1894, Proc. Linn. Soc. New South Wales (2) 8:322 (Type-species: *Amasa thoracicus* Lea = *Tomicus truncatus* Erichson, monobasic)

Anaxyleborus Wood, 1980, Great Basin Nat. 40:90 (Type-species: *Tomicus truncatus* Erichson, original designation). *New synonymy*

When the name *Anaxyleborus* Wood (1980) was proposed, I overlooked the synonymy (Lea, 1904, Linn. Soc. New South Wales 29:106) of the type-species, *Tomicus truncatus* Erichson, with *Amasa thoracicus* Lea. In view of this synonymy involving the type-species, *Anaxyleborus* automatically becomes a synonym of *Amasa*.

[1]Life Science Museum and Department of Zoology, Brigham Young University, Provo, Utah 84602.

Cryptocurus Schedl

Cryptocurus Schedl, 1957, Ann. Mag. Nat. Hist. (12) 10:869 (Type-species: *Cryptocurus spinipennis* Schedl, monobasic)

Hyloperus Browne, 1970, J. Nat. Hist. 4:546 (Type-species: *Hyloperus bicornis* Browne, original designation). *New synonymy*

The male holotype of *Cryptocurus spinipennis* Schedl and the female holotype of *Hyloperus bicornis* Browne were examined and compared directly to one another and to other members of this species. They represent opposite sexes of the same species. Consequently, *Hyloperus* becomes a junior synonym of the older name.

Hylesinopsis Eggers

Hylesinopsis Eggers, 1920, Ent. Blätt. 16:40 (Type-species: *Hylesinopsis dubius* Eggers, monobasic)

Trypographus Schedl, 1950, Rev. Francaise Ent. 17:213 (Type-species: *Trypographus joveri* Schedl, monobasic). *New synonymy*

Chilodendron Schedl, 1953, Mem. Inst. Sci. Madagascar (E) 3:74 (Type-species: *Chilodendron planicolle* Schedl, monobasic). *New synonymy*

When *Hylesinopsis* Eggers (1920), *Trypographus* Schedl (1950), and *Chilodendron* Schedl (1953) were named, there may have been some justification for the recognition of three genera. However, the subsequent discovery of additional species has closed the character gap used to distinguish them. I now see no justification for the recognition of more than one genus and place *Typographus* and *Chilodendron* in synonymy under *Hylesinopsis* as indicated above.

Hypothenemus Westwood

Hypothenemus Westwood, 1836, Trans. Ent. Soc. London 1:34 (Type-species: *Hypothenemus eruditus* Westwood, monobasic)

Stylotentus Schedl, 1939, Rev. Zool. Bot. Afr. 32:380 (Type-species: *Hypothenemus concolor* Hagedorn, subsequent designation by Schedl, 1961, Rev. Ent. Moçambique 4:448). *New synonymy*

Schedl (1936:380) established the genus *Stylotentus* on the basis of a peculiarity in the antennal club and funicle. The club appears to have fused with funicular segments 4 and 5; funicular segments 1–3 are normal. The funicle in *Hypothenemus* is unstable, varying from three to five segments. Parital fusion of segments is a common feature, and occasionally the left and right antennae will bear different numbers of segments. Of the three specimens of *concolor* Hagedorn in my collection, the funicle of one is 5-segmented, one 3-segmented, and one 2-segmented (all four flagellar segments are fused). Two of the three specimens of *ater* (Eggers), also assigned by Schedl to *Stylotentus*, have the funicle 4-segmented. In view of the instability of this character in these species, and the variability of funicular segmentation in other *Hypothenemus*, *Stylotentus* is placed in synonymy under the senior name *Hypothenemus*.

Metahylesinus Eggers

Metahylesinus Eggers, 1922, Ent. Blätt. 18:165 (Type-species: *Pseudohylesinus togonus* Eggers, automatic)

Glochicopterus Schedl, 1954, Rev. Zool. Bot. Afr. 50:75 (Type-species: *Glochicopterus baphiae* Schedl, monobasic). *New synonymy*

Following a study of *Metahylesinus togonus* (Eggers), of five other species currently assigned to *Metahylesinus* Eggers, and of *Glochicopterus baphiae* Schedl, I am unable to detect characters that separate these species into distinct genera. For this reason, *Glochicopterus* is placed in synonymy as indicated above.

Phloeotribus Latreille

Phloeotribus Latreille, 1797, Prec. caract. gen. insects, p. 50 (Type-species: *Hylesinus oleae* Fabricius = *Scolytus scarabaeoides* Bernard, monobasic)

Neophloeotribus Eggers, 1943, Mitt. Münchner Ent. Ges. 33:349 (Type-species: *Phloeotribus nubilus* Blandford, present designation). *New synonymy*

Eggers (1943) proposed the subgeneric name *Neophloeotribus* for a group of species that included *Phloeotribus nubilus* Blandford and *Phloeotribus suturalis* Eggers. I designate *Phloeotribus nubilus* Blandford as the type-species of *Neophloeotribus*. At the present time, I see no need to subdivide *Phloeotribus* and therefore place *Neophloeotribus* in synonymy as indicated above.

Pityophthorus Eichhoff

Pityophthorus Eichhoff, 1864, Berliner Ent. Zeitschr. 8:39 (Type-species: *Bostrichus lichtensteini* Ratzeburg)

Hypopityophthorus Bright, 1981, Mem. Ent. Soc. Canada 118:14 (Type-species: *Pityophthorus inops* Wood). *New synonymy*

Bright (1981) established the subgenus *Hypopityophthorus* on the basis of degenerate sutures in the antennal club. The characters are exactly the same as those used by Blackman to characterize *Pityophthoroides*. Neotropical *Pityophthorus* exhibit varying degrees of suture deterioration on an antennal club that increases in thickness. The trend is gradual and is best seen in the smallest species. Because *Hypopityophthorus* was proposed for the same group as *Pityophthoroides*, which is no more than a species group of indefinite extent, it is placed in synonymy under *Pityophthorus*.

Scolytoplatypus Schaufuss

Scolytoplatypus Schaufuss, 1890, Beitrag zur Käferfauna Madagascars 2:31 (Type-species: *Scolytoplatypus permirus* Schaufuss, monobasic)

Spongocerus Blandford, 1893, Trans. Ent. Soc. London 1893:431 (Type-species: *Scolytoplatypus tycon* Blandford, subsequent designation by Hopkins, 1914, Proc. U.S. Nat. Mus. 48:129). *New synonymy*

Taeniocerus Blandford, 1893, Trans. Ent. Soc. London 1893:431 (Type-species: *Scolytoplatypus mikado* Blandford, subsequent designation by Hopkins, 1914, Proc. U.S. Nat. Mus. 48:431). Preoccupied by Kamp 1871

Strophionocerus Sampson, 1921, Ann. Mag. Nat. Hist. (9) 7:36. (Replacement name for *Taeniocerus* Blandford). *New synonymy*

Blandford (1893) proposed for the genus *Scolytoplatypus* Schaufuss the subgeneric names *Spongocerus* and *Taeniocerus*. The latter name was a homonym that was replaced by *Strophionocerus*. These names were unnecessary in the classification of the genus and have been ignored by subsequent workers treating the genus. Attention is called to them for the purpose of placing them in synonymy as indicated above.

Scolytus Geoffroy

Scolytus Geoffroy, 1762, Histoire abrégée des insects, p. 309 (Type-species: *Bostrichus scolytus* Fabricius, subsequent designation by International Commission on Zoological Nomenclature)

Archaeoscolytus Butovitsch, 1929, Stettiner Ent. Zeit. 90:21, 23 (Species group name for *Scolytus claviger* Blandford). *No status*

Spinuloscolytus Butovitsch, 1929 Stettiner Ent. Zeit. 90:21, 24 (Species group name for *Ips multistriatus* Marsham, *Scolytus orientalis* Eggers, *Scolytus ecksteini* Butovitsch). *No status*

Tuboloscolytus Butovitsch, 1929, Stettiner Ent. Zeit. 90:21, 24 (Species group name for *Eccoptogaster intricatus*, *Eccoptogaster carpini* Ratzeburg, *Scolytus koenigi* Schevyrew). *No status*

Pygmaeoscolytus Butovitsch, 1929, Stettiner Ent. Zeit. 90:21, 28 (Species group name for *Scolytus kirschi* Skalitzky, *Scolytus fasciatus* Reitter, *Bostricnus pygmaeus* Fabricius, *Scolytus ensifer* Eichhoff, *Scolytus zaitzevi* Butovitsch). *No status*

Pinetoscolytus Butovitsch, 1929, Stettiner Ent. Zeit. 90:22, 48 (Species group name for *Scolytus morawitzi* Semenov). *No status*

Confusoscolytus Tsai & Hwang, 1962, Acta Ent. Sinica 11:4, 14 (Type-species: *Eccoptogaster confusus* Eggers). *New synonymy*

Several mononominal designations within the genus *Scolytus* Geoffroy have been published that have caused confusion in the literature treating Scolytidae. Five of these were published by Butovitsch (1929) in one paper, including *Archaeoscolytus*, *Spinuloscolytus*, *Tubuloscolytus*, *Pygmaeoscolytus*, and *Pinetoscolytus*, as species-group names. As such they have no status in nomenclature. They were not intended to be genus-group names and should not be cited as such.

The name *Confusoscolytus* Tsai & Hwang (1962) was presented as a subgenus of *Scolytus* and is of nomenclatural interest. However, because the *Scolytus* species of Europe, Asia, and North America are not divisible into recognizable subgenera, *Confusoscolytus* has value no greater than a species-group and, therefore, must be treated as a synonym of *Scolytus*.

Styracoptinus Wood

Styracoptinus Wood, 1962, Great Basin Nat. 22:77 (Replacement name for *Styracopterus* Blandford, preoccupied, Type-species: *Styracopterus murex* Blandford, automatic)

Afrotrypetus Bright, 1981, Coleopt. Bull. 35:113 (Type-species: *Afrotrypetus euphorbiae* Bright, original designation. *New synonymy*

During a visit with Dr. K. E. Schedl in 1965, I showed him a pair of specimens from the same series Bright (1981) later named as *Afrotrypetus euphorbiae*. We agreed that the species represented *Styracoptinus*. He had a vague recollection of having named it in another genus from a unique specimen that was deposited in another collection. Since then, other *Styracoptinus* have been named that more fully bridge the gap between *murex* and *euphorbiae*. For this reason *Afrotrypetus* must become a junior synonym of *Styracoptinus*.

Sueus Murayama

Sueus Murayama, 1951, Bull. Facul. Agric. Yamaguti Univ. 2:1 (Type-species: *Sueus sphaerotrypoides* Murayama = *Hyorrhynchus niisimai* Eggers, original designation)

Neohyorrhynchus Schedl, 1962, Ent. Blätt. 58:202 (Type-species: *Hyorrhynchus niisimai* Eggers, monobasic). *New synonymy*

The female holotypes of *Sueus sphaerotrypoides* Murayama and *Hyorrhynchus niisimai* Eggers were examined and compared directly to my specimens. Because they represent the same species, *Neohyorrhynchus* Schedl becomes an objective junior synonym of the older name.

Taphrorychus Eichhoff

Taphrorychus Eichhoff, 1878, preprint of Mem. Soc. Roy. Sci. Liége (2) 8:49, 204 (Type-species: *Bostrichus bicolor* Herbst, subsequent designation by Hopkins, 1914, Proc. U.S. Nat. Mus. 43:130)

Pseudopoecilips Murayama, 1957, Bull, Facul. Agric. Yamaguti Univ. 8:614 (Type-species: *Pseudopoecilips mikuniyamensis* Murayama, original designation). *New synonymy*

Following my examination of authentic specimens of all species currently assigned to *Taphrorychus* Eichhoff and of the three species of *Pseudopoecilips* named by Murayama, it was concluded that *Pseudopoecilips* fits well within the anatomical and biological limits of *Taphrorychus*. Accordingly, *Pseudopoecilips* is placed in synonymy under *Taphrorychus* as indicated above.

Webbia Hopkins

Webbia Hopkins, 1915, U.S. Department of Agriculture Bur. Ent. Tech Bull. 17(2):222 (Type-species: *Webbia dipterocarpi* Hopkins, original designation)

Pseudowebbia Browne, 1961, Sarawak Mus. J. 10:308 (Type-species: *Xyleborus trepanicauda* Eggers, original designation). *New synonymy*

In my review of the status of the genera of Scolytidae, the type specimens of the type species of *Webbia* Hopkins (*W. dipterocarpi* Hopkins) and *Pseudowebbia* Browne (*Xyleborus trepanicauda* Eggers) were examined along with almost all the other species in these genera. It is apparent that *dipterocarpi* and *trepanicauda* both represent the same species group within the genus. For this reason, the junior name, *Pseudowebbia*, must be placed in synonymy.

Webbia dipterocarpi Hopkins

Webbia dipterocarpi Hopkins, 1915, U.S. Department of Agriculture Bur. Ent. Tech Bull. 17(2):223 (Holotype, female; near Pagbilao, Philippine Islands; U.S. Nat. Mus.)

Webbia 18-spinatus Sampson, 1921, Ann. Mag. Nat. Hist. (9)7:34 (Holotype, female; Penang, Bryant; British Mus. Nat. His.). *New synonymy*

The female holotypes of *Webbia dipterocarpi* Hopkins and *Webbia 18-spinatus* Sampson were both compared directly to my specimens from the Philippines and Malaya. Because they are identical in all respects, it is concluded that they represent the same species. For this reason, *18-spinatus* is placed in synonymy as indicated above.

Xyleborus Eichhoff

Xyleborus Eichhoff, 1864, Berliner Ent. Zeitschr. 8:37 (Type-species: *Bostrichus monographus* Fabricius, subsequent designation by Lacardaire, 1866, Hist. Gen. Coleopt. 7:381)

Anaeretus Dugès, 1887, Ann. Soc. Ent. Belgique 31:141 (Type-species: *Anaeretus guanaguatensis* Dugès = *Bostrichus volvulus* Fabricius). *New synonymy*

The genus *Anaeretus* Dugès was established for *guanaguatensis* Dugès and based on specimens deposited in the Museo Nacional de Historia Natural at Mexico City. The major portion of the Dugès collection was later moved to the Universidad Nacional Autonoma de Mexico, also in Mexico City. Two unsuccessful searches were conducted for the types of *Anaeretus guanaguatensis*, first in 1974 by me, the second by W. F. Barr in February 1982. The specimens could not be found and are presumed to be lost.

From the rather complete description of *guanaguatensis*, it is apparent that the type series was of either *Xyleborus volvulus* (Fabricius) or, possibly, *X. affinis* Eichhoff, both of which are common throughout Mexico except for the very dry northern areas. In order to remove ambiguity from the placement of *Anaeretus* in the classification of Scolytidae, I here designate as the neotype of *Anaeretus guanaguatensis* Dugès the female lectotype of *Xyleborus volvulus* (Fabricius) that is in the Copenhagen museum.

CORRECTION

Cnesinus equihuai Wood, emendation

Cnesinus aquihuai Wood, 1982, Great Basin Nat. 42:226 (Holotype, female; between Cuetzalan and Pasa del Jardin, Puebla, Mexico; Wood Collection).

Lapsus calmi

A proofreading error occurred in the original spelling of the specific name of this species and in references to the name of the collector. Armando Equihua has been an enthusiastic student of the Scolytidae and an ardent collector of numerous rare forms, many of which have been named as new to science.

New Taxa

Cactopinus atkinsoni, n. sp.

This species is distinguished from *nausutus* Wood by the smaller size, by the less deeply excavated male frons with the upper margin more rounded, and by the steeper lower declivity.

Male.— Length 1.3 mm (paratypes 1.3–1.5 mm), 2.4 times as long as wide; color black.

Frons similar to *nausutus* except upper area of frons not as widely or as deeply excavated, upper margin much less acute; horn averaging smaller.

Pronotum as in *nausutus*.

Elytra as in *nausutus* except declivity steeper, more narrowly sulcate.

Female.— Similar to male except frons about as in female *nausutus*.

Type locality.— Estación de Biología, Chamela, Jalisco, Mexico.

Type material.— The male holotype, female allotype, and 18 paratypes were taken at the type locality on 28–V–1982, 80 m, S-497, *Pachycerus*, T. H. Atkinson and A. Equihua.

The holotype, allotype, and paratypes are in my collection.

Cactopinus burjosi, n. sp.

This species is distinguished from *niger* Wood by the less distinctly concave male frons, by the larger strial punctures, by the presence of interstrial tubercles, and by the very different declivity as described below.

Male.— Length 1.5 mm (paratypes 1.5–1.6 mm), 2.3 times as long as wide; color black.

Frons largely hidden by pronotum, impression apparently limited, if present; horns basally contiguous and of about same size and form as *cactophthorus* Wood. Antennal club small, sutures weakly procurved, almost straight.

Pronotum about as in *niger* except asperities and tubercles in lateral areas larger.

Elytra 1.4 times as long as wide; sides almost straight and parallel on basal two-thirds, rather narrowly rounded behind; striae 1 weakly, others not impressed, punctures very coarse, deep, and poorly formed on basal half, decreasing posteriorly until obsolete by base of declivity, small granules between punctures on posterior half of disc gradually replace punctures posteriorly; interstriae about half as wide as striae, irregular, each armed by a uniseriate row of small tubercules except basal half of even-numbered interstriae indistinctly punctured. Declivity occupying posterior third, less abrupt and less strongly sulcate than in related species; striae and interstriae marked by small, acutely rounded tubercles, except on lower third of sulcus only obscure strial punctures indicated. Vestiture of sparse, confused, minute hairlike setae.

Female.— Similar to male except frons similar to females of related species.

Type locality.— Tepenene, Puebla, Mexico.

Type material.— The male holotype, female allotype, and two paratypes were taken on 1–X–1982, 1240 m, B–070, *Neobuxbaumia mezealensis*, A. Burjos and E. Saucedo.

The holotype, allotype, and paratypes are in my collection.

Cactopinus granulatus, n. sp.

This species is distinguished from *nausutus* Wood by the smaller pronotal asperities and by the presence of discal tubercles on the striae and interstriae.

Male.— Length 1.7 mm (paratypes 1.6–1.8 mm), 2.3 times as long as wide; color black.

Frons as in *nausutus* except excavated area not quite as wide above eyes.

Pronotum as in *nausutus* except asperities distinctly smaller.

Elytra about as in *nausutus* except strial punctures larger, deeper; interstriae irregular on basal half, posterior half armed by irregularly placed small tubercles, a few similar tubercles on striae between punctures. Declivity similar to *nausutus*, strial punctures continue to apex, strial and interstrial tubercles absent except on interstriae 1 and 3. Vestiture sparse, short, of fine interstrial hair.

Female.— Similar to male except frons as in female *nausutus.*

Type locality.— Autlan, carr. Barra de Navidad km 163, Jalisco, Mexico.

Type material.— The male holotype, female allotype, and eight paratypes were taken at the type locality on 3-VII-1982, S-751, Cactaceae, A. Equihua.

The holotype, allotype, and paratypes are in my collection.

Cactopinus setosus, n. sp.

This species is distinguished from *nausutus* Wood by the stout body form, by the smaller strial punctures, and by the rather abundant elytral vestiture.

Male.— Length 1.6 mm (paratypes 1.4–1.7 mm), 2.2 times as long as wide; color black.

Frons similar to *nausutus* except upper excavated area less strongly impressed; horn averaging slightly shorter, its apices usually blunt.

Pronotum similar to *nausutus* except asperities less numerous and smaller, median basal area more rounded and with fewer asperities.

Elytra similar to *nausutus* except declivity less strongly, more narrowly sulcate; discal surface largely obscured by incrustation, apparently strial punctures smaller, not as deep, interstriae smooth, uniseriate punctures small; a few small granules on odd-numbered interstriae toward declivity; declivital strial punctures larger and deeper than on disc. Vestiture of rows of rather coarse, erect interstrial setae, each seta very slightly longer than distance between rows or between setae within a row.

Female.— Similar to male except frons similar to female *nausutus.*

Type locality.— Estación de Biología, Chamela, Jalisco, Mexico.

Type material.— The male holotype, female allotype, and 13 paratypes were taken at the type locality on 28-V-1982, 80 m, S-498, Cactaceae, T. H. Atkinson and A. Equihua.

The holotype, allotype, and paratypes are in my collection.

Carphobius pilifer, n. sp.

This species is distinguished from *cupressi* Wood by the much more abundant, longer vestiture throughout the body, by the finer pronotal punctures, and by other characters cited below.

Female.— Length 2.9 mm (paratypes 2.8–3.0 mm), 2.3 times as long as wide; color very dark brown, elytra rather dark brown.

Frons as in *cupressi* except epistomal process more conspicuous, vestiture more abundant and much coarser.

Pronotum as in *cupressi* except punctures half as large, closer, not as deep; vestiture obscurely subplumose, appearing much coarser, longer, more abundant.

Elytra as in *cupressi* except declivity steeper, strial punctures smaller, interstriae wider, with punctures more numerous and confused, vestiture obscurely subplumose, longer, much more abundant.

Type locality.— Trés Marías, Morelos, Mexico.

Type material.— The female holotype and two female paratypes were taken at the type locality on 30-V-1982, 2790 m, B-029, *Cupressus lindleyi*, A. Burjos and E. Saucedo.

The holotype and paratypes are in my collection.

Chaetophloeus confinis, n. sp.

This species is distinguished from *struthanthi* Wood by the less strongly concave male frons, by the larger frontal granules in both sexes, and by the longer, more slender setae on the elytral declivity.

Male.— Length 1.7 mm (allotype 1.7 mm), 1.7 times as long as wide; color dark brown.

Frons shallowly concave to slightly above upper level of eyes; similar to *struthanthi* except concavity not as deep nor extending as high on vertex; long setae on upper margin shorter, not reaching middle of frons.

Pronotum as in *struthanthi* except vestiture distinctly longer, surface without any reticulation.

Elytra as in *struthanthi* except striae less distinctly impressed, punctures slightly larger, setae longer; longest setae at base of declivity six times as long as wide (in *struthanthi* not more than four times as long as wide.)

Female.— Similar to male except frons convex, frontal tubercles larger, frontal vestiture normal.

Type locality.— Cuernavaca, Morelos, Mexico.

Type material.— The male holotype was taken at the type locality on 28–VI–1982, 1500 m, AB-070 *Phoradendron*, by A. Burjos; the allotype from the same locality 4–VII–1982, 1519 m, SH–011, *Phoradendron* by E. Saucedo.

The holotype and allotype are in my collection.

Chramesus exilis, n. sp.

This species is distinguished from *gracilis* Wood by the smaller size, by the finer, more slender (but not longer) vestiture, by the more slender pronotum, and by the less strongly impressed male frons.

Male.— Length 1.7 mm (paratypes 1.6–1.8 mm), 2.3 times as long as wide, color very dark brown, vestiture pale.

Frons moderately, concavely impressed on median two-thirds of lower two-thirds; surface reticulate, punctures not clearly evident; tubercles smaller and vestiture finer than in *gracilis*.

Pronotum 0.94 times as long as wide; surface as in *gracilis* except granules more regularly present and vestiture finer.

Female.— Similar to male except frons convex, a slight transverse impression just above epistoma; frontal tubercles present, but smalller.

Type locality.— El Tuito, Jalisco, Mexico.

Type material.— The male holotype, female allotype, and 30 paratypes were taken at the type locality on 28–V–1982, 640 m, S–707, from *Smilax* by T. H. Atkinson and A. Equihua.

The holotype, allotype, and paratypes are in my collection.

Chramesus exul, n. sp.

This species is distinguished from *vitiosus* Wood by the absence of pronotal reticulation and by the punctured male striae. Although it superficially resembles *vitiosus*, its true relationships are probably much closer to *xylophagus* Wood.

Male.— Length 1.3 mm (paratypes 1.1–1.5 mm), 1.5 times as long as wide; color very dark brown, with pale vestiture.

Frons moderately, somewhat narrowly concave from epistoma to upper level of eyes, lateral margins weakly elevated, armed immediately below level of antennal insertion by a small tubercle; surface almost smooth, obscurely rugose-reticulate; vestiture fine, short, inconspicuous.

Pronotum resembling *xylophagus* except more strongly arched, punctures closer, smaller, and deeper; vestiture short, rather stout (each at least six times as long as wide), moderately abundant.

Elytra about as in *xylophagus* except setae in ground cover much stouter, erect setae of equal width and about twice as long as ground setae; each erect seta about three to four times as long as wide.

Female.— Similar to male except frons convex, lateral tubercles absent.

Type locality.— Nine km southeast of Totolapan, Oaxaca, Mexico.

Type material.— The male holotype, female allotype, and 10 paratypes were taken at the type locality, 21–VI–1967, 1000 m, No. 70, from an unidentified shrub, by me; 16 paratypes are from Estación de Biología, Chamela, Jalisco, 19–VIII–1982, 100 m, S–758, from a Leguminosae, by A. Equihua.

The holotype, allotype, and paratypes are in my collection.

Chramesus securus, n. sp.

This species is distinguished from *vitiosus* Wood by the smooth, shining surface of the pronotum (between the small tubercles), by the more strongly arched elytral declivity, and by the more slender, erect interstrial setae.

Male.— Length 1.5 mm (paratypes 1.5–1.7 mm), 1.5 times as long as wide; color dark reddish brown, vestiture pale.

Frons as in *vitiosus* except lateral margin at level of antennal insertion more strongly, acutely elevated, with tubercle slightly above level of antennal insertion.

Pronotum as in *vitiosus* except surface smooth, shining, punctures near median base very small.

Elytra as in *vitiosus* except declivity beginning at middle of elytra, more strongly arched, steeper, erect interstrial setae slightly stouter.

Female.— Similar to male except frons convex, its lateral margins unarmed by tubercles.

Type locality.— Estación de Biología, Chamela, Jalisco, Mexico.

Type material.— The male holotype, female allotype, and six paratypes were taken at the type locality on 4-III-1982, 100 m, S-365, from a Leguminosae, by A. Equihua.

The holotype, allotype, and paratypes are in my collection.

Chramesus tibialis, n. sp.

Although the *Scolytodes*-like protibia is unique in the genus, this species is somewhat remotely allied to *incomptus* Wood. This and other unique characters are described below.

Male.— Length 1.6 mm (paratypes 1.6-1.8 mm), 2.1 times as long as wide; color very dark brown to almost black.

Frons broadly, moderately concave from epistoma to slightly below upper level of eyes; lateral margins rather abrupt, neither acute nor armed, epistoma normal; surface shining, subreticulate at vertex, gradually becoming minutely subrugose toward epistoma. Vestiture fine, moderately long, mostly on margins.

Pronotum 0.91 times as long as wide; shape typical of genus; surface finely reticulate; median basal area with fine, shallow punctures, these replaced by small, rounded tubercles anteriorly and laterally. Vestiture of fine, slender hair.

Elytra 1.3 times as long as wide; sides almost straight and parallel on basal two-thirds, broadly rounded behind; striae not impressed, punctures shallow, small; interstriae smooth, shining, about three times as wide as striae, uniseriate punctures largely replaced by small granules. Declivity steep, rather narrowly convex; sculpture about as on disc except surface rather dull, granules smaller. Vestiture of minute strial hair and erect interstrial hairlike setae, each seta shorter than distance between rows.

Protibia with outer apical angle produced into dominant spine somewhat similar to *Scolytodes*, two minute socketed denticles on lateral margin above spine.

Female.— Similar to male except frons convex.

Type locality.— Urpanapan, Veracruz, Mexico.

Type material.— The male holotype, female allotype, and one male paratype were taken at Hidalgotitlan at the type locality, 27-IV-1982, S-442, from *Olmeca recta*, by T. H. Atkinson.

The holotype, allotype, and paratype are in my collection.

Cnemonyx equihuai, n. sp.

This species is distinguished from *liratus* Wood by the very different frons as described below, by the less deep, oval pronotal punctures, and by the somewhat more broadly flattened lower declivity.

Male.— Length 1.4 mm (paratypes 1.5 mm), 2.5 times as long as wide; color yellowish brown.

Frons convex except median third concavely impressed on triangular area from epistoma to upper level of eyes, concave area glabrous and reticulate except lateral margins with a row of rather fine, moderately long setae, lower margin of concavity marked by a low, straight, acute carina.

Pronotum about as in *liratus* except surface slightly shagreened, punctures oval, less strongly impressed.

Elytra similar to *liratus* except on disc striae less distinctly impressed, punctures not as close, declivity much more broadly convex on lower half, not as steep, tubercles similarly placed but averaging smaller, particularly in lateral areas; vestiture stouter, about half as long.

Female.— Similar to male except frontal impression very weak.

Type locality.— Km 150 carr. Melaque—Puerto Vallarta, Jalisco, Mexico.

Type material.— The male holotype, female allotype, and one male paratype were taken at the type locality on 6-III-1982, 300 m, S-383, *Hura polyandra*, A. Equihua.

The holotype, allotype, and paratype are in my collection.

Cnemonyx evidens, n. sp.

This species is distinguished from *vagabundus* Wood by the larger size, by the reticulate, more shallowly, more broadly impressed frons, by the more closely spaced interstrial punctures, and by the declivital sculpture.

Male.— Length 1.8 mm (paratypes 1.7–1.9 mm), 2.5 times as long as wide; color very dark reddish brown.

Frons very shallowly concave almost from eye to eye from epistoma to slightly above upper level of eyes; surface reticulate, punctures minute, obscure; epistoma shining, slightly elevated, a feeble, transverse carina on its lower margin; vestiture on median two-thirds of lower two-thirds except reduced to almost absent on and near median line, consisting of abundant, stout, erect setae, each slightly longer than distance equal to width of scape.

Pronotum similar to *vagabundus*, except punctures slightly smaller.

Elytra outline about as in *vagabundus;* striae weakly impressed toward declivity, punctures small, moderately deep; interstriae twice as wide as striae, feebly convex, almost smooth, shining, punctures fine, distinctly impressed, almost uniseriate, more closely spaced than those of striae. Declivity convex, rather steep; striae narrower and more deeply impressed than on disc, interstriae more strongly convex, 1 slightly, 7 and 9 more distinctly elevated, 7 and 9 joining and continuing almost to 1; punctures on all interstriae largely replaced by fine, pointed tubercles, costal margin near apex finely serrate. Vestiture almost obsolete, consisting of very minute, rather stout interstrial setae.

Female.— Similar to male except frontal impression slightly less extensive, frontal vestiture slightly less abundant.

Type locality.— Las Granjas, Morelos, Mexico.

Type material.— The male holotype, female allotype, and six paratypes were taken at the type locality on 8–VI–1982, in *Ficus*, by E. Martinez.

The holotype, allotype, and paratypes are in my collection.

Cnesinus cornutus, n. sp.

This species is distinguished from *bicornis* Wood by the smaller size, by the less extensively, less deeply impressed frons, and by very different armature of the epistoma.

Female.— Length 2.8 mm (paratypes 2.8–2.9 mm), 2.7 times as long as wide; color dark reddish brown.

Frons strongly, broadly impressed to upper level of eyes (otherwise about as in *bicornis*); epistoma on median fourth strongly elevated into an almost hornlike process, this process as high as wide and equal in length to combined width of four facets of eye, its apex armed by a pair of small, transversely arranged tubercles.

Pronotum about as in *bicornis* except grooves between longitudinal elevations on disc slightly wider and somewhat subreticulate.

Elytra as in *bicornis* except ground vestiture slightly finer and shorter, erect setae very slightly stouter.

Male.— Similar to female except epistomal armature absent; vestiture apparently slightly longer and more abundant.

Type locality.— San Tlatotico, Morelos, Mexico.

Type material.— The female holotype, male allotype, and four paratypes were taken at the type locality on 27 May 1982, 2110 m, S–675, from a Compositae, by A. Burjos and E. Saucedo.

The holotype, allotype, and paratypes are in my collection.

Cnesinus nebulosus, n. sp.

This species is distinguished from *carinatus* Wood by the very different female frons and sculpture of the pronotum as described below.

Female.— Length 2.4 mm (paratypes 2.4–2.7 mm), 2.3 times as long as wide; color dark reddish brown, vestiture pale except tan on declivity.

Frons similar to *carinatus* except weak carina poorly formed, area above carina broader and distinctly impressed, more coarsely, closely, uniformly punctured; vestiture longer, more uniformly distributed, less specialized; eyes separated by 2.0 times width of an eye.

Pronotum similar to *carinatus* except rugae higher, shorter, much more tortuous.

Elytra similar to *carinatus* except not impressed or sulcate on declivity, ground setae stouter, erect setae stouter and shorter, not longer on declivity and present on declivital interstriae 1 and 2; vestiture pale on the disc and sides, tan on declivity.

Male.— Similar to female except frons shallowly impressed on lower half, carina absent, frontal setae shorter.

Type locality.— Pachuca, Hidalgo, Mexico.

Type material.— The female holotype, male allotype, and one female paratype were taken at the type locality on 2 April 1982, 2400 m, S–463, by A. Equihua.

The holotype, allotype, and paratype are in my collection.

Cnesinus parvicornis, n. sp.

This species is distinguished from other members of the *elegans* group by the more extensive base and the more dorsal position of the epistomal tubercles, by the coarse, almost oval pronotal punctures, and by the uniformly rather short, almost scalelike elytral setae.

Female.— Length 2.8 mm (paratypes 2.8–3.3 mm), 2.3 times as long as wide; color reddish brown.

Frons moderately impressed on slightly more than lower half, impressed area partly filled by a low, triangular elevation arising on median half of episoma and extending dorsad almost to upper limits of impressed area; this elevated area armed by a pair of basally separate, small tubercles in a slightly more dorsal position than in related species; upper area convex, shining, impunctate in central area; vestiture of short, stout setae generally distributed except in upper impunctate area.

Pronotum 1.0 times as long as wide; surface smooth, shining, punctures rather coarse, elongate-oval, separated transversely by diameter of a puncture, longitudinally by one-fourth that distance; glabrous, except at margins.

Elytra 1.6 times as long as wide, 1.9 times as long as pronotum; sides straight and parallel on more than basal two-thirds, broadly rounded behind; striae narrowly impressed, punctures small, shallow, spaced by one and one-half diameters of a puncture; interstriae two to three times as wide as striae, weakly convex, almost smooth, shining, punctures almost uniseriate, rather small, their anterior margins weakly subcrenulate. Declivity steep, convex, except shallowly sulcate on lower half between interstriae 3; sculpture about as on disc except interstrial tubercles not evident. Vestiture of minute strial hair and erect interstrial setae, these one-ranked on interstriae 1, 3-ranked on others, middle rank pale tan and half as long as distance between rows and slightly longer than pale marginal rows; all setae of uniformly short length throughout.

Male.— Similar to female except frontal elevation feeble, tubercle absent.

Type locality.— Ruinas de Xochicalco, Morelos, Mexico.

Type material.— The female holotype, male allotype, and nine paratypes were taken at the type locality on 21 February 1982, 1200 m, S–323, by T. H. Atkinson and A. Equihua.

The holotype, allotype, and paratypes are in my collection.

Dendrosinus mexicanus, n. sp.

This species is distinguished from *globosus* Eichhoff by the shallowly concave, more coarsely punctured frons and by the much more coarsely, deeply punctured pronotum.

Male.— Length 3.5 mm (paratypes 3.0–3.9 mm), 2.3 times as long as wide; color black, with dark vestiture.

Frons very shallowly, broadly concave from epistoma to vertex; surface smooth, shining, and densely, rather coarsely punctured, except impunctate along epistomal margin and on median line on lower half; vestiture mostly pale, rather abundant, much longer than in *globosus*, setae equal in length to almost one-third distance between eyes. Antennal club slightly wider than in *globosus*.

Pronotum as in *globosus* except punctures distinctly larger and deeper and anterolateral areas always with two clusters of asperities (usually three in each cluster).

Elytra as in *globosus* except vestiture more slender.

Female.— Similar to male in all respects except for segmentation of abdominal terga.

Type locality.— Estación de Biología, Chamela, Jalisco, Mexico.

Type material.— The male holotype, female allotype, and six paratypes were taken on 5-III-1982, 60 m, S–372, by A. Equihua.

The holotype, allotype, and paratypes are in my collection.

Liparthrum mexicanum, n. sp.

This species is distinguished from *thevetiae* Wood by the presence of six crenulations on the base of each elytron, by the much more closely set interstrial scales, and by the more slender pronotum.

Male.— Length 0.9 mm (paratypes 0.9–1.0 mm), 2.4 times as long as wide; color brown.

Frons as in *thevetiae.*

Pronotum 0.9 times as long as wide; more narrowly rounded in front and asperities distinctly larger than in *thevetiae.*

Elytra 1.5 times as long as wide; about as in *thevetiae* except strial punctures more deeply impressed, interstrial scales shorter, wider, much closer, spaced within a row by length of a scale; slender interstrial setae as long as scales, usually alternating with them on disc but not on declivity.

Female.— Similar to male except pronotal asperities mostly reduced, those on anterior margin absent.

Type locality.— Cuernavaca, Morelos, Mexico.

Type material.— The male holotype and two paratypes were taken at the type locality on 27–X–1982, 1670 m, B–077, by A. Burjos and E. Saucedo. The allotype and three paratypes are from Jesu. Sta. Ma. Chihuappa, Tlaclizapan, Morelos, 3–XII–1982, 1000 m, B–122, by the same collectors.

The holotype, allotype, and paratypes are in my collection.

Liparthrum pruni, n. sp.

This species is distinguished from *albosetosum* (Bright) by the smaller, shallower strial punctures, by the shorter, stouter interstrial scales, and by other characters cited below.

Male.— Length 1.1 mm (paratypes 1.0–1.3 mm), 2.2 times as long as wide; color black.

Frons convex, about as in *albosetosum.*

Pronotum about as in *albosetosum* except more strongly convex, asperities distinctly larger.

Elytra about as in *albosetosum* except strial punctures much smaller, not as deep, interstrial setae shorter, each about as wide as long, spaced within a row by distances equal to about one and one-half times length of a scale.

Female.— Similar to male except pronotal asperities smaller.

Type locality.— Aranza, Michoacán, Mexico.

Type material.— The male holotype, female allotype, and 14 paratypes were taken at the type locality on 10–VII–1982, S–756, *Prunus serotina*, by A. Equihua.

The holotype, allotype, and paratypes are in my collection.

Ten specimens that probably belong to this species are from El Tuito, Jalisco, Mexico, 28–V–1982, 640 m, S–710, T. H. Atkinson and A. Equihua.

Phloeotribus geminus, n. sp.

This species is distinguished from *demissus* Blandford by the more coarsely punctured pronotum, with no granules on the disc, by the more slender pronotal and elytral vestiture, and, in the male, by the presence of a transverse, epistomal carina and a pair of small tubercles on the lateral margin of the frons at the level of the antennal insertion. The Acatlan series was erroneously reported as *demissus* in my monograph.

Male.— Length 2.1 mm (paratypes 1.7–2.1 mm), 2.0 times as long as wide; color very dark brown to almost black, vestiture pale.

Frons more narrowly but as deeply impressed as in *demissus,* impression ending slightly below upper level of eyes; epistoma armed on median third by a low, acute, transverse carina; lateral margins at level of antennal insertion armed by a pair of small tubercles as in many other species of this genus. Segments of antenna club much more strongly produced than in *demissus,* each about nine times as wide as long.

Pronotum as in *demissus* except surface smooth, shining, punctures larger, more sharply, more strongly impressed, with no granules on disc.

Elytra about as in *demissus* except interstrial granules smaller, interstriae 9 slightly more strongly, acutely elevated in declivital area, apical margin from level of striae 3 to suture more strongly serrate, vestiture slightly more slender and very slightly longer.

Female.— Similar to male except frons convex, tubercles absent; pronotal and elytral vestiture more slender.

Type locality.— Acatlan, Jalisco, Mexico.

Type material.— The male holotype, female allotype, and four paratypes were taken at the type locality 3-VII-1965, 1300 m, No. 158, from *Ficus*, by me. Eight paratypes are from Estación de Biología, Chamela, Jalisco, 1-VII-1982, 110 m, S-731, by A. Equihua.

The holotype, allotype, and paratypes are in my collection.

Pycnarthrum amersum, n. sp.

This species is distinguished from *brosimi* Wood by the larger size and stouter form, by the coarser vestiture, and by the evenly convex declivity.

Male.— Length 2.0 mm (paratypes 2.0-2.3 mm), 2.0 times as long as wide; color brown, vestiture pale.

Frons similar to *brosimi* except more strongly flattened over larger area; eyes separated by 1.8 times width of an eye (1.0 in *brosimi*).

Pronotum similar to *brosimi* except vestiture much coarser.

Elytra resembling *brosimi* except declivity convex, not impressed, interstriae without tubercles, erect interstrial bristles much stouter and strongly confused on 2, less confused on 3, minute ground setae stouter; discal striae 1 impressed, punctures on 1 and 2 slightly larger, deeper.

Female.— Similar to male except frons convex.

Type locality.— Tenacatita, Jalisco, Mexico.

Type material.— The male holotype, female allotype, and six paratypes were taken at the type locality on 4-II-1983, 40 m, S-883, *Brosimum alicastrum*, T. H. Atkinson and N. Bautista.

The holotype, allotype, and paratypes are in my collection.

Scolytodes plumericolens, n. sp.

This species is distinguished from *plumeriae* Wood by the smaller size, by the more slender body form, and by numerous other characters, some of which are treated below.

Female.— Length 1.5 mm (paratypes 1.5-1.7 mm), 2.3 times as long as wide; color almost black.

Frons resembling *plumeriae* except somewhat more strongly convex, surface punctured throughout (without an impunctate area), vestiture much less abundant, finer, ending well below upper level of eyes on a narrower area.

Pronotum 1.0 times as long as wide; surface uniformly reticulate, punctures conspicuously smaller than in *plumeriae*.

Elytra 1.4 times as long as wide; about as in *plumeriae* except minute interstrial punctures almost uniseriate; very minute, erect interstrial hair present.

Type locality.— Estación de Biología, Chamela, Jalisco, Mexico.

Type material.— The female holotype and two female paratypes were taken at the type locality on 2-VII-1982, 90 m, S-736, *Plumeria rubra*, A. Equihua.

The holotype and paratypes are in my collection.

Scolytodes retifer, n. sp.

This species is distinguished from *ficivorus* Wood by the larger size, by the reticulate elytra, and by the very different female frons as described below.

Female.— Length 2.0 mm (paratypes 1.8-2.2 mm), 2.2 times as long as wide; color brown to dark brown.

Frons flattened on an ovate area from eye to eye from epistoma to vertex (stronger and more extensive than in *ficivorus*); oval area on central third of lower half impunctate, glaborous, reticulate, remaining areas closely, finely punctured and setose; vestiture consisting of abundant, long, subplumose, yellow hair, longest setae equal in length to more than half distance between eyes.

Pronotum and elytra strongly reticulate, very similar to *reticulatus* Wood except all punctures much smaller and anterior margin of pronotum neither costate nor serrate. Subglabrous, a very few hairlike setae on odd-numbered interstriae.

Male.— Similar to female except frons convex, of uniform sculpture, setae sparse, inconspicuous.

Type locality.— Texeal, Mpiotepoztlan, Morelos, Mexico.

Type material.— The female holotype, male allotype, and eight paratypes were taken on 1-XI-1982, 1710 m, B-082, *Ceiba*, A. Burjos.

The holotype, allotype, and paratypes are in my collection.

PLANT COMMUNITY VARIABILITY ON A SMALL AREA IN SOUTHEASTERN MONTANA

James G. MacCracken[1,2], Daniel W. Uresk[3], and Richard M. Hansen[1]

Abstract.— Plant communities are inherently variable due to a number of environmental and biological forces. Canopy cover and aboveground biomass were determined for understory vegetation in plant communities of a prairie grassland—forest ecotone in southeastern Montana. Vegetation units were described using polar ordination and stepwise discriminant analysis. Nine of a total of 88 plant species encountered and cover of litter were the most useful variables in distinguishing among vegetation units on the study area and accounted for nearly 100 percent of the variation in the data. Seven vegetation units were different ($P < 0.05$) after all 10 variables had been entered into the analysis. Some plant communities were represented by two or three different vegetation units, indicating that some plant communities were variable and nonuniform in botanical composition over a relatively small area. This variability will influence management practices for these areas. Multiple-use management will benefit by recognition of inherent plant community variation.

Mueller-Dombois and Ellenberg (1972) defined plant communities as concrete definable units of vegetation that can be recognized and are obvious to the eye. Plant communities are often named after species that contribute to their unique structure or composition, or they are named after a unique environmental condition. Some examples from southeastern Montana include sagebrush-grassland, pine forest, and riparian communities. However, plant communities are variable and can be a mosaic of finer units of vegetation. Poore (1955) termed these vegetation abstractions *noda*, and they are presumably analagous to Whittaker's (1967) ecological groups.

The variability within plant communities at any time is due to a number of environmental and biological forces. Environmental influences include the geology of an area, soil communities, climate, solar radiation, and fire. Biological influences can be soil microbes, grazing animals, intra- and interspecific competition, genetics, successional patterns, and evolution. These forces create a dynamic process of vegetation patterning. Within a person's lifetime, however, plant communities are relatively stable, barring catastrophic events.

Variations within plant communities have long been recognized. Gleason (1926) stated that no two plant communities are exactly alike even though they contain the same species. Whittaker (1970) noted that plant communities are often less than discrete units, with no absolute boundaries among communities. Other plant ecologists have come to similar conclusions (Curtis and McIntosh 1950, Cottam 1949, Goodall 1953). Mueller-Dombois and Ellenberg (1972), however, suggested that plant communities can be individualists as well as continua. One aspect of current vegetaton ecology is the study of community variability and how that relates to the consequences of land management and the effects of human technology.

Plant community variability can create problems for land managers regardless of the source of variability. Successful management of vegetation for livestock grazing, wildlife habitat, water yield, soil conservation, etc., requires knowledge of plant community variability. Different vegetation units will not respond similarly to management. Practices recommended for one situation may be unsuccessful in another, even though the plant community appears to be the same. Many hectares of native rangeland are being manipulated primarily to increase the number of livestock supported, while still maintaining a viable ecosystem.

[1]Department of Range Science, Colorado State University, Fort Collins, Colorado 80523.
[2]Present address: University of Alaska, Agricultural Experiment Station, Palmer Research Center, P.O. Box AE, Palmer, Alaska 99645.
[3]USDA, Forest Service, Rocky Mountain Forest and Range Experiment Station, SDSM&T, Rapid City, South Dakota 57701.

Much rangeland in the western United States, including southeastern Montana, is without acceptably published information on vegetation characteristics. We believe that recent quantitative practices in plant ecology can and should be applied to management problems at the local level.

The purposes of this paper are (1) to present a method of assessing plant community variation, (2) to illustrate the variability within plant communities on a small study site, and (3) to identify potential consequences of plant community variation for management practices.

Study Area and Methods

The study was conducted on about 11,300 ha of rangelands along the northern edge of the Black Hills in southeastern Montana. The study area was immediately west of Alzada, Carter County. Elevation ranged from 1036 to 1128 m and average annual precipitation is approximately 37 cm.

Soils included alluvial clayey deposits in bottom areas and shale at higher elevations. Surface deposits of bentonite clay were numerous. Bentonic soils are characterized by a shallow A horizon and are saline or sodic (Bjugstad et al. 1981).

Most of the area was in private ownership and grazed by both sheep and cattle on a rest rotation system. Mule deer (*Odocoileus hemionus*), white-tailed deer (*O. virginianus*), and pronghorn (*Antilocapra americana*) were present on the study area.

Southeastern Montana is classified as a wheatgrass-needlegrass (*Agropyron-Stipa*) prairie by Küchler (1964). Garrison et al. (1977) classified the study area as plains grassland with ponderosa pine (*Pinus ponderosa*) forest. Plant names follow those given by Scott and Wasser (1980).

Four plant communities were recognized on the study area. A sagebrush-grassland community occupied a majority of the area. This community was dominated by big sagebrush (*Artemisia tridentata*) and buffalo grass (*Buchloe dactyloides*). A riparian community, primarily wooded stream bottoms, was the next most abundant plant community. Major plants there were boxelder maple (*Acer negundo*) and snowberry (*Symphoricarpos* spp.). A pine forest community existed at higher elevations, consisting of ponderosa pine and western wheatgrass (*Agropyron smithii*). Isolated portions of the study area were open grassland. The most abundant plants there were western wheatgrass and needleleaf sedge (*Carex eleocharis*). These subjective classifications were made to facilitate design of an adequate sampling scheme.

Four sample sites were selected in both the sagebrush and riparian communities. Two sample sites were studied in the pine forest and two in the grassland community. These sites were judged to be representative of their respective plant communities, and encompassed the range of perceived variability within these communities. The number of sampling sites established in each plant community was based on the total area occupied by that community, and/or the observed variability within each community.

Canopy cover and aboveground biomass of plant species were estimated in each sampling site during summers of 1979 and 1980. Three parallel 50-m line transects were systematically established approximately 30.5 m apart at each site. Canopy cover was measured using 50 plots (2 × 5 dm) systematically spaced at 1-m intervals along each transect (Daubenmire 1959). Six hundred plots were observed in both riparian and sagebrush areas and 300 in grassland and pine forest communities each year of the study. We assessed the adequacy of our sample size using the formula presented by Johnson and Laycock (1972), with a degree of precision needed to estimate plant species within 15 percent of their mean with 95 percent confidence.

Aboveground biomass at peak growth was estimated by clipping 20 plots at 5-m intervals along two of the transect lines at each site. All plants, excluding shrubs, were clipped at ground level, air dried for two weeks, oven dried at 60 C for 24 hours, then weighed to the nearest one-tenth gram.

Individual transects of each year were grouped into similar vegetation units using multidimensional polar ordination (Bray and Curtis 1957), as described by Mueller-Dombois and Ellenberg (1974). Ordination axes endpoints were chosen using guidelines and criteria suggested by Mueller-Dombois

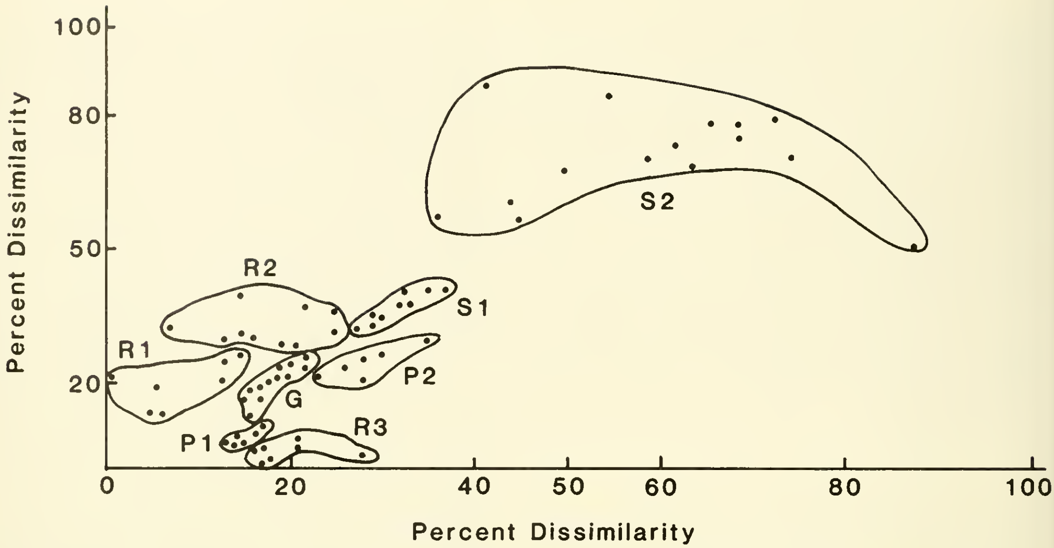

Fig. 1. Location of vegetation transects along ordination axes and grouping of transects into vegetation groups. R = riparian, P = pine forest, G = grassland, and S = sagebrush.

and Ellenberg (1974) and Newsome and Dix (1968). For this analysis transects were ordinated based on canopy cover estimates. Such an approach provided for the assessment of variability among transects and sampling sites within a plant community. Gauch et al. (1977) found that polar ordination was subject to less distortion than other ordination procedures when sampling is clustered and outlier samples are included.

The vegetation groups were then analyzed with stepwise discriminant analysis for three reasons (Cooley and Lohnes 1962, Klebenow 1969, Klecka 1975). Since polar ordination is somewhat subjective and based on sample similarities with axes endpoints, some vegetation groups may be erroneous. Most clustering techniques do in fact derive nonsignificant groups (Strauss 1982). Discriminant analysis maximizes differences among groups and was used to determine if vegetation groups were significantly different from one another. Green (1980) suggested that multivariate tests were so powerful in detecting differences that a nonsignificant result may be more meaningful than a significant result. Discriminant analysis also selects the set of variables (plant species) that are the most useful in differentiating among groups. This property is desirable in that many plant species are encountered that added little to explaining variation within and among plant communities. Discriminant analysis also generates classification functions from the most useful variables. These functions can be used to determine the vegetation groups to which nonsignificant groups were most similar. The classification functions could also be used to assign samples from future surveys to the vegetation group they most nearly resemble (MacCracken and Hansen 1982).

Aboveground biomass was analyzed by testing for differences between vegetation units (as determined by ordination and discriminant analysis), categories (grasses and forbs), and years, using a three-way analysis of variance test followed by Duncan's new multiple range test. Differences were considered significant at $\alpha = 0.05$.

Results

The number of plots needed to estimate canopy cover of plants with the degree of precision stated was 1025 and 1098 in 1979 and 1980, respectively. Our observation of 1800 plots per year was more than adequate.

Ordination arranged the 72 transects in such a manner that eight groups could be delineated based on the proximity of transects from similar sample sites (Fig. 1). Sagebrush and pine communities were each represented by two groups, riparian communities by three, and the grassland community by one. Discriminant analysis indicated that the two sagebrush groups were not distinct ($P > 0.05$). As a result, both sagebrush groups were combined for final analysis, resulting in seven groups defined at this point as seven vegetation units.

Eighty-eight plant species were encountered along the transects; of these, 9 plant species and percent cover of litter were the most useful variables in discriminating between vegetation units and accounted for nearly 100 percent of data variation (Table 1). Those discriminating variables, in order of significance, were smooth brome (*Bromus inermis*), litter, starry cerastium (*Cerastium arvense*), Rocky Mountain juniper (*Juniperus scopulorum*), snowberry (*Symphoricarpos* spp.), red threeawn (*Aristida longiseta*), big

Table 1. Mean percent canopy cover of plant species, bare ground, and litter of seven vegetation units in southeastern Montana. Estimates were taken during summers 1979 and 1980.

	Vegetation units						
	Riparian			Grassland	Pine		Sagebrush
Categories	1	2	3		1	2	
Bare ground	8	8	4	23	16	8	20
Litter +	29	22	44	28	53	48	15
Total cover	64	81	67	41	16	44	64
Grasses							
Agropyron smithii +	2	16	3	16	4	3	7
Agropyron spp.	10	8			°	°	°
Aristida longiseta +					1	°	
Bouteloua gracilis				1	4	2	1
Bromus inermis +		°	59				
B. japonicus	°	°	°	1	°	1	°
B. tectorum	2	°			1		°
Buchloe dactyloides				°	1	3	20
Carex spp.		3	°	5	3	14	5
Calamovilfa longifolia	°			1	1	°	2
Elymus macounii	°	5					
Hordeum jubatum	°	3	°				
Koeleria cristata		°		°	°	1	2
Muhlenbergia richardsonus	°						
Panicum capillare		°					
Phleum pratense	°	8					
Poa spp.	21	14	1	°	°	°	°
Schedonnardus paniculatus				°		°	°
Stipa viridula		°		°		°	1
Unidentified		3					
Forbs							
Achillea millefolium	°	°	1	°	1	2	1
Cerastium arvense +					°	2	
Geum aleppicum		°					
Lactuca serriola	1	°					
Plantago spinulosa				1	°	°	°
Rumex crispus	1	1					
Sphaeralcea coccinea				°			
Taraxicum officinale	1	5	1	°	°	°	°
Thlaspi arvense	°	°		°			
Vicia americana			°				°
Shrubs							
Artemisia tridentata +				1	°	1	11
Juniperus scopulorum +					2	1	
Opuntia polycantha +				4	°	1	2
Phlox hoodii				°		°	2
Sarcobatus vermiculatus	°						°
Symphoricarpos spp. +	27	17	1				
Rosa spp. +	1	5		1			°

°<1

+ Indicates plant species and variables most useful in discriminating between the seven vegetation units.

sagebrush, western wheatgrass, rose (*Rosa* spp.), and plains prickly pear (*Opuntia polyacantha*). Smooth brome, litter, and starry cerastium alone accounted for 94 percent of data variation. However, the remaining seven variables contributed significantly to the separation of vegetation units. Discriminant function classification coefficients ranged from –0.01 to 56.42 (Table 2).

Differences among the seven vegetation units ($P < 0.05$) arose as each variable was entered into discriminant analysis. These differences changed slightly as each variable was considered, but the seven units were distinct ($P < 0.05$) after all 10 variables had been considered. Transects from each site combined into the same vegetation unit for each year, indicating that differences in plant canopy cover were not significant between years. Generally, transects from one or more sampling sites combined to produce a vegetation unit. Nevertheless, there was some mixing of transects from the four riparian sites sampled among the three Riparian vegetation units.

Differences were detected in aboveground biomass among units and plant taxa (Table 3). The Riparian 3 unit had more grass ($P < 0.01$) than the Riparian 1 and 2 units, sagebrush, grassland, and both pine units. Grass biomass was also greater ($P < 0.01$) in the Riparian 2 unit, sagebrush and grassland units than in both pine forest units. Still, forb biomass between units was similar ($P > 0.05$). Grass biomass was higher than forb biomass ($P < 0.01$) in all riparian units. Grass and forb biomass in other units were similar ($P > 0.05$). No year differences were observed for total biomass ($P > 0.05$) for any vegetation unit or category. Some plant species were common to all units, but others were indicative of a particular vegetation unit. Western wheatgrass was most abundant in the Grassland and Riparian 2 units. Red threeawn and starry cerastium were confined to pine forest areas. Smooth brome and snowberry occurred exclusively in riparian units, as did combined wheatgrasses. Common tumblegrass (*Shedonnardis paniculatus*), and plains prickly pear were useful in distinguishing the grassland unit, and big sagebrush was dominant in the sagebrush unit.

Discussion

Vegetation units as defined in this study represent areas that are the most similar in vegetative composition. Variation inherent in sampling methods has been reduced to a minimum by the quantitative techniques used, and accurately describes these vegetation units at a refined level. The methods used illustrate the variation from site to site within some plant communities. Discriminant analysis indicated that relatively few plant species accounted for the majority of variation attributable to differences in plant cover among the vegetation units.

TABLE 2. Discriminant function coefficients for the 10 variables most useful in distinguishing between vegetation units in southeastern Montana.

	Vegetation units						
	Riparian			Grassland	Pine		Sagebrush
Variables	1	2	3		1	2	
Litter	1.63	0.92	1.19	1.34	4.42	4.49	0.82
Constant	–32.87	–28.74	–57.49	–22.11	–174.09	–185.15	–12.31
GRASSES							
Agropyron smithii	0.08	0.97	–0.31	0.09	–1.01	–1.03	–0.04
Aristida longiseta	15.39	7.47	11.84	12.61	56.42	46.68	8.13
Bromus inermis	–0.66	–0.43	1.01	–0.54	–1.71	–1.74	–0.32
FORBS							
Cerastium arvense	12.89	6.88	9.66	10.73	34.38	49.26	6.06
SHRUBS							
Artemisia tridentata	0.19	0.14	0.13	–0.01	0.48	0.51	0.88
Juniperus scopulorum	11.86	6.49	8.82	9.89	36.15	33.83	6.00
Rosa spp.	0.01	1.39	–0.50	–0.06	–1.72	–1.76	–0.16
Symphoricarpos spp.	0.53	0.61	–0.04	0.07	–0.12	–0.12	0.01
Opuntia polyacantha	–1.54	–2.55	–0.44	0.17	–1.81	–1.94	–0.53

Polar ordination arranged transects along a moisture gradient for both axes. Vegetation units representing areas of high soil moisture (based on plant species presence) fell into the bottom left quadrant and xeric vegetation units fell into the upper right quadrant (Fig. 1). Many studies have shown strong correlations between plant community composition and soil moisture regimes in the western United States (Dahl 1963, Galbraith 1971, Marks and Harcombe 1981, Monk 1960, Marks and Harcombe 1975, Harniss and West 1973). Marks and Harcombe (1981) interpreted an ordination axis as representing a soil moisture gradient even through they did not measure soil moisture directly.

Some plant communities in southeastern Montana are relatively homogenous. The sagebrush-grass and grassland communities were not different in plant cover among the sites sampled within each type. We did subjectively divide the sagebrush-grass transects into two groups based on ordination results; however, discriminant analysis did not detect any differences ($P > 0.05$) in plant cover among the two groups. Polar ordination when used as a clustering technique can produce nonsignificant groups. Current studies in plant community classification often use an ordination or clustering technique to define plant community types (Marks and Harcombe 1981, Thilenius 1972, Severson and Thilenius 1976). Rarely are the groups that result from these techniques tested for significance (Strauss 1982).

Riparian and pine forest communities are relatively heterogenous in southeastern Montana. The variation and factors producing dif-

Table 3. Mean kilograms per hectare of grasses and forbs occurring in seven vegetation units in southeastern Montana. Estimates were taken during summers of 1979 and 1980.

	Vegetation units						
	Riparian			Grassland	Pine		Sagebrush
Plant species	1	2	3		1	2	
Grasses							
Agropyron smithii	75	192	11	222	48	59	125
Agropyron spp.	24	°			5	4	6
Aristida longiseta					6	°	
Bouteloua gracilis				6	30	21	14
Bromus inermis		109	5998				
B. japonicus	5	1		1		2	2
B. tectorum					8	4	3
Buchloe dactyloides				1	5	17	115
Carex spp.		14					66
Calamovilfa longifolia				7			86
Elymus macounii	13	22	°				
Hordeum jubatum		25					
Koeleria cristata				1		3	12
Muhlenbergia richardsonus	°						
Panicum capillare		°					
Phleum pratense		137					
Poa spp.	263	179	3	3		1	3
Schedonnardus paniculatus				5		°	2
Stipa viridula		2		2		6	29
Others		50					
Total Grass	106	156	802	78	30	36	86
Forbs							
Achillea millefolium	7	°	1	1	2	20	10
Cerastium arvense					°	18	
Geum aleppicum		°					
Lactuca serriola	20	22					
Plantago spinulosa				3	°	1	
Rumex crispus	21	7					
Sphaeralcea coccinea				1			2
Taraxicum officinale	6	25	1	3		2	3
Thlaspi arvense	3	7					
Vicia americana		°	°				°
Total Forb	10	20	11	5	5	9	16

°<1

ferences among sites in riparian and pine forest communities are recognizable and interpretable. For example, riparian communities (i.e., hardwood forests along stream bottoms) were divided into three distinct vegetation units in this study (Table 1 and 3, Fig. 1). In general, hardwood forests, occurring as woody draws and stringer woodlands, are declining on the northern Great Plains (Boldt et al. 1978). Declining woodlands are represented by trees of old age, decadence, and advanced stages of breakup. Reproduction is poor and ground cover is primarily herbaceous. In contrast, "healthy" woody draws are characterized by thrifty, moderately dense stands of trees, and a vigorous shrub understory (Boldt et al. 1978). The Riparian 1 unit was representative of a healthy area. Shrub cover averaged 27 percent, and herbaceous vegetative growth averaged approximately 117 kg/ha. The Riparian 3 unit represented a declining woodland. Shrub cover averaged 1 percent, and herbaceous growth averaged 817 kg/ha, primarily because of the invasion of smooth brome from nearby hay meadows. The decline of hardwood forests on the northern Great Plains has been attributed to a number of environmental and biological factors (Boldt et al. 1978).

Two vegetation units were recognized in the pine forest community. These units are more easily interpreted than those of riparian sites. The Pine 1 unit had a relatively dense stand of trees (Table 4). Understory cover and aboveground biomass were lower than in the Pine 2 unit, but percent ground litter was higher in this unit. The Pine 2 unit had a relatively more open stand of trees, with greater growth of understory vegetation and less ground litter. The difference in tree density between the two units was perhaps due to moisture regimes as related to aspect of the sites.

Management Implications

Results of this study show that some plant communities in southeastern Montana are variable in botanical composition, being composed of distinct and differing vegetation units. This variability can be attributed to a number of environmental or biological factors. Different vegetation units within a plant community will respond differently to management practices. This site-specific variability, once recognized, will influence management decisions. For example, consider an area of riparian community in southeastern Montana in which a rancher wishes to convert part to hay meadows. If all three Riparian units were present, the decadent woodland would probably be most easily converted. The healthy woodland would be valuable as wildlife habitat, to trap winter snows to fill stock ponds downstream, and as shading areas for livestock. The Riparian 2 unit, an intermediate unit between healthy and decadent stands, could be slated for improvement toward a healthy stand. Boldt et al. (1979) presented treatments aimed at improving decadent woodlands on the northern Great Plains. The Pine 1 unit could be thinned to increase forage production for livestock, water yield, and timber production.

By simply recognizing the inherent variability in plant communities, a number of management options became apparent. On federal lands, where multiple use management is law, this approach should be readily utilizable.

TABLE 4. Density (no/ha) of trees in pine and riparian vegetation units in southeastern Montana.

	Vegetation units				
	Pine		Riparian		
Tree	1	2	1	2	3
Pinus ponderosa	172	20			
Quercus macrocarpa	192	52			
Juniperus scopulorum	88	184			
Fraxinus pennsylvanicas			600	976	872
Acer negundo			524	496	260
Prunus virginiana					352
Salix amygdaloides			5		
Total	452	256	1144	1472	1484

Recognition of some vegetation units defined in this study may not be easy, especially the Riparian 2 unit. However, discriminant classification functions can be used for that purpose. Using estimates of mean percent canopy cover of discriminator species multiplied by discriminant function coefficients (Table 2), a composite score can be derived by adding the products for any sample. The function producing the largest score indicates the vegetation unit from which the sample came. Since only ground litter and nine plant species were important in distinguishing among the vegetation units on the study area, only these variables need be measured in future surveys (MacCracken and Hansen 1982). This should greatly reduce field effort and associated costs. The application of these classification functions beyond the immediate study area is questionable. However, they may be suitable for portions of southeastern Montana where the same plant communities occur and environmental and biological forces similar to those at work here operate.

Ideally, each vegetation unit defined in this study should be managed on an individual basis, using practices known to benefit those units whether management be for livestock, wildlife, water, or minerals. This would require intensive management to achieve desired results. Nevertheless, it is possible to classify existing areas based on unit dominance and manage for that unit.

Acknowledgments

The authors wish to thank L. E. Alexander, D. Oligmiller, V. Todd, and M. Loring for their assistance in this study and the Fosters of Wyotana Ranch, G. Brimmer, and the Carlton Grazing Association for access to their properties.

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NEW LEAFHOPPER SPECIES OF *COELIDIA* WITH A REVISED KEY AND NOTES ON HOMONYMY AND DISTRIBUTION (HOMOPTERA: CICADELLIDAE, COELIDIINAE)

Mervin W. Nielson[1]

Abstract.— Five new species of *Coelidia* are described and illustrated. These include *panamensis* and *simplex* from Panama and *retrorsa*, *cochloea*, and *tortula* from Brazil. A revised key is also presented for 13 of the 14 species for which males are known. *Coelidia gladia* is proposed as a new name for *Coelidia spangbergi* Nielson, 1982 nec *Coelidia spangbergi* Linnavuori, 1956 and *Coelidia spangbergi* Metcalf, 1964.

The nominate genus *Coelidia* Germar of the subfamily Coelidiinae was treated in Part IV of my revision of the tribe Coelidiini (Nielson 1982). In that work nine species were included in a conceptually restricted group that formerly encompassed over 200 species represented in all zoogeographical regions of the world. In this paper five new species are described with a revised key to 13 of 14 species for which males are known. A new name is proposed for *Coelidia spangbergi* Nielson, 1982, preoccupied by *Coelidia spangbergi* Linnavuori, 1956, and *Coelidia spangbergi* Metcalf, 1964.

The genus *Coelidia* is characterized as having a large elevated crown that is usually broader than the width of the eyes, carinate laterally, and produced distally beyond the anterior margin of the eyes. The clypeus has an incomplete median longitudinal carina in some species, including the type species, *venosa* Germar. The clypeal carina is the primary tribal character that separates Teruliini from Coelidiini. It is absent in all genera of the latter tribe except *Clypeolidia* Nielson and 4 of 14 known species of *Coelidia*, where it is present but incomplete, i.e., does not reach the transclypeal suture from its anterior origin.

The genitalic characters of *Coelidia* include a pair of prominent processes on the caudal margin of the male pygofer, usually very long styles, and an elongate aedeagus that usually has 1–2 distal processes or a recurved extension of the shaft.

The present distribution of the genus is Neotropical. *Coelidia venosa* is the only widespread species and it ranges from Brazil to Colombia. Four species occur in Brazil, four in Colombia, and four in Panama. One species is common to Brazil and Colombia and one is common to Colombia and Panama, suggesting that Colombia is the center of the southern (Brazil) and northern range (Panama) of the genus.

Key to Males of *Coelidia*[2]

1.	Aedeagus with 1–2 prominent distal or subdistal processes	2
—	Aedeagus without such processes, if present, only about as long as wide	11
2(1).	Aedeagus with 1 distal process	3
—	Aedeagus with 2 distal processes	7
3(2).	Style short, length about equal to arms of connective (Fig. 3)	4
—	Style long, length much greater than arms of connective (Fig. 8)	5

[1]Department of Zoology and Life Science Museum, Brigham Young University, Provo, Utah 84602.

[2]Includes 13 of the 14 known species; *stalii* (Spångberg), known only from ♀ is not keyed.

4(3). Aedeagus with short distal process, process about 1/4 length of shaft (Fig. 862, Nielson 1982); pygofer with ornate caudodorsal process (Fig. 858, Nielson 1982) .... *venosa* Germar

— Aedeagus with long distal process, process about 1/2 length of shaft (Fig. 4); pygofer with broad, simple caudodorsal process (Fig. 1) .... *retrorsa,* n. sp.

5(3). Pygofer with long, narrow, sharply pointed caudoventral process (Figs. 864 and 898, Nielson 1982) 6

— Pygofer with a long, narrow, but distally enlarged caudoventral process (Fig. 7) .... *panamensis,* n. sp.

6(5). Pygofer with very long caudoventral process, process extending distally beyond apex of caudodorsal process (Fig. 898, Nielson 1982); aedeagus with short distal process, process 2–3 times as long as wide in lateral view (Fig. 902, Nielson 1982) .... *attenuata* Nielson

— Pygofer with short caudoventral process, process not reaching apex of caudodorsal process (Fig. 864, Nielson 1982); aedeagus with long distal process, process 5–8 times as long as wide in lateral view (Fig. 868, Nielson 1982) .... *gernnari* Nielson

7(2). Aedeagus with 1 distal process and 1 subdistal process, processes unequal in length and in configuration (Figs. 873, 876, 882, Nielson 1982) 8

— Aedeagus with 2 distal processes, processes nearly equal in length and in configuration (Fig. 17) .... *tortula,* n. sp.

8(7). Aedeagus with long subdistal process, apex reaching to about midlength of shaft in lateral view (Figs. 876 and 882, Nielson 1982) 9

— Aedeagus with short subdistal process, apex not reaching midlength of shaft in lateral view (Fig. 873, Nielson 1982) .... *atra* Walker

9(8). Style in dorsal view very narrow at distal 2/3, narrower than aedeagal shaft (Figs. 879 and 884, Nielson 1982) 10

— Style in dorsal view broad at distal 2/3, as broad as or broader than aedeagal shaft (Figs. 877, Nielson 1982) .... *nigra* (Spangberg)

10(9). Aedeagus with very broad subdistal process, process broader than aedeagal shaft in dorsal and lateral views (Figs. 881 and 882, Nielson 1982) ..... *gladia,* n. name

— Aedeagus with very narrow subdistal process, process narrower than aedeagal shaft in lateral view (Fig. 888, Nielson 1982) .... *gorgonensis* Nielson

11(2). Aedeagus and style narrowed distally (Figs. 21 and 23) 12

— Aedeagus and style greatly enlarged distally (Figs. 891 and 894, Nielson) .... *bulbata* Nielson

12(11). Pygofer with ornate caudodorsal process, process enlarged basally with slender curved distal process (Fig. 19) .... *cochloea,* n. sp.

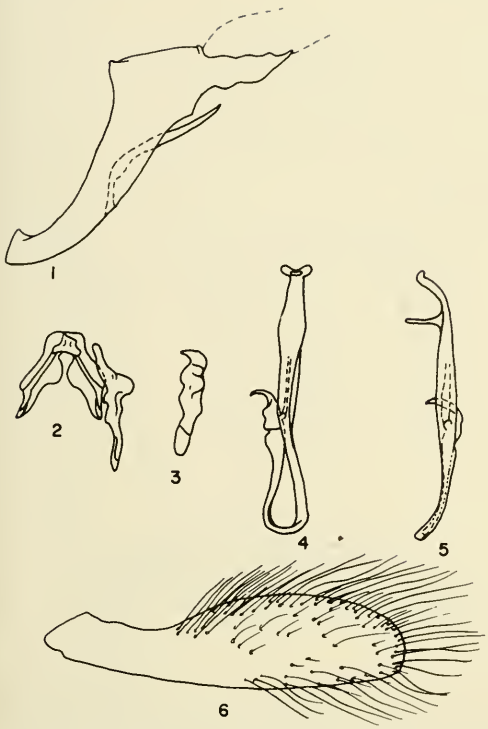
— Pygofer with long caudodorsal process, process narrow, fingerlike (Fig. 25) .... *simplex,* n. sp.

Coelidia retrorsa, n. sp.
(Figs. 1–6)

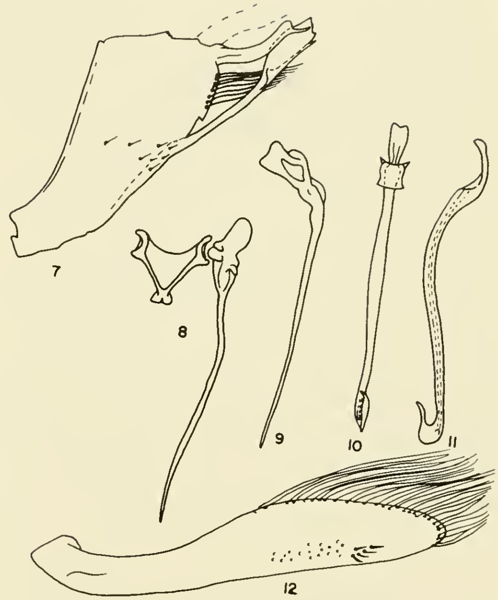
Length: ♂ 10.00 mm.

General color deep ochraceous with fuscous costa and 5 narrow longitudinal pale flavous stripes on pronotum; veins of forewings flavous anteriorly, becoming spotted with fuscous markings posteriorly.

Head small, much narrower than pronotum, anterior margin obtusely angulate; crown produced beyond anterior margin of eyes, broad, width greater than width of eyes,



Figs. 1–6. *Coelidia retrorsa*: 1, Male pygofer, lateral view. 2, Connective and right style, dorsal view. 3, Style, lateral view. 4, Aedeagus, dorsal view. 5, Aedeagus, lateral view. 6, Plate, ventral view.



Figs. 7–12. *Coelidia panamensis*: 7, Male pygofer, lateral view. 8, Connective and right style, dorsal view. 9, Style, lateral view. 10, Aedeagus, dorsal view. 11, Aedeagus, lateral view. 12, Plate, ventral view.

elevated above level of eyes, carinate laterally, foveate on either side of middle, lateral margins parallel; eyes large, elongate-ovoid, occupying less than 2/3 of entire dorsal area of head; pronotum very large, scutellum large; forewing elongate, apex broadly angulate, venation typical, appendix well developed; clypeus long and broad with an incomplete median longitudinal carina, extending from anterior margin to about 2/3 length of clypeus; clypellus long, narrowed basally, expanded distally.

♂. Pygofer in lateral view very narrow with long, narrow caudoventral process and moderately long, broad caudodorsal process; 10th segment long and narrow, without ventral processes; aedeagus asymmetrical, long, slightly tubular, distal part recurved and extending to about midlength of shaft, shaft narrowed along recurved portion, wrinkled and enlarged subapically, becoming slightly hooked distally; gonopore medial on shaft; connective Y-shaped with short stem and long arms; style very short, about as long as arms of connective; plate long, profusely setose.

♀. Unknown.

Holotype (♂), BRAZIL: Amazon, Tonantins, no date, no collector, (NR).

Remarks: This species is similar in general habitus and some male genital characteristics to *venosa* Germar but can be distinguished by the long recurved portion of the aedeagus and by the gonopore that is medial on the shaft.

Coelidia panamensis, n. sp.

(Figs. 7–12)

Length: ♂ 8.40 mm.

General color deep fuscous with 5 narrow flavous longitudinal lines and broad flavous band on lateral margins of pronotum, veins of forewing with flavous spots.

Head small, much narrower than pronotum, anterior margin obtusely angled; crown distinctly produced beyond anterior margin of eyes, broad, width about equal to width of eyes, elevated above level of eyes, foveate medially, lateral margins carinate; eyes large, semiglobular, occupying less than 2/3 of entire dorsal area of head; pronotum and scutellum very large; forewing elongate, rounded distally, venation typical, appendix well developed; clypeus long and broad, without median longitudinal carina; clypellus long and narrow, expanded distally.

♂. Pygofer in lateral view moderately broad with very long caudoventral process, process narrow at basal 2/3, enlarged at distal 1/3 with small ventral spine, caudodorsal margin with long narrow process, process abruptly pointed distally; aedeagus partially asymmetrical, long, narrow, tubular throughout, recurved distally, distal portion very short and narrow; gonopore subapical; connective broadly Y-shaped with short stem and long arms; style very long, about as long as aedeagus, narrow throughout; plate long and narrow, setose along outer margin at distal half.

♀. Unknown

Holotype (♂), PANAMA: San Blas, near Punta Escoces, 77°42'W: 8°48'N., 2-II-79. Caroline Ash (USNM).

Remarks: Coelidia panamensis is similar in male genital characteristics to *attenuata* Nielson but can be easily separated by the caudoventral process of the pygofer, which is enlarged distally and bears a ventral spine.

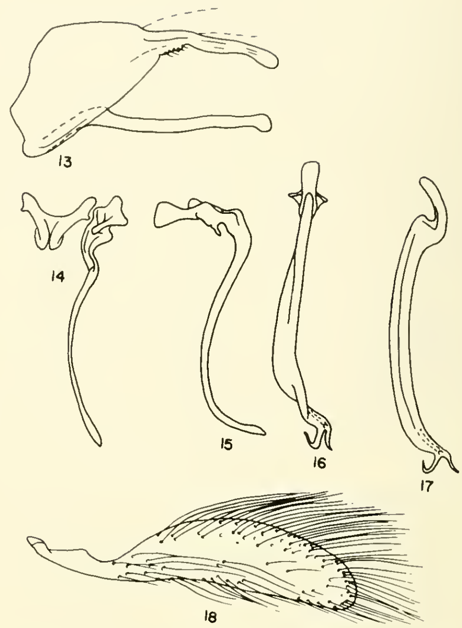
Coelidia tortula, n. sp.
(Figs. 13–18)

Length: ♂, 10.00 mm.

General color fusco-piceous, except for flavous apex on forewing, veins with ochraceous spots.

Head much narrower than pronotum, anterior margin obtusely angled; crown produced beyond anterior margin of eyes, broad, broader than width of eyes, elevated above level of eyes, foveate medially, carinate laterally, eyes semiglobular, large, occupying less than 2/3 of entire dorsal area of head; pronotum and scutellum large; forewing elongate, apex rounded, venation typical, appendix well developed; clypeus long and broad, without median longitudinal carina; clypellus long and narrow, apex expanded.

♂. Pygofer in lateral view moderately broad, with long caudoventral process and shorter caudodorsal process, both processes except for length about equal in width and



Figs. 13–18. *Coelidia tortula*: 13, Male pygofer, lateral view. 14, Connective and right style, dorsal view. 15, Style, lateral view. 16, Aedeagus, dorsal view. 17, Aedeagus, lateral view. 18, Plate, ventral view.

similar in configuration, aedeagus asymmetrical, long, broad, twisted subapically in dorsal view, with 2 narrow, curved, distal processes; gonopore near apex of shaft basad of distal processes; connective broadly Y-shaped, stem short, arms long; style long, narrow, about as long as aedeagus; plate elongate, profusely setose.

♀. Unknown.

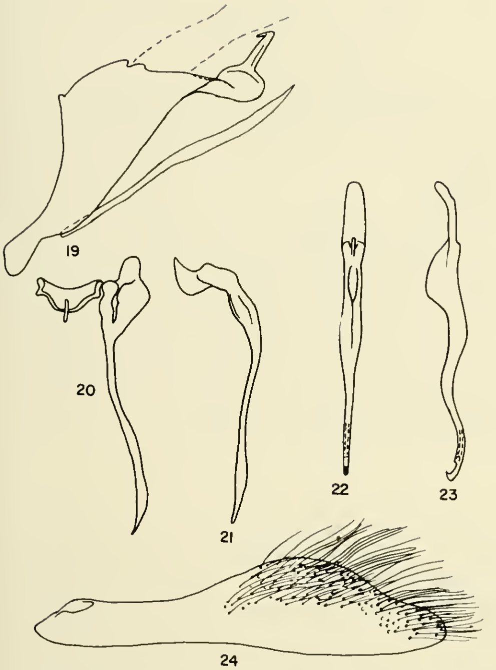
Holotype (♂), BRAZIL: Amazon, Fonteboa, no date, no collector (NR).

Remarks: This species has no apparent close relatives but is nearest to *atra* Walker. It can be distinguished from all known species of *Coelidia* by the aedeagus with a twisted shaft and the distal processes, which are nearly of equal length and configuration and arise from the apex of the shaft.

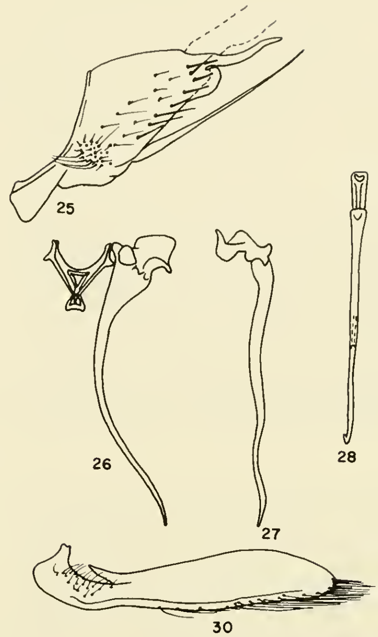
Coelidia cochloea, n. sp.
(Figs. 19–24)

Length: ♂, 8.60 mm., ♀, 9.00–9.70 mm.

General color ochraceous, forewings with piceous pigmentation along basal 2/3 of costa and with broad, smoky, fuscous, oblique



Figs. 19–24. *Coelidia cochloea*: 19, Male pygofer, lateral view. 20, Connective and right style, dorsal view. 21, Style, lateral view. 22, Aedeagus, dorsal view. 23, Aedeagus, lateral view. 24, Plate, ventral view.



Figs. 25–30. *Coelidia simplex*: 25, Male pygofer, lateral view. 26, Connective and right style, dorsal view. 27, Style, lateral view. 28, Aedeagus, dorsal view. 29, Aedeagus, lateral view. 30, Plate, ventral view.

band subapically, distal 1/4 and middle of forewing translucent.

Head small, much narrower than pronotum, anterior margin obtusely angled, crown produced slightly beyond anterior margin of eyes, broad, slightly broader than width of eyes, elevated above level of eyes, slightly carinate laterally; eyes large, semiglobular, occupying less than 2/3 of entire dorsal area of head, pronotum and scutellum large; forewing elongate, rounded distally, venation typical, appendix well developed; clypeus long and broad, without median longitudinal carina; clypellus long and narrow, margins expanded distally.

♂. Pygofer in lateral view broad, with long, bladelike caudoventral process and large ornate caudodorsal process, which is enlarged basally, slightly twisted basally and abruptly curved at distal half; aedeagus nearly symmetrical, simple, broad at basal 2/3 and narrowed at distal 1/3 in dorsal view, sinuate in lateral view, apex slightly hooked; gonopore subapical; connective broadly Y-shaped; style long, about as long as aedeagus, narrow at distal 2/3; plate elongate, profusely setose at distal half along outer marginal area.

♀. Seventh sternum large, about 2X as long as preceding segment, caudal margin produced along middle.

Holotype (♂), BRAZIL: Para, Belen Mocambo, 05–III–1977, T. Pimentel (OSU). Allotype ♀, same data as holotype except collector, A. Y. Harada (OSU). Paratypes. BRAZIL: Manaos, 1 ♀, 19–XI., no year, no collector (author's collection), Prata, 1 ♀, 19–VII., no year, no collector (OSU), Para, Sta. Isabel, 1 ♀, 13–VII–1973, B. Mascarenhas (USNM).

Remarks: Coelidia cochloea is most closely related to *simplex* Nielson, and can be separated by the pygofer with the ornate caudodorsal process, which is enlarged basally and narrowed distally.

Coelidia simplex, n. sp.

(Figs. 25–30)

Length: ♂, 8.60 mm.

General color piceous except for narrow translucent apex on forewing, ochraceous spots on veins, 5 narrow longitudinal lines on pronotum, 3 similar ones on scutellum, and broad ochraceous band on lateral margins of pronotum.

Head small, much narrower than pronotum, anterior margin obtusely angled; crown produced beyond anterior margin of eyes, broad, about as broad as width of eye, carinate laterally; eyes large, semiglobular, occupying nearly 2/3 of entire dorsal area of head; pronotum and scutellum large; forewing (right one missing on holotype) elongate, obtusely rounded distally, appendix well developed; clypeus long and broad, without median longitudinal carina; clypellus long, narrow, lateral margins expanded distally.

♂. Pygofer in lateral view broad, with very long, slender, acuminate caudoventral process and long, fingerlike caudodorsal process; aedeagus nearly asymmetrical, simple, long, narrow, tubular, broadly sinuate in lateral view, apex slightly recurved; gonopore near middle of shaft; connective broadly Y-shaped; style very long, longer than aedeagus, very narrow, tapered distally; plate elongate, with numerous setae along outer margin.

♀. Unknown.

Holotype (♂), PANAMA: Barro Colorado, Canal Zone, forest, 3–VI–1976. H. Wolda (USNM).

Remarks: This species is similar to *cochlea* Nielson in characters of the aedeagus but can be distinguished by caudal processes on the pygofer. The caudoventral process is very long, acuminate, and reaches the apex of the slender, fingerlike caudodorsal process.

Coelidia gladia, n. name

Coelidia spangbergi Nielson 1982 is a junior homonym of *Coelidia spangbergi* Linnavuori, 1956, and *Coelidia spangbergi* Metcalf, 1964, and must be replaced.

In my revision of the tribe Teruliini (Nielson 1979), *Docalidia metcalfi* Nielson was proposed as a new name for *Coelidia spangbergi* Metcalf, 1964, nec *Coelidia spangbergi* Linnavuori, 1956. Metcalf (1964) proposed *Coelidia spangbergi* as a new name for *Jassus flavicosta* Spångberg, 1878, nec *Jassus flavicosta* Stål, 1862. *Coelidia spangbergi* Linnavuori was made a junior synonym of *Stalolidia dissoluta* (Jacobi) by Nielson (1979). All the Spångberg names originally assigned to *Coelidia* are either synonyms or homonyms and thus are no longer valid.

ACKNOWLEDGMENTS

I appreciate the loan of specimens for this study provided by the following institutions and individuals: Dr. Per Inge Persson, Naturhistoriska Riksmuseum, Stockholm (NR), Dr. J. P. Kramer, U.S. National Museum of Natural History, Washington, D.C., (USNM), Dr. C. H. Triplehorn, Ohio State University, Columbus (OSU), and Dr. H. Wolda, Smithsonian Research Institute, Washington, D.C., (USNM). I am also indebted to Mr. Joel Floyd for preparing the illustrations.

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EYE FLUKE (*DIPLOSTOMUM SPATHACEUM*) OF FISHES FROM THE UPPER SALMON RIVER NEAR OBSIDIAN, IDAHO

Richard Heckmann[1]

ABSTRACT.— Following a preliminary survey (1981) of diplostomatosis in fish from the Salmon River near Obsidian, Idaho, an extensive survey was conducted during the summer of 1982. From the initial sampling site on the Salmon River, 98 percent of 384 sculpin, *Cottus bairdi*, 8 percent of 317 salmonids, and 13 percent of 16 Dace and suckers were infected with *Diplostomum spathaceum*. Upriver from the initial sampling site and from three drainages entering the Salmon River 28 percent of 185 sculpin and 1 percent of 70 salmonids were infected with *D. spathaceum*. The number of worms per eye was greater for sculpin (1 to 100+) than for salmonids (1 to 18) from the same area. The metacercariae of *D. spathaceum* occupy the vitreous body-retina area of infected fish. There is a prominent pathology associated with the infection, including detachment of the retina. Sculpin represent an indicator species for the range of diplostomatosis. The high infection rate of sculpin is associated with their bottom-dwelling characteristic and with their feeding habits.

Following a preliminary study of the eye fluke of fishes from the Upper Salmon River during the summer of 1981, an extensive survey was conducted on the incidence of *Diplostomum spathaceum* of fishes from the same locality during 1982.

Diplostomum spathaceum (Rudolfi 1819) (Diplostomidae), the fish eye fluke that causes the disease diplostomatosis (diplostomatiasis), has been reported in many areas of North America and other parts of the world. Extensive surveys have been conducted in Utah concerning incidence, life history, and pathology (Heckmann 1978). Diplostomatosis, which is due to the presence of the metacercarial stage of this parasite in fish, causes cataracts of the lens and damage to the vitreous body and the retina of the eye.

Diplostomum spathaceum is a digenetic trematode that has numerous synonyms in the literature (McDonald 1969).

The life cycle of *D. spathaceum* includes the adult parasite that lives in the intestinal tract of a piscivorous bird. The eggs from the adult trematode are passed in fecal deposits from the definitive host. The eggs embryonate in water and release a free-swimming miracidium in two to three weeks. The miracidium has approximately 24 hours in which to locate and infect the first intermediate host, which is a species of snail. In the snail the mother and daughter sporocysts develop in liver tissue. The daughter sporocysts release free-swimming cercariae in approximately 6 weeks after miracidial penetration of the snail. The cercariae have from 24 to 48 hours to penetrate the second intermediate host. Fish are the most common second intermediate hosts; however, infections in amphibians, reptiles, and mammals have also been reported (Ferguson 1943). Once the cercariae have penetrated the second intermediate host, they lose their forked tails and migrate to the lens tissue, where the metacercariae develop in 50 to 60 days (Erasmus 1958). When infected lens tissue is eaten by a bird, the adult fluke develops in the gut within five days (Oliver 1940). To date, 15 species of snails, 70 species of fish, and 37 species of birds have been reported worldwide as hosts for *D. spathaceum* (Palmieri et al. 1977).

Currently there are several studies underway throughout this country to determine the correct binominal name for the fish eye fluke. Consensus is that the metacercariae inhabiting the orbit of fish eyes in the Upper Salmon River is *D. spathaceum*. Hoffman (1970) states that the genus *Diplostomum* includes metacercarial stages in the eyes of fish. He lists two species for the eyes; *D. spathaceum* found in the lens with a distinct hindbody and *D. huronense* found in the vitreous chamber, a worm less than three times

[1]Department of Zoology, Brigham Young University, Provo, Utah 84602.

as long as broad with a distinct hindbody. In both cases gulls are listed as the primary definitive host, with *Lymnaea* snails as the preferred first intermediate host. According to the above characteristics, the eye fluke we have studied for this report should be *D. huronense*, but Dubois (1935) and Dubois and Mahon (1959) consider *D. huronense* to be a synonym for *D. spathaceum*. Thus, we will consider the fish eye fluke of the Upper Salmon River to be *D. spathaceum*.

Beginning in June and ending in September, sampling was conducted in a series of four periods in 1982. One of the major objectives of this study was to determine the number of metacercariae in fish from (a) the bank and (b) midwater of the Upper Salmon River and streams draining into the river.

Materials and Methods

Four collection trips were scheduled and completed to the Upper Salmon River area. During each trip, fish were collected by one of three methods: electrofishing, hook and line, and nets. Where possible, samples were obtained from fishermen. Each fish was examined for eye flukes by removing the soft tissue from the orbit of the eye, placing the contents in a petri dish, and examining the sample with a dissecting microscope. Samples of eyes that contained numerous metacercariae (80 to 100+ per eye) were fixed in 10 percent formalin for sectioning and staining to determine the pathology of the infection. Fish were sampled from the Upper Salmon River near Obsidian, Idaho, and from four other locations upriver that are identified in Tables 1–3.

Results

The results of fish samples taken from the Upper Salmon River area are found in Tables 1, 2, and 3. From these data it is apparent that the mottled sculpin (*Cottus bairdi*) is the most susceptible to the eye fluke. The sculpin was used as a primary indicator species for other areas and feeder streams (Table 4). Whitefish (*Prosopium williamsoni*) (Table 2) carried the second highest number of metacercariae within the eye orbit. Chinook salmon (*Oncorhynchus tshawytscha*) are relatively free of the fish eye fluke. These tables also show that the infection in fish reached a peak toward the end of the summer.

Fish sampled from upriver sites contained a lower number of metacercariae (Decker Flat) to no worms for fish from feeder streams and the headwaters of the Salmon River (Tables 2 and 4). Fish inhabiting slow-moving water and pools in the main river are more susceptible to cercarial invasion than those in fast water (Table 1). As expected, larger fish of the same species in general carry a greater number of worms than smaller fish (Table 1).

Histological examination of the infected fish indicated a vitreous body-retina location for the worms (Fig. 1).

The metacercariae cause a detachment of the retina from the outer vascular and fibrous coats (choroid, sclera). Thus, heavily infected fish (40+ worms) are blind. The eye fluke found in fish in Utah inhabits the lens.

The pathological effects of *Diplostomum spatheceum* upon the fish host are many. Examination of those fish blinded with cataract and containing a heavy burden or larval metacercariae revealed stunted growth (length, girth, and weight), abnormal feeding behavior (lack of response to visual stimuli), and decreased vital acuity (Palmieri et al. 1977). Ashton et al. (1969) reported that larvae migrate to the eye via vascularvenous channels and showed that the lens, vitreous, or cortex of the eye may be proliferated with metacercariae. In older fish, chronic infections and pronounced subacute inflammatory reactions in the vitreous involving heterophils, eosinophils, and macrophages with ingested lens material occurred.

Visual acuity for infected fish can be slightly hampered or lost due to worm burden. In addition to visual loss and concomitant pathogenesis, fish show retarded growth and a change in food habits. Fishermen consider the fluke as one of the reasons for a decrease in number of fish caught on artificial lures.

Discussion

Due to the unique nature and location of this fluke within the eye of the fish and due to its associated pathogenicity, much time

TABLE 1. Summary of all samples from the mottled sculpin, *Cottus bairdi*, checked for the eye fluke, *Diplostomum spathaceum* during 1982, Salmon River, Idaho.

Location	Date of sample in 1982	Number of fish	Size class*	Number with eye fluke	Eye flukes per eye
Salmon River (Side channel)	28 June	9	M	9	6
	27 July	15	M and L	14	23
	29 July	10	M	10	16
	25 Aug	3	L	3	48
		6	M	6	18
		12	S	12	5
	1 Oct	8	L	8	7
		4	M	4	5
		2	S	2	2
Salmon River (Middle channel)	28 June	0	High water	No sample	
	27 July	32	M and L	31	39
	25 Aug	12	L	12	88+
		9	M	9	43
		10	S	10	11
	1 Oct	1	XL	1	100+
		14	L	14	81+
		11	M	11	35+
		6	S	6	27+
Salmon River (Main channel)	28 June	0	High water	No sample	
	29 July	2	M	2	10
	25 Aug	4	L	4	56
		14	M	14	7
		4	S	4	5
	1 Oct	5	L	5	7
		4	M	3	6
		2	S	1	6
Frenchman Creek	28 July	12	M	0	0
Headwaters (Salmon River)	28 July	10	M	0	0
Salmon River (Decker Flat)	25 Aug	9	L	8	3
		15	M	13	3
		7	S	4	1
Beaver Creek	26 Aug	12	M	0	0
		7	S	0	0
Frenchman Creek	26 Aug	2	L	0	0
		10	M	0	0
		3	S	0	0
Headwaters (Salmon River)	26 Aug	6	L	0	0
		12	M	0	0
		12	S	0	0
Salmon River (Decker Flat)	2 Oct	3	L	3	2
		21	M	21	2
		2	S	2	1
Beaver Creek	2 Oct	8	L	0	0
		12	M	0	0
		2	S	0	0
Frenchman Creek	2 Oct	4	L	0	0
		10	M	0	0
		4	S	0	0
Headwaters (Salmon River)	2 Oct	2	M	0	0

*The sculpin were divided into four size classes based on total length (TL). XL: greater than 115 mm TL, L: 95 to 115 mm TL, M: 85 to 94 mm TL, S: 65 to 84 mm TL.

**When there is more than 100 metacercariae in the orbit of a fish eye, a plus (+) designation is used.

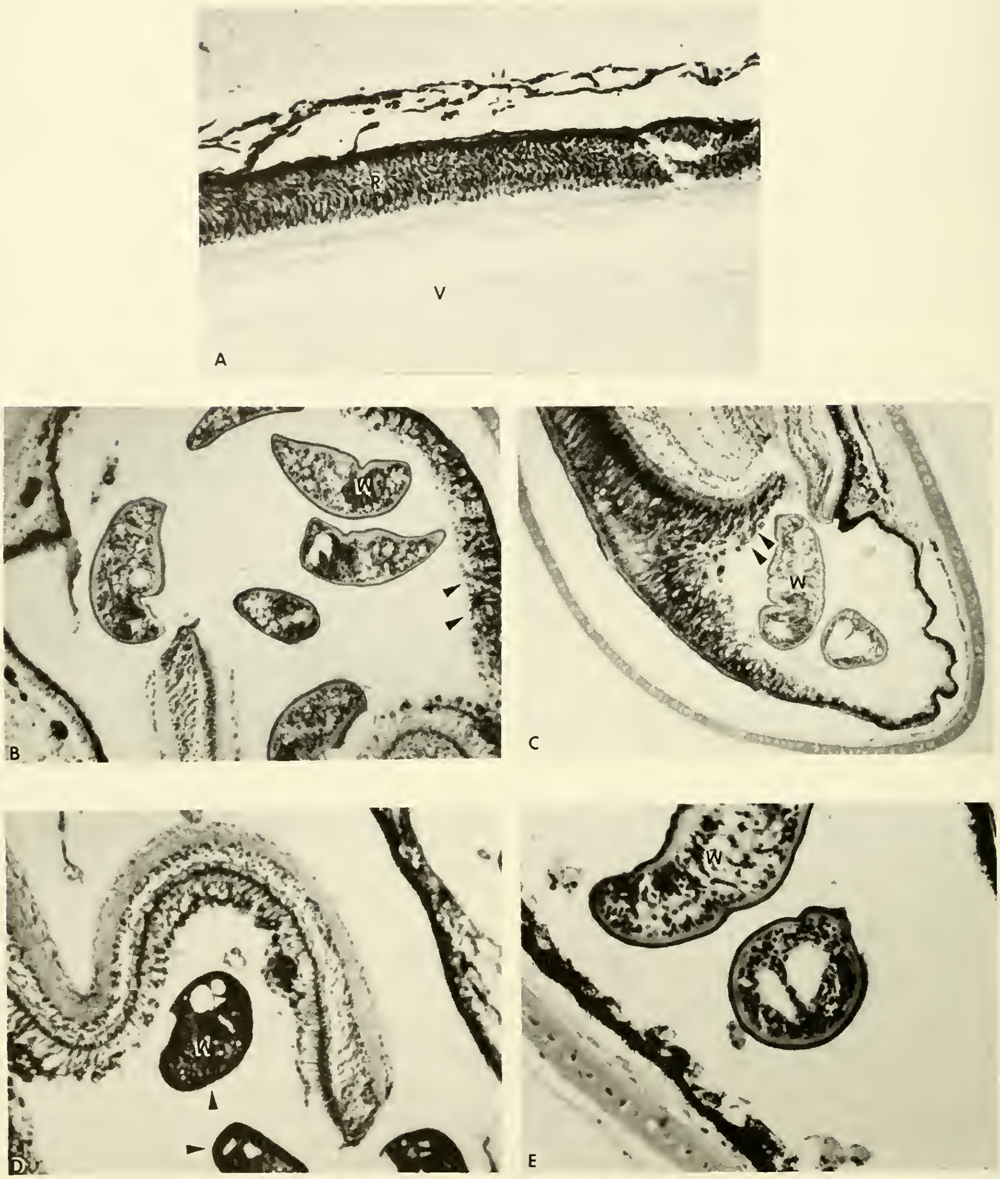

Fig. 1. Figure A represents normal tissue found in the vitreous-retina area of a fish eye. B,C,D,E show infected eyes of a sculpin in which the *Diplostomum* metacercariae occupy the vitreous-body (V)–retina (R) area of fish. Note the detachment (arrow) of the retina due to metacercarial invasion (B,C).

and money have been spent in an attempt to control and ultimately eradicate it. The greatest damage caused by this fluke is blindness and death in a variety of game fish throughout the world and specifically in Utah and Idaho.

The survey completed on the potential hosts from the ichthyofauna of the Upper Salmon River and drainages is quite extensive. During 1982, 384 sculpin were obtained from the main Salmon River near Obsidian, Idaho, of which 98 percent were infected with the eye fluke (1 to 100+ worms per eye); 185 sculpins were sampled upriver from the first collection site and from drainages into the river, of which 28 percent were infected (1 to 3 worms per eye); 317 salmonids and 16 Dace and Suckers were sampled from

TABLE 2. Summary of all samples from fish representing the family Salmonidae checked for the fish eye fluke, *Diplostomum spathaceum*, 1982, Salmon River, Idaho.

Location	Date of sample in 1982	Species of fish	Number of fish	Size of fish	Number with eye flukes	Eye flukes per eye
Salmon River (Side channel)	28 June	Chinook *Oncorhynchus tshawytscha*	35	Fingerling	1	1
		Steelhead *Salmo gairdneri*	12	Catchable 10–14 inches (TL)*	1	1
Salmon River (Main channel)	29 June	Whitefish *Prosopium williamsoni*	3	10–16 inches (TL)	2	18
		Steelhead *Salmo gairdneri*	4	10–14 inches (TL)	0	0
		Rainbow Trout *Salmo gairdneri*	1	12 inches (TL)	0	0
	30 June	Whitefish *Prosopim williamsoni*	2	10–14 inches (TL)	2	15
		Steelhead *Salmo gairdneri*	3	10–16 inches (TL)	0	0
	1 Aug	Whitefish *Prosopium williamsoni*	1	12 inches (TL)	0	0
	27 Aug	Rainbow Trout *Salmo gairdneri*	5	10–15 inches (TL)	4	2
Salmon River (Main channel)	27 Aug	Steelhead *Salmo gairdneri*	6	10–14 inches (TL)	1	1
		Chinook *Oncorhynchus tshawytscha*	17	Fingerling	2	1
Salmon River (Main channel)	28 July	Brook Trout *Salvelinus fontinalis*	1	15 inches (TL)	0	0
		Rainbow Trout *Salmo gairdneri*	3	9–14 inches (TL)	1	1
Salmon River (Side channel)	29 July	Chinook *Oncorhynchus tshawytscha*	12	Fingerling	0	0
Holding tank (Salmon River water)	29 July	Chinook *Oncorhynchus tshawytscha*	12	Fingerling	0	0
Salmon River (Middle channel)	25 Aug	Chinook *Oncorhynchus tshawytscha*	15	Fingerling	0	0
Salmon River (Side channel)	25 Aug	Chinook *Oncorhynchus tshawytscha*	32	Fingerling	0	0
Salmon River (Main channel)	25 Aug	Chinook *Oncorhynchus tshawytscha*	14	Fingerling	1	1
Salmon River (Middle channel)	25 Aug	Rainbow Trout *Salmo gairdneri*	7	9–15 inches (TL)	3	3
Salmon River (Side channel)	25 Aug	Rainbow Trout *Salmo gairdneri*	2	10–12 inches (TL)	2	1
Salmon River (Side channel)	25 Aug	Chinook *Oncorhynchus tshawytscha*	5	Spawners 26–36 inches (TL)	0	0
Salmon River (Side channel)	26 Aug	Chinook *Oncorhynchus tshawytscha*	6	Spawners 26–42 inches (TL)	0	0

*TL: total length of fish.

Table 2 continued.

Location	Date of sample in 1982	Species of fish	Number of fish	Size of fish	Number with eye flukes	Eye flukes per eye
Holding Tank (Salmon River water)	26 Aug	Chinook *Oncorhynchus tshawytscha*	26	Fingerlings	1	1
Salmon River (Middle channel)	1 Oct	Chinook *Oncorhynchus tshawytscha*	19	Fingerlings	1	1
Salmon River (Main channel)		Chinook *Oncorhynchus tshawytscha*	6	Fingerlings	0	0
Salmon River (Side channel)		Chinook *Oncorhynchus tshawytscha*	25	Fingerlings	0	0
Holding Tank (Salmon River water)	1 Oct	Chinook *Oncorhynchus tshawytscha*	20	Fingerlings	1	1
Salmon River (Middle channel)	1 Oct	Rainbow Trout *Salmo gairdneri*	3	7–12 inches (TL)	1	3
Beaver Creek	28 July	Brook Trout *Salvelinus fontinalis*	3	6–10 inches (TL)	0	0
Frenchman Creek	28 July	Brook Trout *Salvelinus fontinalis*	3	5–9 inches (TL)	0	0
Frenchman Creek	28 July	Chinook *Oncorhynchus tshawytscha*	1	Fingerling	0	0
Salmon River (Decker Flat)	25 Aug	Rainbow Trout *Salmo gairdneri*	2	6–7 inches (TL)	0	0
		Brook Trout *Salvelinus fontinalis*	2	5–6 inches (TL)	0	0
Beaver Creek	26 Aug	Brook Trout *Salvelinus fontinalis*	7	4–10 inches (TL)	0	0
Frenchman Creek	26 Aug	Brook Trout *Salvelinus fontinalis*	2	5–8 inches (TL)	0	0
Headwaters	26 Aug	Brook Trout *Salvelinus fontinalis*	1	5 inches (TL)	0	0
Salmon River (Decker Flat)	2 Oct	Chinook *Oncorhynchus tshawytscha*	26	Fingerlings	1	1
Beaver Creek	2 Oct	Rainbow Trout *Salmo gairdneri*	4	8–10 inches (TL)	0	0
		Brook Trout *Salvelinus fontinalis*	7	3–8 inches	0	0
Frenchman Creek	2 Oct	Brook Trout *Salvelinus fontinalis*	19	7–12 inches (TL)	0	0

*TL: total length of fish.

the first site, of which 81 percent (1 to 18 worms per eye) and 13 percent (1 worm per eye) were infected, respectively; and upriver only 1 percent of the 70 salmonids was infected with 1 worm per eye. I have checked most of the fish species in that part of the Salmon River for metacercariae. The sculpin, *Cottus bairdi*, appears to be an excellent indicator host for the eye fluke. The fluctuation in numbers of metacercariae per infected fish correlates with sporocyst stages in the snail, which will be the topic for another paper. Diplostomatosis has been reported in Russia, Germany, Finland, Ireland, Mexico, Italy, Africa, England, Scotland, and the United States (Hoffman 1970, Davies 1972).

Diplostomatosis is considered to be specific for freshwater fish. Dogiel (1962 and 1934) showed that lampreys and salmon become infected with the eye fluke during spawning migrations to fresh water. It is possible that salmon fry become free of *Diplostomum* after they return to the sea (Dogiel 1962).

Direct contact between the fish and its parasite is required for cercarial penetration. Thus, the fish must swim into the infected areas since cercariae have a limited swimming ability. Slyczynska-Jurewuz (1959) utilized cages to show that fish have a greater tendency to get diplostomatosis as they move closer to the shore. This is due to the preferred habitat of snails. The maximum rate of infection occurs during the months of June and July, coinciding with the peak of cercarial discharge (Kamenskii 1964). The peak infection occurred during August and September for the current study.

Snails prefer warm, clean, slow-moving water with vegetation in which to live (Macon 1950). This was also observed for snails infected with sporocysts from the Upper Salmon River. Lymnaeidae are generally found in water with at least 15 parts per million of bound carbon dioxide and with a pH of 7 or above (Pennak 1953). These snails are known to eat both plant and animal material but prefer vegetation when available. They live approximately one and a half years and have been known to estivate up to 3 years (Pennak 1953). Lymnaeids usually are found in less than 4.5 feet of water and can live without free oxygen (Cheatum 1934). Young snails are more susceptible to miracidial penetration than older snails, which appear to have some type of resistance (Cort et al. 1957).

Fish and other cold-blooded vertebrates seem to have a fairly low resistance to metazoan parasites; thus, extensive damage to host tissue is not uncommon (Snieszko 1969). There continues to be debate concerning the general pathologic effects of *D. spathaceum* infecting the fish lens. Visual perception of infected fish varies from total blindness (Ferguson 1943a) to impaired vision (Ghittino 1974).

Pathologic effects to the eye by the parasite are characterized by inflammation, vascular disturbances, exophthalmia, destruction of lens tissue, necrosis, ulceration of the cornea, and eventual loss of the lens. Secondary damage can occur through the development of *Saprolegnia* within the necrotic tissue (Palmieri et al. 1976).

Diplostomum spathaceum causes several diseases of the eye region in a variety of fish. First signs of an infection are a number of localized swellings or red patches on the fins, body, or eye area where cercariae penetrate and cause rupture of the surface blood vessels. In certain reported cases, mass entry of cercariae through the skin or gills causes obstruction of the blood vessels in the gills, resulting in asphyxia, shock, and damage to the nervous system. Once the ultimate site location is found, metacercariae penetrate the iris, retina, and lens capsule by means of anterior spines and secretions of the anterior penetration glands and encyst in these tissues or within the vitreous body or crystalline lens of the infected fish, causing immediate hemorrhaging of the local area. The worms may

TABLE 3. Summary of all samples from Dace and Suckers checked for the fish eye fluke, *Diplostomum spathaceum*, 1982, Salmon River, Idaho.

Location	Date of sample in 1982	Species of fish	Number of fish	Size of fish	Number with eye flukes	Eye flukes per eye
Salmon River (Side channel)	28 June	Dace (*Rhinichthyes*)	4	2–4 inches (TL)	1	1
Salmon River (Main channel)	1 July	Sucker (*Catostomus*)	1	14 inches (TL)	0	0
Salmon River (Main channel)	27 July	Dace (*Rhinichthyes*)	1	3 inches (TL)	0	0
Salmon River (Side channel)	28 July	Dace (*Rhinichthyes*)	4	3–4 inches (TL)	1	1
Salmon River (Side channel)	25 Aug	Dace (*Rhinichthyes*)	6	4–5 inches (TL)	0	0

*TL: total length of fish.

TABLE 4. Range of eye fluke infection; from initial sampling area along the Upper Salmon River to the headwaters of the Salmon River: *Cottus bairdi* (Sculpin) indicator species.

Location of sample	Miles from initial sample site	Species	Date in 1982	Total fish	Number infected	*Number of eye flukes per eye
Salmon River (Initial site)	0	Sculpin	27 July	32	31	39
Frenchman Creek	22	Sculpin	28 July	12	0	0
Headwaters (Salmon River)	23	Sculpin	28 July	10	0	0
Salmon River (Initial site)	0	Sculpin	25 Aug	31	31	46+
Salmon River (Decker Flat)	9	Sculpin	25 Aug	31	25	2
Beaver Creek	18	Sculpin	26 Aug	19	0	0
Frenchman Creek	22	Sculpin	26 Aug	15	0	0
Headwaters (Salmon River)	23	Sculpin	26 Aug	30	0	0
Salmon River (Initial site)	0	Sculpin	1 Oct	32	32	61+
Salmon River (Decker Flat)	9	Sculpin	2 Oct	26	26	2
Beaver Creek	18	Sculpin	2 Oct	22	0	0
Frenchman Creek	22	Sculpin	2 Oct	18	0	0
Headwaters (Salmon River)	23	Sculpin	2 Oct	2	0	0

*When there is more than 100 metacercariae in the orbit of a fish eye, a plus (+) designation is used.

stay viable from 10 months to two years or longer, causing chronic blindness due to parasitic cataract, keratoglobus, herniation, and tumor formation. During this time fish cannot feed normally, and they stop growing or die.

ACKNOWLEDGMENTS

Thanks are given to the Idaho Fish and Game Commission for their financial support of the project, especially to Grant Christensen, who made final arrangements for the study. Arnie Miller and Gary Gadwa helped with the collections of fish during each trip.

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EVALUATION OF VARIETIES IN *STANLEYA PINNATA* (CRUCIFERAE)

Robert W. Lichvar[1]

Abstract.— *Stanleya pinnata* var. *gibberosa* Rollins is a narrow endemic from southwestern Wyoming. This taxon is based upon the morphological characters of crooked petals and all leaves bipinnate. During field work in 1980, a population near the type locality of this variety was located that had plants with both bipinnate and entire leaves. Due to this unusual population, further field and herbarium studies were done to resolve the taxonomy of var. *gibberosa*. These further studies showed that this taxon is based upon young individuals of var. *bipinnata*.

Rollins (1939), in his monograph of the genus *Stanleya*, treated four varieties under *S. pinnata* (Pursh) Britt. He felt that this polymorphous species treated with just four varietal entities was rather unsatisfactory because such a large range of variation had to be included.

During field work in 1980 to evaluate the threats to, and distribution of *Stanleya pinnata* var. *gibberosa* Rollins for proposed protection under the Endangered Species Act, an unusual population of *S. pinnata* was discovered near the type locality for var. *gibberosa*. Var. *gibberosa* was characterized by Rollins (1939) as having a crooked petal and all leaves bipinnate. The unusual population from near Ft. Bridger, Wyoming, had plants with both bipinnate and entire leaves and straight and crooked petals. Another population located in 1982 near the Owl Creek Range in central Wyoming showed the same variable characteristics as those from Ft. Bridger. These two populations were studied further.

Methods

Both field and herbarium studies were undertaken to sample the range of variation for *Stanleya pinnata* var. *gibberosa*. The closest variety morphologically, var. *bipinnata* (Greene) Rollins, was used for comparison. Field observations included flowering dates, habitats, leaf and petal shapes, and variations within the populations. Herbarium studies were done at the Rocky Mountain Herbarium (RM), Laramie, Wyoming, the New York Botanical Garden (NY), Bronx, New York, and the Gray Herbarium (GH), Cambridge, Massachusetts. All the characters used to separate varieties of *S. pinnata* were studied. The following set of specimens were most pertinent to the study: at RM: Rollins 2320, 2351, 2382, 2388, 3077; Dorn 2942; Lichvar 2859, 4196, 5174; Nelson 3562, 7375; Porter 3367, 7768; Freytag 16; Berth s.n.; Goodding 1925; and Osterhout 1094: at GH: Rollins 2320, 2351, 2382, 2388, 3077, 57265, 79155: and at NY: Rollins 57265.

Results and Discussion

The questionable status of *Stanleya pinnata* var. *gibberosa*, a narrow endemic, was first apparent after a visit to a population at Ft. Bridger, Wyoming, on 11 June 1980. This population had individuals with two different types of leaves and a wide range of plant heights. Those plants that were smaller in stature had all leaves bipinnate, and those individuals larger in stature had bipinnate, pinnate, and entire leaves. A continuum of these characters existed in this population between the two extremes of all bipinnate or all simple leaves, however. These observations, combined with those of Dorn (1979), stating that the key character of a crooked petal had broken down due to it being found in other varieties of the species, warranted further field and herbarium studies.

The main morphological characters that have been used to separate var. *gibberosa* and var. *bipinnata* are:

[1]Wyoming Natural Heritage Program, The Nature Conservancy, 1603 Capitol Avenue, Room 325, Cheyenne, Wyoming 82001.

1. Petals straight or nearly so; leaves bipinnate to entire .... var. *bipinnata*
— Petals strongly crooked between blade and claw; all leaves bipinnate .. var. *gibberosa*

Rollins (1939) stated that these two varieties each had a separate unified range in certain parts of Wyoming and Colorado. Based on his interpretation of ranges of these taxa, all the specimens that are used in this study had been previously identified according to the ranges given by Rollins.

Specimens of both varieties were compared (Table 1) and showed that three specimens of var. *gibberosa* had crooked petals and five specimens had straight petals. Four collections of var. *bipinnata* had crooked petals and four had either all straight or a mixture of crooked and straight petals. This variation confirmed observations made by Dorn (1979).

The same group of herbarium specimens was also compared for pubescence and leaf shape. Three specimens of var. *gibberosa* had scant pubescence, three had dense, and two had a combination of dense and scant hairs. In var. *bipinnata*, five specimens had scant hairs and three had scant to dense hairs. Complete overlap occurs in the pubescence. Var. *gibberosa* had five specimens with some upper leaves entire and three with all leaves bipinnate. Var. *bipinnata* had five specimens with entire upper leaves and three with bipinnate upper leaves. The leaf characters of these two varieties overlap. Also, three other characters were recorded from herbarium sheets, the flowering dates, fruit shapes, and habitat types. All three of these features showed a continuous overlap.

The combination of petal and leaf shapes in these two varieties showed similar overlap. Var. *gibberosa* had four specimens with straight petals and entire leaves at the summit of the plants, the combination for var. *bipinnata*. Var. *bipinnata* had two specimens with crooked petals and all leaves bipinnate, the combination for var. *gibberosa*. These two specimens, Porter 3367 and Nelson 7375, are from southeastern Wyoming and are far outside the supposed range of var. *gibberosa*.

Field studies showed the same kind of overlap. Lichvar 5174 was collected in 1982 in the upper edge of the Wind River Basin along the south flank of the Owl Creek Mountains, Wyoming. This population of *Stanleya pinnata* included a series of plants that ranged from all bipinnate leaves to ones with a mixture of pinnate and entire leaves. The plants in this population also had flowers that had both straight and crooked petals. The individuals that had a combination of all bipinnate leaves and crooked petals were small in stature and were young in age. As the individuals in this population grew in stature and older in age, the leaf shapes

TABLE 1. Analysis of herbarium specimens of two varieties of *Stanleya pinnata*.

Character	Var. *gibberosa*	Var. *bipinnata*
Petal shape	3 crooked* 5 straight	4 crooked 4 with a mixture of crooked or straight
Leaf shape	3 all bipinnate 5 entire	3 all bipinnate 5 entire
Pubescence	3 scant 3 dense 2 with dense and scant	5 scant 3 scant to dense
Flowering dates	24 May to 29 June	2 May to 3 July
Fruit shape	Torulose	Torulose
Habitat type	disturbed soil of canal banks to limy bluff	gumbo swales to limy gravelly ridge
Combination of petal and leaf shapes	4—straight petals with some entire leaves 1—crooked petals and all leaves bipinnate 3—crooked petals and some entire leaves	2—straight petals and some leaves entire 2—crooked petals with all leaves bipinnate 2—straight petals with all leaves bipinnate 1—plants in fruit with some leaves entire 1—plants in fruit with all bipinnate leaves

*The number represents the number of herbarium specimens with that character.

ranged from pinnate to entire and had a mixture of crooked and straight petals. The smaller individuals in the population were of the var. *gibberosa* aspect and the larger individuals were both the var. *bipinnata* and var. *pinnata* aspects. This population expressed the same type of variability as the one at Ft. Bridger but was 180 miles (288 km) outside the previously known distribution of var. *gibberosa*.

Conclusions

A reevaluation of the status of *Stanleya pinnata* var. *gibberosa* can now be made because of the availability of more collections and further field observations. The small stature of var. *gibberosa* with nearly all or all bipinnate leaves is not necessarily unique to this taxon. Several specimens from well outside the supposed range of var. *gibberosa* are identical. Also, at least two populations exist with highly variable morphology encompassing both var. *gibberosa* and var. *bipinnata*. Both populations have a continuum of var. *gibberosa* type individuals that are small in stature and young in age with all leaves bipinnate and crooked petals to older individuals with pinnate leaves plus a mixture of crooked and straight petals.

Other genera in Cruciferae have similar variation in leaf shapes. Within *Lepidium densiflorum* Schrad. there are several different shapes of leaves. The basal leaves range from entire to pinnatifid, but no varietal distinctions have been based upon these various leaf shapes.

If the Ft. Bridger and the Owl Creek Range populations represent two varieties at each location that are hybridizing and backcrossing with the parents, then one would expect several different types of plants with various age groups for each. Instead, these two populations have a continuum of characters that are associated with variously aged individuals.

It appears that var. *gibberosa* is based on young individuals with a small stature. Therefore, it is concluded that var. *gibberosa* is synonymous with var. *bipinnata*. Further study may show both are synonymous with var. *pinnata*.

Acknowledgments

Reed Rollins is thanked for openly discussing his views of the taxonomy of *Stanleya pinnata* and Robert Dorn for reviewing the manuscript and making valuable comments.

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SOME ASPECTS OF THE PRESETTLEMENT VEGETATION OF THE PICEANCE BASIN, COLORADO

William L. Baker[1]

Abstract.— Eight plant associations, not previously described in Colorado, and representative of part of the presettlement vegetation spectrum in the oil shale region of northwestern Colorado, are described and illustrated, based on an inventory of relatively undisturbed vegetation remnants.

The Piceance Basin is underlain by oil shale estimated to contain 1.2 trillion barrels of oil (Murray and Haun 1974). Interest in the potential development of this resource has resulted in extensive study of the current vegetation of the basin. Most of this research consists of reports (Ferchau 1974, Keammerer 1977, Keammerer and Stoecker 1975) and theses (Tiedeman 1978, Vories 1974), though two published studies are available (Tiedeman and Terwilliger 1978, Ward et al. 1974). A few regional studies (James and Marr 1966, Marr and Buckner 1974, Marr et al. 1973) contain some quantitative data or general description of the Piceance Basin.

Some additional reports pertain to the Roan and Parachute Creek areas south of the Piceance Basin (Ferchau 1973, Keammerer 1974, Keammerer and Keammerer 1980, Keammerer and Peterson 1981, Thorne Ecological Institute 1973). Graham (1937) provides a general overview of major vegetation types in the Uinta Basin, including this general area of Colorado.

None of these studies characterizes potential vegetation, presettlement vegetation, or habitat types (Daubenmire 1952), concentrating instead on existing vegetation, much of which has been altered by over 100 years of domestic livestock grazing and agriculture. Knowledge of both potential and existing vegetation is essential if land managers are to be able to effectively rehabilitate disturbed lands.

The goal of this paper is to discuss and present data on eight plant associations representative of presettlement vegetation in the Piceance Basin, based on a study of relatively undisturbed remnants. A qualitative overview of the vegetation in this area, and the impacts of grazing on this vegetation are discussed in Baker (1982). This information was gathered as part of a general botanical inventory of the Piceance Basin (Peterson and Baker 1982).

Study Area

The Piceance Basin is located in Rio Blanco and Garfield counties in northwestern Colorado. It is an approximately 2850 km^2 (1100 mi^2) saucer-shaped basin bounded on the south by the Roan Plateau, on the west by the Douglas Creek drainage, on the north by the White River, and on the east by the Grand Hogback. The Piceance Basin is often considered to be a part of the eastern Uinta Basin.

The entire study area is underlain by the Eocene Green River Formation, a kerogen-bearing marlstone (Donnell 1961), which outcrops as large cliff exposures around the margin of the basin, and also occurs scattered throughout the central part of the basin as narrow bands, or tongues, in a Uinta Formation matrix. The Eocene Uinta Formation, predominately a brown sandstone, is the primary exposed surface rock over much of the central part of the basin.

Climatic data are available from Craig, Colorado (Gale Research Co. 1980), 75 km northeast of the study area, at about the same elevation as the central part of the basin. Mean annual precipitation there is 338 mm,

[1]Colorado Natural Heritage Inventory, 1550 Lincoln Street, Suite 110, Denver, Colorado 80203.

distributed fairly evenly throughout the year, with a slight peak from afternoon convective thundershowers in August. Mean January temperature is -7.7 C, with mean July temperature 19.4 C.

The study area is vegetationally similar to other parts of the Uinta Basin. *Atriplex confertifolia* stands occur at the lowest elevations on slopes, with *Artemisia tridentata* stands, sometimes mixed with *Sarcobatus vermiculatus*, occupying draws and creek bottoms. *Juniperus osteosperma–Pinus edulis* woodlands alternate with *Artemisia tridentata* openings on uplands below 2300 m, with *Agropyron spicatum* var. *inerme* grasslands formerly occupying flat ridges and uplands, and southerly-facing slopes. Above 2300 m, these grasslands are interrupted on slopes by a mixed shrub vegetation dominated by *Quercus gambelii*, *Amelanchier utahensis*, *Prunus virginiana*, *Rosa woodsii*, *Cercocarpus montanus*, and *Symphoricarpos oreophilus*, and occasional patches of *Pseudotsuga menziesii* or *Populus tremuloides* forests on the most protected northerly-facing slopes. The study area has been extensively grazed by cattle and sheep since the late 1800s. Many of the valley bottoms have been converted to agriculture. Mining of oil shale is currently limited to two 5000-acre Federal prototype lease tracts.

Methods

From May to August 1982, a reconnaissance survey was conducted to locate relatively ungrazed and unlogged vegetation remnants in the study area. Every section of approximately 1100 sections in the study area was searched. Methods of locating such remnants are similar to methods used by Daubenmire (1970). Remnant areas were recognized by the following general features: (1) absence of obvious physical signs of grazing, such as cattle and sheep trails and terraced slopes, bedding areas, excessive amounts of trampled and broken shrub stems, compacted soils, scat, and logging or woodcutting signs, such as stumps, access roads, cutting debris, etc.; (2) absence or low coverage of exotic plant species (e.g., *Bromus tectorum*, *Poa pratensis*, *Chorispora tenella*); (3) low coverage of plant species known to increase when domestic grazing occurs (e.g., *Chrysothamnus* spp., *Gutierrezia sarothrae*, *Artemisia frigida*); (4) presence of at least remnants of a soil cryptogam layer on relatively flat sandy to silty soils. On rocky sites, slopes, or talus, presence of large crustose lichens on exposed rock surfaces is suggestive of lack of recent heavy use, because rocks turned or dislodged by cattle and sheep hoof action cannot maintain large lichen growths; (5) presence of healthy, large native plants, generally abundant grass cover, with individual grass plants having many flower stalks, standing litter, and live centers; (6) general absence of plant pedestaling, excessive rilling and gullying, and other signs of excessive or accelerated erosion. Some additional features are specific to particular associations. Generally, a combination of these factors made identification of remnants relatively simple. Remnants generally occurred on steep or inaccessible slopes far from water, or in areas excluded from grazing by accidents of fencing. Observations on effects of grazing on each association are based on a qualitative comparison of several sites and fenceline contrasts.

Remnants located were sampled quantitatively using a .1 hectare (20 × 50 m) plot method widely used in gradient analysis (e.g., Peet 1981). Shrub and herb percent canopy cover were sampled along the center line of the plot using 25 consecutive .5 × 2 m quadrats. Plots were located in areas of visually homogenous vegetation. Tree size class structure was sampled by tallying stem within the plot in 2-inch size classes, with diameter measured at breast height, or below the major point of branching (on *Juniperus* and *Pinus*).

This study concentrates on eight plant associations sampled and characterized based on 27 stands. Classification follows the methods of Daubenmire (1970). The entire spectrum of presettlement vegetation in the Piceance Basin could not be sampled quantitatively, partly because of time constraints, and partly because sufficient remnants could not be located that were free of disturbance effects, to characterize the original composition of all the associations. A preliminary qualitative classification of the original vegetation of the basin, based on inference and reconnaissance data, and comparison with literature from adjoining areas is in Baker (1982).

Nomenclature follows Kartesz and Kartesz (1980). Voucher specimens are deposited at the Colorado State University Herbarium (CS). Soil types cited with each association were not sampled in each plot, but are based on recent soil maps (Tripp et al. 1982).

Results and Discussion

Table 1 summarizes shrub and herb percent cover. Table 2 summarizes tree size class data. Each of the associations is illustrated in Figure 1 and discussed below.

1. *Juniperus osteosperma–Pinus edulis/ Agropyron spicatum* var. *inerme*

This association occupies gently sloping ridge tops and crests of low hills and mesas, often southerly-facing, between 1700 and 2150 m in elevation. It most often occurs on Uinta Formation sandstone, but may also occur on Green River Formation marlstone. Sampled stands occur exclusively on the Rentsac soil series, a Lithic Ustic Torriorthent, common in the basin (Tripp et al. 1982).

The association has a savannalike appearance (Figure 1a), with widely spaced trees in a dense grass matrix and few shrubs present. *Oryzopsis hymenoides* may codominate in some stands, but is most commonly a minor species or is absent entirely. A moderately developed soil cryptogam layer occurs in excellent condition stands.

The association is at the lower, drier elevational end of the pinyon-juniper zone in this area. *Juniperus* appears to be slightly better adapted to these sites than *Pinus*, having more stems on most sites (Table 2). A few sites may lack *Pinus* entirely. Both species generally have good reproduction and commonly have a few large, old stems on most sites.

The association degrades on relatively flat sites, under heavy domestic grazing, to a similar community with *Haplopappus acaulis* dominant in the understory. This community has been described by Vories (1974, Association 14). On more sloping sites *Artemisia tridentata*, *Gutierrezia sarothrae*, *Chrysothamnus* spp., and *Bromus tectorum* become dominants.

This association has not been reported from other parts of Colorado, but Shute and West (no date) mention a similar association from the Uinta Basin near Price, Utah, where *Agropyron spicatum* var. *inerme* dominates the understory of pinyon-juniper woodlands on "level mesa tops, deep wind-deposited (or sandy if shallow over sandstone) soils . . ." (p. 26). Though compositional data are not provided, this is a similar environmental position and similar dominants. Data in Isaacson (1967, Table 5, plots 147–149, 192) also appear to represent this association. These data were collected at unspecified localities in the Uinta Basin of Colorado and Utah. It appears likely that this association occurs in scattered localities across the Uinta Basin. This association is related to the *Juniperus osteosperma/Agropyron spicatum* association common in western Wyoming (Wight and Fisser 1968), which also occurs in Moffat County, Colorado. That association occurs north of the range limit of *Pinus edulis*. The awned variety (var. *spicatum*) of *Agropyron spicatum* is rare in the Piceance Basin, and never occurs mixed with *A. spicatum* var. *inerme*.

2. *Juniperus osteosperma–Pinus edulis/ Amelanchier utahensis–Cercocarpus montanus* marlstone barren

This association occurs on generally southerly-facing slopes of white marlstone of the Green River Formation, from 1975 to 2450 m in elevation. These sites have soils mapped as a complex of Torriorthents and Rock Outcrops (Tripp et al. 1982).

A well-developed tree and shrub layer are always present, but almost no herbaceous layer occurs. The association has conspicuous expanses of open, bare, exposed, partly decomposed white marlstone (Fig. 1b), alternating with clumps of *Amelanchier and Cercocarpus*. *Ephedra viridis* is often present.

Pinus edulis is often more abundant than *Juniperus osteosperma* on these sites, but old stems of both species commonly occur. *Pinus edulis* generally has more seedlings and saplings in this association than in any other association in the basin (Table 2).

TABLE 1. Percent cover and constancy of shrubs and herbs. Plant association numbers correspond to those in the text. 1 = *Juniperus osteosperma–Pinus edulis/Agropyron spicatum* var. *inerme*, 2 = *Juniperus osteosperma–Pinus edulis/Amelanchier utahensis–Cercocarpus montanus* marlstone barren, 3 = *Pinus edulis/Amelanchier utahensis–Arctostaphylos patula–Cercocarpus montanus/Carex pityophila*, 4 = *Pseudotsuga menziesii/Amelanchier utahensis–Quercus gambelii–Symphoricarpos oreophilus/Carex geyeri–Poa fendleriana*, 5 = *Artemisia tridentata* ssp. *wyomingensis–Symphoricarpos oreophilus/Elymus cinereus*, 6 = *Atriplex confertifolia/Agropyron spicatum* var. *inerme–Oryzopsis hymenoides*, 7 = *Agropyron spicatum* var. *inerme* Great Basin grassland, 8 = *Agropyron spicatum* var. *inerme–Oryzopsis hymenoides* Great Basin grassland. Table entries are percent canopy cover, followed by percent constancy, tr = trace quantities (less than .5 percent average cover); 100 percent is abbreviated to 99.9 percent.

Plant association number	1	2	3	4	5	6	7	8
Number of stands	4	3	3	3	3	4	4	3
SHRUBS								
Artemisia tridentata ssp. *wyomingensis*	.9 99.9	tr 33.3		tr 99.9	19.1 99.9	.8 99.9	tr 50.0	tr 99.9
Atriplex confertifolia	tr 25.0					5.4 99.9	tr 25.0	
Chrysothamnus viscidiflorus	tr 75.0	tr 33.3	tr 66.6	tr 33.3	1.9 99.9	tr 75.0	1.0 50.0	1.7 66.6
Chrysothamnus nauseosus	tr 75.0				3.0 66.6			tr 66.6
Symphoricarpos oreophilus	tr 99.9	tr 66.6	tr 66.6	12.4 99.9	28.6 99.9	tr 25.0	tr 25.0	
Tetradymia canescens	tr 50.0		tr 33.3				tr 75.0	
Ceratoides lanata	tr 25.0						tr 50.0	
Amelanchier utahensis	tr 25.0	11.5 99.9	11.7 99.9	3.7 66.6	tr 99.9		tr 50.0	
Cercocarpus montanus	tr 25.0	15.1 99.9	16.9 99.9	tr 33.3				tr 33.3
Quercus gambelii				13.6 99.9				
Ephedra viridis		1.3 33.3						
Purshia tridentata	tr 50.0	tr 33.3	tr 33.3	tr 33.3				
Mahonia repens		tr 66.6	tr 66.6	tr 99.9				
Gutierrezia sarothrae	tr 99.9			tr 33.3		tr 50.0	tr 50.0	
Chrysothamnus parryi						tr 25.0		
Arctostaphylos patula			24.8	99.9				
Pachistima myrsinites			tr 33.3	.6 66.6				
Artemisia frigida	tr 50.0					.9 99.9	tr 75.0	.8 99.9
Rosa woodsii				tr 33.3	.8 33.3			
Ribes inerme				tr 66.6				
Ceanothus martinii			tr 33.3					
Ribes cereum	tr 25.0							
GRAMINOIDS								
Carex pityophila	.6 99.9	tr 66.6	4.2 99.9	.8 99.9				
Carex geyeri				7.8 99.9	1.9 66.6			
Carex sp.					tr 66.6			
Bromus tectorum	tr 75.0				tr 33.3	tr 25.0		tr 33.3
Stipa comata	1.4 75.0				1.6 33.3	tr 25.0	.6 25.0	tr 66.6
Poa sandbergii	tr 75.0						tr 25.0	
Poa fendleriana	tr 75.0			3.2 99.9	tr 33.3			
Agropyron spicatum var. *inerme*	16.0 99.9	tr 33.3	tr 66.6	tr 33.3		13.8 99.9	22.1 99.9	11.8 99.9
Oryzopsis hymenoides	5.1 99.9	tr 33.3	tr 66.6	tr 99.9	tr 66.6	5.6 99.9	1.2 99.9	9.8 99.9
Koeleria cristata	1.8 99.9			tr 99.9	tr 33.3	tr 25.0	2.4 75.0	
Oryzopsis micrantha				1.0 66.6				
Bromus ciliatus				tr 33.3	1.5 99.9			
Elymus cinereus				tr 33.3	20.5 99.9			tr 33.3
Stipa columbiana					1.8 99.9			
Poa pratensis					1.9 66.6			
Agropyron smithii				tr 33.3	.5 99.9		tr 25.0	
Agropyron trachycaulum				tr 66.6	5.6 99.9			
Poa interior					.8 99.9			
Bromus carinatus					tr 66.6			
Stipa lettermanii				tr 33.3	tr 66.6			
Poa nevadensis					tr 33.3			
Sitanion hystrix				tr 66.6		tr 25.0		
FORBS								
Eriogonum umbellatum	tr 50.0		tr 33.3	tr 66.6	tr 33.3			
Machaeranthera grindelioides	.8 99.9	tr 66.6	tr 99.9			tr 50.0		

Table 1 continued.

Plant association number	1	2	3	4	5	6	7	8
Number of stands	4	3	3	3	3	4	4	3
Opuntia polyacantha	tr 50.0							
Chamaesyce fendleri	tr 50.0							
Phlox hoodii	.9 99.9							
Physaria acutifolia	tr 75.0	tr 99.9	tr 66.6			tr 75.0	tr 75.0	tr 66.6
Taraxacum officinale	tr 25.0			tr 33.3	1.5 99.9			
Galium coloradense	.6 99.9					tr 25.0	tr 25.0	1.1 33.3
Haplopappus acaulis	.7 75.0							
Cryptantha sericea	tr 99.9	tr 33.3	tr 33.3	tr 66.6		tr 75.0	.5 75.0	tr 33.3
Commandra umbellata	tr 50.0			tr 33.3			tr 25.0	
Astragalus chamaeleuce	tr 50.0					tr 50.0	tr 50.0	tr 33.3
Hymenopappus filifolius	.5 25.0		tr 33.3			tr 25.0	tr 25.0	
Senecio multilobatus	tr 99.9		tr 66.6	tr 33.3			tr 25.0	
Arabis spp.	tr 25.0	tr 33.3		tr 33.3			tr 25.0	tr 33.3
Eriogonum lonchophyllum	tr 75.0					1.4 99.9	1.5 99.9	1.4 99.9
Cirsium spp.	tr 75.0					tr 50.0	1.4 75.0	.9 66.6
Stephanomeria tenuifolia	tr 50.0					tr 25.0	tr 50.0	tr 66.6
Leptodactylon pungens	tr 33.3					tr 25.0	tr 25.0	tr 33.3
Astragalus convallarius	tr 75.0			tr 33.3	tr 33.3	tr 25.0	tr 25.0	tr 33.3
Senecio werneriifolius	tr 50.0							
Arabis lignifera	tr 75.0	tr 33.3						
Ipomopsis aggregata	tr 50.0			tr 33.3			tr 25.0	tr 33.3
Penstemon osterhoutii	tr 50.0					tr 25.0	tr 25.0	
Eriogonum alatum	tr 25.0						tr 25.0	
Phlox austromontana		.6 99.9	2.1 66.6					tr 66.6
Streptanthus cordatus	tr 50.0	tr 66.6	tr 66.6					
Draba sp.		tr 33.3						
Cryptantha flavoculata		tr 99.9	tr 33.3				tr 25.0	
Descurainea sp.		tr 33.3					tr 25.0	
Penstemon caespitosus	tr 25.0	tr 66.6	tr 99.9	tr 33.3			tr 25.0	
Lithospermum ruderale			tr 33.3		.5 99.9			
Frasera speciosa			tr 33.3	tr 33.3				
Achillea millefolium var. *lanulosa*			tr 66.6	tr 66.6	1.5 99.9			tr 33.3
Astragalus miser			.8 33.3	1.4 66.6	tr 33.3			
Caulanthus crassicaulis	tr 25.0	tr 33.3	tr 66.6			tr 25.0		
Galium boreale				tr 66.6	.9 99.9	tr 25.0		
Erigeron speciosus				1.8 99.9	tr 99.9			
Clematis occidentalis var. *dissecta*				tr 33.3				
Penstemon strictus				tr 33.3	tr 66.6			
Balsamorhiza sagittata		tr 66.6	tr 66.6	tr 66.6	tr 66.6			
Castilleja linariifolia				tr 66.6	tr 99.9			
Crepis occidentalis				tr 33.3	tr 66.6			
Calochortus gunnisonii				tr 33.3	tr 99.9			
Cirsium calcareum		tr 33.3	tr 33.3	tr 66.6			tr 25.0	
Artemisia ludoviciana	tr 25.0			tr 66.6	tr 33.3	tr 50.0	tr 50.0	1.8 99.9
Viguiera multiflora					tr 33.3			
Chenopodium sp.					tr 33.3			tr 66.6
Crepis acuminata					tr 33.3			
Oenothera sp.					1.5 99.9			
Descurainea pinnata					tr 33.3			
Collomia linearis					tr 66.6			
Androsace septentrionalis				tr 33.3	tr 33.3			
Microsteris gracilis ssp. *humilis*					tr 33.3			
Penstemon watsonii				tr 66.6	.5 33.3			
Ligusticum porteri					tr 66.6			
Geranium fremontii					.9 99.9			
Lupinus caudatus					1.1 66.6			
Composite sp.				tr 33.3	tr 66.6			

Table 1 continued.

Plant association number	1	2	3	4	5	6	7	8
Number of stands	4	3	3	3	3	4	4	3
Potentilla gracilis var. *pulcherrima*					tr 33.3			
Tragopogon dubius					tr 99.9			
Astragalus lutosus						tr 25.0	tr 50.0	
Penstemon sp.	tr 25.0					tr 25.0	tr 25.0	tr 33.3
Artemisia dracunculus						tr 75.0	tr 25.0	tr 66.6
Mentzelia humilis						tr 50.0	tr 25.0	.8 99.9
Astragalus kentrophyta	tr 75.0					tr 25.0	1.5 25.0	tr 33.3
Linum lewisii	tr 25.0						.7 75.0	tr 33.3
Euphorbia robusta	tr 50.0		tr 33.3			tr 25.0	tr 50.0	tr 66.6
Phacelia heterophylla				tr 33.3			tr 25.0	tr 33.3
Penstemon fremontii	tr 25.0			tr 33.3		tr 50.0	tr 25.0	
Lesquerella sp.							tr 25.0	
Erysimum asperum				tr 66.6	tr 66.6	tr 25.0	tr 50.0	
Astragalus spatulatus	tr 25.0						tr 25.0	
Hedysarum boreale			tr 33.3				tr 25.0	1.1 33.3
Phlox longifolia							tr 25.0	
Hymenoxys acaulis							tr 25.0	
Chaenactis douglasii							tr 50.0	
Oenothera caespitosa						tr 50.0		tr 66.6

The association has not been reported or named from other areas, though data in Keammerer and Peterson (1981:24) suggest an association very similar to this in composition occurs on the Naval Oil Shale Reserve directly adjoining the southern boundary of this study area. It is likely the association is restricted to Green River Formation exposures in the Piceance Basin/Roan Plateau area of Colorado.

3. *Pinus edulis/Amelanchier utahensis–Arctostaphylos patula–Cercocarpus montanus/Carex pityophila*

This association occurs on flat to gently sloping ridge top exposures of Green River Formation marlstone, from 2100 to 2450 m in elevation. All stands are mapped as occurring on the Rentsac soil series, a Lithic Ustic Torriorthent common in the basin (Tripp et al. 1982).

This association has a very dense shrub layer, and a depauperate herbaceous layer. It is the only association in the basin containing *Arctostaphylos patula* and *Ceanothus martinii.* The association always has very sharp boundaries. One can step across a line onto adjoining Uinta Formation sandstone, where *Arctostaphylos* does not occur, *Juniperus osteosperma* is co-dominant with *Pinus edulis,* and the herbaceous layer is much better developed. *Pinus edulis* is the only tree present on most sites. *Juniperus osteosperma* may have a few stems or seedlings on some sites (Table 2).

The association appears to be very fire susceptible, possibly due to the high shrub density. About half the range of the association in the basin has burned in the 100 years, and is in a postburn stage dominated by the three shrubs dominant in the understory of the mature stage.

This association has not been reported from other areas. It may be restricted to midelevation exposures of Green River Formation in the Piceance Basin.

4. *Pseudotsuga menziesii/Amelanchier utahensis–Quercus gambelii–Symphoricarpos oreophilus/Carex geyeri–Poa fendleriana*

This association typically occurs on the brows of northerly-facing slopes of draws, 1900–2600 m in elevation. It occurs on either Uinta Formation sandstone or Green River Formation marlstone. Slopes generally do not exceed about 30 degrees. Soils are highly variable from stand to stand, ranging from Cryoborolls and Haploborolls to Torriorthents (Tripp et al. 1982).

This association is more open and less protected than the *Pseudotsuga menziesii/Symphoricarpos oreophilus/Carex geyeri–Poa fendleriana* association also found in the basin (Baker 1982) on steeper slopes and in more mesic locations. The association has a dense shrub layer, with patches of *Carex* often densest under shrubs, and with *Poa* in the openings. *Quercus* seldom reaches tall shrub stature in this association, most commonly occurring as a low, often trailing shrub. *Amelanchier* may be absent from some low elevation stands on the driest sites. *Quercus* may also be absent from an occasional stand.

Pseudotsuga menziesii may be the only tree in some stands. *Juniperus scopulorum* is more commonly present, and may codominate on the most open, driest sites. Both trees appear to reproduce well in this association. *J. scopulorum* is excluded from the name because of only moderate constancy.

The association characteristically is crisscrossed with game trails, which result in much bare ground. Grazing of domestic animals generally reduces *Carex* and *Poa* and results in an increase in the exotic *Poa pratensis* and bare ground.

The association has not been described or named previously, but data in Vories (1974, Association 1), Keammerer (1974:23, 1977:43), Marr et al. (1973, plot 43), and Ferchau (1973:23) probably represent the association. The association has not been located outside the Piceance Basin/Roan Plateau area of Colorado.

5. *Artemisia tridentata* ssp. *wyomingensis–Symphoricarpos oreophilus/Elymus cinereus*

This association occurs near the heads of draws on alluvium, from 2200 to 2600 m in elevation. Soils are mapped in several series, all Cryoborolls (Tripp et al. 1982). The association grades downstream into an *Artemisia tridentata* ssp. *tridentata/Elymus cinereus* association. The association typically occupies only the upper 1–2 km and headwaters area of intermittent stream drainages.

The association is characterized by *Artemisia* scattered through a matrix of tall *Elymus* clumps. *Symphoricarpos* often grows under or interwoven with the *Artemisia* stems and is not readily visible (Figure 1e).

Grazing by domestic animals decreases *Elymus cinereus*, which results in an increase in exotic species (e.g., *Poa pratensis, Bromus tectorum*), and the density of shrubs.

This association apparently has not been described previously. It has been observed by this author in scattered localities in western Colorado, including the Danforth-Gray Hills area north of Meeker, and in northern Eagle county, always in essentially the same environmental position near the heads of draws at midelevations.

6. *Atriplex confertifolia/Agropyron spicatum* var. *inerme–Oryzopsis hymenoides*

This association occurs on moderately steep to steep talus slopes of Uinta Formation sandstone, or occasionally on tongues of Green River Formation, from 1850 to 2075 m in elevation. It often occurs on southerly-facing slopes, but may also occur on other aspects. These sites have soils mapped as a complex of Torriorthents and Rock Outcrops (Tripp et al. 1982).

The association has a grassland appearance (Figure 1f), but consistently contains 5–6 percent cover of *Atriplex confertifolia*. The association is characteristically sparse, with only 20–25 percent total cover, and much exposed bare soil.

Grazing by domestic animals generally decreases perennial grasses, and results in increases in *Artemisia tridentata, Gutierrezia sarothrae*, and bare ground. Only very rarely does *Atriplex confertifolia* become dense under heavy grazing pressure.

This association apparently has not been described previously. Tiedeman and Terwilliger (1978, p. 212) describe a soil-vegetation unit in the Piceance Basin similar to this association, but with the *Agropyron* identified as *A. trachycaulum*. This author has seen only *A. spicatum* var. *inerme* on dry slopes mixed with *Atriplex, A. trachycaulum* being found on more sheltered mesic north-facing slopes and in draws with a mixture of *Amelanchier, Artemisia, Symphoricarpos*, and other shrubs. A related association, *Atriplex confertifolia/Oryzopsis hymenoides* also occurs in the Piceance Basin and in the Roan Plateau area (Baker 1982), where it is very common on more directly south-facing slopes. This latter association also occurs across the northern Great Basin to California.

7. *Agropyron spicatum* var. *inerme* Great Basin grassland.

This association occurs in two settings in the Piceance Basin: (1) from 1950 to 2450 m in elevation on generally south-facing slopes, often on steep talus, on either Uinta Formation sandstone or Green River Formation marlstone, on soils mapped as a complex of Torriorthents and Rock Outcrops (Tripp et al. 1982); (2) from 2450 to 2700 m in elevation on broad ridge tops and plateaus that are often gently south or southwest facing, occurring on either Uinta Formation sandstone or Green River Formation marlstone, on soils mapped as the Starman-Vandamore complex, which is a complex of Lithic and Typic Cryorthents (Tripp et al. 1982).

This association is a rather sparse grassland with 15–30 percent total cover. *Oryzopsis hymenoides*, which co-dominates in association 8, occurs in this type with generally less than 10 percent of the cover of *Agropyron spicatum* var. *inerme*, and is most often absent entirely. Where it does have significant cover in this association, it has low frequency, occurring as occasional small, dense patches.

After observing numerous stands lacking the undisturbed characteristics cited in the methods section, five successional stages were recognized, based on increasing amounts of grazing impact to this association: (1) *Agropyron spicatum* var. *inerme* dominated climax, (2) *Agropyron spicatum* var. *inerme*–*Koeleria cristata*, (3) *Koeleria cristata* dominated, with occasional small patches of

TABLE 2. Tree diameter size distribution. Tree diameters are in inches measured at breast height (DBH). Seedlings are less than 1 in DBH and less than 1 m tall. Saplings are less than 1 in DBH and greater than 1 m tall. Entries are number of stems per size class. Species codes are JUOS = *Juniperus osteosperma*, JUSC = *Juniperus scopulorum*, PIED = *Pinus edulis*, PSME = *Pseudotsuga menziesii*.

Stand No.	Species code	Seedlings	Saplings	1–3	3–5	5–7	7–9
Juniperus osteosperma–Pinus edulis/Agropyron spicatum var. *inerme*							
1	JUOS	0	0	0	1	5	0
	PIED	0	0	0	1	2	2
2	JUOS	2	0	1	2	2	1
	PIED	4	0	1	4	2	0
3	JUOS	2	0	2	3	8	0
	PIED	4	0	1	0	1	1
	JUSC	0	0	2	0	3	0
4	JUOS	11	4	6	4	4	0
	PIED	3	1	2	2	0	1
Juniperus osteosperma–Pinus edulis/Amelanchier utahensis–Cercocarpus montanus marlstone barren							
5	JUOS	4	0	4	2	0	0
	PIED	16	12	10	8	4	10
6	JUOS	0	4	2	5	0	0
	PIED	4	8	9	14	6	5
7	JUOS	0	1	2	0	0	0
	PIED	5	10	15	4	3	3
Pinus edulis/Amelanchier utahensis–Arctostaphylos patula–Cercocarpus montanus/Carex pityophila							
8	PIED	3	1	3	3	1	2
9	JUOS	1	1	0	1	0	1
	PIED	4	0	3	2	2	2
10	JUOS	2	0	0	0	0	0
	PIED	6	6	12	13	3	1
Pseudotsuga menziesii/Amelanchier utahensis–Quercus gambelii–Symphoricarpos oreophilus/Carex geyeri–Poa fendleriana							
11	PSME	23	11	13	11	8	10
12	PSME	18	16	12	2	2	2
	JUSC	18	16	6	6	2	2
13	PSME	10	2	4	0	2	8
	JUSC	14	4	4	12	12	0
	PIED	2	0	0	0	0	0

Agropyron, (4) *Gutierrezia sarothrae*–*Chrysothamnus* spp.–*Cryptantha sericea* dominated, with patches of *Koeleria*, (5) bare ground. On steep slopes, stages 2 and 3 may not occur, and *Artemisia frigida*, *Machaeranthera grindelioides*, and other weedy species may mix with stage 4 species. Photographs illustrating each of these stages are in Baker (1982). Hanson and Stoddart (1940) discuss reasons *Agropyron spicatum* var. *inerme* is easily damaged by domestic grazing.

Formerly this very likely was one of the most common vegetation types in the Piceance Basin. Now, perhaps 100–200 acres remain in stage 1 or 2, with most of the former range in stage 3. Hanson and Stoddart (1940) indicate that the association has been similarly depleted in northeastern Utah and southeastern Idaho by overgrazing domestic livestock, though they do not describe successional stages.

This association is known to have occurred in the northern Great Basin in the Cache Valley area of northeastern Utah and southeastern Idaho (Hull and Hull 1974, Hanson 1939, Hanson and Stoddart 1940), approximately 400 km northwest of the Piceance Basin, where it has similarly been described as representative of presettlement conditions in that area. The association has not been described in Colorado. Data in Keammerer and Stoecker (1975:13), and in Tiedeman and Terwilliger (1978:200) appear to represent the *Koeleria* successional stage of this associ-

Table 2 continued.

Inches									
9–11	11–13	13–15	15–17	17–19	19–21	21–23	23–25	25–27	27+
2	3	3	0	1	1	1	1	2	1(30 in)
1	1	0	0	0	0	0	0	0	0
2	0	1	2	0	1	0	2	0	1(34 in)
2	1	1	1	1	1	1	0	0	1(36 in)
8	0	0	1	1	0	0	0	1	1(36 in)
1	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0
3	1	1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
4	2	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
4	0	0	0	2	0	0	0	0	1(40 in)
0	0	2	1	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
2	0	1	1	0	1	0	0	0	0
3	0	1	0	0	0	0	0	0	0
0	1	0	0	0	0	0	0	0	0
0	1	1	0	0	0	0	2	0	0
0	0	0	0	0	0	0	0	0	0
0	1	0	0	0	0	0	0	0	0
4	5	5	3	1	1	0	0	0	0
2	2	2	2	0	0	0	0	0	0
0	0	2	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
0	4	2	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

ation. These latter authors suggest that, if undisturbed, this type "would reach a stable plant community dominated by needle and thread" (p. 201). We could not locate any remnant areas dominated by *Stipa comata*. *Stipa comata* is commonly a minor component of the higher elevation version of climax *Agropyron spicatum* var. *inerme* grasslands. Where it occurs most commonly, there is always abundant evidence of domestic livestock use, suggesting it may increase temporarily at the expense of the more palatable *A. spicatum* var. *inerme*, and then also decline as impact increases. Data in Vories (1974, Association 3) appear to represent stage 4 of the successional series.

This association is undoubtedly related to the *Agropyron spicatum* associations typical of the Palouse region in the Columbia River Basin of Washington, Idaho, and northern Utah and Nevada, which are represented in the northern Rocky Mountains as montane grasslands, and also occur in central and northern Colorado. Typical *A. spicatum* var. *spicatum*, with long divaricate awns, is rare in the Piceance Basin and never forms grasslands or mixes with *A. spicatum* var. *inerme*. This appears to be the case in northeastern Utah also, where grasslands of the two varieties do occur, but generally are geographically separated (Hull and Hull 1974). Passey and Hugie's (1963) data suggest that *A. spicatum* var. *inerme* grasslands may be limited to the northern Great Basin, not extending into the typical Palouse region, where *A. spicatum* var. *spicatum* dominates.

8. *Agropyron spicatum* var. *inerme*–*Oryzopsis hymenoides* Great Basin grassland

This association occurs on southerly-facing steep talus slopes of Uinta Formation sandstone, from 1975 to 2200 m in elevation. Soils are mapped as a complex of Torriorthents and Rock Outcrops (Tripp et al. 1982).

This association is also a sparse grassland, with 15–25 percent total cover. *Oryzopsis hymenoides* has half or more of the cover of *Agropyron spicatum* var. *inerme*, and high frequency.

Grazing by domestic animals decreases perennial grasses and results in an increase in *Artemisia frigida*, *Artemisia tridentata*, and *Chrysothamnus* spp., along with the exotic *Bromus tectorum*. This association does not follow the same successional sequence as occurs with association 7.

This association apparently has not been described previously. Vories (1974, Association 25) describes a community that may represent a poor condition example of this association, but the species of *Agropyron* is not identified. Ward et al. (1974, Type II-E) mention this combination of co-dominants but give no additional details. Ferchau (1974, p. 2) mentions a "Wheatgrass-Ricegrass" type that may represent this association, but the species of *Agropyron* is not identified. This association is apparently restricted to the Piceance Basin/Roan Plateau area of Colorado.

Current data, from this study and from Colorado Natural Heritage Inventory files, suggest associations 2, 3, 4, 6, and 8 are restricted to the Piceance Basin/Roan Plateau area of Colorado, though additional information is needed from similar exposures of Green River Formation in northeastern Utah. Associations 1, 5, and 7 are more wide ranging, occurring in scattered localities in northern Utah and northwestern Colorado. Baker (1982) lists an additional three associations, not quantitatively sampled, that are apparently restricted to the Piceance Basin/Roan Plateau area of Colorado. With the exception of association 4, restricted associations are either found on dry southerly-facing slopes and ridge tops (associations 6 and 8), or on rocky exposures of Green River Formation marlstone (association 2 and 3). These more extreme environments in the basin have unique plant associations, in addition to being primary habitat for most of the basin's rare plant taxa (Peterson and Baker 1982). More mesic areas tend to contain wide-ranging associations (e.g., association 5) and lack rare taxa.

Although the concept of climax and the validity of the plant association continue to be subjects of ecological debate, many of the remaining fragments of the presettlement vegetation spectrum are being subjected to inadvertent loss during development and land use. Much of the forest vegetation of the western United States is being or has been studied and classified (cf. Pfister 1982) based

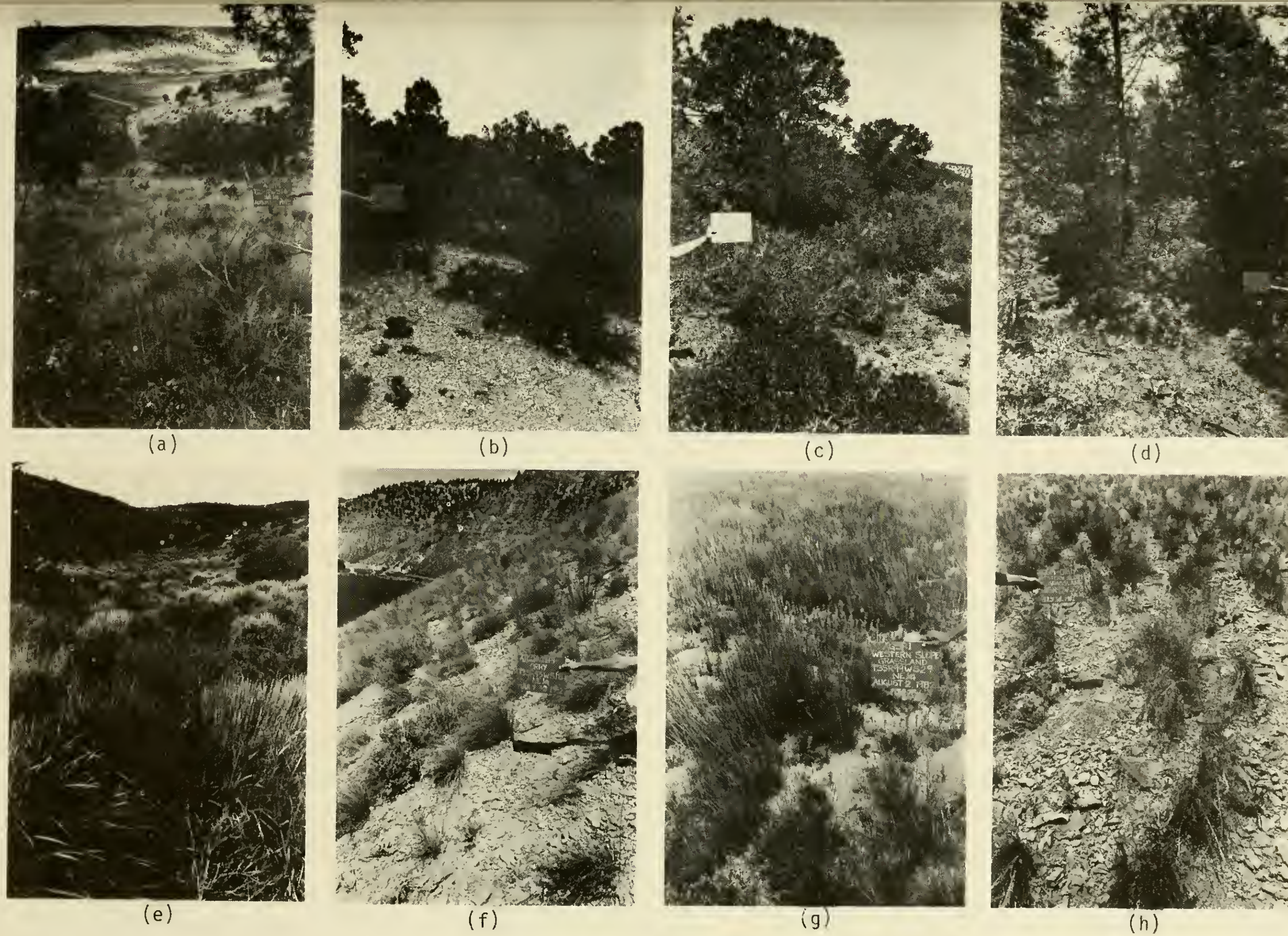

Fig. 1. Eight Piceance Basin plant associations. (a) *Juniperus osteosperma–Pinus edulis/Agropyron spicatum* var. *inerme*, (b) *Juniperus osteosperma–Pinus edulis/Amelanchier utahensis–Cercocarpus montanus* marlstone barren, (c) *Pinus edulis/Amelanchier utahensis–Arctostaphylos patula–Cercocarpus montanus/Carex pityophila*, (d) *Pseudotsuga menziesii/Amelanchier utahensis–Quercus gambelii–Symphoricarpos oreophilus/Carex geyeri–Poa fendleriana*, (e) *Artemisia tridentata* ssp. *wyomingensis–Symphoricarpos oreophilus/Elymus cinereus*, (f) *Atriplex confertifolia/Agropyron spicatum* var. *inerme–Oryzopsis hymenoides*, (g) *Agropyron spicatum* var. *inerme* Great Basin grassland, (h) *Agropyron spicatum* var. *inerme–Oryzopsis hymenoides* Great Basin grassland.

on potential or presettlement plant associations, but a similar effort is needed to catalog and describe plant associations on nonforested and lower elevation sites prior to the loss of the remaining opportunities for study. Although in many areas, such as the Piceance Basin, it may be too late to comprehensively describe and classify the presettlement vegetation spectrum, land managers charged with rehabilitating disturbed lands cannot begin to effectively achieve this goal without as much information as can now be provided on predisturbance conditions.

Acknowledgments

Part of this study was completed during a contract with the Bureau of Land Management, Craig District Office, Craig, Colorado. I am grateful to Karen Wiley-Eberle, Vernie Armstrong, and Curt Smith of BLM for assistance with logistics. Field crews assisted in locating remnant vegetation areas. I appreciate the efforts of Dr. Dieter Wilken of the Colorado State University Herbarium, who verified all plant specimens. Warren Keammerer, K. Vories, John Marr, Thorne Ecological Institute, EXXON, TOSCO, ARCO, and TRW all supplied access to unpublished data and reports. This study could not have been completed without Tamara Naumann, who volunteered assistance in field sampling. I am also grateful for the support and encouragement of J. Scott Peterson.

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NEW VARIETY OF *OPUNTIA BASILARIS* (CACTACEAE) FROM UTAH

Stanley L. Welsh[1] and Elizabeth Neese[2]

ABSTRACT.— Described as a new variety is *Opuntia basilaris* Engelm. & Bigel. var. *heilii* Welsh & Neese.

Work leading to a treatment of the flora of Utah has drawn attention to the presence of a segment of the variation within *Opuntia basilaris* that is beyond the circumscription of previously described infraspecific taxa (Benson, 1982). The plants stand apart from the remainder of the complex, being situated on saline soils of the southern end of the San Rafael Swell and the north end of the Henry Mountains. The remainder of the species is far to the south and southwest of this area.

The variety is named in honor of Kenneth Heil, enthusiastic student of the Cactaceae.

Opuntia basilaris Engelm. & Bigel. var. *heilii* Welsh & Neese. Similis var. *basilaris* sed in articulis coloris (non violaceis) glochidis stramineis et ambitis differt.

Joints spatulate to obovate, rounded to truncate apically, yellowish (rarely bluish) green; areoles lacking spines, 8–22 mm apart; glochids straw colored; flowers 4.5–6 cm long, violet; ovaries and fruit areolate, with glochids and often with spinules; fruit dry, ca 2 cm long and 1.5 cm wide; seeds ca 7.3 mm long, pale tan.

TYPE: USA Utah. Wayne Co., T29S, R10E, S23 (NW1½), Blue Benches SW of Hanksville, N of Henry Mts., 1464 m, sandy clay, Mancos Shale Formation, 1 July 1978, E. Neese 5938 (Holotype BRY).

ADDITIONAL SPECIMENS: Emery Co., T25S, R10E, S1 (SW1½), 8.8 km WNW of Goblin Valley Campground, 1479 m, salt desert shrub community, Curtis Formation, soil powdery silty sand, 19 May 1982, E. Neese & K. Mutz 11715 (BRY); do, T26S, R9E, S4, San Rafael Swell, Keesle Country, near Delta Mine, 1586 m, ephedra-atriplex community, sandy soil and rocky outcrops, 3 June 1980, J. G. Harris 833 (BRY).

This variety is similar to var. *basilaris*, differing in subtle modifications of joint outline, in color, and in glochid color. It is isolated from the type variety by 200 km and from var. *aurea* by 100 km. It is similar in pad color to var. *aurea*, but differs in pad outline and in flower color.

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[1]Life Science Museum and Department of Botany and Range Science, Brigham Young University, Provo, Utah 84602.
[2]Life Science Museum, Brigham Young University, Provo, Utah 84602.

VEGETATIVE TYPES AND ENDEMIC PLANTS OF THE BRYCE CANYON BREAKS

Robert A. Graybosch[1] and Hayle Buchanan[2]

Abstract.— The scenic Bryce Canyon "breaks" constitute harsh and inhospitable habitats for plant life. The eroded pink cliffs and talus slopes are sites of some of the most rapid natural erosion on earth. This paper divides the plant life on the breaks of the main Bryce Canyon amphitheater into four vegetative types. A checklist of all plant species found in the main amphitheater is included. Many of the rare and endangered endemic species of the park are found in the *Pinus longaeva* vegetative type. Recommendations for managing the breaks to protect endemics are presented.

The breaks community is one of the six major plant communities of Bryce Canyon National Park as described by Buchanan (1960). It consists of a relatively narrow band of unvegetated or sparsely vegetated badlands formed by the red beds of Claron (Wasatch) formation along the eastern edge of the Pausaugunt Plateau. This paper represents the results of a study of the main amphitheater of Bryce Canyon to define the vegetative units.

Intricate erosional formations can be viewed from Sunrise, Sunset, Inspiration, and Bryce viewpoints. The diverse topography and beauty of the formations attract thousands of park visitors to the viewpoints and rim trails, although relatively few of them venture into the main amphitheater. The majority of hikers and horse riders who traverse the breaks remain on well-maintained trails, and thus have relatively little impact on the plant communities.

The flora of Bryce Canyon is rich in species endemic to the High Plateaus of southern Utah (Welsh and Thorn 1979, Buchanan and Grayboseh 1981). Several of these threatened and endangered plant species have limited populations in the main Bryce Canyon amphitheater. Preservation of such species depends on recognition of preferred habitats and provision of means to protect them from visitor impact.

Description of the Study Area

Bryce Canyon National Park is located on the eastern edge of the Pausaugunt Plateau in south central Utah. The Pausaugunt Plateau occupies a position midway between 37° and 39° north latitude 10 miles west of the 110th meridian. The boundaries of the main amphitheater circumscribe the drainage system of Bryce Wash, an intermittent tributary to the Paria River, an area 4.5 km². The boundaries differ somewhat from those considered by Lindquist (1977) and Buchanan and Graybosch (1981). Elevations within the study area range from 2,200 to 2,530 m (7,250–8,300 ft). The study area lies along the western border of the Kaiparowits Basin, the flora of which was reported by Welsh et al. (1978).

The geologic stratigraphy of the study area is reported by Brox (1961), Anderson and Rowley (1975), Doelling (1975), and Lindquist (1980). The Claron limestone, a Tertiary deposit, is divisible into Red Eocene beds and White Oligocene beds, which differ somewhat in presence or absence of pigmentation in the form of iron and manganese oxides, and in amounts of sand and conglomerates in the limestone. The Claron formation is characterized by a rapid rate of erosion, largely a function of creep resulting from winter freeze-thaw activity and wash-

[1]Department of Genetics, Iowa State University, Ames, Iowa 50011.
[2]Department of Botany, Weber State College, Ogden, Utah 84408.

away by summer thunderstorm runoff. Freeze-thaw cycles are most pronounced on south-facing slopes. Soil development is limited.

Climatic features of the study area may be inferred from weather records kept at park headquarters, 2 km from the main amphitheater. The average annual precipitation is 41 cm, falling largely in the form of winter snow and late summer thunderstorms. Mean January maximum temperature is 20 C; mean July maximum temperature is 27 C. The mean January and July minimum temperatures are −13 and 7.6 degrees C, respectively. The main amphitheater is generally more xeric than these values indicate (Buchanan 1960), with higher temperatures and a greater evaporative capacity of the air prevailing. Water availability to plants is decreased on the predominantly dry substrates, which have low infiltration rates and high runoff. Ravines and north-facing slopes within the main amphitheater are probably more hydric than the adjacent plateau forest at park headquarters.

Methods

The vegetation of the study area was surveyed by means of 100 × 100 m^2 plots. Plots were subjectively placed in areas of homogeneous vegetation among the clifflike formations. Within each plot, density and basal area of all mature trees (over 5 cm dbh) and density only of juvenile trees (less than 5 cm dbh) were recorded. An importance value was formulated for mature trees by summing the relative values of density and basal area. Understory vegetation was surveyed through the use of four 10 m line intercepts, placed at 2 m intervals. Importance values for understory herbs and shrubs were determined through the summation of the relative values of density, dominance, and frequency. Understory species present in plots but failing to contact the survey lines were recorded as being present and this information was used in determining the relative frequency values.

Using the importance values of dominant species, plots of similar composition were grouped together to define vegetative types. The mean importance values for all species in each type were determined, and comparisons were made between types for all species having a mean importance value of greater than 1.0 (all trees, five shrubs, and seven herbs) using Sorensen's Index of Similarity (Sorensen 1948).

All species present in the study area were recorded and assigned to vegetative types when possible. Voucher specimens are on file in the herbarium of Bryce Canyon National Park. Nomenclature employed is that of Welsh et al. (1981).

Results and Discussion

A complete list of species occurring in the main amphitheater is presented in the Appendix. Two species, *Puccinellia nuttalliana* and *Schizachyrium scoparium*, are additions to the flora of Bryce Canyon as reported by Buchanan and Graybosch (1981). Additions to the flora of the Kaiparowits Basin, based on Welsh et al. (1978), are noted in the Appendix.

Data to be presented below allows the division of the breaks (as it occurs in the main amphitheater) into the following vegetative types. Some of these are variable and are further divided into phases. Each shall be discussed in turn.

1. *Pinus ponderosa—Arctostaphylos patula* type (Pipe-Arpa type)
2. *P. ponderosa—A. patula* type, *Cercocarpus montanus* phase (Pipo-Arpa type, Cemo phase)
3. *P. ponderosa—Pseudotsuga menziesii* type (Pipo-Psme type)
4. Mixed coniferous type, *Picea pungens* phase (MC type, Pipu phase)
5. Mixed coniferous type, *Abies concolor* phase (MC type, Abco phase)
6. *Pinus longaeva* type (Pilo type)
7. Washes, clay and talus slopes

Table 1 summarizes the dominant species of each vegetative type in terms of mean importance values. A similarity matrix is given in Table 2, comparing the various types and phases.

Description of Types and Phases

1. Pipo-Arpa Type

Occurrence: Canyon bottoms and south-facing slopes between elevations of 2,200 and

TABLE 1. Dominant species (in terms of mean importance value) in each vegetative type and phase. Types and phases are given the numerical designation employed in the text.

	Type or phase					
Species	1	2	3	4	5	6
Trees						
Abies concolor mean					81.7	
s.d.					33.3	
Juniperus scopulorum	29.3	27.2	13.0	24.2	25.8	
	37.9	24.2	21.4	27.2	29.7	
Picea pungens	2.3			89.7	25.3	
	8.1			36.3	29.7	
Pinus flexilis	7.6		17.2	22.5	3.0	44.9
	23.6		23.1	31.5	6.6	48.4
Pinus longaeva	1.0			4.0		128.3
	5.9			19.2		71.3
Pinus ponderosa	158.8	172.8	102.1	35.2	35.5	8.6
	43.9	24.2	45.6	36.0	29.6	16.8
Pseudotsuga menziesii	1.0		67.6	25.9	28.8	
	4.4		48.1	25.1	24.9	
Shrubs						
Acer glabrum		3.2	19.4	19.1	19.8	
		7.9	29.8	25.9	23.9	
Amelanchier utahensis		20.2	1.3	1.8		
		31.3	4.7	5.1		
Arctostaphylos patula	85.6	14.1	70.9	57.9	19.7	76.8
	32.0	18.6	58.1	40.7	40.5	43.7
Ceanothus martinii	12.2	4.5	7.0	8.9	2.0	2.2
	13.0	7.3	7.9	9.2	4.5	7.3
Cercocarpus montanus	5.4	138.0		23.6	30.1	2.2
	13.8	49.7		50.2	46.8	7.2
Juniperus communis	2.1			19.1	34.4	4.4
	6.9			25.9	46.8	7.2
Mahonia repens	35.7	15.9	46.7	50.3	89.6	1.5
	27.3	26.2	39.6	40.5	60.1	3.3
Purshia tridentata	1.0	1.2		1.4	16.1	
	2.5	2.9		4.4	46.1	
Ribes cereum			1.7			
			5.6			
Xanthocephalum sarothrae	1.9					1.0
	4.9					1.7
Grasses and forbs						
Astragalus kentrophyta					1.0	
					1.7	
Cirsium arizonicum	6.4		3.9	4.0	1.4	3.9
	6.7		6.5	6.6	4.7	5.8
Clematis columbiana	1.9		2.1	4.0		
	4.4		3.3	6.6		
Crytantha abata	2.7	3.5				
	4.6	3.5				
Cymopteris purpureus						7.2
						7.4
Elymus salina	34.4	4.0	36.6	13.7		5.3
	34.8	9.9	32.9	19.7		10.5
Eriogonum panguicense						11.8
						10.4

Table 1 continued.

Species	Type or phase 1	2	3	4	5	6
Haplopappus armerioides	5.9 11.0	2.6 6.2	2.0 7.1	1.0 2.6		6.4 8.8
Hymenopappus filifolius						7.9 13.8
Ivesia sabulosa						14.2 19.4
Linum kingii						17.9 14.7
Lithospermum multiflorum	6.7 8.9	1.3 3.1	2.0 3.2			
Machaeranthera grindelioides						6.7 7.0
Oenothera brachycarpa	4.4 4.4		1.5 2.5			
Oryzopsis hymenoides	13.6 10.2	1.7 4.2	4.8 10.1	11.1 12.9	1.0 3.2	10.7 9.6

2,400 m, continuing to lower elevations outside the study area. Occurs on substrates derived from both the Claron formation and Quarternary alluvium.

Vegetation: The dominant tree is *P. ponderosa*, with *Juniperus scopulorum* and *Pinus flexilis* as common associates. Thickets of *Quercus gambelii* occur, although infrequently. The shrub layer is dominated by *A. patula*, with *Mahonia repens* and *Ceonothus martinii* of secondary importance. The most common herbs are *Elymus salina* and *Oryzopsis hymenoides*. In contrast to the ponderosa pine forests of the adjacent plateau, *Purshia tridentata* is rare. A total of 65 species occurs in this type, several being restricted to it. There are largely taxa (i.e., *Mahonia fremontii*, *Streptanthus cordatus*, and *Euphorbia fendleri*) that are nearing their upper elevational limits in the study area.

Relation to other types and phases: Closest resemblance is seen between this type and the Pipo-Psme type and the Pipo-Arpa type, Cemo phase. It forms ecotones with all other types, as well as with a woodland of *Juniperus osteosperma*, *Pinus edulis*, and *Quercus gambelii* at the lower elevational limits of the study area.

2. Pipo-Arpa type, Cemo Phase

Occurrence: Adjacent to washes, on alluvium, between elevations of 2,200 and 2,300 m.

Vegetation: The dominant trees are *P. ponderosa* and *J. scopulorum*, with an understory dominated by *Cercocarpus montanus*. *Amelanchier utahensis* is an additional frequently encountered shrub. *Arctostaphylos patula* is infrequent and variable in importance values. Herbaceous vegetation is uncommon.

Relation to other types and phases: This particular phase exists only in narrow bands adjacent to washes and is generally surrounded by the Pipo-Arpa type in its typical manifestation. Possibly recognized as a distinct type if more widespread, it is most closely related to additional types dominated by *P. ponderosa*. The importance values of *P. ponderosa* and *J. scopulorum* are nearly identical in plots assignable to this phase and those in the typical Pipo-Arpa type (Table 1). This phase probably exists as a result of periodic flooding, with subsequent alteration of the physical features of the substrate. This provides a microhabitat that evidently favors *C. montanus* over *A. patula*, but does not influence the nature of the canopy.

3. Pipo-Psme Type

Occurrence: North-facing slopes of the Claron formation between elevations of 2,285 and 2,380 m. Soil development is extensive due to limited winter freeze-thaw activity.

Vegetation: Dominance is shared by *P. ponderosa* and *P. menziesii*; *Pinus flexilis* is occasionally encountered. The principle shrub is *A. patula*, with *M. repens* a common associate. In several plots, however, the density of trees was of sufficient magnitude to exclude most understory species. A significant increase in the abundance of more mesophytic species (i.e., *Acer glabrum*, *Clematis columbiana*) is noted when this type is compared to the Pipo-Arpa type. A total of 38 species was found in this type.

Relation to other types and phases: Most closely related to the Pipo-Arpa type, this type also shows affinities with the phases of the MC type. Ecotones are formed with these communities.

MC Type

Occurrence: Canyon bottoms and steep north-facing slopes; substrates occupied are derived from both Red and White members of the Claron formation. Elevational distribution is between 2,285 and 2,450 m; the lowest elevation corresponds to the furthest extension of hoodoos. Ill-defined and somewhat polymorphic, this type is best described in terms of its two phases. Fifty-five species occur within this type.

4. MC Type, Pipu Phase

Vegetation: This phase is recognized by the consistent dominance of *P. pungens* in either pure stands or in mixed associations with additional conifers, the most common of these being *P. ponderosa*, *P. menziesii*, *P. flexilis*, and *J. scopulorum*. The understory varies from sparse along washes (where both *C. montanus* and *C. ledifolius* are frequent) to dense in plots not subjected to inundation. In the latter, *A. patula*, *M. repens*, *Juniperus communis*, and *A. glabrum* predominate.

Relation to other types and phases: This phase is most similar to the MC type, Abco phase. The differences between the two lie largely in the paucity of herbs and grasses in the Abco phase. Both are characterized by a high diversity of conifers, the primary difference between the two canopies being the identity of the dominant tree. Ecotones occur with the Pipo-Arpa type, the Pipo-Arpa type, Cemo phase, and the Pipo-Psme type. On upper slopes this phase gradually thins to relatively isolated individual trees.

5. MC Type, Abco Phase

Vegetation: Consistent dominance by *A. concolor*, and lack of dominance by *P. pungens*, is the hallmark of this phase. Most of the other conifers are common. Table 1 indicates *P. ponderosa* as having the second highest mean importance value. However, this phase is present on the White limestone where *P. ponderosa* is infrequent. In such stands, *P. menziesii* and *P. pungens* are the most common associates. Dominant shrubs are largely those of the Pipu phase, although *P. tridentata* is more common.

Relation to other types and phases: This phase is most closely allied to the MC type, Pipu phase. The two are separated spatially; the Abco phase occurs only on north-facing slopes and canyons east and north of the Wall-of-Windows, with an isolated stand in the Queen's Garden. It is possible that the Pipu phase represents an early seral stage of the Abco phase, although no juveniles of *A. concolor* were found in plots assignable to the Pipu phase. More likely, the two phases represent points along a moisture gradient. *P. pungens* seems able to exist in situations that are too dry to allow growth of *A. concolor*. The two phases do not form ecotones, except in the Queen's Garden. Here, *A. concolor* is found in a nearly pure stand in the shade of some isolated hoodoos. On more exposed sites at higher elevations in the same canyon it is absent, the area being dominated by *P. pungens*. Ecotones are recognizable between this phase and both the Pipo-Psme and Pipo-Arpa types.

6. Pilo Type

Occurrence: This type is well defined only on badlands of the Claron formation, espe-

TABLE 2. Matrix comparing vegetative types and phases through use of Index of Similarity (Sorensen 1948). Consult text for information on the numbering system.

	1	2	3	4	5
1					
2	58				
3	70	40			
4	51	31.5	61		
5	32.5	31	42	60	
6	33	9.6	32	30	11

cially on the ridgeline dividing the drainages of Bryce Wash and Campbell Canyon. There is no soil development; the substrate is generally clay-limestone overlaid by gravels or larger particles. The type ranges in elevation from 2,200 to 2,400 m. Bailey (1970) reports the lowest elevational record of *P. longaeva* as being 2,200 m.

Vegetation: P. longaeva in open stands is the usual appearance of this type. *Pinus ponderosa* and *P. flexilis* may also occur, all trees being twisted and stunted. It should be noted that *P. longaeva* does not attain the wide girth that one usually associates with the species (the largest specimen had a dbh of 22 cm). Because of this it is doubtful that it reaches the extreme ages of 4,000–5,000 years that have been reported (Cronquist et al. 1972). LaMarche (1969) mentions that the oldest reported bristlecone pine in Bryce Canyon is 1,560 years of age; the number of trees and their exact location was not given.

Shrubs are uncommon; only *A. patula* is of any real abundance. Understory vegetation generally covers less than 10 percent of the plots. The forb component differs from that of all other types; *Linum kingii, Ivesia sabulosa,* and *Eriogonum panguicense* var. *panguicense* are the most common. A total of 48 species was recorded for this type, several of which are typical of subalpine zones. Based on the distributions given by Cronquist et al. (1972), Dixon (1935), Ellison (1954), Harrington (1954), and Welsh and Moore (1973), these are: *Agropyron scribneri, Aquilegia scopulorum, Aster glaucodes, Erigeron simplex, Monardella odoratissima, P. longaeva, Potentilla fruticosa, Senecio attratus,* and *Silene pettersonii.*

Relation to other types and phases: As seen from the similarity matrix, this type has little in common with any others, the highest IS being 33. Ecotones are formed only with the Pipo-Arpa type, which extends up narrow washes draining the badlands.

7. Washes, Clay, and Talus Slopes

Much of the main amphitheater is devoid of vegetation or contains only infrequently encountered individuals of numerous species scattered about the eroding Claron formation. Structured plant communities tend to cluster in canyon bottoms, on the slopes of the wider canyons, or on rolling badlands. Species found on these barren areas have been recorded and are cited in the Appendix. Most of these slopes are not easily accessible; hence, the list may be incomplete. Plots were not used to survey such areas; if any pattern exists in the distribution of species, it has not been determined. The White beds form only vertical cliffs in the study area; plots were placed only on the Red member.

TABLE 3. Distribution of trees as a function of moisture availability. Types and phases are given in order of most xeric to most mesic. A = Pilo type; B = Pipo-Arpa type; C = Pipo-Arpa type, Cemo phase; D = Pipo-Psme type; E = MC type, Pipu phase; F = MC type, Abco phase.

Mean i.v.	A	B	C	D	E	F	A	B	C	D	E	F	A	B	C	D	E	F	A	B	C	D	E	F	A	B	C	D	E	F	A	B	C	D	E	F	A	B	C	D	E	F
0	+	+	+	+	+		+						+		+	+					+						+	+		+							+		+			
1–10														+						+				+		+			+		+							+				
11–20										+												+																				
21–30								+	+		+	+						+					+																		+	+
31–40																																			+	+						
41–50																			+																							
51–60																																										
61–70																																										
71–80																																								+		
81–90						+											+																									
91–100																																										
101–110																																		z								
111–120																																										
121–130																									+																	
131–140																																										
141–150																																										
151–160																																+										
161–175																																	+									
Species			Abco						Jusc						Pipu						Pifl						Pilo						Pipo						Psme			

ENVIRONMENTAL FACTORS INFLUENCING DISTRIBUTION OF TYPES

At this point, it can only be speculated as to which environmental parameters are most critical in determining distribution of species. Moisture availability and solar insolation may be critical, but variation in substrates may also warrant consideration. Based on topography, substrate, and exposure, it is believed that moisture availability in communities increases in the order presented in Tables 3 and 4. Mean importance values for all trees and the most common shrubs are plotted as a function of increasing moisture availability. Certain trees cluster at a given end of the spectrum; *A. concolor*, *P. pungens*, and *P. menziesii* are common only in moist situations. *Pinus longaeva* is restricted to the most arid sites. *Juniperus scopulorum* and *P. flexilis* occur at somewhat constant levels throughout, although both diverge from this pattern by decreasing in a given area. *Pinus ponderosa,* although uncommon in the most xeric area, generally decreases with increasing moisture levels.

For shrubs the pattern is similar though more complex. *Acer glabrum*, *J. communis*, and *M. repens* increase with moisture levels; *A. patula* decreases, *C. martinii* remains constant. However, *A. utahensis* and *C. montanus* both demonstrate substantial increases in the Pipo-Arpa type, Cemo phase, apparently at the expense of *A. patula* and *M. repens.*

From this it can be concluded that gradients of moisture availability are involved in sorting species into communities. However, moisture is not always the factor of paramount importance. Differences in substrate may be responsible for part of the pattern, especially in the increased abundance of *A. utahensis* and *C. montanus* in one given type. Only a complete ecological survey of the area will provide an answer to this question.

DISTRIBUTION OF ENDEMIC SPECIES

Species endemic to southern Utah and found within the main amphitheater are listed in Table 5, along with their ecological distribution within the study area. Also given for each species is its current status (Federal Register, 15 Dec. 1980, vol. 45, No. 242). No status is given for *E. panguicense* var. *panguicense,* which, although restricted in range (Reveal 1965), is apparently not rare (Welsh et al. 1975, Welsh and Thorne 1979). Status is defined by the following categories.

Category 1. Information is presently on hand to support listing as endangered or threatened species.

Category 2. Information is available that indicates a probable appropriateness of listing, but sufficient information is not yet available to support listing as endangered or threatened.

TABLE 4. Distribution of most abundant shrubs as a function of moisture availability. Types and phases given as in Table 3.

Mean i.v.	A	B	C	D	E	F	A	B	C	D	E	F	A	B	C	D	E	F	A	B	C	D	E	F	A	B	C	D	E	F	A	B	C	D	E	F	A	B	C	D	E	F
0	+	+					+	+	+																			+					+	+								
1–10			+								+	+							+		+	+	+	+	+	+					+	+					+					
11–20				+	+	+				+					+			+		+															+				+			
21–30																													+	+												
31–40																																				+		+				
41–50																																								+	+	
51–60																	+																									
61–70																																										
71–80													+			+																										
81–90														+																												+
91–100																																										
101–110																																										
111–120																																										
121–130																																										
131–140																											+															
	Acgl						Amut						Arpa						Cema						Cemo						Juco						Mare					

Category 3c. Taxa proven to be more abundant or widespread than previously considered. Not under consideration at the present time.

From Table 5 it may be seen that 9 of the 11 species listed occur in the Pilo type, 3 are found in the Pipo-Arpa type, and 2 occur in the MC type. Two species, *Oxytropis jonesii* and *Psoralea pariensis*, were not found in a recognizable vegetative type. Species that occur only in the Pilo type have the narrowest geographic distributions, although *Eriogonum panguicense* var. *panguicense* is an exception. It evidently has broader ecological tolerance inasmuch as it has been observed in several additional portions of Bryce Canyon. The narrow distributions of most of these species is no doubt a function of the uncommon occurrence of *P. longaeva* communities or other similar habitat throughout the High Plateaus.

Within Bryce Canyon, most of these endemics are restricted to the Claron formation. In this study, however, *Draba subalpina*, *Lesquerella rubicundula*, and *Townsendia minima* were observed on Quarternary alluvium, a formation from which they have not previously been reported. *Oxytropis jonesii*, *P. pariensis*, and *E. panguicense* are not limited to the Claron formation throughout their geographic range. The remainder of the endemics have been reported only from the Claron formation.

The majority of the vast number of endemic species found in southern Utah are restricted to substrates derived from a specific geologic formation (Welsh 1979). Welsh notes that most of these taxa are found in areas of exposed parent material; soil development provides a barrier between plant and substrate. In the main amphitheater, soils are well defined only in the Pipo-Psme type. It is significant that no endemic species occur in this type.

The distribution of endemic species in Utah is not a random one; fine-textured substrates support more species than coarser

TABLE 5. Distribution of endemic species in the main amphitheater.

Species	Status[1]	Distribution in[2] Utah (counties)	Geologic distribution[3]	Ecologic distribution in main amphitheater
Castilleja revealii	1	Garfield	R; W	Pilo type; washes, clay-limestone slopes
Cryptantha ochroleuca	1	Garfield	R; W	Pilo type; clay-limestone slopes
Draba subalpina	3c	Garfield, Iron, Kane, Millard	R; W; QA	Pipo-Arpa type, Pilo type, MC type
Eriogonum panguicense var. *panguicense*	—	Garfield, Iron, Kane, Sevier, Washington	R; W[4]	Pilo type, clay-limestone slopes
Lesquerella rubicundula	2	Garfield	R; W; QA	Pipo-Arpa type, Pilo type, clay-limestone slopes
Lomatium minimum	1	Garfield, Iron, Kane	R; W	Pilo type, clay-limestone slopes
Oxytropis jonesii	3c	Emery, Garfield, Uintah	W; Flagstaff limestone, Green River shale	Sand-limestone slopes
Penstemon bracteatus	1	Garfield	R	Pilo type, clay-limestone slopes
Psoralea pariensis	1	Garfield, Kane	R; alluvium and sandy alluvium	clay-limestone slopes
Silene pettersonii var. *minor*	1	Garfield, Iron	R	Pilo type, clay-limestone slopes
Townsendia minima	2	Garfield, Kane	R; W; QA	Pilo type, Pipo-Arpa type, MC type

[1]See text for discussion.
[2]From: Reveal 1965, Welsh et al. 1975, Welsh 1978a, Welsh and Thorne 1979.
[3]Refers to the entire range of species. From: Welsh 1978a, Welsh and Thorne 1979, personal observations. R = Red beds of Claron formation; W = White beds, QA = Quarternary alluvium.
[4]Reveal (1965) defines the typical substrate of the species only by the designation "clay slopes." With its wide geographic range it probably occurs on substrates other than those derived from the Claron formation.

ones, and desert and foothill vegetation is richer in endemic species than montane communities (Welsh 1978b, 1979). Based on these observations, Welsh has developed a "predictive model for establishing priority areas for the study of endangered and threatened plants of Utah," in which the highest priority is assigned to fine-textured soils supporting pinyon-juniper or desert shrub vegetation. A similar model may now be established for endemics of the Claron formation. Outcrops of this formation supporting communities of bristlecone pine are most likely to contain endemic species. Based on this assumption, populations of these species have been found at several locations in Bryce Canyon. Species generally restricted to such habitat conditions are likely to be less widely distributed than those capable of invading other communities on the Claron limestone. Higher priority for listing as threatened or endangered species should be assigned to those taxa concentrating in such habitat. The protection of sites containing populations of bristlecone pine promises to be the most productive strategy for ensuring the continued survival of these plants.

Stands of *P. longaeva* within Bryce Canyon National Park are of critical importance to botanical science. In addition to representing the preferred habitat of several endemic species, they are of interest as subalpine vegetation found at atypical elevations. Additional investigation of such areas is likely to be fruitful in studies of the population biology of endemic species and the environmental factors that govern plant distribution.

Within the main amphitheater, the heavy use by visitors does not seem to present any danger to plant populations. The only activities are hiking and horseback riding, both restricted to established trails. Few seem to stray from the trails because the steep topography makes getting lost or injured a high probability. By preventing expansion of the existing trail system, park officials can likely maintain species populations at the present levels.

Summary

An investigation on plant community structure in the main amphitheater of Bryce Canyon National Park has shown that the vegetative community previously referred to as the "breaks" is divisible into discrete vegetative types. Although most of the area consists of sparsely vegetated cliffs and slopes, well-defined communities are found on gentle lower slopes, rolling badlands, and canyon bottoms. Four major types are recognized, some being further divided into phases. Each has been characterized as to canopy, understory vegetation, and relationship to other types. A checklist of all species found in the area is given in the Appendix.

The ecologic distribution of several endemic species of southern Utah is given. The *Pinus longaeva* type is shown to be the richest in rare plants. This habitat is also unique in that it contains species normally found at subalpine elevations. It is predicted that endemic species of the Claron formation will tend to cluster in similar habitat. Protection of bristlecone pine communities is urged as the simplest means of providing protection for these rare plants.

Appendix

Checklist of species and their ecological distribution in the main amphitheater, Bryce Canyon National Park. I = Pipo-Arpa type, II = Pipo-Psme type, III = MC type, IV = Pilo type, V = washes, clay and talus slopes. ° = additions to the flora of the Kaiparowitz Basin.

	Vegetative type				
Species	I	II	III	IV	V
ACERACEAE					
Acer glabrum Torr.	+	+	+		+
APIACEAE (Umbelliferae)					
Cymopterus purpureus Wats.	+	+	+	+	+
Lomatium minimum (Mathias) Mathias				+	+

Appendix continued.

Species	Vegetative type I	II	III	IV	V
APOCYNACEAE					
Apocynum androsaemifolium L.		+		+	+
ASCLEPIDACEAE					
Asclepias asperula (Decne) Woodson	+				
ASTERACEAE (Compositae)					
Aster glaucodes Blake	+	+	+		+
Chrysothamnus nauseosus (Pallas) Britt.	+				+
C. parryi (Gray) Greene	+				+
Cirsium arizonicum (Gray) Petrak	+	+	+	+	+
Erigeron simplex Greene°				+	+
Haplopappus armerioides (Nutt.) Gray	+	+	+	+	+
Hymenopappus filifolius Hook.	+	+	+	+	+
Hymenoxys acaulis (Pursh) Parker	+			+	+
H. richardsonii (Hook.) Cockerell					+
Leucelene ericoides (Torr.) Greene	+				
Machaeranthera grindelioides (Nutt.) Shinners	+	+	+	+	+
Petradoria pumila (Nutt.) Greene	+		+		+
Senecio attratus Greene°			+		+
S. multilobatus T. & G. ex Gray	+	+		+	
Solidago sparsiflora Gray	+	+	+		
Stephanomeria tenuifolia (Torr.) Hall	+				+
Tetradymia canescens DC.	+				+
Townsendia exscapa (Richards) T. C. Porter					+
T. minima Eastwood	+		+	+	+
Xanthocephalum sarothrae (Pursh) Shinners (= *Gutierrezia sarothrae* Pursh)	+			+	
BERBERIDACEAE					
Mahonia fremontii (Torr.) Fedde (= *Berberis fremontii* Torr.)	+				
M. repens (Lindl.) G. Don. (= *B. repens* Lindl.)	+	+	+	+	+
BETULACEAE					
Betula occidentalis Hook.			+		+
BORAGINACEAE					
Cryptantha abata Johnst.	+		+	+	
C. ochroleuca Higgins°				+	+
Lithospermum multiflorum T. & G.	+	+	+	+	
BRASSICACEAE (Cruciferae)					
Arabis pendulina Greene	+				
Descurainia sophia (L.) Webb. ex Engler & Prantl.					+
Draba subalpina Goodmn. & Hitchc.	+		+	+	
Lesquerella rubicundula Rollins	+			+	+
Physaria chambersii Rollins	+		+	+	+
Streptanthus cordatus Nutt. ex T. & G.	+				
Thlaspi arvense L.					+
CAPRIFOLIACEAE					
Sambucus caerulea Raf.	+	+	+		+
Symphoricarpos oreophilus Gray	+	+	+		+
CARYOPHYLLACEAE					
Arenaria fendleri (Rydb.) Fern.			+		
Silene pettersonii Maguire var. *minor* Hitchc. & Maguire				+	+
CORNACEAE					
Cornus stolonifera Michx.°					+
CUPRESSACEAE					
Juniperus communis L.	+	+	+	+	+
J. osteosperma (Torr.) Little	+				+
J. scopulorum Sarg.	+	+	+	+	+

Appendix continued.

Species	Vegetative type I	II	III	IV	V
ERICACEAE					
Arctostaphylos patula Greene	+	+	+	+	+
ELAEAGNACEAE					
Shepherdia canadensis (L.) Nutt.		+	+		
EUPHORBIACEAE					
Euphorbia fendleri T. & G.	+				
E. lurida Engelmn. ex Ives°	+	+	+	+	+
FABACEAE (Leguminosae)					
Astragalus convallarius Greene°	+	+	+		
A. kentrophyta Gray			+		+
A. megacarpus (Nutt.) Gray	+		+		+
Oxytropis jonesii Barneby					+
Psoralea pariensis Welsh & Atwood°					+
FAGACEAE					
Quercus gambelii Nutt.	+	+	+		
GENTIANACEAE					
Gentianella tenella (Rottb.) Borner° (= *Gentiana tenella* Rottb.)		+		+	+
Swertia radiata (Kellogg) Kuntze°	+	+	+	+	
LAMIACEAE (Labiatae)					
Monardella odoratissima Benth.				+	+
LINACEAE					
Linum kingii Wats.	+		+	+	+
L. perenne L. var. *lewisii* (Pursh) Eat. & Wright	+		+		+
ONAGRACEAE					
Calylophus lavandulaefolia (T. & G.) Raven (= *Oenothera lavandulaefolia* T. & G.)	+			+	+
Oenthera brachycarpa (Gray) Britt.	+	+	+	+	+
PINACEAE					
Abies concolor (Gord. & Glend.) Lindl. ex Hildebr.	+		+		+
Picea pungens Engelmn.	+	+	+	+	+
Pinus edulis Engelmn. & Wisliz.	+				+
P. flexilis James ex Long	+	+	+	+	+
P. longaeva D. K. Bailey	+		+	+	+
P. ponderosa Dougl. ex Lawson	+	+	+	+	+
Pseudotsuga menziesii (Mirb.) Franco	+	+	+	+	+
POACEAE (Gramineae)					
Agropyron cristatum (L.) Gaertn.					+
A. scribneri Vasey°				+	+
A. trachycaulum (Linke) Malte					+
Calamagrostis scopulorum Jones			+		+
Elymus salina Jones	+	+	+	+	+
Oryzopsis hymenoides (R. & S.) Ricker ex Piper	+	+	+	+	+
Poa compressa L.°					+
Puccinellia nuttalliana (Schult.) Hitchc. ex Jeps.					+
Schizachyrium scoparium (Michx.) Nash ex Small°	+				
Sitanion hystrix (Nutt.) J. G. Smith	+				+
Stipa columbiana Macoun°	+				+
POLEMONIACEAE					
Phlox austromontana Cov.	+			+	+
POLYGONACEAE					
Eriogonum corymbosum Benth.					+
E. panguicense (Jones) Reveal var. *panguicense*				+	+
RANUNCULACEAE					
Aquilegia scopulorum Tidestr.	+		+	+	+
Clematis columbiana (Nutt.) T. & G. (= *C. pseudoalpina* (Kuntze) A. Nels.)	+	+	+	+	

Appendix continued.

Species	Vegetative type I	II	III	IV	V
RHAMNACEAE					
Ceonothus martinii Jones	+	+	+	+	+
ROSACEAE					
Amelanchier utahensis Koehn	+	+	+		+
Cercocarpus ledifolius Nutt.°			+	+	
C. montanus Raf.	+	+	+	+	+
Holodiscus dumosus (Nutt.) Heller			+	+	+
Ivesia sabulosa (Jones) Keck	+			+	+
Potentilla fruticosa L.°				+	+
Purshia tridentata (Pursh) DC.	+	+	+	+	+
SALICACEAE					
Populus angustifolia James ex Torr.			+		+
P. tremuloides Michx.					+
Salix exigua Nutt.					+
SAXIFRAGACEAE					
Ribes cereum Dougl.		+	+		+
SCROPHULARIACEAE					
Castilleja linariaefolia Benth. ex DC.	+	+			+
C. revealii N. Holmgren			+	+	
Pedicularis centranthera Gray ex Torr.	+	+	+	+	
Penstemon bracteatus Keck				+	+

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SEASONAL GROWTH OF THE TUI CHUB, *GILA BICOLOR*, IN PYRAMID LAKE, NEVADA

Joseph L. Kennedy[1]

Abstract.— Tui chubs collected from November 1975 through November 1977 from Pyramid Lake, Nevada, were analyzed for seasonal growth patterns. Major growth in length occurred during the fall and early winter, and major reproductive development occurred during the late spring and early summer.

The tui chub, *Gila bicolor*, is the most abundant fish in Pyramid Lake, Nevada, and is the major food source of the threatened Lahontan cutthroat trout, *Salmo clarki henshawi*. The tui chub is found in the drainage of western Nevada and eastern California from the San Joaquin system to southern Oregon and the Columbia River (LaRivers 1962).

The tui chub is an opportunistic feeder that utilizes algae, benthic invertebrates, zooplankton, and fish (Snyder 1917, Kimsey 1954, LaRivers 1962, Langden 1978). The tui chub spawns in late June or early July; during this time they are found in large numbers along the shore (Snyder 1917, Kucera 1978). Aerial surveys have shown that large schools of tui chub are also found in the open water during the spawning season.

Preliminary growth studies of the tui chub suggested that growth in length may not occur during the time of year when food and temperature are optimum. Although this is unusual, the timing of the reproductive cycle and the peak occurrence of some food items suggested the possibility of an atypical growth pattern.

Methods and Materials

From November 1975 through November 1977, 2,400 tui chubs were collected. All fish were measured to the nearest millimeter in fork length and weighed to the nearest gram in body weight.

Age was determined from scales obtained from the left side of the fish above the lateral line. Validity of the scale-based ages and calculations was established using criteria suggested by VanOosten (1979) and Hile (1941). The seasonal growth pattern was portrayed by plotting the length achieved at various intervals throughout the year against the date of scale collection. The length achieved from time of annulus formation was estimated by subtracting length at time of formation of the last annulus from the length at time of capture (Gerking 1966). The length at last annulus formation was determined by extrapolation of the body length–scale radius relationship.

The body-scale relationships and length-weight relationships were calculated according to Tesch (1971). Condition factors (K) were calculated according to Carlander (1969).

Results and Discussion

Seasonal Growth in Length

The Pyramid Lake tui chub population was composed of two morphological forms: coarse rakered with gill raker counts of 9 to 15 and a fine-rakered form with raker counts of 20 to 40. The coarse-rakered form was found inshore or on the bottom. The fine-rakered form was found in the upper 20 m, both offshore and inshore, but was not commonly found offshore on the bottom (Vigg 1978). Their food habits differed, but their growth rates and patterns were similar (Kucera et al. 1978).

The young fish showed almost continuous growth throughout their first two years of life. The fish collected inshore and offshore on the bottom had a slight decrease in

[1]Western Montana College, Dillon, Montana 59725.

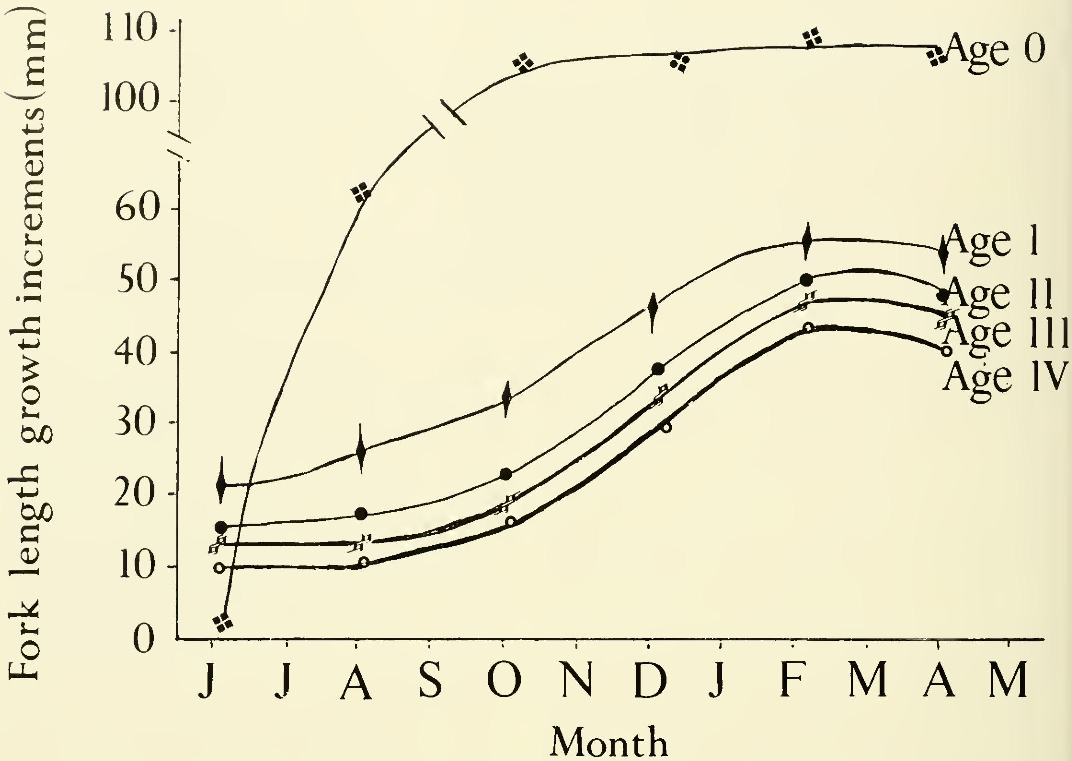

Fig. Seasonal growth curves for tui chub age-groups O through IV, collected in Pyramid Lake, Nevada.

growth in late April and May, but the pelagic chubs collected at the station did not have an interruption in growth until their second year (171 mm FL).

Age-groups II through IV showed the same general pattern of growth, with peaks in the fall and winter and a seasonal low during the late spring and early summer. These age groups never experienced a period of rapid growth in length but had a long, continuous growing season that lasted from late summer through the winter. The peak growth for age-groups II through IV was in late fall–early winter (Figure 1). The young-of-the-year fish achieved most of their growth in length during the first summer of life. This 0 age-group attained a length of 48.5 mm in July and 98.5 mm by September. Total group growth for the first year was 121.9 mm. Annulus formation by II through V began in May, but some did not form an annulus and resume growth until as late as August. The beginning of growth occurred after the major portion of the energy required for reproductive tissue development had been expended, and relatively late in the summer from the standpoint of optimal environmental conditions. The growth curves for all age-groups, other than 0 and 1, showed growth during the time of year when the water temperature was cooling or at a stable, cold temperature (6 C) and little growth in lengths during the spring and summer when warmer temperatures occurred.

Annulus formation also reflected the different growth patterns for young and adult fish. The coarse-rakered young-of-the-year fish formed their annulus/check mark in late April and May. This interruption in scale growth was very narrow and formed in a very short period of time. It also did not have the characteristic crowding of circuli that normally accompanied annulus formation. The fine-rakered chubs did not have an interruption in scale growth during the first year. The adult fish (older than II) formed their annulus from late June through August. The annulus was more diffuse, had the characteristic crowding of circuli, and occurred over a longer time period. This was the case for both the fine-rakered form and the coarse-rakered form. The later annulus formation and the lack of growth in length during the summer months is explained by the timing of the reproductive cycle and probably intense competition from young-of-the-year fish.

The tui chub began to accumulate reproductive tissue during March and April with a major increase in May and June (Kucera 1978). This was followed by spawning in July. The peak in reproductive tissue, indicated by the gonadal somatic index, coincided with the formation of the annulus. Interestingly, the annulus formed by adult fish was actually a combination of an annulus and reproductive check marks. The annulus/check mark formed by the young-of-the-year coarse-rakered group occurred when the lake was rapidly warming. The rapidly changing water temperature and the accompanying change in seasonal distribution pattern probably combined to stress the young fish and induce annulus formation.

Following spawning, the adults began to grow, but the expected rapid growth period did not occur. The onset of adult growth in length coincided with the seasonal low of macroinvertebrates and periphyton (Robertson 1978). Also, the spring peaks of zooplankton had started to decline, possibly from the feeding pressure exerted by the young-of-the-year chubs (Kennedy et al. 1977). But total zooplankton, dominated by *Diaptomus sicilis,* still numbered 18 to 41 organisms per liter during this time (Lider and Langden 1978). This density of zooplankton was equal to or greater than that which Noble (1975) found during peak growth periods for yellow perch.

The growth rates continued to increase throughout the fall and winter, and peaked when periphyton and macroinvertebrates peaked. Growth during the winter months has also been reported for bluegills (Gerking 1966, Krumholz 1948), but I have not found reports of fish species having major growth periods during the winter months. Pyramid Lake may also be unique with the peak abundance of macroinvertebrates and periphyton occurring during the winter. In addition, the total zooplankton numbers are still relatively high during the winter months (Lider and Langden 1978).

The young-of-the-year and the one-year-old fish grew during the warmer summer months, when the adults did not grow in length, and continued to grow during the fall and winter, pausing only briefly during early spring. The much longer growth period of the younger fish was also reflected in the larger increments of growth by the younger fish (I, 123 mm; II, 48 mm; III, 43 mm; IV, 37 mm; V, 35 mm; and VI, 47 mm).

Seasonal Growth in Weight

As with growth in length, the adults and young fish had different patterns of seasonal growth. The young fish (O, I) increased in weight throughout the year in much the same pattern as growth in length. For adults (some II and all older fish) growth in weight included both somatic and reproductive tissue and must be examined with this in mind. The adult fish increased in weight from August after spawning through the following June. There was a significant decrease in weight following spawning, as would be expected. Close examination of the data showed that the mean weight following spawning was higher than the mean weight preceding the rapid increase in reproductive tissue (March), and this probably represents a slight amount of somatic growth that occurred during the spawning season.

Summary

The tui chub shows remarkably synchrony with its environment. The species has evolved to utilize the food available during the fall and winter for much of its somatic growth and to utilize the abundant zooplankton populations in spring and summer for reproductive tissue and growth by young fish. The differential utilization of food allows this species to maximize the energy going into the population and minimize the competition between size or age groups. This adaptation to the particular environment stresses the importance of not introducing exotic species that might compete with the chub or disrupt the timing of their seasonal growth or reproductive cycles.

Acknowledgments

The Pyramid Lake Painted Tribe initiated the ecological study of Pyramid Lake from which this study developed. The research was funded by the Bureau of Indian Affairs, contract H50C14209487. I wish to thank the entire crew of W. F. Sigler and Associates, especially Denise Robertson, our age and growth specialist.

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BIRD DISTRIBUTIONAL AND BREEDING RECORDS FOR SOUTHEASTERN IDAHO, UTAH, AND ADJACENT REGIONS

Clayton M. White[1], Herbert H. Frost[1], Dennis L. Shirley[2], G. Merrill Webb[3], and Richard D. Porter[4]

Abstract.— New distributional records or the status for 33 species of birds that have occurred within Utah, adjacent southeastern portions of Idaho, or along the border of states surrounding Utah are reviewed. Four species, the Cattle Egret (*Bubulcus ibis*), Common Moorhen (*Gallinula chloropus*), Great-tailed Grackle (*Quiscalus mexicanus*), and Common Grackle (*Quiscalus quiscula*), represent new Utah breeding records established within the past decade, and they are commented upon. One other, the Black-tailed Gnatcatcher (*Polioptila melanura*), may be breeding in Utah. The Mockingbird (*Mimus polyglottos*) may likewise be breeding in southeastern Idaho adjacent to Utah.

In 1972 the *Birds of Idaho* appeared (Burleigh 1972). It more or less represented the accumulation of a host of published and unpublished accounts plus observations from the more than 20 years of Burleigh's own field work in Idaho. Unfortunately, Burleigh resided in northern Idaho, where most of the data come from; and a quick review of the book will reveal the spotty nature of data from southern Idaho. For Utah, Behle and Perry (1975) and Hayward et al. (1976) brought together and updated most Utah records. Currently, Behle (pers. comm.) is in the final stages of bringing together his life's work on the birds of Utah. With all this recent material and the summation of Behle's work at hand, it seemed appropriate to record new data for adjacent regions in both states in cases where our new information clarified distribution or added new knowledge. Most of the Idaho data were gathered during an intensive study of raptors in and about the Raft River region of Cassia County, southeastern Idaho, 1976–1980 (Thurow et al. 1980). Some of these data are given to correct the misimpressions left by Burleigh. Much of the Utah material represents information accumulated since about 1974 by graduate students and faculty at Brigham Young University, but after the cutoff date for the *Birds of Utah* by Hayward et al. (1976). Where specimens were available their catalogue numbers are given in parentheses for either the Monte L. Bean Life Science Museum, Brigham Young University (BYU), or the Museum of Natural History, University of Utah (UU). Hereafter, reference to Burleigh, Hayward et al., or Behle and Perry will refer to the above references unless indicated by a date.

Species Accounts:

Cattle Egret (*Bubulcus ibis*). The Cattle Egret was recorded in Utah as occasional by both Behle and Perry and Hayward et al. During the summer of 1980, an estimated 25 pairs were reported nesting along with the Snowy Egret (*Egretta thula*) on a small Utah Lake island at the mouth of Provo Bay (Utah Division of Wildlife Resources personnel — UDWR; see also Kingery 1981c). On 28 July 1981 David Ng, a zoology graduate student, reported seeing 8–10 adults and 15 immature Cattle Egrets at this same heronry. Subsequently we visited the island on 11 August and found 29 nests, 14 with eggs, containing clutches of two to five eggs, as follows: 1/5, 2/4, 9/3, and 2/2. One of the 3 clutch nests had one egg pipping. At least 2 nests had eggs estimated to be no more than three–four days old and were laid in freshly built nests. Several clutches were laid in nests that had been previously used earlier in the season by

[1]Department of Zoology, Brigham Young University, Provo, Utah 84602.
[2]Division of Wildlife Resources, 1115 North Main Street, Springville, Utah 84663.
[3]1063 East 400 North, Orem, Utah 84057.
[4]325 North 300 West, R.R. #1, Mapleton, Utah 84663.

Snowy Egrets, based on the fouling of the nests. At the remaining 15 nests young Cattle Egrets ranged from newly hatched to those moving about in trees and nearly capable of sustained flight. Three of the largest young were collected and these weighed 340 g (BYU 7617), 316 g (BYU 7618), and 340 g (UU 22,603). Palmer (1962) gives adult weights as 300–400 g. Their stomachs were full of orthopterans; one contained 13 heads. In 1982 some 50 nests were found. R. Isham (1975) studied the same island colony in 1973 and did not find this species breeding there with Snowy Egrets. Several of the Snowy Egret nests studied by Isham were marked with metal tags, and these same trees or nests were used by Cattle Egrets in 1981. Their establishment in Utah, Colorado, and Nevada has been summarized by Kingery (1980c); and, according to Rogers (1982b), they may now be breeding about 80 km N of the Utah localities at Lake Walcott, Power County, Idaho.

Cooper's Hawk (*Accipiter cooperi*). A species listed as an uncommon breeder for southern Idaho by Burleigh and by Levy (1962), the Cooper's Hawk was found by us to be rather common in the canyons of the western slope of the Black Pine Mountains overlooking the Raft River Valley (see Thurow et al. 1980). We found them in all canyons that we were able to travel up. They nested both in aspen and conifer trees on south- and north-facing slopes. We suspect they were more common than we found them since we only explored canyons that had roads.

Common Black Hawk (*Buteogallus anthracinus*). Most of the data on this species comes from the 1960s, when it apparently moved into extreme southern Utah as a breeder about 1961–1962 (Hayward et al.). Only one specimen exists for Utah. Here we report a specimen that came to Brigham Young University (BYU 7619) after it had been shot by hunters. An adult female (wt. 866 g), it was reportedly found along the Virgin River N of Littlefield, Arizona, and 6–7 km S of the Utah border. The bird, with tail practically shot off, came to Stelline Ure, a Salt Lake City raptor rehabilitator, on 3 September 1980 and died within the day. It had been originally taken to Cedar City, where it apparently remained for two–three days before being taken to Salt Lake City.

Broad-winged Hawk (*Buteo platypterus*). There were at least two individuals reported for Utah, one near Salt Lake City in 1970 and one in Provo in 1975. Behle and Perry considered it hypothetical, and Hayward et al. assign it an uncertain status. Recent records indicate it to be a rare to casual migrant. Steve Hoffman (pers. comm.), Office of Endangered Species, U.S. Fish and Wildlife Service, and a hawk bander, recorded 17 individuals during fall migrations over a six-year period as follows (some of the records have been listed by Kingery 1980a):

1 ad	18 Sep 1977	Pilot Mt., Box Elder Co., Utah
2 ad– 1 im	19 Sep 1979	Goshute Mts., Elko Co., Nevada (just west of the Utah border)
1 ad	22 Sep 1979	Goshen Mts., Elko Co., Nevada (just west of the Utah border)
1 ad	24 Sep 1979	Wellsville Mts., Box Elder Co., Utah
2 ad	28 Sep 1979	Goshute Mts., Nevada
1 imm	30 Sep 1979	Wellsville Mts., Utah
1 imm	4 Oct 1979	Goshute Mts., Nevada
1 ad	5 Oct 1979	Goshute Mts., Nevada
1 ad	18 Sep 1980	Goshute Mts., Nevada
1 imm	23 Sep 1981	Goshute Mts., Nevada
3 imm	5 Oct 1981	Goshute Mts., Nevada
1 imm	21 Sep 1982	Goshute Mts., Nevada
1 imm	23 Sep 1982	Goshute Mts., Nevada

One of the above immatures was actually trapped but escaped before it could be taken from the trap and banded. On 5 May 1982 an immature was seen in the Cub Creek area of Dinosaur National Monument, Uintah County, Utah, by members of the Utah Field Ornithologists (UFO). This hawk has recently been reported about 160 km N of the Pilot Mts. — Wellsville Mt. area in Idaho (Rogers 1982a).

Red-tailed Hawk (*Buteo jamaicensis harlani*). Accounts by Behle and Perry and Hayward et al. give the impression that this race is rare within Utah. This race of the red-tail has recently been discussed by Mindell (1983) and an analysis of plumage characteristics given. Mindell outlines some of the difficulties of correctly identifying this form, especially the immature, and the widespread nature of intergradation with the race *calurus*. Despite field identification difficulties with typical *harlani*, several interesting sight records have occurred in Utah County in the past five years, and two specimens brought to Brigham Young University are worth reporting. Since 1978 an adult bird of this form, presumably the same individual, occupied a tree perch as part of a winter territory along Interstate Highway 15 near American Fork. It usually arrived by mid-December and was gone by mid-March. It could be approached to within 50 m and gave excellent opportunity for observation, especially of the tail.

The one previous specimen for the state reported by Worthen (1973) was an immature and thus not easily separable from immatures of dark (black)-phased *calurus*. Because of this problem, its proper identity is open to question. In addition to that specimen, we now have received two adults. One (BYU 7621) is a male in dark phase and has a typical *harlani* tail coloration. It weighed 965 g and was found injured at the Lehi airport on 28 December 1981. The other, also a male (BYU 7622) from Provo, found 17 January 1983 (wt. 948 g), has a nearly immaculate breast (light phase?), dark back, and a mottled whitish tail with a rusty tip almost identical to the tail of an adult Ferruginous Hawk (*Buteo regalis*). The tail of this specimen is more like that of a *harlani* x *calurus* intergrade, although the breast is certainly unlike such intergrades (Mindell pers. comm.). The coloration of the tail and whiteness of the breast may be the result of intergradation with *krideri*. The sight records in Kingery (1982b), if correct, may show this race to be a regular visitor to Utah; and this may be a recent event, within the past two decades.

Ferruginous Hawk (*Buteo regalis*). The entire species account in Burleigh misrepresents the status of this hawk, not only within Idaho but in southeastern Idaho in particular. We have not attempted to review the literature for all of Idaho but will restrict our remarks to southeastern Idaho. The reports of Power et al. (1975), Power and Craig (1976), and Thurow et al. (1980) put into perspective the density of this species in but two counties of southeastern Idaho, where as many as 50–75 pairs may nest in "good" food years (perhaps half that many in "poor" years).

Porter (1951) was the first to discuss the species in Cassia County and suggested that it was probably a common summer resident. Burleigh and, earlier, Jollie (1952) were both convinced of quite the contrary, however, based on their limited experience in that region and so it is thus published. The species has been shown to be rather cyclic (Thurow et al. 1980), and it may be that both Burleigh and Jollie (1952) visited the region in a low prey year. The available findings, however, vindicate Porter's initial impressions and show the species to be a common breeder in southeastern Idaho with as many as 20–30 pairs in an average year in a small area of Cassia County alone (Thurow et al. 1980). Mr. Jack Pierce (pers. comm.), who has been a resident of Malta, Cassia County, Idaho, for at least 50 years, remembers that two pairs nested on his property for "as long as I can remember." Although there is a general belief that the Rough-legged Hawk (*Buteo lagopus*) is the only large buteo to "hover" during hunting bouts, we observed the Ferruginous Hawk to use stationary hovering during foraging on numerous occasions.

Rough-legged Hawk (*Buteo lagopus*). This hawk reportedly leaves northern Utah by 16 April for its arctic breeding grounds (Behle and Perry), and in southern Idaho it is said to leave by "the last of April" (Burleigh: 66). We found a freshly shot individual (BYU 7616) on 4 June 1978 about 8 km E of Malta, Idaho. The bird was an immature male in extremely worn plumage but in good physical condition (wt. 948 g). The tips of the primary feathers on the right wing were shot off. We saw another individual 5 km S of Malta on 11 May 1979 as it fed on a dead rabbit on the roadside. An individual, presumably the same, was seen in the above area again on 11 June 1979. Based on the tail coloration (see Cade 1955), this latter individual was also an immature from the previous summer's hatch. Pat Benson (pers. comm.) also had "summer" records from Gray's Lake, Idaho. Porter (1951) reported no late spring or early summer sightings of this species in southeastern Idaho, and most of his data were from this same valley.

American Kestrel (*Falco sparverius*). Despite this species being listed as an uncommon breeder in that portion of southern Idaho encompassing Raft River Valley by Burleigh and by Levy (1962), we, however, found them to be common breeders there. They nested in deciduous trees (three pairs in Malta alone), in buildings (e.g., near Six Mile Canyon, two pairs), in cliffs (at least three pairs), in an abandoned silo (two pairs), or in juniper trees (many pairs, in hollows and in

Black-billed Magpie [*Pica pica*] nests). We saw kestrels enter squirrel holes that were in the cut banks of heavily eroded washes in at least two different localities. We suspected them of nesting in such holes because of their territorial behavior and because they carried food into them. Thus, casual observations, in the course of an intensive study of Ferruginous Hawks, suggested that as many as 25–30 pairs of kestrels bred in the valley.

Nests in junipers were both at the edge of the stands of forest (juniper-sagebrush ecotone), as are Ferruginous Hawks, and deeper within the forest itself. In this latter aspect they were quite unlike that reported by McArthur (1977), who had none of the 20 nesting boxes placed throughout his study area in juniper forest in Millard County, Utah, occupied. This may have been because kestrels were naturally rare there as breeders. McArthur did, however, have some utilization of boxes when placed on poles in open salt desert scrub areas. Likewise, Craig (1979), who worked about 120 km N of Raft River, had good utilization of nest boxes when placed in deciduous trees with large open areas around them or at the edge of woodlots.

Merlin (*Falco columbarius*). Burleigh's discussion of this species pertains mainly to examples from the central or northern part of Idaho. A nest in a juniper was recently reported by Craig and Renn (1977) for the Snake River Plain somewhat north of Cassia County, Idaho. Closer to our study area there are nest records for Bannock County just to the northeast of Cassia County (Stanley A. Temple, pers. comm.). These consisted of egg clutches taken some 70 yrs ago and were apparently from nests in a riparian region. Between May and July 1977 a pair of territorial Merlins were repeatedly seen near Bridge, Cassia County. They frequented an area of abandoned buildings surrounded by cottonwood and box elder trees that contained disused Black-billed Magpie nests. Although no eggs were found, the actions of the pair suggested a breeding attempt. A territorial pair was not seen in subsequent years. On 5 August 1980 White found two young that appeared to be fledged about two weeks earlier 27 km NE of Montpelier, Bear Lake County, Idaho. The date and apparent age of the young suggested they were not too distant from their nest. The habitat was riparian, but there were no large trees other than a few scattered conifers on the hillsides that could harbor nests. If a nest was nearby, it may have been in a magpie nest in willows (*Salix*).

Gyrfalcon (*Falco rusticolus*). Behle and Perry record this species as hypothetical for Utah and provide one sight record. Hayward et al. list it as of uncertain status but provide four additional sight records for northern Utah, all by reliable persons. Three other observations for scattered locations should be placed on record. Howard Brinkerhoff (pers. comm. 1980), a falconer from the Uinta Basin, saw one there "about three years ago" in the early part of a particularly cold winter. Joe Terry, a local falconer, Gerald Richards, a Provo biologist, and Steve Chindgren, Salt Lake Tracy Aviary, (pers. comm.) had a wild Gyrfalcon attracted to their trained Gyrfalcon used in falconry while in Cache Valley, Utah, on 27 October 1978. Lastly, Steve Chindgren (pers. comm.) showed White a photograph of a Gyrfalcon taken on 3 February 1983 west of Kaysville, Utah. Chindgren and Larry Barker were hunting with a trained Northern Goshawk (*Accipiter gentilis*) when the falcon appeared. They watched it for nearly three hours, during which time it attempted to kill prey three different times. The falcon was identified as an immature female because of size and plumage characteristics. To date, most individuals have been gray color phase, although one was called white phase. White, who has had more than 20 years' experience with Gyrfalcons on their arctic breeding grounds, has no doubt as to the identification of the falcon in the photos. Although the species does occasionally escape from falconers and may be seen in the wild, it seems doubtful that enough birds could escape at such a temporal and geographic distribution to account for the Utah sightings. Based on the photograph and accumulation of records, we recommend that the species be removed from the hypothetical category and be considered an occasional winter visitant.

Common Moorhen (*Gallinula chloropus*). Recorded as either a rare permanent resident (Behle and Perry) or of casual occurrence

(Hayward et al.), this species has now established another small breeding population, this time at Utah Lake. Hayward suspected their breeding as early as 1969 but found no definite evidence. Webb found adults and three immatures on 31 July 1980 and saw them again on 11 November 1980 at Powell Slough near the Orem sewage ponds. On 18 July 1981 two immatures and on 29 August 1981 one immature was again seen at the same locality. Several observations of adults with broods along Interstate Highway 15 in the Provo Bay area of Utah Lake in May 1983 may indicate a spread of nesting to the more southern area. They were first suspected of breeding in southern Utah (Washington County) as early as 1964 (see Hayward et al.).

Whooping Crane (*Grus americana*). Until 1976 (see Behle 1981), this species was not heretofore recorded in Utah, although Utah may have been within its historical range. The species is being introduced into Gray's Lake, Caribou County, Idaho (Drewien and Bizeau 1978) where they are being fostered by the Sandhill Crane (*Grus canadensis*). The migratory route normally takes cranes from this region through Colorado into New Mexico to winter.

On 13 April 1983 Webb and Shirley saw two individuals (one adult and one immature) in a flock of approximately 400 Sandhill Cranes near Stewart Lake Waterfowl Management Area, Uintah County, Utah. Both wore colored leg bands indicating that they were part of the cross-fostered flock from Gray's Lake. Single birds were also seen in the spring of 1981 and 1982 in the same area (UDWR personnel). Other records were for Ouray National Wildlife Refuge, near Vernal, Uintah County, for a summering immature also from the Gray's Lake population (Kingery 1976); Hyrum, Cache County, 25 September 1981 (Kingery 1982a), and Jensen, Uintah County, 15 February 1981 (Kingery 1981a).

Mountain Plover (*Charadrius montanus*). Although known for Utah, this species is rare enough to record recent sightings and specimens. Behle and Perry record it as a rare transient, and Hayward et al. give some six separate records for scattered portions of the state. Behle (1981) does not give any records for northeastern Utah. A series of recent records were gathered by Billy Green and A. Ray Johnson (field notes) in Uintah County, Utah (E of Bonanza), and in Rio Blanco County, Colorado. Five individuals were seen between 9 May and 20 June 1979 in Kennedy Basin on or near the Utah-Colorado border, and one was collected (BYU 7075) on 20 June 1979 about one km E of the Colorado border. The individual was a male with testes six mm long, and, although no definite evidence was found, they were suspected of being breeders rather than migrants. This species probably breeds marginally into Utah in the Uinta Basin.

Hudsonian Godwit (*Limosa haemastica*). Based on one April 1968 sight record, this species was considered hypothetical in Utah (Behle and Perry). However, two additional birds in alternate plumage were seen on 5 June 1976 at The Barrens, near Amalga, Cache County, Utah (Sordahl 1981) and seven were reported near Randlett, Uintah County, 2 May 1981 (Kingery 1981b). A specimen (BYU 7615) was collected on 15 May 1982 at Pelican Lake, Uintah County, Utah. The bird was a male in alternate plumage with gonads measuring 10 x 4.5 mm, weighed 256 g, and had heavy subcutaneous fat. The bird was accompanying a flock of 60 Marbled Godwit (*Limosa fedoa*).

Snowy Owl (*Nyctea scandiaca*). Although this species is an occasional or rare winter visitant, there are only three extant specimens recorded by Behle and Perry and four mentioned by Hayward et al. On 25 February 1982 we received a dead bird (BYU 7609) originally found alive "a few miles" northeast of the Salt Lake City International Airport in January. It was turned over to personnel of the Utah Division of Wildlife Resources and then taken to Hogle Zoological Gardens where it subsequently died. When prepared, we found 19 porcupine quills in the forearm and hand of the right wing. They appeared to have been imbedded in the bird for long enough to have healed but may have been the reason that the bird was debilitated and caught. The amount of dark pigmentation and ventral spots suggests that it was an immature, although it lacked any of the first-year gray-colored feathers that are often retained from the juvenile plumage.

Northern Hawk Owl (*Surnia ulula*). On 11 February 1976 one was brought to Brigham Young University (BYU 5895) by a local resident, Alice Chipman. It was found dead on the road "a few miles" from the Sundance Ski Resort in Provo Canyon, about 40 km NE of Provo, Utah County, Utah. The habitat there is mixed coniferous and deciduous forest. It was some time before the owl was received by us and circumstances surrounding the finding were never adequately determined. It is unknown how long it lay dead before being found. The skull was intact, although it was crushed, apparently by a vehicle. The legs, wings, back, and neck were too dry for proper specimen preparation and the sex was not determined. The plumage was badly worn but appeared to be that of an adult rather than an immature in that it lacked the more reddish brown underparts and broadly white-tipped tail (Bent 1938). A specimen taken in Alaska on 9 August shows a decidedly reddish brown cast which is described for the immature, but the amount of spotting on the upper parts agrees with presumably adult Alaskan specimens collected on 8 January and 7 February. Ridgway (1914) made no distinction between adult and immature birds based on plumage. The specimen shows traces of "hunger streaks" or "shock marks" across the rectrices, characteristic of feather growth in birds undergoing physiological stress, such as hunger, at the time the feather is growing. This might indicate a bird of the year raised in a food stress situation. The specimen appears to be the first record in western U.S. south of the Brookings, South Dakota (Serr 1978), Nampa, Idaho (Rogers 1974), and Pocatello, Idaho (Rogers 1978b) regions. We were unable to locate any winter records for Wyoming.

Although this owl appears as an "invasion" species within different areas of its normal winter range, a perusal of *American Birds* for 1975–76 did not show any unusual southward movement of this species that year. Further, most of the winter records are of birds in more open deciduous woods or prairie habitat rather than conifer habitat.

Scissor-tailed Flycatcher (*Tyrannus forficatus*). There are four separate observations of this species in the literature, all based on sight records, and the species is considered accidental in Utah (Hayward et al.). The circumstances surrounding the following additional observation seems noteworthy. On 29 May 1982 there was a large high pressure area over a considerable portion of Utah and Nevada. At Elberta, Utah County, Utah, winds from the south at 40–50 km/h lasted most of the day, but by evening they shifted within 10 min to the north and the temperature dropped 10–15 C within the same time period. These winds lasted throughout the night. The following morning, 30 May, was calm, clear, and unseasonably cool. Martin Dobson and Judy Wray, two zoology graduate students working on a bird project, found this flycatcher foraging along the fence row adjacent to Utah Route 68, eight km N of Elberta. They approached it to within 10 m in a vehicle and watched it forage for about 45 min as it moved south to north. They returned to camp to get cameras; but when they, along with several other people, returned an hour later to the location of the bird, it could not be found. Then, one week later, on 6 June, A. Ray Johnson (pers. comm.) was traveling along the same highway about 17 km N of the previous observation and saw a scissor-tail, perhaps the same individual, foraging along the fence row. He approached to within 25 m and watched it for about one min. He judged the bird to be an adult.

Steller's Jay (*Cyanocitta stelleri*). Behle (1958) did not find this species in the Raft River Mountains, extreme northwestern Box Elder County, Utah, during his extensive studies there. He did, however, indicate that Clarence Cottam found them there and reported them to him. In light of Behle's findings, one observation should be placed on record. Rosey Rosa saw one on 30 November 1950 at Standrod, a ranch area on the north slope of the Raft River Mountains just a few miles south of the Idaho border, and Porter saw one there from December 1950 through 28 January 1951. Behle and Perry indicate that the northern race *annectens* moves into northern Utah in winter. This observation may represent an individual of that race.

American Crow (*Corvus brachyrhynchos*). The breeding distribution of this species for Utah has been most recently discussed by Richards and White (1963). Nowhere in Utah are breeding crows as common as they are in adjacent regions, as for example along the Humbolt River Valley, northern Nevada. Some nesting records come from extreme southwestern Utah, while the rest are from central and eastern Utah. Their status is poorly known for the northwestern part of Utah (Box Elder County) and adjacent Idaho. Burleigh does not describe their nesting distribution for that region of Idaho. Levy (1950) called the species a common summer resident in the south central Idaho region he covered, although most of that region was well northward into southern Idaho. Over a straight line 56 km distance from 14 km N of Malta to Clear Creek, Box Elder County, Utah, we found five nesting pairs. The spacing of pairs was rather regular, and they occurred in the central part of the Raft River Valley. Although one nest was in a juniper tree in a cultivated riparian situation, the others were in deciduous trees in partially cultivated or manipulated areas. This distribution contrasted markedly with the Common Raven (*Corvus corax*), which nested almost exclusively in juniper trees at the edges of the valley (the juniper-sagebrush ecotone), or on tall electric power transmission pylons that ran through the center of the valley. Three were on cliffs. In that same distance we found 15 raven nests.

Four fresh crow eggs were found on 28 April, and at two nests, young 5–7 days old and 10–12 days old were found on 29 May. By contrast, ravens were starting to fledge by 1 June. Thus, the spatial placements of nests, nesting chronology, and density of ravens was notably different from crows, with only limited overlap in these variables. In addition to the Clear Creek, Utah, nest a second nest was found along Grouse Creek, 20 km N of the town of Grouse Creek (ca. 10 km SW of Lynn). Both nests were in willows in a riparian situation. These are the only two nests thus far reported for that region (western Box Elder County) of Utah. Since Behle (1958) worked in the Lynn and Clear Creek areas and did not find them breeding, nor did he have reports from early investigations, and since Porter also failed to see them in the Raft River area during his studies in the early 1950s, they may be recently established there.

Black-tailed Gnatcatcher (*Polioptila melanura*). This species is listed as hypothetical for Utah based on a single December 1969 record in St. George, Washington County (Behle and Perry). There are, however, numerous Nevada records adjacent to Washington County. On 3 April 1982 members of a Brigham Young University ornithology field trip to Beaver Dam Wash, Washington County, watched a pair as they foraged about three to four km N of Lytle's Ranch. They pursued the pair for about 1¼ hours and had many close observations. Members of the group, David Ng, Tod DeLong, Ed Robey, and David Fischer, have had experience with gnatcatchers in a variety of habitats and areas. The black crown was particularly evident. Some of the observers had earlier on the trip seen the Blue-gray Gnatcatcher (*Polioptila caerulea*). Then, on 2 June 1982, A. Ray Johnson and Dan Landeen watched a pair for 8 to 10 min in the same region of the Beaver Dam Wash as on the earlier date. It is doubtful that both parties found the same pair, and it seems likely that a small breeding population exists along Beaver Dam Wash. Members of the Weber State University ornithology class saw a pair in Beaver Dam Wash about 1.6 km E of Terry Ranch in joshua tree habitat on 14 May 1983 (via David Fischer, pers. comm.). Because of the variability in the extent of black on the head, examples of this species should be examined in the hand to verify these observations.

Mockingbird (*Mimus polyglottos*). This species was not recorded as breeding in Idaho by Burleigh and apparently only straggles into that state. Stephens and Reynolds (1983) list it as an occasional erratic visitor to southwestern Idaho. Since it had not been recorded breeding in southern Idaho and its status in northern Utah is not clearly defined and breeding records are rare there (Hayward et al.), the following observations are of value. Steve Hoffman (pers. comm.) saw adults feeding young in late April 1974, 16 km N of the Utah-Idaho border on the W side of the Sublette Hills, Oneida County, Idaho. By 1977, they were reported another 160 km northward at Atomic City, Bingham County, Idaho (Rogers 1978a).

On 28 June 1947 Porter saw five together at Locomotive Springs, Box Elder County.

On 16 June 1953 Porter (Porter, Bushman, and Behle unpubl. ms.) found a nest with three young at Dugway Proving Grounds, Tooele County, Utah (see photograph, page 109 in Hayward et al.). The habitat was desert scrub with an occasional juniper tree. The nest was about 0.7 m above the ground in a 2 m fourwing saltbush (*Atriplex canescens*). The Dugway area was used again in 1966. The species was attempting to breed north of Tooele as early as 1934 (Woodbury et al. ms.). Shirley observed two singing males on territories 5 km SE of Gold Hill, Tooele County, Utah on 25 May 1982.

Bendire's Thrasher (*Toxostoma bendirei*). Mainly a species of the southern half of Utah, there are scattered sight records in north central and northwestern Utah (Behle and Perry). A. Ray Johnson and Billy Green (field notes) took photographs of a pair and recently fledged young in the northeastern portion of the state at Coyote Wash, 17 km NE Bonanza, Uintah County, Utah (see Kingery 1980c). They were seen through the period 31 May – 4 June 1980. This may represent the northern extreme of the breeding range. The species was reported again in 1981 from Randlett, Uintah County, Utah (Kingery 1981c).

Ovenbird (*Seiurus aurocapillus*). Called hypothetical by Behle and Perry and Hayward et al. because of the lack of appropriate documentation (specimen or photograph), the species is now represented by a specimen found by Lloyd Gunther, formerly of the U.S. Fish and Wildlife Service, in Brigham City, Box Elder County, Utah on 20 September 1977 (BYU 5860). The specimen weighed 15 g and is thought to be an adult female. When prepared it was freeze dried, so sex and skull ossification condition could not be examined.

Canada Warbler (*Wilsonia canadensis*). This species was not listed by Behle and Perry, and only the date and location of collection was mentioned by Hayward et al. The specimen (BYU 5390) is an adult male in alternate plumage, based on color and markings, and was well preserved as a mummy except for the loss of the right eye and portions of the right side of the face. This bird was found dead at Callao, Tooele County, Utah, along with numerous other dead and dried birds at the base of a cottonwood tree. They perished in an unseasonable cold and snowy spell between 30 April and 23 May 1975 (see Whitmore et al. 1977 for a discussion of mortality during this period). Many of the specimens were in a similar state of preservation due to the extremely arid conditions of Callao. The date of 31 May 1975 given by Hayward et al. was the date the bird was found and probably represents at least a week after the species actually arrived in Callao, perhaps as much as three weeks after arrival.

Northern Cardinal (*Cardinalis cardinalis*). This species had not been heretofore recorded for Utah. An adult male was seen at the feeder of Merlin Killpack in Ogden, Utah, on 10 March 1983. The bird (BYU 7620) was trapped at the feeder for observation and to photograph, but died before it could be released. It weighed 44.5 g and was in good condition. There is no indication that the cardinal was an escapee from captivity.

Indigo Bunting (*Passerina cyanea*). Burleigh does not list this species for Idaho, and Stephens and Reynolds (1983) list it as accidental for southwestern Idaho. On 18 May 1979 at the mouth of Six Mile Canyon, Raft River Valley, Idaho, we found a male in alternate plumage accompanied by a chestnut-colored female, which we took to be also of this species rather than the more tan-colored female of the Lazuli Bunting (*Passerina amoena*). The male was seen to interact on two occasions with a male Lazuli Bunting. Both times the Lazuli was seen chasing the Indigo Bunting. The pair was seen briefly as they flew across the road on 19 May but not thereafter.

Sage Sparrow (*Amphispiza belli*). Behle and Perry indicated that this species occurs normally in Utah between March and the end of November and leaves the state in midwinter, although it has also been known to occur in extreme southwestern Utah during winter (Hayward et al.) This species, in fact, occurs over a much wider portion of western Utah throughout the entire year, though more scarce and spotty in winter, and should be considered a permanent resident. Porter et al. (unpublished ms) commonly found loose flocks of 3 to 5 and an occasional single species flock of up to 50 individuals from December through March in Dugway Valley, Tooele County, in 1952–1954. They occupied salt scrub habitat where greasewood (*Sarcobatus*) was the principal plant.

Lark Bunting (*Calamospiza melanocorys*). This species occurs near the western edge of its breeding range in western Utah and is rare there (see Porter and Egoscue 1954), with a poorly documented breeding distribution. Behle and Perry list it as an uncommon transient for most of Utah outside of the Uinta Basin, where it is a regular breeder. Hayward et al. list four other scattered or isolated presumed Utah breeding records outside the Uinta Basin based on time of collection or reported egg clutches. Burleigh stated that it reaches the extreme western portion of its breeding range in southern Idaho, that it is a local and uncommon summer resident, and he lists a few summer records of birds in breeding condition. One mentioned by Levy (1962) from the Caribou Basin, some 160 km NE of Raft River, had testes in breeding condition on 28 May. Stephens and Reynolds (1983) list it as an accidental for southwestern Idaho (they consider 114°W Long, about 32 km W of our study area, as the eastern limits of the region covered). On 24 May 1979 we saw a male in Raft River Valley, and on 19 June 1979 found a pair, the male still courting, near the mouth of Six Mile Canyon, Raft River Valley, Cassia County, Idaho. Then, on 12 July 1979 we found three other pairs in the Black Pine Valley (the valley extends from Box Elder County, Utah, into Oneida County, Idaho, and about 19 km SE of the Six Mile Canyon). One male with food in its bill as though feeding young was about 12 km W of Snowville, Utah; directly N about 5 km was another foraging pair, and about 1½ km farther N into Idaho was a third male also gathering food. The habitat is a mixed greasewood-sagebrush-grass community.

Harris' Sparrow (*Zonotrichia querula*). The temporal stay of this species in Utah is given by Behle and Perry as late October to the end of April. It reportedly arrives later than most wintering finches and departs later than many. Its spring departure may in fact be correlated with weather. In 1983 unseasonably cold weather with intermittent snow prevailed throughout the spring with a heavy snow fall during the period of 10–13 May and again on 16 May. On 14 May a bright-pink-billed adult male in alternate plumage was seen in Mapleton, Utah County, Utah, by Porter. It remained until 18 May. Two other individuals also occurred in Pleasant Grove during the same period, arriving on 8 May and departing on 20 May (UDWR personnel). The late date suggests that the species may stay two to three weeks longer than previously recorded, but these later departures may be dictated by weather conditions near normal departure time.

Bobolink (*Dolichonyx oryzivorus*). Because recent data on the Bobolink are scanty and nesting information poor (Hayward et al.), observations from the past few years are of interest. Shirley counted six territorial males on 12 June 1982 in a grassy pasture W of Interstate Highway 15 near Springville, Utah County, Utah. This small nesting population has been observed at the same location for several years. It is unknown whether successful nesting takes place. Each year the grass hay is cut part way through the nesting season, which may destroy the nests. Additional sightings by Webb in 1981 and 1982 of a breeding pair the first week in June near Midway, Heber Valley, may indicate nesting in that area.

Great-tailed Grackle (*Quiscalus mexicanus*). This species is not mentioned by either Behle and Perry or Hayward et al. for Utah. The range, habits, and comparison with a close species, the Boat-tailed Grackle (*Quiscalus major*) has recently been reviewed by Pruitt (1975), and the former is shown to range to about central Arizona and New Mexico. The first Utah record was of a male in worn plumage seen on 1 July 1977 at Mapleton, Utah, by Porter (unpublished ms). The most distinctive feature about the bird, other than the tail, was the disproportionately small head and neck. Then, on 6 June 1978, Webb saw this species along the Virgin River S of St. George, Washington County, Utah. In separate sightings during the week of 13–17 May 1980, as many as 8 were observed near the sewage ponds at Washington, not far from St. George, by Webb and Steve Hedges. Hedges supplied a photograph verifying a state record (Kingery 1980b). On 9 October 1980 Webb then observed a group of 10 (males, females, and immatures) S of Washington. During May 1982 breeding pairs were again seen at the Washington sewage ponds and at Ivin's Reservoir, 12 km W of St. George. Territorial males were observed during the spring of 1983 at Ivin's Reservoir, and on 7 May 3 males and 2 females were seen flying up Magotsu Creek 1.6 km W of Veyo, Utah. During the 1982 Christmas bird count, 5 were seen on the east shore of Utah Lake not far from Provo by Webb. They are also reported to have reached Bicknell, Wayne County, Utah, by 18 April 1981 (Kingery 1981b).

The species has been expanding its range beyond that shown by Pruitt (1975) into several western states. It was recorded to breed for the first time in California's lower Colorado River Valley in 1969 after having been seen first in 1964 (Small 1974). For Colorado the first breeding occurred in Monte Vista in 1973 (Stepney 1975), when eight nests were found, and in Nevada it occurred in Ruby Valley and Sunnyside in 1981 (Kingery 1981b).

Common Grackle (*Quiscalus quiscula*). This species is listed as accidental by Hayward et al. and as a rare transient by Behle and Perry, based on scattered records throughout the year. They were first found breeding in 1977 at Vernal (Behle 1981). Then on 22–23 May 1981 three nests were found on the grounds of the Dinosaur Museum of Natural History, Vernal, Uintah County, Utah, by Steve Hedges. Again on 15 May 1983, four nesting pairs were observed (see Kingery 1981b). It may also be breeding in the area of Utah Lake based on several April 1983 records and an adult male found dead on 22 April 1983 in Springville (BYU 7623) that had testes in a breeding condition (12 x 8 mm). The bird weighed 125 g.

Scott's Oriole (*Icterus parisorum*). Although there are scattered records for this species throughout Utah, neither Behle and Perry nor Hayward et al. mention the 1936 observations of Twomey (1942) for Powder Springs, Uintah County, Utah, nor the adjacent Rio Blanco County, Colorado, records. Twomey's map shows Powder Springs to be in Colorado; his description of the location, page 359, places it in Utah. The 7.5 min USGS Cliff Ridge quadrangle for Utah matches Twomey's description with a Powder Springs Wash, but a Powder Springs location does not appear on the appropriate (Mellen Hill) 7.5 min quadrangle for Colorado to match Twomey's map. Behle (1981) subsequently rightly mentions the Powder Springs location in Utah. In 1979 A. Ray Johnson and Billy Green (field notes and pers. comm.) found this species in June and July 10–12 km from Twomey's Colorado observation, and in August (11–14) four to five individuals were seen directly west of the Colorado sightings some 12–16 km into Uintah County, Utah (see Kingery 1980c). It appears that a limited but consistent population occurs in that region that lies between Rangley, Colorado, and Ouray, Utah, and probably has been there at least in the 40-year period since Twomey. It is interesting to note that the *Colorado Field Ornithologists* (Reddall 1976) opted to drop it from the state list because of what they considered unconvincing details prior to 1974, and then added it in 1975 based on an early May individual from Jefferson County. Although Burleigh does not list them for Idaho, Steve Hoffman (pers. comm.) observed several in the Sublette Hills, approximately 8 km S of Holbrook, Oneida County, Idaho, just to the east of the Raft River Valley during the breeding season of 1974–75. He believed them to be nesting.

Acknowledgment

In addition to the graduate students mentioned in the text, we also thank M. Ralph Browning, U.S. National Museum, for comments on the manuscript, and Tom L. Thurow, Dan Johnson, Richard Howard, William Mader, and T. Craig White for help in the field. Steve Hoffman, U.S. Fish and Wildlife Service, Albuquerque, New Mexico, supplied us with several pertinent records. A. Ray Johnson and Billy Green were funded on a contract from Burns and McDonnell Engineering Company through H. D. Smith.

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BIRDS OF SOUTHWESTERN IDAHO

Daniel A. Stephens[1,2] and Timothy D. Reynolds[1,3]

Abstract.— Based on personal birding experience, interviews with local birders, written comments and responses to a preliminary check-list, and a review of state and federal agency records and the ornithological literature, a list of 333 species of birds known to occur in southwestern Idaho is presented. The preferred habitat, season of use, breeding status, and relative abundance of each species are given.

Idaho has extreme geologic, topographic, and climatic diversity. The diversity of habitats and microhabitats is reflected by the abundance of vertebrate species within the state. In this regard, southwestern Idaho (south of the Salmon River and west of the 114° Meridian; Fig. 1) is no exception. Within this region, elevation ranges from around 350 m ASL in Hells Canyon on the Snake River to over 3,600 m ASL in the White Cloud Peaks of the Sawtooth Mountains. Although sagebrush steppe and coniferous forests are dominant vegetation types in southwestern Idaho, numerous pond, marsh, lake, reservoir, agricultural, alpine, and riparian habitats are present. As the varied habitat suggests, there is a concomitant diversity in the avifauna. Here, typically northern taiga species such as the Boreal Owl (*Aegolius funereus*) can be found less than 200 km from strictly desert species like the Black-throated Sparrow (*Amphispiza bilineata*). The objective of this study was to develop an accurate check-list of the birds occurring in southwestern Idaho, documenting the breeding status, abundance, season of use, and preferred habitat for each species.

Material and Methods

Although many regional bird check-lists are generally a combination of birds known to occupy an area as well as birds suspected to be in the region, our list (Table 1) includes only those species for which there are reliable records. Data were gathered from a series of interviews with local birders, reviewing wildlife records from various state and federal agencies, an extensive review of the ornithological literature, and personal birding experience in southwestern Idaho.

Fig. 1. The southwestern Idaho study area (shaded), south of the Salmon River and west of the 114° longitude.

[1]Department of Biology, Boise State University, Boise, Idaho 83725.
[2]Present address: Biology Department, Central Washington University, Ellensburg, Washington 98926.
[3]Present address: Biology Department, Idaho State University, Pocatello, Idaho 83209.

TABLE 1. Birds of southwestern Idaho. Introduced species are preceded by an asterisk (*)

Taxa	Abundance[1], season and breeding status[2]	Preferred habitat[3]	References
GAVIIFORMES			
Gaviidae			
Red-throated Loon. *Gavia stellata*	V6	w	23, 7, 36
Arctic Loon. *G. artica*	M6	w	MC, JD, RK, AL
Common Loon. *G. immer*	B4, M3, W4	w	
Yellow-billed Loon. *G. adamsii*	7	w	32
PODICIPEDIFORMES			
Podicipedidae			
Pied-bill Grebe. *Podilymbus podiceps*	B2, W4	w	
Horned Grebe. *Podiceps auritus*	M3, W4	w	
Red-necked Grebe. *P. grisegena*	M5	w	7, 13, 23, MC, DJ, TDR, DAS
Eared Grebe. *P. nigricollis*	B3, M2, W4	w	
Western Grebe. *Aechmophorus occidentalis*	B2, M2, W4	w	
PELECANIFORMES			
Pelecanidae			
American White Pelican. *Pelicanus erythrorhynchos*	S4, M3	w	
Brown Pelican. *P. occidentalis*	V6	w	7, 33
Phalacrocoracidae			
Double-crested Cormorant. *Phalacrocorax auritus*	B3, W4	w	
CICONIIFORMES			
Ardeidae			
American Bittern. *Botaurus lentiginosus*	B3	w	
Least Bittern. *Ixobrychus exilis*	M6	w	USFWS
Great Blue Heron. *Ardea herodias*	R2	w	
Great Egret. *Casmerodius albus*	B4, M3, W5	w	
Snowy Egret. *Egretta thula*	B3	w	
Cattle Egret. *Bubulcus ibis*	V5	w, f	AL, IDF&G, USBLM, USFWS
Green-backed Heron. *Butorides straitus*	V4	w	
Black-crowned Night-Heron. *Nycticorax nycticorax*	R3	w, d	
Threskiornithidae			
White Ibis. *Eudocimus albus*	V6	w	7, WB
White-faced Ibis. *Plegadis chihi*	B3	w	
Ciconiidae			
Wood Stork. *Mycteria americana*	V6	d, w	2
ANSERIFORMES			
Anatidae			
Fulvous Whistling-Duck. *Dendrocygna bicolor*	7	w	7, DJ
Tundra Swan. *Cygnus columbianus*	M2, W4	w	
Trumpeter Swan. *C. buccinator*	V5	w	7, JFD, DT, USFWS
Greater White-fronted Goose. *Anser albifrons*	M3	w	
Snow Goose. *Chen caerulescens*	M3	w, f	
Ross' Goose. *C. rossii*	M4	w	
Canada Goose. *Branta canadensis*	R1	w, f	
Wood Duck. *Aix sponsa*	B4, M3, W4	w, d	

[1]See text for Abundance Code.
[2]Breeding and Seasonal Use Code:
- R = Breeder and year-round resident.
- B = Summer breeder
- M = Migrant
- W = Winter visitor
- S = Summer visitor; no breeding records
- V = Erratic visitor; no breeding records

[3]Habitat Code. (Multiple habitats listed for a particular species are given in descending order of occurrence.):
- w = on or near water or marsh
- g = grassland or steppe
- j = juniper woodland
- d = deciduous woodland or riparian
- c = coniferous woodland
- a = alpine
- f = agricultural

Table 1 continued.

Taxa	Abundance[1], season and breeding status[2]	Preferred habitat[3]	References
Green-winged Teal. *Anas crecca*	B3, M1, W3	w	
American Black Duck. *A. rubripes*	7	w	THR
Mallard. *A. platyrhynchos*	R1	w, f	
Northern Pintail. *A. acuta*	B3, M1, W3	w	
Blue-winged Teal. *A. discors*	B4, M3	w	
Cinnamon Teal. *A. cyanoptera*	B2, M2, W6	w	
Northern Shoveler. *A. clypeata*	B4, M2, W4	w	
Gadwall. *A. strepera*	R3	w	
Eurasian Wigeon. *A. penelope*	V5	w	7, 8, TDR, DT
American Wigeon. *A. americana*	B4, M1, W2	w	
Canvasback. *Aythya valisineria*	B4, M2, W4	w	
Redhead. *A. americana*	B2, M2, W4	w	
Ring-necked Duck. *A. collaris*	B4, M3, W4	w	
Greater Scaup. *A. marila*	M6, W5	w	MC, LR, DT
Lesser Scaup. *A. affinis*	B4, M2, W3	w	
Harlequin Duck. *Histrionicus histrionicus*	S6, M6	w	7, 39, MC, BH, DJ, AL
Oldsquaw. *Clangula hyemalis*	M6, W5	w	7, 26, 42, RK, AL, IDF&G
White-winged Scoter. *Melanitta fusca*	V6	w	7, 32, USFWS
Common Goldeneye. *Bucephala clangula*	M2, W2	w	
Barrow's Goldeneye. *B. islandica*	M4, W3	w	
Bufflehead. *B. albeola*	M2, W3	w	
Hooded Merganser. *Lophodytes cucullatus*	M4, W4	w	
Common Merganser. *Mergus merganser*	B3, M2, W2	w	
Red-breasted Merganser. *M. serrator*	M4, W5	w	
Ruddy Duck. *Oxyura jamaicensis*	B3, M2, W4	w	
FALCONIFORMES			
Cathartidae			
Black Vulture. *Coragyps atratus*	7		THR
Turkey Vulture. *Cathartes aura*	B3, W6	g, c, j, f	
Accipitridae			
Osprey. *Pandion haliaetus*	B3, M3, W6	w, c	
Black-shouldered Kite. *Elanus caeruleus*	V6	g	35
Bald Eagle. *Haliaeetus leucocephalus*	B5, M3, W3	w, c, d	
Northern Harrier. *Circus cyaneus*	R2	w, g, f, j	
Sharp-shinned Hawk. *Accipiter striatus*	R3	g, d, f, j, c	
Cooper's Hawk. *A. cooperii*	R3	g, j, d, c	
Northern Goshawk. *A. gentilis*	R3	c, d, j	
Broad-winged Hawk. *Buteo platypterus*	V6	g	6, 7, MC
Swainson's Hawk. *B. swainsoni*	B3	g, d, f	
Red-tailed Hawk. *B. jamaicensis*	R2	g, d, c, j, f	
Ferruginous Hawk. *B. regalis*	B3, W6	g, j	
Rough-legged Hawk. *B. lagopus*	W2	g, f	
Golden Eagle. *Aquila chrysaetos*	R3	g, j, d	
Falconidae			
American Kestrel. *Falco sparverius*	R2	g, f, d, j	
Merlin. *F. columbarius*	R4	d, g, f, c	
Peregrine Falcon. *F. peregrinus*	B?5, M5, W5	g, w, c, a	7, 14, JFD, TDR, CT, IDF&G, USFWS, USBLM
Gyrfalcon. *F. rusticolus*	W6	f, g, w	7, JD
Prairie Falcon. *F. mexicanus*	B2, W3	g, j, a, c	
GALLIFORMES			
Phasianidae			
°Gray Partridge. *Perdix perdix*	R3	g, f	
°Chukar. *Alectoris chukar*	R2	g, j	
°Ring-necked Pheasant. *Phasianus colchicus*	R1	f, g	

Table 1 continued.

Taxa	Abundance[1], season and breeding status[2]	Preferred habitat[1]	References
Spruce Grouse. *Dendragapus canadensis*	R4	c	
Blue Grouse. *D. obscurus*	R3	c	
White-tailed Ptarmigan. *Lagopus leucurus*	R6	a, c	13
Ruffed Grouse. *Bonasa umbellus*	R3	c, d	
Sage Grouse. *Centrocercus urophasianus*	R3	g	
Sharp-tailed Grouse. *Tympanuchus phasianellus*	R4	g	
°Wild Turkey. *Meleagris gallopavo*	R4	d, c	
°Northern Bobwhite. *Colinus virginianus*	R4	f, g, d	
°Gambel's Quail. *Callipepla gambelii*	R5	g, d	2, 31, MC, LR
°California Quail. *C. californica*	R2	g, d, f	
Mountain Quail. *Oreortyx pictus*	R4	d, c, f	
GRUIFORMES			
Rallidae			
Yellow Rail. *Coturnicops noveboracensis*	7	w	28
Black Rail. *Laterallus jamaicensis*	7	w	AL
Virginia Rail. *Rallus limicola*	B3, W6	w	
Sora. *Porzana carolina*	B3, W5	w	
Common Moorhen. *Gallinula chloropus*	V6	w	36
American Coot. *Fulica americana*	B2, M1, W2	w	
Gruidae			
Sandhill Crane. *Grus canadensis*	B4, M2	g, w	
CHARADRIIFORMES			
Charadriidae			
Black-bellied Plover. *Pluvialis squatarola*	M5	w	7, 14, 28, MC, DAS, IDF&G, USFWS
Snowy Plover. *Charadrius alexandrinus*	V5	w	13, JD, LR
Semipalmated Plover. *C. semipalmatus*	M3	w	
Killdeer. *C. vociferus*	B1, M1, W3	w	
Mountain Plover. *C. montanus*	7	g, w	IDF&G
Haematopodidae			
American Oystercatcher. *Haematopus palliatus*	V6	w	38, DAS
Recurvirostridae			
Black-necked Stilt. *Himantopus mexicanus*	B3	w	
American Avocet. *Recurvirostra americana*	B3, M2	w	
Scolopacidae			
Greater Yellowlegs. *Tringa melanoleuca*	M3	w	
Lesser Yellowlegs. *T. flavipes*	M3	w	
Solitary Sandpiper. *T. solitaria*	M4	w	
Willet. *Catoptrophorus semipalmatus*	B3, M3	w	
Spotted Sandpiper. *Actitis macularia*	B2, M3	w	
Upland Sandpiper. *Bartramia longicauda*	B4, M4	g, w	
Long-billed Curlew. *Numenius americanus*	B2	g, w	
Marbled Godwit. *Limosa fedoa*	M4	w	
Ruddy Turnstone. *Arenaria interpres*	7	w	13
Red Knot. *Calidris canutus*	M5	w	13, MC, RK, AL, JM, TDR, DAS
Sanderling. *C. alba*	M4	w	
Semipalmated Sandpiper. *C. pusilla*	M3	w	
Western Sandpiper. *C. mauri*	M2	w	
Least Sandpiper. *C. minutilla*	M2	w	

Table 1 continued.

Taxa	Abundance[1], season and breeding status[2]	Preferred habitat[3]	References
Baird's Sandpiper. *C. bairdii*	M3	w	
Pectoral Sandpiper. *C. melanotos*	M5	w	2, 7, 15, AL, JM, IDF&G
Dunlin. *C. alpina*	M5	w	2, JB, JM, DAS, TDR, USFWS
Stilt Sandpiper. *C. himantopus*	M4	w	
Buff-breasted Sandpiper. *Tryngites subruficollis*	M6	w	15
Long-billed Dowitcher. *Limnodromus scolopaceus*	M3	w	
Common Snipe. *Callinago gallinago*	B2, W4	w	
Wilson's Phalarope. *Phalaropus tricolor*	B3, M2	w	
Red-necked Phalarope. *P. lobatus*	M3	w	
Laridae			
Pomarine Jaeger. *Stercorarius pomarinus*	7	w	7, 24
Franklin's Gull. *Larus pipixcan*	B?4, M3	w	
Bonaparte's Gull. *L. philadelphia*	M4	w	
Ring-billed Gull. *L. delawarensis*	R1	f, w	
California Gull. *L. californicus*	B1, W4	f, w	
Herring Gull. *L. argentatus*	M4, W4	f, w	
Thayer's Gull. *L. thayeri*	7	w	MC
Glaucous-winged Gull. *L. glaucescens*	7	f	27
Glaucous Gull. *L. hyperboreus*	W6	w	4, USFWS
Sabine's Gull. *Xema sabini*	V6	w	7, USFWS
Caspian Tern. *Sterna caspia*	B3, M4	w	
Common Tern. *S. hirundo*	M5	w	7, USFWS
Forster's Tern. *S. forsteri*	B4, M3	w	
Least Tern. *S. antillarum*	V6	w	5
Black Tern. *Chlidonias niger*	B4, M3	w	
Alcidae			
Ancient Murrelet. *Synthliboramphus antiquus*	V6	w	13
COLUMBIFORMES			
Columbidae			
°Rock Dove. *Columba livia*	R1	d, f, j, c	
Band-tailed Pigeon. *C. fasciata*	V4	d, g, j, c	
Mourning Dove. *Zenaida macroura*	B1, M1, W3	g, f, d, j, c	
CUCULIFORMES			
Cuculidae			
Black-billed Cuckoo. *Coccyzus erythropthalmus*	B4	d	
Yellow-billed Cuckoo. *C. americanus*	B5	d	7, 13, 28, AL, USFWS
STRIGIFORMES			
Tytonidae			
Common Barn-Owl. *Tyto alba*	R2	g, f, j, d	
Strigidae			
Flammulated Owl. *Otus flammeolus*	B5	c, j, d	7, 18, LP, TR
Western Screech-Owl. *O. kennicottii*	R3	d, f	
Great Horned Owl. *Bubo virginianus*	R2	g, j, d, c, f	
Snowy Owl. *Nyctea scandiaca*	W5	g	2, 7, 22, DAS
Northern Hawk-Owl. *Surnia ulula*	7		7
Northern Pygmy-Owl. *Glaucidium gnoma*	R3	g, c, d	
Burrowing Owl. *Athene cunicularia*	B2	g, f	
Barred Owl. *Strix varia*	7		LP, USBLM
Great Gray Owl. *S. nebulosa*	R4	c	
Long-eared Owl. *Asio otus*	R3	d, f	
Short-eared Owl. *A. flammeus*	R2	w, f	
Boreal Owl. *Aegolius funereus*	R5	c	MC, DAS
Northern Saw-whet Owl. *A. acadicus*	R4	d, j, c	

Table 1 continued.

Taxa	Abundance[1], season and breeding status[2]	Preferred habitat[3]	References
CAPRIMULGIFORMES			
Caprimulgidae			
Lesser Nighthawk. *Chordeiles acutipennis*	7		THR
Common Nighthawk. *C. minor*	B2	g, d, j, f, c	
Common Poorwill. *Philaenoptilus nuttallii*	B3	g, j, c	
APODIFORMES			
Apodidae			
Black Swift. *Cypseloides niger*	7		7
Vaux's Swift. *Chaetura vauxi*	B3	w, c, d	
White-throated Swift. *Aeronautes saxatalis*	B3	w, g, c, a	
Trochilidae			
Black-chinned Hummingbird. *Archilochus alexandri*	B3, W6	c, d	
Anna's Hummingbird. *Calypte anna*	M5, W5	d	BH, AL, LM, TDR, DAS
Calliope Hummingbird. *Stellula calliope*	B2	c, d	
Broad-tailed Hummingbird. *Selasphorus platycercus*	B4	d, j	
Rufous Hummingbird. *S. rufus*	B3, M4	c, d	
CORACHFORMES			
Alcedinidae			
Belted Kingfisher. *Ceryle alcyon*	R2	w, d	
PICIFORMES			
Picidae			
Lewis' Woodpecker. *Melanerpes lewis*	B2, W4	c, d	
Red-headed Woodpecker. *M. erythrocephalus*	V6	d	7, 25, MC
Yellow-bellied Sapsucker. *Sphyrpicus varius*	B3	c, d	
Williamson's Sapsucker. *S. thyroideus*	B4	c	
Downy Woodpecker. *Picoides pubescens*	R2	d, c	
Hairy Woodpecker. *P. villosus*	R3	d, c	
White-headed Woodpecker. *P. albolarvatus*	R4	c	
Three-toed Woodpecker. *P. tridactylus*	R4	c	
Black-backed Woodpecker. *P. arcticus*	R5	c	2, 7, 16, 17, DJ
Northern Flicker. *Colaptes auratus*	R2	d, c, g, f	
Pileated Woodpecker. *Dryocopus pileatus*	R3	c	
PASSERIFORMES			
Tyrannidae			
Olive-sided Flycatcher. *Contopus borealis*	B3, M3	c, d	
Western Wood-Pewee. *C. sordidulus*	B3, M3	c, d	
Willow Flycatcher. *Empidonax traillii*	B2	d	
Least Flycatcher. *E. minimus*	7	d	MC
Hammond's Flycatcher. *E. hammondii*	B2	c	
Dusky Flycatcher. *E. oberholseri*	B3	d, c, j	
Gray Flycatcher. *E. wrightii*	B3	g, j	
Western Flycatcher. *E. difficilis*	B5	d, c	7, 46, TR, IDF&G, USFWS, USBLM
Black Phoebe. *Sayornis nigricans*	7		7
Say's Phoebe. *S. saya*	B2	g, d	

Table 1 continued.

Taxa	Abundance[1], season and breeding status[2]	Preferred habitat[1]	References
Ash-throated Flycatcher. *Myiarchus cinerascens*	B3	j, g	
Western Kingbird. *Tyrannus verticalis*	B2	f, g, d	
Eastern Kingbird. *T. tyrannus*	B3	d, g, f	
Scissor-tailed Flycatcher. *T. forficatus*	V6	g	40
Alaudidae			
Horned Lark. *Eremophilia alpestris*	R1	g	
Hirundinidae			
Purple Martin. *Progne subis*	M6	w, d	MC, LP
Tree Swallow. *Tachycineta bicolor*	B2, M1	c, d, w	
Violet-green Swallow. *T. thalassina*	B2, M1	c, d, w	
Northern Rough-winged Swallow. *Stelgidopteryx serripennis*	B2, M2	w, c, d	
Bank Swallow. *Riparia riparia*	B2, M2	w, f, g	
Cliff Swallow. *Hirundo pyrrhonota*	B1, M1	g, w, c, f	
Barn Swallow. *H. rustica*	B1, M1	f, w, g	
Corvidae			
Gray Jay. *Perisoreus canadensis*	R3	c	
Steller's Jay. *Cyanocitta stelleri*	R2	c, d	
Blue Jay. *C. cristata*	V4	d	
Scrub Jay. *Aphelocoma coerulescens*	R4	j, g	
Pinyon Jay. *Gymnorhinus cyanocephalus*	R4	j, g	
Clark's nutcracker. *Nucifraga columbiana*	R2	c, a	
Black-billed Magpie. *Pica pica*	R1	g, f, d, j	
American Crow. *Corvus brachyrhynchos*	R1	d, f, g, j, c	
Common Raven. *C. corax*	R2	d, g, j, c, a	
Paridae			
Black-capped Chickadee. *Parus atricapillus*	R2	c, d	
Mountain Chickadee. *P. gambeli*	R2	c, j	
Chestnut-backed Chickadee. *P. rufescens*	7	c	39
Plain Titmouse. *P. inornatus*	R5	j	2, 7, 13, 15, USBLM
Aegithalidae			
Bushtit. *Psaltriparus minimus*	R3	d, j	
Sittidae			
Red-breasted Nuthatch. *Sitta canadensis*	R2	c	
White-breasted Nuthatch. *S. carolinensis*	R3	c, d	
Pygmy Nuthatch. *S. pygmaea*	R4	c	
Certhiidae			
Brown Creeper. *Certhia americana*	R3	c, d	
Troglodytidae			
Rock Wren. *Salpinctes obsoletus*	B2, W5	g, j, a	
Canyon Wren. *Catherpes mexicanus*	B3, W4	g, j	
Bewick's Wren. *Thryomanes bewickii*	7	d	MC
House Wren. *Troglodytes aedon*	B2	d	
Winter Wren. *T. troglodytes*	R3	c, d	
Marsh Wren. *Cistothorus palustris*	B2, W3	w	
Cinclidae			
American Dipper. *Cinclus mexicanus*	R3	w	
Muscicapidae			
Golden-crowned Kinglet. *Regulus satrapa*	B4, W3	c, d	
Ruby-crowned Kinglet. *R. calendula*	R2	c, d	

Table 1 continued.

Taxa	Abundance[1], season and breeding status[2]	Preferred habitat[1]	References
Blue-gray Gnatcatcher. *Polioptila caerulea*	B4	d, j	
Western Bluebird. *Sialia mexicana*	B3	c	
Mountain Bluebird. *S. currucoides*	B2, M1, W5	c, d, j	
Townsend's Solitaire. *Myadestes townsendi*	R3	j, c, d, a	
Veery. *Catharus fuscescens*	B3	d	
Swainson's Thrush. *C. ustulatus*	B2, M3	c, d	
Hermit Thrush. *C. guttatus*	B3, M3, W5	c, d	
Wood Thrush. *Hylocichla mustelina*	7		7
American Robin. *Turdus migratorius*	R1	c, d, f, g, j	
Varied Thrush. *Ixoreus naevius*	B4, M4, W5	c, d	
Mimidae			
Gray Catbird. *Dumetella carolinensis*	B3	d	
Northern Mockingbird. *Mimus polyglottos*	V4	g, d	
Sage Thrasher. *Oreoscoptes montanus*	B2	g	
Motacillidae			
Water Pipit. *Anthus spinoletta*	B?4, M2, W4	g, w, a, f	
Bombycillidae			
Bohemian Waxwing. *Bombycilla garrulus*	W2	c, d, j, f	
Cedar Waxwing. *B. cedrorum*	B3, W2	c, d, j, f	
Laniidae			
Northern Shrike. *Lanius excubitor*	W3	g, f, d, j	
Loggerhead Shrike. *L. ludovicianus*	B3, W4	g, f, d, j	
Sturnidae			
°European Starling. *Sturnus vulgaris*	R1	f, d, g, c, j	
Vireonidae			
Solitary Vireo. *Vireo solitarius*	B3	c, d	
Warbling Vireo. *V. gilvus*	B2	d	
Red-eyed Vireo. *V. olivaceus*	B4	d	
Emberizidae			
Golden-winged Warbler. *Vermivora chrysoptera*	V6	d	TR
Tennessee Warbler. *V. peregrina*	M5	d	7, JB, MC, LM
Orange-crowned Warbler. *V. celata*	B3, W5	d	
Nashville Warbler. *V. ruficapilla*	B3	d, c	
Virginia's Warbler. *V. virginiae*	V5	j, d	7, 14, MC
Yellow Warbler. *Dendroica petechia*	B2	d	
Magnolia Warbler. *D. magnolia*	7	c, d	7
Yellow-rumped Warbler. *D. coronata*	B2, W4	c, d	
Black-throated Gray Warbler. *D. nigrescens*	B3	j	
Townsend's Warbler. *D. townsendi*	B4, M3	c, d	
Blackburnian Warbler. *D. fusca*	7		7
Blackpoll Warbler. *D. striata*	7	d	MC
Black-and-white Warbler. *Mniotilta varia*	M6	d	7, 13, 39, USFWS
American Redstart. *Setophaga ruticilla*	B4, M3	c, d	
Ovenbird. *Seiurus aurocapillus*	M6	d	JD, JM
Northern Waterthrush. *S. noveboracensis*	B5, M5	d, c, w	7, JB, MC, DAS, DT
MacGillivray's Warbler. *Oporornis tolmiei*	B3	d	
Common Yellowthroat. *Geothlypis trichas*	B3	w	
Wilson's Warbler. *Wilsonia pusilla*	B3, M3	d	
Yellow-breasted Chat. *Icteria virens*	B2	d	
Western Tanager. *Piranga ludoviciana*	B2, M2, W5	c, d	

Table 1 continued.

Taxa	Abundance[1], season and breeding status[2]	Preferred habitat[3]	References
Rose-breasted Gosbeak. *Pheucticus ludovicianus*	V6	d	7, RK, AL, JM
Black-headed Grosbeak. *P. melanocephalus*	B3	d	
Blue Grosbeak. *Guiraca caerulea*	B4	d, g	
Lazuli Bunting. *Passerina amoena*	B2, M2	c, d	
Indigo Bunting. *P. cyanea*	V6	d	7, 30, MC, USFWS
Green-tailed Towhee. *Pipilo chlorurus*	B3	j, d, g	
Rufous-sided Towhee. *P. erythrophthalmus*	B2, M3, W4	d, g, j	
American Tree Sparrow. *Spizella arborea*	W3	g, w	
Chipping Sparrow. *S. passerina*	B2, M2, W5	c, d, j	
Clay-colored Sparrow. *S. pallida*	7	g, d	MC
Brewer's Sparrow. *S. breweri*	B1	g	
Vesper Sparrow. *Pooecetes gramineus*	B2	g, c	
Lark Sparrow. *Chondestes grammacus*	B2	g, j	
Black-throated Sparrow. *Amphispiza bilineata*	B4	g	
Sage Sparrow. *A. belli*	B3	g	
Lark Bunting. *Calamospiza melanocorys*	V6	g	7, 35
Savannah Sparrow. *Passerculus sandwichensis*	B2, W5	g, w	
Baird's Sparrow. *Ammodramus bairdii*	7	g	7, 24
Grasshopper Sparrow. *A. savannarum*	B5, M5	g	7, 28, MC, DAS, USBLM
Fox Sparrow. *Passerella iliaca*	B4, M4, W5	c, d	
Song Sparrow. *Melospiza melodia*	R1	w, d	
Lincoln's Sparrow. *M. lincolnii*	B3, W5	d, a	
Swamp Sparrow. *M. georgiana*	W6	d	37
White-throated Sparrow. *Zonotrichia albicollis*	M5, W5	g	7, 41, MC, AL, LM, DT
Golden-crowned Sparrow. *Z. atricapilla*	M5, W6	g, d	7, 9, 10, 13, 26, 29, MC, DT
White-crowned Sparrow. *Z. leucophrys*	R1	g, a, f, d, c	
Harris' Sparrow. *Z. querula*	W4	g, d	
Dark-eyed Junco. *Junco hyemalis*	R1	d, c, g	
Lapland Longspur. *Calcarius lapponicus*	W5	g, c	2, 7, DJ, DT
Snow Bunting. *Plectrophenax nivalis*	W3	g	
Bobolink. *Dolichonyx oryzivorus*	B4, M4	g, d, f	
Red-winged Blackbird. *Agelaius phoeniceus*	R1	w, f, g, d	
Tricolored Blackbird. *A. tricolor*	7	w	7, LM
Western Meadowlark. *Sturnella neglecta*	B1, W2	g, f	
Yellow-headed Blackbird. *Xanthocephalus xanthocephalus*	B1, W4	w, f	
Brewer's Blackbird. *Euphagus cyanocephalus*	R1	g, f, j, c, d	
Common Grackle. *Quiscalus quiscula*	V6	d	MC, GEAS
Bronzed Cowbird. *Molothrus aeneus*	7		7
Brown-headed Cowbird. *M. ater*	B2, W6	g, f	
Orchard Oriole. *Icterus spurius*	7		7
Northern Oriole. *I. galbula*	B2	d	
Fringillidae			
Rosy Finch. *Leucosticte arctoa*	R3	a, g	
Pine Grosbeak. *Pinicola enucleator*	R3	c	
Purple Finch. *Carpodacus purpureus*	V6	d, c	3, 7
Cassin's Finch. *C. cassinii*	R2, M3	c, d	
House Finch. *C. mexicanus*	R2	d, c, f	
Red Crossbill. *Loxia curvirostra*	R2	c	

Table 1 continued.

Taxa	Abundance[1], season and breeding status[2]	Preferred habitat[3]	References
White-winged Crossbill. *L. leucoptera*	W6	c	7, 11, 12
Common Redpoll. *Carduelis flammea*	W4	g, d	
Hoary Redpoll. *C. hornemanni*	7		27
Pine Siskin. *C. pinus*	B2, M2, W3	c, d	
Lesser Goldfinch. *C. psaltria*	B?5	d	7, 34, DAS
American Goldfinch. *C. tristis*	R2	d, g, f	
Evening Grosbeak. *Coccothraustes vespertinus*	R2	d, c	
Passeridae			
°House Sparrow. *Passer domesticus*	R1	g, d, f	

This information was first compiled as a preliminary check-list which was then sent to 30 local birders and other ornithologists with birding expertise and experience in southwestern Idaho for review and modification. The cover letter accompanying each draft asked reviewers to assess the abundance for each species listed, and to include personal observation data (date, location, habitat, and number of individuals observed) for all species tentatively classified as occasional, rare, accidental, vagrant, or hypothetical. The abundance code, though qualitative by necessity, had a quantitative basis. Assuming a competent birder rigorously searched the proper habitat at the correct time of year, abundance categories were:

1. Abundant—more than 40 individuals per day
2. Common—10–39 individuals per day
3. Uncommon—less than 10 individuals per day
4. Occasional—1–5 total records per year
5. Rare—3–10 total records for southwestern Idaho
6. Vagrants—accidental species for which there are 2 or fewer reliable records supported by a photograph, specimen, or detailed and accurate field notes
7. Hypothetical species—unverified sight records not supported by documentation

Results

Table 1 presents the results of our investigations. The sequence of presentation and nomenclature follows the 34th supplement to the *American Ornithologists' Union Check-list of North American birds* (1982). The authority for the rare, vagrant, and hypothetical species are given where known. Initials correspond to contributors credited below or the authors (DAS, TDR); numbers correspond to literature accounts cited at the end of the paper.

Acknowledgments

The following persons, organizations, and agencies were extremely helpful in donating their time, records, and expertise in helping generate this list of birds of southwestern Idaho: J. Barnett, W. Belknap, J. Carson, M. Collie, J. F. Dixon, J. Doremus, Golden Eagle Audubon Society, B. Hammond, D. Jones, R. Kuntz, A. Larson, H. Larson, J. Marks. L. Mohler, L. Powers, T. Rich, T. H. Rogers, L. Reichert, B. Sturges, D. Taylor, C. Trost, E. Yensen, Idaho Department of Fish and Game, U.S. Bureau of Land Management, U.S. Forest Service, and the U.S. Fish and Wildlife Service. We sincerely thank each contributor for their valuable input. We gratefully acknowledge the skills of B. Donahue, C. Levesque, and M. Reynolds in typing and proofreading the manuscript.

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NEW RECORDS FOR THE VASCULAR FLORA OF WYOMING AND MONTANA

Robert W. Lichvar[1], Robert D. Dorn[2], and Erwin F. Evert[3]

ABSTRACT.— Apparent first state records of 11 taxa for Wyoming and one taxon for Montana are listed. A range extension is noted for the genus *Shoshonea*.

Recent field work from 1980 and 1982 has added one additional record to the flora of Montana and 11 additional records for Wyoming. The recently described genus and species *Shoshonea pulvinata* Evert and Constance, thought to have been a highly restricted endemic, is reported here well outside its previously known range.

APIACEAE

Shoshonea pulvinata Evert and Constance, WY, Fremont Co., T6N R5E S34, 2286 m (7500 ft), calcareous ridge, 26 July 1982, *R. Lichvar 5382* RM.

This recently described genus and species by Evert and Constance (1982) was known only from a restricted range near Cody, Wyoming. This collection, *Lichvar 5382*, is a distance of 55.8 km (90 mi) southeast of the Cody sites.

ASTERACEAE

Adenocaulon bicolor Hook., WY, Crook Co., T51N R60W S20, 1646 m (5400 ft), wet ravine, 28 July 1982, *R. Dorn 3798*, COLO, NY, RM. Same county, T51N R61W S11 SE¼, 1646 m (5400 ft), wet ravine, 12 Sept. 1982, *E. Evert 4968*, RM.

BRASSICACEAE

Lepidium sativum L., WY, Laramie Co., T14N R67W S28 SE¼SW¼, 1890 m (6200 ft), disturbed area, 21 Aug. 1982, *R. Dorn 3824*, RM.

CARYOPHYLLACEAE

Gypsophila scorzonerifolia Ser., WY, Laramie Co., T14N R67W S17 N¼, 1890 m (6200 ft), disturbed roadside, 5 Sept. 1982, *R. Dorn 3825*, RM.

CYPERACEAE

Carex alopecoidea Tuckerm., WY, Crook Co., T51N R60W S33 SW¼, 1798 m (5900 ft), wet meadow, 27 July 1982, *R. Dorn 3783*, RM.

C. deweyana Schw. ssp. *deweyana*, WY, Crook Co., T51N R60W S33 SW¼, 1798 m (5900 ft), mossy bank, 27 July 1982, *R. Dorn 3785*, NY, RM.

C. peckii Howe, WY, Crook Co., T51N R60W S20, 1646 m (5400 ft) wet ravine, 28 July 1982, *R. Dorn 3796*, RM.

C. rosea Schk. ex Willd., WY, Crook Co., T51N R60W S33 SW¼, 1798 m (5900 ft), wet meadow, 27 July 1982, *R. Dorn 3781*, RM.

FABACEAE

Astragalus coltonii Jones var. *moabensis* Barneby, WY, Uinta Co., T14N R113W S31, 2195 m (7200 ft), sagebrush, 4 June 1980, *R. Dorn 3447*, RM. Same location and date, *R. Lichvar 2780*, RM. T13N, 113W, S18 SE¼, 5 mi N 25° W of Lonetree, E side Hickey Mtn., S. Goodrich, D. Atwood 17169, 17193, 30 June 1983, BRY. T14N R113W S27, 18 mi N 12° E of Lonetree, N of Sage Cr. Mtn., S. Goodrich, D. Atwood, 17212, 1 July 1982,

[1]Wyoming Natural Heritage Program/The Nature Conservancy, 1603 Capitol Avenue, Room 325, Cheyenne, Wyoming 82001.
[2]P.O. Box 1471, Cheyenne, Wyoming 82003.
[3]1476 Tyrell, Park Ridge, Illinois 60068.

BRY. Sweetwater Co., Cedar Mtn., T13N R111W S3 NE¼, 2195 m (7200 ft), sagebrush, 11 June 1980, *R. Lichvar 2852*, RM. Same location, 8 July 1981, *R. Lichvar 4580*, RM.

This species was discussed by Barneby (1964) as possibly being collected in Wyoming by R. Rollins, no. 177, in 1932. This specimen was distributed by RM as *Hedysarum* sp. The authors were unable to relocate this specimen at RM; it is presumed filed under an *Astragalus*. Barneby felt that this specimen was probably mislabeled. These collections confirm its existence in Wyoming.

Onagraceae

Circaea lutetiana L., WY, Crook Co., T52N R60W S21 E½, 1280 m (4200 ft), stream bank, 26 July 1982, *R. Dorn 3773*, COLO, NY, RM.

Polemoniaceae

Leptodactylon caespitosum Nutt., MT, Carbon Co., T9S R27E S28 and 29 line, 1463 m (4800 ft), barren red slope, 24 June 1982, *R. Dorn 3728*, COLO, NY, RM.

Polygonaceae

Polygonum scandens L., WY, Crook Co., T54N R63W S11 NE¼, 1432 m (4700 ft), edge of beaver pond, 25 July 1982, *R. Dorn 3762*, RM. Same location and date, *R. Lichvar 5375*, RM.

Scrophulariaceae

Veronica arvensis L., WY, Crook Co., T54N R63W S1 SW¼, 1463 m (4800 ft), disturbed area in Ponderosa Pine, 25 July 1982, *R. Dorn 3761*, NY, RM. Same location and date, *R. Lichvar 5336*, RM. Same location and date, *E. Evert 4438*, RM.

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RANGE EXTENSIONS FOR TWO DWARF MISTLETOES (*ARCEUTHOBIUM* SPP.) IN THE SOUTHWEST

Robert L. Mathiasen[1] and Kenneth H. Jones[2]

Abstract.— A second small population of white fir dwarf mistletoe, *Arceuthobium abietinum* f. sp. *concoloris*, is reported from the Santa Catalina Mountains in southern Arizona. The discovery of a second population of this mistletoe in southern Arizona supports the contention that it once had a more southern distribution but has survived past climatic changes in only a few locations in the southwestern United States. The distribution of the Western spruce dwarf mistletoe, *Arceuthobium microcarpum*, is extended to the Sacramento Mountains of south central New Mexico, a range extension of approximately 170 miles. The mistletoe is restricted to an area of about 300 acres, but its potential for further spread is high. The possible implications of this range extension to the biosystematics of *Picea* spp. and the evolution of *A. microcarpum* are discussed.

White fir dwarf mistletoe, *Arceuthobium abietinum* Engelm. ex Munz f. sp. *concoloris* Hawksw. & Wiens, is a serious pathogen of white fir, *Abies concolor* (Gord. & Glend.) Lindl., in the western United States (Scharpf 1964, Scharpf and Parmeter 1967). Hawksworth and Wiens (1972) list the distribution of this dwarf mistletoe from southern Washington southward through the Cascade Range and Sierra Nevada to the San Bernardino Mountains in southern California, with four isolated populations known: the Charleston Mountains and Spring Creek Mountains, Nevada; Kane County in southwestern Utah; and Grand Canyon National Park, Arizona. More recently it has been reported from the Chiricahua Mountains of southeastern Arizona, nearly 300 miles south of the Grand Canyon populations (Mathiasen 1976).

Western spruce dwarf mistletoe, *Arceuthobium microcarpum* (Engelm.) Hawksw. & Wiens, severely parasitizes Engelmann and blue spruce, *Picea engelmannii* Parry and *P. pungens* Engelm., in the southwestern United States (Hawksworth and Graham 1963, Hawksworth and Wiens 1972). In Arizona it is known from the Kaibab Plateau, the San Francisco Peaks and Kendrick Peak, the White Mountains, and the Pinaleno Mountains (Hawksworth and Wiens 1972). In New Mexico it has only been reported from the Mogollon Mountains in the west central part of the state (Hawksworth and Wiens 1972).

This paper reports isolated populations of *A. abietinum* from the Santa Catalina Mountains in south central Arizona and of *A. microcarpum* from the Sacramento Mountains in south central New Mexico.

In 1979 a very small population of *A. abietinum* was discovered parasitizing white fir in the Santa Catalina Mountains of Pima County, Arizona (Fig. 1). The population occurs in an area of about 10 acres in Marshall Gulch (T. 12 S., R. 16 E., Section 6) near the center of the mountain range at elevations of 2,310 to 2,340 m. The predominant tree species in the infested stand are white fir, Douglas fir (*Pseudotsuga menziesii* [Mirb.] Franco), and southwestern white pine (*Pinus strobiformis* Engelm.). Douglas fir dwarf mistletoe (*Arceuthobium douglasii* Engelm.) also occurs in the stand on Douglas fir. Douglas fir dwarf mistletoe has rarely been collected on white fir and can easily be distinguished from white fir dwarf mistletoe using shoot morphology (Hawksworth and Wiens 1972). This is the second report of a small, isolated population of *A. abietinum* from southern Arizona. The first was reported in the Chiricahua Mountains, approximately 100 miles southeast of the Santa Catalina population (Mathiasen 1976). The Santa Catalina population of *A. abietinum* is nearly 260 miles south of the Grand Canyon population of this taxon, and no other populations of *A. abietinum* are known between these localities (Mathiasen 1976).

[1]School of Forestry, Northern Arizona University, Flagstaff, Arizona 86011.
[2]Sacramento Mountain Laboratory, New Mexico State University, Sunspot, New Mexico 88349.

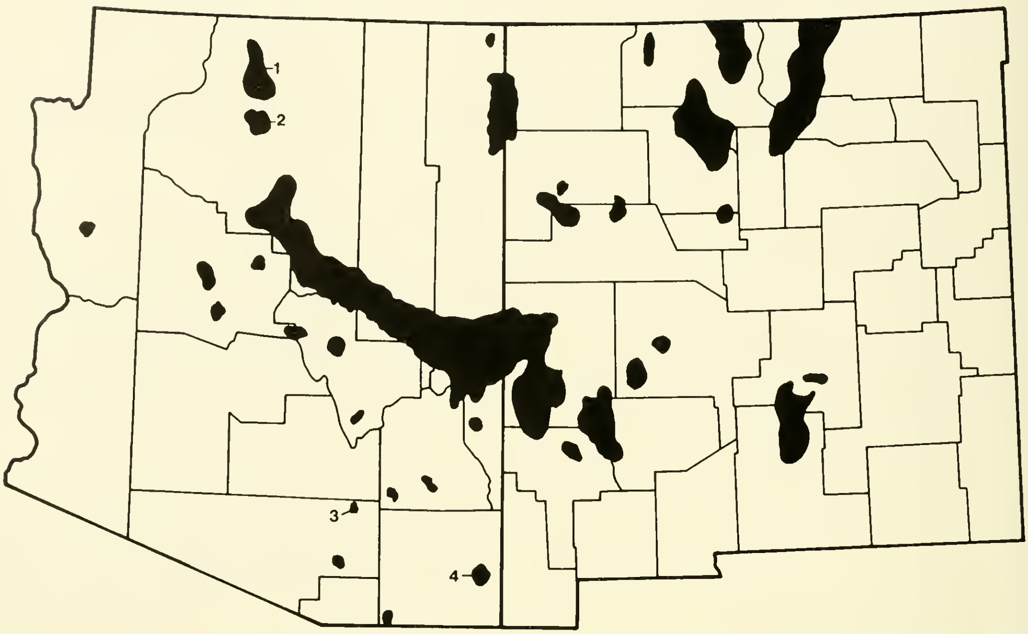

Fig. 1. Distribution of *Abies concolor* and *Arceuthobium abietinum* (1–4) in Arizona and New Mexico. Numbers 3 and 4 represent the *A. abietinum* populations in the Santa Catalina and Chiricahua mountains, respectively.

The discovery of a second population of *A. abietinum* in southern Arizona supports the suggestion that *A. abietinum* had a more widespread southern distribution in the past and only relict populations now exist where climatic conditions have remained favorable for its survival in the southwestern United States (Mathiasen 1976). Both of the southern Arizona populations of *A. abietinum* occur on mesic, north-facing slopes of narrow canyons at approximately the same elevational range, and near the lower elevational limits of white fir in the Southwest. The occurrence of an extremely isolated population of the white fir true mistletoe, *Phoradendron densum* Torr. ex Trel. subsp. *pauciflorum* (Torr.) Wiens, parasitizing white fir in the Santa Catalina Mountains, may indicate this mistletoe had a more southern past distribution also. *Phoradendron densum* subsp. *pauciflorum* has not been found on white fir in other mountain ranges in Arizona, but it does occur in the Sierra San Pedro Mártir in Baja California, which is farther south than the Santa Catalina populations (Wiens 1964). Therefore, it may be possible that both of these white fir parasites migrated to southern Arizona along a southern route when Baja California and the present mainland of Mexico were continuous (Hamilton 1961). However, *A. abietinum* has not been reported from Baja California, but may not have survived there for the same reasons it has not been reported from more localities in the southwestern United States. The discovery of additional relict populations of *A. abietinum* and *P. densum* subsp. *pauciflorum* in Mexico or in the mountain ranges with white fir populations between the Grand Canyon and southern Arizona would provide more evidence concerning the past distribution of these taxa and their probable migration routes into the Southwest.

In 1980, a small population of *A. microcarpum* was discovered parasitizing *Picea engelmannii* in the Sacramento Mountains of Otero County, New Mexico (Fig. 2). This population is approximately 170 miles east and slightly south of the nearest known population of *A. microcarpum* in the Mogollon Mountains of west central New Mexico. Our surveys over the last two years indicate the infestation of *A. microcarpum* in the Sacramento Mountains is restricted to three small populations totaling about 300 acres occurring on northern exposures in the general vicinity of upper Hay Canyon (T. 17 S., R. 12 E., Sections 33–34; T. 18 S. R. 12 E., Sections

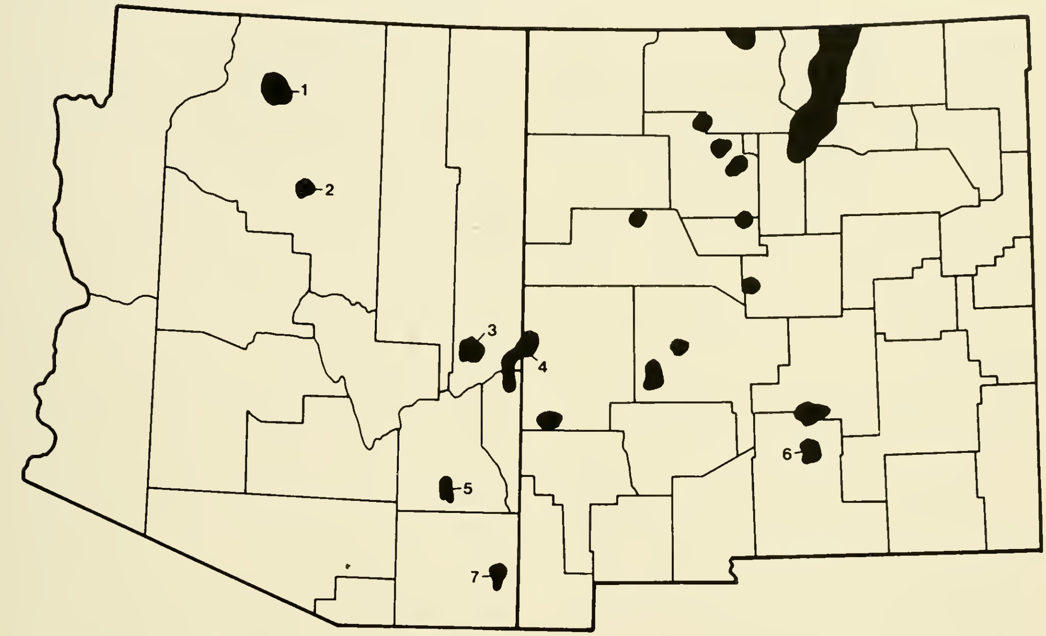

Fig. 2. Distribution of *Picea engelmannii* and *Arceuthobium microcarpum* (1–6) in Arizona and New Mexico. Numbers 5 and 6 represent the *A. microcarpum* populations in the Pinaleno and Sacramento mountains, respectively. Number 7 represents the Chiricahua Mountain population of *Picea engelmannii* var. *mexicana*.

3–4) at elevations ranging from 2,760 to 2,840 m. Our examinations of spruce stands in adjacent Spring, Hubbell, Wills, and Sacramento canyons have not detected additional populations of *A. microcarpum*. These canyons are similar in elevation and topography to Hay Canyon, and their north-facing slopes are dominated by a geographically restricted mixed conifer habitat type (*Picea engelmannii/Acer glabrum* HT) described by Moir and Ludwig (1979) in which Engelmann spruce and Douglas fir are co-dominant overstory species. In addition, all the areas surveyed in the Sacramento Mountains are well below the upper elevational limit of 3,100 m reported for *A. microcarpum* (Acciavatti and Weiss 1974, Hawksworth and Wiens 1972, Mathiasen and Hawksworth 1980). Therefore, the restriction of *A. microcarpum* to this small an area is anomalous because conditions for its spread into adjacent spruce stands appear to be favorable. The apparent confinement of this parasite to Hay Canyon may indicate it has arrived relatively recently in the Sacramento Mountains and did not accompany *P. engelmannii* at the time of this tree's migration into this range. Certainly if *A. microcarpum* had migrated there with *P. engelmannii*, additional populations should have survived elsewhere in the Sacramento Mountains and in the other mountain ranges with large *P. engelmannii* populations in southwestern New Mexico (Little 1971) (Fig. 2). Therefore, the possibility of a more recent introduction of *A. microcarpum* into the Sacramento Mountains would appear more plausible than the relict population hypothesis, which seems more applicable to the disjunct populations of *A. abietinum* in southern Arizona.

A more recent introduction of *A. microcarpum* to the Sacramento Mountains may then be an example of long-range dissemination of a dwarf mistletoe by an avian vector. Hawksworth and Wiens (1972) cite examples of dwarf mistletoe distributions that might be best explained by seed dissemination by avian vectors, and certain infestation patterns of dwarf mistletoes in conifer stands are best explained by this means also (Hudler et al. 1979). One factor that must be considered when assessing the possibilities of long-range dissemination of dwarf mistletoes by birds is that *Arceuthobium* spp. are dioecious, and a male and female plant must become established in an isolated area for a successful infestation to occur. How ever, investigations of small satellite dwarf mistletoe infection centers several meters from larger infestations have demonstrated that both male and female plants can become independently established in satellite centers (Hudler et al. 1979, Ostry 1978). In addition, Hudler et al. (1979) reported that they believe birds are the most likely agents of long-distance dispersal of dwarf mistletoes. Therefore, the possibility of the establishment of the Sacramento Mountains population of *A. microcarpum* by avian vectors should be considered.

The occurrence of *A. microcarpum* in southern New Mexico may be of interest in relation to recent studies of the taxonomic relationships of *Picea* spp. in the southwestern United States and northern Mexico. Engelmann spruce populations in the Sacramento Mountains (32° 48′ N), the Pinaleno Mountains (32° 30′ N), and the Chiricahua Mountains (31° 32′ N) have been considered as the three most southern populations of this species in the United States (Little 1950, 1971, Daubenmire 1972, Taylor et al. 1975). However, Taylor and Patterson (1980) have shown that the *P. engelmannii* population from the Chiricahua Mountains differs slightly morphologically and chemically from more northern populations of this taxon and that the recently described *Picea mexicana* Martinez (Martinez 1961) is in their opinion not sufficiently different from *P. engelmannii* to warrant separation at the specific level. Therefore, they have reduced *P. mexicana* to a variety of *P. engelmannii* (*P. engelmannii* Parry var. *mexicana* (Martínez) Taylor & Patterson) and have included the Chiricahua Mountains population as representative of this combination (Fig. 2). Although Taylor and Patterson (1980) did not include samples of the *P. engelmannii* population from the Sacramento Mountains in their study, they did sample the *P. engelmannii* population in the Pinaleno Mountains and concluded it was representative of *P. engelmannii* var. *engelmannii*. We consider the spruce populations in the Hay Canyon vicinity to be morphologically representative of *P. engelmannii* var. *engelmannii* also (Daubenmire 1972, Jones 1977). In addition, the occurrence of *A. microcarpum* in the Sacramento Mountains may have taxonomic significance regarding the classification of this spruce population. *Arceuthobium microcarpum* has not been reported on spruce in the Chiricahua Mountains (Hawksworth and Wiens 1972), but it is present on *P. engelmannii* in the Pinaleno Mountains, only 60 miles to the northwest, and is here reported on *P. engelmannii* from the Sacramento Mountains. Because dwarf mistletoes are relatively host specific parasites, the absence of *A. microcarpum* from the Chiricahua Mountains may be the result of the close phylogenetic affinities of that spruce population to the Mexican populations of *Picea* reported by Taylor and Patterson (1980). Hawksworth and Wiens (1972) reported that dwarf mistletoes have not been found parasitizing *Picea chihuahuana* Martinez in northern Mexico and there have been no reports of dwarf mistletoes on the Mexican populations of *P. engelmannii* var. *mexicana* (Hawksworth, F. G., pers. comm., 1982). Therefore, these taxa of *Picea* may have diverged from their northern relatives to the extent that they are less susceptible or immune to parasitism by extant species of *Arceuthobium* including *A. microcarpum*. If this is the case, then parasitism of the spruce populations in the Sacramento and Pinaleno mountains would help demonstrate their phyletic affinities to other *P. engelmannii* populations in the Southwest. The apparent absence of *A. microcarpum* from the Chiricahua Mountains does not indicate conclusively that *P. engelmannii* var. *mexicana* is less susceptible or immune to this mistletoe. Most varietal taxa of principal hosts of dwarf mistletoes are susceptible to parasitism when they occur within the mistletoes' geographic range (Hawksworth and Wiens 1972), and the absence of *A. microcarpum* from the Chiricahua Mountains may simply be a result of its geographic isolation from the spruce population there.

Hawksworth and Wiens (1972) suggested that *A. microcarpum* may have had a more northern distribution in the past, but has become isolated as relict endemic populations near the southern limits of its principal host ranges. They hypothesized that *A. microcarpum* may have evolved in a more northern area (possibly from the ancestor of *A. laricis* or *A. tsugense* since these taxa resemble *A. microcarpum* morphologically, our addition), migrated southward, and become isolated in the Southwest. Recent studies of the dwarf mistletoe population parasitizing bristlecone pine, *Pinus aristata* Engelm., as a principal host on the San Francisco Peaks in north central Arizona have shown this mistletoe is *A. microcarpum* (Crawford and Hawksworth 1979, Mathiasen and Hawksworth 1980). However, this population differs morphologically and physiologically from other *A. microcarpum* populations (Mathiasen and Hawksworth 1980), and rarely parasitizes *Pinus strobiformis* and *Abies lasiocarpa* var. *arizonica* (Merriam) Lemm. (Hawksworth and Wiens 1972, Mathiasen and Hawksworth 1980). Therefore, *A. microcarpum* may have evolved in the Southwest from an ancestral species with a broader host range, including species of *Pinus* and *Picea*. The *A. microcarpum* population parasitizing *Pinus aristata* on the San Francisco Peaks would then be an extant population with close phyletic affinities to this hypothesized ancestral species and may indicate a relatively recent evolution of *A. microcarpum* with its radiation and specialization onto *P. engelmannii* and *P. pungens* in the southwestern United States. A more recent evolutionary origin for *A. microcarpum* would mean this species may still be migrating into areas where spruce populations are available for colonization. This may better explain its absence from the extensive spruce-fir forests of the central and northern Rocky Mountains than the hypothesis of a more northern evolutionary origin for *A. microcarpum*. It seems probable that *A. microcarpum* is not restricted to its present geographic range by climatic factors or host susceptibility, but that it evolved and specialized on *Picea* shortly before its potential host populations became isolated into small scattered populations in the higher mountain ranges of the Southwest. At present its further migration is severely hampered by its short dissemination range and hence its inability to spread over the long distances necessary for its migration into the central Rocky Mountains or into Mexico. However, the Sacramento Mountains population of *A. microcarpum* may indicate that this parasite can occasionally make an extremely large extension from its otherwise limited distribution. If it is occasionally possible for *A. microcarpum* to make a large jump, by whatever means of dissemination, then, given enough time, *A. microcarpum* may eventually spread into the more northern and southern spruce populations of North America.

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FIRST NEST RECORDS FOR THE PLAIN TITMOUSE AND BLUE-GRAY GNATCATCHER IN WYOMING

Scott L. Findholt[1]

ABSTRACT.— Nests of Plain Titmice and Blue-gray Gnatcatchers are reported from Wyoming for the first time. Both species probably breed fairly commonly in southwestern and south central portions of the state.

In Wyoming the Plain Titmouse (*Parus inornatus*) and Blue-gray Gnatcatcher (*Polioptila caerulea*) are considered uncommon, peripheral species and occur primarily in southwestern and south central portions of the state (Oakleaf et al. 1982). Nest records have not been previously reported for either species.

The first confirmed nesting record of the Plain Titmouse in Wyoming occurred on 4 June 1981 when S. D. Fitton located a nest near Powder Rim, about 113 km southwest of Rawlins, Sweetwater Co. Evidence of a nest included the presence of two adult titmice that were observed entering and leaving a nest cavity several times. The nest cavity was not examined for the presence of eggs or young.

During 1982 four nests of this species were found in Wyoming. The first nest was located by S. D. Fitton on 17 May near Little Firehole Canyon, 13 km southeast of Green River, Sweetwater Co. On 29 May a second nest was discovered by S. D. Fitton south of Powder Rim, about 22 km southeast of the 1981 nesting locale and approximately 1 km north of Colorado. Both nests contained an undetermined number of young that were audible from the nest cavities. Also, adult titmice were observed defending the nest sites. Six days later I located a Plain Titmouse nest containing two recently hatched nestlings in Firehole Canyon, 18 km southeast of Green River, Sweetwater Co. On the following day I found another nest containing an undetermined number of nestlings near Minnies Gap, approximately 55 km south of Green River, Sweetwater Co., and less than 1 km from Utah. All nests found during 1981 and 1982 were in cavities of Utah juniper (*Juniperus osteosperma*) trees.

Several family groups containing recently fledged young titmice were also located in southwestern and south central Wyoming. This indicates that Plain Titmice probably breed rather commonly throughout these portions of the state.

The first possible breeding evidence for the Blue-gray Gnatcatcher in Wyoming was reported by White and Behle (1960). On 4 July 1959 a family group of gnatcatchers were observed at mile 371 on the Green River, Sweetwater Co. Also, one adult and one juvenile were collected at the same locale. Additional details of this possible breeding record are lacking.

The first nest of the Blue-gray Gnatcatcher in Wyoming was not located until 10 June 1982, when I observed a pair of gnatcatchers constructing a nest in Firehole Canyon, 18 km southeast of Green River, Sweetwater Co. The nest was located in a Utah juniper tree about 6 m from the ground. When the nest was rechecked 10 days later, it contained six eggs. Since the nest site was not revisited, I am uncertain how many eggs hatched or how many young fledged.

On 28 June 1982 S. D. Fitton found the second Wyoming nest near Powder Rim, about 113 km southwest of Rawlins, Sweetwater Co. Three nestlings were present in the nest and about ready to fledge. This nest was also in a Utah juniper tree. Although additional nests or family groups containing

[1]Wyoming Natural Heritage Program, The Nature Conservancy, 1603 Capitol Avenue, Room 325, Cheyenne, Wyoming 82001. Present address: Wyoming State Training School, Lander, Wyoming 82520.

recently fledged young were not found, several pairs of Blue-gray Gnatcatchers were observed in southwestern and south central Wyoming and suspected of breeding. This suggests that the Blue-gray Gnatcatcher may also breed fairly commonly in these portions of the state.

The breeding habitat of the Plain Titmouse and Blue-gray Gnatcatcher consists mainly of Utah juniper woodlands interspersed with open areas containing big sagebrush (*Artemisia tridentata*), other shrubs, and grasses.

Both the Plain Titmouse and Blue-gray Gnatcatcher also breed in adjacent areas of northeastern Utah (Behle 1981), northwestern Colorado (Kingery and Graul 1978), and southeastern Idaho (Burleigh 1972). The lack of observers in southwestern and south central Wyoming has probably accounted for the paucity of nesting records of both species.

I thank S. D. Fitton for allowing me to use his observations in this paper.

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A NEW SPECIES OF *THELESPERMA* (ASTERACEAE) FROM WYOMING

Robert D. Dorn[1]

ABSTRACT.— *Thelesperma pubescens* Dorn is described as new to science from Uinta County, Wyoming.

In southwest Wyoming, I encountered what appeared to be *Thelesperma marginatum* Rydb. but the leaves were conspicuously pubescent. This was very unusual since species of *Thelesperma* in this region are all glabrous or nearly so. Further study revealed that these plants also had a different caudex from *T. marginatum*. These major differences support specific status for these plants.

Thelesperma pubescens Dorn, sp. nov.

Perennis; radicibus crassis lignosis; caudicibus ramosis; caulibus glabris 3–12 cm altis; foliis basalibus plerumque pinnatidivisis pubescentibus; capitulis 1 vel 2; involucris 5–9 mm altis; ligulis nullis; disci corollis luteis ca 5 mm longis; pappi nullis; achaeniis glabris ca 4 mm longis (Fig. 1).

Perennial from a thick woody taproot and branched caudex that bears a dense series of persistent old leaf bases (absent in very young plants); stems 3–12 cm high, glabrous, mostly leafless; leaves mostly basal, 1–5 cm long, pinnately divided into mostly 3–5, usually linear segments, rarely simple, conspicuously pubescent; heads 1 or rarely 2; involucre 5–9 mm high, inner bracts much broader and longer than outer and with broad scarious margins; ray flowers lacking; disk corollas yellow, about 5 mm long, dilated at base, with reddish brown longitudinal veins that split at each corolla sinus and pair and meet with an adjacent vein at tip of corolla lobes; pappus lacking; achenes glabrous, angled, about 4 mm long, each subtended by a longer membranous bract.

TYPE.— USA. Wyoming: Uinta Co., Hickey Mountain, T13N, R114W, S13 E½, 8,400 ft, rocky ridge, 20 August 1982, Dorn 3823 (Holotype RM; Isotypes to be distributed).

OTHER SPECIMENS.— Same location as holotype, 8 July 1982, Dorn 3752 (RM); Wyoming: Uinta Co., Sage Creek Mountain, T14N, R113W, S34 NE¼, 8,200 ft, rocky outcrop, 30 July 1979, Aldrich 592 (RM).

Thelesperma pubescens differs from *T. marginatum* in having conspicuously pubescent leaves and a thicker, more branched caudex with a dense series of persistent old leaf bases. The latter characteristic is common in desert plants. The caudex in *T. marginatum* is generally simple or few-branched, slender, somewhat rhizomatous, and lacks the persistent old leaf bases. Another related species, *T. subnudum* Gray, is similar to *T. marginatum* except ray flowers are usually present. The two are often considered varieties of the same species. These species are quite scattered in their distribution so it is difficult to say from which of these two *T. pubescens* was derived. The location of *T. pubescens* is between the distributions of the other two species. *Thelesperma marginatum* is found to the north, and *T. subnudum* is found to the south. It is also possible, but unlikely, that these two species were both derived from *T. pubescens*.

[1]Box 1471, Cheyenne, Wyoming 82003.

Fig. 1. *Thelesperma pubescens* Dorn: lower center, entire plant, scale bar = 1 cm. Upper left, flower, scale bar = 2 mm. Upper right, leaf tip, scale bar = 1 mm.

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The genera and species described as new to science in this volume appear in bold type in this index.

The Great Basin Naturalist

VOLUME 43, 1983

Editor: Stephen L. Wood

Published at Brigham Young University, by
Brigham Young University

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