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Distribution, Flora, Vegetal Cover

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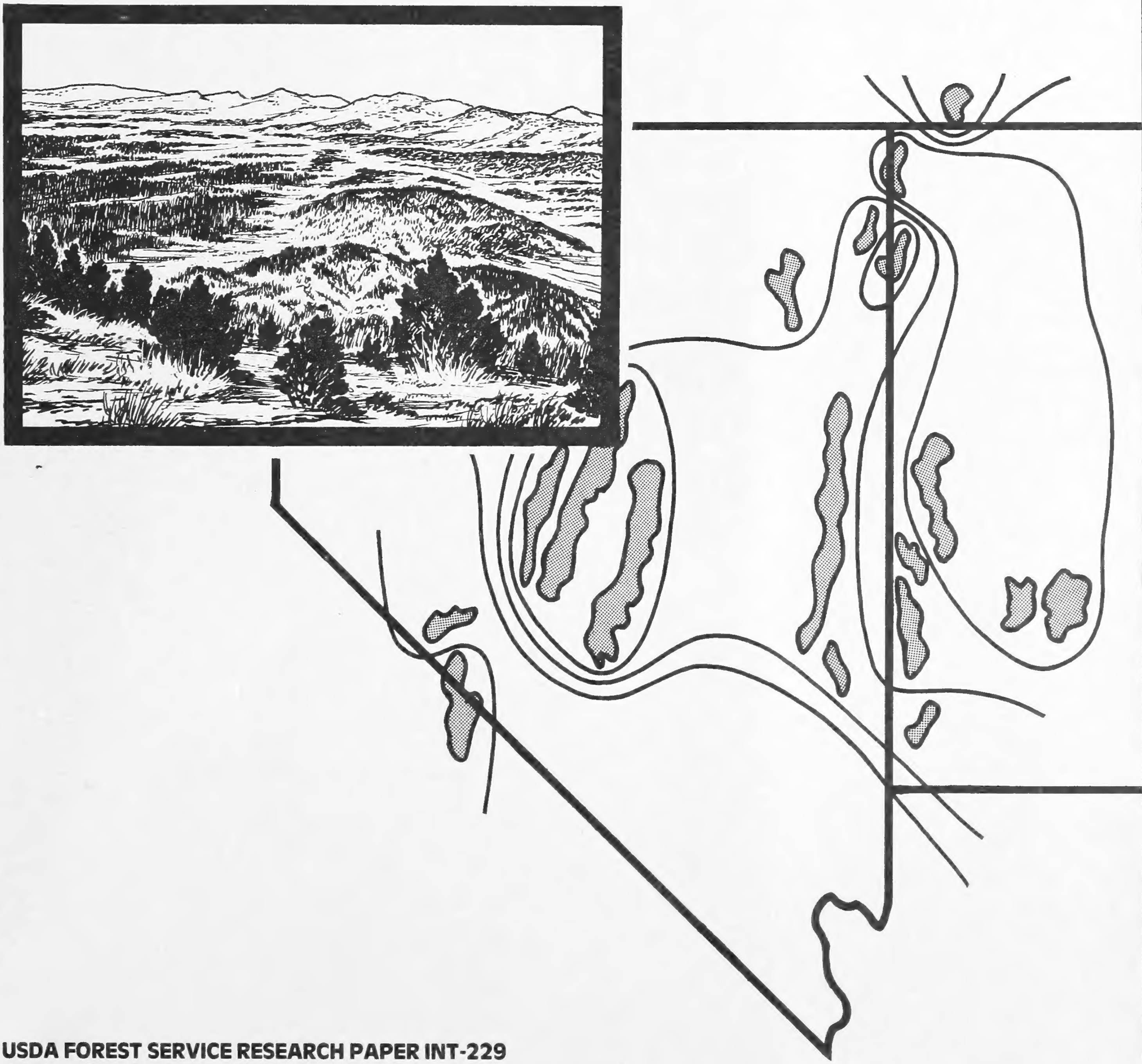

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RESEARCH SUMMARY

The distribution of the pinyon-juniper woodlands of the Great Basin has been mapped from LANDSAT-1 satellite photography. Dot grid analysis of this map indicates that about 17.6 million acres (7.1 million ha) of this woodland are found in the Great Basin. The distribution map was field checked and floristic data were systematically taken at 482 stands on 66 of the approximately 200 mountain ranges in the study area.

A list of 240 positively identified species of vascular plants is provided to help other workers initiate studies in the pinyon-juniper vegetation type.

In this study, variations in total vegetal cover are related to latitude, longitude, and elevation. Vegetal cover increases strongly with elevation and slightly with latitude. Longitudinal patterns are related to increases in average elevation. The greatest average vegetal cover is found in the higher, central portion of the Great Basin. Sorting of the tree species is due more to elevation than latitude or longitude. Junipers occupy the lower, drier elevations, whereas pinyons increase at higher elevations. Double-needle pinyon is found more frequently in the southeastern Great Basin where more of the rainfall comes during the summer.

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INTRODUCTION

The pinyon-juniper woodland vegetation type has historically provided forage (for both livestock and big game), fenceposts, pine nuts, Christmas trees, firewood, charcoal, mine props, and railroad ties. Pinyon-juniper woodlands are becoming increasingly valued for their watershed, esthetic, and recreational values (Gifford and Busby 1975). Planning for the conflicting multiple uses of these woodlands requires better ecological understanding than is now available. Previous research in these woodlands has been confined to small, selected areas. Lack of a broad perspective has limited understanding of how the results of previous studies relate to each other. Without knowledge of variation within the pinyon-juniper type, we cannot efficiently extrapolate management successes to other areas or avoid actions that have produced known shortcomings at one or a few sites.

A cooperative research program designed to provide a synecological stratification of these woodlands was initiated in 1972 by the Department of Range Science at Utah State University; the Renewable Resources Center at the University of Nevada, Reno; and the Intermountain Forest and Range Experiment Station. The overall objective of this program is to gain a broad synecological perspective of pinyon-juniper woodlands in the Great Basin. The distribution of the woodland type, its flora, and variations in the vegetal cover and tree dominants are discussed in this report. Subsequent reports will deal with other aspects of floristic variation, successional patterns, subdivisions of the pinyon-juniper type and their relations to environmental factors, and localized applications of vegetation classification units to land use problems.

PREVIOUS WORK

The literature on pinyon-juniper woodlands has been itemized by West and others (1973), Aldon and Springfield (1973), and Smith and Schuster (1975). Various chapters in the compilation edited by Gifford and Busby (1975) provide an excellent overview of land use history and of current taxonomic, autecologic, and synecologic understanding of this ecosystem. Therefore most references to earlier research will be deferred until our discussion.

A consideration of the extent of pinyon-juniper woodland is, however, appropiate. This woodland is thought to cover from 43 to 100 million acres (17 to 40 million ha) in the southwestern United States. The vast difference in estimated acreage depends on the definition of the pinyon-juniper vegetation type. The smaller figure is based on Küchler's (1964) map of the potential (climax or pristine) juniper-pinyon woodlands centered in the Four Corners States plus Nevada. An estimate of 76 million acres appears in Senate Document 199 (Clapp 1936). Allred (1964) gives the highest estimate. The Clapp and Allred estimates include juniper that has invaded other areas since the activities of white men altered the original vegetation.

West and others (1975) estimate that about 30 million acres (12.5 million ha) of these woodlands occur in the Basin and Range Physiographic Province. This amounts to about 38 percent of the total area of pinyon-juniper dominated vegetation in the United States. Most of this pinyon-juniper is in the Great Basin portion of the Basin and Range Province. Thus, both in terms of area and proportion of the total pinyon-juniper woodland, the Great Basin has major amounts of this kind of vegetation.

STUDY AREA

The study area chosen lies within the boundaries of the Great Basin portion of the Basin and Range Province (Hunt 1974), and encompasses 100,437,610 acres (40,663,000 ha) (fig. 1). Sampling for this study was restricted to areas where stands of vegetation were occupied by any one or any combination of the species *Pinus edulis*, *Pinus monophylla*, and *Juniperus osteosperma*.

The topography of the Great Basin typically consists of linear, north-south oriented mountain ranges separated from one another by dry desert valleys (Thornbury 1965). The ranges vary in size, but are commonly 50 to 75 miles (80 to 120 km) long and 6 to 15 miles (10 to 25 km) wide (Lustig 1969). The mountain ranges rise 6,000 to 14,000 feet (1,800 to 4,300 m) above sea level. The details of the geologic origin of the Basin and Range Province are described by Noland (1943) and Hunt (1974). The rocks which make up these ranges are largely of sedimentary origin, but many ranges consist partly of wholly of igneous rocks (Hunt 1974).

Basic climatic patterns in this area are described by Wernstedt (1960) and Houghton (1969). An outline of the overall floristics of the Great Basin is discussed in Cronquist and others (1972). The general vegetation patterns in relation to environment are discussed by Billings (1951) and Young and others (1976).

Figure 1.--Map showing the major mountain ranges in the studied portion of the Great Basin. The lower mountain boundaries are the same as those in Cronquist and others (1972). The 66 mountain ranges chosen for this study are unshaded and numbered. See table 1 for the names of the studied mountain ranges.

METHODS

Field Procedures

Mountain ranges for study were selected by gridding our study area map (fig. 1) into 1-minute subdivisions for both latitude and longitude. A random list of map intersections was then made, and the first 66 of the approximately 200 mountain ranges (Cronquist and others 1972) which contacted the listed intersections were chosen for study. The choices were then plotted on a map and itineraries planned so that the more southerly mountains were visited early in the season and the more northerly later. Thus, the major period of flowering was observed at each location. These mountain ranges, comprising about one-third of the major Great Basin mountain ranges, were sampled during the 1972-1974 summer field seasons (table 1).

Plots were located on broad, even slopes facing one of the cardinal directions and were placed at regular contour intervals up and down the slope from a baseline of 6,560 ft (2,000 meters). This contour is an elevation common to pinyon-juniper woodlands over most of the Great Basin. This procedure made site selection objective and facilitated direct gradient analysis of data from plots characterizing average situations in the woodland belt of each mountain range. This strategy gave each part of the major complex gradient in the landscape (queued on elevation) equal opportunity to appear in the data set (Whittaker 1973). The strategy also provided for the sampling of a wide variety of pinyon-juniper woodlands. Previous studies have been concentrated on subjectively selected sites with high productivity or with potential for vegetation manipulation to achieve high forage production (Daniel and others 1966).

The criteria used to determine the lowest and uppermost plots on each mountain side were that a plot had to contain at least 25 pinyon and/or juniper trees per hectare (about 10 per acre). Of these, at least one tree had to be of the mature size-age-form class (Blackburn and Tueller 1970). These criteria kept the samples from extending into brushlands or grasslands being invaded by a few small, young trees and concentrated our sampling on sites where woodland can definitely persist. Sampling was further restricted to those sites which showed no evidence of recent fires, extensive tree cutting, chaining, or cabling, in order to reduce part of the secondary successional variability encountered.

Northerly slope exposures sampled were limited to the slopes of the north ends of mountain ranges or hill systems; southerly exposures to the slopes of the south ends of mountain ranges. East and west exposures were sampled near the center of the mountain ranges. Plot locations were marked on the largest scale U.S. Geological Survey maps available (at least 1:25,000). The upper and lower boundaries of the pinyon-juniper woodland for the entire mountain slope were also marked on these topographic maps to aid in checking the accuracy of the woodland distribution map to be made from LANDSAT-1 imagery.

Two levels of sampling were employed--rapid and detailed. In the "rapid" approach macroplots of approximately 66 by 165 feet (20 by 50 m) were paced off with the long axis positioned perpendicular to the slope contour. The macroplots were located at 660-feet (200-m) intervals up the broadest, most even slope available. Within each plot, all plant species were listed in one of four categories: trees, shrubs, grasses, and forbs. With grasses and forbs combined, the resulting three categories represented the layers visible in the physiognomy of the stands. Each of the original four categories was considered separately to assess the relative dominance of each species. A dominance rating was assigned each species in the macroplot (Beeson 1974). A cover

Table 1.--*The mountain ranges sampled, showing the year the sample was taken, the number of plots sampled, the map code used in figure 1, and the type of sampling employed.*

Mountain range	Year sampled	Number of plots sampled	Map code[1]	Type of sampling[2]
California				
Panamint Range	73	4	1	R
White Mountains	72	7	2	D
Idaho				
Albion Mountains	73	2	3	R
Black Pine Peak	72	5	4	D
Sublett Range	73	2	5	R
Nevada				
Bald Mountain	74	6	6	R
Cherry Creek Range	72	6	7	R
Clan Alpine Range	72-73	3	8	R
Desatoya Range	72-73	6	9	R
Diamond Range	72	5	10	R
East Humboldt Range	72	6	11	D
Excelsior Range	72	4	12	D
Fish Creek Range	74	6	13	R
Fortification Range	72	4	14	R
Goose Creek Range	72	4	15	D
Grant Range	72	4	16	R
Highland Range	72	15	17	D
Kawich Range	73	5	18	R
Lower Egan Range	74	4	19	R
Lower Snake Range	72	6	20	R
McCullough Range	73	3	21	R
Monitor Range	72	10	22	D
Pequop Mountains	72	4	23	R
Pine Nut Range	73	8	24	R
Quinn Canyon Range	73	11	25	R
Roberts Creek Range	72	5	26	R
Ruby Mountains	72	4	27	R
Schell Creek Range	72	8	28	D

(con.)

Table 1.--Con.

Mountain range	Year sampled	Number of plots sampled	Map code[1]	Type of sampling[2]
Sheep Range	73	4	29	R
Shoshone Range	73	12	30	D
Silver Creek Range	74	6	31	R
Simpson Park Range	72	4	32	R
Spring Range	73	8	33	R
Spruce Mountain	74	5	34	R
Sulphur Springs Range	73	6	35	R
Toana Range	72	5	36	D
Toiyabe Range	72	9	37	D
Toquima Range	74	6	38	R
Upper Egan Range	74	4	39	R
Upper Snake Range	74	6	40	R
Virginia Range	73	5	41	R
Wassuk Range	73	9	42	R
West Humboldt Range	74	6	43	R
White Pine Mountains	72	5	44	R
Wilson Creek Range	72	4	45	R
Utah				
Beaver Dam Mountains	73	5	46	R
Burbank Hills	72	2	47	D
Canyon Mountains	72	4	48	R
Confusion Range	72	4	49	D
Cricket Mountains	72	4	50	R
Deep Creek Range	73	8	51	R
East Tintic Mountains	72	5	52	R
Enterprise-Beryl Hills	72	7	53	D
House Range	74	4	54	R
Mineral Mountains	72	9	55	D
Needle Range	72-73	13	56	D
Oquirrh Mountains	72	4	57	R
Pavant Range	72	5	58	R
Pilot Range	72	9	59	D
Pine Valley Mountains	73	8	60	R
San Francisco Mountains	72	5	61	R
Sheeprock Mountains	74	2	62	R
Stansbury Mountains	72	4	63	R
Tushar Range	72	7	64	D
Wah Wah Mountains	72	8	65	R
West Tintic Mountains	72	5	66	R

[1] Map code is referenced to figure 1.
[2] R = rapid; D = detailed.

class rating was also assigned (Daubenmire 1959). A size-age-form class rating was assigned each individual tree on the macroplot (Blackburn and Tueller 1970). Further details of the "rapid" methodology, including collection of topographic and edaphic data, can be found elsewhere (Beeson 1974).

In the "detailed" level of sampling, the same plot size and methodology were used, but data were obtained from direct measurements using an expansion and intensification of the proviously described methodology. The 66 by 165 foot (20 by 50 m) macroplots were permanently marked. Four trees of each size-age-form class of each species situated closest to two predetermined points were measured. Crown spread of these trees in the widest and narrowest dimensions was recorded. Tree cover for the plot was estimated by taking an average of tree crown dimensions, computing elliptical area on the measured trees, and multiplying by the number of trees of each size-age-form class. Shrub crown cover was estimated to the nearest 2 percent (Daubenmire 1959) in randomly stratified 1 by 2 m microplots. Forb and grass basal cover was similarly estimated in 3 by 6 m plots located within the shrub sampling scheme. The "detailed" sampling approach is described more fully in Nabi (1978).

All mountain ranges sampled were selected by the same process. The 18 ranges sampled with "detailed" methodology were randomly selected from the larger set (table 1). The remainder were sampled with "rapid" techniques. The procedure for plot location was identical on all mountain ranges regardless of which sampling strategy was used. Plots were thoroughly searched for all plant species present under both "rapid" and "detailed" sampling strategies.

Taxonomic vouchers of plants were collected at each site with special attention given to sagebrush (*Artemisia* spp.). Specimens were checked for proper identification against vouchers at the Intermountain Herbarium, Utah State University. *Artemisia* specimens were segregated morphologically following the works of Brunner (1973) and Winward and Tisdale (1977). However, the more effective process of chromatographic differentiation was used to determine subspecies of *A. tridentata* as well as to confirm placement in other *Artemisia* taxa. The chromatographic procedures used were similar to those described by Hanks and others (1973). Vouchers specimens of all taxa are on file at Utah State University.

Vegetation Type Mapping

Pinyon-juniper woodlands were mapped during the winter of 1973-74, using LANDSAT-1 color-infrared composites (fig 2). Woodland boundaries for the entire study area were mapped to an approximate scale of 1:1,000,000 where 1 inch (2.5 cm) equals approximately 16 miles (26 km) on the ground. Areas of pinyon-juniper woodland as small as 62 acres (25 ha) were mapped. The pinyon-juniper vegetation type was identified by a reddish-orange color on the composites.

The low-elevation boundary of the woodland was easily mapped from summer color composites, but the upper boundary diffused into other, more infrared reflective vegetation types, making the pinyon-juniper difficult to map from photos taken during the growing season. The upper boundary was mapped using winter images taken when pinyon-juniper woodlands were the only infrared reflective vegetation type. All other types of vegetation were either dormant or covered with snow (Tueller and others 1975).

The extent of the pinyon-juniper woodland type in the Great Basin was determined from the completed map using a 256 dot/in^2 (150 dots/cm^2) grid. The total number of dots counted in the woodland was multiplied by an appropriate conversion factor to obtain acres or hectares per dot.

Figure 2.--A map of the pinyon-juniper woodlands of the Great Basin derived from LANDSAT-1 color-infrared imagery and field checking.

RESULTS AND DISCUSSION

Data Base

Sixty-six of the approximately 200 major mountain ranges in the Great Basin were visited and vegetation data were obtained at 482 plots (table 1 and fig. 1). These data, along with additional observations on vegetation boundaries, provided ground truth data for the mapping phase.

Type Map

A detailed map of the distribution of the Great Basin pinyon-juniper woodlands is provided in figure 2. This map is the most detailed and field-verified of any yet available for the pinyon-juniper vegetation type. The map should have many uses in inventory, planning, management, research, and teaching.

There is not complete congruence of the woodland boundaries shown on this map (fig. 2) with the lower boundaries of mountain ranges shown on the topographic-based map (fig. 1). The lack of congruence results from the woodland not occupying perfect belts around every Great Basin mountain range. In the northern Great Basin, pinyon-juniper woodland belts are narrower or lacking altogether on northern exposures. The woodland belt frequently diminishes on southern exposures in the southern Great Basin. East and west-facing woodland belts are not always at the same elevation or of the same width. In southwestern Utah and adjacent Nevada, valley bottoms are at higher elevations and a distinct change occurs from mountain-valley topography to rolling terrain. In these areas woodlands become continuous between ridges. Details of these differences in woodland and mountain range boundaries and their possible causes have already been discussed in West and others (1978).

Comparison of the location of pinyon-juniper boundaries on the map with boundary locations noted during field research allows us to estimate that less than 5 percent error exists; i.e., less that 5 percent of the boundary locations are delinated incorrectly from the LANDSAT-1 imagery. If areas of pinyon-juniper woodland were continuous, densities as low as 41 trees per hectare were visible on LANDSAT-1 color-infrared imagery. Areas of pinyon-juniper woodland as small as 62 acres (25 ha) were visible if there were at least 73 trees per hectare. A discontinuous area of pinyon-juniper having trees only on the lower slopes of many close ridges showed sufficient reflectance to be identified only when tree density exceeded 118 trees per hectare. Generally, a pinyon-juniper community larger than 25 ha with a density of about 75 trees per hectare can be identified on LANDSAT-1 color-infrared imagery.

The area of pinyon-juniper woodlands within the study area boundaries was estimated using the dot grid technique (table 2). This estimate is more that 4 million acres less than an estimate derived from planimetering the major forest-type overlay map (9-W) in Little (1971). This difference could be due to Little's inclusion of some higher mountain centers in his map and/or to his extension of the pinyon-juniper woodland into considerably more open juniper stands at the base of these mountains.

The differences betweeen our acreages and those available from the map on page 111 of Cronquist and others (1972) are less, probably due to Cronquist's distinction of the major mountain centers as "montane zone." The two maps cannot be compared precisely because of the extension of our study area further south than that given in Cronquist and others (1972). The map produced in this study provides more detail on the pinyon-juniper type boundary than theirs because of its larger scale.

Table 2.--*The extent of pinyon-juniper woodlands within the Great Basin, by State*

State	Acres	Hectares	Percent of total
Nevada	11,674,600	4,726,500	66.2
Utah	4,123,200	1,669,300	23.4
California	1,364,400	552,400	7.7
Arizona	298,300	120,800	1.7
Idaho	137,100	70,100	1.0
Total	17,633,600	7,139,100	100.0

Floristics

To help others initiate studies in pinyon-juniper woodlands, we have listed the 240 positively identified species of vascular plants which were found in our sample of Great Basin pinyon-juniper woodlands (table 3). An additional 127 specimens, nearly all annual forbs, could not be positively identified to the generic level because season of collection precluded obtaining specimens with the necessary taxonomic characters. This accounts for the 367 total number of species used in prior discussions (West and others 1978). The number of different species in a plot can be related to probability of sampling, size and height of mountain range, distance from adjacent mountains, and paleo-ecological influences, as well as present environmental variables (West and others 1978). The outstanding feature of the floristics of the pinyon-juniper woodland is the few species it has, considering the large area involved.

Of the positively identified taxa, a total of 5 were trees, 67 were shrubs and succulents, 46 were grasses, and 122 were forbs. Four percent of the total list were exotic (introduced); the remainder are native. None of the species identified were listed in the recent compilation of rare and endangered plant species (U.S. Congress 1976). All of the species are known to occur outside of pinyon-juniper woodland contexts.

Our sampling approach was designed to stress the most common conditions and perennial components of the woodlands of each mountain range. Larger numbers of samples, searches for atypical sites, and sampling earlier in the season would have resulted in the collection of more and rarer species and allowed identifiable vouchers of annuals to be obtained.

Table 3.--*Plant species encountered in study and the percentage of the plots where each species was observed (constancy)*

Scientific name and authority[1]	Common name[2]	Constancy
		Percent
TREES		
Juniperus osteosperma (Torr.) Little	Utah juniper	99.3
Juniperus scopulorum Sarg.	Rocky Mountain juniper	.5
Pinus edulis Engelm.	True pinyon pine	4.1
Pinus monophylla Torr. & Frem.	Single leaf pinyon pine	96.8
Pinus ponderosa Laws.	Ponderosa pine	.2
SHRUBS		
Amelanchier alnifolia Nutt.	Serviceberry	14.6
Artemisia arbuscula Nutt.	Low sagebrush	7.1
Artemisia frigida Willd.	Fringed sagebrush	.2
Artemisia ludoviciana Nutt.	Louisiana sagebrush	.7
Artemisia nova A. Nels.	Black sagebrush	26.3
Artemisia pygmaea A. Gray	Pigmy sagebrush	.5
Artemisia tridentata Nutt. ssp. *tridentata* Ward	Basin big sagebrush	28.5
Artemisia tridentata Nutt. ssp. *vaseyana* (Rydb.) Beetle	Mountain big sagebrush	46.7
Artemisia tridentata Nutt. ssp. *wyomengensis* Beetle	Wyoming big sagebrush	22.6
Atriplex canescens (Pursh.) Nutt.	Fourwing saltbush	2.7
Atriplex confertifolia (Torr. & Frem.) S. Wats.	Shadscale	2.2
Berberis repens Lindl.	Creeping barberry	3.7
Berberis fremontii Torr.	Fremont barberry	.2
Ceanothus greggii Gray	Mountain lilac	.7
Ceanothus sp. L.	Mountain lilac	.2
Ceratoides lanata J. T. Howell	Winterfat	3.1
Cercocarpus ledifolius Nutt.	Curl-leaf mountain mahogany	24.8
Cercocarpus montanus Raf.	Alder-leaf mountain mahogany	4.1
Chamaebatiaria millefolium (Torr.) Maxim	Fern bush	.7
Chrysothamnus greenei (A. Gray) Greene	Greenes rabbitbrush	.5
Chrysothamnus nauseosus (Pall.) Britt.	Rubber rabbitbrush	15.3
Chrysothamnus paniculatus (A. Gray) Hall	Desert rabbitbrush	.2
Chrysothamnus viscidiflorus (Hook.) Nutt.	Douglas rabbitbrush	47.2
Coleogyne ramosissima Torr.	Blackbrush	1.2
Cowania mexicana D. Dom.	Cliffrose	3.4
Dalea sp. Juss.	Indigo bush	13.6
Ephedra nevadensis S. Wats.	Mormon tea	.7
Ephedra viridis Coville	Mormon tea	11.7
Eriogonum microthecum Nutt.	Slenderbush eriogonum	43.6
Eriogonum sphaerocephalum Dougl.	Rock eriogonum	23.1
Eriogonum umbellatum Torr.	Sulfur eriogonum	1.5
Eriogonum spp. Michx.	Wild buckwheat	24.6
Fendlerella utahensis (S. Wats.) Heller	---	.5
Galium sp. L.	Bedstraw	.5
Glossopetalon nevadense Gray	Spiny greenbush	.2
Grayia spinosa (Hook.) Moq.	Spiny hopsage	2.9
Gutierrezia microcephala (DC.) Gray	Snakeweed	3.4
Gutierrezia sarothrae (Pursh) Britt. & Rusby	Snakeweed	33.3
Haplopappus linearifolius DC.	Narrowleaf goldenweed	.3
Haplopappus nanus (Nutt.) DC. Eaton	Dwarf goldenweed	1.5
Holodiscus dumosus (Hook.) Heller	Bush oceanspray	.5
Leptodactylon pungens (Torr.) Nutt.	Prickly phlox	18.7
Leptodactylon watsoni (A. Gray) Rydb.	---	.3
Lycium sp. L.	Wolfberry	.2
Prunus andersonii A. Gray	Anderson peachbrush	40.9
Peraphyllum ramosissimum Nutt.	Squawapple	4.1
Purshia glandulosa Curran.	Desert bitterbrush	2.7
Purshia tridentata (Pursh) DC.	Antelope bitterbrush	6.8
Quercus gambelii Nutt.	Gambel oak	36.0
Quercus turbinella Greene	Shrub live oak	3.7
Rhus trilobata Nutt.	Skunkbrush sumac	1.0
Ribes cereum Dougl.	Gooseberry	.5

(con.)

Table 3.--(con.)

Scientific name and authority	Common name	Constancy
		Percent
Ribes montigenum McClatchie	Gooseberry current	5.6
Ribes velutinum Greene	Desert gooseberry	.2
Ribes sp. L.	Current gooseberry	7.1
Rosa woodsii Lindl.	Wild rose	1.2
Salvia sp. L.	Sage	.2
Sambucus racemosa L.	Elderberry	.2
Symphoricarpos albus L. (Blake)	Snowberry	1.5
Symphoricarpos longiflorus A. Gray	Longflower snowberry	11.2
Symphoricarpos oreophilus A. Gray	Mountain snowberry	8.5
Tetradymia canescens DC.	Gray horsebrush	4.6
Tetradymia glabrata A. Gray	Little horsebrush	15.6
Tetradymia sp. DC.	Horsebrush	1.2
Yucca brevifolia Engelm.	Joshua tree	.2
Opuntia acanthocarpa Engelm. & Bigel.	Buckhorn cholla	1.7
Opuntia polycantha Haw.	Plains prickly pear	3.6
GRASSES AND GRASSLIKE PLANTS		
Agropyron cristatum (L.) Gaertn.	Crested wheatgrass	.5
Agropyron riparium Scribn. & Smith	Streambank wheatgrass	1.7
Agropyron saxicola (Scribn. & Smith) Piper	---	2.0
Agropyron smithii Rydb.	Western wheatgrass	1.0
Agropyron spicatum (Pursh) Scribn. & Smith	Bluebunch wheatgrass	30.7
Agropyron trachycaulum (Lin.) Malte.	Slender wheatgrass	2.4
Aristida fendleriana Steud.	Fendler three-awn	.5
Aristida longiseta Steud.	Red three-awn	1.5
Aristida sp. L.	Three-awn	.7
Avena fatua L.	Wild oats	.2
Bouteloua gracilis (H.B.K.) Lag.	Blue grama	4.9
Bromus marginatus Nees.	Big mountain brome	.7
Bromus rubens L.	Foxtail chess	2.7
Bromus tectorum L.	Cheatgrass	35.5
Carex sp. L.	Sedge	.2
Distichlis spicata Greene	Desert saltgrass	.2
Elymus cinereus Scribn. & Merr.	Wild rye	13.4
Elymus salina M. E. Jones	Salina wild rye	.2
Elymus sp. L.	Wild rye	.7
Festuca idahoensis Elmer	Idaho fescue	8.8
Festuca octoflora Walt.	Sixweeks fescue	1.5
Hilaria jamesii (Torr.) Benth.	Galleta	9.7
Hordeum jubatum L.	Foxtail barley	.2
Koeleria cristata (L.) Pers.	Junegrass	16.1
Leucopoa kingii (S. Wats.) Weber	Spike fescue	1.0
Melica bulbosa Geyer	Onion grass	.7
Melica stricta Bolnd.	Rock melic grass	1.5
Muhlenbergia torreyi (Kunth.) A.S. Hitch.	Ringgrass	.2
Munroa squarrosa (Nutt.) Torr.	Common false buffalograss	.2
Oryzopsis hymenoides (Roem. & Schult.) Ricker	Indian rice grass	53.5
Poa fendleriana (Steud.) Vasey	Muttongrass	9.5
Poa nervosa (Hook.) Vasey	Wheeler bluegrass	.7
Poa nevadensis Vasey	Nevada bluegrass	5.1
Poa sandbergii Vasey	Sandberg bluegrass	57.2
Poa sp. L.	Bluegrass	3.7
Sitanion hystrix (Nutt.) J. G. Smith	Squirreltail	79.8
Sporobolus cryptandrus (Torr.) A. Gray	Sand dropseed	.5
Stipa arida M. E. Jones	Needlegrass	1.2
Stipa columbiana Macoun	Columbia needlegrass	.2
Stipa comata Trin. & Rupr.	Needle-and-thread grass	16.3
Stipa coronata Thurb.	Needlegrass	.5
Stipa lettermani Vasey	Letterman needlegrass	.5
Stipa occidentalis Thurb.	Western needlegrass	16.3
Stipa speciosa Trin. & Rupr.	Desert needlegrass	1.7
Stipa thurberiana Piper	Thurber needlegrass	4.6
Stipa sp. L.	Needlegrass	1.7

(con.)

Table 3.--(con.)

Scientific name and authority	Common name	Constancy
		Percent
FORBS		
Abronia elliptica A. Nels.	Sandverbena	.5
Achillea millefolium L.	Yarrow	.5
Agoseris glauca (Pursh) Raf.	Page agoseris	1.7
Allium acuminatum Hook.	Tapertip onion	3.2
Antennaria rosea Greene	Rose pussytoes	2.2
Arabis holboellii Hornem.	Rockcress	39.2
Aster sp. L.	Aster	2.2
Aster canescens Pursh	Aster	.5
Aster chilensis Nees.	Aster	.2
Astragalus beckwithii Torr. & Frem.	Beckwith milkvetch	1.0
Astragalus calycosus Torr.	---	5.4
Astragalus casei A. Gray	---	6.1
Astragalus mollissimus Torr.	Thompson locoweed	1.7
Astragalus purshii Dougl.	Pursh locoweed	14.1
Astragalus whitneyi A. Gray	---	3.2
Astragalus sp. L.	Locoweed, Milkvetch	10.4
Brassica sp. L.	Mustard	.2
Balsamorhiza hirsuta Nutt.	Hairy balsamroot	.2
Balsamorhiza hookeri Nutt.	Hooker balsamroot	3.9
Balsamorhiza sagittata (Pursh) Nutt.	Arrowleaf balsamroot	15.8
Calochortus sp. Pursh	Mariposa lily	4.6
Castilleja linariaefolia Benth.	Wyoming paintbrush	2.7
Castilleja chromosa A. Nels.	Indian paintbrush	9.0
Caulanthus crassicaulis (Torr.) S. Wats.	Thickstem wild cabbage	4.1
Chaenactis douglassii (Hook.) Hook. & Arn.	Chaenactis	10.5
Chaenactis sp. DC.	Chaenactis	2.5
Cirsium sp. Adans.	Thistle	1.2
Collinsia parviflora Dougl.	Blue eyed mary	10.7
Comandra pallida A. DC.	Bastard toadflax	3.4
Cordylanthus sp. Nutt.	Birdbeak	.2
Crepis acuminata Nutt.	Tapertip hawk's beard	15.1
Crepis occidentalis Nutt.	Western hawk's beard	1.2
Cryptantha bakeri (Greene) Payson	Cryptantha	2.2
Cryptantha confertifolia (Greene) Payson	---	2.2
Cryptantha flavoculata (A. Nels.) Payson	---	13.9
Cryptantha nana (Eastw.) Payson	---	7.8
Cryptantha sp. Lehm.	---	3.4
Delphinium sp. L.	Larkspur	1.7
Descurainia pinnata (Walt.) Britton.	Tansymustard	6.3
Erigeron aphanactis (A. Gray) Green	Fleabane daisy	8.5
Erigeron argentatus A. Gray	---	5.6
Erigeron compositus Pursh	Fernleaf fleabane	.2
Erigeron sp. L.	---	6.3
Eriogonum caespitosum Nutt.	Mat wildbuckwheat	18.5
Eriogonum racemosum Nutt.	Redroot wildbuckwheat	4.1
Eriogonum ovalifolium Nutt.	Cushion wildbuckwheat	11.7
Eriogonum microthecum Nutt.	Slenderwild buckwheat	3.9
Eschscholztia californica Cham.	Calif. poppy	.5
Euphorbia albomarginata Torr. & Gray	Whitemargin spurge	1.5
Euphorbia ocellata Dur. & Hilg.	Spurge	.2
Galium sp. L.	Bedstraw	1.0
Geranium sp. L.	Geranium	1.0
Gilia aggregata (Pursh) Spreng.	Skyrocket gilia	3.4
Gilia congesta Hook.	Ballhead gilia	.5
Gilia leptomeria A. Gray	Gilia	12.4
Halogeton glomeratus (Bieb.) C. A. Meyer	Halogeton	.5
Haplopappus acaulis (Nutt.) A. Gray	Stemless goldenweed	6.8
Haplopappus stenophyllus A. Gray	---	8.8
Hedeoma nanum (Torr.) Briq.	Mock pennyroyal	.2
Hymenopappus filifolius Hook.	Fineleahymenopappus	.5
Hymenoxys acaulis (Pursh) Parker	Stemless hymenoxys	4.6
Iva axillaris Pursh	Poverty sumpweed	5.8

(con.)

Table 3.--(con.)

Scientific name and authority	Common name	Constancy
		Percent
Lappula sp. Moench.	Stickseed	7.1
Lepidium perfoliatum L.	Clasping pepperweed	2.7
Lepidium pubescens Desv.	Pepperweed	9.7
Lesquerella kingii S. Wats.	King's bladderpod	2.9
Leucelen ericoides (Torr) Greene	---	1.7
Linum lewisii Pursh	Lewis flax	1.5
Lithosperum ruderale Dougl.	Wayside gromwell	4.9
Lomatium sp.	---	.5
Lupinus alpestris A. Nels.	Mountain lupine	11.9
Lupinus argenteus Pursh	Silvery lupine	.7
Lupinus excubitus M. E. Jones	Inyo lupine	1.0
Lupinus sp. L.	Lupine	5.8
Lygodesmia spinosa Nutt.	Thorn skeletonweed	8.3
Machaeranthera canescens (Pursh) A. Gray	Hoary machaeranthera	13.1
Machaeranthera leucanthemifolia (Greene) Greene	Machaeranthera	13.1
Mammillaria sp. Haw.	Cushion cactus	2.4
Mentzelia albicaulis Dougl.	Whitestem blazing star	1.2
Mimulus densus Grant	Monkeyflower	1.5
Orobanche multiflora Nutt.	Broomrape	.2
Oxalis sp. L.	Woodsorrel	.5
Pedicularis centranthera A. Gray	Dwarf lousewort	4.1
Penstemon eatoni A. Gray	Eaton penstemon	1.0
Penstemon deustus Dougl.	Scabland penstemon	2.2
Penstemon hymilis Nutt.	Low penstemon	2.0
Penstemon pachyphyllus A. Gray	Thickleaf penstemon	6.6
Penstemon palmeri A. Gray	Palmer penstemon	3.7
Penstemon thompsoniae (A. Gray) Rydb.	Thompson penstemon	1.2
Penstemon sp. Mitch.	Penstemon	7.8
Petalostemon searlsiae A. Gray	Searls prairie clover	1.2
Petradoria pumila (Nutt.) Greene	Rocket goldenrod	5.1
Petrophytum caespitosum (Nutt.) Rydb.	Tufted rockmat	2.0
Phacelia sp. Juss.	Phacelia	3.9
Phlox austromontana Cov.	Desert phlox	3.2
Phlox diffusa Benth.	Spreading phlox	25.6
Phlox hoodii Rich.	Hood's phlox	13.4
Phlox longifolia Nutt.	Longleaf phlox	23.1
Phlox stansburyi (Torr) Heller	Stansbury phlox	23.1
Phlox muscoides Nutt.	Phlox	.5
Physaria chambersii Roll.	Twinpod	3.2
Physaria newberryi A. Gray	Newberry twinpod	2.0
Plantago sp. L.	Plantain	.7
Prunus emarginata (Dougl.) Walp.	Bitter cherry	.5
Psoralea juncea Eastw.	Scurfpea	.2
Salsola kali L.	Russian thistle	.7
Senecio intergerimus Nutt.	Columbia groundsel	2.9
Senecio multilobatus Torr. & Gray	Lobeleaf groundsel	11.9
Spergularia marina (L.) Griseb.	Saltmarsh sandspurry	5.6
Spergularia sp. J. & C. Presl.	Sandspurry	1.0
Sphaeralcea ambigua A. Gray	Desert globemallow	.2
Sphaeralcea caespitosa M.E. Jones	Tufted globemallow	2.4
Sphaeralcea coccinea (Pursh) Rydb.	Scarlet globemallow	3.7
Sphaeralcea parviflora A. Nels.	Globemallow	1.0
Stanleya pinnata (Pursh) Britton	Desert princesplume	1.2
Strepthanthus cordatus Nutt.	Heartleaf twistflower	7.1
Taraxacum officinale Weber	Dandelion	.5
Tragopogon sp. L.	Goatsbeard	.2
Vicia americana Muhl.	American vetch	.5
Vigueria annua (M. E. Jones) Blake	Annual goldeneye	.2
Viola sp. L.	Violet	.2
Zigadenus paniculatus S. Wats.	Foothill death camas	2.2

[1]According to Holmgren and Reveal (1966).

[2]According to Beetle (1970). Dash indicates no published common name available.

Variation in Total Vegetal Cover

Total vegetal cover for the 66 plots sampled at the detailed level varied from 9 to 80 percent. Average total vegetal cover for these plots was greater than 35 percent for about half of the mountain ranges sampled (table 4). Figure 3 shows that higher average vegetal cover is concentrated on the high plateau of central Nevada, the plateau's extensions toward southwestern Utah, and the higher elevation ranges such as the White Mountains of California-Nevada and the Deep Creek Mountains along the Utah-Nevada border. Woodlands on the mountain ranges with lower average elevation and/or lower latitudinal position have less average vegetal cover. The northernmost pinyon-juniper woodlands, in southern Idaho, have higher average total vegetal cover than would be expected from the low elevation of the woodlands there. In this instance, latitude strongly compensates for elevation.

Table 4.--*Average total vegetal cover of each mountain range in the "detailed" sample and relative cover of juniper and pinyon by aspect*

State and mountain range	Average total vegetal cover	Relative cover of juniper and pinyon: All aspects		North aspect		East aspect		South aspect		West aspect	
		Juniper	Pinyon	Juniper	Pinyon	Juniper	Pinyon	Juniper	Pinyon	Juniper	Pinyon
California											
White Mountains	31.5	10	90	4	96	--[1]	--[1]	27	73	0	100
Idaho											
Black Pine Peak	41.9	100	0	--[1]	--[1]	100	0	100	0	100	0
Nevada											
East Humboldt Range	34.9	45	55	--[1]	--[1]	4	96	83	17	48	52
Excelsior Range	23.9	0	100	0	100	0	100	0	100	0	100
Goose Creek Range	25.4	100	0	--[1]	--[1]	100	0	100	0	100	0
Highland Range	32.6	43	57	37	63	34	66	58	42	39	61
Monitor Range	50.0	12	88	2	98	8	92	19	81	18	82
Schell Creek Mountains	37.2	46	54	21	79	41	59	67	33	70	30
Shoshone Range	40.7	13	87	4	96	0	100	10	90	6	94
Toana Range	39.4	55	45	100	0	43	57	23	77	57	43
Toiyabe Range	48.4	24	76	2	98	33	67	0	100	7	93
Utah											
Confusion Range	26.3	48	52	0	100	69	31	--[1]	--[1]	27	73
Enterprise-Beryl Hills	35.8	70	30	61	39	97	3	65	35	82	18
Garrison Hills	32.4	84	16	68	32	100	0	--[1]	--[1]	--[1]	--[1]
Mineral Mountains	30.5	63	37	99	1	50	50	60	40	49	51
Needle Range	34.1	40	60	35	65	46	54	49	51	36	64
Pilot Range	43.2	45	55	45	55	47	53	37	63	49	51
Tushar Range	27.1	64	34	53	47	65	35	58	42	100	0

[1]Plots on this aspect were not available, thus none were sampled.

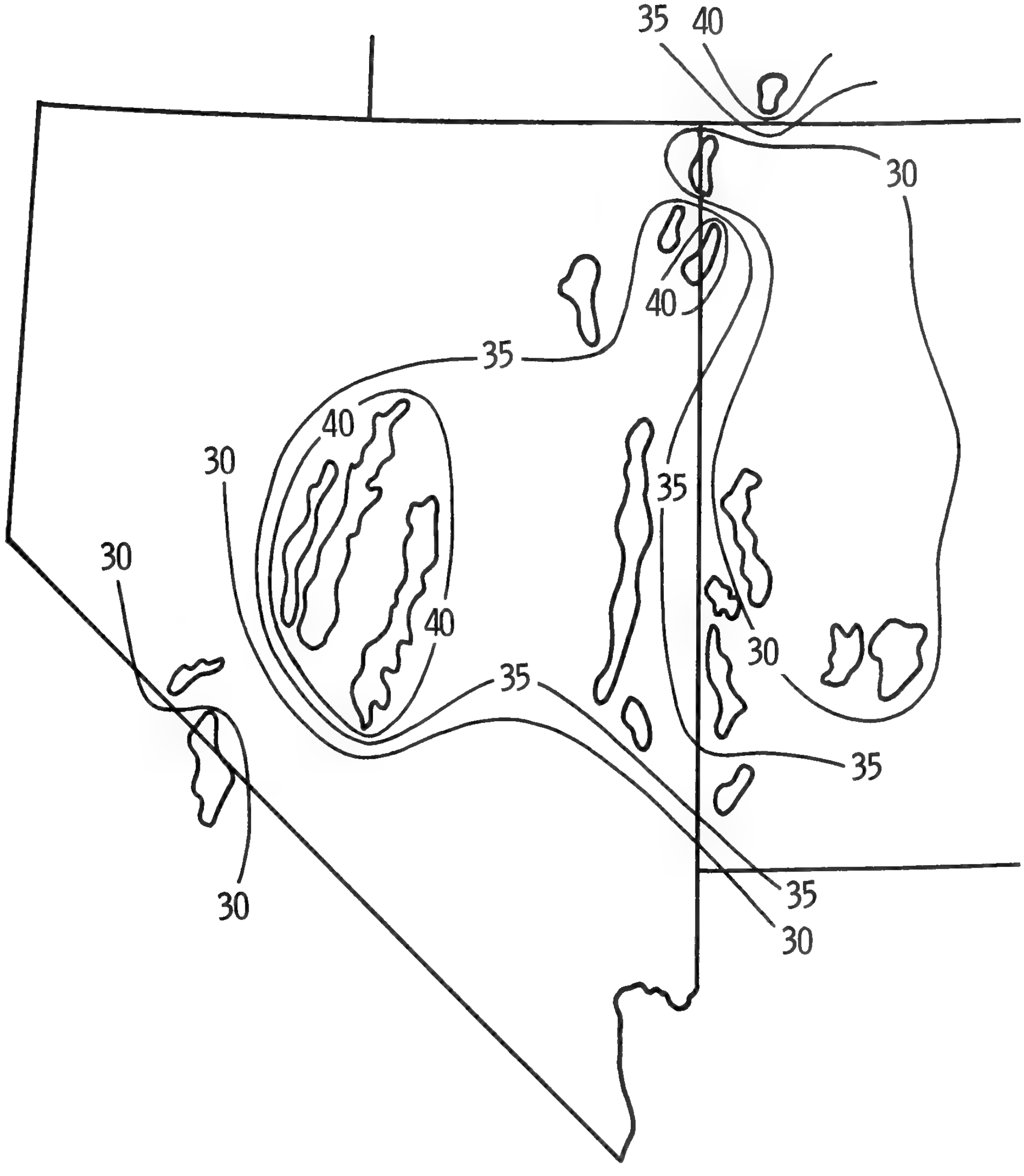

Figure 3.--Map showing the 18 mountain ranges sampled at "detailed" level and isolines of the average total vegetal cover (percent) on these ranges. Average total vegetal cover for each mountain range is given in table 4.

The total vegetal cover per plot increased steadily as elevation rose from 1,800 to 2,200 m (fig. 4). The change in vegetal cover was insignificant between 2,200 and 2,600 m. All of the 1,600 m plots (2) were located at Black Pine Peak, Idaho, near the northernmost limits of the study area. Thus these plots involve cooler temperatures and more mesic sites. The only 2,800 m plot was located on the White Mountains on a site with rocky, shallow soil that could not support much vegetation.

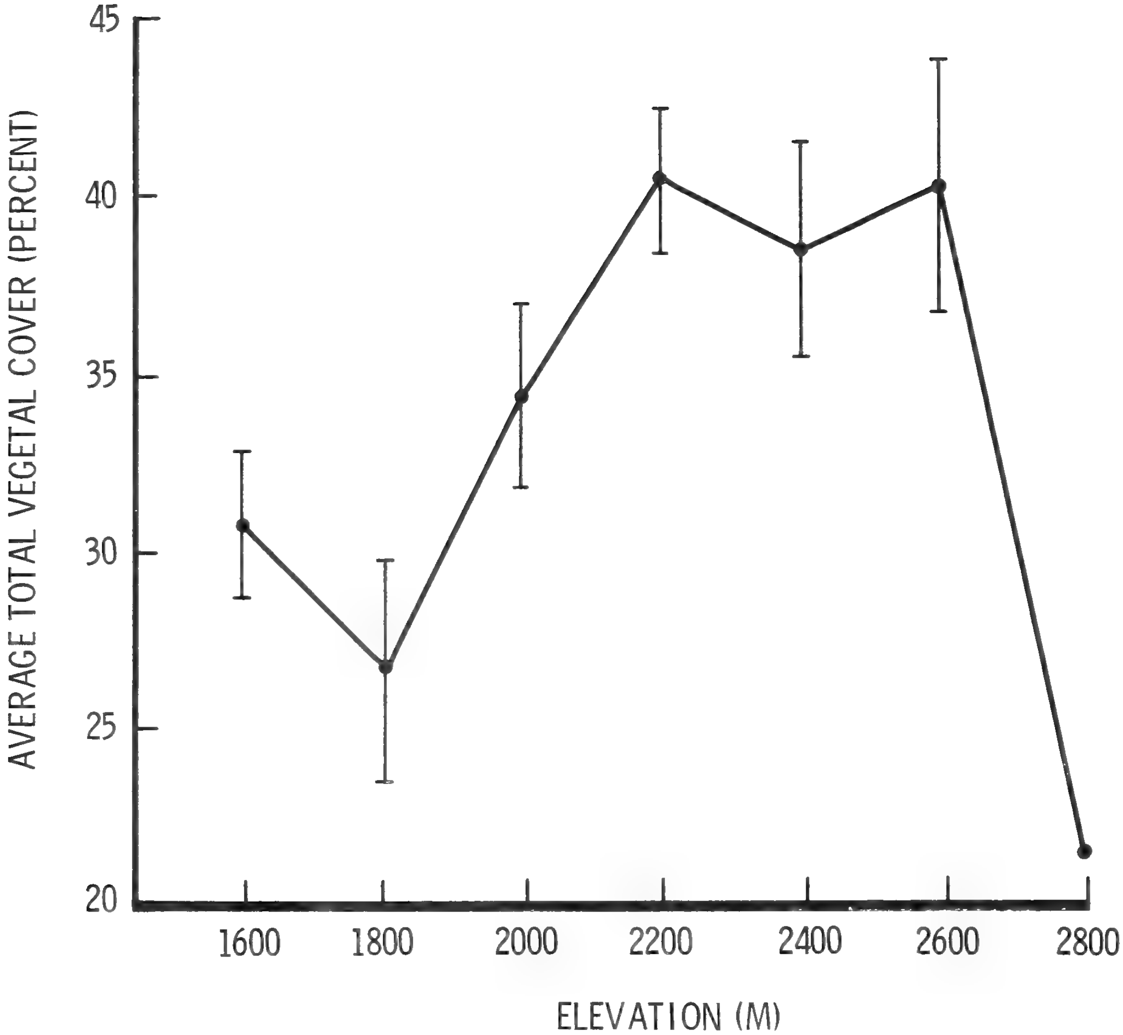

Figure 4.--Relationship of average total vegetal cover to elevation in woodlands sampled on the 18 mountain ranges with "detailed" data. Vertical bars represent one standard error. There is not a standard error bar at 2,800 meters because only one plot was available.

Variation in Tree Distribution and Dominance

The trees are usually the first organisms thought of in describing the pinyon-juniper vegetation type. It therefore seems worthwhile to consider the variation in tree distribution and dominance.

Figure 5 shows that Utah juniper occurs alone only along the northern boundary of the study area and in a few places in the Bonneville Basin of western Utah. Pinyon occurs alone only in the Excelsior Range along the California-Nevada border. Mixtures of pinyon and juniper occur throughout the rest of the study area.

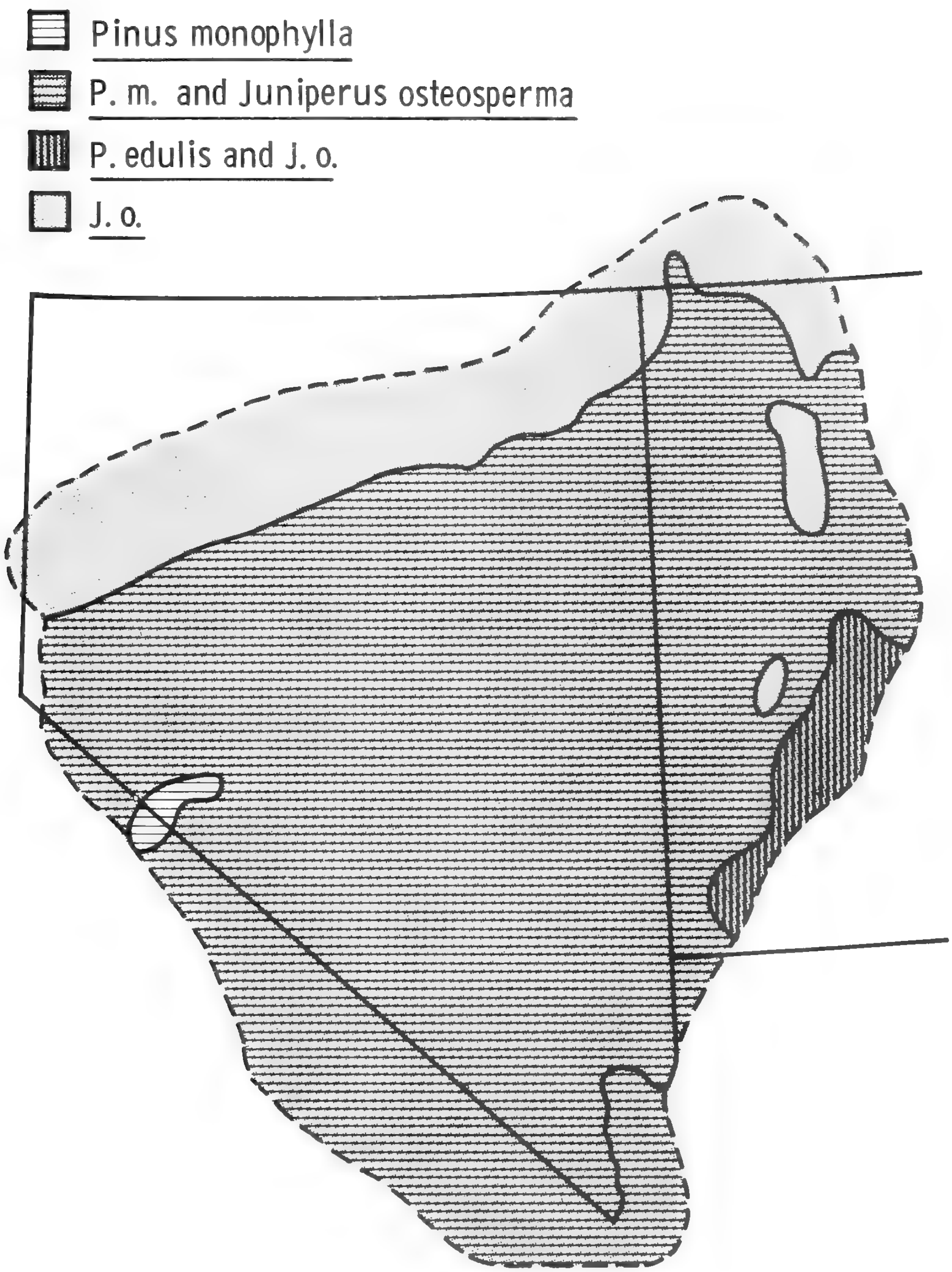

Figure 5.--Distribution of the three major tree species in the pinyon-juniper woodlands of the Great Basin.

The variation in tree dominance was assessed on the 18 mountain ranges on which detailed data were collected by dividing the percent cover of either juniper or pinyon by the total tree cover and multipling by 100 (table 4).

The average relative percent cover contributed by either pinyon or juniper trees shows a definite geographical distribution pattern in the Great Basin (fig. 6). The lowest average relative percent cover of juniper occured in southwestern and central Nevada. Juniper tends to dominate the woodlands in and near the Salt Lake Desert in

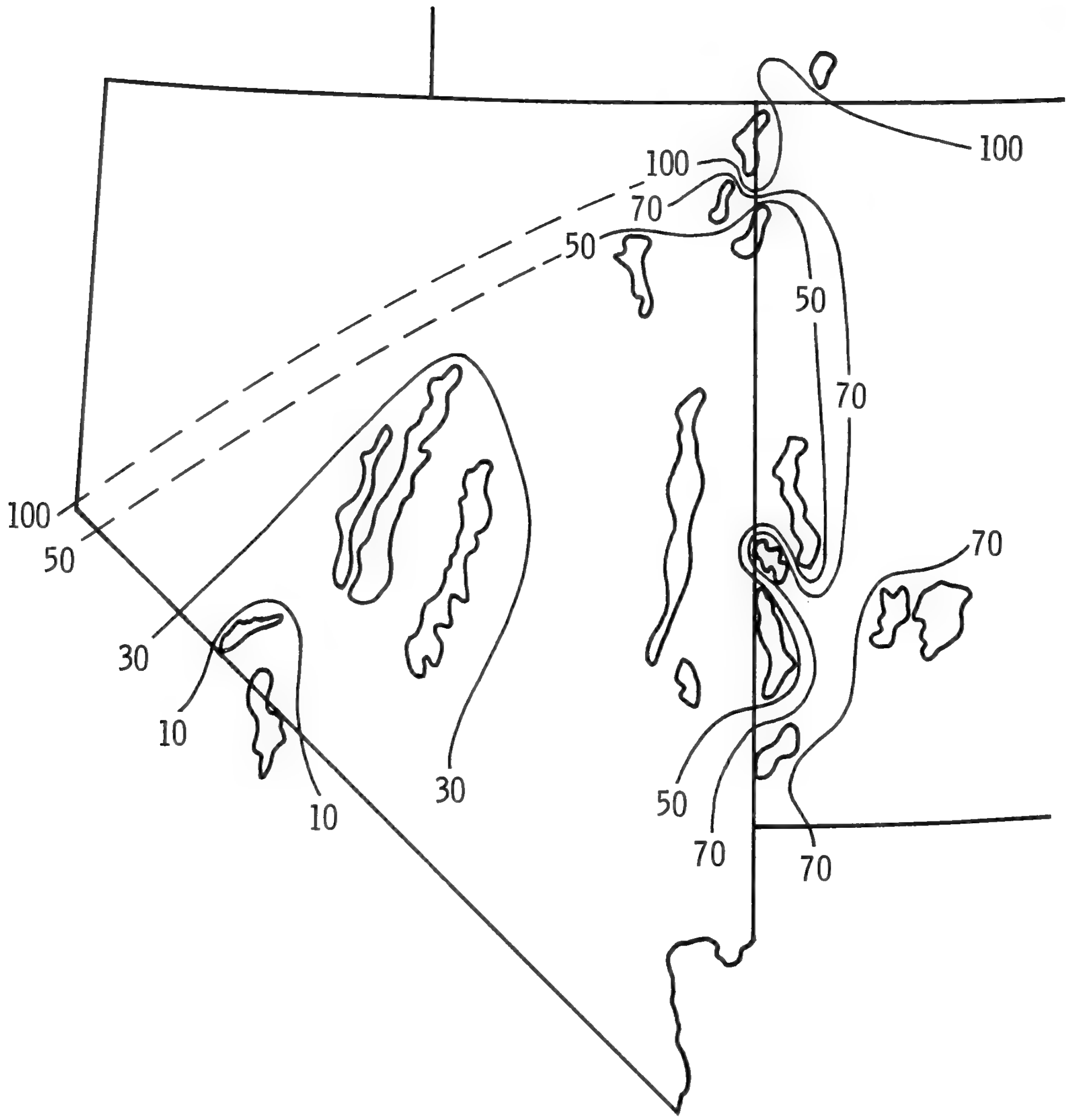

Figure 6.--Map showing the 18 mountain ranges sampled at "detailed" level and isolines of the average percent cover of juniper relative to average total tree cover on these cover on these ranges. The average values for the mountain ranges are listed in table 4.

western Utah, where the mountain ranges are only moderately high. The most northerly mountain ranges, such as the Goose Creek Range in northwestern Utah and Black Pine Peak Range in Idaho, contain predominantly pure stands of juniper trees. Many unsampled mountain ranges located in northern Nevada are also dominated by or contain only juniper (West and others 1978).

The plots were stratified according to their elevational intervals, and the average relative percent cover of pinyon and juniper was computed for each elevational interval. The results show that at 1,600 m juniper is completely dominant (100 percent relative cover) and at 2,600 m pinyon is completely dominant (fig. 7). As elevation increases the relative percent cover of pinyon increases, while the relative percent cover of juniper decreases. At an elevation of 2,000 to 2,200 m the average relative percent cover of both species is about equal.

When these relative cover data are divided on the basis of slope exposures (table 4), the result show some small differences probably due to the modification of climate encountered on different exposures. On the south and east exposures the relative percent cover contributed by juniper is slightly higher at high elevations, although the difference is not statistically significant. The slight difference is probably due to warmer temperatures and effectively drier soils. On north and west aspects the average relative percent cover contributed by pinyon is slightly increased at lower elevations, apparently due to cooler, moister sites encountered. An exception is the White Mountain Range of California where the relative percent cover of pinyon is high even at the lower elevations. This apparently results from the combination of warmer temperatures and of overall aridity of this mountain range, particularly at lower elevations (St. Andre and others 1965).

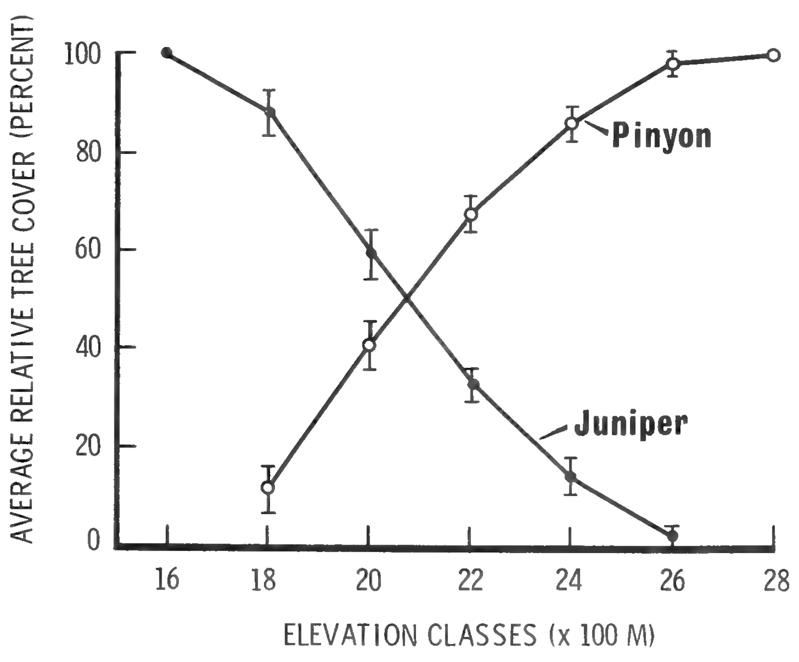

Figure 7.--The average relative cover (percent) of pinyon and juniper for plots of each elevational interval. Vertical bars represent one standard error. There are no bars for 1,600 and 2,800 meters because only one plot was available at these elevations.

In the central and southern Great Basin, where low temperatures are not likely to be a major controlling factor (West and others 1978), relative composition of tree species varies with longitudinal changes in seasonal moisture distribution (fig. 8). As the amount of summer precipitation (July-September) increases from west to east (Stidd 1967), the relative amount of juniper increases. Where summer preciptation exceeds about 3 inches (8 cm), single-needle pinyon is gradually replaced by true pinyon.

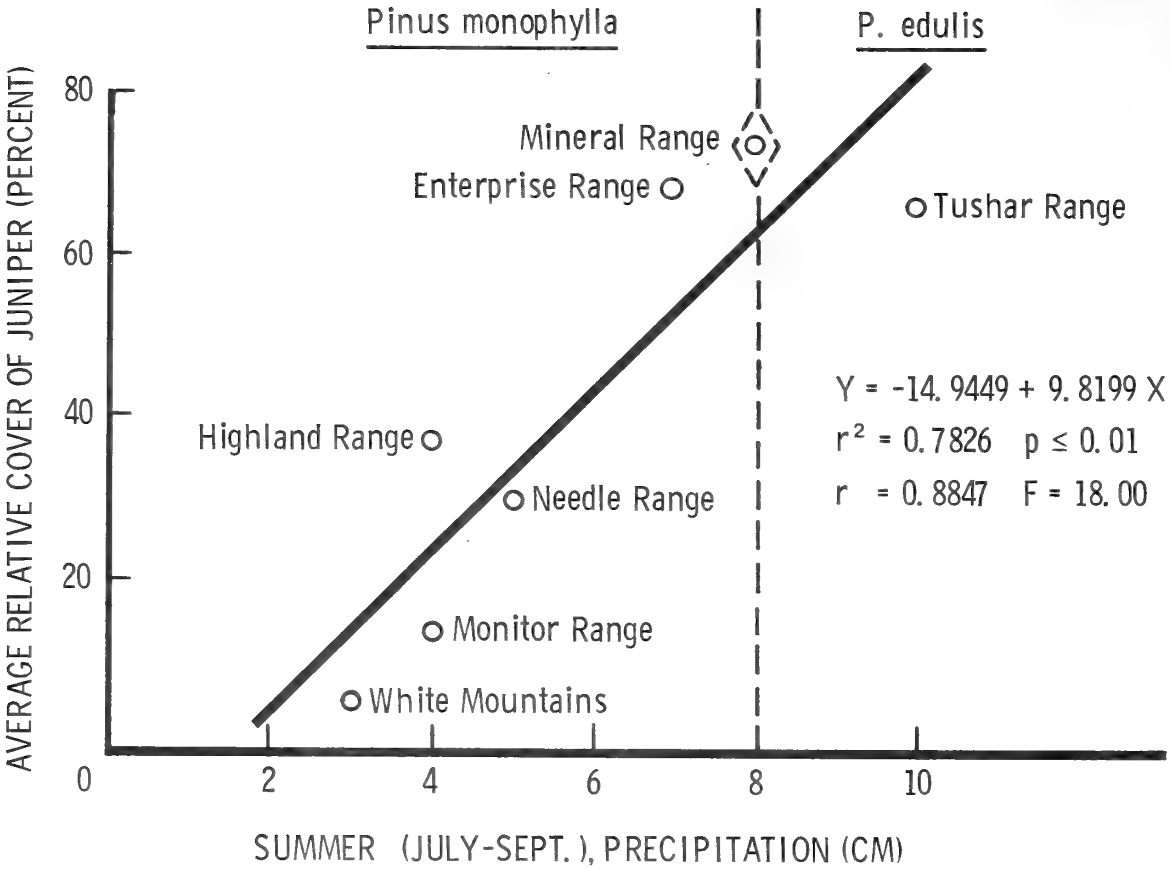

Figure 8.--Relationship of relative juniper tree cover to amount of summer precipitation, derived from Visher (1966).

CONCLUSIONS

The map of the pinyon-juniper vegetation type in the Great Basin provided in this study should more accurately depict the location of these woodlands than previously available maps. This increased accuracy is due to this map's small scale and objectively derived boundaries based on LANDSAT-1 imagery. The map shows that pinyon-juniper woodlands occupy 17.6 million acres (7.1 million ha) in the study area, about two-thirds of which occur in Nevada.

A floristic list of 240 positively identified species was obtained from sampling the woodland vegetation on 482 plots on 66 mountain ranges. This list could help other workers begin vegetation studies in Great Basin pinyon-juniper woodlands.

The proportion of pinyon and the total vegetal cover were found to increase more with elevation than with change in longitude or latitude. Dominance by juniper is associated with lower elevations and with increasing proportions of precipitation coming during the summer. The replacement of single-needle pinyon by double-needle pinyon at higher elevations is also associated with the southeasterly trend toward more summer precipitation. Higher average total vegetal cover is associated with higher altitudes and more northerly latitudes.

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A map of the pinyon-juniper woodland type in the Great Basin was developed from LANDSAT-1 imagery and from field checking of boundaries. A floristic list of 240 positively identified species associated with pinyon-juniper woodlands in the Great Basin is provided. Variations in total vegetal cover and in the relative proportions of pinyon and juniper are related to latitude, longitude, and elevation.

KEYWORDS: pinyon, *Pinus monophylla*, *P. edulis*, juniper, *Juniperus osteosperma*, woodlands, pigmy conifers, Great Basin, synecology, floristics

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Headquarters for the Intermountain Forest and Range Experiment Station are in Ogden, Utah. Field programs and research work units are maintained in:

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- Logan, Utah (in cooperation with Utah State University)
- Missoula, Montana (in cooperation with University of Montana)
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