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Cover: Louise de Kiriline Lawrence at the "sapsucker orchard", Pimisi Bay, Ontario, in the late 1950s. Photograph courtesy of Marianne Gosztonyi Ainley. See tribute and bibliography, pages 111–118.

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The Canadian Field-Naturalist

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Bird Communities Breeding in Selected Spruce and Pine Plantations in New Brunswick

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Breeding bird populations were surveyed on 18 selected forest habitat types in New Brunswick. Habitat types included natural spruce-fir forest, spruce and pine plantations, and natural regeneration after cutting. Breeding densities ranged from 333 to 493 pairs/km^2. The density and diversity of breeding birds increased with age of stand since disturbance (cutting). Richness, density and diversity of breeding bird populations were correlated with the density and heterogeneity of conifer and deciduous stems >1 m tall. Clearcutting, intensive silviculture and single species forest management reduces habitat diversity and decreases the density and diversity of breeding birds.

Key Words: Forest birds, plantations, diversity, New Brunswick.

New Brunswick supports the highest percentage of land in productive forest of any Canadian province (Forestry Canada 1991) and, with the implementation of the Crown Lands and Forest Act in 1982, the province entered into a commitment to long-term management of the forest resource. A program of timber supply analysis and long-term cutting schedules is designed to change the age structure and composition of the forests to ensure higher sustained levels of use (Baskerville 1992).

New Brunswick is also committed to integrating the needs of wildlife into contemporary forest management. A program of forecasting habitat availability, based upon cutting schedules and the diversified animal communities expected to occupy those habitats, is the objective of a new program of habitat supply analysis (Patch 1987). The predictive capability of any model for integrated forestry-wildlife management requires descriptive data on species-specific habitat requirements.

The concept of integrating the requirements of wildlife into programs of forest management is not new, and the principles of multiple-use resource management have been discussed extensively (e.g. Black 1974; Slusher and Hinckley 1974; Smith 1975; Gill et al. 1976; DeGraaf and Evans 1979; Thomas 1979; Regan and Capen 1985; Hunter 1990; and others). However, integration of wildlife and timber interests has been difficult because of conflicts among economic, silvicultural and biological considerations. Clear-cutting is usually the most cost-efficient and commonly-used method of harvesting timber on large-scale areas in northern mixed and conifer-dominated forests, as in New Brunswick.

Most large-scale forest management programs in New Brunswick now include some form of mechanical site preparation immediately after clear-cutting, followed by the establishment of seedling nursery stock and one or two applications of herbicide to suppress early-successional deciduous growth and thus to improve conifer growth. This concept of single-resource (often single-species) management is not compatible with the philosophy of multiple-resource, diversified, forest ecosystems (Seymour and Hunter 1992). Current ecological concern relates to an apparent loss of spatial, temporal and vertical ecosystem diversity. Diversity of plants and niches is considered desirable for a variety of wildlife esthetics and ecosystem stability (White et al. 1975; Swanson and Franklin 1992).

Monoculture systems in forestry have long been associated with reduced capability for supporting many types of wildlife. Harris et al. (1974) and Repenning and Labisky (1985) compared southern pine plantations with natural forests and suggested the former had fewer species and a smaller abundance of birds and mammals. Those studies attributed this difference to reduced canopy closure, reduced understory cover and reduced vertical stratification and litter build-up within plantations, all of which reduce the amount of both food and cover.

There have been a number of studies on the effects of forest harvesting on wildlife species and populations in the central and northeastern United States (Krull 1970; Lovejoy 1975; Kirkland 1977; Soutiere 1979; Crawford and Titterington 1979; Niemi and Hanowski 1984; Monthey and Soutiere 1985; Clough 1987; Elliott 1987; and others). In the Atlantic provinces of Canada, however, comparable data are few (Freedman et al. 1981; Morgan and Freedman 1986), even though the effects of current forest harvesting and silviculture upon habitat structure there may be severe, especially in New Brunswick.

Although several studies have examined the effects of forest harvesting (Monthey and Soutiere 1985; Elliott 1987), herbicide use (D'Anieri et al. 1987; Freedman et al. 1988), and insecticide use (Pearce et al. 1976; Busby et al. 1989) on wildlife in the northeastern United States and Canada, we could find no literature relevant to wildlife populations associated with developing conifer plantations in that region. This study describes the avian communities within selected spruce and pine plantations of various age in New Brunswick, with discussion on the effects of plantations on bird communities normally associated with conifer-dominated, mixed-species Acadian forests.

Study Area and Methods

Study sites were selected using aerial photographs and subsequent ground checks. Plantations of various stock and age, cut-overs left to regenerate naturally, and mature (60+ yr) spruce-fir stands comprised the sample. In 1981 surveys were confined to sites in southern New Brunswick. The oldest available plantations in the southern portion of the province were 11 years; most were 2-8 years old. In 1982 surveys were conducted in some older (17-18 yr) plantations in northern New Brunswick.

Plantations to be surveyed for breeding birds were selected on the basis of stand age and stocking species. Other factors which influenced selection were the size, shape, and location of stands. Following selection from forestry maps, aerial photographs, and ground checks, survey grids were established. The preferred size of each plot was about 12.1 ha (30 acres).

We used the "spot mapping method" for censusing breeding birds (International Bird Census Committee 1970). Using a compass and 50-m tape, a 350 m x 350 m grid was established (12.1 ha). Each 50-m intercept was marked with flagging tape and numbered for spatial reference during the survey. Owing to limitations on the size and shape of most plantations, only eight of 18 study plots met those exact measurements. The average size of the other 10 plots was 10.7 ha (26.5 acres). Eight to 10 surveys were conducted on each plot. Twelve sites were surveyed in 1981 (20 May - 16 July) and six in 1982 (24 May - 10 July). Censuses were conducted in the early morning (dawn to 10:00-11:00), during the period of maximum bird vocalization. The times for surveying specific sites were varied to avoid possible time-specific biases.

Sites were also sampled for plant community composition. Vegetation sample quadrats (1 x 10 m) were positioned at alternate transect intercepts. Each sample quadrat contained sub-quadrats of 1 x 5 m and 1 x 2 m. The percentage ground cover by grasses, sedges, forbs, mosses, ferns, slash, litter and bare ground was estimated in the 1 x 2 m sub-quadrat. The percentage cover of tree and shrub foliage ≤ 2 m in height was estimated in the 1 x 5 m sub-quadrat. The number of conifer and deciduous tree stems were counted by height class within the 1 x 10 m quadrats. There were thirty-two 1 x 10 quadrats on a 12.2 ha sample plot.

Avifaunal nomenclature follows the American Ornithologist's Union (1983). Bird species richness (S) is the number of species breeding. Diversity (H^1) was calculated as $H' = -\sum_{i=1} p_i \log_e P_i$ (Shannon and Weiner 1962; i=1 as applied by Tramer (1969), Kricher (1972) and others to describe bird populations). Density (D) is the estimated number of breeding pairs per square kilometer of habitat surveyed.

We developed a habitat diversity index (HDI) model which integrated the relative importance of stem density and degree of conifer/deciduous interspersion with height strata. The density (number/100 m^2) of conifer or deciduous stems for each height stratum (> 1m) was divided by the total number of stems for that stratum. This percentage value was a measure of the degree of conifer and deciduous interspersion. Percentage values were rated based upon their proximity to equality; i.e., 50% = complete heterogeneity. The following scale for interspersion provided a multiplier for total stems; i.e., the importance (value to breeding birds) of total stems increased proportionate to increases in interspersion of conifer and deciduous tree and shrub stems, to give the value I.

Conifer or deciduous stems / Total stems	Weighted multiplier (x total stems = I)
>0.90	1
0.80 ≤ 0.90	2
>0.70 ≤ 0.80	3
>0.60 ≤ 0.70	4
>0.50 ≤ 0.60	5
>0.40 ≤ 0.50	5
>0.30 ≤ 0.40	4
>0.20 ≤ 0.30	3
>0.10 ≤ 0.20	2
≤0.10	1

For example, a total of 10 stems, all of which were conifer, in a specific height class would receive a rating of 10 (10 x 1 = 10) whereas if five of the 10 stems were deciduous (ie., 0.5), the rating would be 50 (10 x 5 = 50). This stem interspersion, or heterogeneity, score was further weighted for value to breeding bird species by each stem height class (H). We introduced an increasing multiplier for increasing height class; i.e., the same 10 stems have greater influence on richness, abundance and diversity of breeding bird populations (in general) between 3-5 m in height than between 1-2 m in height. We gave no consideration for stems ≤ 1 m high. The following scale was used to obtain a multiplier (H) for application to the subsequent interspersion measurement.

Stem height class	Multiplier
> 1 ≤ 2 m	1
> 2 ≤ 3 m	2
> 3 ≤ 5 m	4
> 5 ≤ 7 m	8
> 7 ≤ 9 m	16
> 9 m	32

The 10 stems with an interspersion value (I) of 50 would be further multiplied by 2 if in the 2-3 m height stratum and by 8 if in the 5-7 m stratum.

The habitat diversity index (HDI) is the summation of the two weighted measures for each stem height stratum (i) divided by 100.

$$HDI = \frac{\sum_{i=1} p_i \bullet H_i}{100}$$

The HDI provides increasing values for habitats with high interspersion of conifer and deciduous stems in the upper height strata. A mature conifer forest stand with normal stocking rate but dense conifer/deciduous understory > 1 m would receive a higher HDI rating than a comparable aged site with the same stocking rate but minimal or no measurable understory.

We measured the compatibility of habitat diversity and bird species diversity, density and richness among the 18 sample sites by Spearman's rank correlation (one-tailed test for positive correlation only). The numerical distribution of species (richness) among habitat types was tested for selection by the Chi-square test of goodness-of-fit.

Results

Plant Communities

Total ground cover of brush and slash, raspberry (*Rubus* spp.) and tree and shrub foliage ≤ 2 m above ground declined during the years following cutting (Figure 1). The relationship between that decline and stand age was significant ($r_s = 0.99$; n = 14; $p < 0.005$). However, the three measured components of the understory demonstrated different relationships with age. Only raspberry declined steadily with stand age. The decline in the raspberry component of the understory was compensated for by an increase in tree and shrub foliage through the 10-12 year old classes followed by declines thereafter. The brush and slash component, most left as debris from cutting operations, also declined with age since harvesting, although that decline stabilized after 10-11 years. These changes in the understory cover are expected as plantations mature and early successional species such as raspberry are replaced in importance by trees and shrubs such as the conifer stock species and deciduous species represented by White Birch (*Betula papyrifera*), Sugar Maple (*Acer saccharum*), Red Maple (*A. rubrum*) and Fire Cherry (*Prunus pensylvanica*).

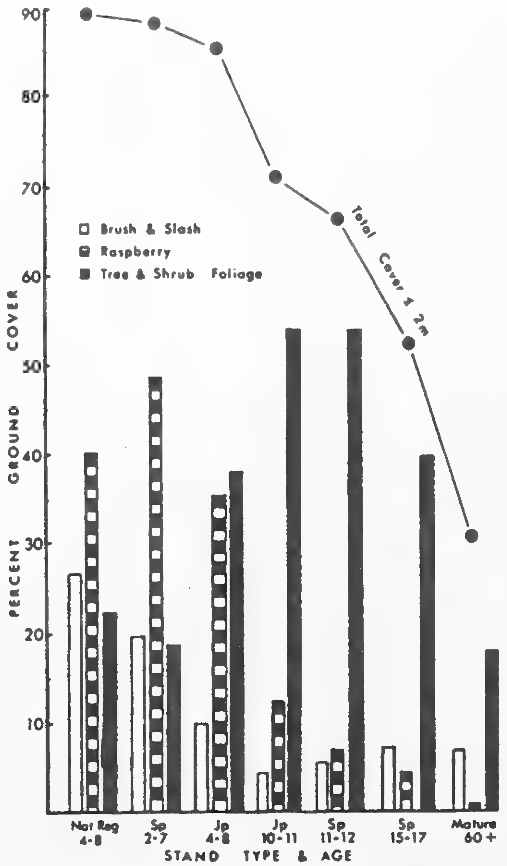

FIGURE 1. The importance (% ground cover) of understory (< 2 m) within areas of natural regeneration, spruce and pine plantations and mature conifer stands.

Concurrent with the changing understory vegetation was an increase in the density of tree and shrub stems > 2 m above ground (Figure 2). Most stems were conifer and sharp declines in stem densities occurred

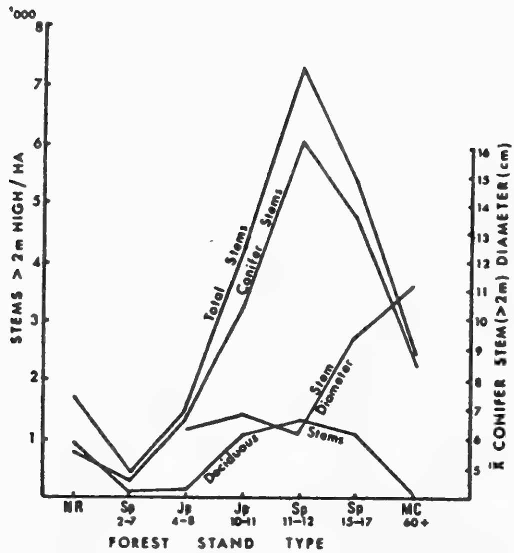

FIGURE 2. The densities of stems by height classes within areas of natural regeneration, spruce and pine plantations and mature conifer stands.

in plantations beyond 12 yr of age, a result of natural tree and shrub mortality from competition for limited space. Increasing mean stem diameter of conifer trees is also an expected element of stand maturity. The decline and virtual elimination of deciduous stems > 2 m high with conifer stand maturity also reflects changing stand structure from competition over time.

Bird Populations

Species distribution: Fifty-three species of birds were recorded as breeding within one or more of the 18 study sites. The 18 study sites were stratified based upon dominant tree and shrub species, age since planting (or since cutting, for natural regenerating sites) and site treatment (uncut; cut not planted; cut and planted). Breeding densities for individual bird species were then used to allocate species to forest types (Table 1). This stratification of species serves to identify those birds associated with specific regenerating forest habitats. Only the White-throated Sparrow (*Zonotrichia albicollis*) was found to breed in all seven forest types.

In sites sampled for breeding birds there were often 1-3 species which we considered abundant (densities > 50 pair/km^2). In regenerating stands (conifer plantations and natural regeneration) < 10 years of age the dominant breeding species were the White-throated Sparrow and Common Yellowthroat (*Geothlypis trichas*). Also common, but not as predictably abundant, were Lincoln's Sparrow (*Melospiza lincolinii*) and Song Sparrow (*M. melodia*). In response to increasing habitat complexity and vertical stratification in plantations 10-12 years old, the Common Yellowthroat and White-throated Sparrow declined in density although both remained common (26-50 pairs/km^2) while the Parulinae assumed dominance, typified by the Palm Warbler (*Dendroica palmarum*), Nashville Warbler (*Vermivora ruficapilla*) and Magnolia Warbler (*D. magnolia*). In older spruce plantations (15-17 years) the dominant breeding species continued to be the Magnolia Warbler, accompanied by the Yellow-rumped Warbler (*D. coronata*), Bay-breasted Warbler (*D. castanea*), Swainson's Thrush (*Catharus ustulatus*) and Veery (*C. fuscescens*). In the mature natural conifer stands the abundant breeding species were the Bay-breasted Warbler and the Tennesseee Warbler (*V. peregrina*) followed in importance by the Yellow-bellied Flycatcher (*Empidonax flaviventris*), Yellow-rumped Warbler and Dark-eyed Junco (*Junco hyemalis*). Other common species in the mature conifer forest sites included the Hermit Thrush (*C. guttatus*). Swainson's Thrush, Nashville Warbler, Black-throated Green Warbler (*D. virens*), Blackburnian Warbler (*D. fusca*), Cape May Warbler (*D. tigrina*), Magnolia Warbler and Golden-crowned Kinglet (*Regulus satrapa*).

Density: Total densities of breeding birds within the seven habitat types varied from 333 to 493 breeding pairs/km^2 (Table 2). Densities were positively correlated to age of stand ($r_s = 0.86$; $p < 0.01$). The increasing complexity of stand structure with age (three-dimensional stratification) provided an increased number of niches and thus of nesting and feeding habitats.

We examined densities of breeding birds for each site to isolate the most abundant breeding species. Only sites where a species was found to breed were included in each sample. Several species of Parulinae (Common Yellowthroat; Magnolia Warbler; Bay-breasted Warbler; Palm Warbler) and the White-throated Sparrow had the greatest means and ranges of breeding densities among the 18 sites. We examined frequencies and mean and maximum densities for the 10 most common species. Neither measure of density was correlated with frequency among the 18 sites.

Richness: Bird species richness within the seven habitat types was positively correlated with species density ($r_s = 0.84$; $p < 0.02 > 0.01$) and age since cutting/planting ($r_s = 0.88$; $p < 0.02 > 0.01$). Changes in species richness, however, do not necessarily influence breeding densities. Seven and 26 species (1:3.71) were recorded breeding in the youngest (2-7 yr) and oldest (60 yr+) habitats, respectively, although respective densities showed significantly less disparity (341.0 vs 488.3; 1:1.43; $p < 0.001$).

TABLE 1. The distribution and mean densities (breeding pairs/km^2) of breeding bird species among forest types sampled in New Brunswick during the summers of 1981 and 1982.

	Forest Types						
		Plantations					
Bird Species	Natural Regeneration 4 - 8 yr (n = 2)	Spruce 2-7 yr (n=2)	Jack Pine 4 - 8 yr (n = 4)	Jack Pine 10 - 11 yr (n = 2)	Spruce 11 - 12 yr (n = 2)	Spruce 15-17 yr (n = 3)	Mature Conifer 60 + yr (n = 3)
Early Successional							
American Kestrel	1*						
Hairy Woodpecker		2					
Downy Woodpecker	1						
Chestnut-sided Warbler	1						
Rusty Blackbird	1						
Savannah Sparrow			1				
Vesper Sparrow			1				
Song Sparrow	4	4	4				
Early to Mid-Successional							
Northern Flicker			1	1	1		
Alder Flycatcher	3	1	3	2	3	2	
American Robin	1		1	2	3	3	
Palm Warbler			3	5	4		
Common Yellowthroat	5	7	7	4	4		
American Redstart	1		1	1	1	3	
Lincoln's Sparrow	4	5	4		1		
Mid-Successional							
Common Nighthawk			1				
Yellow-bellied Sapsucker				1			1
Olive-sided Flycatcher					1		
Blue Jay						1	
Black-capped Chickadee				1	1	1	
Veery					1	4	
Ruby-crowned Kinglet					1	1	
Black-throated Blue Warbler				1			
Blackpoll Warbler					1	1	
Canada Warbler				1	2		
Rose-breasted Grosbeak				1	3	3	
Fox Sparrow				1	3		
Northern Waterthrush				1			
Mid-Successional to Mature							
Ruffed Grouse						1	1
Yellow-bellied Flycatcher				1	3		4
Boreal Chickadee						3	2
Hermit Thrush			1	3	3	2	3
Swainson's Thrush			1		3	4	3
Red-eyed Vireo						3	1
Black-and-White Warbler				3	3		1
Tennessee Warbler						3	5
Nashville Warbler			2	4	5	3	3
Bay-breasted Warbler						4	6
Ovenbird				3		3	1
Purple Finch				1			1
Mature Spruce-Fir							
Solitary Vireo							2
Gray Jay							1
Brown Creeper							1
Golden-crowned Kinglet							3
Black-throated Green Warbler							3
Blackburnian Warbler							3
Cape May Warbler							3

Continued

TABLE 1. *Continued.*

Bird Species	Forest Types						
	Natural Regeneration 4 - 8 yr (n = 2)	Plantations					Mature Conifer 60 + yr (n = 3)
		Spruce 2-7 yr (n=2)	Jack Pine 4 - 8 yr (n = 4)	Jack Pine 10 - 11 yr (n = 2)	Spruce 11 - 12 yr (n = 2)	Spruce 15-17 yr (n = 3)	
Non-Selective							
Magnolia Warbler	4		3	4	7	5	3
Northern Parula	1						1
Yellow-rumped Warbler			1	3	4	4	4
Mourning Warbler	4	2	1	3			2
Dark-eyed Junco	3		2	1	1	1	4
White-throated Sparrow	6	6	6	3	5	3	1

* 1 = $\leqslant$ 5; 2 = 6-10; 3 = 11-25; 4 = 26-50; 5 = 51-75; 6 = 76-100; 7 = >100

TABLE 2. Population characteristics of bird populations breeding within selected regenerating and mature spruce-fir forest stands in New Brunswick.

Population Measurements	Forest Types						
	Natural Regeneration 4 - 8 yr (n = 2)	Plantations					Mature Conifer 60 + yr (n = 3)
		Spruce 2-7 yr (n=2)	Jack Pine 4 - 8 yr (n = 4)	Jack Pine 10 - 11 yr (n = 2)	Spruce 11 - 12 yr (n = 2)	Spruce 15-17 yr (n = 3)	
Density (D)[1]	333.0	341.0	337.3	379.5	492.5	408.3	488.3
Richness (S)[2]	15	7	19	24	24	22	26
Diversity (H′)[3]	2.29	1.42	2.08	2.71	2.57	2.66	2.73

[1]D = breeding pairs/km^2
[2]S = number of breeding species
[3]$H' = -\sum_{i=1} p_i \log_e P_i$ (Tramer 1969)

The numerical distribution of species (richness) among the seven general habitat types was significantly different ($\chi^2 = 14.08$; df = 6; $p < 0.05 > 0.02$). The dominant contributor to the χ^2 variate was the low number of species in the youngest (2-7 yr) plantations. Species richness values were not significantly different among the six older habitats ($\chi^2 = 3.74$; df = 5; $p > 0.05$).

Diversity: Breeding bird species diversity was significantly correlated with stand age ($r_s = 0.89$; $p = 0.01$) and bird species richness ($r_s = 0.90$; $p < 0.01$) among the seven general habitat types. There was no significant correlation between bird species diversity and density.

There were significant positive correlations between HDI and all three measures of breeding bird populations (Table 3). There were also significant positive correlations among the three measures of breeding bird populations. There were no significant correlations between breeding bird species diversity and unweighted habitat measurements (e.g., total stem density: $r_s = 0.08$; total stems in 2-3 m height strata: $r_s = 0.002$).

TABLE 3. Spearman's rank correlation coefficients (r_s) for ranked values of measured variables for habitat and breeding bird populations on 18 sites sampled in New Brunswick in 1981 and 1982.

	Species Diversity	Species Density	Species Richness
Habitat Diversity	0.59 **	0.51 *	0.57 *
Species Diversity	-	0.66 ***	0.94 ***
Species Density	-	-	0.79 ***

* = p < 0.02; ** = p < 0.01 *** = p < 0.001

[1]Habitat diversity index : $HDI = \dfrac{\sum_{i=1}^{n} I_i (H_i)}{100}$

Discussion

In this study of spruce and pine plantations in New Brunswick, breeding bird populations generally increased in richness, density and diversity with age of site. However, as all measures were also significantly correlated with the density and heterogeneity of conifer and deciduous stems > 1 m above ground, silviculture efforts towards single-species management (e.g., suppression of deciduous trees and shrubs) will reduce habitat diversity and consequently numbers and diversity of breeding birds.

We developed a habitat diversity index (HDI) model which integrated the relative importance of stem density and degree of conifer/deciduous interspersion by height strata. The HDI is based upon counts of stems, measurements which are quickly taken and readily incorporated into most forest inventory data sets. The HDI is based on the assumption that diversity of forest structure positively influences the richness, density and diversity of breeding bird populations. Furthermore, diversity of forest structure in the mixed forest is a function of conifer/deciduous interspersion and vertical strata complexity, both of which can be estimated with stem densities within height classes. We chose to apply an HDI to measure value of habitat to bird community structure using measurements compatible to the needs of both forester and biologist.

MacArthur and MacArthur (1961) recognized the importance of foliage height diversity to bird species diversity. Bird species avoid direct competition by choosing to feed and nest within specific niche dimensions. Increasing potential niches through habitat diversification is a goal of most wildlife resource managers.

Many recent studies have relied upon principal component analysis (PCA), discriminant function analysis (DFA) and canonical correlation analysis (CC) to isolate and define the proximate factors which determine species-specific habitat selection. Proximate factors influencing nest site selection can include canopy closure, canopy height, density and size of trees by species, estimates of understory and shrub volume and ground cover (Capen 1982). Capen (1981) provided a review of some multivariate statistical techniques used to describe the multidimensional nature of wildlife habitat.

We suggest that it is the 3-dimensional interaction of habitat variables (e.g., juxtaposition) which often influences forest stand use by breeding birds, not single dimensional or individual habitat components. This limits the precision, and utility, of many recent attempts to explain breeding bird use of habitats through multivariate analysis. Hazards in the misuse of PCA, DFA and CC have been emphasized by Karr and Martin (1981) and Rexstad et al. (1988).

In this study we confirmed the relationship between habitat diversity and bird species diversity, and showed positive correlations between stand age and bird species density, richness and diversity within regenerating seral sites in New Brunswick. These results also allow comment on the wider impact of plantations on bird communities in the province. If a common objective is to manage a unit of land for both wood fibre and wildlife species, then population goals should be towards optimum rather than maximum levels. A structurally diverse forest, with vertical stratification and high interspersion of deciduous and conifer stems and foliage does not provide maximum production of commercial wood fibre. However, for industry to justify forest management economically, a unit of land must provide specific cost benefits. This may require sacrifices by the wildlife manager; the conifer component of most stands will assume priority, although management strategies can be developed to provide stand characteristics favourable to specific wildlife species or populations. Forest management strategies often require only minor manipulation to enhance habitat for wildlife populations (e.g., Thomas 1979). The technical information to develop a diversified and healthy forest ecosystem is available (Welsh 1988). Many states and provinces now have functional forestry-wildlife guidelines for managing forests on public lands, often supplemented with accessible extension services for private woodlot owners (e.g., Bourchier 1988; Williamson 1988; Anonymous 1988; Elliott 1988). We suggest that general forestry-wildlife guidelines be modified/refined through accumulation of data sets on wildlife assemblages at the regional level.

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Nesting Habitat of the Red-throated Loon, *Gavia stellata*, at Toker Point, Northwest Territories

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Dickson, D. Lynne. 1994. Nesting habitat of the Red-throated Loon, *Gavia stellata*, at Toker Point, Northwest Territories. Canadian Field-Naturalist 108(1): 10–16.

The characteristics of 68 nesting ponds for Red-throated Loons, *Gavia stellata*, were described in a 26 km^2 plot near Toker Point, Northwest Territories. Most of the ponds used for nesting were 0.1 - 1.0 ha in surface area and 0.3 - 1.0 m deep. Emergent vegetation covered an average of 17% of the surface area of the ponds, and over half of the ponds had >80% marshy shoreline. A comparison of the surface area of ponds used for nesting to that of lakes and ponds available in the study area indicated that size influenced pond selection by the Red-throated Loon. The majority of nests (68%, N = 88) occurred along wet shorelines of ponds, 18% were on islands and another 10% were in shallow water offshore. There were only three nests along dry shoreline. The nests tended to be located on the windward side of the pond where they were less exposed to wind-driven waves. Nests were an average of 2.0 m from open water. Most (90%) nests were platforms built with aquatic vegetative growth from the previous year. The other 10% were depressions, usually in a moss hummock, with little or no vegetative material in the nest cup.

Key Words: Red-throated Loon, *Gavia stellata*, Beaufort Sea, habitat, Northwest Territories.

Studies in both Europe and North America have noted that the Red-throated Loon, *Gavia stellata*, tends to nest on ponds and small shallow lakes (Parmelee and McDonald 1960; Davis 1972; Bergman and Derksen 1977; Booth 1982). Quantitative data indicated that the nesting pond is usually <1 ha in surface area and <1 m deep (Davis 1972; Bergman and Derksen 1977; Booth 1982), although on the Queen Charlotte Islands, Red-throated Loons showed no preference for smaller ponds (Douglas and Reimchen 1988). Bergman and Derksen (1977) noted that Red-throated Loons in Alaska preferred ponds with about 40% cover of emergent vegetation. Loons in both Scotland (Merrie 1978) and the Queen Charlotte Islands (Douglas and Reimchen 1988) nearly all nested within 8 km of the marine waters where they fed. Studies in Hudson Bay, Canada (Davis 1972), Alaska (Petersen 1976; Bergman and Derksen 1977) and Finland (Lokki and Eklöf 1984) all reported a tendency for Red-throated Loons to nest on islands or in emergent vegetation, rather than on mainland shores.

The habitat preferences of Red-throated Loons nesting along the Canadian coast of the Beaufort Sea have never been described. Information on the types of waterbodies the Red-throated Loon used for nesting and where nests were located on ponds was needed for a program initiated in 1985 to monitor its abundance and productivity (Dickson 1992). The program was established in response to concerns about the effects offshore oil and gas production might have on regional bird populations. Success of the monitoring program depended on locating by helicopter all of the breeding pairs of loons and their nests within several study plots. Familiarity with where to search for nests would increase both efficiency and accuracy of the surveys. Thus, data were gathered at Toker Point from 1985 to 1987 to determine distinguishing characteristics of waterbodies selected by Red-throated Loons for nesting, as well as the appearance of the nests and their location on the waterbody.

Study Area and Methods

The study was conducted in a 26 km^2 plot near Toker Point on the Beaufort Sea coast in the Northwest Territories (69° 37′N; 132° 44′W) (Figure 1). The region is characterized by wet lowland tundra interspersed with drier ridges. Much of the lowland is in the form of distinct basins featuring pingos surrounded by shallow lakes, ponds, marshes, and low and high-centred polygons. Permafrost is continuous, and most of the area is poorly drained with moist to wet cryosolic soils (Wiken 1986).

There is a continuous cover of low-arctic tundra vegetation, mostly <0.5 m high. Wet lowlands are dominated by sedges (*Carex aquatilis*, with lesser amounts of *C. chordorrhiza*, *C. rariflora*, *C. rotundata*) and willows (*Salix* spp.), whereas dry uplands feature willows, Dwarf Birch, *Betula glandulosa*, Crowberry, *Empetrum nigrum*, and several ericaceous species including Labrador Tea, *Ledum decumbens*, Mountain Cranberry, *Vaccinium vitis-idaea*, and Bilberry, *Vaccinium uliginosum*. The tussock-forming Cottongrass, *Eriophorum vaginatum*, covers moist, gentle slopes. Better-drained protected slopes and creek valleys have patches of taller (>0.5 m) willows. Coastal wetlands periodically inundated by seawater are dominated by *Carex subspathacea*,

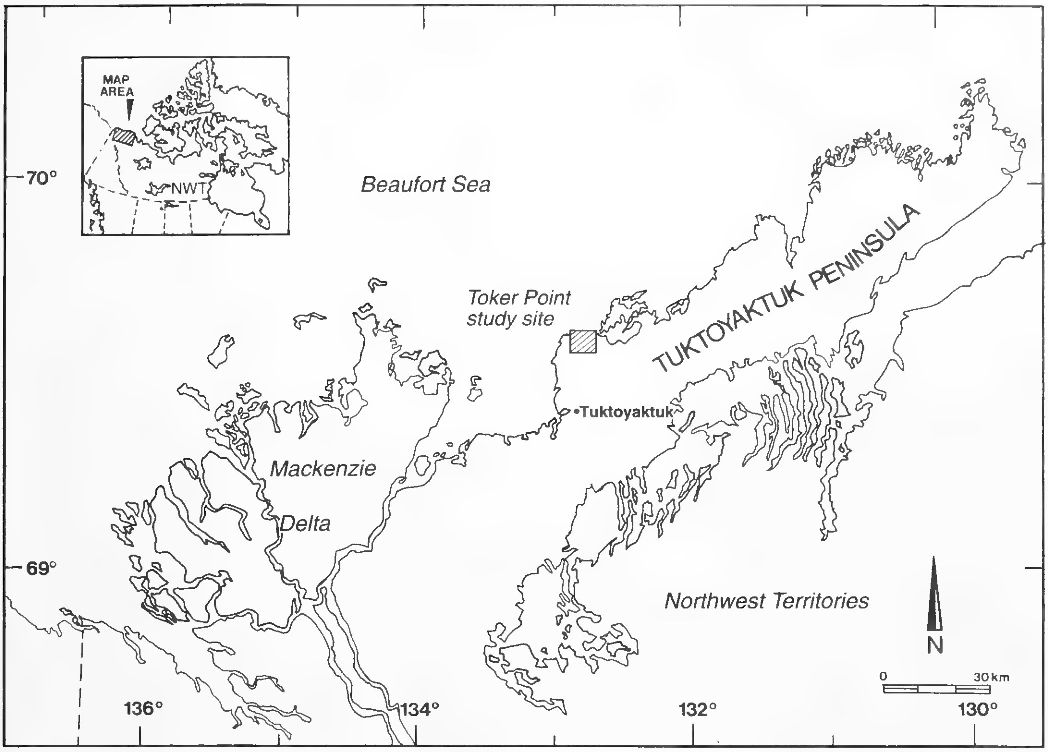

FIGURE 1. Location of study area at Toker Point, Northwest Territories.

Goose Grass, *Puccinellia phryganodes,* and Mare's Tail, *Hippuris tetraphylla*.

The study area was searched by observers on foot throughout June and July from 1985 to 1987 to locate all Red-throated Loon nests. After hatch in July, the characteristics of 68 nesting ponds were described: water depth, bottom type, turbidity, % cover with emergent vegetation, percentage of wet shoreline, dominant species of emergent and shoreline vegetation, and distance to the nearest pond occupied by another pair of Red-throated Loons. A tape measure was used to determine the maximum water depth for ponds up to 1 m deep. Four categories were used to describe pond depth: ≤0.2 m, 0.3–0.5 m, 0.6–1.0 m, and >1.0 m. The surface area of larger ponds was determined from aerial photographs and 1:50 000 scale topographical maps (Canada Map Office, Ottawa). The areas of small ponds <1.0 ha in size were determined using photographs taken from a helicopter. An object of a known size was also photographed from the same height to obtain the scale of the photograph. The surface area was then calculated using a digitizer.

The surface areas of all the other lakes and ponds in the study area (N = 541) were determined using aerial photographs and the following categories: <0.10 ha, 0.10-0.19 ha, 0.20–0.59 ha, 0.60–0.99 ha, 1.0–2.0 ha, >2.0 ha. The size frequency distribution of ponds used for nesting was compared to that of lakes and ponds available using the Chi-Square Test. The lakes and ponds occupied by nesting pairs of Pacific Loons, *Gavia pacifica,* were noted and assigned size categories as above.

After hatch, 88 Red-throated Loon nests were described as follows: length, width, height above water, nest material, and whether the nest was a built-up platform or a depression in the ground. Location of the nest on the pond was also described. Nests were classified as either on an island, in offshore shallow water, on wet shore, on dry shore or on a point of land. Distances were estimated from the nest to open water (area of pond with no vegetation), as well as from the nest to the nearest dry ground. Visibility from the nest, the species of vegetation surrounding the nest, and the side of the pond where the nest was located were also recorded.

Results

Nesting pond characteristics

At Toker Point, the average surface area of ponds used by Red-throated Loons for nesting was 0.49 ha (Table 1). Most (77%) nested on ponds 0.10–0.99 ha

TABLE 1. Characteristics of ponds used by the Red-throated Loon for nesting at Toker Point.

Characteristic	Mean	Mode	Range	N
Surface area (ha)	0.49		0.02 – 2.0	68
Depth (m)[a]		0.6 – 1.0		67
Emergent vegetation (% cover)	17		1 – 90	68
% wet shore	63		0 – 100	68
Distance to nearest occupied territory (m)	390		120 – 880	67

[a]Depth was divided into four categories: ≤0.2, 0.3-0.5, 0.6–1.0, >1.0.

TABLE 2. Dominant species of vegetation found on ponds used by nesting Red-throated Loons compared to all waterbodies.

	Percentage of ponds where occurred	
Species	Offshore	Along wet shore
Carex aquatilis	93	100
Arctophila fulva	32	0
Carex chordorrhiza	10	30
Potentilla palustris	9	10
Salix sp.	0	16
Carex rariflora	0	10
Hippuris tetraphylla	4	0
Eriophorum angustifolium	3	7
Eriophorum russeolum	1	6

in surface area (Figure 2). A comparison of pond sizes used for nesting to sizes available in the study area showed that pond selection was influenced by pond size (χ^2 = 126, 3df, p<0.005). Few Red-throated Loons (10%) nested on ponds < 0.10 ha in size, despite 69% of the ponds in the study area being that size. No nesting occurred on ponds > 2.0 ha in size.

The Pacific Loon, which nested in almost equal abundance as the Red-throated Loon in the study area, tended to use larger ponds. Most (72%, N=50) nested on ponds > 2 ha in surface area, while 22% were on ponds 1.0 to 2.0 ha in size. Only 6% used ponds the size most frequently used by the Red-throated Loon. The smallest pond with Pacific Loons was 0.4 ha.

Most (75%) of the ponds used by the Red-throated Loon for nesting were 0.3–1.0 m deep in mid summer. Only 5 of 67 ponds were <0.3 m in depth, the shallowest pond being 0.1 m. Emergent vegetation covered 17% of the nesting pond on average. Nearly half (49%) of the ponds had <10% cover with emergent vegetation, whereas very few (4%) had >50% cover. Nesting ponds tended to have marshy shoreline. Over half of the ponds had >80% wet shoreline, although nesting also occurred on ponds with only

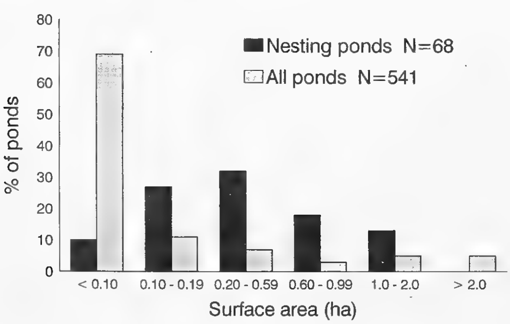

FIGURE 2. Comparison of pond sizes used by the Red-throated Loon for nesting to pond sizes available at Toker Point.

dry shoreline (5 of 68 nesting ponds). The sedge, *Carex aquatilis,* was the most abundant species of emergent vegetation occurring both along wet shore and offshore in most nesting ponds (Table 2). Pendant Grass, *Arctophila fulva,* was found offshore in about one-third of the nesting ponds. Other frequently occurring species were the sedges *Carex chordorrhiza* and *C. rariflora*.

Red-throated Loons nested an average of 390 m apart. The closest distance between two ponds with nests was 120 m. The water in nearly all of the nesting ponds (91%) was clear and the bottom of most (87%) consisted of a layer of loose decayed vegetation on top of permafrost.

Nest location on pond

Seventy-two percent of nests (N = 88) were along the shores of ponds, 18% were on islands and another 10% in shallow water offshore (Table 3). Nearly all (95%) of the nests that were along the shore were in wet sedge marshes averaging 59 ± 95 m (N = 58) from dry land. Only three of the onshore nests were on dry substrate.

The loons tended to build their nests on the windward side of the pond (χ^2=13.5, 7df, p < 0.05) (Figure 3). Weather data for nearby Tuktoyaktuk indicated that in June the prevailing winds, including the strongest winds, were from the north and west (Atmospheric Environment Service, Edmonton). Likewise, 76% of loon nests at Toker Point occurred on the west, northwest, north and northeast sides of the ponds, where they were seldom exposed to wind-driven waves.

There was an average of 2.0 ± 2.8 m (N=85) of vegetative cover between the nest and open water on the pond. However, nests occurred as far inland as 15 m. In June, visibility from the nest for the loon was 360° at all but two nests (N = 86). However, when the vegetation surrounding the nest became fully grown in July, the visibility became restricted to 45° or less at about half of the nests.

Table 3. Type of nest built by the Red-throated Loon at Toker Point and its location on the pond.

	Number of nests				
	Shoreline type		Nest type		
Nest location	Wet	Dry	Platform	Depression	Total
On shore					
Point of land	4	1	5	0	5
Other	56	2	54	4	58
Offshore					
Island	11	5	11	5	16
Shallow water			9	0	9
All	71	8	79	9	88

Nest characteristics

Most (90%, N = 88) were platforms built with vegetative growth from the previous year. The nest material was usually *Carex aquatilis*, but 6 of 79 platforms also included any of the following: *Arctophila fulva*, the Chickweed, *Stellaria humifusa*, *Salix* sp., *Eriophorum* sp. or unidentified graminoid species. The other 10% of the nests were depressions, usually in a moss hummock, with little or no vegetative material in the nest cup.

The average measurements of the nesting platforms were 43.4 ± 9.0 cm by 40.7 ± 7.8 cm (N = 84), ranging from approximately 18 to 60 cm in diameter. Nest height above water averaged 7.4 ± 3.2 cm (N = 83) and ranged from 0 to 15 cm. However, measurements were taken in mid summer when water levels had dropped several centimetres since construction of the nests in June.

FIGURE 3. Location of Red-throated Loon nests in relation to direction of prevailing wind in June at Toker Point.

Discussion

The surface area of the pond influenced which ponds were used for nesting by the Red-throated Loon at Toker Point. Most nested on ponds 0.1 to 1.0 ha in size. Selection of small waterbodies for nesting is an adaptation by the Red-throated Loon to the short open-water season of the Arctic. By nesting on fast-thawing ponds, the Red-throated Loon maximizes the amount of time available to produce young (Davis 1972). Thus, it is able to nest farther north than any other species of loon.

Two characteristics enable the Red-throated Loon to use small shallow ponds. Firstly, it obtains most of the food for its young from the sea or large freshwater lakes rather than the nesting pond (Davis 1972; Reimchen and Douglas 1984; Eriksson et al. 1990). Thus, it is able to nest on ponds which freeze to the bottom, hence contain relatively little food. Other loon species feed their young fish and invertebrates from the nesting pond (Davis 1972; Sjölander and Agren 1976; Bergman and Derksen 1977; Yonge 1981), which restricts them to nesting on waterbodies large enough to support young until they fledge. Secondly, the Red-throated Loon is able to take flight in a very small span of open water. At Toker Point, a pair of loons that occupied a nesting pond only 4 m wide and 10 m long was seen taking flight on several occasions with no apparent difficulty. The smallest nesting pond on record is one 2 m in diameter on the Shetland Islands (Furness 1983).

Competition with the Pacific Loon may also restrict the Red-throated Loon to shallow ponds at Toker Point. The Pacific Loon tended to nest on larger ponds (>2 ha) than those used by the Red-throated Loon, as has been noted in other regions where the two species coexist (Davis 1972; Bergman and Derksen 1977). However, both species used ponds 0.4 to 2.0 ha in size: 28% of the Pacific Loons, and 38% of the Red-throated Loons. At four ponds, tenancy alternated between the two species among years. Two of these ponds were the smallest ones used by Pacific Loons; the other two were the third and fourth largest ponds used by the Red-throated Loons. At seven other sites (four Red-throated Loon territories and three Pacific Loon territories), we observed frequent interspecific territorial encounters, although ownership of the territory never switched. Davis (1972) likewise reported competition between the two species for nesting territories, as well as a higher frequency of interspecific confrontations when Red-throated Loons nested on larger than average ponds.

North of the breeding range of the Pacific Loon, the Red-throated Loon nests on lakes as well as ponds, but not deep lakes (Ellesmere Island - Parmelee and MacDonald 1960; Devon Island - Hussell and Holroyd 1974; Melville Island - Maltby 1978). The short open-water season prevents the loons from using deeper waterbodies which thaw later in spring, but in the absence of Pacific Loons, the Red-throated Loon can use the larger shallow lakes.

Likewise, at the southern limits of its breeding range and in the absence of Pacific Loons, the Red-throated Loon shows no preference for a particular size of waterbody (Queen Charlotte Islands - Douglas and Reimchen 1988; Shetland Islands - reanalysis of Bundy (1976) data by Douglas and Reimchen 1988). Depth of the waterbodies in those study areas was not presented, but it is unlikely to affect use by the Red-throated Loon for nesting because of the long open-water seasons at lower latitudes.

The presence of emergent vegetation in the nesting pond may enhance chick survival. On windy days at Toker Point, chicks tended to rest in patches of emergent vegetation on the sheltered side of the pond. Likewise, when both adults were absent from the nest pond, the chicks usually remained quiet amongst emergent vegetation. If disturbed, the chicks dove into the loose material on the bottom of the pond, stirring it up so that they could not be seen. Eventually the chicks surfaced near shore, usually among emergent vegetation. These behaviours suggest that the emergent vegetation helps to protect chicks from both severe weather and predation.

Bundy (1978) noted that Red-throated Loons on Shetland, Scotland, preferred ponds sufficiently free of vegetation that the chicks could dive if disturbed. At Toker Point, this was not a restricting factor because very few ponds had more than one third cover with emergent vegetation.

Most of the ponds used for nesting by Red-throated Loons at Toker Point were at least 0.2 m deep in mid summer. Davis (1972) noted a similar minimum depth of 0.26 m for ponds used by Red-throated Loons at Hudson Bay. Loon chicks need a pond deep enough that they can dive to escape avian predators (Bundy 1978). Furthermore, many of the shallowest ponds at Toker Point shrank in size as they dried up, leaving insufficient surface area for chicks to escape from predators like the Arctic Fox, *Alopex lagopus*.

Although 40% of the ponds used for nesting at Toker Point had islands, only 18% of the nests were on islands. Elsewhere in its breeding range, the Red-throated Loon showed a stronger preference for islands: northeastern Canada (Davis 1972; Hussell and Holroyd 1974), Alaska (Bergman and Derksen 1977) and Europe (Cramp and Simmons 1977; Lokki and Eklöf 1984). Islands may offer loons greater protection against predation by land mammals (Davis 1972; Vermeer 1973; Petersen 1979). At Toker Point, islands may be less critical for protection due to the vast expanses of wetlands. Most of the nests that occurred along the shores were in sedge marshes and more than 5 m from dry ground. The Arctic Foxes we observed hunting in the wetlands usually searched the ridges of moss and drier ground, rather than wading through the sedge marsh. Thus, they would likely not find a nest built in the marsh.

Nests at Toker Point were an average of 2 m from open water. Locating the nest away from shore may reduce predation of the eggs by Parasitic Jaegers, *Stercorarius parasiticus,* which use environmental cues such as shoreline to increase feeding success (Enquist 1983). It would also protect the eggs from waves and spray during high winds, a factor which Gomersall (1986) suggested caused hatching failure on ponds >1 ha in size in Shetland.

The tendency of the loons at Toker Point to nest on the windward side of the pond also protected the eggs from waves and spray during high winds. Although most nesting ponds at Toker Point were <1 ha in size, it is a relatively windy area with very little vegetation higher than 0.5 m for protection. At nearby Tuktoyaktuk, the mean annual maximum wind speed in July is 64 kph (Atmospheric Environment Service, Edmonton). Thus, most years at Toker Point, there are winds strong enough to cause waves and spray even on small ponds. The tendency to nest on the sheltered side of points and islands has been recorded for both the Pacific Loon (Davis 1972) and the Common Loon (Vermeer 1973; Yonge 1981).

During nest initiation in June, most nests were highly visible platforms rather than concealed from view. To avoid predation of the eggs, it may be more important for the loon to be able to see in all directions from the nest than for the nest to be concealed. Firstly, the eggs are cryptic in colour, blending into the nest material, so vegetative cover to hide the eggs may be unnecessary (Bundy 1978). Secondly, if approached by a ground predator such as a fox or human, incubating loons at Toker Point usually slipped off the nest, dove quietly and resurfaced elsewhere on the pond away from the nest while the predator was still several hundred metres away. The only incident of fox predation we observed during the study occurred when a loon failed to leave the nest until the fox was very close. The fox did not appear to see the nest until the loon leapt off. Thus, a view in all directions from the nest that allows early detection of predators may help to reduce egg losses.

The program to monitor Red-throated Loons included three other study areas on the Tuktoyaktuk Peninsula, as well as an area west of the Mackenzie Delta. Most waterbodies used by nesting Red-throated Loons in these other areas were small shallow ponds, similar to those used at Toker Point. However, a few loons nested in atypical habitat: an enlarged ditch amongst high-centered polygons; an atypically deep center of a low-centered polygon; large shallow lakes up to 20 ha in size (territory usually partially separated from rest of lake by islands or a point of land); a pond on a small island in a large deep lake; an enlarged area within a creek; and brackish ponds susceptible to flooding during storms, but not affected by normal tides. Within its breeding range, the Red-throated Loon is restricted to nesting within about 8 km of either the coast or a large lake due to its reliance on large waterbodies for fish to feed its young (Douglas and Reimchen 1988; Merrie 1978). Having a wide tolerance of the type of pond it uses for nesting enables it to nest along a maximum amount of coastline, thus make use of as many feeding sites as possible. Likewise, it enables the Red-throated Loon to nest in the vicinity of larger loon species such as the Pacific Loon, but not be in direct competition for either food or a nesting territory. Nesting in a variety of habitats may also be a means of avoiding predators. An Arctic Fox or Parasitic Jaeger might learn to search for eggs where nests are most likely to occur, but would less likely check atypical habitat. Thus, reproductive failure due to predation would be lower, especially in a year of high abundance of predators.

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Water Colour as a Predictor of Local Distribution of Blanding's Turtles, *Emydoidea blandingii*, in Nova Scotia

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The distribution of *Emydoidea blandingii* in Kejimkujik National Park, Nova Scotia, closely parallels the distribution of highly (darkly) coloured acidic waters and peaty soils. Mark-recapture and radio-tracking data, as well as observations of reproductive activity, showed that turtles maintained three discrete centers of activity within the park, each associated with highly coloured rivers or streams. At most of these locations, summertime activity of turtles was concentrated near the outflow into associated lakes. Individual selection for highly coloured waters was demonstrated by home range shifts of three males from one highly coloured water body to another, involving minimum movements of 5, 8.5 and 11.5 km overland.

Key Words: Blanding's Turtle, *Emydoidea blandingii*, distribution, water chemistry, Nova Scotia.

Blanding's Turtle, *Emydoidea blandingii* (Holbrook), is a northern freshwater species with a distribution centered in the Great Lakes region (Bleakney 1958; McCoy 1973; Gilhen 1984; Herman et al. *in press*). The species' main range extends from extreme southern Quebec and Ontario south and west to central Nebraska including parts of Pennsylvania, Ohio, Michigan, Indiana, Illinois, Wisconsin, Minnesota, Iowa, Missouri, and South Dakota. The species occurs patchily and at low densities over much of this range. Distinct local populations occur further east in New York, Massachusetts, New Hampshire, Maine and Nova Scotia. The most isolated of these is confined to the vicinity of Kejimkujik National Park in southwestern Nova Scotia (Bleakney 1958; Herman et al. *in press*).

The Nova Scotia population is restricted to an inland plateau characterized by summer temperatures higher than elsewhere in the province. It is considered to be a relict from a warmer climatic period and may have been spatially isolated for several thousand years (Bleakney 1958; Gilhen 1984). The status of this population in Nova Scotia has been designated "Threatened" by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in April 1993 (Herman et al. *in press*).

The ancestral habitat of the species is believed to have been prairie marsh (Cahn 1937; Smith 1961), but modern macro-habitats vary, and include lakes, ponds, marshes, low fields, ditches, creeks, river sloughs and bogs (see references in Herman et al. *in press*). Cahn (1937) suggested that the increased variety of habitat presently used by *E. blandingii* may have resulted partly from destruction of habitat in its primary range. Despite this variety of macro-habitats, in most populations the species is associated with shallow, vegetated water (Conant 1938; Pope 1949; Carr 1952; Adams and Clark 1958; Ernst and Barbour 1972; Gilhen 1984; Kofron and Schreiber 1985), often with deep organic sediments (Ernst and Barbour 1972; Graham and Doyle 1979; Ross 1989; Ross and Anderson 1990).

As part of a study initiated by Environment Canada–Canadian Parks Service to determine the status of the Blanding's Turtle population in Nova Scotia, we examined physical and chemical habitat parameters associated with individual turtle captures. In this paper we examine the possible link between distribution and movements of turtles and distribution of highly (darkly) coloured acid waters in the Park.

Methods

An intensive mark-recapture and radio-tracking project was begun in the Park in 1987 (Power 1989). Lakeshore and riverine habitats throughout the park were sampled visually for hand-collection of turtles in 1987 and 1988 (approximately 1600 km by canoe, approximately 400 km on foot, approximately 2700 person hours). Additionally, habitats traditionally used by turtles (based on data of previous observers) were sampled with basking traps (MacCulloch and Gordon 1978) and baited hoop traps. As well, during waterfowl surveys of all water bodies in the Park during May and June 1988 (approximately 300 person hours) and 1989 (approximately 540 person hours) all observations of Blanding's Turtles were recorded. All turtles were assigned a unique set of marginal scute notches (Cagle 1939), in keeping with the system previously used in the Park. Temporary numbers painted on the carapace facilitated field identification.

Eight females and seven males from three areas in which turtles appeared most abundant were outfitted with radio transmitters. In order to describe seasonal movement patterns, these animals were tracked throughout the active season. In addition, turtles were periodically monitored at their overwintering sites. Data on forty-five turtles, captured throughout the Park and individually marked but not fitted with transmitters, provided additional information on movements and activity throughout the season.

The Aquatic Resources Inventory (1970-1973) and Kejimkujik Calibrated Catchments Program (1978-present) conducted in the Park (Kerekes 1986*) have provided extensive data on spatial and temporal patterns in water chemistry, including water colour and pH (Kerekes et al. 1986*, 1988; Kerekes 1973a*,1973b*, 1986*). In addition those waterbodies most heavily used by turtles were sampled for watercolor analysis during the present study.

Results

During the study 60 individual turtles were identified. Of the 1572 total captures and recaptures, 217 were made during visual surveys and 1291 were radio locations. Sixteen sightings were made during systematic waterfowl surveys of all waterbodies in the park. The most highly coloured waters in Kejimkujik occurred in small streams and lakes draining extensive and/or peaty catchments (Figure 1, Table 1). In general, Kejimkujik Lake and its tributaries were more coloured than the headwater lakes along the southern border of the Park. Water colour within individual water bodies increased with lake levels and/or discharge rates, but water colour varied consistently among water bodies (Kerekes 1986*; Kerekes et al. 1986; Kerekes and Freedman 1988*).

Based on our observations and those of the waterfowl surveyors (including the first author), the distribution of Blanding's Turtle in the Park closely parallels the distribution of these highly coloured acidic waters (Figure 1; Tables 1 and 2). Turtles occurred on ten rivers and streams, and occupied the margins of at least four associated lakes. All of these water bodies, with the exception of Grafton Lake, exceeded 60 Hazen units (H.u.) in colour (Table 1). At most of these locations turtles moved downstream to the lake inflow area in late spring, coincident with increasing water temperature, and moved back upstream in late summer. Three concentrations were apparent: (1) combined area of Atkin's Brook and West River drainages; (2) Heber Meadow Brook; (3) a small section of upper Mersey River (Figure 1).

*Citations marked with an asterisk are unpublished documents and are listed separately following the Acknowledgements and before the Literature Cited sections.

TABLE 1. Water colour (Hazen units) and pH of waters used by Blanding's Turtle in Kejimkujik National Park, Nova Scotia.

Site[a]	Sample Date	Water Colour (H.U.)	pH[b]
1. Rogers Brook	16 VIII 88	210	–
2. Mersey River	11 VIII 88	110	5.4
3. Jeremys Bay	11 VIII 88	70	5.2
4. Heber Meadow Bk	11 VIII 88	400	–
5. West River	7 VIII 88	210	4.6
6. Atkins Brook	7 VIII 88	240	4.5
7. West River Brook #1	7 VIII 88	210	–
8. West River Brook #2	7 VIII 88	180	–
9. West R. Bay	7 VIII 88	200	–
10. Frozen Ocean L.	23 VIII 88	120	5.1
11. Inness Brook	21 VIII 88	160	–
12. Stewart Brook	21 VIII 88	200	–
13. Cannon Brook	14 VIII 88	220	–
14, Lake #28	14 VIII 88	240	5.1
15. Grafton Lake	24 VIII 88	5	6.0

[a]See Figure 1 for location of sites (by number).
[b]pH-based on data from various sampling dates.

Discussion

The three general areas of turtle concentration had previously been identified during a marking program in the park between 1969 and 1982 (Weller 1971-72*; Thexton and Mallet 1977-79*), but since observers relied on visual sightings primarily during the nesting season, the picture of turtle distribution was incomplete. In particular, early observers failed to recognize the extent to which turtles used smaller, highly coloured streams.

Some of these early observations associated turtles with water bodies that were not used outside the nesting season. Grafton Lake, which is relatively clear (Table 1), was long considered an important habitat for Blanding's Turtle (Bleakney 1958, 1963). However, most sightings at this location were of nesting females on nearby roadways or on the dam at the lake outlet (Bleakney 1958, 1963, 1976*; Thexton and Mallet 1977-79*; Weller 1971-72*). Sightings on the lake itself were limited (Dobson 1971; Brownlie, personal communication; Hope personal communication; Swain, personal communication; this study), and most were adjacent to the highly coloured inflow from Little Kempton Lake (220 H.u.; Number 16, Figure 1).

Although turtles concentrated their activity in the three areas described above, some individuals moved from one highly coloured water body, through less coloured waters, to another highly

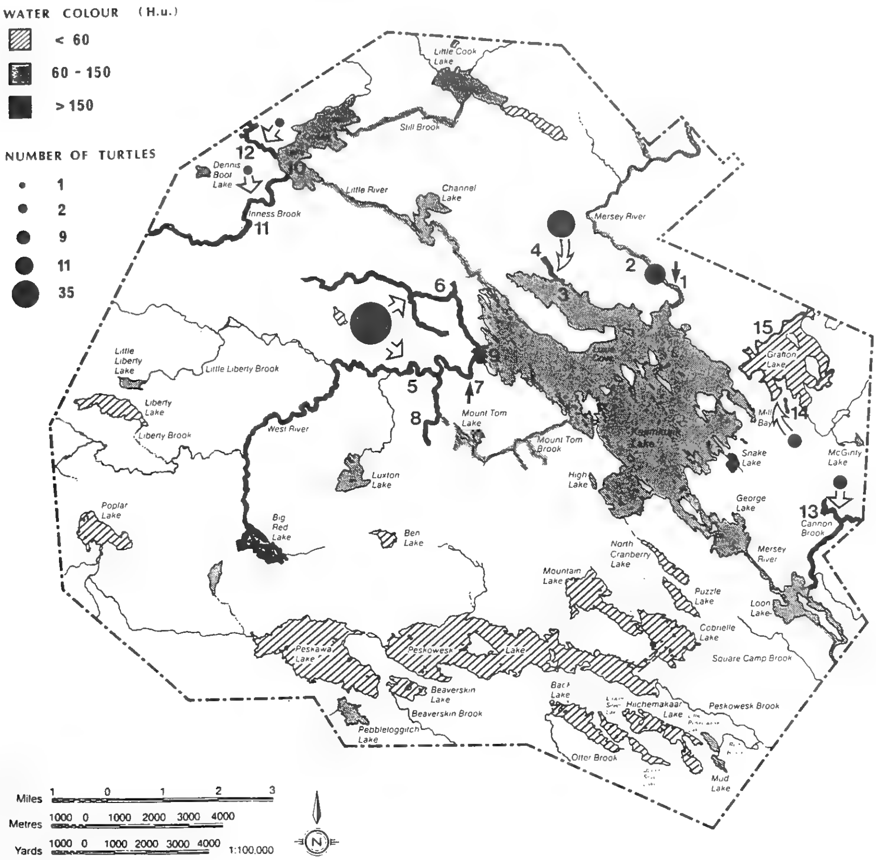

FIGURE 1. Water colour and number of individual Blanding's turtles captured (1987-1988, n = 60) in Kejimkujik National Park, Nova Scotia (see Table 1 for pH and water colour at specific capture locations (1-15)).

coloured water body. Comparison of historical records with our observations show that two males shifted their home ranges among these areas, moving minimum distances of 5 and 11.5 km over their lifetime. Such shifts may occur abruptly. In less than 14 days one radio-tagged male in our study moved a minimum of 3 km overland to establish residency (for at least one year following) in a small unnamed lake (Number 28, Figure 1) with exceptionally dark water (240 H.u.). This lake is approximately 8.5 km from the home range that he used in 1987 as well as in previous years for which there are records. These shifts, involving movements through less coloured waters, indicate active selection of areas characterized by highly coloured waters.

It is unlikely that the parallel between distribution of turtles and highly coloured waters is an artifact of biased sampling. Historical observations did not result from systematic sampling but rather were incidental to other field work. There is no indication that that work was carried out disproportionately in highly coloured waters. As well, the independently conducted survey of breeding waterfowl in 1988 and 1989 revealed no incidental sightings of *E. blandingii* in clear water bodies (Table 2). Blanding's Turtles in Maine also prefer dark waters, particularly those associated with shallow, heavily vegetated, slow-moving streams (Graham 1992).

Why are turtles associated with highly coloured waters and peaty soils in the Park? Blanding's Turtles are primarily carnivorous (Cahn 1937; Conant 1938; Lagler 1943; Carr 1952; Graham and Doyle 1977; Kofron and Schreiber 1985), and in Nova Scotia consume aquatic macro-invertebrates, tadpoles and fish (Bleakney 1963; Weller 1971-72*; this study). If the association is food-related, these areas should be characterized by high secondary productivity. Although secondary productivity in Kejimkujik is not particularly high (Schell and Kerekes 1988), Kerekes

TABLE 2. Incidental sightings of *E. blandingii* during waterfowl surveys in waterbodies of Kejimjujik National Park, grouped according to water colour.

Water colour sightings (Hazen units)	Waterbodies surveyed	Number with turtle sightings			Number of sightings		
		1988	1989	total	1988	1989	total*
<60	16	0	0	0	0	0	0
60 – 150	20	2	2	4	3	2	5
>150	10	4	2	6	6	5	11
Total	46	6	4	10	9	7	16

*Number of waterbodies surveyed vs. total number of sightings: $\chi^2 = 13.75$, $p < 0.001$

and Freedman (1989) showed that macro-invertebrate productivity is significantly greater in highly coloured waters, regardless of acidity, than in water bodies with clear water. Primary productivity is often reduced in highly coloured waters due to rapid attenuation of light, but secondary productivity may be enhanced by the input of organic materials. Allochthonous material is probably greatest on small lakes and first order streams draining organic substrates and at the inflows of these streams on larger lakes. These are precisely the areas most used by *E. blandingii* in the Park.

An analysis of soil maps for the park (Cann and Hilchey 1959; Hilchey et al. 1962; MacDougall et al. 1969) indicates that peaty soils may be even a better predictor of *E. blandingii* distribution than water colour. Within highly coloured waters turtles were concentrated in areas with peaty substrate.

Concentration of summertime activity of turtles near the lake inflows of smaller highly coloured streams is probably associated with feeding, and suggests that secondary production in these areas is relatively higher than elsewhere on the lakes. Other predators, including Painted Turtles (*Chrysemys picta*), Great Blue Herons (*Ardea herodias*), and ducks were also observed in these areas. Throughout the study area, Painted Turtles were more widespread than *E. blandingii* but showed similar patterns of relative abundance. In contrast, Snapping Turtles (*Chelydra serpentina*) may reach their highest densities in the park on clear water lakes (authors unpublished data). Although we have demonstrated an apparent association between *E. blandingii*, peaty soils and highly coloured waters, further work on production and feeding dynamics in these areas, particularly streams, is needed. Improved understanding of this association might allow us to predict the location of additional yet undiscovered populations of this species in Nova Scotia.

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Observations on Moose, *Alces alces,* Habitat and Use on Herbicide-treated Clearcuts in Maine

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I studied Moose (*Alces alces*) habitat and use on glyphosate (nitrogen-phosphonomethyl glycine) (Roundup, Monsanto, St. Louis, Missouri)-treated and untreated clearcuts in north-central Maine. Available browse plants were less abundant on 2-year post-treatment clearcuts compared with untreated clearcuts, except within areas missed during herbicide treatment. Available browse within these skipped areas was similar to that of untreated clearcuts but use was 3.8 times greater in skipped areas. Based on browse use and pellet group distribution, areas of clearcuts missed during treatment were used extensively by Moose. Leaving untreated patches of vegetation in large treated clearcuts is recommended.

Key Words: Moose, *Alces alces*, herbicides, conifer release, glyphosate.

Herbicides used in forestry can potentially affect wildlife by altering habitat (Miller et al. 1990). Herbicides, such as glyphosate, are applied to 3 to 5-yr-old clearcuts in Maine to suppress broadleaf vegetation (Sutton 1978) and hasten reforestation of coniferous trees (McCormack 1985). Consequently, application of glyphosate has the potential to affect availability and use of browse by large ungulates, such as Moose (*Alces alces*), which commonly utilize cutover areas in Maine (Leptich and Gilbert 1989).

Areas of vegetation on treated clearcuts are often unintentionally missed during aerial applications of herbicides. These areas of treated clearcuts, subsequently referred to as skip areas, provide important habitat for other wildlife, including songbirds (Santillo et al. 1989a) and small mammals (Santillo et al. 1989b), for at least three years after treatment. During extensive hours of field research conducted in 1985 and 1986 on songbirds and small mammals on clearcuts in northern Maine, Moose were regularly observed browsing during spring and summer on both treated and untreated clearcuts. Moose observed on treated clearcuts were usually browsing in skip areas. I examined relative indices of moose use and habitat of herbicide-treated clearcuts, particularly skip areas, relative to untreated clearcuts, two to three years after the application of herbicide.

Study Area

The study was conducted in north-central Piscataquis County, Maine (45°14′N, 69°14′W). Landscape was gently rolling with only slight changes in relief (i.e., 305-640 m elevation). Soils were poorly drained inceptisols developed in coarse-loamy glacial till (Rourke et al. 1978). The land, owned by Great Northern Paper Company, was a patchwork of clearcuts, strip cuts, and residual softwood and mixed-wood stands. Commercial clearcutting of Balsam Fir (*Abies balsamea*) and spruce (*Picea mariana*, *P. rubens*, and *P. glauca*) was the most common form of timber harvest. After clearcutting, areas rapidly revegetated with raspberry (*Rubus idaeus*) and early successional hardwoods; e.g. Pin Cherry (*Prunus pensylvanica*), Paper Birch (*Betula papyrifera*), Trembling Aspen (*Populus tremuloides*), and Red Maple (*Acer rubrum*). Natural and artificial spruce and fir regeneration was suppressed by competing hardwoods and herbaceous plant species.

Methods

I selected four 4-5 year-old clearcuts (31-62 ha) that were mechanically harvested from the ground up in 1978-1980 and planted with spruce seedlings within one year. Slopes were 0-5 %, and elevation ranged from 355 to 457 m. Two clearcuts were untreated controls that had been scheduled for treatment in 1985 by Great Northern, but postponed for research purposes. The other two clearcuts had been treated in August 1983 with glyphosate applied by helicopter at a rate of 4.7 L active ingredient/42.1 L water/ha.

The density and canopy height of deciduous browse plants between 0.3 m and 3.5 m in height were measured on 25 m^2 circular plots randomly located on each clearcut. Plants were placed in height categories of 0.3 - 1.0 m, 1.0 - 2.0 m, and 2 - 3.5 m, but were combined for analyses. A total of 60 plots were completed on the two untreated clearcuts and 78 on the two treated clearcuts, 41 of which were located within successfully treated portions (subsequently referred to as spray areas) and 37 of which were located within skip areas.

The number of browsed and unbrowsed deciduous twig ends of previous years growth were counted on

TABLE 1. Browse availability and use on untreated clearcuts and in skipped portions of herbicide-treated clearcuts in northern Maine.

	Total Twigs		Browsed		Unbrowsed		% Browsed	
Treatment	x	SD	x	SD	x	SD	x	SD
Control	95.1	24.1	28.1	18.9	67.0	20.1	17.1	10.3
Treated-Skip	114.0	54.8	78.2	45.7	35.9	14.6	66.5[a]	12.1

[a]More than control, $P < 0.0005$; d.f. = 24

4 m² plots to compare browse availability and use within the skip areas to untreated clearcuts. A total of 25 plots were located on the untreated clearcuts, and 25 were located within skip areas of treated clearcuts.

Pellet surveys were conducted during July on each study clearcut to compare the abundance and distribution of pellet groups on untreated and treated clearcuts. Belt transects 2 m wide and 1800 m in length were located >50 m from a forest edge, on each of the four clearcuts.

The density of available browse plants in spray areas and in skip areas was compared to that on untreated clearcuts using Analysis of Variance and Tukeys studentized t (Berenson et al. 1983). Availability of browse twigs within skip areas also was compared to that on untreated controls using t-tests; percent browse data were transformed using arcsine (Zar 1984).

Results

Vegetation on untreated clearcuts and skip areas of treated clearcuts was more complex than that of successfully treated spray areas. The density of 0.3 - 3.5 m high deciduous browse plants was 29.0 (±13.9) stems/25 m² on untreated clearcuts, and 24.3 (±10.5) stems/25 m² within skip areas. In contrast, the density of browse plants in spray areas, 3.7 (±0.5) stems/25 m², was less than that in both untreated clearcuts and skip areas ($P < 0.5$). The average canopy height of woody vegetation was 1.4 m in untreated clearcuts, 0.9 m in skip areas, and 0.4 m in spray areas.

Although the total number of available twig ends on untreated clearcuts and in skip areas did not differ ($P > 0.05$), the percent of twig ends browsed within skip areas (66.5%) was much greater ($t = 7.85$, $P < 0.0005$) than that of untreated clearcuts (17.1%) (Table 1). Browsing pressure on plants located on untreated clearcuts was heaviest between 1.0 and 2.0 m, which corresponded to the most common height of plants; 62% of plants counted fell within this height interval. Browsing pressure on plants located in skip areas was evenly distributed throughout the 0.3 - 1.0 m and 1.0 - 2.0 m sampling zones; less than 1% of the available browse plants were taller than 2 m.

A total of 52 pellet groups was counted along transects located in the untreated clearcuts, and 37 were counted along transects located in the treated clearcuts. Seventy-three percent of the pellet groups located in treated clearcuts (27 of 37) were found within skip areas, although only 15% of the total transect length traversed skipped portions of the treated clearcut.

Discussion

Habitat as characterized by the density of available browse within portions of glyphosate-treated clearcuts missed during treatment, or "skip areas," was similar to that of similar-aged untreated clearcuts. However, skip areas generally comprise only 1 to 10% of the overall area in a herbicide-treated clearcut (Santillo et al. 1989a), therefore at least a short-term reduction in overall browse available for Moose after herbicide-treatment of a clearcut is likely.

Santillo et al. (1989a) reported that treatment of clearcuts with glyphosate reduced the complexity of vegetation, including stem densities of deciduous shrubs and trees, for at least three years after treatment. In addition, cutover areas treated with herbicides have been found to have less browse available for large herbivores than untreated cutover land for two to five years after treatment (Kennedy 1986; Conner and McMillan 1988; Jordan et al. 1988), and relatively more browse than untreated areas after >10-years post-treatment when untreated deciduous trees and shrubs grow beyond reach of ungulates (Newton et al. 1989).

The high percentage of available twig ends browsed within skip areas indicated a relatively high intensity of use by Moose. I found that few deciduous trees and shrubs within skip areas were taller than 2 m, primarily due to repeated browsing of terminal leaders and subsequent bushing out of plants. Browsing pressure within skip areas may be intense enough to provide some degree of "natural brush control" to complement the chemical control in successfully treated portions of clearcuts.

Consequently, leaving planned skip areas may not result in a significant reduction in the efficacy of an overall herbicide treatment. Moose "aid" of silviculture was also reported by Krefting (1974) who observed extensive areas of Isle Royale where high Moose densities suppressed upland hardwoods such that few exceed 6 ft.

Although there is no proven direct correlation between Moose habitat use and pellet abundance, the abundance and distribution of Moose pellet groups indicated that fewer Moose used herbicide-treated clearcuts, and those that did spent more time in skip areas. I found that most pellet groups in herbicide-treated clearcuts were located in skip areas. An indication that herbicide application reduced Moose use of plantations was also reported by Conner and McMillan (1988) who found 75% more pellet groups on untreated plantations in Ontario than on areas treated two years before with glyphosate.

Herbicide applications for conifer release are typically applied to clearcuts in Maine three to five years after cutting (McCormack 1986). The extent to which Moose depend on skip areas will depend on the amount of cut vs uncut land and herbicide treatment schedule within a Moose range. On a local level, the percentage of harvested forestland that is treated can be large. For example, there were a total of 19 748 ha of forested land in the two townships in which study clearcuts were located. Approximately 5820 ha of forest were cut between the onset of large-scale modern logging in these townships in 1973, and 1988. Over an eight-year period between 1981 and 1988, 60.4% of this cutover land was treated with herbicides (L. Feero, personal communication).

Management Implications

Based on pellet group distribution and browse availability, Moose heavily utilized those areas of herbicide-treated clearcuts that had been missed by herbicide application two years earlier. These skip areas appear to be an important source of browse on clearcuts treated with herbicides in the first few years after treatment when browse is otherwise reduced. Skipped areas are accidental and the objective of herbicide application is to minimize them. However, this study suggests that there may be value in actually planning skip areas. Planned skips within areas of clearcuts with low conifer stocking, such as wet swales and disturbed areas, may ensure the presence of skip areas without reducing overall treatment efficacy.

Although my observations hold promise for providing Moose habitat following herbicide application, results from this study should be cautiously interpreted until additional investigations are completed. Numerous questions remain before management applications can be recommended. For example, do Moose overbrowse skip areas and cause their degeneration?; how long do Moose use skip areas?; how long does Moose usage keep the skip areas in productive condition?; what size skips are most apt to retain their value to Moose?; and what are the long-term consquences to the Moose population?

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Prevalence of Ingested Lead Shot in American Black Duck, *Anas rubripes,* and Ring-necked Duck, *Aythya collaris,* Gizzards from Nova Scotia and Prince Edward Island

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A sample of 591 American Black Duck, *Anas rubripes,* gizzards from Nova Scotia (N.S.) included 4.6% that contained ingested lead shot. Among those, 7.1% of 198 gizzards from Cumberland County contained shot. In Prince Edward Island (P.E.I.), 7.1% of 224 Black Duck gizzards contained ingested shot, including 11.1% of 63 from Queens Co. In N.S., 14.3% of 91 Ring-necked Ducks, *Aythya collaris,* contained ingested shot, including 13.0% of 77 from Cumberland Co. In P.E.I., 52.8% of 53 Ring-necked Duck gizzards contained ingested shot, all but three of these from Pisquid Pond, Kings Co. In certain areas, these proportions exceeded ($\alpha = 0.05$) the 5% maximum suggested by the Canadian Wildlife Service (CWS) as requiring further study, but they rarely exceeded ($\alpha = 0.05$) the 10% maximum suggested as requiring a lead shot ban. Nevertheless, lead shot ingestion by N.S. and P.E.I. waterfowl is causing mortality. Our data suggested that non-toxic shot zones for the hunting of waterfowl be established on the following areas: East Amherst Marsh and Wallace Bay National Wildlife Area, Cumberland Co., N.S.; Pisquid Pond, Kings Co., P.E.I.; and wetlands in the central area of Queens Co., P.E.I., and this recommendation has been implemented for some areas already.

Key Words: American Black Duck, *Anas rubripes,* Ring-necked Duck, *Aythya collaris,* lead shot ingestion, lead poisoning, Prince Edward Island, Nova Scotia.

Many studies have used gizzards of waterfowl from the hunter harvest to measure the extent of shot ingestion (see Bellrose 1959; Sanderson and Bellrose 1986; United States Fish and Wildlife Service, Department of the Interior 1986; for summaries). There are problems with the use of gizzard content analysis to provide an index of shot ingestion and resulting poisoning. Lead shot remain recognizable in waterfowl gizzards a maximum of 20 days, a short period relative to the concentration of lead in blood which can be detected 90 days after shot ingestion (Finley and Dieter 1978). Well-worn shot frequently are not identified by ocular examination of gizzard contents (Montalbano and Hines 1978; Anderson and Havera 1985). Lead-poisoned waterfowl also are more susceptible to being harvested (Bellrose 1959). Nevertheless, Canadian Wildlife Service (CWS) Atlantic region has identified the examination of lead shot in gizzards from hunter-harvested waterfowl as one of the most cost-effective methods of obtaining information on lead-poisoning problems. With appropriate care in interpretation, such data can be a useful aid for management decisions.

Schwab and Daury (1989) found ingested lead shot in gizzards of a substantial proportion (13%) of hunter-harvested waterfowl species prone to ingesting shot from a managed fresh-water marsh whereas a lower proportion (4.5%) from tidal salt marshes contained shot. Since those data were collected, a draft CWS policy suggests that non-toxic shot should be used for hunting ducks, geese and snipe on areas where > 10% of large dabbling ducks contain ingested shot. At this level of exposure to lead, carcasses of lead-poisoned waterfowl were readily apparent in Lake St. Clair, Ontario. With this serious problem, immediate action banning the use of lead shot for hunting ducks, geese and snipe became necessary. In addition, CWS has established > 5% of large dabbling ducks ingesting lead as the threshold, beyond which further study of lead shot ingestion problems is required. CWS Atlantic Region utilizes American Black Ducks, *Anas rubripes*, to monitor shot ingestion (CWS 1990).

The earlier study by Schwab and Daury (1989) led to further investigation of shot ingestion by waterfowl in Nova Scotia (N.S.) and Prince Edward Island (P.E.I.) by examining lead shot deposited in sediments (Daury et al. 1992) and blood lead concentrations of waterfowl (Daury et al. 1993). The objective of the study reported here was to determine the proportion of harvested waterfowl from N.S. and P.E.I. with ingested shot. In consideration of the upper maximum proportions with ingested shot, we emphasized determining the proportion of American Black Ducks containing ingested lead

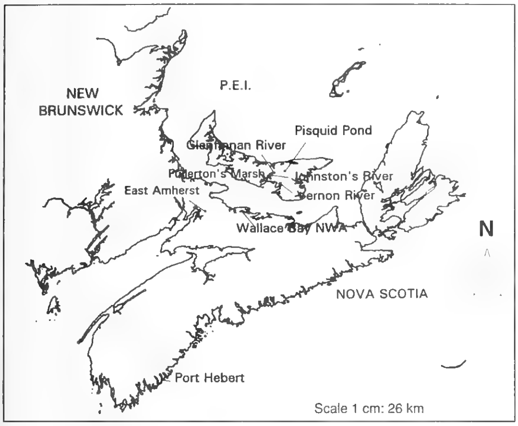

FIGURE 1. Location of various marshes in Nova Scotia and Prince Edward Island that were of interest when examining gizzards from hunter-harvested waterfowl for ingested lead shot, October 1988 through January 1991.

shot. We also considered the proportion of Ring-necked Ducks, *Aythya collaris*, containing ingested lead because that species also has a proclivity to ingest pellets.

Methods

Gizzards were collected from hunter-shot waterfowl in N.S. and P.E.I. during the 1988-1989, 1989-1990, and 1990-1991 waterfowl seasons. Sampling efforts were directed to heavily hunted marshes on the opening day of the waterfowl hunting season: East Amherst Marsh (45°50′N, 64°10′W) and Wallace Bay NWA (45°49′N, 63°31′W), Cumberland Co., N.S.; Fullerton's Marsh (46°14′N, 63°03′W) and Johnston's River (46°16′N, 63°01′W), Queens Co., P.E.I.; and Pisquid Pond (46°19′N, 62°48′W), Kings Co., P.E.I. (Figure 1). Wildlife management personnel collected the gizzard and wing of each harvested bird, and recorded the date and location of kill. Hunters also were asked to contribute to the project by submitting gizzards and wings with the date and location of kill. Samples were stored frozen.

Wings were aged and sexed according to Carney (1964). Gizzards were bisected, the appearance and colour of the lining noted, and contents of the lumen rinsed into a 7 x 14 x 21 cm white-bottomed pan. A gentle flow of water allowed decantation of most of the vegetation in the lumen. Contents remaining in the pan were examined under bright light to detect fragments of shot.

Possible fragments of shot were examined under a 25-power stereo-microscope for abrasions from grit, resulting from muscular action, and indentations from gun discharge. Shot were squeezed with forceps to confirm that they were malleable; i.e., "lead-like"; and tested with a magnet to confirm that they were lead not steel. If shot were found in the lumen, adipose and connective tissues on the exterior surface of the gizzard were removed. The

TABLE 1. Number of ingested lead shot in gizzards of waterfowl harvested in Nova Scotia and Prince Edward Island, October 1988 through January 1991.

Species	Number examined	Σ	Numbers containing various amounts of shot 1	2	3	4	5	>5
Canada Goose, *Branta candensis*	74	1	1	–	–	–	–	–
Wood Duck, *Aix sponsa*	26	0	–	–	–	–	–	–
Green-winged Teal, *Anas crecca*	727	5	5	–	–	–	–	–
American Black Duck, *Anas rubripes*	815	43	26	7	3	1	5	1
Mallard, *Anas platyrhynos*	46	3	3	–	–	–	–	–
Hybrid, *Anas rubripes* x *platyrhynchos*	25	3	2	1	–	–	–	–
Northern Pintail, *Anas acuta*	60	5	3	–	1	–	1	–
Blue-winged Teal, *Anas discors*	124	0	–	–	–	–	–	–
Northern Shoveler, *Anas clypeata*	1	0	–	–	–	–	–	–
Gadwall, *Anas strepera*	10	0	–	–	–	–	–	–
American Wigeon, *Anas americana*	60	2	2	–	–	–	–	–
Ring-necked Duck, *Aythya collaris*	144	41	14	5	3	–	4	15
Scaup, *Aythya* spp.	8	0	–	–	–	–	–	–
Common Eider, *Somateria mollissima*	1	0	–	–	–	–	–	–
Surf Scoter, *Melanitta perspicillata*	1	0	–	–	–	–	–	–
Common Goldeneye, *Bucephala clangula*	9	0	–	–	–	–	–	–
Bufflehead, *Bucephala albeola*	5	0	–	–	–	–	–	–
Merganser, *Mergus* spp.	36	0	–	–	–	–	–	–
Grand Total	2172	103	56	13	7	1	10	16

TABLE 2. Prevalence of ingested shot in gizzards of American Black Ducks and Ring-necked Ducks from Nova Scotia and Prince Edward Island, October 1988 through January 1991.

Location	No. of American Black Ducks examined	% with lead shot	No. of Ring-necked Ducks examined	% with lead shot
Annapolis County	8	0	0	–
Antigonish County	15	6.7	0	–
Cape Breton County	1	0	0	–
Colchester County	2	0	0	–
Cumberland County[1]	198	7.1	77	13.0[2]
East Amherst	70	10.0[2]	25	16.0[2]
Wallace Bay NWA	80	8.8	38	7.9
Digby County	5	20.0	0	–
Halifax County	65	1.5	1	100.0
Hants County	2	0	0	–
Kings County	6	16.7	0	–
Queens County	140	3.6	5	0
Shelburne County	40	5.0	0	–
Yarmouth County	104	1.9	8	25.0
Unkown	5	0	0	–
N.S. total	591	4.6	91	14.3[2]
Kings County[1]	21	4.8	52	53.8[3]
Pisquid Pond	1	0	50	54.0[3]
Prince County	127	3.9	1	0
Queens County[1]	63	11.1[1]	0	–
Glefinnan River	36	11.1[2]	0	–
Johnston's River	12	25.0[3]	0	–
Unknown	12	25.0	0	–
P.E.I. total	224	7.1	53	52.8[3]
Grand Total	815	5.3	144	28.5[3]

[1]includes heavily-hunted marshes within the county.
[2]%>5%, $P < 0.05$
[3]%>10%, $P < 0.05$

exterior surface and lining of the gizzard were examined for shot holes from an entry wound. If entry wounds were found and the shot lacked abrasions from grit, then that pellet was classified as embedded and was not included in the calculations for ingestion.

Tests for differences between proportions were conducted (Daniel 1977) when one proportion was the critical value of either 5 or 10%, established by CWS (1990), and the other was the proportion of waterfowl containing ingested lead shot, according to location of collection.

Results

Number of Ingested Shot

A total of 2172 gizzards from hunter-harvested waterfowl was examined. No steel shot were found. One hundred and three waterfowl (4.7%) contained ingested lead shot (hereafter shot) (Table 1). Twenty-seven shot were excluded as embedded. One Mallard (*A. platyrhynchos*) contained a copper-plated lead shot.

Fifty-six of the 103 waterfowl (54.4%) ingesting shot contained only one pellet. Twenty-six of 34 (76%) waterfowl containing ≥ 3 shot were harvested at Glenfinnan (46°17′N, 62°59′W) and Johnston's Rivers, Queens Co., and Pisquid Pond. In addition, three birds from East Amherst, one from Wallace Bay NWA, and one from Port Hebert (43°48′N, 64°56′W), Shelburne Co., N.S., contained ≥3 shot. One bird from Vernon River (46°10′N, 62°53′W), Queens Co., P.E.I. (Figure 1) and one from an unknown location in P.E.I. also ingested multiple shot. The greatest number of ingested pellets was 42, recorded for a Ring-necked Duck taken at Pisquid Pond.

Most of the waterfowl that contained more than one ingested shot were American Black Ducks and Ring-necked Ducks. Kings and Queens Cos, P.E.I., and Cumberland Co., N.S., produced the largest numbers of ducks containing multiple pellets. Ring-necked Ducks from Pisquid Pond that contained shot averaged 8.1 pellets per gizzard. Marshes where waterfowl frequently ingest several pellets are likely causing more mortality from plumbism than the frequency of birds ingesting shot would suggest because the greater the number of lead shot ingested, the greater the probability of experiencing lead poisoning or plumbism (Chasko et al. 1984).

American Black Ducks

Of 815 American Black Duck gizzards examined, 43 (5.3%) contained ingested shot (Table 2). In N.S. 4.6% (27 of 591) of these gizzards contained ingested shot. Large proportions of gizzards from the following specific areas contained ingested shot: East Amherst 10% (7 of 70), a proportion greater than 5% ($Z = 1.92$, $P = 0.03$); Wallace Bay NWA 8.8% (7 of 80); and Cumberland Co., including East Amherst and Wallace Bay NWA, 7.1% (14 of 198) ingested shot. This proportion is not significantly greatest than 5% ($Z = 1.36$, $P = 0.09$) at $\alpha = 0.05$. The prevalence of shot ingestion among American Black Ducks in N.S. was lower than reported in Maine (6.9%) and for the Atlantic Flyway (8.8%) (Sanderson and Bellrose 1986).

In P.E.I., 7.1% (16 of 224) American Black Duck gizzards contained shot. Large proportions of gizzards from the following specific areas contained shot: Glenfinnan River, 11.1% (4 of 36), a proportion greater than 5% ($Z = 1.68$, $P = 0.05$); Johnston's River, 25% (3 of 12), a proportion greater than 10% ($Z = 1.73$, $P = 0.04$); and Queens Co., including Glenfinnan and Johnston's rivers, 11% (7 of 63), a proportion greater than 5% ($Z = 2.22$, $P = 0.01$). The proportion of American Black Ducks harvested from P.E.I. containing ingested shot was greater than that of N.S., or nearby Maine (6.9%) (Sanderson and Bellrose 1986) where non-toxic shot regulations have been introduced (USFWS 1986), and slightly lower than that for the Atlantic Flyway (Sanderson and Bellrose 1986).

Ring-necked Ducks

Of the 144 Ring-necked Duck gizzards examined, 41 (28.5%) contained ingested shot (Table 2), a proportion greater than 10% ($Z = 7.40$, $P < 0.01$). In N.S., 14.3% (13 of 91) of these gizzards contained ingested shot, a proportion greater than 5% ($Z = 4.07$, $P < 0.01$). Similar to American Black Ducks, large proportions of gizzards from the following specific areas contained ingested shot: East Amherst, 16.0% (4 of 25), a proportion greater than 5% ($Z = 2.52$, $P < 0.01$); Wallace Bay NWA, 7.9% (3 of 38); and Cumberland Co., including East Amherst and Wallace Bay NWA, 13.0% (10 of 77) ingested shot, a proportion greater than 5% ($Z = 3.22$, $P < 0.01$). The prevalence of shot ingestion among Ring-necked Ducks in N.S. (14.3%) was lower than reported in Maine (20%) and the Atlantic Flyway (20%) (Sanderson and Bellrose 1986).

Almost all of the Ring-necked Duck gizzards collected in P.E.I. came from Pisquid Pond where 54.0% (27 of 50) contained ingested shot. This proportion is greater than 10% ($Z = 10.4$, $P < 0.01$). The proportion (28.5%) of Ring-necked Duck gizzards containing shot was greater than for the same species in other areas of Maine (20%) and the Atlantic Flyway (20.0%) (Sanderson and Bellrose 1986).

The following behaviour of this benthic-feeding species often results in shot ingestion. Their high protein diet may produce a higher tolerance to lead than other species because diets high in protein may mitigate the effects of lead (Sanderson and Bellrose 1986). Nevertheless, diet should not eliminate concern about detrimental effects of ingested lead in this diving duck. For example, we have recovered dead and dying Ring-necked Ducks from P.E.I. marshes which were determined, by pathologists at the Atlantic Veterinary College, to have likely died from or were suffering from lead poisoning (P.-Y. Daoust, Atlantic Veterinary College, Charlottetown, P.E.I., personal communication).

Other Species

Among other species 3 of 25 (12%) American Black Duck/Mallard hybrids (*Anas rubripes* x *A. platyrhynchos*), 2 of 60 (3.3%) American Wigeon (*A. americana*), 1 of 74 (1.4%) Canada Geese (*Branta canadensis*), 5 of 727 (0.7%) Green-winged Teal (*A. crecca*), 3 of 46 (6.5%) Mallards, and 5 of 60 (8.3%) Northern Pintails (*A. acuta*) contained ingested shot.

Discussion

Canadian proponents of non-toxic shot zones for waterfowl hunting face a dilemma. Large sample sizes are required to produce sufficient power ($1 - \beta$) to state with confidence ($\alpha < 0.05$) that a moderate proportion of waterfowl from a particular area ingesting shot is greater than 10%; for example, a sample size of 370 is required to state that 15% is greater than 10% ($\alpha = 0.05$, $\beta = 0.10$) (Cohen 1988). Gizzard collections early in the waterfowl hunting seasons have been proven to provide a conservative estimate because, in addition to the short retention time of evidence of shot ingestion, the prevalence of ingested shot increases as the hunting season progresses (Bellrose 1959). Unless a large proportion of waterfowl are ingesting lead shot, it is unlikely that a conservative index of shot ingestion will statistically exceed maximum limits, even where shot ingestion is a serious problem.

As a result of discussions stimulated partly by the present study, non-toxic shot zones for hunting ducks, geese, and snipe have been established at East Amherst, Wallace Bay NWA, and Pisquid Pond. Wetlands located in Queens Co., P.E.I., will be regulated as a non-toxic shot zone by autumn 1994. All of the Maritime Provinces of Canada will be a non-toxic shot zone for hunting ducks, geese, and snipe by autumn 1997.

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Butterflies and Skippers of Conservation Concern in British Columbia

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A preliminary assessment of the status of the butterflies and skippers of conservation concern in the province of British Columbia, Canada is provided. A conservation status is suggested for each species and subspecies using criteria modeled after those of the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and The Nature Conservancy (United States), with the assessments being solely the authors' responsibility. There are a total of 266 species and subspecies of butterflies and skippers known from British Columbia. Of these, 52 species and subspecies (20%) are of conservation concern within British Columbia. Twenty-four (9%) are of conservation concern for Canada as a whole, and four (2%) are endemic to BC and therefore are of conservation concern globally. One subspecies is considered extinct, and one species and one subspecies extirpated from British Columbia. Thirty-eight species and subspecies are considered endangered, threatened, or vulnerable, and the remaining eleven are listed as 'status unknown'. These butterfly and skipper species and subspecies should be the focus of conservation efforts in British Columbia.

Key Words: Lepidoptera, Hesperiidae, Papilionidae, Pieridae, Nymphalidae, Lycaenidae, Satyridae, Riodinidae, butterfly, skipper, conservation, endangered, British Columbia, Canada.

There are 176 species and an additional 90 subspecies of butterflies known to occur in British Columbia (Guppy and Shepard 1994, with two additional species). There is no recognition of butterflies under either Canadian federal law or British Columbian provincial law, as is the case for most other invertebrates. As a result there is no legislation under which butterfly species threatened with extirpation or extinction can be protected.

There is, however, a growing public interest in the conservation of butterflies and hence a need for information on the status of each species. Status reports have been completed in Ontario for two butterflies, the Karner Blue and the Frosted Elfin (Irene Bowman, personal communication). The Nature Conservancy (United States) has completed global status rankings for all North American butterflies (unpublished database), and they are provided in Table 2 for the species discussed in this paper. Holmes et al (1991) used the classification system of The Nature Conservancy to suggest provincial rankings for all the butterfly species in Ontario. Other status assessments are being worked on across Canada, with varying degrees of authority. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC), which designates species and subspecies at risk nationally in Canada on the basis of individual status reports, has only considered vertebrate animals and vascular plants to date (Anonymous 1991a). No invertebrates have yet been designated, although consideration is being given to including them in future.

In this paper we list and briefly discuss the species of butterflies in British Columbia (abbreviated as 'BC') which we believe are of conservation concern. In doing so we hope to provide a focus for research and for efforts to preserve the habitats which support the butterfly populations. We believe that habitat destruction or alteration is the primary reason for the inclusion of most of the butterflies on this list. In most cases the butterfly species of concern are at the edges of their ranges in BC, and therefore have never had large or widespread populations in this province. The butterflies of the greatest conservation concern occur in four areas of the province (Guppy and Shepard 1994):

1. the south coast, especially southeastern Vancouver Island;
2. the southern interior, especially the southern Okanagan Valley and the adjacent Similkameen Valley;
3. the southeast Kootenays; and
4. the Peace River Lowlands, especially the Peace River canyon.

In all four areas increasing urbanization, industrialization, resource extraction, grazing, and agriculture are resulting in rapid degradation and destruction of the natural habitats.

It is important to note that general butterfly collecting, which is not extensive in BC, at present has little or no effect on the province's butterfly populations. However, commercial collecting (collecting primarily for financial gain) can be damaging to local populations of rare species because of the attendant heavy collecting pressure. The species most sought after for commercial gain frequently have only a few populations, which in turn may also have small numbers of individuals, and hence are prone to extirpation. In the alpine areas of Pink Mountain, northwest of Fort St. John, the combined effects of hobby, scientific, and especially commercial collecting apparently have severely depressed populations of some butterfly species.

In this paper we use, with slight modifications, the terms and criteria of the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and The Nature Conservancy (United States) for suggesting the status of a species or subspecies, but we strongly emphasize that these designations are strictly our opinions. They are preliminary designations which are the best that can be arrived at given the current level of our knowledge. This paper is intended to allow resources, as they become available, to be focused on examining the status of the species in greatest need of conservation.

Methods

One of us (Jon H. Shepard) has spent several decades compiling a file card catalogue of data for butterflies and skippers collected in BC, as well as drafting unpublished distribution maps, from museum specimens and the collections of private individuals. Data from all public and private collections which have a significant number of butterfly specimens from British Columbia are included in the catalogue. In addition we have extensive personal collections, as well as knowledge resulting from many decades of collecting butterflies throughout northwestern North America. Common and scientific names follow Miller (1992) except where otherwise noted.

The possible status of the butterflies and skippers of British Columbia is suggested at the provincial and national levels using slightly modified COSEWIC and Nature Conservancy criteria. National assessments are provided only for species or subspecies whose entire, or nearly entire range is within BC. Global assessments are provided for the four subspecies which are endemic to BC.

COSEWIC System

The COSEWIC classification system used (Anonymous 1991a), as modified to apply to butterflies and skippers in BC, is:

EXTINCT: Any species or subspecies formerly indigenous to BC, which no longer exists anywhere in the world.

EXTIRPATED: Any indigenous species or subspecies no longer known to exist in BC, but existing elsewhere.

ENDANGERED: Any indigenous species or subspecies that is threatened with imminent extirpation or extinction throughout all or a significant portion of its range in BC.

THREATENED: Any indigenous species or subspecies that is likely to become endangered in BC if the factors affecting its vulnerability do not become reversed.

VULNERABLE: Any indigenous species or subspecies that is particularly at risk in BC because of low numbers of populations, occurrence at the fringe of its range, or in restricted areas, or for some other reason, but is not a threatened species.

Nature Conservancy System

For each species or subspecies a status is also suggested based on a modified form of the classification system of The Nature Conservancy (United States) (Anonymous 1991b). The "Global" rankings are from the Nature Conservancy (British Columbia) database as of May 1993, the "National" and "Provincial" rankings are suggested by the present authors. Each species is ranked at three geographic levels (G, N or S), and the status of a species is indicated on a scale of one to five or with a letter code. We can only estimate the number of occurrences (populations) for each butterfly species; further study is needed to define the abundances more rigorously. A rank of 4 or 5 indicates that the species or subspecies is not currently at risk within the indicated geographic level.

G - the status of a species throughout its entire ("Global") range. This is followed by a global ranking for the listed subspecies.

N - the status of a species throughout its Canadian ("National") range. The ranking is given only for the listed subspecies, without a ranking for the species as a whole in Canada.

S - the status of a species throughout its British Columbian ("Subnational") range. The ranking is given only for the listed subspecies, without a ranking for the species as a whole in BC.

1 - Critically imperiled because of extreme rarity (5 or fewer occurrences or very few remaining individuals) or because some factor(s) making it especially vulnerable to extirpation or extinction.

2 - Imperiled because of rarity (typically 6-20 occurrences or few remaining individuals) or because of some factor(s) making it vulnerable to extirpation or extinction.

3 - Rare or uncommon (typically 21-100 occurrences); may be susceptible to large-scale disturbances; e.g. may have lost extensive peripheral populations.

4 - Frequent to common (greater than 100 occurrences); apparently secure but may have a restricted distribution; or there may be perceived future threats.

5 - Common to very common; demonstrably secure and essentially ineradicable under present conditions.

X - Apparently extinct or extirpated, without the expectation that it will be rediscovered.

U - Status uncertain, often because of low search effort or cryptic nature of the species; uncertainty spans a range of 4 or 5 ranks (less uncertainty is specified by giving a range of ranks).

? - No information available or the number of extant occurrences is unreliably estimated.

T - a qualifier which indicates that a rank is associated with a subspecies.

Q - A qualifier which indicates that the taxonomic validity of the species or subspecies is not clear or is in question.

Six other ranks (Z, H, R, RF, A, E) and two other letter qualifiers of rank (B, N) are available, but are not used in this report.

Results and Discussion

In the following discussion we refer only to the modified COSEWIC-type rankings to maintain brevity (see also Table 2). The Nature Conservancy rankings are given in Table 2 for comparison. We discuss the species within geographic areas of BC because the butterflies of greatest conservation concern are found in comparatively small areas of BC (Guppy and Shepard 1994). The number of species at different levels of conservation concern for different areas of the province are summarized in Table 1, and the rankings for individual species (listed in taxonomic order) in Table 2.

A) The South Coast

The Garry Oak (*Quercus garryana* Douglas) forest/meadow habitats of southern Vancouver Island and the adjacent Gulf Islands in Georgia Strait are unique in Canada. Two small stands of Garry Oak occur on the mainland in the lower Fraser Valley, but apparently without most of the butterflies associated with them on Vancouver Island. These habitats have been almost completely destroyed by human activity during the past one hundred years. Garry Oaks are still common, because they are prized as ornamental trees, but most of the associated open meadows and rocky knolls have been destroyed through urbanization, industrialization, agriculture or other habitat alteration. The few surviving fragments of the original habitat are greatly altered, in part through direct human "improvements", and in part through the invasion of introduced weeds such as grasses and Scotch Broom, *Cytisus scoparius* (L.). The best example of the original habitats were downtown Victoria and Beacon Hill Park, but human "improvements" have eliminated all but a few common species of butterflies from the park and the city itself has almost none. The natural history (including butterflies) of the Garry Oak forest/meadow habitats is summarized by many authors in Hebda and Aitkens (1993).

Southern Vancouver Island was home to an undescribed subspecies of Large Marble, *Euchloe ausonides* (L.). It is apparently extinct, although there is a very small chance an undiscovered population may exist on one of the islands in the Gulf of Georgia. Thirteen specimens are known to exist in museums around the world, the last of which was collected in 1908 on Gabriola Island. The known world distribution of the Vancouver Island subspecies consisted of three populations on Vancouver Island and the adjacent Gabriola Island. Other subspecies of Large Marble are widespread in western North America, from Alaska south to California east of the coastal mountain ranges.

At low elevations on southern Vancouver Island, both in the Garry Oak meadows and the dry Douglas Fir (*Pseudotsuga menziesii* (Mirbel) Franco) forest meadows, are eight other butterfly subspecies of conservation concern. One of them, a subspecies of Chalcedon Checkerspot, *Euphydryas chalcedona perdiccas* (Edwards), has apparently been extirpated from Canada. Of the only two populations known historically, the one formerly present on Mt. Finlayson (north of Victoria) has definitely been extirpated. The exact location of the population formerly present on Mt. Tsuhalem (east of Duncan) is unknown, but it has probably also been extirpated. Richard Guppy collected the area in the 1970s, and Crispin Guppy in the 1980s, without finding any checkerspots.

A subspecies of Edith's Checkerspot, *Euphydryas editha taylori* (Edwards), is apparently endangered in Canada, with only two known extant populations. A population on Vancouver Island between Mill Bay and Shawnigan Lake is in a powerline right-of-way, and could be extirpated through use of pesticides, herbicides, or land clearing at any time. The other small population is along the shore in Helliwell Provincial Park on Hornby Island in Georgia Strait; its habitat is reasonably secure unless future park development occurs. Also, opossums have become established on the island and could become a significant predator on the overwintering larvae. Curious members of the public occasionally take adults and caterpillars from this population (in violation of the requirement to have a collecting permit from the Regional Director of Parks) to the Forestry Canada centre in Victoria for identification (R. Duncan, personal communication). Many populations were known historically from the Saanich Peninsula, but all appear to have been extirpated through urban and agricultural development. This species is notorious for its population fluctuations and any population could easily become extirpated without human intervention.

Barry's Hairstreak, *Mitoura barryi acuminata* K. Johnson, is apparently endangered in Canada, with the two known Canadian populations on Vancouver Island. A healthy population at Yellow Point (near Ladysmith) is in a small private nature resort, and hence unprotected in the long term. The other population or group of populations has a very low population density and is scattered sporadically along the

TABLE 1. Summary of the suggested "provincial" status of British Columbia butterflies and skippers. The number of species and subspecies of conservation concern in different regions of British Columbia. Regions not listed lack species and subspecies of provincial level conservation concern, although they may be of local interest. This table is updated from Guppy and Shepard (1994).

Suggested Status in British Columbia		Regions of British Columbia					All Regions	
		South Coast & Cascades	Okanagan Similkameen	Kootenays & Rockies	Peace River Lowland	Montane Northern B.C.	Total	Grand Total
Extinct	Species						0	1
	Subspecies	1					1	
Extirpated	Species		1				1	2
	Subspecies	1					1	
Endangered	Species	2	3	1			6	10
	Subspecies	4					4	
Threatened	Species		2		4		6	9
	Subspecies		1		2		3	
Vulnerable	Species	2	4	3		2	11	19
	Subspecies	2		1	4	1	8	
Status Unknown	Species			3		5	8	11
	Subspecies			1		2	3	
Total	Species	4	10	7	4	7	32	52
	Subspecies	8	1	2	6	3	20	
Grand Total	Species & Subspecies	12	11	9	10	1	52	

eastern sea edge of the Saanich Peninsula, with urbanization rapidly decreasing the suitable habitat. There is a very old historical record from Esquimault, which may represent a still extant population. A small number of other populations probably exist, scattered along the coast of Vancouver Island and the Gulf Islands. The larval foodplant is Rocky Mountain Juniper, *Juniperus scopulorum* Sarg., which was always uncommon around Vancouver Island. Residential developments are clearing the juniper from ocean side areas (the primary habitat) in order to open up ocean views.

There are no known extant populations of a subspecies of Zerene Fritillary (*Speyeria zerene bremneri* (W. H. Edwards)) or a subspecies of Greenish Blue (*Plebejus saepiolus insulanus* (Blackmore)), and only two known populations (near Nanaimo and Shawnigan Lake) of a subspecies of Icarioides Blue (*Icaricia icariodes blackmorei* Barnes & McDunnough) in Canada. We do not consider the first two subspecies to be extirpated, because it is likely that a few populations still exist but are unrecorded because of lack of recent collecting. Historically the ranges of all three subspecies were restricted to southern Vancouver Island, and we consider all three subspecies to be presently endangered in Canada. The world distribution of these subspecies of Greenish Blue and Icariodes Blue is southern Vancouver Island, hence we consider them endangered globally.

The nominate subspecies of Moss's Elfin, *Incisalia mossii mossii* (Hy. Edwards), is apparently vulnerable. Populations outside the parks and ecological reserves are likely to be destroyed or greatly reduced by urbanization over the next few decades because the rock knolls and seashore cliffs inhabited by Moss's Elfins are prime residential building sites. Most municipal and regional parks and the ecological reserves on southern Vancouver Island include populations of Moss's Elfins, therefore the species is not in immediate danger. Their world distribution is southern Vancouver Island and some of the adjacent islands in Georgia Strait, hence we consider them vulnerable globally.

A subspecies of Ringlet, *Coenonympha tullia insulana* McDunnough, is restricted to southern Vancouver Island, and is apparently vulnerable in Canada. Although the range apparently expanded in the 1950s (Shepard 1977), the number of populations is currently declining due to habitat destruction. The subspecies has two generations per year, one in May-July and one in August-October. Each generation oviposits on grass, and the larvae require green grass for food. Hence Ringlets can only exist in areas which are damp enough to maintain green grass throughout the driest period of the summer, and yet do not flood excessively in the winter. Such areas became more common due to land clearing, but are now becoming overgrown by brush and trees or destroyed through urbanization.

The next three species discussed occur both on Vancouver Island and in the adjacent Lower Fraser Valley or Fraser Canyon. However, the wider range does not make them of lesser conservation concern than those restricted to southern Vancouver Island. The human population of Greater Vancouver has passed 1.6 million, and is still growing rapidly. There is little left of the original habitats of the Lower Fraser Valley, except for parts of the surrounding mountains, most of which have been logged at least once.

Johnson's Hairstreak, *Mitoura johnsoni* (Skinner), is apparently endangered in Canada. The historical range included southern Vancouver Island, Greater Vancouver, and the vicinity of Hope. Extant populations are known only from the Greater Vancouver area (Stanley Park, Lynn Canyon Park, Pacific Spirit Park, and the UBC Haney Research Forest). This area is subject to high human activity, especially clearcut logging and mistletoe (the larval foodplant) control. The first two of the four populations were included in the area sprayed with pesticides to control Gypsy Moth (*Lymantria dispar* (L.)) in 1992, and there is a mistletoe control program in Stanley Park. The fate of those populations is unknown because of lack of monitoring, but similar and other human activity is likely to accelerate over the next few decades due to expanding population and economic pressures.

The Dun Skipper, *Euphyes vestris metacomet* (Harris), is apparently vulnerable in BC, although not in Canada as a whole. The subspecies occurs throughout much of North America from southern Canada southward, but in BC there are only a few known populations on southern Vancouver Island and in the Fraser Canyon. They may actually be "threatened", but their current status is too poorly known to assign that status given their relatively large historical range and the difficulties in sampling this species. They generally have low population densities and are difficult to see and capture due to their rapid and erratic flight pattern.

Propertius Dusky Wings, *Erynnis propertius* (Scudder and Burgess), are apparently vulnerable in Canada, and primarily occur in the Garry Oak (the larval foodplant) areas of southern Vancouver Island and probably some of the Gulf Islands (unsampled). There are several puzzling records on the south coast of the mainland which are not in association with Garry Oak. If they represent permanent populations they are endangered in themselves. The Vancouver Island populations are still reasonably healthy, but are in areas with rapidly increasing urbanization. Propertius Dusky Wings disappear from urban areas even when the Garry Oaks are left intact. This is apparently in part because of sporadic pesticide spraying for defoliators such as Winter Moth (*Operophtera brumata* (L.)), and in part because removal of ground debris containing overwintering pupae. However, most of the regional parks and one ecological reserve on southern Vancouver Island include good stands of Garry Oak which support populations of Propertius Dusky Wings. Hence, as with Moss's Elfin, they are less likely to be extirpated than many of the other butterflies of southern Vancouver Island.

B) Cascade Mountains

Indra Swallowtails, *Papilio indra indra* Reakirt, are apparently vulnerable in Canada, where they are known only from Manning Provincial Park. Forest fires and/or park developments could threaten the population, but little is known of their distribution within the park. The relative security of the park status of the habitat results in the "vulnerable" status, rather than the "endangered" or "threatened" which would normally be expected for a species known only from one population.

C) Okanagan and Similkameen Valleys

The valley bottoms of the south Okanagan Valley, and to a lesser extent the Similkameen Valley, are undergoing rapid urban, industrial, and agricultural development. Logging and grazing are very extensive at all elevations, and residential development is moving up the sides of the Okanagan Valley due to the highest rate of population growth in the province.

Viceroys, *Limenitis archippus archippus* (Cramer), have apparently been extirpated from BC. They formerly occurred in the southern interior, and the last one was collected at Lillooet in 1930. There is a verbal report of one specimen having been reared by Fred Guertz in the "1960s" from a larva collected on Black Cottonwood (*Populus trichocarpa* T. & G.) across the railroad from Inkaneep Lodge north of Osoyoos. The information came to Jon Shepard from Dave Threatful who was told of it by Jim Grant who was told by Fred Guertz. We do not accept this report in part because of its third party nature, and in part because the closest validated record since 1940 is from the southwest corner of Okanogan County, Washington in 1961. According to T. C. Hopfinger "up to 1916 this insect [the Viceroy in Okanogan County, near Brewster, Washington State] was as common as *Basilarchia lorquini* Bdv. [= Lorquin's Admiral, *Limenitis lorquini* (Boisduval)]. About that year it began to go downhill and after 1922 I did not see a specimen till I took a female near my house in July, 1940" (T. C. Hopfinger quoted in Leighton (1946)). All the collection dates from British Columbia are from the period 1913 to 1920, except

TABLE 2. Status of the butterfly and skipper species and subspecies of conservation concern in BC.

Butterfly and Skipper Species and Subspecies	Suggested Status Based on COSEWIC Criteria	Suggested Status Based on Nature Conservancy Criteria	Known Modern Distribution in British Columbia
Skippers (Family Hesperiidae)			
Propertius Dusky Wing *Erynnis propertius* (Scudder and Burgess 1870)	VULNERABLE (BC, Canada)	G5; N3; S3	S. Vancouver Island and Gulf Islands Hope, Pemberton
Afranius Dusky Wing *Erynnis afranius* (Lintner [1876])	UNKNOWN (BC)	G5; N3N4; SU	New Aiyansh
Common Branded Skipper *Hesperia comma assiniboia* (Lyman 1892)	VULNERABLE (BC)	G5T5; N5; S2S3	Peace River Lowland
Nevada Skipper *Hesperia nevada* (Scudder 1874)	VULNERABLE (BC)	G5; N3N4; S3	Similkameen and Okanagan Valleys
Draco Skipper *Polites draco* (W. H. Edwards 1871)	VULNERABLE (BC)	G5; N4; S1S2	Atlin
Sonora Skipper *Polites sonora sonora* (Scudder 1872)	THREATENED (BC, Canada)	G5T4; N1; S1	Similkameen Valley
Dun Skipper *Euphyes vestris metacomet* (Harris 1862)	VULNERABLE (BC)	G5T5; N5; S2S3	S. Vancouver Island Fraser Canyon
Parnassians and Swallowtails (Family Papilionidae)			
Old World Swallowtail *Papilio machaon pikei* Sperling 1987	THREATENED (BC) VULNERABLE (Canada)	G4T2; N2; S2	Peace River canyon
Indra Swallowtail *Papilio indra indra* Reakirt 1866	VULNERABLE (BC, Canada)	G5T5; N1; S1	Manning Provincial Park
Whites and Sulphurs (Family Pieridae)			
Large Marble *Euchloe ausonides* (Lucas 1852) (undescribed subspecies)	EXTINCT (Globally)	G5TXQ; NX; SX	Formerly S. Vancouver Island Gabriola Island
Yukon Marble *Euchloe ogilvia* Back 1990 (see text)	UNKNOWN (BC)	G?Q; N?; S?	Atlin
Gossamer Wings (Family Lycaenidae)			
Large Copper *Gaeides xanthoides dione* (Scudder 1868)	ENDANGERED (BC)	G5T4; N4; S1	Elizabeth Lake at Cranbrook
Nivalis Copper *Epidemia nivalis browni* (dos Passos 1938)	VULNERABLE (BC, Canada)	G5T5; N2; S2	Okanagan Valley
Behr's Hairstreak *Satyrium behrii columbia* (McDunnough 1944)	ENDANGERED (BC, Canada)	G5T4; N1; S1	S. Okanagan Valley
Sooty Gossammer Wing *Satyrium fuliginosum semiluna* (Klots 1930)	ENDANGERED (BC, Canada)	G4T4; N2; S2	Anarchist Mountain Similkameen Valley
California Hairstreak *Satyrium californicum* (W.H. Edwards 1862)	THREATENED (BC, Canada)	G4T4; N2; S2	S. Okanagan Valley Similkameen, Merritt
Striped Hairstreak *Satyrium liparops fletcheri* (Michener & dos Passos 1942)	THREATENED (BC)	G5T4; N4; S1	Peace River Canyon
Immaculate Green Hairstreak *Callophrys affinis washingtonia* (Clench 1944)	VULNERABLE (BC, Canada)	G4T4; N2N3; S2 S3	Okanagan Valley
Johnson's Hairstreak *Mitoura johnsoni* (Skinner 1904)	ENDANGERED (BC, Canada)	G3; N1N2; S1S2	Greater Vancouver
Barry's Hairstreak *Mitoura barryi acuminata* K. Johnson 1976	ENDANGERED (BC, Canada)	GUTUQ; N1N2; S1S2S	S. Vancouver Island
Moss's Elfin *Incisalia mossii mossii* (Hy. Edwards 1881)	VULNERABLE (Globally)	G4T3; N3; S3	S. Vancouver Island

(Continued)

TABLE 2. *Continued*

Butterfly and Skipper Species and Subspecies	Suggested Status Based on COSEWIC Criteria	Suggested Status Based on Nature Conservancy Criteria	Known Modern Distribution in British Columbia
Eastern Tailed Blue *Everes comyntas comyntas* (Godart 1824)	VULNERABLE (BC)	G5T5; N5; S1S3	southeast Kootenays
Greenish Blue *Plebejus saepiolus insulanus* Blackmore 1919	ENDANGERED (Globally)	G5T1; N1; S1	S. Vancouver Island
Icarioides Blue *Icaricia icarioides blackmorei* (Barnes and McDunnough 1919)	ENDANGERED (Globally)	G5T1; N1; S1	S. Vancouver Island
Metalmarks (Family Riodinidae)			
Mormon Metalmark *Apodemia mormo mormo* (C. and R. Felder 1859)	ENDANGERED (BC, Canada)	G5T4; N1; S1	Keremeos
Brushfoots (Family Nymphalidae)			
Great Spangled Fritillary *Speyeria cybele pseudocarpenteri* (F. & R. Chermock 1940)	THREATENED (BC)	G5T5; N5; S1	Peace River canyon
Aphrodite Fritillary *Speyeria aphrodite manitoba* (F. & R. Chermock 1940)	THREATENED (BC)	G5T5; N5; S1	Peace River canyon
Zerene Fritillary *Speyeria zerene bremneri* (W.H. Edwards 1872)	ENDANGERED (BC, Canada)	G5T4; N1; S1	S. Vancouver Island
Egleis Fritillary *Speyeria egleis* (Behr 1862) undetermined subspecies	VULNERABLE (BC, Canada)	G5T?Q; N1; S1	southeast Kootenays
Natazhati Fritillary *Clossiana natazhati nabokovi* (D. Stallings & Turner 1947)	UNKNOWN (BC, Canada)	G4T3; N3; SU	Stone Mountain Provincial Park
Alberta Fritillary *Clossiana alberta* (W.H. Edwards 1890)	UNKNOWN (BC)	G4; N4; SU	southern BC Rockies
Astarte Fritillary *Clossiana astarte distincta* (Gibson 1920)	UNKNOWN (BC)	G5T5; N5; SU	Atlin
Tawny Crescent *Phyciodes batesii* (Reakirt 1865)	THREATENED (BC)	G3G4; N3N4; S2	Peace River canyon
Gillette's Checkerspot *Euphydryas gillettii* (Barnes 1921)	VULNERABLE (BC)	G3; N2; S1S2	East Kootenays
Anicia Checkerspot *Euphydryas anicia helvia* (Scudder 1869)	VULNERABLE (BC)	G5T4; N3; S1S2	Atlin
Chalcedon Checkerspot *Euphydryas chalcedona perdiccas* (W.H. Edwards 1881)	EXTIRPATED (BC, Canada)	G5T2T3; NX; SX	formerly S. Vancouver Island
Edith's Checkerspot *Euphydryas editha taylori* (W.H. Edwards 1888)	ENDANGERED (BC, Canada)	G5T2T3; N1; S1	S. Vancouver Island Hornby Island
Viceroy *Limenitis archippus archippus* (Cramer [1776])	EXTIRPATED (BC)	G5T5; N5; SX	formerly southern Interior
Satyrs, Browns and Woodnymphs (Family Satyridae)			
Ringlet *Coenonympha tullia benjamini* McDunnough 1928	VULNERABLE (BC)	G5T4; N4; S2S3	Peace River Lowland S.E. Kootenays
Ringlet *Coenonympha tullia insulana* McDunnough 1928	VULNERABLE (BC, Canada)	G5T3T4; N3; S3	S. Vancouver Island

(Continued)

TABLE 2. *Concluded*

Butterfly and Skipper Species and Subspecies	Suggested Status Based on COSEWIC Criteria	Suggested Status Based on Nature Conservancy Criteria	Known Modern Distribution in British Columbia
Common Wood Nymph *Cercyonis pegala ino* Hall 1924	VULNERABLE (BC)	G5T5; N5; S2	Peace River Lowland
Magdalene Alpine *Erebia magdalena saxicola* Hilchie 1990	UNKNOWN (BC, Canada)	G5T2T3; N2N3; S1S3	McBride
Theano Alpine *Erebia theano alaskensis* Holland 1900	UNKNOWN (BC)	G4T4; N3; SU	Stone Mountain Provincial Park
Common Alpine *Erebia epipsodea freemani* P. Ehrlich 1954	VULNERABLE (BC)	G5T4; N4; S3	Peace River Lowland
Uhler's Arctic *Oeneis uhleri varuna* (W.H. Edwards 1882)	THREATENED (BC)	G5T4; N4; S1	Peace River canyon
Alberta Arctic *Oeneis alberta alberta* Elwes 1893	THREATENED (BC)	G4T4; N4; S1	Peace River canyon
White-veined Arctic *Oeneis taygete edwardsi* dos Passos 1949	UNKNOWN (BC, Canada)	G5T3; N3; S2	S. BC Rockies
Polixenes Arctic *Oeneis polixenes yukonensis* Gibson 1920	UNKNOWN (BC)	G5T5; N5; SU	Haines Road
Philip's Arctic *Oeneis philipi* Troubridge 1988	UNKNOWN (BC)	GUQ; NUQ; SUQ	Stone Mountain Provincial Park

for the single record from Lillooet in 1930, indicating the same pattern of decline occurred in BC as in Okanogan County, Washington. The Viceroy commonly uses cultivated apple as a larval food plant, and the decline in the species coincides with the beginning of pesticide spraying by the apple industry. This suggests that the decline and extirpation of the Viceroy in British Columbia may have resulted from the use of pesticides on apple orchards, compounded by habitat alterations of the riparian habitats of major river valleys.

Mormon Metalmarks, *Apodemia mormo mormo* (C. and R. Felder), are apparently endangered in Canada. There are two historical collection records from the south Okanagan Valley, but the only known extant population is on the outskirts of Keremeos in the Similkameen Valley. Potential urban and industrial expansion of Keremeos threatens the population. Behr's Hairstreak (*Satyrium behrii columbia* (McDunnough)) and Sooty Gossammer Wings (*Satyrium fuliginosum semiluna* (Klots)) are also apparently endangered in Canada, with their ranges confined to areas of high human activity in the southern Okanagan Valley and Similkameen Valley. There is also one old record of a Sooty Gossammer Wing from extreme southwestern Alberta.

California Hairstreaks (*Satyrium californicum* (W.H. Edwards)) and Sonora Skippers, (*Polites sonora sonora* (Scudder)) are apparently threatened in Canada, with their ranges confined to areas of high human activity in the southern interior. Sonora Skippers occur in a few populations in the Similkameen Valley, in mid-elevation forest openings. California Hairstreaks occur in the valley bottom of the southern Okanagan Valley, Similkameen Valley, and the vicinity of Merritt, all of which are subject to rapidly increasing urbanization and agriculture.

Nivalis Coppers (*Epidemia nivalis browni* (dos Passos)) and Immaculate Green Hairstreaks (*Callophyrs affinis washingtonia* (Clench)) are apparently vulnerable in Canada, with their ranges restricted to the Okanagan Valley. Nevada Skippers, *Hesperia nevada* (Scudder), are also apparently vulnerable in BC, but not in Canada as a whole. All extant BC populations of Nevada Skippers are in the Similkameen and Okanagan Valleys. The extant populations of all three species are in areas of extensive grazing, logging and urbanization.

D) East Kootenays

Large Coppers, *Gaeides xanthoides dione* (Scudder), are apparently endangered in BC, but not in Canada as a whole. Elizabeth Lake at Cranbrook has the only known population of Large Coppers in British Columbia, and it is currently at great risk due to habitat alteration around the lake.

Gillette's Checkerspot (*Euphydryas gillettii* (Barnes)) has three known populations in BC, and the Egleis Fritillary (*Speyeria egleis* ssp.) and the Eastern Tailed Blue (*Everes comyntas comyntas*

(Godart)) each have only one known population in BC. We consider these three species to be vulnerable in BC, but not in Canada as a whole. The known range of these species is restricted to the southeast Kootenays in areas currently undergoing widespread clearcut logging. We believe that they are more widespread than is indicated by the small number of known populations, because the area is very poorly collected. The subspecies of Egleis Fritillary present in BC is as yet undetermined. A subspecies of Ringlet, *Coenonympha tullia benjamini* McDunnough, is apparently vulnerable in BC, and occurs in restricted areas of the southeast Kootenays and the Peace River Lowland.

E) Southern Rocky Mountains

The status of several rarely collected butterflies in the alpine areas of the southern Rocky Mountains of BC is unknown in BC, but should be investigated to determine if they are of conservation concern. There are only two populations recorded of the Alberta Fritillary (*Clossiana alberta* (W.H. Edwards)) and only one known population of the White-veined Arctic (*Oeneis taygete edwardsi* dos Passos). Magdalene Alpines, *Erebia magdelena saxicola* Hilchie, are known from only one population near McBride. A population similar to Magdalene Alpines has also been documented in Stone Mountain Provincial Park on the Alaska Highway, but it is not clear what species or subspecies it is (J. Troubridge, personal communication).

F) Peace River Lowland

Most of the native parkland in the Peace River Lowland has been irreversibly altered by agriculture, and the Peace River canyon is subject to modification or destruction through hydroelectric dam building and grazing. There are many butterfly species which are widespread from the Peace River District of BC south and east into Alberta. The range within BC of seven of these species and subspecies is confined to the canyon of the Peace River and some tributary valleys. They are apparently threatened in BC by dam building, grazing, farming, and, in some cases, by natural succession of grasslands to shrubs and trees in the absence of wildfire. These are a subspecies of Old World Swallowtail (*Papilio machaon pikei* Sperling, probably vulnerable nationally and globally), a subspecies of Striped Hairstreak (*Satyrium liparops fletcheri* (Michener and dos Passos)), a subspecies of Great Spangled Fritillary (*Speyeria cybele pseudocarpenteri* (F. and R. Chermock)), a subspecies of Aphrodite Fritillary (*Speyeria aphrodite manitoba* (F. and R. Chermock)), Tawny Crescents (*Phyciodes batesii* (Reakirt)), a subspecies of Uhler's Arctic (*Oeneis uhleri varuna* (W.H. Edwards)), and the nominate subspecies of Alberta Arctic (*Oeneis alberta alberta* Elwes).

Another four species and subspecies are not completely confined to the Peace River canyon, but are apparently vulnerable in BC because most of the natural grassland habitat of the Peace River Lowland has been irreversibly altered by farming, leaving the fragmented remaining populations vulnerable to extinction with little opportunity for recolonization. These species are a subspecies of Common Branded Skipper (*Hesperia comma assiniboia* (Lyman)), a subspecies of Common Wood Nymph (*Cercyonis pegala ino* Hall), a subspecies of Common Alpine (*Erebia epipsodea freemani* P. Ehrlich), and a subspecies of Ringlet (*Coenonympha tullia benjamini* McDunnough). The Ringlet subspecies also occurs in a restricted part of the Flathead region of the Kootenays, as noted above.

G) Montane Northern B.C.

The status of the Natazhati Fritillary (*Clossiana natazhati nabokovi* (D. Stallings and Turner)) and the Theano Alpine (*Erebia theano alaskensis* Holland) is unknown, but they may be vulnerable in BC. Each species has only one population known in BC, in Stone Mountain Provincial Park. Only a few other populations may occur in the mountains of northern BC, because both species have specialized habitat requirements.

Draco Skippers (*Polites draco* (W.H. Edwards)) and a subspecies of Anicia Checkerspot (*Euphydryas anicia helvia* (Scudder)) are also apparently vulnerable in BC, being known only from low elevations near Atlin. Only a small number of other populations are likely to exist in northern BC near Atlin and south of Carcross. The relatively low level of habitat degradation in the Atlin area results in the assessment of "vulnerable", rather than the "threatened" or "endangered" which would be expected in southern BC.

The status of Afranius Dusky Wings (*Erynnis afranius* (Lintner)) is unknown in BC, but they may be vulnerable. They are known from only one population near New Aiyansh in the Nass Valley, but may extend across central British Columbia. The presence of this skipper is difficult to detect because in BC its wing pattern is virtually identical to the more common Persius Dusky Wing, *Erynnis persius* (Scudder). Genitalic dissection is needed to separate the two species.

Euchloe ogilvia Back, was described by Back (1990) and its taxonomic status is unclear. We have coined the common name of "Yukon Marble", because the species was not listed by Miller (1992). The status in BC of the Yukon Marble, as well as a subspecies of Astarte Fritillary (*Clossiana astarte distincta* (Gibson)), Philip's Arctic (*Oeneis philipi* Troubridge) and Polixenes Arctics (*Oeneis polixenes yukonensis* Gibson) is unknown. Yukon Marbles are known in BC only from near Atlin, the *distincta* subspecies of Astarte Fritillary is known in BC from only one alpine population near Atlin, Philip's Arctics are known in BC only from Stone Mountain Provincial Park, and the *yukonensis* subspecies of Polixenes Arctics are known in BC from only a single population along the Haines Road. It is highly probable, but must be confirmed, that other populations of all four species exist in the alpine habitats of northern BC.

Conclusions and Recommended Conservation Priorities

There are 266 species and subspecies of butterflies known from British Columbia (Guppy and Shepard 1994, with two additional species). Of these 52 (20%) are of conservation concern within the province (Table 1), and 24 (9%) are of conservation concern within Canada because they (except one subspecies) occur only in BC in Canada (Table 2). Four subspecies (2%), of which one is extinct, are endemic to BC. Conservation efforts are too late for the one subspecies which is extinct, and the one species and one subspecies which have been extirpated. The other 49 species and subspecies can be retained as part of the fauna of the province.

We suggest the following conservation strategy:

(1) Compile a list of the locations of all known extant and historical populations of butterflies of conservation concern. [A computerized database of all available collection data for the butterflies and skippers of BC (and the rest of Canada) is currently being compiled through the efforts of a large group of lepidopterists. A visit to The Natural History Museum (London, England) to record important historical records for BC is necessary to complete the database. The database will continue to grow for many years, but once it contains all the historical records and most of the modern records it can be used for conservation purposes. The data for the butterflies and skippers of conservation concern will then need to be extracted *and interpreted*.]

(2) Identify the location of all examples of habitats in which each species or subspecies might exist, including the historical locations which are not known to have extant populations.

(3) Survey the habitats to locate as many extant populations as possible.

(4) Re-evaluate the status of each species and subspecies. With the additional survey data some species and subspecies will be recognized as being of greater or lesser conservation concern than initially thought.

(5) Protect and manage the habitats upon which the existing populations depend. This is the most critical component of the conservation strategy, but does not necessarily preclude other uses of the land such as private ownership, grazing, forestry or public park. All such activities may be possible, depending on the requirements of each species.

(6) Protect known populations from unregulated collecting.

The order of conservation priority is given by the status of each species. The greater the level of concern, the higher the priority for conservation efforts, although all of the species and subspecies should be considered at some time. In general it will be better to concentrate conservation efforts regionally, because inventories and habitat conservation will frequently be able to deal with more than one species at a time. The regions should be priorized in the order: South Coast/Okanagan-Similkameen, Kootenays and Rockies, Peace River Lowland, and Montane Northern BC. This regional priority order reflects both the number of endangered and threatened species and the rate of threat to their habitats through urbanization and industrialization. The South Coast and the Okanagan-Similkameen are equally critical, and conservation efforts in both areas must occur rapidly to be successful.

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Observed Acts of Egg Destruction, Egg Removal, and Predation on Nests of Passerine Birds at Delta Marsh, Manitoba

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I describe 13 observed acts of predation on eggs and nestlings of seven passerine bird species, witnessed from 1978 to 1992 in the forested dune ridge, Delta Marsh, Manitoba. The predators were two mammals (weasel, *Mustela* sp.; American Red Squirrel) and two birds (Black-billed Cuckoo and Common Grackle). In addition, I describe five acts of egg removal by the Brown-headed Cowbird (four by females, one by a male), one act of egg destruction and two attempts by House Wrens, two acts of egg destruction by Gray Catbirds, and single acts of egg destruction by a Red-winged Blackbird, Yellow-headed Blackbird, and Northern Oriole. I examine behaviour of the attendant adults at nests under attack, outcomes of predatory acts, i.e., partial or total destruction of clutches or broods, condition of nests after predation, and response of victimized adults, i.e., desertion or tolerance of the disturbance.

Key Words: Predators, predation events, egg destruction, egg removal, egg eating, breeding biology, nest-defense behaviour, passerines, Delta Marsh, Manitoba.

Predation is the major cause of nest failure in many studies of the breeding biology of open-cup nesting birds (e.g., Ricklefs 1969). Nevertheless, field workers seldom witness acts of predation on the contents of nests (Pettingill 1976), and the identities of the predators usually remain unknown or are only inferred. Inference of the identity of a predator after the event requires reliable documentation of the appearance of destroyed nests and their contents. In the literature on passerine birds, this information is scarce (see Major 1991), despite the fact that accurate identification of nest predators can influence conclusions drawn from nesting studies (Knight et al. 1985).

Closed-circuit television and photography (e.g., Barkley 1972; Hussell 1974; Picman 1987; Major 1991) used at nests have provided unusual instances of predation being recorded undisturbed by human presence. Cameras are usually focused only on the nests, however, and information on the responses to predators by the parents, and possibly other birds in the vicinity, generally are not recorded. Eye-witness accounts of acts of predation, even though often anecdotal and usually restricted to daylight hours, are important because they provide information on the interactions between predators and their intended victims usually not obtained from photographs.

Nesting success of passerine birds may also be reduced by acts that are behaviourally similar to those of predation but which are driven by different selective pressures. Individuals of some species destroy eggs and nestlings of conspecifics and other species (e.g., wrens) but they normally do not ingest them. This behaviour may result from aggression leading to reduced interference (Picman 1977a, b; Picman and Picman 1980; Belles-Isles 1986a; Picman and Belles-Isles 1987).

Brown-headed Cowbirds (*Molothrus ater*) sometimes remove an egg from nests they parasitize (Sealy 1992), but few workers have witnessed this (often inferred) behaviour. Studies involving closely watched nests and comparisons of clutch-sizes of parasitized versus unparasitized nests of several host species (e.g., Smith 1981; Zimmerman 1983; Sealy 1992) revealed that the cowbird's tendency to remove a host egg, and sometimes eat it (Scott et al. 1992), is part of its breeding strategy rather than a form of predation (see also Scott et al. 1992; Sealy 1992).

From 1974 to 1987, co-workers and I studied the breeding ecology of birds that nest on the forested dune ridge that separates Delta Marsh and Lake Manitoba, Manitoba. During many of these studies, empty and disrupted nests, missing and punctured eggs, and missing or partially eaten nestlings revealed that predation was a major source of egg and nestling losses in this habitat (e.g., Goossen and Sealy 1982; Briskie and Sealy 1989a; Sealy, unpublished data). In 1987 to 1992, co-workers and I conducted experimental studies of the interactions between parasitic Brown-headed Cowbirds and their hosts in and around Delta Marsh. Several projects in both phases of this work involved nest-watches to determine nestling feeding rates and nestling diets, participation of the sexes in nest building, mate guarding, and time of day of egg laying. These watches also provided opportunities to observe visits to nests by cowbirds, predators, and other egg destroyers, and the responses of attendant adults to these intruders. Overall, from 1974 to 1992 we witnessed 13 acts of predation and

13 acts of egg destruction and egg removal by 10 species of perpetrator. We observed 22 of these acts opportunistically while we searched for or inspected nests and the other four acts while we watched nests, either hidden in blinds erected 10–15 m away, or using a spotting scope or binoculars while hidden farther from the nest (details of nest-watches given by Neudorf and Sealy 1994).

We made most of the observations described in the present paper on a 3-km portion of the ridge forest (see MacKenzie 1982) that stretches westward from the Portage Diversion to Cram Creek (map in Sealy 1980) on the adjoining properties of the University of Manitoba Field Station and Portage Country Club (50°11′N, 98°19′W). Since the inception of the study in 1974, I recorded 10 nonpasserine species nesting in various years in the dune-ridge forest, and 21 to 28 passerine birds nesting each year, with many of the species nesting at extremely high densities (MacKenzie et al. 1982; Sealy, unpublished data).

Observations

Egg destruction and egg removal

Under this heading, I have included acts where there exists evidence that the primary function of the behaviour in the species is not one of predation. Consumption of egg contents on its own is not adequate evidence for predation being the primary selective force driving the behaviour. As long as eggs offer the individual a free meal, individuals should make use of them if their fitness might be increased. I also included acts of egg destruction and removal by individuals recorded here engaged in this behaviour for the first time. I considered the ingestion of nestlings to be acts of predation.

HOUSE WREN, *Troglodytes aedon*

1. At 09:20 (all times CST) on 20 May 1982, Daniel M. Guinan and I watched a House Wren as it emerged from a nest site in an electrical fixture and flew to a nearby wire where it sang for a few seconds. It then flew about 15 m to the unattended nest of an American Robin (*Turdus migratorius*) that contained four eggs. Unmolested by the robins, the wren pecked one or more eggs several times with such force that we could hear its beak striking eggs from where we stood, about 25 m away. After several seconds, the wren flew away. We examined the eggs immediately, but found that none had been damaged.

2. While watching an American Robin's nest on 20 May 1992, I recorded the female robin leaving the nest at 05:58 to forage on the ground below. At 06:02 a House Wren flew to the nest and, unmolested by the robins, pecked several times at the single egg, but left without damaging it. At 06:13 the robin settled again on the nest and laid its second egg between 08:38 and 11:01. Two more eggs were laid in the nest.

3. Paula M. Grieef saw a House Wren destroy a Cedar Waxwing's (*Bombycilla cedrorum*) egg on 8 July 1992. At 06:51 the nest contained one partially buried egg, and between 07:12 and 08:03 the female laid her second egg. By 08:05 both waxwings had left the vicinity of the nest. At 08:19 a House Wren flew to the nest and pecked twice at the eggs and then flew away. The waxwings returned at 08:27 and over the next 7–8 minutes the female stood on the edge of the nest and probed the eggs with her bill. At about 08:39 both waxwings flew out of sight with the female apparently carrying a damaged egg. The newly laid egg was gone. The nest was eventually deserted.

GRAY CATBIRD, *Dumetella carolinensis*

4. At 07:50 on 8 June 1986, Keith A. Hobson saw two Gray Catbirds fly to an Eastern Kingbird (*Tyrannus tyrannus*) nest containing four eggs, which at that moment was exposed during an incubation break. One of the catbirds perched on the rim of the nest, pecked the eggs several times, and then consumed part of one egg. The catbird then grasped a broken egg and flew, followed by the other catbird, to a perch about 20 m from the nest. Both kingbirds were perched about 40 m from the nest during the minute the catbird was at the nest, and although the kingbirds uttered alarm calls from their perches, they did not interact with the catbirds. The female kingbird returned about one minute after the catbirds left, and over the next 2–3 minutes she removed from the nest fragments of eggshells. Within a few minutes the female kingbird resumed incubating the two remaining eggs. Two young eventually fledged.

5. At 08:07 on 3 June 1987, Ronald C. Bazin experimentally introduced a real cowbird egg into an unfinished Eastern Kingbird nest. A catbird arrived at the nest at 09:31, pecked the cowbird egg but did not remove it, and then carried away some nesting material. Two minutes later, it, or another catbird, returned and took away more nesting material. The damaged cowbird egg was switched with another fresh cowbird egg at 08:35. A kingbird returned to the nest at 08:55, but soon left without ejecting the cowbird egg. At 09:06, the catbird returned again and pecked the new cowbird egg, fed on fragments of eggshell left over from the previously damaged cowbird egg, and then left. Bazin removed the second cowbird egg, leaving the nest empty. The next day the nest was slightly torn apart, and by 5 June it was abandoned.

RED-WINGED BLACKBIRD, *Agelaius phoeniceus*

6. During a one-hour nest-watch on 27 June 1985, Dawn L. Sutherland witnessed predation by an adult male Red-winged Blackbird on a clutch of Yellow Warblers (*Dendroica petechia*). Twenty-seven minutes into the watch, the female warbler left the nest and foraged about 10 m away, with the male nearby. About 10 minutes later, an adult male Red-winged

Blackbird came to the nest and consumed eggs. The warblers perched about 3 m from the nest during this time and "chipped" (Hobson et al. 1988) incessantly. After about 11 minutes, the blackbird left. Neither warbler immediately inspected the nest, but instead both remained about 10 m away from it. Two of the three eggs in the clutch were gone, and the remaining egg was punctured. The blackbird had consumed the shells and most of the eggs' contents, and the nest bowl and remaining egg were stained with albumen. The nest had been abandoned by the next day.

YELLOW-HEADED BLACKBIRD, *Xanthocephalus xanthocephalus*

7. At 06:42 on 22 June 1991, I watched two Warbling Vireos (*Vireo gilvus*) unsuccessfully defend their nest against an adult male Yellow-headed Blackbird. For at least 30 seconds, both vireos uttered alarm calls and made close passes by the blackbird, before the latter left. Less than one minute later, the Yellow-headed Blackbird, or another individual, returned, went straight to the nest, and despite persistent close passes and alarm calling by both vireos, spiked one of the eggs on the tips of its opened mandibles and flew away with it toward the marsh, pursued by both vireos. The vireos were feeding nestlings six days later, but I did not ascertain whether they eventually fledged any young.

BROWN-HEADED COWBIRD, *Molothrus ater*

8. In early June 1986, at about 09:00, Keith A. Hobson watched a female cowbird at the edge of a road eating a fresh Yellow Warbler egg and part of the shell.

9. At 09:47 on 12 June 1988, Percy N. Hébert and Wendy L. Manchur flushed a female cowbird that carried a small embryo of a Yellow Warbler away in its bill, leaving part of the shell on the edge of the road.

10. On 23 May 1991, Keith A. Hobson presented a taxidermic model of a Common Grackle at an American Robin nest that contained three robin eggs. Both adult robins had vigorously attacked the model. After a 15-minute rest period, a model female cowbird was presented, but neither robin returned to the nest, although both birds were perched about 30 m away. At 15:07, a female cowbird flew in to within 5 m of the nest, and perched on a branch overlooking the nest. A few seconds later the cowbird flew to the nest branch, walked past the model and perched on the rim of the nest. It then leaned into the nest bowl, removed one of the eggs by grasping it, and immediately carried it to the ground about 3 m from the nest where it broke open the egg and ate some of its contents. The cowbird then flew with most of the egg to a perch about 5 m from the nest where it continued to eat the contents. It then flew off leaving shell fragments behind. The entire incident took about 15 seconds, and the robins did not return or interact with the cowbird. Two days later, the nest contained only one robin egg and was deserted.

11. On 27 May 1991, I experimentally introduced a real cowbird egg into a lined but empty Yellow Warbler nest. From 28 May through 1 June one warbler egg was laid each day until the nest contained five warbler eggs plus the cowbird egg. At 08:36 on 2 June 1991, the nest contained the cowbird egg and four warbler eggs. The nest was damp and slightly dishevelled and no adult warblers were present. At 08:47, when I returned to the nest, a female cowbird flew from it carrying a warbler egg impaled on the tips of its mandibles. By 10:30 that day, the nest contained only the cowbird and three warbler eggs, and the contents stayed this way until at least 15:33 on 3 June. On 4 June, only the original cowbird egg remained, and over the next two days the nest was torn apart and the cowbird egg disappeared.

12. In 1987, Ronald C. Bazin observed a male cowbird removing an Eastern Kingbird egg from a nest. At 06:00 on 9 July, Bazin experimentally parasitized the kingbird's nest with a real cowbird egg. At 06:26 a cowbird flew to the nest after the attendant kingbird had left it 11 min. earlier. The cowbird spiked a kingbird egg, carried it to a nearby road and ate its contents, leaving most of the shell.

NORTHERN ORIOLE, *Icterus galbula*

13. At 09:40 on 15 June 1989, Ronald C. Bazin placed a real cowbird egg into a lined but empty Eastern Kingbird nest. At about 09:55, an adult male Northern Oriole landed on the edge of the nest, and during the next three minutes, in the absence of the kingbirds, pecked at the cowbird egg, and then left without consuming any of the egg's contents. When examined at 10:40, the cowbird egg contained a small hole. Bazin switched the damaged egg with another fresh cowbird egg, but this egg was gone when he checked the nest again at 14:36. The nest was inactive when checked on 24 June.

Observed acts of predation

BLACK-BILLED CUCKOO, *Coccyzus erythropthalmus*

14. At about 13:00 on 16 June 1986, James V. Briskie saw a Black-billed Cuckoo flying from a Least Flycatcher (*Empidonax mimimus*) nest carrying a flycatcher egg. Checking the nest, he found it contained only fresh albumen on the bottom of the nest bowl (it contained three eggs earlier in the day). A few pieces of eggshell were on the ground under the nest.

COMMON GRACKLE, *Quiscalus quiscula*

15. At 12:00 on 30 June 1983, I witnessed a pair of Yellow Warblers attempting to defend their nest from a male and female Common Grackle. The male grackle was perched about 1 m from the nest on the branch on which the nest was saddled; the female was perched about 2 m above and to the side of the

nest. Both warblers "chipped" and "wing-fluttered" (Hobson et al. 1988); the female warbler moved within a few centimetres of the nest, while the male warbler advanced toward the male grackle as it sidled slowly along the branch toward the nest. Upon reaching the nest, the male grackle picked up one of the 3-to 4-day-old nestlings, and flew away with it. Both warblers pursued the grackle for 30 m or so until I could no longer see them. Without removing any nestlings, the female grackle flew in the direction the male had flown moments before. Three warblers eventually fledged from the nest.

16. Keith A. Hobson observed at 06:40 on 30 June 1985 a male Common Grackle that flew to the rim of the nest of a Least Flycatcher and picked up and carried away one nestling. The flycatchers did not interact with the grackle, and it was not until about one minute after the grackle had left that a flycatcher returned to the nest. The nest had contained one egg and three young when checked on 25 June, but when checked later on 30 June after the predation was observed, it was empty.

17. At about 12:45 on 28 June 1992, the alarm calls of six Yellow Warblers, one Northern Oriole, and two Gray Catbirds drew the attention of Sharon A. Gill and D. Glen McMaster. The birds were mobbing an unsexed Common Grackle. Perched about 10 m from them, when the grackle flew off pursued by two warblers, the observers saw that it carried a nestling bird in its bill.

WEASEL, *Mustela* sp.

18. In the mid-morning of early June 1986, Elizabeth J. Hoving approached a Gray Catbird nest to measure and weigh the nestlings. When she was a few metres from the nest she heard a rustling in the vegetation nearby, and soon saw a weasel's head appear over the side of the nest farthest from her. The weasel immediately took one of the four catbird nestlings in its mouth and carried it away. The nest still contained three nestlings an hour after the event, but by the next morning it was empty.

AMERICAN RED SQUIRREL, *Tamiasciurus hudsonicus*

19. At 18:55 on 19 July 1978, I observed a Red Squirrel retreating from an Eastern Kingbird nest carrying one of the four well-developed nestlings. It carried the nestling to the ground and ran out of my sight. Both kingbirds hovered and uttered alarm calls about 2 m above the squirrel, but neither adult struck it. The three remaining young fledged.

20. At 14:45 on 18 June 1980, the alarm calls of a pair of Brown Thrashers (*Toxostoma rufum*) revealed a Red Squirrel sitting on the edge of a thrasher nest, eating a nestling. Joan L. Morgan noted that the squirrel remained there for about 5 minutes despite persistent mobbing by both thrashers, but it eventually left. Although there had been five eggs in the nest on 9 June, only one egg and one young were in the nest after the predation on 18 June. By 21 June only one nestling was present, and it eventually fledged.

21. Joan L. Morgan's attention was drawn at 17:55 on 23 June 1980 to a Western Kingbird (*T. verticalis*) nest about 12 m high. At that moment, a Red Squirrel was climbing down the nest tree, a kingbird egg in its mouth, and when the squirrel was about 2 m below the nest, both adult kingbirds mobbed it, continuing to do so, as well as uttering alarm calls, until the squirrel reached the base of the tree. There the squirrel ate the contents of the egg over the next 2 minutes before it climbed a neighbouring tree. The kingbirds again mobbed the squirrel, but it retreated to the ground and started to climb another tree several metres away. Again, it was mobbed by the kingbirds. Finally, the squirrel moved into the underbrush. Two eggs remained in the nest immediately after the predation but by the next day at least one egg had been punctured and the nest was unattended.

22. Heidi E. den Haan saw a Red Squirrel at 06:00 on 22 May 1982 sitting on the edge of an American Robin's nest, eating one of the two eggs. The squirrel stayed there for the next several minutes, despite being mobbed by both adult robins, which were vocalizing loudly. The squirrel then retreated with part of the shell, in response to den Haan's presence. The robins deserted the nest.

23. The alarm calls of a pair of Eastern Kingbirds drew Gloria C. Biermann's attention to a nest at 09:55 on 8 June 1982, in which a Red Squirrel was sitting and eating an egg. Both kingbirds mobbed the squirrel and came within a few centimetres of striking it several times until the squirrel left the nest. A few seconds later it returned and ate the remaining two eggs, before climbing down the nest tree, still mobbed by the kingbirds. The kingbirds then hovered near the nest before one of the adults perched about 2 m from it, while the other parent perched on the nest and peered into it. They then flew off, but returned within a few seconds and mobbed two Gray Catbirds that had been perched about 1 m from the nest when the events described were occurring. Although the catbirds had uttered alarm calls, they otherwise did not mob the squirrel. The nest was abandoned.

24. At 09:24 on 28 June 1982, Gloria C. Biermann watched a Red Squirrel remove one egg from a Western Kingbird nest and, sitting near the nest, consume it. No adult kingbirds were nearby at the time, but several minutes after the squirrel left the site, kingbirds uttered alarm calls. At 13:18 on the same day, a squirrel (same one?) visited the nest and ate another egg. This time, an adult kingbird attacked the squirrel, and uttered alarm calls. The squirrel climbed down the nest tree carrying the egg. The kingbird flew to the nest, perched, and peered

into it. Later that day, D. M. Guinan observed a Western Kingbird removing pieces of eggshell from the nest. Two young eventually fledged.

25. At 05:55 on 15 July 1989, Ronald C. Bazin introduced a kingbird egg into a lined but empty Eastern Kingbird nest. At 06:30, a Red Squirrel appeared at the nest, sat on its edge, and over the next three minutes ate the contents of the egg, leaving half of the shell in the otherwise undisturbed nest. The squirrel then moved out of sight and did not return before observations ceased at 06:55. Neither of the adult kingbirds was seen during the hour of observation. Bazin then added another kingbird egg to the nest and on 17 July it was still present, undamaged, in the now-abandoned nest.

26. On 10 June 1992, I watched a Red Squirrel eat the eggs in a Yellow Warbler nest. The female warbler had laid her second egg at about 04:44 and was still on the nest at 04:51 when a squirrel ran up the branch to the nest. The female, which had been sitting tightly in the nest after laying its egg, flushed when the squirrel was a few centimetres from her. The squirrel sat in the nest and ate each egg in turn, dropping the uneaten shells over the side of the nest. The first shell stuck to the side of the nest, but the second fell to the ground. The squirrel then looked underneath itself and, not finding any more eggs, moved to a perch nearby, chattered a few seconds, and then left the area. Several times when the squirrel was eating the eggs the female warbler flew within a few centimetres of it and "chipped", but the squirrel did not flinch. The male warbler was never seen. After the squirrel left, the female warbler removed several pieces of eggshell from inside the nest and picked up the piece of shell that had stuck to the edge of the nest, and dropped it below the nest. The warbler then began to forage about 2 m from the nest. The nest had been dismantled by the next day.

Suspected predators

In addition to the predators observed in action above, we suspected three other species to have destroyed the contents of nests on the study area: the Leopard Frog (*Rana pipiens*); Gapper's Red-backed Vole (*Clethrionomys gapperi*); and White-tailed Deer (*Odocoileus virginianus*).

During a two-year study of the ecology of the Leopard Frog at Delta Marsh, in the early 1970's, Susan Eddy (personal communication) removed three unidentified nestling birds from the stomach of an adult frog taken at the edge of the marsh. Although we did not attribute predation on nests to the Leopard Frog, in 1975 and 1984 frogs killed or attempted to kill birds captured in mist nets set in the ridge forest. In early August 1975, three dead Yellow Warblers and several other individuals of this species were found entangled in nets at ground level; their heads and necks were soaked and the feathers were matted. In the case of one of the dead warblers, some skin and flesh had been removed from the carcass. On 6 August, we startled a large frog holding a struggling Yellow Warbler's head in its mouth, and realized at that moment that the injured birds noted on previous days probably would have been killed if we had not checked the nets every 15–20 minutes, thus interrupting the frogs in the act of killing birds. We eliminated this "predation" by stretching the nets so that their bottom tiers were several centimetres above the ground. In 1984, two Yellow Warblers injured in the manner described above were encountered on 29 July, and we immediately re-set the nets to prevent any further mortality. Other workers have reported frogs, including Leopard Frogs, capturing and eating free-flying adult birds (e.g., Norris-Elye 1944; Gollob 1978).

On 9 June 1980, I found an American Robin nest situated 0.3 m high in a willow in which a red-backed vole had built a nest that contained four young. The vole nest consisted of *Typha* down with an entrance hole along the rim of the robin's nest. Eggshells were neither present in the nest (checked later in June when there were no voles) nor under it. Had voles depredated the egg(s), fragments of shell probably would have been present because small rodents usually do not eat all of the shell when they depredate eggs (Maxson and Oring 1978; Smith 1984).

A Yellow Warbler nest that was nearing completion on 26 June 1984, about one metre high in a Red-osier Dogwood (*Cornus stolonifera*), received its third egg on 30 June. By 5 July, the nest contained only one warbler egg and one egg of the cowbird. On this date, as I neared the nest, a red-backed vole ran from the nest down the slanted supporting stem to the ground. The next day the nest was empty, although there were fragments of eggshells in the bottom of the nest. When I visited the nest again on 21 July, a vole had built a domed nest in the cup of the warbler nest. Although voles usurped the Yellow Warbler nest under observation, the eggs may have been removed by another predator, or a cowbird (see Sealy 1992), and the warblers may have already deserted the nest before the voles took it over. Other small rodents, including voles of the genus *Clethrionomys,* have been reported or suspected of eating birds' eggs (e.g., Landry 1970, Maxson and Oring 1978; Sealy 1982), and Gapper's Red-backed Voles have been reported eating insects (Hamilton 1941).

In 1983, White-tailed Deer ate two passerine birds captured in our mist nets. On 6 June, the remains of an unidentified bird about 1.5 m high in a net suggested deer predation. The net was matted together with saliva where the bird had been entangled, but only a few wetted feathers and scutes from the tarsi were evident. None of the net strands had been broken. Deer tracks were present in the moist soil beside the net. The next day, I came upon a female White-tailed Deer at the same net eating a Mourning Warbler (*Oporornis philadelphia*). The bird was partially eaten and the net was matted in the manner observed the previous day and similar to that illustrated in a photograph in Carlson and Sloan (1975).

On 27 May 1985, I found a Yellow Warbler nest at the base of a willow along a path used by White-tailed Deer. The five-egg clutch was completed on 2 June, but by the morning of 4 June the clutch was gone. The inside of the nest was smeared with albumen, yolk and tiny pieces of eggshell, which suggested that a deer licked the clutch out of the nest. White-tailed Deer have been reported consuming a variety of animals (e.g., Olson 1932; Shaw 1963; Stone and Palmateer 1970). Carlson and Sloan (1975) and Allan (1978) reported several instances of birds entangled in mist nets being eaten, and implicated White-tailed Deer. My observations confirm the eating of mist-netted birds by White-tailed Deer.

Discussion

Predation in the ridge forest

Pettingill (1976) described 12 acts of predation on nests witnessed in Michigan over 35 years, involving some 850 student observers. He considered this number of observations to be very small compared with the high number of nests that failed each year because of predation. Pettingill concluded that most predators acted at night when people generally did not move about the area or observe nests. In the present study, we made the 26 observations of egg destruction, egg removal, and predation described over 19 years with only about 40 people involved. Perhaps we witnessed these events more often on our study area because of the high densities at which many of the species nest, both predators and prey (see MacKenzie et al. 1982; Sealy, unpublished data), and the more intensive observations.

Acts of egg destruction and egg removal

House Wren attacks on nests of other species of birds have been reported from several localities throughout North America (reviewed by Belles-Isles and Picman 1986a). The instances of this behaviour reported in the present paper add another locality, and strengthen Belles-Isles and Picman's (1986a) conclusion that egg destruction characterizes all House Wren populations. Although the wrens we observed pecking robins' eggs failed to break them, Belles-Isles and Picman (1986a) determined experimentally that House Wrens routinely broke up to robin-sized eggs, but that they seldom succeeded in breaking larger eggs. Belles-Isles and Picman (1986a) reported male wrens pecking eggs only up to the time they acquired mates, at which time they stopped. One of the wrens we saw pecking a robin's egg was unmated at the time, and it was not until 10 days later that the first egg appeared in this male's nest.

Belles-Isles and Picman (1986b) confirmed experimentally, with convincing sample sizes, that Gray Catbirds peck eggs of many species and, although they sometimes carried away the shells, the catbirds did not eat the eggs. Previously, only four or five observations had been made of catbirds destroying eggs (Pearson 1936; Bent 1948), but one of these observations (Dixon 1930) and one from the present study, revealed that catbirds occasionally do eat eggs.

The observation of a male Northern Oriole pecking an egg is the first record of this behaviour by a male of this species. Female Northern Orioles puncture and eject cowbird eggs from their nests, however, males have not been observed ejecting cowbird eggs from their nest (Rothstein 1977). Whether males totally lack rejection behaviour is an important question that remains critical to understanding the population genetics of the rejection trait (Rothstein 1975).

We have long suspected both Yellow-headed and Red-winged blackbirds to be predators on nests in the ridge community, but lacked proof until we made the observations detailed above. Periodically, massive emergences of adult midges (Diptera: Chironomidae) occur at Delta Marsh during the summer months (e.g., Busby and Sealy 1979; Guinan and Sealy 1987; Briskie and Sealy 1989b). Midges swarm above and settle on the foliage in the ridge forest. This behaviour attracts both Red-winged and Yellow-headed blackbirds, which move from their nest sites in the adjacent marsh to feed on the insects (Pohajdak 1988) or take them to their nestlings (personal observations). Foraging in mixed flocks of often hundreds of individuals, the blackbirds land in the canopy of the ridge forest and glean the insects, probably encountering nests in the process and opportunistically removing their contents. We have noticed that during these emergences the frequency of nest losses was higher, and decreased after the midges had died off and the large numbers of blackbirds no longer foraged on the ridge.

Nevertheless, the observation of the male Yellow-headed Blackbird removing an egg is the first such record for this species, although Pickett et al. (1988) suspected Yellow-headed and Red-winged blackbirds of preying on eggs of Spotted Sandpipers (*Actitis macularia*). On the other hand, single records have been reported of male Red-winged Blackbirds destroying eggs (Pessino 1968) and killing birds in mist nets (Helms 1962).

Clark and Robertson (1979) suggested that benefits accrue Yellow Warblers that nest within the response ranges of Red-winged Blackbirds and Gray Catbirds because the warblers can capitalize on the blackbirds' aggressive responses to cowbirds and predators. These authors believed this may be the main selective force that has led Yellow Warblers to nest near these species. However, the destructive behaviour of Gray Catbirds and Red-winged Blackbirds, as revealed by observations described by Belles-Isles and Picman (1986b) and in the present paper, respectively, suggest that in such a nesting relationship a previously unidentified trade-off exists between any protection gained, on the one hand, and possible nest loss by warblers, on the other. In the ridge forest, Yellow Warblers and catbirds nest at high densities (Goossen and Sealy 1982; MacKenzie et al. 1982; Sealy, unpublished data), and few Yellow Warblers there nest outside the response range of catbirds. Although warblers incur egg loss, especially during laying at nests parasitized by cowbirds (Sealy 1992), we do not know the impact of predation by catbirds on warbler nest success. Red-winged Blackbirds nest in the marsh only up to the interface between the forest and marsh, and only occasionally where Yellow Warblers can nest near them.

Acts of egg removal by cowbirds

Observers who have mentioned or illustrated the method by which female cowbirds carry eggs have indicated that they spiked them on their opened mandibles (e.g., Hann 1941; Norris 1944; Harrison 1952). Of the two observations in the present study in which the method of transport was ascertained, one female spiked the egg while the other grasped it. In the case of the removed robin's egg, the cowbird grasped the egg and carried it to the ground almost under the nest, rather than to distances greater than 10 m away (Nice 1929; Hann 1941; Olson 1943; this study; but see Earley 1991). Interestingly, the only other cowbird observed removing a robin's egg also carried it to the ground under the nest (Blincoe 1935).

The observation in the present study of a wild male cowbird removing an egg , and eating part of it, is the first such observation known to me. In fact, evidence for "interest" in nests shown by wild male cowbirds is meagre. Friedmann (1929: 295) found a piece of unidentified shell in the stomach of a male cowbird taken during the breeding season, but he thought the fragment might be from a snail. King (1979: 11–13), while studying captive breeding cowbirds, never saw males visit nests. Male cowbirds have been observed occasionally accompanying females near host nests (e.g., Laskey 1950; Mengel and Jenkinson 1970; Rothstein et al. 1984), but such observations do not even suggest that males remove eggs commonly. However, that some host species respond aggressively towards male cowbirds (Robertson and Norman 1976; Burgham and Picman 1989; Neudorf, Gill and Sealy, unpublished data; but see Folkers 1982) suggests they also recognize males as a threat to their nests.

Responses to predator-induced changes in nest contents

A predator at a nest, unless interrupted or thwarted, often takes all the eggs or young, either at one time or on successive visits in a short span of time (e.g., Pettingill 1976; Knight et al. 1985). Thus, workers often assume that predators usually destroy entire clutches or broods (e.g., Shipley 1979; Robinson 1981). Indeed, at all 12 nests at which Pettingill (1976) observed predators in action, they destroyed the entire nest contents. This led Pettingill to conclude that when predators are able to withstand the aggressive responses of the attendant adults they simply make the most of their opportunities.

Several observations of predation in the present paper revealed that clutches or broods may suffer only partial loss to predators. All acts of predation during the laying stage of the victims (including experimental nests) left nests empty or with broken eggs, and the adults that nested again must have done so in new nests. However, most nests from which completed clutches or broods suffered only partial loss were not deserted and eventually fledged young.

In another study, Sealy (1992) experimentally reduced Yellow Warbler clutches. In one group eggs were removed as they were laid, while in the other group, completed clutches were reduced abruptly a few days after incubation began. Results showed that warblers tolerated clutches reduced gradually during laying, which sometimes left nests empty, until the number of eggs destined to have made up the complete clutches had been laid, and at some of these nests single young fledged. Clutches incubated slightly when reduced generally were abandoned when more than two-thirds of their volume was removed. Although we have not experimentally reduced broods of any species, broods of Yellow Warblers were sometimes reduced naturally to one nestling and these were not abandoned (Sealy 1992). Similarly, hosts of many brood parasites often rear only the single parasitic young, their own young having been evicted from the nest or outcompeted by the parasitic nestling (e.g., Davies and Brooke 1988). In the present study, adults in all cases deserted their nests after predators removed the eggs during laying. This suggests that the likelihood of nests being deserted is related to the time in the nesting cycle that partial predation takes place (see Zwickel and Carveth 1978).

Responses to predators by nest owners

All acts of predation described in the present paper were successful, despite widely varying aggressiveness of the attendant adults, including their neighbours. Among the tyrannid flycatchers, the belligerency of Eastern Kingbirds is well known (Davis 1941). Nevertheless, observations presented here indicate both Eastern and Western kingbirds generally were passive when predators attacked their nests, and in some instances the adults were absent during the entire episodes. At only one nest of each kingbird species did the adults actually attack the predator, in both cases an American Red Squirrel. At another Eastern Kingbird nest, while a Gray Catbird ate and removed eggs, the nest owners perched nearby and called.

Nevertheless, experimental evidence suggests that aggressive nest defense by Eastern Kingbirds may be effective (Blancher and Robertson 1982), and in the ridge forest, adult kingbirds at some nests responded aggressively to the threat of predation (simulated with models), with the level of aggression increasing slightly over the course of the nesting cycle (Bazin and Sealy 1993).

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Note Added in Proof

During the field seasons of 1993 and 1994, we observed 12 additional acts of egg destruction, egg removal, and predation on nests of passerine birds at Delta Marsh. Five observations were of predation on eggs, by a Franklin's Ground Squirrel (Gray Catbird nest) and American Red Squirrels (Western Kingbird nest, three Yellow Warbler nests). Two acts of egg destruction (by Gray Catbird and Northern Oriole) were witnessed, and five observations were made of egg removal by Brown-headed Cowbirds (three by females, two by males). Except for the acts of predation by Red Squirrels, the observations are described below.

Observations of egg destruction and egg removal

GRAY CATBIRD

1. During a nest-watch on 5 June 1994, D. Glen McMaster observed a Gray Catbird destroy one of three eggs in another catbird nest. At 03:55, the female catbird, which had roosted on the nest the previous night, left the nest that contained three eggs and disappeared in the underbrush near the nest. At 03:57, a catbird landed at the edge of the nest and pecked the eggs 7–10 times. One minute later, a male catbird began singing about 20 m from the nest and then flew directly to the nest and chased away the intruding catbird. At 04:02, the male flew to a perch about 5 m from the nest where it was joined one minute later by another catbird (the female?). The second catbird went to the nest and over the next 40 seconds ate pieces of egg, putting its bill into the nest and then exhibiting "biting" motions. It did this 5–6 times. The catbird repeated this behaviour once and then flew away. At 04:17 a catbird approached the nest and within a few seconds settled into the nest in an incubation posture. Ten minutes later the catbird left the nest. The catbird had punctured one of the catbird eggs. By the next day, the nest was abandoned.

BROWN-HEADED COWBIRD

2. At 10:42 on 1 June 1993, Doug Froese watched a male Brown-headed Cowbird flush from underbrush carrying an egg impaled on the tip of its lower mandible and clasped by its upper mandible. It perched low on a branch for several seconds, and then flew out of sight carrying the egg.

3. Graham Stinson watched a male Brown-headed Cowbird, at 09:56 on 27 May 1994, land on a large branch about 8 m above the ground, about 1.5 m from an American Robin nest. Within seconds the cowbird moved down the branch to the nest, leaned into it and removed one of three robin's eggs. The cowbird immediately started to fly away with the egg but the egg fell almost directly under the nest. The cowbird immediately perched in a nearby tree but was chased away seconds later by a robin.

4. While testing a Clay-colored Sparrow (*Spizella pusilla*) nest with a predator model, at 14:22 on 31 May 1994, Paula M. Grieef recorded the return of a sparrow to the vicinity of the nest, which contained two sparrow eggs. About 10 seconds later a female Brown-headed Cowbird flew into the area and without vocalizing dropped to the ground out of sight about 0.5 m from the nest. Less than 60 seconds later the cowbird flew up carrying a sparrow egg impaled on the opened tips of her mandibles. The cowbird landed about 10 m from the nest on a road and ingested the albumen and part of the eggshell. A few seconds later, the cowbird carried the remainder of the egg farther down the road and ingested the rest of the egg. Although a sparrow was near the nest when the cowbird removed the egg, it neither uttered alarm calls nor was otherwise aggressive toward the cowbird, although it did follow the cowbird to the road. This nest was never parasitized and the sparrow completed its clutch.

5. At 09:30 on 1 June 1994, Sharon A. Gill played a female Brown-headed Cowbird vocalization near a Yellow Warbler nest. Within minutes, a female cowbird flew in and landed about 2 m from the speaker, looked around for almost 20 seconds, and then moved to a perch about 20 cm from a Northern Oriole nest. The female cowbird "chattered" (Lowther 1993) a few times and disappeared within the foliage concealing the oriole nest. At that moment, a male cowbird flew in and landed several metres from the female cowbird but the two cowbirds did not interact. The female cowbird then appeared with an oriole egg, landed on a branch near the ground, ate part of the egg, and then hopped to the ground and ingested the rest of the egg. After the egg had been ingested and the cowbird had moved away on the ground in the underbrush, a male Northern Oriole landed near the nest and sang, but did not visit the nest.

6. At 09:30 on 1 June 1994, Gerry Alderson observed a female Brown-headed Cowbird carry an egg to a road at the edge of the marsh. During the next 10 seconds, the cowbird broke the Yellow Warbler egg and ate some of the shell and contents before it was chased by three male cowbirds.

NORTHERN ORIOLE

7. At 10:45 on 16 June 1994, Gabriela Lichtenstein found a Yellow Warbler nest that contained one cowbird egg. By the time Sharon A. Gill and she returned to the nest about five minutes later, the cowbird egg had been pecked. A few minutes later, D. Glen McMaster switched the pecked cowbird egg with an artificial cowbird egg used in

experiments, and the three observers backed away from the nest and watched it. Soon the Yellow Warblers uttered "seet" calls and exhibited distraction displays (Hobson and Sealy 1989) as a male Northern Oriole approached their nest. For several seconds, the oriole pecked the artificial egg, as the nest owners vocalized and displayed nearby. After the oriole left, an examination of the artificial egg revealed several peck marks.

Act of predation

FRANKLIN'S GROUND SQUIRREL (*Spermophilus franklinii*)

8. While positioning a blind on 5 June 1994 for observations the next morning at a Gray Catbird nest, D. Glen McMaster heard something rustling in the vegetation near the nest. At 15:37 a Franklin's Ground Squirrel climbed through the vegetation and eventually entered the nest. Over the next four minutes it ate the single catbird egg, pausing every few seconds to scan the area around the nest. The squirrel left the nest at 15:48. Catbirds were neither seen nor heard during the predation event. The nest was later abandoned.

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Seasonal and Circadian Activity Patterns of Female Fishers, *Martes pennanti*, with Kits

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To assess factors that may influence reproductive success of Fishers (*Martes pennanti*), we investigated the effects of kit development and litter size on circadian pattern and levels of activity (proportion of locations classified as active) of four radio-collared females with kits in southcentral Maine during the March-June denning period in 1988, and two of these four females in 1989. Activity levels varied greatly among individuals ($P = 0.0057$). A significant interaction between circadian and developmental periods ($P = 0.025$) indicated that the circadian pattern of activity changed after young were weaned. Females caring for weaned offspring showed more diurnal activity, suggesting increased energetic costs because of foraging. The activity level during kit rearing did not increase significantly with litter size ($P > 0.08$).

Key Words: Fisher, *Martes pennanti,* activity, denning, Maine.

Female Fishers (*Martes pennanti*) can first mate when 1-year-old and exhibit delayed implantation for approximately 11 months after mating, followed by an active gestation of approximately 30 days (Eadie and Hamilton 1958; Wright and Coulter 1967). Mating occurs during late winter, which in parturient females is shortly after birth of the previous litter (Hall 1942; Wright and Coulter 1967). The female must leave the newborn offspring unattended and vulnerable to cold temperatures or other hazards while she attempts to mate. The reasons for this unlikely mating system are unclear (Powell 1982). However, Arthur and Krohn (1991) speculated that energy demands on females with kits increased during summer, presumably because of increased foraging for the weaned kits, and this precluded mating during that season. These authors assumed that activity levels indicated the relative level of energy expenditure for foraging and noted that an adult female with kits was more active during daylight hours in summer than were females without kits.

Litter size, postpartum growth of offspring, and the switch from milk to solid food for offspring are all expected to influence the energy requirements of a parturient female (Gittleman and Thompson 1988). Powell and Leonard (1983) estimated that the total energy expenditure of a wild female Fisher in Manitoba increased during kit rearing (13 April-26 May). Because the estimated expenditure for lactation remained relatively constant (35-45% of total), they inferred that the increase in total expenditure was due to obtaining food for the growing kits. Although the amount of energy put into milk production *versus* other lactation costs is difficult to partition (Gittleman and Thompson 1988), patterns in the amount of time a female spends foraging for lactation and to feed the growing kits should be detectable by sampling activity levels of the female.

Additional evidence suggesting an increase in energy expenditure during spring was found by Leonard (1980) and Paragi (1990), who reported that radio-collared adult females with young spent more time away from their natal dens as the denning season progressed. Similarly, Kelly (1977) observed that distances between daily locations of adult females increased through spring and summer, and a female with young increased the size of her home range in June, at about the time of weaning.

During an intensive radiotelemetry study of Fishers in southcentral Maine, we noted that fewer young were produced than expected based on ovulation rates of adult females (Arthur and Krohn 1991; Paragi 1990; Shea et al. 1985). To assess factors that may influence the reproductive success of Fishers (i.e., kit survival until breeding age), we estimated the activity levels of females with kits during spring and early summer of 1988 and 1989. Our objectives were to characterize the diurnal pattern of activity and test the hypothesis that the circadian pattern of activity level for parturient females is influenced by litter size or stage of kit development.

Methods

The study area encompassed ca. 500 km² near Brooks and Monroe in Waldo County, Maine

(44°30′N, 69°05′ W); it was described in detail by Arthur et al. (1989b). This coastal region consisted of rolling hills to 370 m covered primarily by mixed forests interspersed with small farms, pastures, and farmland reverting to forest. Upland forests were characterized by Trembling Aspen (*Populus tremuloides*), White Pine (*Pinus strobus*), oaks (*Quercus* spp.), maples (*Acer* spp.), and birches (*Betula* spp.), while lowlands had Balsam Fir (*Abies balsamea*), Red Spruce (*Picea rubens*), Black Spruce (*P. mariana*), and Larch (*Larix laricina*). Temperature ranged from a mean low of –9°C in January to a mean high of 20°C in July, and annual precipitation was ca. 90 cm (U.S. Weather Bureau 1982).

Fishers were captured and fitted with radio collars according to procedures described by Arthur (1988) and Paragi (1990). Age of captured Fishers was estimated by counting cementum annuli of a first premolar (Arthur et al. 1992; Strickland et al. 1982). Radio-collared Fishers were located using 2-element Yagi antennas from small aircraft or by triangulation on the ground (Arthur et al. 1989a; Paragi 1990). We attempted to locate adult females daily from late February to mid-June to determine if they consistently rested in the same hollow trees (natal dens). Location of these dens was verified by quietly approaching and circling the den to confirm the source of the transmitter signal. Denning was estimated to have started on the first day that triangulations were <100 m from a later-confirmed den (triangulation error was <175 m; Paragi 1990). We usually visited dens on the third consecutive day that triangulations indicated a similar location. We assumed kits were born on the date the initial den was established. Initial and subsequent dens were visited every 2–4 days, and kits were counted and examined at 5–8 weeks of age when the female was away from the den. We estimated that natal denning ended when a female stopped using any single resting site for >2 consecutive days.

Activity patterns of four adult females with kits were monitored from 30 March to 28 June 1988. Two of the four females from 1988 were also monitored in 1989. We divided the 12 weeks into periods of nursing (30 March-14 May) and weaning (15 May-28 June) based on kit development (teeth erupting and eyes opening by mid-May) and their end of dependence on milk at 8–10 weeks of age (Coulter 1966; Powell 1982). The circadian cycle was divided into four periods: dawn (2 h prior to sunrise until sunrise), day (0900-1500 h), dusk (sunset until 2 h after sunset), and night (2100-0300 h or between dusk and dawn); sunrise and sunset times were determined by averaging times for Augusta and Old Town, Maine (U.S. Naval Observatory, Nautical Almanac). We chose fixed time lengths for circadian periods to standardize sampling as day length changed from 12.5 h to 15.5 h. The 2-h period at dawn and dusk was the minimum necessary for finding all four females during each sampling bout.

We sampled once per week during dawn and dusk and three times per week during day and night to make activity sampling proportional to length of circadian periods. Each female was monitored for all periods each week during the 12 weeks; thus, distribution of activity samples was the same for all females. The order in which females were sampled within a period was systematically changed with each sampling bout. Sampling was by triangulation, and each of three or more readings obtained within 30 min was monitored for >2 min to discern signal characteristics (cf. Lindzey and Meslow 1977). We classified Fishers as active when tone and audible amplitude of most (>50%) of the readings showed strong variation, indicating transmitter movement (Kelly 1977). For each period, we determined the proportion of all locations of a female that were classified as active. We assumed that errors in activity classification of Fishers were consistent across time of day, season, and among individuals to assess relative differences in activity among females.

Consecutive sampling periods were separated by ≥12 h; Arthur and Krohn (1991) determined that there was no significant relationship between probabilities of being active on two consecutive locations separated by ≥2 h. Sampling was rescheduled if either heavy rain or wind ≥25 km/h during monitoring hindered telemetry procedures and interpretation of signal characteristics.

We tested for differences in proportions of active locations among individuals, circadian periods, periods of kit development, and interactions among these effects using analyses of repeated counts (Koch et al. 1977) with marginals as the response (CATMOD procedure; SAS Institute Inc. 1985). The initial test included all three main effects and all interactions. We then used four separate tests to compare activity among individuals and between developmental periods, nesting within each of the four circadian periods. To determine if litter size influenced activity level, we tested among the females using the proportion of activity for all circadian and developmental periods combined, weighted by relative length of the circadian period (Zar 1984: 400-402). In separate analyses, we used a Z-test (Zar 1984: 396) to examine differences between years in the proportion of daytime locations (0900-1500 h) classified as active for two females monitored during both 1988 and 1989.

Results

Individual variation had a strong influence (P = 0.0057) on level of female activity, whereas circadi-

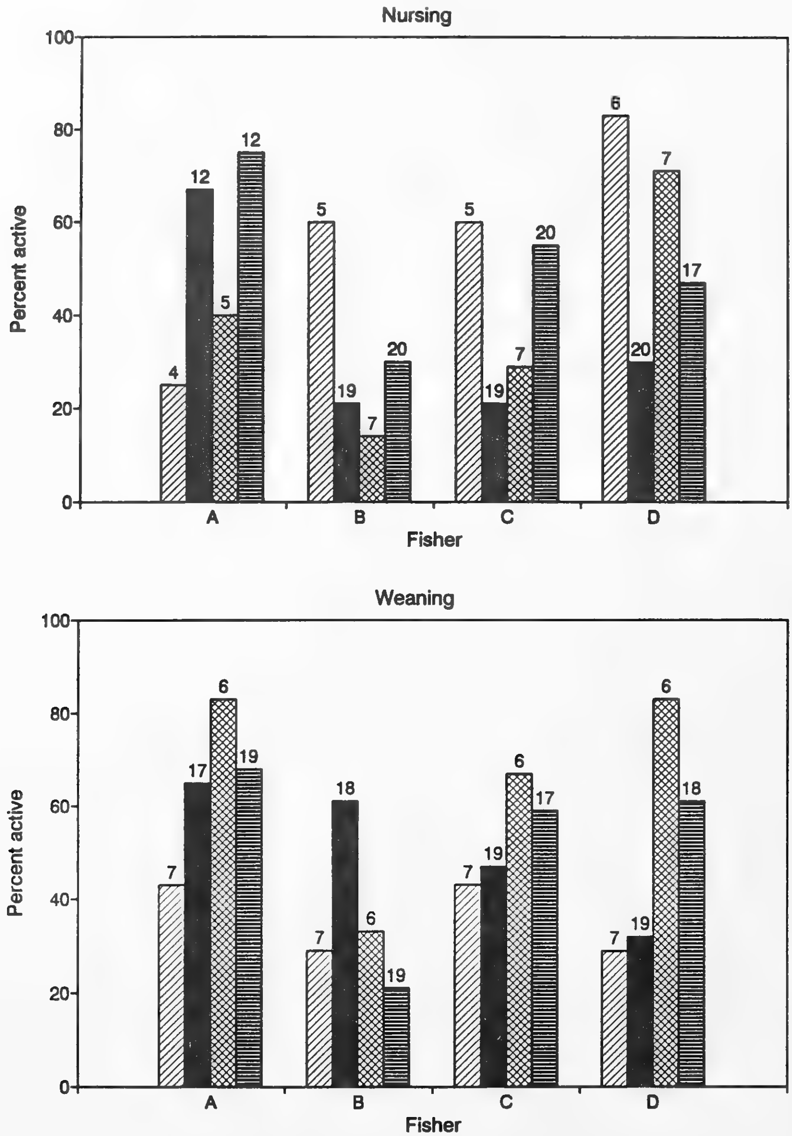

FIGURE 1. Percentage of telemetry readings considered active during developmental and circadian periods for four female Fishers with kits in southcentral Maine during 1988. Circadian periods are: 2 h before sunrise until sunrise (diagonal lines), 0900-1500 h (solid bars), sunset until 2 h after sunset (crosshatch), and 2100-0300 h (horizontal lines). Numbers above bars indicate numbers of locations per period. Development periods: top - nursing = 30 March-14 May; bottom - weaning = 15 May-28 June.

an and development periods did not (P = 0.34 and 0.27, respectively). Significant interactions suggested that some individuals were more active during some ciradian periods (P = 0.007) and that the circadian pattern of activity changed between developmental periods (P = 0.025). The latter interaction was confirmed by the tests of individual and weaning period, nested within circadian period: activity increased from nursing to weaning periods during day and dusk (P = 0.027 and 0.011, respectively), but was unchanged during dawn and night (P = 0.11 and 0.94, respectively). During the nursing period

TABLE 1. Comparison of activity level, litter size, and age among four adult female Fishers in southcentral Maine during late March-late June 1988. Percentages are weighted means from all circadian, nursing, and weaning periods combined.

Animal	% Active Locations	n	Age (years)	Litter size
A	63	82[1]	6	3
B	48[2]	101	3	2[3]
C	46[2]	100	4	1
D	33	100	7	2

[1]This female slipped her collar and was not monitored for 1.5 weeks in April-May until she was captured and recollared.
[2]Proportions with the same superscript were not different ($P > 0.50$); other proportions were different ($P < 0.0001$, five of six pairwise comparisons, q distribution; Zar 1984:402).
[3]One kit was found in the den, and another was subsequently captured and radiocollared nearby (Paragi 1990: 44).

(Figure 1a), three of the four Fishers showed a pattern similar to nondenning Fishers (Arthur and Krohn 1991), with most activity occurring during dawn and night. During the weaning period (Figure 1b), none of the denning females showed the daytime reduction in activity typical of nondenning Fishers.

Multiple comparisons among females, using proportion of locations when a female was active (weighted mean of all periods combined) indicated that one female with three kits was more active than each of the three females with one or two kits during 1988 (Table 1). Comparing activity of two individual females suggested the same pattern of more activity with larger litters, but differences were not significant (Table 2).

Discussion

Radio signals that indicated resting individuals were often confirmed (Arthur and Krohn 1991), but the secretive nature of Fishers in their forested environment generally precluded observations of active individuals to fully validate our remote sensing of activity patterns. Although characteristics of radio signals might poorly represent specific activities (Garshelis et al. 1982), observations of instrumented animals suggest that audible qualities of radio signals can provide a reliable estimate of the occurrence of general activity patterns (Lindzey and Meslow 1977). Differences in signal characteristics between resting and active Fishers were so great that we believe errors in detecting activity were rare.

Activity levels (hence energy expenditure) among adult female Fishers are likely influenced by individual variation in the interrelated factors of age, health, litter size, foraging experience, and food abundance. The four females we monitored in 1988 had given birth during 14-21 March and likely had mated prior to our starting activity sampling; therefore, we believe mating activities did not affect our estimates of activity levels during nursing. A decline in litter size during sampling also might affect activity level. However, periodic observations of litters after mid-June gave us no indication that kit mortality occurred after we handled the kits in mid-May. Finally, we acknowledge that our visits to the dens might have influenced female behavior (Paragi 1990; cf. Leonard 1986), but all dens were visited at similar time intervals.

The increase in diurnal activity during weaning might have been because females foraged more frequently while caring for the growing offspring or because they began exploiting different types of food. The only obvious seasonal change in diet of Fishers that we noted was the use of fruits during late summer and autumn (Arthur et al. 1989a), but fruits were not yet available at the time young Fishers were weaned. Parturient females might also increase daytime activity during kit development because adult males tend to be less active during

TABLE 2. Activity and litter sizes of two female Fishers compared between years in southcentral Maine 1988 and 1989.

			30 March-28 June		15 May-28 June[1]	
Fisher	Year	n kits	% active[2]	n locations	% active[2]	n locations
B	1988	2[3]	31[4]	39	32[6]	19
B	1989	3	40[4]	20	64[6]	11
D	1988	2	41[5]	37	61[7]	18
D	1989	0	27[5]	11	22[7]	9

[1]Weaning period.
[2]Percentage of locations classified as active.
[3]One kit was found in the den, and another was subsequently captured and radiocollared nearby.
[4]$Z = -0.677$, $P = 0.50$ (test of difference between years).
[5]$Z = 0.765$, $P = 0.44$.
[6]$Z = -0.568$, $P = 0.57$.
[7]$Z = 1.76$, $P = 0.078$

daylight hours in spring and summer (Arthur and Krohn 1991). Several authors have speculated that adult males may pose a threat to Fisher kits, but this has not been confirmed. Although kits are silent when the maternal female is absent (Leonard 1986; personal observation), most females moved kits to 1–4 different tree dens during the denning period (Paragi 1990), potentially allowing males to detect their scent near the ground. Whatever the cause, increased activity at any time of day may increase Fisher mortality from automobiles or predators. During our study, two juvenile Fishers were killed by automobiles during daylight hours, and one adult female was killed in mid-January by a Coyote (*Canis latrans*). Roy (1991) reported that three Fishers (2 female, 1 male) were killed between 11 February and 16 May by Coyotes during a Fisher reintroduction program in northwestern Montana. The female killed in May had three dependent kits.

The increase in diurnal activity from nursing to weaning suggests that energy expenditure increased because of foraging as kit rearing progressed. Thus, prey abundance at the time weaning may strongly influence kit survival. However, our data suggest that individual variation among females may affect activity levels more strongly than the encompassing factors of circadian period, stage of kit development, or variation in litter size. Because of individual variation, data from more individuals are needed to critically test hypotheses on foraging costs based on the activity levels of female Fishers with kits during nursing and weaning.

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Population Estimation of the Snail *Bithynia tentaculata* (Gastropoda: Prosobranchia) Using Mark-recapture and the Examination of Snail Movement in Pools

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Mark-recapture techniques were used to estimate the population size of *Bithynia tentaculata* (Gastropoda: Prosobranchia), the intermediate host of at least two important waterfowl parasites, at a field site in southern Quebec in 1990. The population (n ± SE per 1 m^3) was approximately 2300 ± 1430 on 25 June, 740 ± 430 on 16 July, and 1950 ± 1890 on 6 August. In outdoor experimental pools, *B. tentaculata* moved on average between 12 and 38 cm during the day (3.0–9.5 cm / hr) and between 19 and 82 cm overnight (0.9– 4.1 cm / hr), depending on the pool size. Snail movement in pools increased with increasing water temperature but was not related to snail size or age class. The average distance moved in pools should be sufficient to allow marked snails to mix back into wild populations, thus validating the use of mark-recapture techniques. Results are discussed in the context of parasite transmission.

Key Words: *Bithynia tentaculata*, snail, mark-recapture, movement, Quebec.

The digenean parasites *Cyathocotyle bushiensis* Khan 1962 and *Sphaeridiotrema pseudoglobulus* McLaughlin, Scott and Huffman 1993 (originally described as *Sphaeridiotrema globulus* (Rudolphi 1814) by Hoeve and Scott 1988) are implicated in the deaths of dabbling ducks in southern Quebec (Gibson et al. 1972; Hoeve and Scott 1988). The aquatic prosobranch snail *Bithynia tentaculata* Linnaeus 1767 is probably the most important intermediate host for both parasites (Ménard and Scott 1987; Lepitzki 1993). Eventual control of these parasites may lie in controlling their intermediate host. It is therefore necessary to understand not only the transmission dynamics of the parasites but also the population characteristics of the intermediate host.

In this study estimates of the absolute density of *Bithynia tentaculata* were made at a field location using the Jolly-Seber stochastic method for multiple mark-recaptures. However, for reliable estimates of population density, there must be complete mixing of the marked individuals with the rest of the population (Woolhouse 1988). Movement patterns and total distances moved are unknown for most snails including *B. tentaculata*. To test the requirement for mixing within the snail population, additional studies established movement patterns of *B. tentaculata* in outdoor pools. These movement patterns could also have significant effects on parasite transmission.

Methods

Mark-recapture at DND

The mark-recapture study took place in a small pond (approximately 10 m by 125 m) on the Department of National Defense Proof and Experimental Test Establishment near Nicolet, Quebec (DND: 46° 13′ N, 72° 39′ W) from 4 June to 17 September 1990. The pond had been a stream which probably drained into Lac St-Pierre but man-made filling operations eliminated its drainage some time ago. Although the pond was divided by a culvert (approximately 2 m diameter) under a road, water and aquatic biota could move between both sections. The edges of the pond were lined with emergent vegetation (primarily *Decodon* sp. interspersed with *Carex* spp. and *Typha* sp.) while submerged macrophytes (*Ceratophyllum* sp., *Elodea* sp., *Myriophyllum* sp., *Potamegeton* spp.) were rooted in the bottom of mud and decaying vegetation and duck weed (*Lemna* spp.) floated on the water surface.

Eight sites, four on either side of the culvert, were arbitrarily selected approximately 10 m apart along the shoreline. One plastic mesh dip net (30 cm x 26 cm, mesh size 1 mm) scoop in a maximum arc of 1.5 m was taken at each site once every three weeks. The scoop samples were made along the aquatic vegetation away from the banks as this was where the snails tended to concentrate (personal observation).

Fingernail varnish was applied to the cleaned and dried *B. tentaculata* shells. After the varnish dried, the marked snails were released at their capture site; they were out of the water for no more than 30 minutes. Snails similarly marked with fingernail varnish and kept in aquaria in the laboratory retained their marks for at least six months with no apparent effect on mortality rate.

For each mark-recapture date a different colour of mark was applied. A record was kept of the number of snails captured and recaptured with the colour of the marks indicating the capture history of recaptured individuals. Dead snails were ignored.

Population size was estimated using the Jolly-Seber stochastic model (Caughley 1977). This multiple mark-recapture technique has several advantages as it estimates population parameters over an extended period and allows for emigration or mortality and immigration or birth. In addition, it is possible to estimate the population at each capture.

Snail movement in pools

One large (642 cm diameter) and two small (90 cm diameter) shallow wading pools filled with water to an approximate depth of 16 cm were used to observe *B. tentaculata* movement and habitat associations. The pools were kept outside and were exposed to natural temperature and light regimes. Habitat within the large pool consisted of 19 rocks extending in a straight line from the centre of the pool (rock 1) to its edge (rock 19); the small pools contained sand and rocks collected from the south shore of the Ottawa River near Hawkesbury, Ontario (HAW: 45° 35′ N, 74° 32′ W). Although the two small pools had similar underwater substrates, the placement of the larger rocks differed. In one (POOL A) the larger rocks were placed near the edge; in the other (POOL B) the larger rocks were more central. Observations on snails in the large pool extended for 21 days from 26 June to 10 July, 1990. Observations of 17 days duration were replicated three times in each of the two small pools between 20 June and 17 August, 1990.

Bithynia tentaculata, collected at HAW and individually identified with different colours and patterns of fingernail varnish, were placed in the centre of each pool on Day 0. Two size classes (5–7 mm and 7–9 mm total shell length) and several age classes (Vincent and Vaillancourt 1981) were used. A total of 48 snails were placed in the large pool and 16, 21, and 20 snails were used in each of the two small pools in each of the three replicates, respectively.

The location of each snail and the water temperature were recorded in the morning (between 0900 and 1000 hrs) and afternoon (between 1300 and 1400 hrs) on each day of observation. The snails were not disturbed although observations were made on their precise location in association with the rocks or on the bottom or sides of the pool. Previously established grid lines were used as a reference system for locating the snails; these snail locations were then transformed into x and y coordinates with the centre of the pool being 0,0. Direct distance between the morning and afternoon observation (daytime movement with an average of approximately 4 hrs between locations) and between the afternoon and next morning observation (overnight movement with an average of approximately 20 hrs between locations) were calculated using $d = \sqrt{[(x_2 - x_1)^2 + (y_2 - y_1)^2]}$. It is acknowledged that the snails probably did not move in a straight line and actually travelled a significantly greater distance.

Parametric and non-parametric statistical procedures (Rohlf 1983; SAS Institute 1988) were used to assess differences in snail movement and habitat association with age or size class of snail and water temperature. Dunn's non-parametric procedure (Hollander and Wolfe 1973) was used for multiple comparisons of mean ranks. To determine if the snails behaved differently in the last half of the study, the data sets were divided into two periods. Early and late periods corresponded to days 1 to 10 and 11 to 21 in the large pool and days 1 to 8 and 9 to 17 in the small pools. In the small pools, differences in snail movement and habitat association between the two pools and among the three replicates were also analyzed. A probability level of $P < 0.05$ indicated statistical significance. Analyses were done on the actual distances moved but for clarity some of the results have been subsequently converted into rates of movement (cm per hr) and analyzed using SYSTAT (Wilkinson 1989).

Results

Mark-recapture at DND

A total of 582 *B. tentaculata* were marked at DND (Table 1); of these, only 24 were recaptured. As 21 of the 24 recaptures were at site 5 and the different sites varied greatly in the number of snails captured, only data from site 5 were used in Jolly-Seber population estimates. The three estimates of the population (n ± SE) at site 5 were: 269 ± 167 on 25 June; 87 ± 50 on 16 July; and 228 ± 221 on 6 August. The size of the home range of these snails is not known and it is difficult to delineate the boundaries of this population. As a result, these population estimates use the volume swept by the dip net as a unit of measurement. The dip net was swept through an arc of approximately 150 cm covering a volume of 0.12 m^3.

Snail movement in the large pool

In the large pool *B. tentaculata* moved an average of 38 cm during the day and 82 cm overnight at speeds of 9.5 and 4.1 cm / hr, respectively (Table 2). There were no significant differences in daytime or overnight movement among ages or size classes of snails, between the first and last halves of the study, or in association with water temperature (Table 3). Although there was variability among snails in the amount of daytime and overnight movement, no significant differences were found between individuals (Table 3). It appeared that when snails moved large distances during the day, they continued to do so during the night as there was a significant positive

TABLE 1. Number of *Bithynia tentaculata* (Gastropoda) captured and recaptured at DND, near Nicolet, Quebec, in 1990.

Date	Number of snails	Site 1	2	3	4	5	6	7	8	Total
4 June	Total captures	1	2	9	2	39	13	7	6	79
	Recaptures	–	–	–	–	–	–	–	–	–
25 June	Total captures	2	10	17	5	40	2	10	6	92
	Recaptures	0	0	1	0	2	0	0	0	3
16 July	Total captures	4	17	12	40	20	14	18	3	128
	Recaptures	0	0	0	0	6	0	0	0	6
6 August	Total captures	1	27	11	2	43	9	3	1	97
	Recaptures	0	0	0	0	5	0	0	0	5
27 August	Total captures	11	6	19	0	43	6	2	0	87
	Recaptures	0	0	0	0	0	0	0	0	0
17 September	Total captures	2	12	5	3	62	15	0	0	99
	Recaptures	0	0	1	0	8	1	0	0	10

TABLE 2. Movement of *Bithynia tentaculata* (Gastropoda) in large (642 cm diameter) and small (90 cm) outdoor experimental pools June through August, 1990. Daytime movement was calculated as direct distance between two locations from observations separated by approximately 4 hours while overnight movement was calculated as direct distance between the last daily location and that of the next morning approximately 20 hrs later.

Time of day	n	Distance moved (cm) mean ± SE	Distance moved (cm) range	Speed (cm / hr) mean ± SE	Speed (cm / hr) range
		LARGE POOL			
daytime	271	38 ± 6	0 - 483	9.5 ± 1.4	0 - 120.8
overnight	188	82 ± 11	0 - 604	4.1 ± 0.6	0 - 30.2
		SMALL POOLS (overall)			
daytime	726	12 ± 1	0 - 81	3.0 ± 0.2	0 - 20.2
overnight	594	19 ± 1	0 - 84	0.9 ± 0.1	0 - 4.2
		SMALL POOLS (by replicate and pool)			
daytime					
(Repl.1, Pool A)	103	13 ± 2	0 - 70	3.3 ± 0.5	0 - 17.5
(Repl.1, Pool B)	73	9 ± 2	0 - 62	2.3 ± 0.5	0 - 15.5
(Repl.2, Pool A)	126	12 ± 2	0 - 76	3.0 ± 0.5	0 - 19.0
(Repl.2, Pool B)	145	11 ± 1	0 - 72	2.8 ± 0.3	0 - 18.0
(Repl.3, Pool A)	133	14 ± 2	0 - 81	3.5 ± 0.5	0 - 20.3
(Repl.3, Pool B)	146	13 ± 2	0 - 77	3.3 ± 0.5	0 - 19.3
overnight					
(Repl.1, Pool A)[a]	87	18 ± 2	0 - 78	0.9 ± 0.1	0 - 3.9
(Repl.1, Pool B)	55	12 ± 2	0 - 63	0.6 ± 0.1	0 - 3.2
(Repl.2, Pool A)[a]	116	24 ± 2	0 - 72	1.2 ± 0.1	0 - 3.6
(Repl.2, Pool B)	127	16 ± 2	0 - 75	0.8 ± 0.1	0 - 3.8
(Repl.3, Pool A)	100	18 ± 2	0 - 83	0.9 ± 0.1	0 - 4.2
(Repl.3, Pool B)	109	21 ± 2	0 - 84	1.1 ± 0.1	0 - 4.2

[a]Average overnight distances moved by snails in pools A and B of replicates 1 and 2 were significantly different (Dunn's procedure, $P < 0.05$).

association between overnight movement and the previous day's movement (Table 3). Although the snails moved twice as fast during the day as overnight (Table 2) these rates of movement were not significantly different (Table 3). Data on individual snails are deposited in the Canadian Institute for Scientific and Technical Information Depository of Unpublished Data*.

In the large pool snails were classified as on the rocks or elsewhere. For statistical analyses the

*Data may be purchased, at a nominal charge, from the Depository of Unpublished Data, CISTI, National Research Council of Canada, Ottawa, Ontario, Canada K1A 0S2.

TABLE 3. Summary of statistical analyses of *Bithynia tentaculata* (Gastropoda) movement in large (642 cm diameter) and small (90 cm) outdoor experimental pools June through August 1990. Daytime movement was calculated as direct distance between two locations from observations separated by approximately 4 hours while overnight movement was calculated as direct distance between the last daily location and that of the next morning approximately 20 hrs later.

Movement	Variable tested	Test and parameter[a]	P	Comments[b]
		LARGE POOL		
daytime	snail age class	$\chi^2_2 = 3.98$	0.1366	NS
	snail size class	$Z_1 = -0.778$	0.4364	NS
	1st vs 2nd half	$Z_1 = -0.479$	0.6316	NS
	water temperature	$F_{1,269} = 3.76$	0.0536	NS
	among snails	$\chi^2_{45} = 107.11$	0.0001	NS pairs
overnight	snail age class	$\chi^2_2 = 3.87$	0.1442	NS
	snail size class	$Z_1 = -1.22$	0.2224	NS
	1st vs 2nd half	$Z_1 = -0.156$	0.8760	NS
	water temperature	$F_{1,186} = 0.01$	0.9393	NS
	among snails	$\chi^2_{44} = 103.18$	0.0001	NS pairs
	vs daytime	$F_{1,184} = 132.95$	0.0001	SIG. DIF.
rates	day vs overnight	$U_1 = 24625.5$	0.4760	NS
		SMALL POOLS		
daytime	snail age class	$\chi^2_2 = 1.2750$	0.5286	NS
	snail size class	$Z_1 = -0.2531$	0.8002	NS
	1st vs 2nd half	$Z_1 = -0.3422$	0.7322	NS
	water temperature	$F_{1,724} = 7.99$	0.0048	SIG. DIF.
	among replicates	replicate $F_{2,720} = 0.02$	0.9777	NS
	and pools	pool $F_{1,720} = 4.23$	0.0402	SIG. DIF.
		repl*pool $F_{2,720} = 0.59$	0.5533	NS
	among replicates	$\chi^2_2 = 0.2220$	0.8945	NS
	between pools	$Z_1 = 2.027$	0.0427	NS pairs
	among snails			
	(Repl.1, Pool A)	$\chi^2_{15} = 13.333$	0.5766	NS
	(Repl.1, Pool B)	$\chi^2_{15} = 17.853$	0.2705	NS
	(Repl.2, Pool A)	$\chi^2_{19} = 21.715$	0.2987	NS
	(Repl.2, Pool B)	$\chi^2_{20} = 18.698$	0.5415	NS
	(Repl.3, Pool A)	$\chi^2_{19} = 21.367$	0.3169	NS
	(Repl.3, Pool B)	$\chi^2_{18} = 30.326$	0.0344	NS pairs
overnight	snail age class	$\chi^2_2 = 5.8131$	0.0547	NS
	snail size class	$Z_1 = 0.2549$	0.7987	NS
	1st vs 2nd half	$Z_1 = 0.7681$	0.4424	NS
	water temperature	$F_{1,581} = 2.21$	0.1374	NS
	among replicates	replicate $F_{2,588} = 1.73$	0.1787	NS
	and pools	pool $F_{1,588} = 9.17$	0.0026	SIG. DIF.
		repl*pool $F_{2,588} = 5.06$	0.0066	SIG. DIF.
	among replicates	$\chi^2_2 = 2.015$	0.3652	NS
	between pools	$Z_1 = -2.987$	0.0028	SIG. DIF.
	among snails			
	(Repl.1, Pool A)	$\chi^2_{15} = 22.798$	0.0885	NS
	(Repl.1, Pool B)	$\chi^2_{15} = 21.557$	0.1200	NS
	(Repl.2, Pool A)	$\chi^2_{19} = 21.827$	0.2930	NS
	(Repl.2, Pool B)	$\chi^2_{20} = 21.275$	0.3811	NS
	(Repl.3, Pool A)	$\chi^2_{18} = 34.048$	0.0124	NS pairs
	(Repl.3, Pool B)	$\chi^2_{18} = 30.495$	0.0329	1 SIG.DIF. pair
	vs daytime	daytime $F_{1,565} = 100.71$	0.0001	SIG.DIF.
		pool $F_{1,565} = 9.06$	0.0027	SIG.DIF.
		day*pool $F_{1,565} = 4.58$	0.0328	SIG.DIF.
rates	day vs overnight	$U_1 = 228023.0$	0.0600	NS

[a]χ^2 = Kruskal-Wallis chi-square approximation; Z = Wilcoxon normal approximation; U = Mann-Whitney test; F = ANOVA on ranks (except water temperature where ANOVA was parametric) or ANCOVA on ranks (comparing daytime vs overnight movement including the covariate pool) where, as for 2-way ANOVAs, F's for the individual variables within the model are indicated.

[b]NS = not significant ($P > 0.05$); SIG. DIF. = significant ($P < 0.05$); NS pairs = although the overall test was significant, subsequent pairwise comparisons of mean ranks using Dunn's procedure failed to show any significant pairs.

straight line of rocks extending from the centre (rock 1) to the edge (rock 19) of the pool was divided into three groups: rocks 1–5, 6–12, and 13–19. As results from morning and afternoon observations were identical, data were pooled. More snails were found associated with the rocks than elsewhere in the pool (Figure 1) regardless of size or age class of snail; however, they were not equally distributed among the rocks. Significantly fewer (G_1 = 19.353, $P < 0.001$) snails were associated with rocks 1–5 in the last half of the study than in the first half (Figure 1); concurrently, significantly more snails were found on rocks 6-12 (G_1 = 7.895, P = 0.005) and on rocks 13-19 (G_1 = 24.980, $P < 0.001$) in the last half (Figure 1).

Snail movement in the small pools

In the small pools *B. tentaculata* moved an average of 12 cm during the day and 19 cm overnight at speeds of 3.0 and 0.9 cm / hr, respectively (Table 2). There were no significant differences in daytime and overnight movement among ages or size classes of snail or between the first and last halves of the study (Table 3). While there was no association between overnight movement and water temperature, water temperature had a significant effect on snail movement during the day (Table 3) with neither replicate nor pool affecting the relationship. As the difference between the morning and afternoon water temperatures (TEMP) increased, so did the amount of snail movement (DAYTIME MOVEMENT$_{(cm)}$ = a + b(TEMP); a = -2.7 ± 5.2, b = 0.6 ± 0.2; r^2 = 0.011). Although the amount of daytime movement was not affected by either replicate or pool (Table 3, 2-way ANOVA on ranks and single factor non-parametric analyses), overnight movement varied among pools and replicates (Table 3, 2-factor ANOVA on ranks). Snails in POOL A moved significantly further ($P < 0.05$, Dunn's multiple mean rank comparisons) than snails in POOL B during the night in both the first and second replicates (Table 2).

In contrast to that seen in the large pool, there was some evidence that individual snails moved different amounts in the small pools. Overall statistically significant differences were found among snails in their daytime movement in POOL B of the last replicate and in their overnight movement in POOLs A and B of the last replicate (Table 3); however, subsequent pairwise comparisons of mean ranks yielded only one marginally significant difference among snails in replicate 3, POOL B (Table 3).

As in the large pool, overnight movement was significantly and positively associated with daytime movement but due to differences in snail movements among pools and replicates, this relationship varied between the two small pools (Table 3). Similarly, although snails in the small pools moved three times as fast during the day as overnight

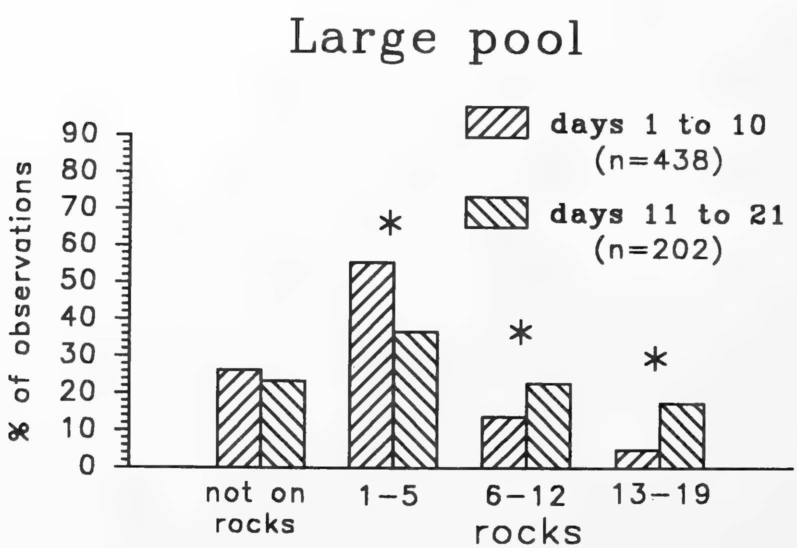

FIGURE 1. Habitat associations of *Bithynia tentaculata* (Gastropoda) in the large outdoor experimental pool for the first (days 1 to 10) and last (days 11 to 21) halves of the study. Rocks were set in a straight line from the centre (rock 1) to the edge (rock 19) of the pool. Asterisks (*) indicate significant differences (G-test, $P < 0.05$) between the first and last halves of the study and n indicates the number of observations on a total of 48 snails.

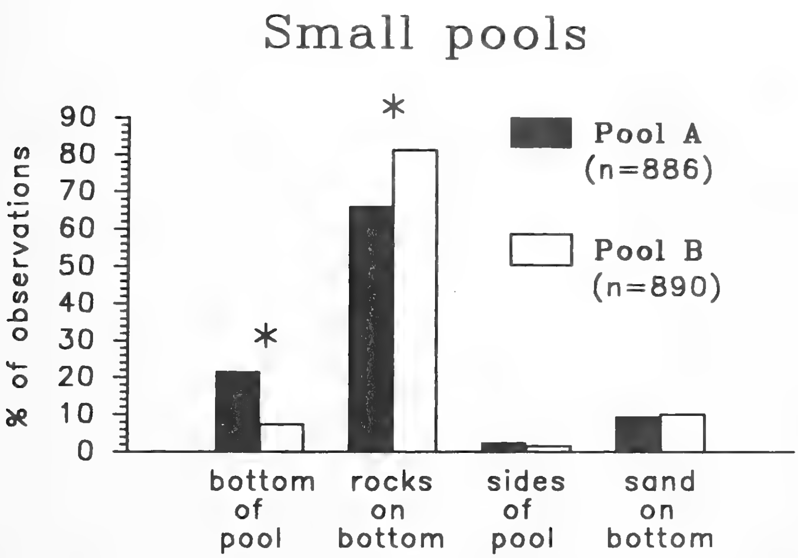

FIGURE 2. Habitat associations of *Bithynia tentaculata* (Gastropoda) in the two small outdoor experimental pools. Asterisks (*) indicate significant differences (*G*-test, $P < 0.05$) between POOLs A and B and n indicates the number of observations on totals of 55 snails in each pool.

(Table 2) these rates of movement were not significantly different (Table 3).

Snails in the small pools could be associated with one of four habitats: the bare bottom, the large rocks, the sand on the bottom of the pool, and the sides of the pool. As results from morning and afternoon observations were identical, data were pooled. More snails were found associated with the rocks on the bottom of the pool than with the other habitats (Figure 2) regardless of size or age class of snail and first versus last half of the study; however, some differences were seen between the pools. Significantly more ($G_1 = 52.763$, $P < 0.001$) snails were on the rocks in POOL B than in POOL A (Figure 2); concurrently, significantly fewer ($G_1 = 76.904$, $P < 0.001$) snails were on the bare bottom in POOL B (Figure 2).

Discussion

Mark-recapture techniques have only recently been used to examine freshwater snail population dynamics in the context of parasitology. Fenwick and Amin (1983) tested the recoverability of marked snail intermediate hosts of schistosomiasis in irrigation canals of Sudan and Woolhouse (1988) used Bailey's triple catch method in ecological studies of schistosomiasis in snail populations of Zimbabwe. In North America, few have used mark-release-recapture methods although Goater et al. (1989), Fernandez and Esch (1991a), and Williams and Esch (1991) followed the progress of parasite infections and the structuring of helminth communities in marked planorbid snail (*Helisoma anceps*) populations. Fernandez and Esch (1991b) also used the Jolly-Seber mark-recapture technique to estimate the size of their *H. anceps* population. Our study is the first to use mark-recapture techniques on *B. tentaculata*. In addition, although the movement of other snail species has been examined by using mark-recapture (e.g. *Helisoma trivolvis* by Boerger 1975; *Physa integra* by Clampitt 1974), no studies on movement of *B. tentaculata* in the field or laboratory have been reported. Due to the importance snail movement may have in the determination of spatial and temporal heterogeneity of helminth infections, we believe additional studies on snail movement are necessary.

Marked snails must be able to move away from their site of capture and unmarked snails must be able to move into the capture area to obtain accurate population estimates using mark-recapture techniques. Therefore *B. tentaculata* must move a distance greater than the arc of the dip net for the technique to work at DND. Data on snail movement in pools indicated that there is sufficient movement. As a result, the mark-recapture technique may be very valuable in future studies on the population dynamics of *B. tentaculata*. However, due to heterogeneity in numbers of captures and recaptures among our sites, many more sampling sites would be needed to estimate the population of the entire pond. Such a study would be very labour intensive as suggested by Woolhouse (1988).

Other quantitative techniques such as Shipek and Petersen dredges have been used to obtain density estimates of *B. tentaculata* populations in southern Quebec. Estimates have ranged from a low of 30 snails / m^2 (Legendre et al. 1984) to a maximum of 14 450 snails / m^2 (Vincent and Létourneau 1985) with snail populations fluctuating spatially and temporally (Vincent et al. 1981). Our estimates of approximately 2300 ± 1430, 740 ± 430, and 1950 ± 1890 snails / m^3 are difficult to compare with others due to the units of measurement but appear to be intermediate.

Very few marked *B. tentaculata* were recovered at DND (4.1% overall, 8.5% at site 5). Others have had higher recapture success rates in both long and short term studies on other snail species (Clampitt 1974; Goater et al. 1989) even though recovery most likely declines with time as found by Boerger (1975). Although we have assumed that marked snails were not prone to selective predation, the possibility should be considered. Another possible explanation for low recapture rates is that the snails moved away from capture sites. Some snail species show strong site fidelity (Goater et al. 1989; Fernandez and Esch 1991a) whereas others may disperse long distances (Boerger 1975). It is not known whether *B. tentaculata* have small home ranges but we suspect that this may depend on their habitat and the reasons snails move in general.

All ages and sizes of *B. tentaculata* moved similar distances in both large and small pools even though smaller *B. tentaculata* were more active than larger snails in aquaria (Lepitzki 1993). On average snails in the pools did not move far. Some of the individuals in the large pool did however travel substantial distances; it is likely that in the small pools this happened also, but because of sheer physical limitations, these snails ended up in a spot fairly close to the previously recorded location.

The snails moved further overnight than during the day but if distances were converted into speed, the snails appeared to move two to three times faster during the day than overnight, depending on the pool size. Although daytime and overnight speeds were not significantly different, a possible explanation for this trend may be water temperature. In the small pools snail movement showed a linear and positive relationship with water temperature. This relationship is most likely a general increase in movement rather than a potentially directional movement to shaded sections of the pools as the pools were in full sunlight during both morning and afternoon observations. Boerger (1975) also noted an increase in dispersal rate with warmer water temperatures. Similar results were not seen in the large pool as the water temperature was more constant. In the small pools water temperature ranged from 15 to 35 °C with an average change of around 10 °C between the morning and afternoon observation. In the large pool water temperature ranged from 15 to 31 °C, the largest change over the course of one day was 7 °C, and the average change was only 2 to 3 °C. Any effect of temperature on snail movement was likely too small to detect in the large pool with its very small temperature fluctuations.

Another explanation for the apparent difference in the speed of the snails during the day and night is the presence of circadian rhythms. Unfortunately, the possibility of circadian rhythms could not be examined due to the timing of our observations.

Differences found in movement of snails between the two small pools may suggest that *B. tentaculata* have different movement patterns and, by extrapolation, possibly different home range sizes in different habitats. Underwood and Chapman (1989) have reported that the intertidal snail *Littorina unifasciata* moved further and more directionally on simple as opposed to topographically more complex substrates. Although the two small pools were the same size and had similar underwater substrates, large rocks were placed differently. In POOL B the large rocks were more central, closer to where the snails were originally placed in the pool. In POOL A, the large rocks were placed near the edge; snails moved significantly further overnight in this pool than in the other in the first two replicates. This suggests that if a suitable microhabitat was found, the snails did not move while if no suitable site was encountered the snails continued to move.

In the pools this suitable microhabitat may have been the large rocks as the snails seemed to be associated with the large rocks in all pools. Shelter and/or food probably in the form of *Aufwuchs* on the rocks may be very important to these snails. Weber and Lodge (1990) have noted increased use of rocks by various snail species with increasing periphyton cover. The diet of *B. tentaculata* consists primarily of *Aufwuchs* (Aldridge 1983) although Tashiro and Colman (1982) suggested that *B. tentaculata* filter feed as well as graze.

Although we now have an indication of movement of *B. tentaculata* in pools and in nature, there remain questions as to cause and, in our case, effect on parasite transmission. The *B. tentaculata* appeared to move in a random pattern until a suitable site was encountered (personal observation). If a rock was encountered, the snails appeared to settle awhile before moving again. Evidence for this type of movement may be seen in the large pool where significantly more snails were found on the outer rocks and significantly fewer on the central rocks in the last half of the study. As time past the snails appeared to spread over more of the large pool. The random movement until a food source is located and then the resumption of random movement once the food source has been depleted has been reported for other snail species

(Bovbjerg 1965; Weber and Lodge 1990). Furthermore, Bovbjerg (1965) suggested that these snail movement patterns were a classical example of kinesis which results in the aggregated distributions of freshwater invertebrates commonly found in nature.

Snails with small home ranges or with aggregated distributions caused by kinesis produce several effects in the context of parasite transmission. If snails are in habitats with clumped food sources whose presence does not fluctuate temporally, they may be expected to have small home ranges. However, if food sources fluctuate spatially or temporally, the snails may be expected to travel longer distances and have larger home ranges. In the case of the two parasites, *C. bushiensis* and *S. pseudoglobulus*, which use *B. tentaculata* as both first and second intermediate hosts, snails in productive habitats with plenty of food sources would be expected to have small home ranges. Snails with small home ranges and larval parasite stages with little ability or opportunity to disperse could result in spatially small foci of infection. In this case, waterfowl are definitive hosts and become infected by ingesting snails infected with encysted metacercariae. Indeed, small scale spatial heterogenity at the scale of 10 m has been found in studies examining the distribution of metacercariae in *B. tentaculata* (Lepitzki 1993).

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Habitat Use and Distribution of the Mice *Peromyscus leucopus* and *P. maniculatus* on Mount Desert Island, Maine

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We studied habitat use and distribution of *Peromyscus leucopus* (White-footed Mouse) and *P. maniculatus* (Deer Mouse) on Mount Desert Island, Maine. *Peromyscus leucopus* used areas dominated by deciduous vegetation whereas *P. maniculatus* was more of a habitat generalist occurring equally in deciduous and coniferous habitats. Extent of overlap of these two species does not support an hypothesis of interspecific interactions; *P. leucopus* appears limited solely by habitat. *Peromyscus leucopus* and *P. maniculatus* have been identified as important components in the transmission cycle of Lyme disease which has been documented from a small section of Mount Desert Island. Land management practices that increase suitable habitat and influence population densities of *P. leucopus*, the primary host for the Lyme disease spirochete, may locally increase the incidence of this disease.

Key Words: Deer Mouse, *Peromyscus maniculatus*, White-footed Mouse, *Peromyscus leucopus*, Lyme disease, habitat use, Maine, Mount Desert Island.

Choate (1973), based on data available to him, noted a geographic separation of *Peromyscus* species in Maine based on habitat preferences, with *Peromyscus maniculatus* (Deer Mouse) occupying the mesic coniferous region north and east of the Penobscot River, and *P. leucopus* (White-footed Mouse) inhabiting the more arid habitats dominated by transitional hardwoods, White Pine (*Pinus strobus*), and Hemlock (*Tsuga canadensis*) in the region south and west of the Penobscot river. Since then, the known range of *P. leucopus* has been extended along coastal Maine as far as Mount Desert Island (MDI) (44° 12′- 44° 27′ N., 68° 10′- 68° 27′W.) located approximately 50 km east of the Penobscot River (Aquadro et al. 1980). Prior to 1957 small-mammal trapping studies failed to indicate the presence of *P. leucopus* on MDI which lies only 0.6 km from the mainland (Branin 1939; Manville 1942, 1960). This species was first suspected by Calhoun and Arata (1957) and later verified by chromosomal analysis of two specimens by Aquadro et al. (1980). These authors suggested that *P. leucopus* became established on MDI due to the large expanse of suitable hardwood habitat resulting from a catastrophic wildfire in 1947 and implied that the species was recently established. However, given the short distance between the mainland and MDI, access across a roadway established in 1836 or via tidal flats or ice may have permitted earlier colonization by *P. leucopus*.

The extent to which *P. leucopus* has colonized MDI has not been thoroughly investigated, however. Confirmed records have been limited to less than 10 specimens from only four locations. Factors other than habitat availability may limit its distribution. Negative interactions between *Peromyscus* species have been reported in the northeastern United States (Klein 1960; Parren and Capen 1985). Use of post-fire hardwood habitat on MDI by the indigenous *P. maniculatus* and the degree of habitat overlap with *P. leucopus* is unknown.

With the recent discovery of Lyme disease on MDI (Ginsberg and Ewing 1988) and the role of *P. leucopus* and *P. maniculatus* as competent reservoirs for the Lyme disease spirochete (Donahue et al. 1987; Rand et al. 1993), there is an increased need to determine the distribution of both species of *Peromyscus*. Herein, we report on their habitat use and distribution on MDI.

Study Area and Methods

Mount Desert Island falls within the spruce-fir northern hardwoods zone of Westveld et al. (1956). The western side of MDI is covered by a mosaic of coniferous forests of mature Red Spruce (*Picea rubens*), Northern White Cedar (*Thuja occidentalis*), Black Spruce (*P. mariana*), and hardwood patches of primarily aspen (*Populus grandidentata*, *P. tremuloides*), birch (*Betula papyrifera*, *B. populifolia*), and Red Maple (*Acer rubrum*) (Figure 1). Conifer and mixed hardwood-softwood stands covered the eastern side of the island prior to a large wildfire in 1947 (Smith 1960). Much of the burned area is currently dominated by 40+ year-old forests of Aspen and Birch.

Live-trapping was conducted on grids and along transects. All grids and transects were located on exposed upland sites. Grids were trapped during June-September 1987-1988; transects during June-August 1989. Grids were located in three mature stands of Red Spruce and three secondary hardwood stands located within the area burned by the 1947 fire. Each grid contained 42 (6x7) trap stations with a 15-m interval between traps. Nineteen transects were established in stands of mature conifers (n = 10) and in 40-80 year-old hardwood stands (n = 9) dominated by Aspen and Birch. Each transect was 250 m long with a trap station every 10 m and two Sherman live-traps at each station. Traps were baited with mixtures of peanut butter, sunflower seeds, raisins, rolled oats, and suet. Identification of *Peromyscus* specimens recorded on grids was made in the field, based on external characteristics (Choate 1973). Saliva was collected from questionable specimens only during grid trapping and species confirmation was made from these using the electrophoretic technique of Aquadro and Patton (1980) with modifications (Garman 1991). A discriminant-function classification equation derived from grid captures, using tail-to-body length ratio as the independent variable, was used to classify species of *Peromyscus* captured on transects.

Capture rates for *Peromyscus* spp. were calculated as the number of individuals per 1000 undisturbed trap nights. Capture rates were pooled across trapping periods and compared between deciduous and coniferous habitat types for each species and between species within each habitat type using one-way ANOVAs. Pairwise comparison of means were performed using the Bonferroni multiple comparison procedure (Neter and Wasserman 1974) with a significance level of $P \leq 0.01$ (n = 4).

Results and Discussion

Habitat Use

Totals of 382 and 114 individuals of *P. maniculatus* and *P. leucopus*, respectively, were captured. *Peromyscus maniculatus* occurred more frequently in coniferous habitats, but there was no significant difference ($P > 0.01$) in mean rate of capture between habitat types (Table 1). Captures of *P. maniculatus* were recorded on all sites and in each trapping period. *Peromyscus leucopus*, however, clearly exhibited a preference for deciduous habitats ($P < 0.01$). All grids and all but two transects in deciduous habitats recorded captures of this species, whereas captures occurred on all grids, but on only four transects in coniferous habitat.

Although the number of captures of *P. maniculatus* was about twice that of its congener, there was no significant difference ($P > 0.01$) in the capture rate between species in deciduous habitat. There was, however, a substantial difference ($P < 0.01$) between capture rates of the species in coniferous habitat, where the mean capture rate of *P. maniculatus* was a magnitude greater than that of *P. leucopus*.

TABLE 1. Capture rates of *Peromyscus* spp. in deciduous and coniferous habitats on Mount Desert Island, Maine.

Species	Deciduous Habitat		Coniferous Habitat	
	n	Capture Rate[1]	n	Capture Rate[2]
P. maniculatus	168	20.75A[3]	214	27.50A
P. leucopus	94	13.11A	20	2.47B

[1]Based on 33 trapping periods.
[2]Based on 34 trapping periods.
[3]Column or row sharing a letter in common are not significantly different.

Other authors have reported *P. maniculatus* to be more common in moist coniferous forests and northern hardwoods (Morris 1955; Klein 1960; Smith and Speller 1970; Wrigley 1969). Some studies have found habitat use by *P. maniculatus* may be influenced by competition with the Red-backed Vole (*Clethrionomys gapperi*) (Kirkland and Griffin 1974; Vickery 1981). In an experimental introduction of selected small mammal species on a coastal Maine island, Crowell and Pimm (1976) found *C. gapperi* to displace *P. maniculatus* from woodland habitats especially under increasing densities. Our findings indicate that *P. maniculatus* on MDI is a habitat generalist occurring equally in deciduous and coniferous habitats. Based on vegetation and environmental features at trap stations in both habitat types microhabitat analyses failed to show a significant ($P > 0.05$) negative interaction between *C. gapperi* and either *Peromyscus* species (Garman 1991). In addition, a higher degree of overlap in microhabitat use with increasing density was also evident, further indicating that habitat use by either species of *Peromyscus* was not limited by *C. gapperi*. Lack of interspecific competition between *P. maniculatus* and *C. gapperi* has also been reported in Maryland (Barry et al. 1990), Virginia (Wolff and Dueser 1986), and New York (Stewart 1991).

The strong selection of deciduous habitats by *P. leucopus* detected in this study is in agreement with results of other studies (Klein 1960; Smith and Speller 1970; Wrigley 1969). Although captures of *P. leucopus* in coniferous habitats on MDI suggest some use of this vegetation type, some individuals may have been transients. Recapture rates of *P. leucopus* in coniferous habitat (30%) was less than half of that in deciduous habitat (67%) and about half of that for *P. maniculatus* (55%) in either habitat type. Despite attempts to place grid traps in coniferous sites away from noticeable edges, most were within 300 m of deciduous stands of varying sizes. This distance is well within the dispersal range of *P. leucopus* (Stickel 1968). Field observa-

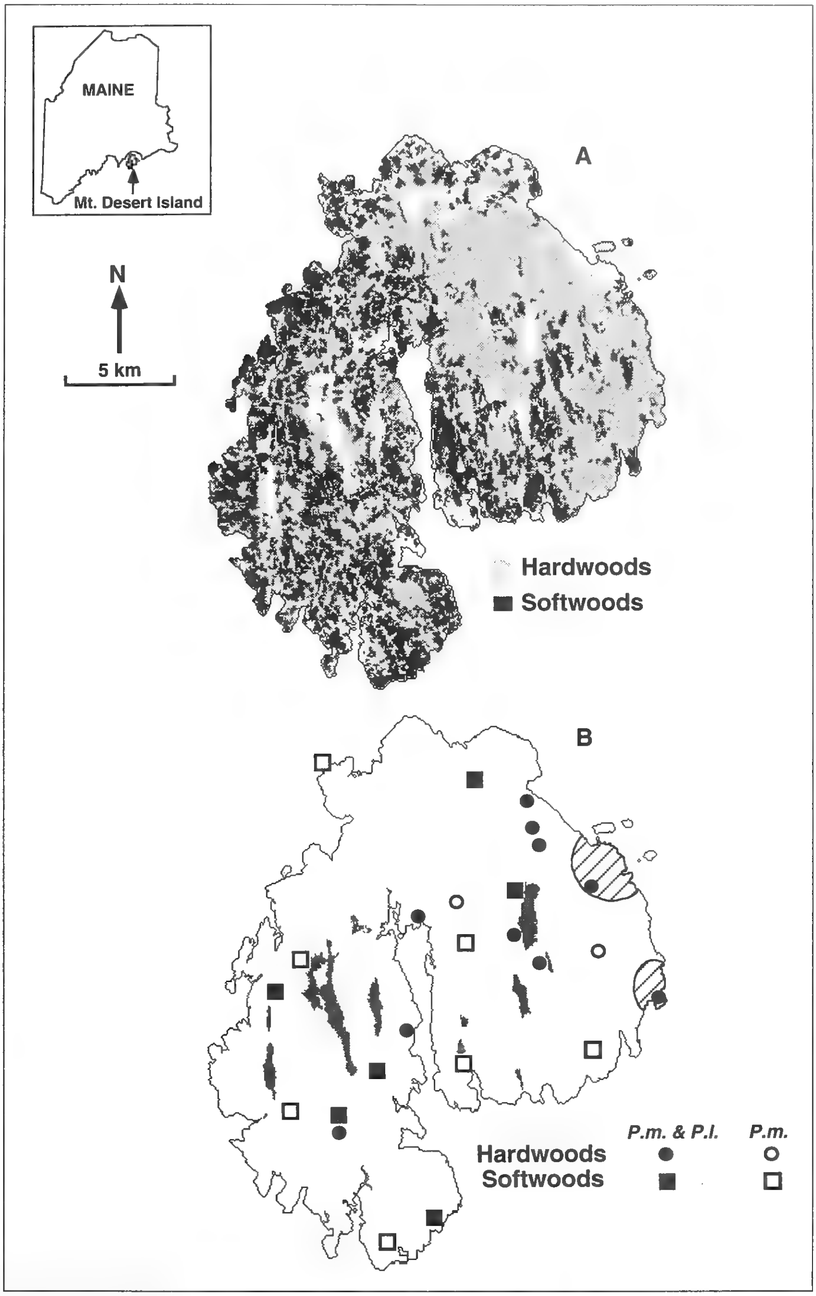

FIGURE 1. A: Map of hardwood and softwood cover types on Mount Desert Island, Maine. Water, rock, and developed areas are coded in white. B: Location of trap sites and captures of *Peromyscus maniculatus* (P.m.) and *P. leucopus* (P.l.). Hatched areas are where Lyme disease has been documented based on Ginsberg and Ewing (1988) and Hazen et al. (1992).

tions of movements by *P. leucopus* from mature Red Spruce to hardwood stands indicated overnight travel exceeding 250 m.

Similar capture rates and co-occurrence in 26 of the 31 trapping periods in deciduous habitat of *P. leucopus* and *P. maniculatus* indicate a high degree of overlap. Analyses of microhabitat use for grid captures failed to show significant negative interactions between *Peromyscus* species but indicated that *P. leucopus* was positively associated with shrub and herbaceous cover less than 0.5 m high in deciduous habitat (Garman 1991). Microhabitat use by *P. leucopus* in deciduous habitat became less selective with increasing density of either *Peromyscus* species indicating that intraspecific interactions (i.e., density) may be important in determining trap site selection for either species of *Peromyscus* (Garman 1991). Similar findings were reported by Wolff (1985) in Virginia where space use by species of *Peromyscus* was found to be regulated equally by intraspecific and interspecific aggression.

Distribution

Although trap sites were not located randomly or systematically, trapping results provided an indication of species distribution across MDI. *Peromyscus maniculatus* appears to be the most widespread small mammal currently on MDI. Any negative effect the 1947 fire may have had on its distribution has been obviated over the 40 years of vegetative change. It is apparent, from visually interpolating among trap sites for captures of *P. leucopus,* that this species has become widely established throughout the area burned by the 1947 fire on the eastern side of MDI. The relatively large contiguous tracts of secondary hardwoods established after 1947 likely provided ample habitat for rapid dispersal, whereas the degree of interspersion of hardwoods among softwoods on the western side of MDI evidently has permitted colonization of suitable habitat.

Distribution of the indigenous *P. maniculatus* on MDI does not appear limited by habitat or by interspecific interactions with the recently established *P. leucopus*. Conversely, habitat alone seems to limit the distribution of *P. leucopus*, and given the current amount of available habitat, this species appears to have an extensive yet localized distribution across MDI.

Currently, the occurrence of Lyme disease on MDI appears limited to a small area (Ginsberg and Ewing 1988; Connery et al. 1992; see Figure 1). However, *P. maniculatus* is reservoir competent for the Lyme disease spirochete in nature (Rand et al. 1993) and the widespread distribution of this species on MDI may facilitate local spread of Lyme disease. Further, the presence of *P. leucopus* may increase the incidence of Lyme disease, especially if land-use practices increase the amount and connectivity of suitable habitat across the MDI landscape.

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Notes

The Migration of a Tagged Leatherback Turtle, *Dermochelys coriacea*, from French Guiana, South America, to Newfoundland, Canada, in 128 Days

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The recovery in Placentia Bay, Newfoundland at 47°19′N of a Leatherback Turtle, *Dermochelys coriacea*, tagged in French Guiana indicated a directed movement at a minimum rate of 39 km/day (or 0.45 m/sec) for 128 days to travel a straight line distance of 5000 km. This turtle was accompanied by a school of nine Pilotfish, *Naucrates ductor*, a species whose previous distribution in the NW Atlantic had not been recorded to extend past 43°10′N. The behaviour of these pilotfish was observed underwater.

Key Words: Leatherback Turtle, *Dermochelys coriacea*, Pilotfish, *Naucrates ductor*, tagged, Newfoundland, French Guiana, migration rate.

Leatherback Turtles, *Dermochelys coriacea*, are large, pelagic marine animals which are regularly observed in cold northern oceans during the late summer feeding on arctic jellyfish (Bleakney 1965; Lazell 1980; Goff and Lien 1988). Tag recoveries and post-nesting movements of female leatherbacks have not determined whether their northward movements represent indirect or direct migration (Pritchard 1976). Their pelagic habits usually made it difficult to exploit opportunities to experimentally study their movements over long distances. Previous reports of Leatherback Turtles in northern oceans have mentioned the presence of small fish that accompany a swimming turtle (Squires 1954; Willgohs 1957; Threlfall 1978).

During 1987, studies of Leatherback Turtles in Newfoundland we encountered a turtle tagged that same summer 5000 km south in French Guiana. This turtle was accompanied by a school of Pilotfish, *Naucrates ductor*. These fish were observed while this turtle was tethered to the dock.

The leatherback was 157 cm curved carapace length and found entangled in a fisherman's nets at 0700 hrs on 17 September 1987, approximately 8 km from Fox Harbour, Newfoundland (47°19′N, 53°55′W), in Placentia Bay. The turtle was towed to Fox Harbour wharf and tethered. It was still swimming vigorously when we first saw the animal at 1445 hrs. The turtle carried a French monel tag numbered G25376 attached to the left rear flipper.

The water temperature in the harbour was 15°C. Thirty minutes observation of the behaviour of the Pilotfish were recorded on a slate by a diver. Still photographs of the fish were taken underwater. Observations were terminated when a large fishing boat manoeuvered to the wharf causing substantial turbulence and turbidity in the water. The Pilotfish disappeared during this disturbance and did not return.

It was later established that the turtle was tagged in French Guiana on 12 May 1987, only 128 days prior to its recovery in Newfoundland. This represents a minimum direct line movement of 39 km each day at a minimum continuous rate of 0.45 m/sec. Six prior tag recoveries on Leatherback Turtles have reported periods from 8 to 37 months following nesting (Pritchard 1976) but none have provided an estimate of the speed of movement over those extended periods.

The nine blue-and-black striped Pilotfish swimming near the tethered turtle and had been present since the turtle was brought to the wharf. The fish swam continuously and moved away slightly whenever the diver approached. They always returned to the area under the turtle when the diver retreated. Several unsuccessful attempts to net a specimen underwater resulted in the fish temporarily fleeing out of view. These fish were slender and approximately 30-40 cm in length. Seven wide, black vertical bars alternated with blue along the body in a distinct pattern. The posterior bar traversed through the deeply forked caudal fin. The species identification was confirmed as *N. ductor* based on examination of the photographs by other scientists familiar with the species, and reference literature (Bigelow and Schroeder 1953; Liem and Scott 1966; Robbins and Ray 1986).

The Pilotfish is a pelagic species which has a circumpolar distribution in warm oceanic waters (Smith-Vaniz 1987). The northernmost distribution of Pilotfish in the western North-Atlantic extends to 43°10′N. Adults and subadults have been reported during the summer off Nova Scotia (Vladykov 1935; Scott and Scott 1988). These Newfoundland observations extend the range of Pilotfish in the western North Atlantic to 47°19′N.

Fish previously sighted accompanying Leatherback Turtles around Newfoundland (Squires 1954; Threlfall 1973) were tentatively identified as remoras. However Willgohs (1957) suggested that Pilotfish may have accompanied a Leatherback Turtle in the North Sea off Norway. Pilotfish commonly attend sharks, rays and other large fish in tropical seas feeding on scraps from these fish in a semi-obligate commensal relationship (Smith-Vaniz 1987). They may also benefit from association with these larger animals through protection from predation (Magnuson and Gooding 1971). Adult Pilotfish often follow vessels.

Juvenile Pilotfish are frequently found associated with floating seaweeds and jellyfish (Eschmeyer et al. 1983; Smith-Vaniz 1987). The importance of jellyfish in the diet of Leatherback Turtles (Bleakney 1965; Pritchard 1971) and the association of juvenile Pilotfish with jellyfish may provide a convenient route for Pilotfish to switch commensal relationships as they develop.

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Migration Bearing and Distance Memory by Translocated White-tailed Deer, *Odocoileus virginianus*

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Nelson, Michael E. 1994. Migration bearing and distance memory by translocated White-tailed Deer, *Odocoileus virginianus*. Canadian Field-Naturalist 108(1): 74–76.

Of nine White-tailed Deer (*Odocoileus virginianus*) translocated during winter, four attempted to return 10-22 km to their capture sites and two did so successfully. Three deer translocated 22 km did not attempt to home but established summer home ranges with distances and bearings from winter ranges that mimicked those of their group members not translocated. Apparently, memory of distance and direction of a migration pattern is part of the navigation process and independent of the topography in which the migration first occurred.

Key Words: White-tailed Deer, *Odocoileus virginianus*, migration, translocation, navigation.

Wildlife managers have translocated White-Tailed Deer, *Odocoileus virginianus*, to create and re-establish populations (Halls 1984) as well as to mitigate effects of overpopulation (Jones and Witham 1990). The literature on translocations of deer emphasizes survival, but homing tendency, distances traveled from release sites, and sizes of post-release home ranges are also documented (Hahn 1945; Glazener 1948; Hamilton 1962; Hawkins and Montgomery 1969; Jones and Witham 1990).

Except for the early observations of homing (Verme 1973), we do not know the movement effects of translocations of northern White-tailed Deer that migrate between traditional summer and winter ranges. Do these deer continue migratory behavior after being translocated? Do adults and fawns show the same propensity to migrate after being translocated? Is the migration behavior and pattern learned by fawns retained by them when permanently separated from their mothers? Does the migration pattern used by a deer in one area influence its subsequent movements when translocated to an unfamiliar area? To begin to examine these questions, I radio-collared deer social groups and then translocated at least one member of each group to a new and unfamiliar area.

Materials and Methods

The deer in this study were followed during 1983-1988 and were from an intensively studied population in northeastern Minnesota (Nelson and Mech 1981, 1987). Eighty percent of the deer in the region migrate seasonally between traditional winter and summer ranges. Fawns accompany their mothers during their first migration to winter ranges, thus learning and repeating the movement patterns of their mothers. Winter weather occurs there between November through April with temperatures between –20° to 10°C and average weekly snow depths of 0.5 m. The topography is relatively flat and mixed coniferous-deciduous forests predominate.

I captured deer family groups by rocket-net in two winter-concentration areas, radio-collared, and radio-tracked them 1-2 times per week. Fawns were presumed to be the offspring of the adult females they were captured with because of the close association between mothers and offspring up to one year of age (Hawkins and Klimstra 1970; Nelson and Mech 1981, 1984). At least one member from each group was translocated distances of 10 to 22 km to unfamiliar areas (except for one) during three winters. The remaining group members were released at their capture sites and migrated in spring presumably to their traditional and familiar summer ranges. Thus, these deer served as controls for comparisons with their social cohorts released in unfamiliar terrain.

Results and Discussion

Nine deer were translocated 10-22 km, of which one was killed by Wolves (*Canis lupus*) at three days post-release, one moved 18 km in a direction away from its winter range before being killed by Wolves 35 days later, four moved homeward, and three established new home ranges. Of the returning deer, an adult female and male fawn successfully returned and an adult female was 10 km short of returning when also killed by Wolves. The fourth, a female fawn, stopped halfway home and later dispersed to a new home range. The summer ranges of all four deer were known from previous radio-tracking or from tracking of other family members. The two adult females homed through unfamiliar areas and the male fawn returned to its winter range after translocation to its summer range. The female fawn may have been in familiar terrain because it was released between its natal and winter ranges.

The three deer establishing new home ranges are the focus of this report because their post-release movements in an unfamiliar area 20 km from their capture sites, mimicked those of their social cohorts not translocated (Table 1, Figure 1).

TABLE 1. Movement and demographic data of translocated deer and their social cohorts in northeastern Minnesota, 1983-1986.

Social Group	Deer No.	Sex	Age	Capture Date	Migration Date or First Move[2,3]	Home Range Bearing	Home Range Dist(km)	Status (T/R)[1]
1	6463	F	2.8	4 March 1983	10 March	300	6.4	T
	6455	F	0.8	4 March 1983	1 May	300	6.4	R
	6465	F	0.8	4 March 1983	1 May	300	6.4	R
2	6482	F	5.8	14 March 1983	4 April	163	6.4	T
	6478	F	0.8	14 March 1983	3 May	155	8.0	R
3	6878	M	0.8	2 April 1986	6 April	137	4.8	T
	6882	F	1.8	2 April 1986	15 April	123	4.8	R

[1] T - translocated, R - released at capture site.
[2] First move after translocation.
[3] Mean Migration Onset of nontranslocated deer: 20 April 1983 (8 April to 25 April) n = 10 deer.
9 April 1986 (7 April to 10 April) n = 4 deer.

Doe 6463 moved from her translocated site 42 days before other deer were leaving winter ranges. She moved minimum distances ≤ 13 km from the translocation site, always within a 180-300° heading. She returned to the translocation site a minimum of six times throughout summer before settling on a new home range, apparently without a new fawn (based on fall observations). The move to her new home range mimicked precisely the migration home range-pattern of her two female fawns that had been left on winter range. Doe 6463 remained on her new summer range as a nonmigratory deer for 18 months thereafter and produced at least one fawn before her collar expired.

Despite the separation from their mother, 6463's daughters retained their natal home range and migration pattern and associated together to at least three years-old when their radios expired. A car killed one of them on their traditional winter range three-years later (then six years old).

Doe 6482 migrated from her translocated site simultaneous with other migrating deer and settled on a summer range where she had a minimum of one fawn. She was located at her translocation site once in late August, but otherwise kept the same migration pattern (two spring and fall migrations) until killed 14 months later. This new home-range-migration pattern was nearly identical in bearing and distance to that of her surviving female fawn left on winter range. Fawn 6478 continued its original home range pattern to at least 3.5-years old when its collar expired.

Buck fawn 6878 migrated simultaneously with other migratory deer but did return to his translocation site 1 month later before settling as a nonmigratory deer during 38 months of radio-tracking. The doe caught with 6878 migrated to a summer range that had roughly the same bearing and distance between seasonal ranges as that between 6878's new range and translocation site.

These findings are descriptive and preliminary but they do indicate that adult deer both continued and later discarded previous migration behavior and pattern following translocation to unfamiliar areas. They further indicate that a fawn discontinued previously learned migration behavior but after an initial migration response following separation from its family group and translocation. In contrast, fawns separated from their social groups but not translocated continued their traditional migration pattern through at least 3.5-years old.

It might be questioned whether 10-month-old fawns migrated to natal summer ranges after their social cohorts were translocated. If not, then they would be invalid controls for the translocated deer. Three lines of evidence suggest otherwise. First, the control fawns all migrated directly to specific sites and in syncrony with other migratory deer. They did not roam widely as if searching for familiar terrain. Second, previously studied fawns successfully returned to their natal range without their mother (Nelson and Mech 1984). One male fawn in this study also returned to his winter range after being translocated to his summer range, demonstrating ability to learn and remember his migration route after his first migration. Finally, the possibility that the control fawns would by chance closely match range bearings and directions of their social cohorts seems an improbable if not impossible scenario. Thus, the ranges of nontranslocated fawns appear to be valid indicators of previous ranges of their translocated cohorts.

An unexpected result from this study suggests that memory of distance and direction may play a role in navigation and migration behavior. The identical and nearly identical migration patterns of translocated

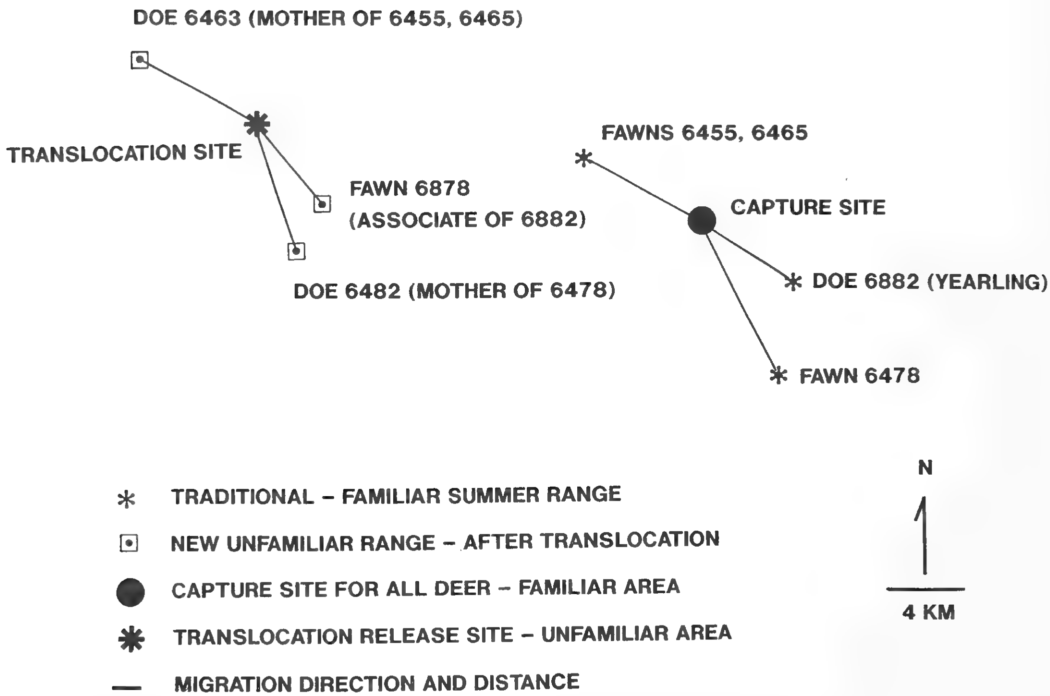

FIGURE 1. Migration direction and distance, and home range locations of translocated deer and their social cohorts not translocated in northeastern Minnesota, 1983-1988.

deer and their nontranslocated cohorts are direct evidence of such memory by deer independent of the original topography in which the migration patterns were first learned. However, the returns to the translocation site by translocated deer suggest attempts to search for familiar terrain in unfamiliar surroundings. Perhaps deer navigate using a combination of these processes and possibly others not examined here. Whatever the case, these results emphasize the strong influence of early social experience and learning on migration behavior (Nelson and Mech 1981, 1984). At the same time, the shift to nonmigratory movements by two of the translocated deer demonstrates that migration was not an obligatory behavior.

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A Mountain-avens, *Dryas* x *sundermannii* Kellerer ex Sündermann, in Alberta

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A hybrid mountain-avens, *Dryas drummondii D. octopetala,* combining many vegetative characters of the former and the floral characters of the latter has been found in Alberta. It is the first known natural occurrence this hybrid. A hybrid of this parentage has been previously synthesized, in a horticultural context, and described as *D.* x *sundermannii.*

Key Words: Mountain-avens, *Dryas* x *sundermannii, D. drummondii,* natural hybrid, Alberta.

Dryas (Mountain-avens) is a widely distributed circumpolar arctic-alpine genus. Hultén (1959) in a worldwide consideration of *Dryas* suggested that it "is a tertiary genus early differentiated into three types: the two closely related *D. octopetala* and *D. integrifolia* and the more different *D. drummondii*". Porsild (1947), in a study more specifically of the genus in North America, would seen to agree as is indicated by his diagram of relationships.

The main purpose of this note is to report the first known natural occurrence of a hybrid between *D. drummondii* and *D. octopetala* (Figure 1). The collection data are as follows: Alberta, Jasper National Park, Vine Creek. Flows SE into Athabasca River between Grassy Ridge and De Smet Range (River mouth 53° 04′ N, 118° 05′ W). Rock outcrops, southern exposure, 4300′–1500′. L. R. Hettinger 219, June 4, 1971. ALTA, accession number 45478.

Dryas drummondii, a plant of gravel bars and talus, is endemic to North America and is widely distributed in the northwest, extending east to about 110°W and from Alaska south in the Rocky Mountains to Montana and northern Oregon. A disjunct population occurs in the Gaspé area of Quebec and adjacent Newfoundland and there is another on the north shore of Lake Superior (Slate Island). It is a very distinct species and exhibits no great degree of morphological variation. The main characters distinguishing *D. drummondii* from the other species are its flat receptacle, nodding flowers, erect yellow petals and pubescent stamen filaments. It is invariably treated as belonging to a distinct section of *Dryas* and Hultén (1959) suggests that it "could easily be taken to belong to a separate genus".

Dryas octopetala, a true arctic-alpine plant of tundra heaths, is a species with a very extensive circumpolar distribution, through not well represented in eastern North America. It is characterized by a convex receptacle, erect flowers, spreading white petals, and glabrous stamen filaments. In contrast to *D. drummondii, D. octopetala* is a morphologically labile species, the leaves exhibiting tremendous variation in size and shape, abundance of glands (stipitate on the lower surface, punctate on the upper, occurrence of "octopetala scales", the amount of tomentum, and rugulosity. The patterns of variation tend to have geographical correlations and as a consequence numerous taxonomic segregates have been recognized. These are taken to be subspecies and varieties by some (Hultén 1959), and by others to be species (Porsild 1947).

In North America there are three such taxa, subspecies *octopetala,* subspecies *alaskensis* and subspecies *hookeriana.* In the context of the present paper the taxon of particular interest is subspecies *hookeriana* because it has a Rocky Mountain distribution and is the only one that occurs in Alberta. *Dryas octopetala* ssp. *hookeriana* is a perfectly respectable taxon and has a suite of leaf characters that readily distinguish it from the other *Dryas* taxa in North America. Of considerable significance is a character that Hultén (1959) describes as "octopetala scales". These are elongate hairs, shiny, reddish-brown, with an axis 0.1–1.0 mm long, from which many ascending white hairs arise forming a tuft. The term is an unfortunate misnomer because the structures are not scale-like, not found in all the subspecies of *D. octopetala* (subspecies *hookeriana* being a case in point) and they are invariable present in *D. drummondii,* through more abundantly on the petioles than on the midvein of the lower surface as is typical of their occurrence in *D. octopetala.*

The recognition of the Hettinger specimen as being a hybrid between *D. drummundii* and *D. octopetala* would have been made more problematical but for the remarkable circumstance that such a hybrid has been produced artificially, in a horticultural context. It was named *D.* x *sundermannii* and formally described by Sündermann (1925). The original description is a perfunctory sentence stating that "The hybrid has slightly drooping flowers, which are yellow in the bud stage, white-yellow when starting to bloom, but white in full bloom" (translated from the original German). Fortunately, Hultén (1959) provides invaluable additional information based on his examination of specimens (isotype?) deposited in the herbarium of the Bergius Foundation, Stockholm (SBT). The flowers are erect, have white petals, glabrous filaments and the leaves are ovate, broadest

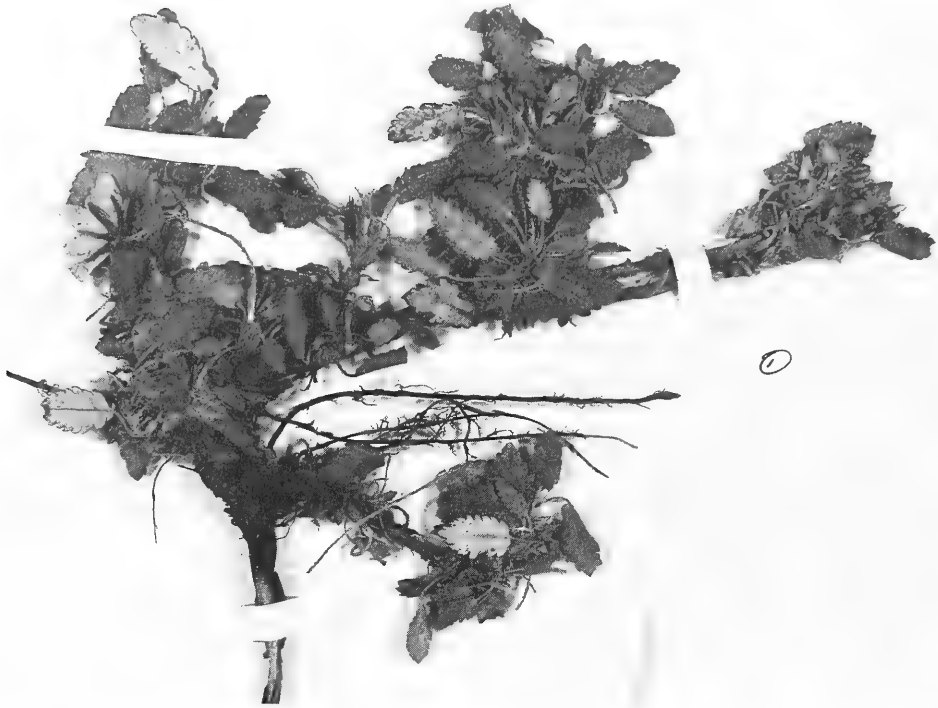

FIGURE 1. The Hettinger specimen from Jasper National Park, Alberta (see text for collection data).

near the base. He goes on to say that "The traces of *D. drummondii* are the large coarse leaves with 8-10 coarse teeth and long coarse creeping stems". It is to be noted in this synthesized hybrid that the flowers exhibit none of the features associated with *D. drummondii* and that the hybrid nature of the plants is expressed only in the vegetative characters.

In assessing the hybrid nature of the Hettinger specimen it is to be observed that it is precisely comparable to the synthesized hybrid *D.* x *sundermannii* in that it possess all the floral characters of *D. octopetala* and that the *D. drummondii* component is evident only in its vegetative parts. In Table 1 the critical leaf characters of *D. octopetala* ssp. *hookeriana, D. drummondii* and the Hettinger specimen are listed for comparison. The latter is intermediate in some characters but in others exhibits the character of one or other of the putative parental species. Overall though there is a decided tendency towards *D. drummondii.* This is also to be seen in the general leaf morphology and habit of the Hettinger specimen shown in Figure 1.

It is clearly evident that, while the Hettinger specimen is not as good as on would wish to have in either quality or quantity, it combines the floral characteristics of *D. octopetala* ssp. *hookeriana* with many of the vegetative characters of *D. drummondii.* This is precisely what one would have anticipated and I have no hesitation in recognizing the Hettinger collection from Jasper National Park as *D.* x *sundermannii.* It is the first known natural occurrence of the hybrid between *D. octopetala* (ssp. *hookeriana*) and *D. drummondii.*

While this is the first report of the natural occurrence of *D.* x *sundermannii,* there exists an earlier record of a hybrid between *D. drummondii* and *D. integrifolia* that was described by Rouleau (1956) and named *D.* x *lewinii.* It was based on material he collected from Wild Cove, near Humbermouth, Newfoundland, where both putative parents were also growing. Rouleau's description of the flower is not detailed but he indicates that the petals are white and spreading; basically similar to *D. integrifolia.* Examination of type material confirms the similarity. The flowers are erect and have stamens with glabrous filaments. As in *D.* x *sundermannii* the hybrid is lacking any of the floral characters typical of *D. drummondii* but in the vegetative parts, in particular the leaves, the evidence of hybridization can be seen. The description of the leaves given by Rouleau for *D.* x *lewinii* (they are also given for *D. integrifolia* and *D. drummondii*) provides an indication of their intermediate nature and this is more clearly apparent from the photographs he includes and from my examination of type material. I would agree with Rouleau that *D.* x *lewinii* is a hybrid between *D. drummondii* and *D. integrifolia.*

However, as a footnote to the above, I am less certain about the material in the herbarium of the Institut Botanique, Université de Montréal, that was

TABLE 1. A comparison of the surface characters of the leaves of *D. octopetala* ssp. *hookeriana*, *D. drummondii*, and the Hettinger specimen.

D. octopetala ssp. *hookeriana*	*D. drummondii*	Hettinger specimen
Lower leaf surface and petiole		
"octopetala scales" absent	"octopetala scales" present (abundant)	"octopetala scales" present (very occasional)
median vein and lateral veins viscid from abundant stipitate glandular hairs	median vein and lateral veins not viscid, stipitate glandular hairs generally sparse or absent	median and lateral veins not viscid, stipitate glandular hairs absent
median and lateral veins exposed, not covered by tomentum	median and lateral veins covered by tomentum	median and lateral veins covered by tomentum
Upper leaf surface		
shiny	dull	shiny
strongly rugulose	reticulate to somewhat rugulose	somewhat rugulose
very viscid from abundant punctate epidermal glands	not viscid, punctate epidermal glands absent	not viscid, punctate epidermal glands absent
glabrous to sparsely arachnoid tomentose along the main vein	glabrous to densely canescant over entire surface	canescent to densely canescent over entire surface

collected in 1952 by Marie Victorin and his associates from Mingan island (Quebec) to which Rouleau also applied the name *D.* x *lewinii.* Both Porsild (an annotated herbarium specimen) and Hultén (1959) have previously expressed reservations respecting these determinations, though Boivin (1966) concurred with Rouleau.

From the foregoing consideration of the only two unequivocal occurrences of *Dryas* hybrids that have *D. drummondii* as a parental species, an obvious question arises. Given the fact that such natural hybridization does occur (and apparently these hybrids are not difficult to produce in vitro), what factors account for their apparent rarity. In this connection, it should be borne in mind that in continental North America the three basic species, *D. drummondii, D. octopetala* and *D. integrifolia*, have overlapping distributions, and while they all have different ecological requirements they often grow in adjacent habitats and can be sympatric in ecotonal areas. Also to be noted is the fact that the pollen of the Hettinger specimen is properly formed and has a high stainability.

No simple answer to this question is presently available. However, one possibility that should be fully explored is that the hybrids are not so much rare as overlooked. This could come about by a combination of two circumstances. The fact that all three species are generally very common in the habitats they occupy, coupled with the fact that the flowers of the hybrids are identical to those of *D. octopetala* or *D. integrifolia.* Field botanists generally do not collect many samples of very common species,a practice for which there are sound economic and logistic reasons. As a consequence it could easily be that hybrids involving *D. drummondii* are passed over because, when flowering (the time when field work is usually undertaken) they are simply assumed to be *D. octopetala* or *D. integrifolia.* The Hettinger specimen was originally determined as *D. octopetala* ssp. *hookeriana.* I would recommend that anyone engaged in field work, where *D. drummondii* and one or other of the *Dryas* species are encountered in the same area, periodically examine the leaves and habit of the white-flowered plants they are walking over or around. If they look like *D. drummondii* they are probably hybrids.

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Use of Mammalian Prey by Nesting Merlins, *Falco columbarius*, in Atlantic Canada

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A pair of Merlins, *Falco columbarius*, nesting in eastern Newfoundland in typical open forest habitat stocked with suitable avian prey species, used mammalian prey in courtship, food exchanges, and feeding of their young. In northern Nova Scotia, adult Merlins fed small mammals to recently fledged young in two nesting areas, and another adult carried a small mammal for 1.5 km, presumably to feed to its young.

Key Words: Merlin, *Falco columbarius,* prey items, small mammals, Newfoundland, Nova Scotia.

On 9 May 1987, a pair of Merlins *Falco columbarius*, in an agitated state, were seen around an abandoned nest of American Crow, *Corvus brachyrhynchos*, in the Newman Sound area of Terra Nova National Park, Newfoundland (48°33′N 53°59′W). The nest was ca. 8 cm up, well-concealed in the crown of a live 10 m Balsam Fir, *Abies balsamea*, tree. Other typical boreal trees such as Black Spruce, *Picea mariana*, and White Birch, *Betula papyrifera*, were scattered in the vicinity, where openings for houses and lawns occupied about 15% of the surface area.

The following passerine birds, presumably all acceptable prey, were present in the study area: Hermit Thrush, *Catharus guttatus*, American Robin, *Turdus migratorius*, Black-throated Green Warbler, *Dendroica virens*, White-throated Sparrow, *Zonotrichia albicollis*. Only two small (mouse-sized) mammals were known to occur in the area: the native Meadow Vole, *Microtus pennsylvanicus*, and the introduced Masked Shrew, *Sorex cinereus*. The vole was common, especially among the grasses and sedges of a nearby septic field, and the shrew was abundant, being observed visually almost daily. Red Squirrels, *Tamiasciurus hudsonicus*, were also common, following a recent introduction to the region.

During intermittent observations over the season, all observed prey loads (seven in total) brought by Merlins to the vicinity of the nest were assessed as being small mammals. These included three passed to the female by the male, on 15, 21 and 25 June, and two brought to or fed on by flying young, on 11 and 20 August. The item being eaten on 11 August appeared large enough to have been a sub-adult squirrel; all others were "mouse-sized". All observations were confirmed by 8 × 30 binoculars.

The literature implies that passerines make up all or nearly all the prey fed to Merlin nestlings (e.g., Becker 1984; Bent 1938; Newton et al. 1984; Knapton and Sanderson 1985; Temple 1972; Watson 1979). Although my absence from the area during most of July limited my time for watching them, it seemed obvious that this pair used mammalian prey regularly despite the availability there of (more usual) avian prey species. Mammals as prey are recorded rarely to very rarely in most studies. Becker (1984) found a total of 1951 individual prey remains and 110 pellets were collected from nests and perches during 88 visits to nest sites. These items represented at least 427 prey items (393 birds of 28 species; 22 insects = moths and grasshoppers; 11 mammals = 8 Thirteen-lined Ground Squirrels, 2 *Myotis* spp. and one least chipmunk; 1 reptile). Newton et al. (1984) described the diet of Merlins in Northumbria, U.K. from prey remains found near nests, April-July 1974–1982. Of 1991 individuals recorded, 1908 (96%) were birds representing 50 species (one species accounted for 59% of all birds); 78 insects of six species; and five mammals (two voles, one mouse, one bat, one shrew). "It was surprising that mammals formed such a small part of the diet, because Field Voles were abundant in young pine plantations and similar species have been found in the food of Merlins in northern Norway in good vole years. Having said this, however the Merlin's hunting methods are not well suited to catching rodents."

Temple (1972) made observations at 20 Merlin nests in Newfoundland. "Of 136 prey remains found at Merlin nests, three species comprised over half of the Merlin's diet: the Gray Jay, the Robin and the Savannah Sparrow."

The following records, extracted from files of the Maritimes Breeding Bird Atlas by A. J. Erskine, provide additional evidence for this previously unreported flexibility in prey use by breeding Merlins. On 10 August 1985, Thane Watts saw a recently fledged young Merlin feeding on a "small rodent" near a nest in the Ingonish Beach campground, Cape Breton Highlands National Park, Nova Scotia (46°51′N, 63°24′W). On 23 July 1988, Fulton Lavender watched an adult Merlin carry a "small rodent" over a distance estimated at one mile (1.6 km) until it disappeared over woodland, presumably to feed young birds, near Port Philip bridge, Nova Scotia (45°51′N, 63°44′W). The same files also included nine references to Merlins preying on small birds during the nesting season or carrying avian prey to their nests. Thus, mammals were reported in one quarter of the 12 cases in the Maritimes where prey of nesting Merlins was classified.

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Marten, *Martes americana*, Predation on a Northern Goshawk, *Accipter gentilis*

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Paragi, Thomas F., and George M. Wholecheese. 1994. Marten, *Martes americana*, predation on a Northern Goshawk, *Accipter gentilis*. Canadian Field-Naturalist 108(1): 81–82.

The site where a Marten *Martes americana* killed a Northern Goshawk *Accipter gentilis* was found during snowtracking in the taiga of western interior Alaska. The Marten dragged the raptor >0.5 km before beginning to feed on it. Although Martens are known to prey on passerines and gallinaceous birds, this is apparently the first report of one attacking and consuming a raptor.

Key Words: Marten, *Martes americana*, predation, Northern Goshawk, *Accipter gentilis*.

While snowtracking a Marten for a study of habitat use in post-fire seral stages of the Alaskan taiga (64°40′N, 154°00′W), the junior author found evidence that a Marten had located and killed a Northern Goshawk after a 5 m stalk and short (2 m) struggle. The Goshawk had apparently been perched ca. 20 cm above the snow on a leaning dead Black Spruce, *Picea mariana,* tree 10 cm in diameter. The perch was in a strip of mature coniferous forest (ca. 100-115 yrs old, canopy cover ⩾50%) consisting primarily of Black Spruce and Larch, *Larix laricina,* adjacent to regrowth from a 1966 fire (canopy cover <50%). A gray pellet (ca. 2 cm × 7 cm) was found at the kill site, suggesting that the Goshawk may have been preoccupied with regurgitating (Craighead and Craighead 1956: 126). The Marten dragged the Goshawk for >0.5 km (paced trail): 165 m through mature coniferous forest; 106 m in the sparse regrowth of the burn; 73 m along a ridge of unburned Quaking Aspen, *Populus tremuloides,* in the burn; and then 225 m into another strip of mature coniferous forest. The Marten pulled the Goshawk carcass into a hole and dismembered it under the snow. Blood, a few downy feathers, and a lower leg were found at this site, and a primary feather was found along the drag trail. (T. Swem, U.S. Fish and Wildlife Service, Fairbanks, Alaska, identified the Goshawk as an adult female based on plumage and tarsus size.) Tracking conditions were excellent; a light, granular snowfall (ca. 0.5 cm) had occurred three days before (15 February 1993), the sky was clear, and no drifting of the tracks had occurred since the snowfall. The junior author returned to the feeding site the following day with a shovel, but the subnivian spaces were extensive, and no further remains of the Goshawk were found.

Marten diets are composed largely of microtine rodents and Snowshoe Hares, *Lepus americana,* during winter in North America (*see* Slough et al. [1989] and the review of food habits studies in Strickland and Douglas [1987]). They are known to seasonally prey on a variety of passerine and gallinaceous birds, but we found no mention of raptors in the Marten diet. However, Martens are opportunistic scavengers (Strickland and Douglas 1987), so birds of prey could occur in their diet. Moving large prey to secluded or subnivian feeding sites is not uncommon in Martens (Pulliainen 1981*a*; Henry et al. 1990). We also found no records of raptors in the diet of Fishers, *Martes pennanti* (Powell 1982: Table 9; Douglas and Strickland 1987), even though the Fisher (2-4 kg) is larger than the Marten (0.8-1.2 kg). However, Paragi (1990:100) noted the foot of a juvenile raptor (species not determined) at the rest site of a female Fisher with kits.

Known avian predators of martens, *Martes americana* and *Martes martes,* include Great Horned Owls, *Bubo virginianus* (Grinnell et al. 1937 *in* Hargis and McCullough 1984; G. Bamford, Kobuk, Alaska, personal communication); Golden Eagles, *Aquila chrysaetos* (Nyholm 1970; Huhtala et al. 1976 *in* Pulliainen 1981*b*; Korpimaki and Norrdahl 1989); and possibly Eagle Owls, *Bubo bubo* (Pulliainen 1981*b*). Mean weight of Golden Eagles and Eagle Owls from Eurasia (Korpimaki and Norrdahl 1989) and of Great Horned Owls (Craighead and Craighead 1956: 427) is generally greater than that of Martens. Northern Goshawks are of similar weight as Martens (Craighead and Craighead 1956: 427; T. Swem, *in correspondence*); however, weasels, *Mustela* spp., were the only mustelid found in their diet (Craighead and Craighead 1956: 287; Schnell 1958: 384).

The dark pelage of Martens makes them conspicuous against the snow, and some studies have suggested that Martens avoid habitats of little or no overhead cover in winter because of avian predators (Herman and Fuller 1974; Pulliainen 1981*b*; Hargis and McCullough 1984). However, Magoun and Vernam (1986) and our on-going study (W. N. Johnson and T. F. Paragi: The relationship of wildfire to Lynx and Marten populations and habitat in interior Alaska. Annual Report, Calendar Year 1993. U.S. Fish and Wildlife Service, Galena, Alaska) have found that Martens may live entirely within recent burns (<10 years old) that have overhead cover limited mostly to fallen and leaning trees that had died in the fire. This coarse woody debris may provide Martens with sufficient access to subnivian spaces as escape terrain from avian predators. Alternatively, Korpimaki and Norrdahl (1989) hypothesized that Martens and Mink, *Mustela vison,* maintain a dark winter coat because they have few avian predators, whereas smaller mustelids such as weasels evolved a white coat for winter because they are subject to predation by a larger suite of birds of prey.

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The Large Yellow Underwing, *Noctua pronuba* Linn. (Lepidoptera: Noctuidae), in Ontario

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Morton, J. K. 1994. The Large Yellow Underwing, *Noctua pronuba* Linn. (Lepidoptera: Noctuidae) in Ontario. Canadian Field-Naturalist 108(1): 83.

A single female specimen of the Large Yellow Underwing, *Noctua pronuba* Linn., was collected in the Manitoulin District of Central Ontario in the late summer of 1992. This represents a notable westward extension of the known range of the species in North America, previously recorded west to Montreal, and is the first report from the Province of Ontario.

Key Words: Large Yellow Underwing Moth, *Noctua pronuba*, Cutworm, Ontario, range.

Noctua pronuba Linnaeus is a common cutworm moth in Britain and Western Europe. It was first reported as an introduction in North America in Halifax, Nova Scotia in 1979 (Neil 1981). Since then it has spread throughout the Atlantic Provinces and into Newfoundland, Quebec and Maine (Morris 1987; Wright and Neil 1983; Wright 1987; Néron and Legault 1992). Its appearance in Central Ontario represents an extension of its known range of distribution by about 650 km. The single specimen, a female (voucher in author's collection), was collected on 18 September 1992 on Little La Cloche Island, Manitoulin District in a black-light trap. The occurrence of this species here is more remarkable because the locality is remote from major arteries of transportation and settlement. It suggests that the moth spread here by its own flight rather than by human agencies. This raises the probability that the insect occurs at locations between Little La Cloche Island and Montreal, its previously most westerly known location. Collectors should be on the look-out for it.

Noctua pronuba is a large moth - wing span about 55 mm. With its black-bordered yellow hind wings it cannot be confused with any other species of moth in North America. The larvae are cutworms which feed, mainly at night, on a wide variety of low plants including grasses. In Britain they are a common garden pest, cutting off leaves and partially defoliating the plants. They over-winter in the larval state and pupate during the spring.

Figure 1. Large Yellow Underwing Moth, *Noctua pronuba* Linnaeus collected in the Manitoulin District, Ontario.

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Addendum:

Since this report was written the Large Yellow Underwing has been collected on nearby Manitoulin Island — on Greenbush Road, Howland Township, 4 August 1994, one freshly emerged male.

14 September 1994

Distribution and Abundance of Common Map Turtles, *Graptemys geographica,* in the Ottawa River, Québec

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Daigle, Claude, Alian Desrosiers, and Joël Bonin. 1994. Distribution and abundance of Common Map Turtles, *Graptemys geographica*, in the Ottawa River, Québec. Canadian Field-Naturalist 108(1): 84–86.

During the spring and summer of 1992, we searched for Common Map Turtles (*Graptemys geographica*) on the Québec side of the Ottawa River. We found that Common Map Turtles as well as Painted Turtles (*Chrysemys picta*) were abundant and widely distributed in the study area. Of the 544 turtles observed during this study, 334 were Common Map Turtles, 204 were Painted Turtles, one was a Snapping Turtle (*Chelydra serpentina*) and five were unidentified. Until recently, the only known important Common Map Turtle population documented with counts was located at the mouth of the Ottawa River near Montreal. The existence of other important populations 200 to 350 km upstream in this river is now verified.

Au printemps et à l'été 1992, nous avons vérifié la présence de la Tortue géographique (*Graptemys geographica*) dans la partie québécoise de la rivière des Outaouais. Nous avons trouvé que la Tortue géographique, tout comme la Tortue peinte (*Chrysemys picta*) étaient abondantes et largement distribuées dans l'aire d'étude. Durant nos travaux, nous avons observé 334 tortues géographiques, 204 tortues peintes, une chélydre serpentine (*Chelydra serpentina*) et 5 tortues non-identifiées pour un total de 544 tortues. Jusqu'à tout récemment, on ne connaissait qu'une seule population de Tortue géographique d'importance au Québec, cette dernière située à l'embouchure de la rivière des Outaouais près de Montréal. L'existence d'autres populations importantes 200 à 350 kilomètres en amont sur cette rivière est maintenant vérifiée.

Key Words: Common Map Turtle, *Graptemys geographica*, abundance, distribution, Ottawa River, Québec.

Common Map Turtles (*Graptemys geographica*) are found in the United States, from Minnesota and Wisconsin to Arkansas, in Oklahoma and Kansas, and from Alabama to southern Canada (Ernst and Barbour 1972). In Canada, this turtle is present in southern Ontario and southwestern Québec (Cook 1984). Until recently, we knew of only one well-documented population in Québec. This population, located in lac des Deux-Montagnes, at the mouth of the Ottawa River near Montreal, represents the northestern limit of distribution for this species. It had been estimated at 350 individuals (Gordon and MacCulloch 1980). Records compiled by Bider and Matte (1991) indicated that there could be a second important population 200 km upstream in the Ottawa River. They report six records for the 1922-1989 period. They also note nine Common Map Turtles for this same sector in 1990, of which eight were net captured during a fish survey. The earliest report of this population was by Patch (1925) who had recorded one taken in September 1922 and 10 on 29 June 1924. The Common Map Turtle is likely to be designated threatened or vulnerable in Québec (Beaulieu 1992) and before doing so, there was a need to determine the status of this species more exactly. During the spring of 1992, we looked at the abundance and distribution of the Common Map Turtle in the Ottawa River, and the results of this survey are reported here.

Study Area

The study area is part of the St-Lawrence lowlands natural region (Ministère du Loisir, de la Chasse et de la Pêche 1986). This region has the warmest climate in Québec, with a mean annual temperature of 5.0°C and a growing season with an annual number of degree-days between 3000 and 3200 degree-days. The area investigated included only the Québec side of the Ottawa River, between Hull and Rapides-des-Joachims (Figure 1). Along its approximately 200 kilometers, it is intersected by four hydro-electrical dams, but otherwise is only moderately used by man. Although there are a few lodges and occasional villages and towns, the river banks are generally not very disturbed. Current varies greatly. Generally the river flows slowly, enlarging in some places to form lakes of many hundred hectares. Some sections, however contain more rapid water; and the fastest sections could not be surveyed. Islands and bays, as well as basking sites for turtles, are numerous. Other than the Common Map Turtle, two species of turtles are common: the Painted Turtle (*Chrysemys picta*) and the Snapping Turtle (*Chelydra serpentina*). Bider and Matte (1991) also report a few records of Common Musk Turtle (*Sternotherus odoratus*), Blanding's Turtle (*Emydoidea blandingi*) and Eastern Spiny Softshell (*Apalone spinifera*) from the area .

Methods

During spring, Common Map Turtles spend much time basking on exposed rocks, logs, and river banks where they are particularly easy to see (Gordon and MacCulloch 1980). We surveyed the major part of the study area between 25 May and 12 June, 1992 (section "B" on Figure 1). Two other sections were sur-

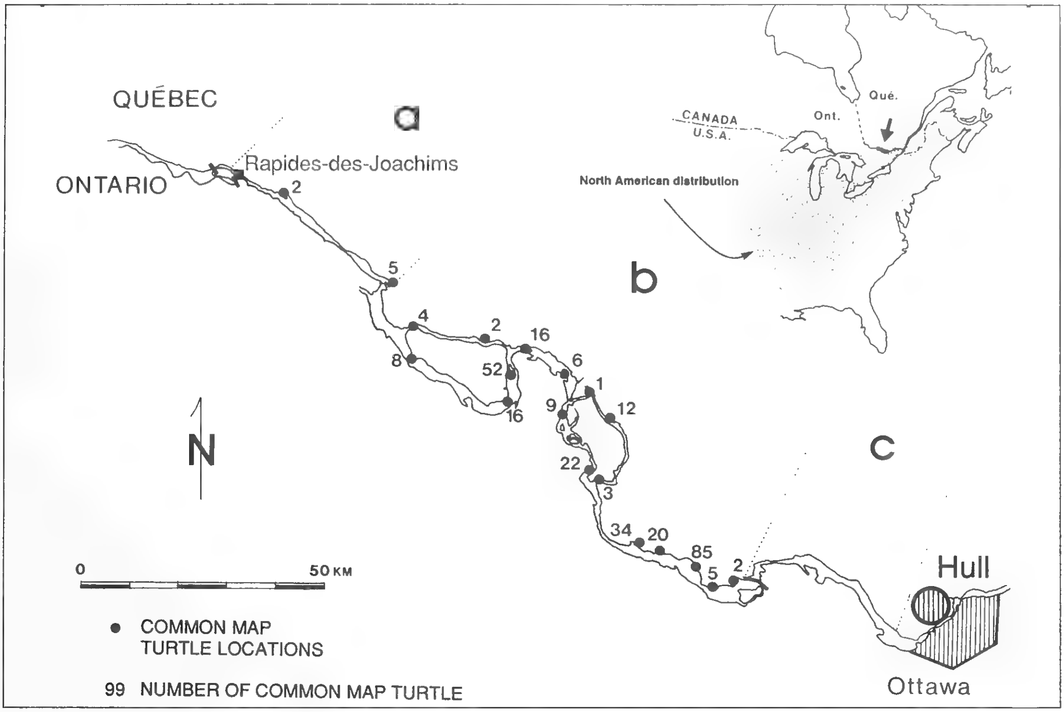

FIGURE 1. Common Map Turtle distribution in the study area.

veyed later in summer. The upstream section "A", from Rapides-des-Joachims to Downey Bay, was visited on 15 July while the downstream section "C", from Quyon to Hull, was surveyed on 12 August.

Two observers explored the area in a motorboat driven at low speed (<5km/h). Potential basking sites were scrutinized with binoculars. Observations were localized on 1:20 000 topographic maps used for navigation. Precise location (longitude and latitude) of each observation were recorded on a data sheet. Common Map Turtles are shy and wary (Froom 1976). On most occasions, we approached turtles by boat, with one observer watching them with binoculars to tentatively identify and count them before they disappeared under water. On other occasions, we approached them on land using forest cover to finally identify them with a telescope (25X). Afterwards, we examined the vicinity closely looking for other turtles, particularly Common Map Turtles which are notably gregarious (Ernst and Barbour 1972). Turtles were identified based on morphological descriptions and illustrations presented by Cook (1984). There was no attempt to determine sex or age class of turtles. In some occasions we captured turtles using a large dip net. These captures helped familiarize us with details of the species' morphology.

Results and discussion

We observed 334 Common Map Turtles, 204 Painted Turtles, 1 Snapping Turtle and 5 unidentified turtles, for a total of 544. Common Map Turtles were abundant and widely distributed in the study area. The northernmost sighting of that species was two females in a large shallow bay 7 km north of

TABLE 1. Turtle observations by habitat type in the Ottawa River, Québec, in 1992.

Species	Habitat type		
	Rocky	Marshy	Sand beach
Common Map Turtle	152	118	11
Painted Turtle	29	142	1
Snapping Turtle	0	1	0
Total[1]	181	261	12

[1]Information related to habitat not available for all observations.

Deep River, Ontario (77° 33′ 20″W, 46° 10′10″ N). Common Map Turtles were seen alone or in groups of up to 30. Highest concentrations were found along the east shore of Fraser Island (52 turtles; 76° 50′ W, 45° 51′ N) and in marshy bays of lac des Chats, about 5 km west of Norway Bay (20 and 34 turtles; 76° 32′ W, 45° 32′ N) and 5 km southeast of Norway Bay (85 turtles; 76° 23′ W, 45° 29′ N). Turtles were found mostly in bays or among islands. These were either marshy habitats with abundant emergent vegetation or rocky environments with little vegetation but with numerous basking sites. On one occasion we found 11 Common Map Turtles on a sand beach (Table 1). When Common Map Turtles were found we often spotted some more in the vicinity. We observed them basking in company of Painted Turtles, a species also abundant and widely distributed in the study area, but with a preference for marshy habitat. The only Snapping Turtle observed was located on a Muskrat lodge (*Ondatra zibethicus*) in a marshy bay.

Weather during our spring survey was propitious for turtle basking. On a scale of 1 to 10, sunniness averaged 9. Air temperature varied between 12 and 24°C with an average of 17°C, being generally higher than water temperature, which varied from 13 to 15°C. Regardless of weather, we observed turtles each day. Both 15 July and 12 August (sections A and C) were warm sunny days with little wind. Only seven Common Map Turtles were seen in section "A" while none (even heads) were seen in section "C". For these two sections, a small number of sightings of that species was expected because of reduced basking activity during July and August (Gordon and MacCulloch 1980).

Results of this study were influenced by the methods used and the turtles' behavior. Our methods did not allow an exact estimate of population size. We travelled many kilometres on the river each day and it seems unlikely that any turtles had daily movements large enough to be counted more than once. Only two places were visited twice. By subtracting the 30 Common Map Turtles and seven Painted Turtles possibly seen a second time, we obtained a minimal estimate of the study area populations of 304 Common Map Turtles, 197 Painted Turtles, 1 Snapping Turtle and 5 unidentified turtles for a total of 507 individual turtles. Under similar conditions in lac des Deux-Montagnes, Gordon and MacCulloch (1980) observed daily between 50 and 60 Common Map Turtles for a population they estimated at 350 individuals. This is roughly the numbers of turtles we observed at each of the three different concentration areas. In a part of our study area, where we found 85 Common Map Turtles, Chabot and al. (1993) estimated during the same period the population at roughly 350 individuals. Those results suggest that there are over 1000 Common Map Turtles in the area covered by our surveys

Acknowledgments

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Allogrooming by Rocky Mountain Bighorn Sheep, *Ovis canadensis canadensis*, in Glacier National Park, Montana

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Keating, K. A. 1994. Allogrooming by Rocky Mountain Bighorn Sheep, *Ovis canadensis canadensis*, in Glacier National Park, Montana. Canadian Field-Naturalist 108(1): 87–88.

Allogrooming between adults has been reported for many ungulate species, but not for sheep (*Ovis* spp.). I observed nine instances of allogrooming between adult Rocky Mountain Bighorn Sheep (*O. canadensis canadensis*) in Glacier National Park, Montana. Observations failed to support the hypothesis that an individual's role during allogrooming is related to social dominance. Seasonality, grooming behaviors, and observations of ticks (Acarina, Ixodidae) being consumed all supported the hypothesis that allogrooming is an adaptation to ectoparasites.

Key Words: Bighorn Sheep, *Ovis canadensis*, Ixodidae, ectoparasites, ticks, allogrooming.

Allogrooming (i.e., the grooming of one individual by another) has been observed between adults of many ungulate species (Browman and Hudson 1957; Struhsaker 1966; Miller 1971; Hafez and Bouissou 1975; Signoret et al. 1975; Waring et al. 1975; Dubost and Feer 1981; Hall 1983; Hart and Hart 1988; Forand and Marchinton 1989). However, observations of allogrooming between adult sheep (*Ovis* spp.) are conspicuously lacking (Hall 1983; Hulet et al. 1975). This note reports on allogrooming between adult Rocky Mountain Bighorn Sheep (*O. canadensis canadensis*) and considers these observations in light of hypotheses about the underlying determinants of such behavior.

During April 1987 and May 1988, I observed nine instances of allogrooming between adult Bighorn Sheep on the Mt. Altyn winter range in Glacier National Park, Montana. Grooming consisted of nibbling along the back and lower neck. In all cases, allogrooming was non-mutual and was initiated by the groomer, an adult female. In 1988, two unsuccessful grooming attempts were inferred when the groomer approached another female but was rebuffed with head butts; successful groomings of other individuals immediately preceded and followed these consecutive attempts. Of nine successful allogroomings, seven were with other adult females and two were with an approximately four-year-old male. The same female was the groomer in eight consecutive events during an approximately 30-minute period in 1988, and may also have been the groomer in the one event observed in 1987. Hall (1983) similarly reported that the same female was the groomer in 78% of observed allogroomings in Red Deer (*Cervus elaphus*).

Observing that dominant individuals initiated allogrooming between adult Mule Deer (*Odocoileus hemionus*), Miller (1971) suggested that allogrooming reinforces social bonds between dominant and subordinate animals, thereby strengthening group unity in a manner "beneficial to the species." Although the selective mechanisms underlying this hypothesis remain unclear, the idea that social dominance is related to an individual's role during allogrooming is, nonetheless, implicit in recent work: Hall (1983) observed that most allogrooming in Red Deer was conducted by a single, socially dominant female, while Dubost and Feer (1981) reported that allogrooming in Blackbuck (*Antilope cervicapra*) did not normally involve the alpha female. Among the Bighorn Sheep I observed, no clear relationship existed between social status and an individual's role during allogrooming. In one instance, the female being groomed rubbed her forehead and horns against the side and flank of the groomer, indicating that she was subordinate to the groomer (cf. Geist 1971). However, the groomer was subordinate to the female that rebuffed two grooming attempts and to the four-year-old male. Dominance behaviors were absent in the remaining interactions.

Mooring (1989) and Hart (1990) hypothesized that allogrooming is an adaptive response to ectoparasites, noting that tick loads may be much greater on animals prevented from self-grooming or allogrooming (Snowball 1956; Hart 1990), and may cause reduced growth rates, lower body weights, and increased mortality (Little 1963; Seebeck et al. 1971). This hypothesis is supported by the fact that allogrooming in ungulates is often focused around the head, neck, and shoulders (Struhsaker 1966; Miller 1971; Dubost and Feer 1981; Hall 1983; Hart and Hart 1988; this study) — areas inaccessible to self-grooming (Struhsaker 1966; Mooring 1989). This hypothesis also is supported by the observation that allogrooming is common in Mule Deer and Impala (*Aepyceros melampus*), which "frequent brushy areas that presumably place the animals more at risk for acquiring ticks" (Hart 1990: 278), but is rare or absent in grassland species such as Grant's Gazelle (*Gazella granti*) or Wildebeest (*Connochaetes taurinus*) (Hart and Hart 1988).

My observations were consistent with the ectoparasite hypothesis. Allogrooming was observed only during spring, the period when ticks (Acarina: Ixodidae) most often are encountered in Glacier National Park. Ticks commonly were seen on Bighorn Sheep during this period, and individuals often were observed rubbing the back of the neck and shoulders with the tips of their horns, sometimes until the skin was quite raw. Geist (1971:276) observed similar responses to ticks by Bighorn Sheep in Canada. Together with the prevalence of ticks, this behavior suggested that ticks were a common irritant on areas of the body that were inaccessible to self-grooming and which received the most attention during allogrooming. During allogrooming, nibbling and chewing behavior suggested that ectoparasites were being actively sought and consumed. I watched as one tick was removed and eaten during allogrooming, and saw another consumed during self-grooming.

Although Rocky Mountain Bighorn Sheep typically occupy grassland habitats (Buechner 1960; Geist 1971), they were commonly observed foraging in brushy areas at the base of Mt. Altyn, particularly during spring. Thus, my observations were consistent with the hypothesis (Hart 1990) that allogrooming is adaptive for ungulates occupying brushy, tick-infested habitats. However, the fact that Bighorn Sheep usually are associated with montane grasslands or meadows suggests that allogrooming may be part of the behavioral repertoire of even so-called "grassland" species. Correlations between habitat and allogrooming (Hart and Hart 1988) may, therefore, reflect differences in tick abundances rather than inherent constraints upon species' behavioral responses. Genetic and environmental determinants of allogrooming should be distinguishable by comparing allogrooming behaviors among experimentally infected individuals of both grassland- and brushland-associated species.

Acknowledgments

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First Confirmed Breeding Record for the Upland Sandpiper, *Bartramia longicauda,* in British Columbia

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van den Driessche, Ruth, Stephen D. McConnell, and Tracey D. Hooper. 1994. First confirmed breeding record for the Upland Sandpiper, *Bartramia longicauda,* in British Columbia. Canadian Field-Naturalist 108(1): 89–91.

The first confirmed breeding record of the Upland Sandpiper, *Bartramia longicauda,* for British Columbia was recorded in summer 1992 near Riske Creek in the Cariboo-Chilcotin region of the province.

Key Words: Upland Sandpiper, *Bartramia longicauda,* breeding, Riske Creek, British Columbia.

The breeding range of the Upland Sandpiper, *Bartramia longicauda,* in North America includes north-central Alaska, northern Yukon, southwestern Mackenzie, northern Alberta, Saskatchewan, southern Manitoba, southern Ontario, southern Quebec, New Brunswick, and 15 of the lower 48 states including eastern Washington and northeastern Oregon (American Ornithologists' Union 1983). The Upland Sandpiper is known to breed in all states, provinces, and territories in the Pacific Northwest excluding British Columbia. Its status within Oregon is listed as a very rare summer resident (Gabrielson and Jewett 1970). Breeding in Washington state occurs in Spokane County, east of the Cascades (Jewett et al. 1953; Larrison 1981). The Upland Sandpiper breeds locally in most of Alberta east of the foothills (Salt and Salt 1976) and in the Northwest Territories (Scotter et al. 1985), the Yukon Territory (Frisch 1982) and Alaska (Campbell 1967; Gabrielson and Lincoln 1959).

The breeding status of the Upland Sandpiper within British Columbia is uncertain (Campbell et al. 1990). Unconfirmed reports of breeding have been obtained from the Peace River area in northeastern British Columbia (Cowan 1939; Munro and Cowan 1947; Guiguet 1955; Roberson 1980; Godfrey 1986), northern British Columbia (Cannings et al. 1987), and 145 km west of Williams Lake (Godfrey 1986). The Upland Sandpiper is suspected to have once bred in the Okanagan (Guiguet 1955; Cannings et al. 1987), the interior (Brooks and Swarth 1925) and as far east as Newgate in the East Kootenays in southeastern British Columbia (Brooks 1920). Although these breeding records have not been confirmed (Campbell et al. 1990), they do suggest that nesting activity occurs in the province.

Upland Sandpipers were discovered on 17 May 1991, near Riske Creek, British Columbia during a survey of grassland breeding birds. The birds remained in the area until at least 7 July, and were thought to be breeding at this time, although no evidence was found to substantiate this.

Riske Creek is 45 km southwest of Williams Lake (51° 52″N, 122° 21″W), on the Fraser plateau in southern interior British Columbia. This area represents the northern limit of grasslands in the Interior Douglas-fir and Bunchgrass biogeoclimatic zones. Characteristic bird species found on this high-elevation (970 m) grassland are Vesper Sparrow (*Pooecetes gramineus*), Savannah Sparrow (*Passerculus sandwichensis*), Horned Lark (*Eremophila alpestris*), Mountain Bluebird (*Sialia currucoides*), Western Meadowlark (*Sturnella neglecta*), and Long-billed Curlew (*Numenius americanus*) (Hooper and Savard 1991).

During 1992, grassland breeding bird surveys were continued in the Riske Creek area. Two Upland Sandpipers appeared on 12 May. Dates of arrival for breeding Upland Sandpipers elsewhere were 20 May in the Peace River region (Cowan 1939), and mid-May in the Yukon (Frisch 1982).

On 17 May, at least four Upland Sandpipers appeared in the same pasture as in 1991. They were very vocal and very visible. Between 1 and 6 June, subsequent visits to the area revealed two to five Upland Sandpipers. The exact number of individuals present was difficult to determine, mainly because the birds, on landing in the long grass, ran at such a pace that their movements could not be traced.

On 2 and 4 June, the suspected breeding site was systematically searched by "sweeping" the area with a 50 m nylon chain kept taut enough to just make contact with the ground. No nests were found using this method. On 7 June, the nest was discovered when the area was searched on foot.

The nest was located in a grassy alcove with trees and shrubs on three sides and open to the west (16 m to the north, 9 m to the east, 7 m to the south). The area had been lightly grazed for a short period early in the spring (K. MacDonald, personal communication), but otherwise was undisturbed grassland. In Alberta, Upland Sandpipers nested on large undisturbed stretches of grassland (Salt and Salt 1976) and in short-grass prairies of locally-dense herbaceous vegetation (Rand 1948).

Vegetation surrounding the nest was dominated by *Stipa occidentalis*, with *Agropyron trachycaulum* and *Koeleria macrantha* also present. Horizontal canopy cover of vegetation/non-vegetation classes at the nest site were: grasses (75–95%), bare ground (5–25%), litter (5–25%), forbs (0–5%), and bryophytes (0–5%) (see Daubenmire 1959). Average grass height surrounding the nest was 11.5 cm. In North Dakota, Upland Sandpipers nested in grassland dominated by *Agropyron trachycaulum*, *Koeleria cristata*, *Stipa comata*, and *S. viridula* (Higgins and Kirsch 1975).

The nest was a bowl of densely matted grasses hidden inside a tuft of grass. The nest lining was mostly *Stipa occidentalis* with a few stems of *Tragopogon dubius*. Interior dimensions were 12 to 13 cm diameter and 5 to 6 cm depth. These measurements agree with those given by Harrison (1978). The nest was covered by a loose canopy of *Stipa occidentalis*, 18 to 19 cm in height as measured from the bottom of the nest bowl.

There were four eggs at the nest – three within and one beside. The number, colour and pattern of the eggs were consistent with descriptions by Bent (1929), Higgins and Kirsch (1975), Harrison (1978) and Godfrey (1986) and identification was confirmed by R. W. Campbell (personal communication). The eggs were deposited with the Royal British Columbia Museum as catalogue number E1027.

The nest had been predated, and by the appearance of the eggs, predation had likely occurred within the previous 24 hours. Distinctive triangular holes measuring an average of 3 cm by 2.6 cm, in the side of the eggs, suggested the predator was a Common Raven (R. W. Campbell, personal communication). The incubation period before predation had been short, as indicated by the lack of blood attachment to the embryo on the interior of the eggs (R. W. Campbell, personal communication).

The Upland Sandpipers were not heard again until 15 June 1992, in another tall grass field, 1 km from the original nest site. On 21 June, they were seen again in this field. This suggests the possibility of either a second breeding attempt or nesting by another pair of sandpipers.

Acknowledgments

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First Confirmed Sighting of the Parakeet Auklet, *Cyclorrhynchus psittacula,* in Canada.

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Sirois, Jacques, and Robert W. Butler. 1994. First confirmed sighting of the Parakeet Auklet, *Cyclorrhynchus psittacula,* in Canada. Canadian Field-Naturalist 108(1): 91–92.

We report the first confirmed sighting of three Parakeet Auklets (*Cyclorrhynchus psittacula)* in Canadian waters, 1.5 km northeast of Heming Head, Talunkwan Island (52°51'N, 131°38'W) in the Queen Charlotte Islands archipelago, 13 May 1993.

Key Words: Parakeet Auklet, *Cyclorrhynchus psittacula,* Queen Charlotte Islands, British Columbia.

On 13 May 1993, at 1645 h PDT, we observed three Parakeet Auklets, *Cyclorrhynchus psittacula,* about 1.5 km northeast of Heming Head, Talunkwan Island (52°51′N, 131°38′W) in the Queen Charlotte Islands archipelago. The auklets surfaced 5-10 m from the bow of our boat, swam away from us for about 5 seconds and then flew out of sight. We observed them with the naked eye and through 7 x 35 and 7 x 26 binoculars on a smooth sea with a small swell in bright sunlight. All three birds had large, bright-red, stubby bills, light-coloured eyes, and long whitish plumes extending well behind the eye. The head, neck, back, and wings were black and white bellies became visible when they took flight. Their necks appeared long compared to other auklets and murrelets.

The Parakeet Auklet breeds in the Sea of Okhotsk and the Bering Sea (Springer et al. 1993). It is particularly abundant on the Pribilof Islands, but it also breeds from the Diomede Islands south to the Aleutian Islands, and east to the eastern Gulf of Alaska. It does not breed in British Columbia (McTaggart-Cowan 1989, Campbell et al. 1990; Gaston 1992). The nearest breeding colonies to the Queen Charlotte Islands are about 1200 km to the northwest, in Prince William Sound, Alaska (Springer et al. 1993). Parakeet Auklets spend the winter from the Bering Sea south to southern California (Gabrielson and Lincoln 1959; A.O.U. 1983).

The occurrence of the Parakeet Auklet in Canada is considered hypothetical by Godfrey (1986) and casual by Campbell et al. (1990). Up to 15 individuals washed ashore during an oil spill off the west coast of Vancouver Island, in December 1988 and January 1989 (Rodway et al. 1989), but it is unknown if these auklets were wintering in Canadian waters or were carried north with the oil spill from Washington State. There are also several unconfirmed sightings of Parakeet Auklets in British Columbia waters (Campbell et al. 1990, Morgan et al. 1991) made by single observers (R. W. Campbell and K. Morgan, personal communications). Moreover, Wahl et al. (1993) considered this species to be casual in offshore waters, based upon unconfirmed records reported by Morgan et al. (1991) and indicated there were no inshore records. Thus, our sighting is noteworthy because it represents the first confirmed sighting of this species in Canadian waters by two experienced observers familiar with Alcids, but not with this species in particular, and it indicates that Parakeet Auklets use inshore waters.

The presence of Parakeet Auklets in the Queen Charlotte Islands in mid- or late May is somewhat peculiar in light of their breeding phenology at Buldir Island (52°21′N, 175°56′W), in the Aleutian Islands. Most Parakeet Auklets arrive there by the end of April and lay eggs in the second half of May (Byrd and Day 1986). Strong westerly winds in the week previous to our sighting might have blown the three auklets into British Columbia waters. Alternately, they might have been attracted to the large numbers of jellyfish, a principal prey of Parakeet Auklets (Harrison 1990), present along the Queen Charlotte Islands during our visit.

This species is no longer hypothetical (Godfrey 1986) in Canada, but remains "casual", as defined by Campbell et al. (1990).

Acknowledgments

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Nomenclatural Changes and New Taxa for the Yukon Flora

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Cody, William J. 1994. Nomenclatural changes and new taxa for the Yukon Flora. Canadian Field-Naturalist 108(1): 93–95.

Nomenclatural changes (new combinations), new taxa (forma) for 21 combinations and 5 forma for the Yukon Flora are here proposed in the following genera: *Braya*, *Cardamine*, *Elymus*, *Gentianella*, *Hedysarum*, *Lagotis*, *Lupinus*, *Myosotis*, *Oxytropis*, *Parrya*, *Petasites*, *Saussurea*, *Saxifraga*, *Silene*, *Smelowskia*, *Thalictrum* and *Veronica*.

Key Words: Nomenclatural changes, new taxa, Yukon Flora.

The first flora that included the Yukon Territory and treated all the taxa known to occur there was Eric Hultén's *Flora of Alaska and Yukon* (1941-1950). These 10 volumes contained keys and a wealth of information including maps of the known distribution, but no descriptions of the individual taxa. Hultén (1968) in his *Flora of Alaska and Neighboring Territories* provided keys, descriptions, distribution maps and illustrations, and Welsh (1974) in *Anderson's Flora of Alaska and adjacent parts of Canada* provided a useful volume with keys, descriptions and additional information, but did not illustrate the species or include distribution maps. To the east, Porsild and Cody (1980) in *Vascular Plants of Continental Northwest Territories, Canada* described the flora of that region, but to date no flora has yet been published treating only the Yukon Territory.

In 1980 I began field work in the Yukon which continued to 1984. Modern air transportation vastly aided the collecting of specimens in remote and previously unstudied areas. In addition many specimens have been provided by other interested individuals, which have greatly increased my knowledge of the plants of the Territory. The result has been the writing of a flora which is uniquely Yukon. During the preparation of the flora it was found necessary to change the nomenclatural status of a number of taxa in order that they would be consistent with other taxa in the same group, and a number of colour forms were described to draw attention to their existence. These are presented below. The *Yukon Flora* will be published by Agriculture Canada (Cody, *in press*).

Editor's note: To conform with taxonomic botanical paper conventions literature abreviations are used throughout in taxa descriptions, rather than normal full forms used elsewhere in *The Canadian Field-Naturalist.*

GRAMINEAE

Elymus trachycaulus (Link) Gould ex Shinners ssp. ***glaucus*** (Pease & Moore) Cody, comb. & stat. nov., BASIONYM: *Agropyron caninum* (L.) Beauv. f. *glaucum* Pease & Moore, Rhodora 12: 71. 1910. *A. trachycaulum* var. *glaucum* (Pease & Moore) Malte.

CARYOPHYLLACEAE

Silene acaulis L. ssp. ***subacaulescens*** (F.N. Williams) Hultén forma ***albiflora*** Cody forma nova — a forma typica differt corollis albis. — YUKON: moist sunny hillside, alpine, elev. 5,800 ft., Km 21 Upper Sheep Creek Rd. off Km 154 Canol Rd., *V. Hodgson 1421A*, 27 July 1984 (Holotype DAO); BRITISH COLUMBIA: Yoho National Park, Wiwaxy Gap, 51°21′10″N 116°20′30″W, 2430 m, *G.W. Scotter 6*, 13 Aug. 1991 (Paratype DAO).

RANUNCULACEAE

Thalictrum sparsiflorum Turcz. ssp. ***richardsonii*** (Gray) Cody comb. & stat. nov., BASIONYM: *T. richardsonii* Gray, Amer. J. Sci. 42: 17. 1842, *T. sparsiflorum* Turcz. var. *richardsonii* (Gray) Boivin, Rhodora 46: 369. 1944.

CRUCIFERAE

Braya glabella Richards. ssp. ***purpurascens*** (R.Br.) Cody, comb. & stat. nov., BASIONYM: *Platypetalum purpurascens* R.Br., Chloris Melvilliana p. 9 & 50. 1823.

Cardamine oligosperma Nutt. ssp. ***kamtschatica*** (Regel) Cody, comb. & stat. nov., BASIONYM: *Cardamine sylvatica* ß *kamtschatica* Regel, Bull. Soc. Nat. Mosc. 34(2): 171–172. 1861.

Cardamine purpurea Cham. & Schlecht. forma ***albiflora*** (Hultén) Cody, comb. & stat. nov., BASIONYM: *Cardamine purpurea* Cham. & Schlecht. var. *albiflos* Hultén, Arkiv för Botanik (n.s.) 7(1): 62. 1967; Madrono 19: 223. 1968. This taxon was not validly published by Hultén in 1967, but was later validated by him in the journal Madroño; Hultén (1968) corrected the spelling to *albiflora* in his Flora of Alaska and neighboring territories.

Parrya nudicaulis (L.) Regel forma ***albiflora*** Cody, forma nova — a forma typica differt corollis albis. *Betula glandulosa* - lichen + occasional *Picea glauca* association, hills 15 mi S of Dawson, 63°55′N 139°28′W, alt. 3800 ft., *Cody & Ginns 33444*, 5 July 1984 (Holotype DAO); Paratypes: sunny damp area, Km 12½ Seagull Lake Road, east of Km 162 Canol Road, *V. Hodgson 776*, 29 June 1982 (DAO); Richardson Mts., wet meadow in valley on N side of Mt. Cronin, 66°48′N 136°13′W, *Cody & Ginns 30718*, 7 July 1982 (DAO); District of Mackenzie, Mackenzie Mts.: tundra patches on slope, Mirror Lake, east side of Carcajou Range, 64°52'N 126°55'W, *Cody & Brigham 20380*, 3 July 1972 (DAO); Redstone River, 62°30′-63°15′N 126°30′-127°05′W, *Johnson & Munro 16*, June 1962 (DAO); bog margin, Dal Lake, Redstone River Region, 63°08′N 126°30′W, *Kvale & Haggard 7b*, 3 June 1963 (DAO); grassy slope saturated with spring runoff, Redstone River Region, 62°55′N 126°38′W, *Kvale & Haggard 40*, 21 June 1963 (DAO).

Smelowskia borealis (Greene) Drury & Rollins ssp. ***jordalii*** (Drury & Rollins) Cody, comb. & stat. nov.; BASIONYM: *S. borealis* (Greene) Drury & Rollins var. *jordalii* Drury & Rollins, Rhodora 54: 116. 1952.

SAXIFRAGACEAE

Saxifraga bronchialis L. ssp. ***codyana*** (Zhmylev) Cody, comb. & stat. nov., BASIONYM: *S. codyana* Zhmylev, Bull. Moscow Soc. Nat. Biol. Serv. 97(1): 95–96. 1992.

LEGUMINOSAE

Hedysarum alpinum L. forma ***albiforum*** (Standley) Cody, comb. nov., BASIONYM: *H. americanum* (Michx.) Britt. f. *albiflorum* Standley, Field Mus. Pub. Bot. 8: 15. 1930. *H. alpinum* L. var. *americanum* Michx. f. *albiflorum* (Standley) Fern.

Hedysarum boreale Nutt. ssp. ***mackenzii*** (Richards.) Welsh forma ***niveum*** (Boivin) Cody, comb. nov., BASIONYM: *H. mackenzii* Richards. f. *niveum* Boivin, Can. Field-Nat. 65: 20. 1951.

Lupinus arcticus S. Wats. forma ***albus*** Cody forma nova — a forma typica differt corollis albis. Found growing with the typical blue-flowered form on a broken rocky mountain top, Yukon Territory, Richardson Mts., S end of Skull Range, 68°28′N 137°27′W, alt. 2200 ft., *Cody & Ginns 31629*, 12 July 1982 (Holotype DAO); open rocky slope, about 15 miles on 60 Mile Road from West Dawson to Alaskan border, *Calder & Billard 3750*, 11 July 1949 (Paratype DAO).

Oxytropis campestris (L.) DC. ssp. ***roaldii*** (Ostenf.) Cody, comb. & stat. nov., BASIONYM: *O. roaldii* Ostenf., Vasc. Pl. Arct. N. Amer., Gjöa Exped., 54. 1910.

Oxytropis campestris (L.) DC. ssp. ***varians*** (Rydb.) Cody, comb. & stat. nov., BASIONYM: *Aragallus varians* Rydb. Bull. N.Y. Bot. Gard. 2: 176. 1901.

Oxytropis deflexa (Pall.) DC. ssp. ***foliolosa*** (Hook.) Cody, comb. & stat. nov., BASIONYM: *Oxytropis foliolosa* Hook. Fl. Bor.-Amer. 1: 46. 1834.

Oxytropis deflexa (Pall.) DC. ssp. ***sericea*** (T. & G.) Cody, comb. & stat. nov., BASIONYM: *Oxytropis deflexa* var. *sericea* T. & G. Fl. N. Amer. 1: 342. 1838.

Oxytropis nigrescens (Pall.) Fisch. ssp. ***lonchopoda*** (Barneby) Cody, comb. & stat. nov., BASIONYM: *O. nigrescens* (Pall.) Fisch. var. *lonchopoda* Barneby. Leaflets of Western Botany 10: 23. 1963.

Oxytropis sericea Nutt. ssp. ***spicata*** (Hook.) Cody, comb. & stat. nov., BASIONYM: *Oxytropis campestris spicata* Hook. Fl. Bor.-Amer. 1: 147. 1834.

GENTIANACEAE

Gentianella amarella (L.) Börner ssp. ***acuta*** (Michx.) J.M. Gillett forma ***albescens*** (Lepage) Cody, comb. nov., BASIONYM: *Gentiana acuta* Michx. f. *albescens* Lepage, Nat. can. 77: 228. 1950.

BORAGINACEAE

Myosotis alpestris Schm. ssp. ***asiatica*** Vestergr. ex Hultén forma ***eyerdamii*** (Boivin) Cody, comb. nov., BASIONYM: *M. sylvatica* Hoffm. var. *alpestris* (Schm.) Koch forma *eyerdamii* Boivin, Nat. can. 93: 1061. 1966.

SCROPHULARIACEAE

Lagotis glauca Gaertn. ssp. ***minor*** (Willd.) Hultén forma ***albiflora*** Cody forma nova, a forma typica differt corollis albis. Yukon Territory, Ogilvie Mts., wet turf by mountain stream, 7 miles S of Tombstone Mountain, 64°18′N 138°38′W, alt. 4750 ft., *Cody & Ginns 34664*, 16 July 1984 (Holotype DAO).

Veronica wormskjoldii R. & S. forma ***albiflora*** Cody, forma nova — a forma typica differt corollis albis. Dempster Highway, Km 80, *G. Brunner*, 3 Aug. 1990 (Holotype DAO).

COMPOSITAE

Petasites frigidus (L.) Fries ssp. ***arcticus*** (A.E. Porsild) Cody, stat. & comb. nov., BASIONYM: *P. arcticus* A.E. Porsild, Sargentia 4: 74. 1943.

Petasites frigidus (L.) Fries ssp. ***nivalis*** (Greene) Cody, stat. & comb. nov., BASIONYM: *P. nivalis* Greene, Pittonia 2: 18. 1889, *P. frigidus* (L.) Fries var. *nivalis* (Greene) Cronquist, Leafl. West. Bot. 7: 30. 1953.

Petasites frigidus (L.) Fries ssp. ***palmatus*** (Ait.) Cody, comb. & stat. nov., BASIONYM: *Tussilago* *palmata* Ait., Hort. Kew. 3: 188. 1789. *P. palmatus* (Ait.) Gray, Bot. Calif. 1: 407. 1876, *P. frigidus* (L.) Fries var. *palmatus* (Ait.) Cronquist, Rhodora 48: 124. 1946.

Saussurea angustifolia (Willd.) DC. ssp. ***yukonensis*** (A. E. Porsild) Cody comb. & stat. nov., BASIONYM: *S. angustifolia* (Willd.) DC. var. *yukonensis* Porsild, National Museum, Canada, Bulletin 101: 28. 1945.

Literature Cited

Cody, W. J. *in press*. Yukon Flora. Agriculture Canada.

Hultén, E. 1941-1950. Flora of Alaska and Yukon, 1–10. Lunds Universitets Arsskrift N.F., Aud. 2. Volumes 37–46. 1902 pages.

Hultén, E. 1968. Flora of Alaska and Neighboring Territories. Stanford University Press, Stanford, California. 1008 pages.

Porsild, A. E., and **W. J. Cody.** 1980. Vascular Plants of Continental Northwest Territories, Canada. National Museum of Natural Sciences, Ottawa. 667 pages.

Welsh, S. L. 1974. Anderson's Flora of Alaska and adjacent parts of Canada. Brigham Young University Press, Provo, Utah. 724 pages.

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News and Comment

Snow Ecology: A Report on a New Initiative

Snow plays a key role in the ecology of much of Earth's surface, especially in circumpolar and high-altitude regions where ecosystems are under increasing stress from global changes in climate and local human development. Until recently, our knowledge of snow has been restricted to areas of study associated with specific physical, chemical and biological disciplines. Although this research has resulted in a significant progress in understanding snowcover dynamics, there has been no concerted attempt to integrate the results of these studies to further our knowledge of snow as a life-support milieu and as a component of larger terrestrial ecosystems. In order to develop a better understanding of snow ecology through interdisciplinary studies, a nucleus of research workers from both the physical and biological sciences recently formed the Snow Ecology Working Group (SEWG). The SEWG was approved as a contribution of the International Commission on Snow and Ice (ICSI) to the International Geosphere-Biosphere Program (IGBP) at the ICSI Bureau Meeting in Vienna in August 1991. ICSI is a commission of the International Association of Hydrological Sciences (IAHS).

The objectives of the Working Group are to:

(1) facilitate exchange of knowledge and expertise on snow and snow-covered systems between researchers in the physical, chemical and biological sciences.

(2) develop a conceptual framework for snow ecology as a science and an experimental methodology for the study of snow and snow-covered systems.

(3) develop conceptual and applied comprehensive models for the processes, states, evolution and stability of snow ecosystems,

(4) produce documents which outline the conceptual framework of snow ecology, the state of the science and appropriate experimental methods,

(5) organize an international conference with emphasis on the methodology and application of the conceptual framework to the development of models which explain the evolution of snow and snow-related ecosystems.

To achieve these objectives, a Snow Ecology Workshop was convened by SEWG in Québec City, 3-7 June 1993. The Workshop was sponsored by the Natural Sciences and Engineering Research Council of Canada, Hydro-Québec, The Canadian Polar Commission, the Institut national de la recherche scientifique (Université du Québec) and the Department of the Environment of the Government of Québec (Environnement Québec). The Workshop was attended by university and government researchers and graduate students; the 20 participants included climatologists, physicists, chemists, microbiologists, plant ecologists, and invertebrate and large-mammal ecologists.

The format of the Workshop consisted of state-of-the-science reviews followed by in-depth discussions on the linkages and feedback mechanisms between the physical, chemical and biological phenomena in snow.

The reviews on the first day traced the physical progression of snow from snowfall and snowcover formation on a global scale to snow metamorphism on the ground, snow redistribution and sublimation in forested and open environments, the melt of snow and chemicals contained in the snow to the interaction between the snow chemistry and the biological components of snow (microbes, invertebrates and mammals). The second day considered the life cycles and habitats of snow microbes such as bacteria, algae, fungi and small invertebrates; the accumulation of organic debris and the relationship of larger life forms such as spiders, collembola and large plants to snow in alpine and arctic ecosystems. The reviews of the third day were devoted to the larger mammals that live in and on snow, with special emphasis on the caribou.

In this manner we developed specific hypotheses on how the physical, chemical and biological components interact and modify each other in order to produce the multi-phase, multi-life form milieu we know as the snowcover. It is now evident that the snowcover is an ecosystem which evolves in response to meteorological and biological inputs and, in return, fundamentally changing these factors.

Certain considerations may be drawn from information presented at the Workshop. One is that as an ecosystem, snow may be considered analogous to a lake and as an interdisciplinary science, snow ecology may be considered analogous to limnology. The snow ecosystem functions at three critical levels that are defined by boundaries at the snow-air and snow-soil interfaces:

(1) Supra-nival — above snow, including large plants and animals and the atmosphere;

(2) Intra-nival — within snow, including small plants, microbes, invertebrates, small mammals and snowcover properties; and
(3) Sub-nival — below snow, including small plants and animals, microbes, invertebrates and the soil.

A further consideration of this concept of snow as an ecosystem, is that the snowcover is the mediator between micro-organisms, plants, animals, chemicals, atmosphere and soil. Snow mediates because it functions as an:
(1) Energy Bank — snow stores and releases energy. It stores latent heat of fusion and sublimation and crystal bonding forces. The bonding forces are applied by atmospheric shear stress, drifting snow-particle impact and the impact of animals walking over the snowcover. The intake and release of energy at various times of the year thus makes snow a variable habitat for intranivean organisms and is a cause of their migration within the snow environment.
(2) Radiation Shield — cold snow reflects most shortwave radiation, and absorbs and re-emits most thermal infrared radiation. Its reflectance of shortwave is a critical characteristic of the global climate system. As snowmelt progresses, the snowcover reflects less shortwave radiation due to a change in its physical properties. This reflectance can be additionally reduced in the order of 10% by in situ life forms such as populations of red snow algae.
(3) Insulator — as a porous medium with a large air content, snow has a high insulation capacity and plays an important role protecting microorganisms, plants and animals from wind and severe winter temperatures. Its insulation can result in strong temperature gradients which fundamentally restructure the snow composition and provide opportunities and constraints for organisms that live in the snowcover. In windswept areas specific organisms take advantage of enhanced snowcover insulation where vegetation is relatively dense; however, their further interaction with this vegetation is presently unknown.
(4) Reservoir — snow is a reservoir for water, chemicals and organic debris that provides habitat and food sources for various life stages of microbes, invertebrates and small mammals. The physical and chemical properties of snow, especially radiation penetration, gas content, temperature, wetness, porosity, pH, inorganic chemistry and organic debris content control intra-nivean biological activity and in turn are influenced by the behaviour of nivean organisms.
(5) Transport Medium — snow moves as a particulate flux as it is relocated by the wind in open environments or intercepted by vegetation in forests. It moves as a vapour flux because of sublimation, resulting in transport to colder surfaces or to the atmosphere. During melt, snow moves as meltwater in preferential pathways within the snowcover to the soil or directly to streams and lakes. These transport phenomena are taken advantage of by certain snow organisms but can also cause limitations to the success and survival of their populations.
(6) Host for a Food Web — a food web which occurs both within the snowcover and at the snow-atmosphere and snow-soil interfaces involves many families and species of organisms. Within the snowcover, snow algae are primary producers grazed upon by primary consumers including protozoa and small invertebrates. Small forms such as the fungi and bacteria are decomposers and some invertebrates are probable detritivores. The invertebrates are in turn preyed upon by other invertebrates and small mammals. Small mammals become the prey to larger mammals, which either hunt them on the surface or dig into the snowcover to retrieve them. Large and small mammals also graze upon plants that protrude into the snowcover or are buried by it. Leachates from organic substrates are an important feature in this food web, particularly in the effect of plant residues and animal wastes upon microbial activity.

These snow ecosystem functions occur over time scales that are diurnal, seasonal and decadal. Furthermore the functions have important spatial interactions at three scales:

(1) Micro Scale — variation from centimetres to metres both vertically through the cover and horizontally across the snowcover, correlated strongly to individual plants, meltwater flow paths, terrain discontinuities, soil properties, food webs and local populations of intranivean inhabitants;
(2) Landscape/Meso Scale — variation from tens of metres to kilometres, correlated strongly to the communities of the largest vegetation forms, elevation, slope, aspect, orography and exposure to the wind;
(3) Macro Scale — variation from tens to thousands of kilometres, correlated strongly to persistent synoptic weather patterns, continental wind flows, location with respect to the poles, oceans, lakes and continental scale biomes.

After consideration of the critical issues in separate fields of snow investigation, and identification of the major linkages between living things and the physical and chemical properties of snow, the participants raised the following questions regarding snow as an ecosystem:

(1) Can we devise tests of hypotheses regarding the structure and function of snow ecosystems?
(2) Do snow ecosystems have a series of quasi-stable states?
(3) What scales of states and processes are important from micro to macroscale?
(4) Do snow ecosystem variables and states cycle over time? Are these cycles correlated and do they enhance or dampen each other?
(5) How may we scale snow ecosystem variables over space and time? How do we go from micro scale to macro scale, diurnal to seasonal and decadal?

The SEWG intends to answer these questions as part of multi-disciplinary studies occurring in various snow biomes. For more information regarding participation in these working group activities please contact Professor H. Gerald Jones, Institut national de la recherche scientifique-eau, Université du Québec, Ste-Foy, Québec, Canada, G1V 4C7. FAX 1-418-654-2562.

H. G. JONES, J. W. POMEROY, D. A. WALKER, and R. A. WHARTON

for the Snow Ecology Working Group.

Notice of the 116th Annual Business Meeting of The Ottawa Field-Naturalists' Club

The 116th Annual Business Meeting of The Ottawa Field-Naturalists' Club will be held in the auditorium of the Victoria Memorial Museum Building, McLeod and Metcalfe streets, Ottawa on Tuesday 10 January 1995 at 19:30 h.

STEPHEN GAWN

Recording Secretary

Call for Nominations: The Ottawa Field-Naturalists' Club 1995 Council

Candidates for Council may be nominated by any member of The Ottawa Field-Naturalists' Club. Nominations require the signature of the nominator and a statement of willingness to serve in the position for which nominated by the nominee. Some relevant background information on the nominee should be also provided. Deadline for nominations is 1 December 1994.

BARBARA CAMPELL

Chair, Nominating Committee

Call for Nominations: The Ottawa Field-Naturalists' Club 1994 Awards

Nominations are requested from members of The Ottawa Field-Naturalists, Club for the following: Honorary Membership, Member of the Year, George McGee Service Award Citation, Conservation, and the Anne Hanes Natural History Award. Descriptions of these awards appeared in *The Canadian Field-Naturalist* 96(3): 367 (1982). With the exception of nominations for Honorary Member, all nominees must be Club members in good standing. Deadline for nominations is 13 December 1994.

ENID FRANKTON

Chair, Awards Committee

Erratum *The Canadian Field-Naturalist* 107(4)

Omitted from the bottom of the inside front cover of *The Canadian Field-Naturalist* 107(4) were the following additional details: The cover photograph was taken by Sebastian Brennan, 8 August 1990, on board the vessel *Elendil* at 43° 50' N, 58° 53' W.

FRANCIS R. COOK

Editor

Minutes of the 115th Annual Business Meeting of The Ottawa Field-Naturalists' Club 11 January 1994

Place and Time: Auditorium, Canadian Museum of Nature, Metcalfe and McLeod Streets, Ottawa, 19:30 hrs
Chairperson: Frank Pope, President
Attendance: Thirty people attended the meeting

The first 30 minutes were used to provide members with an opportunity to peruse the minutes of the previous meeting, the Constitution, the financial report, and the report of Council.

1. Minutes of the Previous Meeting

Stephen Gawn, Recording Secretary, read out the minutes of the previous meeting. Item 6: The correct spelling is "Thomson", not "Thompson". It was moved by Jack Romanow (2nd Ron Bedford) that the minutes be accepted.

(Motion Carried)

2. Business Arising from the Minutes

Two motions pertaining to the proposal for a revised Constitution and By-Laws, published in Volume 106 Number 1 of *The Canadian Field-Naturalist*, were presented for ratification:

a) Revised Article 17. Revised Article 17 allows members to vote on considering proposed changes to the Constitution article-by-article or as a group. In either case, written notice of any proposed amendments shall be published in *The Canadian Field-Naturalist* at least one month before they are to be presented at the Annual Business Meeting.

It was moved by Bill Gummer (2nd Colin Gaskell) that the Motion carried at the 114th Annual Business Meeting to accept the revised Article 17, be ratified.

There was discussion as to what was meant by "major revision to the Constitution". One view was that a large number of small changes, because of their widespread effect, could be considered a major revision. Concern was expressed that the group approach, because it precludes members from voting on each proposed change, prevents discussion about the possible effects of each change and poses a risk that significant policy changes could pass without scrutiny. It was noted that since the proposed amendments are published well before the Annual Business Meeting, members have ample opportunity to study them and prepare a case against the use of the group approach.

A vote was then taken on the ratification.

(Ratification Carried with one opposed)

b) Balance of Amendments. The remaining amendments consist mostly of clarifications, corrections, terminology updating, and changes resulting from a review for consistency.

It was moved by Bill Gummer (2nd David Moore) that the Motion carried at the 114th Annual Business Meeting to accept the balance of the revised Constitution, be ratified.

(Ratification Carried)

3. Financial Report

Gillian Marston, Treasurer, reviewed the financial statements for the year ending 30 September 1993.

Members' equity dropped by $844 to $191,140. Assets are largely cash, GICs, and Treasury Bills. A bequest of $6627 from the estate of Louise de Kiriline-Lawrence was used to establish the de Kiriline-Lawrence Fund. The Club has five such funds; contributions are made via member-specified donations or from some of the income generated by the Club.

It was moved by Gillian Marston (2nd Ken Young) that the Financial Report be accepted.

(Motion Carried)

4. Report of Council

Representatives of each committee were on hand to answer questions or reply to comments on the committee reports provided in the Report of Council. The following items came up:

a) Fletcher:
- the ceremony was for the Model Backyard Garden
- the second logo will probably be used for merchandising

b) Macoun:
- the Museum of Nature should have application forms
- the field trip was to the Bonnechere Caves
- the computer was donated by the Museum of Civilization

c) Membership:
- Macoun members are not included in the count because

they do not pay for Club membership

d) Publications: - the name is "Stephen Smith", not "Stephen Hall"

It was moved by Bill Cody (2nd Ellaine Dickson) that the Report of Council be accepted.

(Motion Carried)

5. Nomination of the Auditor

It was moved by Ken Young (2nd Jack Romanow) that Janet Gehr continue as auditor for another year.

(Motion Carried)

6. Report of the Nomination Committee

Bill Gummer presented the Nomination Committee (Barbara Campbell, Eileen Evans, and Bill Gummer) recommendations for the 1994 Council officers and members (new members' names are followed by an asterisk):

President:	Frank Pope
Vice-President:	Michael Murphy
Vice-President:	David Moore
Recording Secretary:	Stephen Gawn
Corresponding Secretary:	Eileen Evans
Treasurer:	Gillian Marston

Other Council Members:

Ron Bedford	Carol German*
Fenja Brodo	Bill Gummer
Lee Cairnie	Jeff Harrison
Bill Cody	Cendrine Huemer*
Francis Cook	Patricia Narraway
Ellaine Dickson	Jack Romanow
Enid Frankton	David Smythe
Colin Gaskell	Jane Topping*
	Ken Young

Bruce Summers and Martha Camfield have stepped down as members of Council.

It was moved by Bill Gummer (2nd Michael Murphy) that the slate of Councilors be accepted.

(Motion Carried)

7. New Business

Frank Pope reported that, at the Governor General's Levee, Governor General Ray Hnatyshyn made it clear that he was fully aware that he is the Club's patron and that appreciated the efforts of the Club.

Frank Pope commented that the past year had been particularly busy but that, personally, he had found it to be a great year.

Ellaine Dickson made an appeal for people interested in helping lead trips for the Macoun Field Club to contact her.

8. Presentation by the Publications Committee

Ron Bedford, the Chairperson of the Publications Committee, described how the Club has been functioning as a natural history publishing house ever since its inception in 1879. He talked about the history of the Club's publications, their roles, their contributions, their benefits, and their costs. He concluded that the money spent by the Club on its publications was money well-spent.

9. Adjournment

At 21:50 hrs it was moved by Enid Frankton (2nd Michael Murphy) that the meeting be adjourned.

(Motion Carried)

STEPHEN GAWN
Recording Secretary

Committee Reports for 1993

Awards Committee

The following awards were presented at the annual soiree held on April 30, 1993:

1. Honorary Member: Dr. George Ledingham of Regina, Saskatchewan.
2. 1992 Member of the Year: Colin Gaskell.
3. George McGee Service Award: Patricia Narraway.
4. Conservation Award (member): Ian Huggett.
5. Conservation Award (non-member): Kanata Lakes Natural Environment Area Committee under the leadership of Merle Nicholds, mayor of Kanata, and Alan Austin, Committee Chairperson.
6. The Anne Hanes Natural History Award: Donald Cuddy.
7. President's Prize: awarded by Frank Pope to Gillian Marston.

Citations were published in *Trail & Landscape* and *The Canadian Field-Naturalist.*

ENID FRANKTON

Birds Committee

The Committee revised the *Birder's Checklist of Ottawa* and made it available for the FON conference. The Committee maintained the bird status telephone line for another busy year.

The Committee finalized the 1992 Christmas Bird Count results, organized a four-week fall count, and began preparations for the 1993 Christmas Bird Count. The Committee looked after the Club's bird-feeders using seed purchased through the Annual Seedathon.

The Committee was represented at organizational meetings for the Richmond Lagoon Bird Sanctuary. The Committee caught up the "Recent Bird Sightings" articles for *Trail & Landscape* and initiated a project to archive some of the Committee's files and records.

The Bird Records Sub-committee did not meet.

JACK ROMANOW

Computer Management Committee

The Committee made recommendations to Council for the replacement of the computer used by the Membership Committee, as well as a memory upgrade and other improvements to the computer used for producing *Trail & Landscape*. The computer used by the Membership Committee will be used by the Fletcher Wildlife Garden Management Committee. The Committee started investigating upgrade requirements for the computer used for producing *The Canadian Field-Naturalist*.

MICHAEL MURPHY

Conservation Committee

The Conservation Committee acted on behalf of the Club on a number of conservation and environmental matters, including:

- Britannia Mud Lake
- Carson Grove
- City of Nepean Official Plan
- City of Ottawa Official Plan
- Gatineau Park
- Kanata North urban expansion (proposed)
- Lanark County Timber Management Plan
- Lietrim Wetland - Ontario Municipal Board Hearings
- McCarthy Woods
- McConnell/Laramee Highway extension
- National Capital Greenbelt
- Ontario Commission on Planning and Development Reform
- Regional Municipality of Ottawa-Carleton Official Plan
- Sawmill Creek Watershed Study

MICHAEL MURPHY

Education and Publicity Committee

The Education and Publicity Committee set up the Club's display at 6 locations, covering 14 1/2 days, and using about 70 Club volunteers. Prices for Club items sold at the displays were revised to facilitate sales. At the FON conference, in addition to setting up the display, the Committee also set up signs and distributed free books and pamphlets.

The Committee supplied speakers/leaders for 6 presentations and took a reporter for *Seniors Magazine* on a Club outing to the Purdon Fen.

The Committee promoted advertising for Club meetings; the promotions included designing advertising posters. The Committee supplied judges for the annual Ottawa Science Fair and arranged for prizes.

The Committee produced a new slide presentation and audio tapes. Work is underway on a new set of slides and on a pocket-sized card with the Shirley's Bay access rules.

DAVID MOORE

Excursions and Lectures Committee

The Committee organized 46 field trips: 41 of these were within the Ottawa District. Two extended excursions were made in May: a weekend trip to Algonquin Provincial Park and a four-day trip to Point Pelee National Park.

The Committee also arranged a wide range of evening lectures, all of which were complemented by slide presentations. One popular evening event was the members' slide night.

The Committee arranged two social functions: the Soiree in April and the New Members Night in November. Both functions were well received, although attendance was somewhat disappointing.

Committee members helped out in the field trips for the Federation of Ontario Naturalists Conference hosted by the Club.

COLIN GASKELL

Executive Committee

The Executive Committee met once, early in the year to discuss a funding crisis for the Fletcher Wildlife Garden.

FRANK POPE

Finance Committee

In addition to dealing with recurring items such as membership dues, insurance, and the annual budget, the Committee reviewed prices for Club items, looked into developing a policy for issuing charitable receipts for donations in kind and for the appropriate level of financial reserves to be held by the Club.

KEN YOUNG

Fletcher Wildlife Garden Management Committee

The Committee used funding from the Environmental Youth Corps to hire someone for several months to provide administrative support and develop an interpretive plan for the Fletcher Wildlife Garden.

Work on the Fletcher Wildlife Garden concentrated on the Backyard Garden portion. The Backyard Garden is about 75% complete. Other work consisted of additional planting in the sedge meadow, enlarging the butterfly meadow test plot, and planting most of the hedgerow.

An official opening ceremony was held in September for the Model Backyard Garden. At the ceremony, Memoranda of Understanding between Landscape Ontario, Friends of the Farm, and the Club were signed, and signs were unveiled commemorating the contributions of the major corporate donors.

A formal submission was made to Agriculture Canada for the use of Building 138.

Two logos were selected, a portable exhibit was developed, brochures were printed, and work on soliciting funds was begun.

JEFF HARRISON

FON Conference Organizing Committee

The Committee's first meeting was in April, 1992 and its thirteenth and last meeting was in July, 1993. The group started off with 10 people; it grew to about 90 people by time the Federation of Ontario Naturalists Conference was held at Carleton University June 18, 19, and 20.

Attendance at the conference was 250, down about 100 from the previous year. Nevertheless, through careful management, a surplus of $2,800 was realized. Under the theme "Habitat Natural Capital", the conference was a showcase of local talent. There were 10 lectures and 24 field trips on the theme. In addition to the Annual Business Meeting of the FON, there were many exhibits, two receptions, and a banquet.

FRANK POPE

Macoun Committee

The Committee organized a range of activities for the members of the Macoun Field Club. Many of the Committee members were also active in the leadership of the Macoun Field Club meetings and field trips. Committee members active in the field were provided with first aid training. A major trip was an all-day bus trip arranged by the Excursions and Lectures Committee.

The Canadian Museum of Civilization has lent a personal computer to the Macoun Field Club. It has been loaded with educational software and catalogues of the Macoun Field Club collections and library.

The Macoun Field Club published the 47th issue of *The Little Bear* in June.

ROBERT E. LEE

Membership Committee

In November 1993, membership in the Club stood at 1041. A detailed membership breakdown, with 1992 figures in brackets, is provided in the table (see below).

A total of 134 new members joined during the year (1 Sustaining, 64 Family, and 69 Individual). Of members who did not renew for 1993, it appeared that for many, OFNC membership is now a luxury item that cannot be afforded.

One Honorary membership was conferred: Dr. George F. Ledingham, of Regina.

Sheila Thomson, of Ottawa, and Dr. C. Stuart Houston, of Saskatoon, both members since 1943, were added to the "Golden Anniversary" list.

PATRICIA J. NARRAWAY

Publications Committee

The Committee oversaw the publication of two issues of *The Canadian Field-Naturalist* (both under the editorship of Francis Cook), four issues of *Trail & Landscape* (the first three under the editorship of Bill Gummer; the fourth under Fenja Brodo), and four issues of the *Greenline* (all under the editorship of Jim Reil).

Volume 106, Issues 2 and 3 of *The Canadian Field-Naturalist* contained 252 pages, 26 articles, 20 notes, 56 book reviews, 150 new titles, and 11 pages of news and comments. The outlook is good for regaining the normal publishing schedule in 1994. More that 800 copies of *The Canadian Field-Naturalist* were mailed to non-Club-member subscribers; almost half of these were outside Canada. Associate editor Stephen Smith (*Trail and Landscape*) and indexer Harvey Beck (*The Canadian Field-Naturalist*) resigned during the year.

Volume 27, Issues 1 to 4 of *Trail and Landscape* contained 152 pages, about a quarter of which were bird-related.

RONALD E. BEDFORD

Membership in The Ottawa Field-Naturalists Club (does not include individual or institutional subscriptions.)

	CANADA		FOREIGN		TOTAL
Type	Local	Other	USA	Other	
Individual	368 (379)	155 (167)	33 (39)	5 (7)	561 (592)
Family	335 (320)	23 (26)	4 (3)	0 (0)	362 (349)
Sustaining	49 (45)	3 (2)	2 (2)	0 (0)	54 (49)
Honorary	15 (17)	9 (6)	1 (1)	0 (0)	25 (24)
Life	15 (14)	18 (18)	4 (4)	2 (2)	39 (38)
Total	782 (775)	208 (219)	44 (49)	7 (9)	1041 (1052)

Auditor's Report
To The Members of
THE OTTAWA FIELD-NATURALIST' CLUB

I have audited the balance sheet of The Ottawa Field-Naturalists' Club as at September 30, 1993, and the statement of operations for the year then ended. These financial statements are the responsibility of the organization's management. My responsibility is to express an opinion on these statements based on my audit.

Except as explained in the follwing paragraph, I conducted my audit in accordance with generally accepted auditing standards. Those standards require that I plan and perform an audit to obtain reasonable assurance whether the financial statements are free of material misstatement. An audit includes examining evidence supporting the amounts and disclosures in the financial statements. An audit also includes assessing the accounting principles used and significant estimates made by management, as well as evaluating the overall financial statement presentation.

In common with many non-profit organizations, the Ottawa Field-Naturalists' derives some of its revenue from memberships and fund raising activities. These revenues are not readily susceptible to complete audit verification, and accordingly, my verification was limited to accounting for the amounts reflected in the records of the organization.

In my opinion, except for the effect of the adjustments, if any, which I might have determined to be necessary had I been able to satisfy myself concerning the completeness of the revenues referred to in the preceding paragraph, these financial statements present fairly, in all material respects, the financial position of the organization as at September 30, 1993, and the results of its operations for the year then ended in accordance with generally accepted accounting principles.

JANET M. GEHER
Chartered Accountant

North Gower, Ontario
4 January, 1994

The Ottawa Field-Naturalists' Club
BALANCE SHEET
September 30, 1993

	1993	1992
Assets		
CURRENT ASSETS		
Cash	245,502	214,946
Accounts Receivable	12,237	15,789
Interest Receivable	2,860	1,453
FON Conference Advance		1,704
Fletcher Wildlife Garden Loan		6,610
Prepaid Expenses	1,595	1,394
	262,164	241,893
FIXED (Note 3)	1,255	2,756
LAND - Alfred Bog	3,348	3,348
	266,797	247,997
Liabilities, Funds and Members' Equity		
CURRENT LIABILITIES		
Account Payable	43,348	29,750
Deferred Income	11,668	11,296
	55,016	41,046
FUNDS (Note 4)	13,341	8,967
LIFE MEMBERSHIPS	6,500	6,500
MEMBERS' EQUITY	191,940	191,984
	266,797	247,997

The Ottawa Field-Naturalists' Club
STATEMENT OF MEMBERS' EQUITY
Year Ended September 30, 1993

	1993	1992
EXCESS INCOME (EXPENDITURES)		
The Ottawa Field-Naturalist' Club	1,064	2,388
Canadian Field Naturalist	-4,420	10,935
	-3,356	13,323
OTHER INCOME (ALLOCATIONS)		
Bequest - L. de Kiriline-Lawrence	6,627	749
Donations - For wetlands.	200	310
Donations - Misc. upon membership renewal	3,112	2,559
Allocation to de Kiriline-lawrence Fund	-6,627	
Allocation to Alfred Bog		-3,618
	3,312	0
TOTAL INCOME	-44	13,323
MEMBERS' EQUITY, Beginning of Year	191,984	178,661
MEMBERS' EQUITY End of Year	191,940	191,984

The Ottawa Field-Naturalists' Club
STATEMENT OF OPERATIONS - OFNC
Year Ended September 30, 1993

	1993	1992
INCOME		
Memberships	14,288	14,400
T&L Subscription and Back Issues	1,467	478
Interest	2,063	1,916
Other Sales	2,290	3,056
Special Publications	357	646
Conference (Net)	1,429	
Total Income	21,864	20,496
EXPENSES		
OPERATION EXPENSES		
Affiliation fees	235	435
Computer	444	404
Depreciation	1,500	1,500
Membership	2,327	1,334
Office assistant	730	710
Operations	2,874	1,931
OFNC GST Rebate	-879	-479
Total Operations Expenses	7,231	5,835
CLUB ACTIVITY EXPENSES (Net)		
Awards	54	
Soiree	274	
Birds	1,976	131
Conservation	30	30
Education and Publicity	283	1,757
Excursions and Lectures	-1,012	-370
Fletcher Wildlife Garden	200	58
Macoun Club	1,030	1,168
Trail & Landscape	6,688	5,797
Total Club Activity Expenses	9,523	8,571
	16,754	14,406
Income Over Expenses	5,140	6,090
Allocation to Alfred Bog	4,076	3,702
Income Over Expenses and Allocations	1,064	2,388

The Ottawa Field-Naturalists' Club
STATEMENT OF OPERATIONS -
The Canadian Field-Naturalist
Year Ended September 30, 1993

	1993	1992
INCOME		
Memberships	9,525	9,400
Subscription	23,196	25,094
Sub-Total	32,721	34,494
Reprints	4,480	4,383
Publication charges	9,454	24,817
Back numbers	98	404
Interest and exchange	11,184	9,029
Total Income	57,937	73,127
EXPENSES		
Publishing	39,619	41,811
Reprints	4,197	3,281
Circulation	9,996	7,985
Editing	901	1,637
Office assistant	4,542	4,410
Office supplies	1,631	1,341
Advertising	134	134
Honoraria	3,000	3,000
GST Rebate	-1,663	-1,407
	62,357	62,192
Income Over Expenses	$ 4,420	$ 10,935

The Ottawa Field-Naturalists' Club
Notes To The Financial Statements
September 30, 1992

1. Authority and Activities

The Ottawa Field-Naturalists' Club is a non-profit organization incorporated under the laws of Ontario (1884). The Ottawa Field-Naturalists' Club promotes the appreciation, preservation and conservation of Canada's natural heritage; encourages investigation and publishes the results of research in all fields of natural history and diffuses information on these fields as widely as possible. It also supports and cooperates with organizations engaged in preserving, maintaining or restoring environments of high quality living things. Membership is open to any person or family, upon application and payment of dues. Payment of the Annual Dues as set out in the By-laws will be a necessary condition of the continuation of Membership.

2. Significant Accounting Policies

Membership, subscriptions and donations are recorded as received. All other revenues and expenditures except for inventory are accounted for on the accrual basis. Memberships are allocated to the Canadian Field-Naturalist publication on a pre-determined percentage.

Supplies, records, tapes and other items held for resale are expensed when purchased.

Fixed assets are recorded at cost and are depreciated on a straight line basis, for assets acquired prior to 1990. Fixed assets acquired after 1989 are expensed.

Life memberships paid since 1977 are recorded at the fee in effect at that time. There are 39 life members.

3. Fixed Assets

	1993	1992
Cost	16,748	$ 16,748
Accumulated Depreciation	15,492	13,992
Net Book Value	$1,256	$ 2,756

4. Funds

	1993	1992
Baldwin Memorial Fund	$ 358	$ 358
Seedathon	875	1,018
Anne Haines Memorial Fund	890	945
de Kiriline Lawrence Fund	6,627	
Alfred Bog	4,591	6,646
	$ 13,341	$ 8,967

The Ottawa Field-Naturalists' Club: Publication Policy – Revision 1994

The Ottawa Field-Naturalists' Club (OFNC) has published *The Canadian Field-Naturalist* (and its predecessors) for over a century. In 1967, the local natural history journal *Trail & Landscape* was introduced, replacing *The Ottawa Field-Naturalists' Club Newsletter* that had appeared irregularly for more than 25 years. For about a decade, beginning in 1976, a bimonthly newsletter of local bird sightings, *The Shrike*, was published. Various Special Publications appeared from time to time. A formal publications policy to underpin all of these activities was enunciated in 1983, and published in *The Canadian Field-Naturalist* 97(2): 231–234 (1983). The background to this policy is described in the preamble to the latter.

During the ensuing decade, minor revisions to the original Publication Policy were made from time to time. With the cessation of publication of *The Shrike*, and the change of *Trail & Landscape* to quarterly issues, a more detailed revision was required. On the recommendation of the Publications Committee, Council has approved the collating of all of these changes into a revised version of the OFNC Publications Policy which is printed herewith in its entirety.

R.E. Bedford
Chairman, Publications Committee

The Ottawa Field-Naturalists' Club Publications Policy: Revised Edition, February 1994

A – Introduction

Although The Ottawa Field-Naturalists' Club has been involved with publications almost since its inception, the first formal publications policy was produced in 1983. This followed from the work of an ad hoc committee established in 1978 and reporting to Council in 1980. Regular review of the Publication Policy is the responsibility of the Publications Committee.

The Ottawa Field-Naturalists' Club currently publishes two quarterly periodicals and, from time to time, books or monographs as Special Publications. The two periodicals differ in purpose and scope. *The Canadian Field-Naturalist* is essentially a scientific journal devoted to the publication of refereed papers concerned with natural history that is relevant to Canada. It is the official organ of the Club*. *Trail & Landscape* is a less formal periodical presenting refereed articles pertaining chiefly to the natural history of the Ottawa area and to providing information aimed at the local readership. Special Publications embrace material better suited to separate publication. All of these publications support the Club's objective "...to promote the appreciation, preservation and conservation of Canada's natural heritage; to encourage investigation and the publishing of the results of research in all fields of natural history and to diffuse information on these fields as widely as possible; to support and cooperate with organizations engaged in preserving, maintaining or restoring environments of high quality for living things".

This document outlines the policy governing publication of each of the above.

B – *The Canadian Field-Naturalist*

The Canadian Field-Naturalist, the official Club publication, is published quarterly and is available through separate subscription and to members of the Club. It is managed within an annual budget.

(1) – Objectives:

- (a) to be the official publication of The Ottawa Field-Naturalists' Club, as stated in the Constitution.
- (b) to publish refereed scientific papers by amateur and professional naturalists or field-biologists reporting observations and results of investigations in any field of natural history provided that they are original, significant, and relevant to Canada.
- (c) to publish news, comments, review articles, book reviews, and other such material that is in accord with objectives (a) and (b).
- (d) to publish minutes of the OFNC annual business meeting, including annual committee reports to the Council** and the financial statements, amendments to the

* Wherever the term "the Club" appears in this document, it is to mean The Ottawa Field-Naturalists' Club.
**Wherever the term "Council" appears in this document, it is to mean the Council of The Ottawa Field-Naturalists' Club.

Constitution and the By-Laws, and notices concerned with Club business.

(2) – Achievement of the Objectives:

Useful indicators for the achievement of the objectives for *The Canadian Field-Naturalist* include:

(a) unsolicited letters to the Editor or the Club.
(b) feedback from the Council.
(c) the degree to which Canada's prominent field-naturalists support *The Canadian Field-Naturalist* by submitting papers.
(d) submission of a sufficient number of high quality papers.
(e) government responses to applications for funding.
(f) trends in the number and geographic distribution of subscriptions.
(g) citations in other publications.
(h) adherence to a regular publication schedule.

(3) – The Ottawa Field-Naturalists' Club as Publisher:

The Canadian Field-Naturalist is the only publication of its kind in North America. It is recognized as being an asset to The Ottawa Field-Naturalists' Club through the national and international acclaim it brings to the Club. The Club, therefore, has a large responsibility for *The Canadian Field-Naturalist* and recognizes the requirement to ensure its continued publication and high standards. The broadly-based interests of The Ottawa Field-Naturalists' Club are seen as an important factor in maintaining the topical diversity and widely-based appeal that exists for *The Canadian Field-Naturalist* in Canada and beyond.

The Ottawa Field-Naturalists' Club will continue to publish *The Canadian Field-Naturalist*.

(4) – Editorial Board:

The Editor and Associate Editors should be:

(a) scientists who are experienced in field-based natural history investigation.
(b) appointed for one year terms, renewable without limit.

(5) – Support for Publication of Manuscripts:

Independent authors are those who submit papers to *The Canadian Field-Naturalist* without the benefit of institutional support or research grant funding. The Ottawa Field-Naturalists' Club recognizes the extra effort required by such contributors in the preparation of their papers and that such self-motivated efforts have contributed significantly to the development of knowledge in the natural sciences in Canada. To assist such independent efforts, as part of The Ottawa Field-Naturalists' Club's commitment to the development of naturalists as well as natural history knowledge, a measure of logistical support will be provided by The Ottawa Field-Naturalists' Club. For authors with minimal financial resources, limited journal funds are available to help offset publication charges. Requests for such financial assistance may be made to the Editor if the manuscript is accepted for publication.

(6) – Special Status for Ottawa District Natural History Studies:

The Ottawa District will not be afforded special status in evaluating submissions to *The Canadian Field-Naturalist*. Such papers must meet the same standards by which all other submissions are judged.

(7) – Content and Readability:

The content and readability of *The Canadian Field-Naturalist* are satisfactory at the present time.

To satisfy its primary responsibility for reporting findings, *The Canadian Field-Naturalist* papers must continue to use the appropriate technical and scientific terminology. It is desirable however, that abstracts be written in fairly simple language (when this is possible without sacrificing accuracy) so that the widest possible readership is reached.

(8) – Funds in reserve for *The Canadian Field-Naturalist*:

Funds in reserve for *The Canadian Field-Naturalist* ensure that, in the face of an economic disaster within The Ottawa Field-Naturalists' Club, the journal would have sufficient funds to publish further volumes and, thus, enough time to make other publishing arrangements. Funds will not be permitted to decline below a minimum level established by the Finance Committee (and reviewed by that committee as required).

C – *Trail & Landscape*

Although the information presented in *Trail & Landscape* must be factually correct, its manner of presentation will usually be less rigorously structured and more discursive than for *The Canadian Field-Naturalist*. This reflects this publication's conscious effort to educate interested lay persons concerning the natural history of the Ottawa area.

Trail & Landscape is published quarterly and is available to all local members, on demand to members outside the Ottawa District, and to institutions on subscription. It is managed within an annual budget. Without second class mailing privileges, mailing costs could become prohibitively expensive. In order to use second class mailing, the percentage of total paging devoted to items of Club business in *Trail & Landscape* must not exceed 20 percent.

(1) – Objectives:

(a) to publish refereed papers reporting new knowledge, review papers, and other topics of interest about the natural history of the Ottawa District.
(b) to encourage the membership to make and to publish natural history observations that are related to the Ottawa District.

(c) to promote and to report on Club activities and participation in such activities.
(d) to present, analyze and comment on natural history issues (such as conservation) of significance to the Ottawa area.

(2) – Achievement of the Objectives:
Useful indicators for the achievement of the objectives for *Trail & Landscape* include the following:
(a) unsolicited comments by readers on an issue-by-issue basis.
(b) the effort required by editorial staff to obtain sufficient appropriate material.
(c) the results from reader surveys.
(d) citations in other publications.
(e) adherence to a regular publication schedule.

(3) – Content and Readability:
Trail & Landscape will continue to provide a balanced mixture of natural history articles oriented towards people, activities, and education.

D – *THE SHRIKE*

The Shrike was a newsletter dedicated to the interests of bird-watchers which was available, by subscription only, to The Ottawa Field-Naturalists' Club members and to the general public. Publication was suspended in 1986.

E – SPECIAL PUBLICATIONS PROGRAM

The Club has two regular publications - *The Canadian Field-Naturalist* and *Trail & Landscape*. It should be recognized, however, that from time to time there may be material that would be better suited to separate publication. In considering a special publication the following guidelines should be used, with these general comments:

(1) each case will be treated on its own merits.
(2) authors are not to profit financially from the undertaking.
(3) assistance to authors will be considered on an individual basis.
(4) achievement of objectives will be assessed, as with other Club publications.
(5) accountability to Council for a special publication will rest with the Publications Committee.
(6) the style used should be in accord with that of *The Canadian Field-Naturalist* and *Trail & Landscape*. A different style must have the specific approval of the Publications Committee.

Guidelines:

(1) Council approval-in-principle to be sought, following which, action is to be taken by the Publications Committee.
(2) The Publications Committee to assess proposal or manuscript and to recommend approval or rejection to Council. If approval is recommended, to recommend also an Editor for the undertaking.
(3) Council to approve or to reject the proposal.
(4) If the proposal is approved, Editor installs project committee, arranges contact with author(s), and appoints reviewers.
  (a) The Editorial Committee to include:
  – at least one specialist in an appropriate field of study
  – at least one Council member
  – the Editor
  – a person knowledgeable in publication marketing (not all members need be Club members)
  (b) The Editorial Committee to develop, first with the author and then with appropriate Club committees, a Publication Plan for Council approval. The Plan will include:
  – assessment of the proposal's significance with respect to the Club's mandate
  – budget estimates and funding sources, including possible cooperative publication efforts and availability of grants
  – contractual proposal for the author
  – marketing assessment and plan
  – production schedule
(5) The Publications Committee to review the Publication Plan and, if it is acceptable, to pass it to Council for approval.
(6) Council approval of Publication Plan to lead to development of contract with author, printer, and illustrators.
(7) Contracts to be given final Council approval.
(8) Document to be published and distributed.
(9) Feedback on value of the publication to be sought, including volume of demand (vs. forecast of demand) and audience reaction. A report to Council to be made, evaluating the undertaking, by the Editor.

F – GENERAL ISSUES

(1) – The Ottawa Field-Naturalists' Club Publications Committee:
  (a) Duties: The duties of the Publications Committee are as follows:
    (i) to supervise the policy, finances, and distribution of the Club's publications.
    (ii) to act in an advisory capacity to Council in all matters pertaining to the publications of the Club.
    (iii) to recommend an Editor and a Business Manager for each publication, as required, for approval by the Council and to appoint Associate Editors.

(iv) to ensure that The Ottawa Field-Naturalists' Club publications are oriented to meeting the objectives of the Club by regularly reviewing the achievement indicators described for each.

(v) to act as a liaison between Council and the Editors and to maintain a constructive dialogue with the Editors on matters of policy, operations, and procedures.

(vi) to resolve concerns of the Editors or members of the Club respecting the publications.

(vii) to recommend an Editor for each Special Publication for approval by Council and to act as liaison with him or her in the development of Special Publications in the manner prescribed in Section E.

(viii) to ensure that the Editors of the various publications meet occasionally with Council.

(ix) to review the Publications Policy annually and to report on such review to Council.

(b) Membership: The membership of the committee will consist of at least the following individuals:

(i) the Editors of *The Canadian Field-Naturalist* and *Trail & Landscape*.

(ii) the Business Manager of *The Canadian Field-Naturalist*.

(iii) an Ottawa Field-Naturalists' Club Vice president and three or more members in good standing of The Ottawa Field-Naturalists' Club who are not directly associated with a publication.

(iv) the Editor of each Special Publication as an ex officio member until the Publication is completed.

(c) Chairman: The Chairman will be a member of Council and not directly associated with a publication of The Ottawa Field-Naturalists' Club.

(2) – Editorials and Changes in Editorial Policy:

In order to maintain a balance between editorial freedom and the policy- and direction-setting responsibility of The Ottawa Field-Naturalists' Club, broadly accepted mechanisms for consultation and approval are required. The following mechanisms aim to maintain that balance:

(a) policy change proposals will be presented to the Publications Committee by Editors; minor changes will be dealt with by the Committee and major policy changes will be referred to the Council.

(b) the Editor, or an Associate Editor, of each publication will be sought as a member of Council. If attendance is difficult, Council should arrange at least one annual meeting with each Editor for review of publishing status and success.

(c) before the appointment of any new Editor, he or she will meet with the Executive and Publications Committees to discuss The Ottawa Field-Naturalists' Club publications policy for that publication.

(d) the authorship of all material must be specified.

(e) Editors must send a copy of all editorials to the President in advance of publication for his or her information.

Louise de Kiriline Lawrence Conservation Action Fund, The Ottawa Field-Naturalists' Club

On 14 March 1994 The OFNC Council established a conservation action fund in the name of Louise de Kiriline Lawrence. The policy guidelines presented below are based on a proposal prepared by Gillian marston, Frank Pope, and Stephen Gawn, tabled at Council on 14 February 1994 and on Council's recommendations of 14 March 1994.

Fund Name: The fund is known as the Louise de Kiriline Lawrence Conservation Action Fund.

Purpose: The fund is to honour the memory of Louise de Kiriline Lawrence for her popular writings which were based upon an understanding of the natural world gained from scientific observation and analysis of the world around her. The fund will accomplish this by strategic and timely expenditures toward the conservation of natural areas.

Source: The initial deposit to this fund was a bequest from the Louise de Kiriline Lawrence estate in 1993 (identified in the 1992-93 OFNC Financial Statements as the "Louise de Kiriline Lawrence Fund"). Further deposits will come from: (1) proceeds from the sale of "Nature and Natural Areas in Canada's Capital"; (2) donations and bequests to the OFNC specified for conservation purposes; (3) donations and bequests to the OFNC not specified for any other purpose, as approved by the OFNC Council; (4) proceeds from sale of OFNC items, as approved by the OFNC Council.

Disbursements: Withdrawals from the fund will only be made upon the approval of the OFNC Council. Some examples of strategic and timely expenditures toward the conservation of natural areas are: (1) legal fees to open court challenges when natural areas are threatened; (2) expert witnesses and presentations; (3) field studies where more information on a natural area is needed; (4) publishing of relevant information that would not otherwise be available.

The Louise de Kiriline Lawrence Nature Writing Award

An announcement of the establishment of an award of special interest to Canadian writers in natural history areas coincided with the Canadian Booksellers Association Annual Convention and Trade Show, Toronto, Ontario, 15-20 June 1994. *The Louise de Kiriline Lawrence Nature Writing Award* honours the memory of the late Swedish-Canadian writer, whose books and articles brought her honours and international standing (see tribute and bibliography on pages 111–118).

In 1988, the idea of a nature writing award in her name was first broached to Louise de Kiriline Lawrence during a visit to her wilderness home at Pimisi Bay near Mattawa. She was delighted and excited by the suggestion and gave her immediate approval. It will provide encouragement to emulate the high standards of writing and accuracy that marked her works. A jury panel is now being established which includes ornithologist Dr. Robert W. Nero of Winnipeg, Manitoba, and wildlife artist Aleta Karstad of Bishops Mills, Ontario, both well known for their own natural history writing.

Entry forms and details concerning the award are available from Natural Heritage/Natural History Inc. as of 1 September 1994. The award will be presented annually, beginning in 1995, with the winner receiving $1500 and a framed illustrated Award Certificate. Two honourable mentions will also be recognized.

BARRY L. PENHALE

Natural Heritage/Natural History Inc., P.O. Box 95,
Station O, Toronto, Ontario M4A 2M8
(phone 416 694-7907; fax 416 690-0819)

Louise de Kiriline Lawrence (1894-1992) and the World of Nature: A Tribute

Marianne Gosztonyi Ainley

Simone de Beauvoir Institute, Concordia University, Montreal H3G 1M8

Ainley, Marianne Gosztonyi. 1994. Louise de Kiriline Lawrence (1894-1992) and the world of nature: A tribute. Canadian Field-Naturalist 108(1): 111–198.

Louise Vendela Augusta Jana, elder daughter of Hillevid Neergaard and Sixten Flach, developed her special affinity with nature in Sweden. Born on 30 January 1894 into a well-off family, with connections to both the Danish and Swedish nobility, she was privately educated in the usual school-subjects. More importantly, at an early age, she learned the oneness with nature that comes from living close to the land. Excursions with her beloved father, himself an enthusiastic naturalist and hunter (terms not considered contradictory at the time), introduced Louise to the ever changing landscape of sea and sky. Visitors to the Flach estate included other naturalists, including Bruno Liljefors. More than half a century later, Liljefors's painting of a pair of pheasants came to occupy the focal point in Louise's loghouse along the Mattawa River, Ontario.

Louise's journey from the "Big House" at Svenskund to the "Loghouse Nest" at Pimisi Bay was one of commitment, service to humanity, as well as an intensely personal journey. At the beginning of World War One, Louise exchanged a life of leisure (which bored her) for that of a nurse, one of the few acceptable careers for women at the time. As a member of the Danish Red Cross she encountered wounded soldiers and heard of the horrors of warfare. Among the prisoners of war was Gleb de Kirilin, a White Russian officer. As she later recounted in her hauntingly beautiful autobiography, *Another Winter, Another Spring: A love remembered* (1977), the two fell in love, married, and she followed him back to Russia and its devastating Civil War. It was characteristic of Louise to remain in Russia after her husband's disappearance and presumed death, for, having overcome her personal tragedy, she sought to alleviate the sufferings of others.

She later recalled, "before I left, I had come to know Russia from the White to the Black seas, from the Baltic to the Siberian taiga."[1] As a relief delegate of the Nansen Mission (and a member of the Swedish Red Cross Expedition), she tried to help the victims of the Volga district famine (1921-24). Following this, as a member of the European Student Relief, she lived with the Cossacks and "the work and the travel linked with it afforded ... unique opportunities to learn about Russia and to understand better the nature of her people." [2]

Although Louise returned to her native Sweden, she felt alienated from people who were unaware of, and uninterested in, larger issues. In 1927 she left her homeland for another northern country, where she could use her skills, determination, and compassion to improve health and nutrition among the poor. She chose Canada because of its "unspoiled soil, [and] life-giving space..." [3] As a Canadian Red Cross outpost-service nurse she was well-known across northeastern Ontario: in farms and schoolhouses, in Indian reservations and logging camps.

In 1934, Louise de Kiriline became the chief nurse-in-charge of the Dionne quintuplets. The ensuing unwelcome publicity led to her decision to give up nursing. In 1935 she found an environment where she would have "fresh air, space to move ... [and] unadulterated solitude, time to think." [4] So began a new life, one that was to bring her deep satisfaction, inner peace and, although she never sought it, considerable fame.

In a small log-cabin, on the "rough, rocky, unyielding and magnificent land" so typical of the Canadian Shield, she "took root." [5] There, in the company of her second husband Len Lawrence, Louise developed a new awareness of nature. This led to two major interests that, for more than half a century, were to enrich the lives of countless people who read her scientific work and her nature writing.

In the first instance, though making new discoveries, identifying birds with the help of a small Chester Reed field guide, and taking notes of her findings, Louise de Kiriline Lawrence had "an entirely anthropomorphic appreciation of the birds and their behaviour." After her husband enlisted, at the beginning of World War Two, she sought an "absorbing and worthwhile" pursuit, and found that it "was the chance of a lifetime to concentrate on the serious study of the life around me." [6] When a friend gave her Percy A. Taverner's *Birds of Canada* (1938), she read it avidly and, plucking up her courage, wrote to Taverner. Although neither of them could have known it, the letter of 9 June 1940, marked a turning point in her journey. She wrote:

Louise de Kiriline Lawrence in the late 1930s. Photograph courtesty of Georgina Rawn.

My BIRDS OF CANADA lives with me in a log-house perched on a cliff over a little lake that is part of the Mattawa River ... Birds find the environment of our home attractive and with feeding trays and suet tied on branches and sundry other attractions we are deriving an immense pleasure in their ever increasing tameness and in absorbing observations of their behaviour and antics. With the help of your book I have begun to keep records of each species I can positively identify, but being only an amateur in bird study, though a most ardent one, I am completely confused by the warblers and make flagrant mistakes about the thrushes until I am fly-bitten and exasperated.[7]

Taverner replied, " You must be beautifully situated for enjoying birds … In these days of great trial it seems that the study of little birds is futile … but when I get such letters it makes one feel that life has not been entirely wasted."[8]

Encouraged by Taverner, Louise de Kiriline Lawrence continued her observations and began to write nature stories, while, in the absence of her husband, she also managed their mink farm and did all the work around the house on her own. Realizing that she needed both a focus and an aim, in June

Louise de Kiriline Lawrence, bird-banding at Pimisi Bay, 1940s.

1942, she once again turned to Taverner. "I think I want you to tell me … what I can do … ? How should I record what I see? … How can I do more, study better … and let it come to some use for all our knowledge."[9] She enclosed a couple of her nature stories for which she could find no publisher.

The recently retired Taverner considered her stories "literature as well as good natural history and hence hardly material for 'popular' magazines. I should think they are Atlantic Monthly stuff…"[10] He advised her to take up bird banding. With a government banding permit in hand, Louise de Kiriline Lawrence was soon trapping and banding birds. She sold a story to *Farmer's Magazine*, and was "writing and writing."[11] She began illustrating her bird stories and they were getting accepted by various magazines. Her early writing success led to an invitation, in 1944, to join the Canadian Authors' Association.

Louise later recalled that in May 1944 "I had the unbelievable luck of having Murray and Doris Speirs ... walk in on me without warning." The unexpected visit provided her with the "rare chance at long last having somebody whom I could talk to and who knew vastly more about birds than I did…."[12] Contact with her new friends led to a regional study of birds "centring around the banding and the birds of my own home woods, marshes and fields ... I am having the area properly mapped this spring [1945] and from then on I shall be able to say exactly where whose territory is and how far so and so goes for food or fight or just meandering."[13]

Her first nature book *The Loghouse Nest* was published in February 1945. At age 51 Louise de Kiriline Lawrence was launched on an illustrious career as nature writer/ornithologist. She wrote for *Audubon Magazine* as well as the more scientifically inclined readers of *The Canadian Field-Naturalist*, *The Wilson Bulletin*, and *The Auk*. She was particularly interested in the life-history studies of woodland birds, such as woodpeckers, jays, vireos, and warblers. Her first paper "Five days with a pair of nesting Canada Jays" appeared in *The Canadian Field-Naturalist* in 1947. The following year a "Comparative study of the nesting behaviour of the

Chestnut-sided and Nashville warblers" was published in *The Auk*.

For Louise, being an integral part of her study area was totally absorbing. She had little need and desire to visit large cities and, although she joined the American Ornithologists' Union in 1946 and became an Elective Member in 1954, she rarely attended meetings. The world came to her in her northern "outpost" - ornithologists, conservationists, artists, and writers. In June 1950 Margaret Morse Nice visited the Loghouse. The two became close friends and carried on a lively correspondence. Nice's detailed life-history study of the Song Sparrow greatly influenced Louise's work. Other corespondents included Harrison F. Lewis, Austin Rand, W. Earl Godfrey, and an increasing number of American and European scientists. To provide her with the freedom to follow her new career, and to create a peaceful environment for her writing and research, Len Lawrence accepted a variety of outdoor jobs, some taking him away from the Loghouse for days at a time.[14]

By 1950 Louise de Kiriline Lawrence developed a pattern that she was to follow for the next 35 years. It consisted of long hours of patient observation in the field and many others spent indoors reading the scientific literature, discussing it in her correspondence, and working on her popular and scientific articles. Encouraged by Margaret Morse Nice, in the early 1950s, Louise began her long-term, comparative, life-history study of four species of woodpeckers. She had already banded and observed several woodpecker species during the 1940s, and was fascinated by their behaviour. MAR, the male yellow-bellied sapsucker she banded in 1949 was to become the subject of both a scientific study and a carefully crafted individual life history, Louise's personal "glimpse into the natural life of a bird" (1976).

From 1953 through 1959, Louise de Kiriline Lawrence spent more than 800 hours observing the communication, breeding, and post-nesting behaviours of the Yellow-bellied Sapsucker, Northern Flicker, and Hairy and Downy woodpeckers. The study area around Pimisi Bay was "choice habitat" for year-round observations. She was a firm believer, as was Niko Tinbergen, in the "natural experiment." So she observed in the open, without the restriction of a blind which "screens out the more distant stimuli that often account for many important and interesting variations in the birds behavior."[15] Daily observations led her to realize that "the keys to accurate interpretations of bird behavior are seldom extracted from disconnected samples of activities, but are found secreted deeply within sequences of events whose correlations may be lost with missed installments."[16]

During the 1960s, Louise continued her daily observations of the natural world around her while working on two books: one a scientific monograph on woodpecker behaviour, the other, aimed at a broader readership, a personal narrative of her life at Pimisi Bay. The first, *A Comparative Life-History Study of Four Species of Woodpeckers* was published by the American Ornithologists' Union in 1967, as Ornithological Monograph Number 5. It was favourably reviewed in scientific journals. J. David Ligon wrote,

> Her detailed accounts of the year-to-year activities of marked birds (changes of territories, mates, etc.) strikingly illustrate the variation in behaviour that may occur among individuals of a population and point out the value of long-term studies... This work is an important contribution to the knowledge and understanding of woodpecker biology.[17]

The Lovely and the Wild (1968), is Louise de Kiriline Lawrence's intensely personal story of her relationship with nature in Sweden and Canada, her love of the land and her growing awareness of the intricate web of life around her. It was enthusiastically received by readers and critics. Book review editor J. W. Hardy of the *Auk* wrote: "Known to *Auk* readers as a thorough scientist ... the author has here produced a delightful and informal account of her everyday confrontation with nature and especially the lives of birds."[18] In 1969, the 75 year-old author went to New York, where, at the American Museum of Natural History, she was presented with one of the most important awards for nature writing, the coveted John Burroughs Medal. The same year she also received the Sir Charles G. D. Roberts Special Award. The following year she was awarded an Honorary Doctor of Literature degree from Laurentian University.

Notwithstanding her new fame, Louise was happiest at the Loghouse where she continued her field observations and writing two new books. One was her own autobiography, the other a "biography" of the male Yellow-bellied Sapsucker, MAR.

Louise first began an autobiography, based on her letters written to her mother from Russia, in the 1920s. But she was still too close to the events that changed her life and abandoned the project. In the late 1960s, with two major works behind her, she was ready to deal with this important "slice of life" and felt that now she was able to present "a historical episode as it is now perceived from a greater distance in time and possibly a truer perspective."[19] *Another Winter, Another Spring: A love remembered* was published in 1977. More than a love story, it is a first hand view of history as well as an account of the first 30 years of Louise's life, most of which she had deliberately left out of her other writing.

Her other book, *MAR : A glimpse into the natural life of a bird* (1976), was one of Louise de Kiriline Lawrence's favourite "productions." Many years later she recalled "I loved writing it."[20]

Louise de Kiriline Lawrence, Pimisi Bay, Ontario, 1984. Photograph courtesy of Iola Price.

Through her interpretation of this bird's life, she had sought "to discover the interplay between the living creature and its environment and to determine the impact of events, trends and changes upon the individual's tolerance and responses."[21] MAR appealed to and enchanted a variety of readers, young and old, and created new interest in Louise's nature stories. Although she had steadily published in *Audubon* for more than 30 years, many of her shorter works never appeared in Canada. *To Whom the Wilderness Speaks* (1980), published when the author was 86 years old, remedied this situation. For this work she received the Francis H. Kortright Outdoor Writing Award.

In spite of her ongoing success as an author, Louise de Kiriline Lawrence felt that she was slowing down. "Planting, raking, watching, counting, observing, keep me too busy to achieve much else these days" she wrote to Doris H. Speirs.[22] She continued writing, however, and, in the early 1980s she was working on two nature stories, on woodpecker and Ruffed Grouse behaviour respectively. The first, "From hostility to amity" was published in *The Living Bird Quarterly* in 1984, the second "A springtime affair" appeared in *Audubon* in 1985. They were her last original publications.

In her early 90s, Louise could still get excited about discovering a new orchid on her land or watching a Barred Owl dash after a mouse. Having renewed her driving licence in 1984, she still drove to Rutherglen, Mattawa, or North Bay for supplies. But looking after Len, who was in poor health, occupied more of her time and used up most of her energy. In 1986, Louise made a decision that she sometimes regretted but never reversed; she gave up her forest home that for 50 years provided her with artistic and scientific inspiration and moved to North Bay with Len who had to be hospitalized. Although she retained a keen interest in the world around her and was delighted that her books were being republished, she knew that her active, creative days were over. The well-known author and naturalist died in North Bay on 27 April 1992, at age 98.

Louise de Kiriline Lawrence's life and work made an impact on a variety of people: prisoners of war, Russian peasants, Canadian loggers, friends and correspondents, world renowned scientists and the general public. She attributed her success to the support of her husband Len as well as to "two simple things… a consuming interest in nature and life, and a willingness to work at it with perseverance …"[23] Louise had the capacity to evoke love and friendship, to inspire poetry, and to encourage scholarly works. The interplay of her own life with a variety of events, her own responses and adaptations, remain as fascinating as were her writings about the natural world she loved so much.

Acknowledgments

I am grateful to J. Murray and the late Doris H. Speirs for having made some of Louise's correspondence available to me, to Bob Nero for the inspiration he gave to Louise in her old age, to David and Mark Ainley and to Iola Price for keeping me company on several visits to the Loghouse at Pimisi Bay, and finally to Louise de Kiriline Lawrence herself for having been such a wonderful writer, naturalist, personal friend and role model.

Notes

1 *Another winter, another spring: A love remembered*, page 265.

2 Ibid. page 266.

3 Louise de Kiriline Lawrence, "Why did I come to Canada?" *Chatelaine*, October 1937, page 53.

4 *To whom the wilderness speaks*, page vii.

5 *The lovely and the wild*, page 14.

6 Ibid. page 38.

7 Louise de Kiriline Lawrence to P. A. Taverner, 9 June 1940. P. A. Taverner Papers, Canadian Museum of Nature, Ottawa, hereafter PATP.

8 P. A. Taverner to Louise de Kiriline Lawrence, 21 June 1940, Louise de Kiriline Lawrence Papers, National Archives of Canada, hereafter LKLP.

9 Louise de Kiriline Lawrence to P. A. Taverner, 16 June 1942, PATP.

10 P. A. Taverner to Louise de Kiriline Lawrence, 30 June 1942, LKLP.

11 Louise de Kiriline Lawrence to P. A. Taverner, 13 October 1942, PATP.

12 Louise de Kiriline Lawrence to P. A. Taverner, 24 February 1945, PATP.

13 Ibid.

14 Louise de Kiriline Lawrence, conversation with the author, 1982.

15 *A comparative life-history study of four species of woodpeckers*, page 5.

16 Ibid.

17 *Auk*, 1968: 700.

18 *Auk*, 1968: 702.

19 *Another winter*, page vii.

20 Louise de Kiriline Lawrence to Doris H. Speirs, 25 December 1984, Speirs Family Papers, Pickering, Ontario, hereafter SFP.

21 "Foreword," *MAR: A glimpse into the natural history of a bird.*

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23 Louise de Kiriline Lawrence, Autobiographical Notes, 1975. American Ornithologists' Union Papers, Smithsonian Institution Archives, Washington, D. C.

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Ornithological Bibliography of Louise de Kiriline Lawrence

Editor's note:

The basis of this bibligraphy is one prepared by Louise de Kiriline Lawrence, updated by her to about 1985, on file at the Smithsonian Archives, Washington, D.C. 20560, where it is Record Unit 7308, American Ornithologists' Union, Biographical Files. My thanks to Susan W. Glenn, Assistant Archivist, for conveying permission to use it here. Marianne Ainley has updated entries 66 and 67 and Barry Penhale, Publisher, Natural Heritage/Natural History Inc., P.O. Box 95, Station 0, Toronto, Ontario M4A 2M8, added the new editions listed as 70 to 74. These are available from the publisher. Issue and page numbers omitted in the author's list have been added and titles (perhaps manuscript originals) have been corrected in entries 1, 3, 4, 6 (*Farmer's Magazine*) and 35 (*Audubon Magazine*). Two titles (7, 8) have been added and subsequent entries renumbered. The *Farmer's Magazine* (Canada) was published in Toronto, Ontario, and a set is held at the Agriculture Canada Library in Ottawa. Arch Stewart, Chief of the Library and Archives, Canadian Museum of Nature, Ottawa, and Christina Valliers, Circulation Library, Agriculture Canada, Central Experimental Farm, Ottawa, gave invaluable assistance in locating periodicles. Articles in the *Farmer's Magazine* and *Audubon Magazine* were published under Louise de Kiriline, most others under Louise de Kiriline Lawrence.

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6. 1945. Winter motif in red. Farmer's Magazine (Canada) 42(2): 18–19.
7. 1945. My friend the bachelor. Farmer's Magazine (Canada) 42(4): 18, 21, 29.
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Book Reviews

Zoology

Atlas of Breeding Birds of the Maritime Provinces

By Anthony J. Erskine. 1992. Nimbus Publishing and the Nova Scotia Museum, Halifax. x + 270 pp., illus. $29.95.

This book is the outcome of the Maritime Breeding Bird Atlas project, an effort that involved 1120 volunteers who spent 43 093 hours over five field seasons (1986-1990) systematically combing the three Maritime provinces (New Brunswick, Prince Edward Island, and Nova Scotia) for evidence of breeding birds. Although many people were part of the Atlas Steering Committee, it fell upon one of them, Anthony Erskine, to write up the results, a task for which he was well suited given his 30-year experience as a professional ornithologist working for the Canadian Wildlife Service (Atlantic Region). It is also a task which he fulfilled very competently.

The bulk of the volume is occupied by individual species accounts. Each of the 188 main species is given a full page treatment which consists of: (1) the name of the species in English, French, and Latin; (2) an ink drawing of the bird by Azor Vienneau; (3) a text of some 325 words describing the species' North American distribution, its natural history, habitat use, reported Maritime sightings before and during the Atlas project, and reflections on the past, present, and possible future abundance in the Maritimes; (4) an estimate of the current population size in each province; (5) a diagram showing the breeding chronology; and most importantly (6) a map of the three provinces showing the location of sightings, with dots of various sizes denoting confirmed, probable, or possible breeding. The original 10 x 10 km sampling squares delineate the resolution of the maps, but an additional map in inset is drawn to a resolution of 20 x 20 km squares, to smooth out inequalities in sampling effort within these larger squares. There are also 26 half-page treatments of peripheral species, and a list of 16 species that were not mapped because of questionable wild status, questionable breeding evidence, or no evidence despite some pre-Atlas reports to the contrary. All of this is sandwiched between various chapters and appendices that deal with technical aspects of the project and its potential impact on the understanding and management of bird populations in the area. A list of 159 references, most of them on the biology and distribution of local birds, is a useful addition.

For the individual, the main advantage of owning an *Atlas of Breeding Birds* is to have a more precise description of a species' breeding range than is available from the maps of field guides. In that respect, it is noteworthy that this *Atlas* reports many "firsts", such as the first breeding Pine Warblers in the Maritimes (SW New Brunswick), the first breeding Indigo Bunting in Nova Scotia, and the first breeding Three-toed Woodpeckers in Prince Edward Island and Nova Scotia (Cape Breton Island), to name just a few. A birder can use the maps to learn where breeding birds of locally uncommon species have been sighted, and therefore where they stand a good chance of being seen again. Note however that the maps in this *Atlas* do not show towns and roads; there are many map overlays at the end of the book, showing among other things elevation contours, major rivers and lakes, and distribution of human population, but none with towns and roads.

Together with the *Atlas of Breeding Birds of Ontario* and the upcoming *Quebec Atlas of Breeding Birds*, this well-designed and objectively presented volume will provide birders with an excellent tool to locate the best areas to observe breeding birds in Eastern Canada, and to determine the novelty of any rare sightings they may wish to report.

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Bats

By M. Brock Fenton. 1992. Facts On File, New York. xvi + 207 pp., illus. $55.00.

This book combines a diverse array of information on bats in an attractively illustrated publication. As is his usual style, Dr. Fenton presents an engaging narrative on these unique and intriguing animals, the only mammals to possess true flight. One of the foremost bat researchers in the world, he will stimulate both the specialist and general reader alike.

The book is divided into 13 chapters with a range of interesting subjects such as the scientific process of studying bats, facts and fiction of vampire bats, and differing cultural perceptions of bats. Other more traditional topics include echolocation, feeding strategies, roosts, social behaviour, public health, conservation, natural history, and general biology. Interspersed throughout the book are 20 accounts of more specialized subject matter with detailed explanations. Some of these interesting discussions cover bat photography, technical aspects of echolocation, and the building of bat houses. There will surely be a fascinating topic to satisfy most curiosities such as a summary on bat detectors, devices used to listen to bats at night.

Drawing extensively on his own research programmes, supplemented with references to general books and specialized articles, Dr. Fenton is able to comment authoritatively on many aspects of bats, from the scientific to the artistic. Not only does he discuss echolocation, one of his primary areas of study, but also differing human social views of bats as evidenced in textiles, ceramics, and other art media. For example, although some bats may consume the equivalent of their own body weight in insects, many insects have specialized strategies to lessen their chance of predation. Some insects have ears sensitive to bat echolocation allowing them to detect and avoid bats whereas others utilize secretions in combination with audible noises to alert bats to their unpalatable taste. For most North Americans, bats usually conjure images of blood-sucking vampires or pests in their cottages. However, the reader will discover that bats roosting in cottages are very beneficial because they consume large quantities of insects. For the record, vampire bats are found only in Central and South America (one stray record from Texas) usually in close association with domesticated livestock. In contrast, Chinese culture portrays bats as symbols of joy and happiness with their images appearing in artwork and on everyday items such as rice bowls and clothing.

Liberally sprinkled throughout the book are numerous photographs of bats. They are of exceptional quality with most in colour and with many bats in natural setting. All but a few photographs are taken by the author and they represent over one hundred different species of bats. This attests not only to the wide species diversity found in this order of mammals, but also to Dr. Fenton's vast field experience with bats throughout the world. An appendix lists the common name, scientific name, and taxonomic family for all bats mentioned in the text. This represents almost one-fifth of the currently recognized species and all families of bats, testament to the breadth of the book and the author's knowledge of bats.

Without trying to look for typographical errors, one did catch my eye; the misspelling of the scientific name for moustached or leaf-chinned bats (family Mormoopidae) in the appendix on page 192. Some added features include the italicizing of page number in the index for illustrations and the listing of references by chapter in the bibliography with extra information on general works, books for younger readers, and two bat newsletters from the scientific community but also suitable for the amateur naturalist.

This book has successfully combined coffee-table presentation with scientific-based facts in a publication that will likely appeal to a wide readership. Very few scientists are able to consistently communicate their ideas to both the public and scientific communities. Considering the quality of publication and the information contained within, this is a very reasonably priced book that will be stimulating to both the amateur and the specialist interested in bats.

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A History and Atlas of the Fishes of the Antarctic Ocean

By Richard Gordon Miller. 1993. Foresta Institute for Ocean and Mountain Studies, Carson City, Nevada. xx + 792 pp., illus. Cloth U.S. $95; paper U.S. $78.

This book, a Special Publication of Foresta Institute, is a "Contribution to International Geosphere and Biosphere Program of International Council of Scientific Unions". It consists of two parts. Part 1 describes historical, physical, and zoogeographical aspects of the Antarctic Ocean, the history of ichthyology of the Antarctic Ocean, and exploitation and conservation of the Antarctic fishery. Part 2 consists of an atlas of the fishes. In all, some 378 species are described. A special chapter by Dr. Philip A. Hastings reviews relationships of fishes of the perciform suborder Notothenioidei.

Although this book will be a primary interest to biologists wishing to have a good treatment of Antarctic fishes, it will interest all readers wishing to make, for example, comparisons with other groups in cold adaptation. Biologists interested in the fishes of the Arctic Ocean will be envious of the recent comprehensive books available on Antarctic fishes; in addition to this fine contribution by Richard Miller, there are two other recent volumes:

Antarctic Fish Biology by J. T. Eastman, 1993, Academic Press, and *Fishes of the Southern Ocean* edited by O. Gon and P. C. Heemstra 1990, J. L. B. Smith Institute of South Africa.

Although a similar degree of endemism in the fishes does not exist in the northern counterpart, one hopes that we may soon see at least one comparable treatment of the biodiversity of Arctic fishes.

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Owls: Their Natural and Unnatural History

By John Sparks and Tony Soper. 1989. Facts on File, Inc., New York. 240 pp.

Books on owls have been among the more popular of natural history books recently, ranging from coffee table books to biological treatises. *Owls. Their Natural and Unnatural History* is a revised edition of a book originally published in 1970. It presents a considerable wealth of information on owls in layman's terms, including biology, mythology and ecology. Although updated, the book still retains the impression of its original publishing date. Of 86 dated references that are listed, only 9% were published after 1970.

The book suffers from a lack of obvious organization. Within the text, owls are not dealt with individually or by genera, but by general topic. These provide interesting, functionally-related discussions, but they are difficult to keep up with and to locate information within; examples of the inclusive chapter headings include "Owls of all Shapes and Sizes", "Owls and Man", and "Numbers of Owls". It is not a book that you can scan or quickly reference for information, but rather one to sit down and read through. This book also ends abruptly in appendices, with no logical conclusion or wrap-up.

The book is intended to be comprehensive, purporting to deal with more than 130 species of owls worldwide. However, as the authors are from Great Britain there is an apparent European bias that may reduce the book's attractiveness to North Americans. North American owls on occasion appear to be given less attention — as an example a section on owls using artificial nesting structures does not mention recent initiatives in nesting structures for Great Gray Owls, Burrowing Owls or Screech Owls. The circumpolar nature of many owl species is not well addressed; in one example the Long-eared Owl is represented as being only from Europe, and the sketches of representative owl species from both continents do not acknowledge that many of the European species also occur in North America. The Boreal (Richardson's) Owl is referred to only by its Old World name "Tengmalm's Owl", except for a reference in the Appendix; however sketches of both the Boreal Owl and Tengmalm's Owl are shown as representatives of the tundra/taiga for North America and Europe respectively, without acknowledging that they are the same species.

This book contains many informative natural history sketches illustrating such aspects as appearance, food habits, pellets, and ecological parallels between hawks and owls. The sketches are generally good and located with the appropriate text; in at least one case a black-and-white sketch was inappropriate to illustrate the differing plumage characteristics between a gray phase and a brown phase Screech Owl. The book also contains a number of excellent photographs, usually in colour; these photographs are almost without exception clear, bright and in focus. The diversity of illustrations lends to the book's appeal and ability to provide information. Both the sketches and photographs are difficult to locate — there is no index to them, the photographs especially do not appear to be placed in the text in any systematic or logical order, in some cases there are no legends at all, and the figures are not numbered so they cannot be cross-referenced with the text. This cross-referencing problem extends to the references. Several reference sources are listed in the book, but they are not cited directly in the text, making it more difficult to obtain specific follow-up information.

This book presents a curious and interesting mix of scientific and non-scientific information. It does cover a considerable amount of general biology, and draws thoughtful parallels to owls from throughout the animal kingdom; one example is the territorial similarities of owls hooting and thrushes singing. However, these comparisons can be carried to the extreme, and at times the book becomes a rambling collection of trivial facts about various mammals, bird and insect species. Examples include diverting a discussion from the communal nesting of owls to the habits of pied wagtails and pill bugs, and comparing owls' habit of remaining immobile upon discovery during the day to the hedgehog's strategy of rolling into a ball. Habitat management or protection is given little recognition in the book, other than general calls for efforts to reduce environmental pollution.

This is not a rigidly scientific book, nor is it intended to be one. The chapter on "Owls — The Unnatural History" should confirm that. This is an interesting and wide-ranging review of owl folklore, from Shakespeare to the Romans, from Genghis Khan to native North Americans. It is interesting, nonscientific, and fun. There is even a section on owl slang (eg. to "take the owl" in the 18th century was to become angry).

A tangential attribute to this book is the opportunity provided for expanding the reader's grasp of the language or, depending on your outlook, for causing frustration because of the need to consult a dictionary. My favourite words included parlous, lustration and abstemious. The writing style is at times too detailed and cumbersome; as an example I offer the following 48 word sentence: "Besides which, practically all owls, even the fish-catching species, look unmistakably like owls, with the possible exception of the hawk owl which, through convergent evolution, has come to resemble a falcon and, with less conservative tastes than the specialist bird-eating peregrines, even to behave like one."

My conclusion after reading this book was that the authors really like owls, they had collected a wide range of information on owls from both scientific and folklore sources, and they wanted to combine it all within one book to celebrate owls on earth, providing both interesting information and an enjoyable read. To that end, they have achieved their goal.

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The Birdwatcher's Book of Lists: Western Region

By Lester L. Short. 1987. Running Heads, New York and Raincoast Books, Vancouver. 128 pp., illus. $8.95.

This small book consists of two main parts, a series of 23 "birding lists" and an array of range maps of some species of western North America. Dr. Short's introduction explains that the book is designed primarily for beginners, outlines the purpose and use of the lists and offers advice on note taking. The lists stress relatively common birds and are arranged from activities requiring little effort (bird feeder birds; birds nesting in your back yard) to those that require somewhat more effort, either by nature of the activity (night birding; weekend spring warbler watch) or because they require effort to reach a destination (southwestern deserts; Hawaiian bird specialties; North American and World travel lists, etc.). Some consist of essentially blank pages for the reader to fill in, while others list two to eight pages of species that might be encountered in western North America under the prescribed circumstance. Names are listed in both English and Latin by the sixth (1983) edition of the Américan Ornithologists' Union Check-list. The longest is a 21-page life list. Space is left in the margins of some for notes and illustrations by Juan Luis G. Vela are scattered throughout. An appendix of sources (organizations and publications) and an index complete the volume.

Because the lists that do list species are intended for all of western North America, most are of little use locally. For example, bird feeder watchers in Canada are not likely to see Inca Doves or Mexican Chickadees, while both prairie and Arizona feeder watchers would be phoning hot lines if a Chestnut-sided Chickadee showed up. Even the life list would be useful only to beginners, as several regular but relatively scarce western North American species (e.g., Yellow-billed Loon) are missing. Thus, the primary usefulness of the lists lies in their ideas rather than in the lists themselves. Bird names and ranges are generally accurate, but several errors have crept in. The most amusing is the creation of a new bird family, Icingfishers (p. 29). Storks have been added to the Anatidae (p. 36), the Olive-sided Flycatcher has moved from *Contopus* to *Mionectes* (pp. 36 and 102) and Ann appears to have stolen a hummingbird from Anna (p. 116). Some ranges are incomplete, as exemplified by the listing of Heerman's Gull as only southern on the coastal wetlands list in spite of its ranging to the northern limit of the range maps after nesting. The range maps extend north only to about the southern third of British Columbia and the prairie provinces and omit several regular, albeit uncommon, species from coastal B.C. (e.g., Green Heron, Bewick's Wren) and even such common species as Mallard and Snow Goose. Canadian Wildlife Service officials will be astonished to find themselves listed among Canadian national ornithological and naturalist societies, and several recommended sources are less appropriate than others that are not listed.

In short, the book falls far short of being "the most ingenious and useful assemblage you have ever seen of record keeping material ..." claimed by the publishers on the dust jacket. The author's more modest ambition of providing an aid to those with a new interest in birding has been partially fulfilled, but even for that purpose, its usefulness is somewhat limited.

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Oklahoma Bird Life

By Frederick M. Baumgartner and A. Marguerite Baumgartner; illustrated by Wallace Hughes. 1992. University of Oklahoma Press, Norman, Oklahoma. xxxv + 443 pp., illus. + plates. U.S. $49.95.

This book provides an excellent and attractive introduction to the birds of Oklahoma and it is obvious the authors know their material. In the 26-year period the Baumgartners spent living and working in Oklahoma they published extensively in scientific journals and were active members of the Oklahoma Ornithological Society. In addition, Frederick Baumgartner was the regional editor from 1949-1965 for Audubon Field Notes (now American Birds) and a professor at Oklahoma State University. Margaret Morse Nice, the well-known field ornithologist who wrote the first publications entitled *Birds of Oklahoma* in 1924 and 1931, was influential in encouraging the Baumgartners to write this present book.

For the field naturalist, Oklahoma has a wide diversity of habitats to offer. This includes 10 different biotic associations comprising a variety of forest, grassland, and mesa habitats. The topography consists of generally flat to rolling plains and mountainous areas. Six major rivers traverse the state. One should be aware that when visiting the state the weather can be very erratic. In fact, Oklahoma is in a part of the United States dubbed "Tornado Alley". Therefore, in the appropriate season, violent thunder and hail storms are not uncommon. The most important 'must see' birds are probably the endangered Black-capped Vireo and Greater Prairie Chicken. The Black-capped Vireo is restricted to the Post Oak-Black Jack Oak Forest Association, the second largest forest association in Oklahoma. Similarly, the Greater Prairie Chicken has become an uncommon to rare resident of the tall grass prairie, large expanses of which still exist in Oklahoma but are becoming increasingly fragmented.

A better name for the Baumgartners' book might be the "Encyclopaedia of Oklahoma Birds" since it is so thorough in its coverage. The bulk of the book consists of the introductory and species account sections. The initial chapters are extensive, numbering approximately 50 pages, and provide a thorough background to both bird study and to Oklahoma avifauna. Titles such as "Seasonal and Regional Distribution of Oklahoma Birds", "A History of Ornithology in Oklahoma", "Bird Study as a Hobby", and "Breeding Bird Surveys" attest to this. Appendices include a list of stragglers (occasional, accidental records), foreign recoveries of banded birds, state organizations, recommended reading, extinct species, and a key to birds' nests. It should be noted that although much of the literature cited is relevant it tends to be to older material. For example, in the "Recommended Reading" section the most recent reference is dated 1984.

The bulk of the text consists of accounts of the 355 species of regular occurrence which have been verified by specimens, photographs, and written reports. Each account includes information on the ecology, status, and occurrence (to 1986) of each species. Also included is nesting and breeding bird survey data. The enthusiasm the authors have for their subject is obvious with their very lively writing style. For instance, in describing the Chestnut-sided Warbler, they write: "The Chestnut-sided is everything one could desire.... He has a stripe of chestnut on the length of his snowy chest."

For the most part the line drawings are fine although they tend to be variable in quality and the odd photograph is a little fuzzy. Despite this, the tables and maps are exceptionally clear and detailed. The plates painted by Wallace Hughes are attractive and an additional aid for field identification. On 51 colour plates, he has depicted 257 species, in typical habitat, with plenty of background detail. Importantly, the plates include immature plumages of a large proportion of the species illustrated.

A book of this size, approximately 9″ x 12″, is too unwieldy for the field but it would be an invaluable resource prior to planning a trip or to keep in the car for on-site use. A book due to become a classic text in the collections of North American ornithologists.

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Bird Census Techniques

By C. J. Bibby, N. D. Burgess, and D. A. Hill. 1992. Academic Press, San Diego. xvii + 257 pp., illus. U.S. $19.50.

No sooner had this book landed on my desk for review that a graduate student snatched it up from my hands and hurriedly left to study it. His master's work was on the effect of logging on bird communities, and he had been searching the scientific literature for information on bird census techniques, with only mixed success. Thus, right from the start, I believed the authors' claim that their book provides a useful central compilation of information not easily accessible elsewhere.

The following bird census techniques are covered: territory mapping, counts along line transects, point counts, capture-recapture, catch per unit effort, direct and indirect counts of particular species (e.g. flocking birds, seabirds, raptors, etc.), and distribution studies (e.g. atlases). Most of these methods receive full-chapter treatment, in which the authors discuss the types of question for which the method is appropriate, explain how the technique should be carried out, present the assumptions and limits of the method, give a few examples from the scientific literature, and provide a summary. Tables, figures, and explanations based on figures are gathered in boxes in the middle of each chapter. Equations to calculate densities are given, along with examples. The text is clearly written, but readers should be aware that the subject matter is intrinsically related to statistics and that analytical thinking is needed to understand some of the arguments and examples.

There are two things that readers should not expect to find in this book. First, the book is not an exhaustive collection of references on census techniques; only two or three examples (many of them on British birds) are given for each technique. However, at least three other books which contain more references are cited. Second, the book will not provide solutions for the shortcomings of the techniques. The reason is simple: such solutions do not exist. Instead, the authors make the readers aware of the shortcomings when choosing a method to address a specific question.

Very seldom does a counting method give an exact estimate of population size, and this book makes it clear. However, if one follows the authors' recommendations, it should be possible to draw valid conclusions from comparisons between habitats in the same year, or between years in the same habitat. These conclusions could influence management decisions and conservation of bird populations and habitats. This book will undoubtedly be useful to professional bird ecologists, but I would also recommend it to serious bird-watchers who are willing to put in the time necessary for thorough bird-counting. The reward could be a worthy contribution by birders to the conservation of birds and their habitats.

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The Ecology, Status, and Conservation of Marine and Shoreline Birds on the West Coast of Vancouver Island

Edited by Kees Vermeer, Robert W. Butler, and Ken H. Morgan. 1992. Occasional Paper (Canadian Wildlife Service) number 75. Canadian Wildlife Service, Ottawa. 136 pp. Free.

This is the 75th publication in the excellent Occasional Paper series produced by the Canadian Wildlife Service. This timely and useful book brings together a series of 17 papers which were presented at a symposium held in April 1991 at the Institute of Ocean Sciences in Sidney, British Columbia. The purpose of the symposium was to bring together researchers from various disciplines to discuss the marine biology of the west coast of Vancouver Island with particular emphasis being on birds. The 1989 Nestucca oil spill and the resultant dying of thousands of oil-covered seabirds increased awareness of the sensitivity of this coastline to disturbance, and to the avian populations that were dependant on this marine ecosystem for breeding, migration, and feeding. As well, the presence of increased logging activities, the industrial development of estuaries, mudflats and spawning grounds, fisheries operations, human disturbance of colonies, and introduced predators have all put pressures on this coastal area. The coastline is remarkably productive due to a combination of the presence of a continental shelf, favourable currents which create productive upwellings, large tidal flats, and good breeding locations.

The papers are organized into four topical areas: "Physical and Biological Environment", "Population and Breeding Ecology", "Distribution", and "Oil Pollution and Conservation". The accompanying figures, tables, and maps are clear and well-presented and the text is not overrun with technical jargon. All the papers have ample "literature cited" sections and include a short abstract. One of the more important papers is that presented by Manley, Shortt, and Burger in which they describe the first two Marbled Murrelet nests found in British Columbia and discuss the importance of old growth forests as nesting sites for this species.

This book is invaluable for anyone interested in marine and shoreline birds and for the price of a postage stamp it is a bargain. To obtain a copy write: Publications, Canadian Wildlife Service, Environment Canada, Ottawa K1A 0H3 or phone (613) 997-1095.

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BOTANY

Vascular Plants of Wyoming, Second Edition

By Robert D. Dorn. 1992. Mountain West Publishing, Cheyenne, Wyoming. 340 pp., paper U.S. $13.00 postage included.

The first edition of *Vascular Plants of Wyoming* (1988), according to the author, added more than 200 species to the number treated in his *Manual of the Vascular Plants of Wyoming*, which was published in 1977. Both of these titles are now out of print. The present volume, according to a flyer, contains keys to 123 families, 662 genera, 2398 species and 709 varieties. This is a great step from the 1977 flora which did not include infraspecific taxa, some annual grain field weeds and species growing under irrigation, including lawn weeds.

Two new species, *Cirsium aridum* and *Phlox opalensis*, and three new combinations, *Ipomopsis aggregata* var. *tenuituba*, *I. spicata* var. *robruthiorum*, and *Potentilla hippiana* var. *effusa* are presented on pages 304 and 306 and appear in the text, but these pages are not listed in the index. In the first edition of Vascular Plants of Wyoming there were $5^1/_2$ pages of new taxa and new combinations which were not found by the authors of Index Kewensis — Supplement XIX (1876-1990). Hopefully these and those of the second edition and the earlier flora will all be in Supplement XX. It would have been better to have published them in a readily accessible journal such as Rhodora, Madroño, Phytologia, Great Basin Naturalist, or Taxon.

The Introduction is short and the user is referred to the Introduction of the earlier edition and Taxonomic Notes also found there for basic background material. In view of the fact that the earlier edition is out of print, it would have been better to repeat these few pages in this edition.

Short descriptions are provided for the families and genera. No descriptions are provided for species or lesser taxa, but considerable information can be obtained by working back through the keys. Common names are given to the families and genera but not to the species or subspecific taxa. Habitat information is very brief, and distribution information is given by county or coded to a map facing the inside back cover. Pertinent references may be found adjacent to the generic names throughout the text.

As in the first edition the text has been divided into three major groups: Pteridophytes, Gymnosperms, and Angiosperms, in each of which the families and genera are in alphabetical order. This reviewer would have preferred to see the Angiosperms divided into Monocotyledons and Dicotyledons and thus not find the Cyperaceae lodged between the Cucurbitaceae and Dipsacaceae, and the Orchidaceae between the Onagraceae and Orobanchaceae. Synonyms are not provided in the text, but some may be traced in the index to the accepted names.

Although this volume has a soft heavy paper cover, the pages are bound in fascicles (not perfect) and thus should withstand the battering that it might receive in a pack sack. It is very inexpensive when compared to many other botanical books on the market today, and should prove to be a most useful tool for botany students in Wyoming and adjacent states.

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Alaska's Wild Plants: A Guide to Alaska's Edible Harvest

By Janice J. Schofield. 1993. Alaska Northwest Books, Seattle, WA. 96 pp., illus. Paper U.S. $12.95; $16.95 in Canada.

For someone interested in sampling wild plants, this is an interesting publication. Some 72 species both native and introduced are illustrated in colour and organized by the habitat in which they are usually found. Useful notes that include information about each species or group of species, derivation of the latin name, additional common names, range, harvesting directions, food use, medicinal use, and other uses are presented. Another section entitled "Cooking with wild plants" includes recipes for salads, dressings and sauces, snacks and appetizers, soups, main meals, beverages, breads and butters, and desserts. Two pages on which seven species of poisonous plants are illustrated and described and information on the types of poisoning are also included.

In the introduction there is a "word of caution": "Be certain to review the "Caution" sections carefully. Some plants, such as cow parsnip, can cause dermatitis; others, like red elder, have both edible and toxic portions. When eating any new food for the first time, consume a small amount only. Be sensitive to the effect on your body, and discontinue use immediately and seek medical attention if you experience adverse reactions or allergies. Above all, be positive of identification: a nibble of poison hemlock can have dire consequences".

Also in the introduction is an important section entitled "Harvesting with awareness" in which those gathering plants are warned not to over harvest or to gather samples from restricted areas.

This is a delightful little book which can readily be carried in your pack sack or in your car, but it is most important that you are absolutely sure of the identification of the plants harvested, or there might be "dire consequences".

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Bitterroot

By Jerry DeSanto. 1993. Lere Press, Babb, Montana. 120 pp., illus. Available from the author, P.O. Box 91, Babb, Montana 59411. U.S. $13.00

The author became intrigued by Bitterroot (*Lewisia rediviva*) when he first came upon it in Yellowstone National Park where he was a seasonal employee of the National Park Service in the early 1950s. Since that time he has scrupulously gathered all sorts of information on this plant which occurs in western North America from northern Colorado, Wyoming and southern Montana westward to California, Oregon and Washington and barely enters southwestern Alberta and southern British Columbia.

The resulting data include its use as a food and what it was called by the early inhabitants of the region, its first collection by a white man (Lewis and Clark expedition 1806), its description by Pursh in 1814 and the disappearance of the type specimen for many years, its habitat and growth, attempts at cultivation, many colour variations, and ends up with two Appendixes "Ethnobotany of Lewis and Clark Expedition" and "Travellers Rest" where Bitterroot was collected by Lewis, and a useful bibliography. Some excellent photographs are included which show the various colour forms of Bitterroot as well as some other plants discussed in the text.

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Les Cypéracées de l'est du Canada

By Bernard Boivin, illustrated by Marcel Jomphe. 1992. Provancheria No. 25. Herbier Louis-Marie, Université Laval, Québec. 230 pp., illus. $15.00.

Here is the culmination of years of effort by the late Bernard Boivin in understanding the large, difficult, and important family Cyperaceae in eastern Canada. The book was published posthumously seven years after Boivin's death, thanks to the efforts of Robert Gauthier, editor of Provancheria, and of Jacques Cayouette and Paul Catling.

After an introductory section outlining the history, philosophy, and scope of the work, as well as definitions and abbreviations, this book consists mostly of keys to genera and species and descriptions of species. The keys are original, and focus on readily observable features. On the whole, these keys are much easier to use than those in most manuals and the descriptions, though brief, are also original. Division of *Carex* into easily recognized groups for keying is a notable feature in this book. Keys to *Cyperus* and *Eleocharis* are split geographically, making identification much easier in those large areas of eastern Canada where few species occur. The keys to *Carex* also occasionally use geography as a key character. The treatment of the complex and species rich section *Ovales* is especially noteworthy. A long introductory section lists species having various distinctive combinations of characters. This is a very helpful approach, almost like a polyclave key, and should allow people to have greater confidence in their identification. Illustrations are numerous, and are a very helpful feature of this book.

Unlike many floristic botanists, Boivin — as he was known to everyone — was not afraid of the sedge family, and his extensive knowledge of them made him, for many years, one of the very few people in Canada who could reliably identify them. As such, ranges and citations of collections are highly reliable, and form a firm foundation for future work. Especially valuable in this work are the numerous cases where Boivin tracked down specimens supporting erroneous reports of a wide range of species and reported on their disposition.

Boivin was a great believer in the practicality of systematics, and practical considerations of utility and ease of use sometimes more heavily influenced his decision making than evolutionary considerations. Thus, the taxonomy is somewhat conservative. Specialists in certain groups may split species where Boivin recognized only varieties or even lumped taxa altogether. However, this does not diminish the usefulness of the book. Reasons for lumping are usually given, and synonymy and sometimes literature citations are provided for those who wish to do further research on the group.

It is unfortunate that Boivin did not have a few more years to work with the manuscript. Not long after his premature death, there was a great upsurge in interest in sedges, resulting in the discovery of a number of species new to the eastern Canadian flora, especially from Ontario, as well as the publication of a substantial number of floristic and systematic papers on Cyperaceae. Fortunately, these discoveries and publications are listed in the detailed protologue to the book by Jacques Cayouette and Paul Catling. Nomenclatural innovations are also summarized in a table in the protologue material. Note that the combination *Carex atlantica* var. *capillacea* (Boott) Boivin was predated by about a year by the same combination made by Art Cronquist in the second edition of the new Gleason and Cronquist *Manual of Vascular Plants*.

One particular predeliction of Boivin's deserves brief comment. Under a number of rare southern Ontario sedges; e.g., *Carex careyana, C. lupuliformis, C. trichocarpa, Scleria verticillata, S. triglomerata*; Boivin noted that some or all of the stations may have been the result of deliberate plantings into the wild. While it may be flattering to people working on sedges to think that there was great horticultural interest in planting them in natural habitats in the latter part of the last century and the early years of this century, the truth is more prosaic. In fact, all these species were, and often still are, present at these early collection sites. It is simply that for many years, sedges were largely ignored by collectors, or only the common species incidentally collected. As an herbarium botanist with limited field experience, Boivin may not have realized that many of these uncommon plants are very unlikely to be found unless specifically sought, and deliberate planting seemed a plausible explanation for the mysterious lack of recent collections. Unfortunately, once such speculations are codified in print and on annotation labels, these perfectly valid records — tributes, in fact, to the keen skills of these early field botanists — are forever dogged by needless doubt.

Overall, the book is quite well laid out and free of typographical errors. Illustrations are numerous and very helpful, especially in difficult groups. In plate 34 (page 124), the labels are confused for three illustrations. The illustration labelled *C. molesta* is *C. hormathodes*, that labelled *C. hormathodes* is *C. silicea*, and that labelled *C. silicea* is *C. molesta*. A few other illustrations are somewhat uncharacteristic, including the drawings of both *Carex hostiana* and *C. pallescens* with nodding lower spikes, surely a rare occurrence (plates 49 and 51). The "perfect" binding, with a tape backing, unfortunately, will quickly need repair.

These minor problems aside, the book is a must for anyone interested in Canadian sedges, and at $15.00 is good value.

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The Jepson Manual: Higher Plants of California

Edited by James C. Hickman. 1993. University of California Press, Berkeley. xvii + 1400 pp., illus. Cloth U.S. $65.00 + $4.50 shipping and handling.

It was in 1925 that Willis Linn Jepson completed the sixth part of his *Manual of the Flowering Plants of California*. This work, which numbered 1238 pages, described 4019 species, of which 3727 were native and 292 alien. The present work, which is in a larger format, numbers 1400 pages and includes descriptions of 5862 species, of which 1169 are endemic, plus 737 endemic subspecies or varieties. Of these, 26 species are presumed to be extinct.

The stimulus for *The Jepson Manual*, Lawrence R. Heckard, most unfortunately did not live to see the final result which took about 10 years and involved some 189 contributing authors, whose efforts would never have been published without a hard working staff, consultants, volunteers, and generous benefactors.

The book is designed for easy accessibility to information within the four major groups of higher plants, ferns and fern allies, gymnosperms, dicots, and monocots. The families, genera and species, and infraspecific taxa are arranged alphabetically. The family key is designed to work and reach the correct answer even if the user makes a technical error. Keys to genera and species appear to be quite workable. Detailed but concise descriptions are provided for families (where there is more than one genus), genera (where there is more than one species), and species. The user must however familiarize himself or herself with abbreviations and certain symbols which may at first slow down comprehension, but the size of the book would have been much greater and the book thus more costly if they had not been used. Habitats and ranges in California are given together with overall range and origin of introduced or escaped from cultivation. Uses are also provided. In the text, accepted species are in bold face italics while introduced species are only in italics, but both are in bold face in the keys.

The text is accompanied by some 242 pages of illustrations by Emily E. Reid, each page containing nine blocks of fine drawings which were designed to portray key characters and show variation between species. Unfortunately not all the species in the flora are illustrated, but to have done so would have required an impossible number of additional pages. However, at least one species per genus has been included.

The introductory section of the volume includes a short preface regarding Willis Linn Jepson, acknowledgements, and a list of the contributing authors. This is followed by the introduction, which should be read by anyone using the flora: Philosophy and History of The Jepson Manual Project, Conventions Used in the Jepson Manual, Pronunciation of Scientific Names, Glossary, Abbreviations and Symbols, Commonness and Rarity, Horticultural Information in The Jepson Manual, Geographic Subdivisions of California, California's Geological History and Changing Landscapes, and California's Changing Climates and Flora. Three appendices follow the text: Floristic Summary, Classification of California Plant Families, and Name Changes from Recent References.

The Jepson Manual like its predecessor *Manual of the Flowering Plants of California* will now become a standard reference for teachers, students, and naturalists interested in learning about the plants of California. It will also be invaluable for individuals in adjoining states, and botanists throughout North America and around the world interested in the plants of this extremely interesting region. And the price is remarkable!!!

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ENVIRONMENT

Climate Change and its Biological Consequences

By David M. Gates. 1993. Sinauer Associates. Sunderland, Massachusetts. vi+280 pp., illus. U.S. $18.95.

Here is another addition to the ever-growing pile of books on what-the-future-holds. Chapter 5 seems to be the heart of the book. It summarizes some of the many models that have been devised to predict how forests are likely to alter, in composition and geographic range, as a consequence of climatic warming. Model outputs are given for eastern North America, Canada as well as USA. Some models show predicted range changes of important tree species; other models the range shifts of whole forest types, assuming that forest composition will remain more or less unaltered. The brief accounts of the salient features of the models and their predictions may be useful to students wanting an overview of the subject, but the style is that of a technical report and makes dry reading for naturalist readers.

More importantly, the author has nothing to say on whether, and if so why, there is any point in predicting the range changes of various tree species for 600 years into the future, on the dubious assumption that all change will be the outcome of greenhouse warming. It seems to me a laborious and rather dull game of make-believe.

Predictions about organisms other than forest trees come in chapter 6, which seems to have been written for a different readership than chapter 5. Its qualitative speculations about what *could* happen for given changes in atmospheric carbon dioxide may interest the general reader who is willing to take notes, but no overall picture emerges.

Errors are distressingly numerous. Some of those I spotted are the following:

The figure on page 42, illustrating the earth's orbit, shows perihelion coming three months after aphelion.

How do we interpret the following (page 40)? Radioactive carbon dating assumes that "carbon 14 is *assimilated at the same rate as* carbon 13 and carbon 12. ... During photosynthesis, an isotopic fractionation occurs because carbon 12 is *more readily assimilated than* carbon 13 or 14 [italics mine]."

On page 53 it is implied that the Holocene Epoch began at 12,000 BP, instead of the formally recognized 10,000 BP.

On page 54 we are told that "The seasonal and latitudinal distribution of solar radiation [at 18,000 BP] was similar to that of today" notwithstanding the description, a few pages earlier, of the Milankovitch cycle.

Page 79 asserts that the cones of jack pine and lodgepole pine open *only* when heated by fire [italics mine].

Page 173 gives the range of the pika as "alpine meadows of the western United States mountains."

I am left wondering about the errors I didn't recognize.

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Water Quality in North American River Systems

Edited by C. Dale Becker and Duane A. Neitzel. 1992. Battelle Press, Columbus. xiii + 304 pp., illus. $44.95.

This interesting book offers both less and more than its title suggests. It is not a general review of water quality in North American rivers but rather a collection of essays dealing with selected rivers; such major rivers as the Mackenzie, the Colorado, and the Saint Lawrence are not discussed. The editors refer in their Introduction to a number of works in which information on other rivers can be found. On the other hand the book discusses a good deal more than simply water quality in a narrow sense. Most of the essays discuss the hydrology, biology, and sometimes the history of the rivers in greater or lesser detail.

Some of the papers are based on presentations at a symposium on water quality at the 117th meeting of the American Fisheries Society in 1987, and others were contributed later. Some have references to publications as recent as 1990, but in general they seem to describe the conditions of the various rivers as they were in about 1987. The book therefore does not necessarily describe the states of the rivers at the present time. For example the Bow River in western Canada had not, at the time of writing, responded to reductions in phosphate loading started in 1982.

Of the 12 river systems discussed, two are entirely in Canada and one, the Columbia, runs through Canada for part of its extent. One is in Mexico. The others are entirely in the United States. Certain problems appear to be common to most or all of them. These include eutrophication from sewage plants, contamination from industry and agriculture, and increased silt loads as a result of construction, logging, and other activities in their basins. Increased dissolved solids as a result of return of irrigation water is a concern in some. The fish populations of some have been changed by the accidental or deliberate introduction of exotic species. The larger rivers have all been extensively dammed for navigation or hydroelectric power generation, or both, sometimes causing profound changes in their character. Such changes are usually detrimental to fish, especially important anadromous species. They also appear to have a harmful effect on certain invertebrates, particularly mussels.

Other problems are peculiar to certain rivers. The Chena River runs through a subarctic region in Alaska. It contains only 13 species of fish, and these grow slowly. In most streams, organic material derived from leaf litter is more important than primary productivity as a base for the food chain, but here the amount of leaf litter entering the stream is low. Primary productivity is also low, however, so it is uncertain which source of organic carbon is the more important.

The Columbia suffers from a special water quality problem, gas supersaturation below dams. This occurs when water plunging over a spillway carries entrained air deep below the surface, and can cause severe mortality among fish as a result of gas bubble formation in their tissues. It is also threatened by proposed large-scale water transfers.

In the Missouri, once known as the "Big Muddy", dam construction has led to sedimentation in the impoundments so that the amount of silt reaching the mouth has been reduced by about 50%, and clear-water erosion causes degradation below the dams.

The Sacramento-San Joachin River System in California probably shows the greatest impact of human activity. It provides more than half the surface water used in the state, and its morphology and hydrology have subject to modification for the past two hundred years, particularly in the delta, which has been converted by a system of levees from a marshland into rich agricultural land.

The La Grande Rivière in Quebec has been much modified by the construction associated with the James Bay hydroelectric project. By far the most serious effect of this has been a great elevation of the concentration of mercury in the tissues of fish.

The blackwater rivers of the coastal plains of the United States show some interesting features. Two of these, the Ogeechee and the Satilla in Georgia, are discussed in the book. These owe their colour to high concentrations of fulvic acids leached from the soil of their basins. Their water quality is naturally poor, owing to their colour, their low pH values, and sometimes reduced dissolved oxygen concentrations resulting from bacterial respiration supported by the high concentrations of dissolved organic matter. These rivers have not been regulated to any significant extent, but they have been subjected to another type of human interference, snag removal. This is the removal of woody debris to facilitate navigation. This debris provides the only stable substrate for the attachment of many species of aquatic organisms which in turn are major food sources for several species of fish. Consequently snag removal, which was practised from the early part of the last century until the 1950s, had a significant impact on the ecology of these rivers.

Anyone concerned with river management or ecology should find much of interest in this book. A useful feature is that all the papers contain extensive references to what is sometimes called the grey literature, the great mass of reports from various agencies and government departments which is not usually readily accessible.

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World Soil Erosion and Conservation

Edited by David Pimental. 1993. Cambridge studies in applied ecology and resource management. Cambridge University Press, Cambridge. 349 pp. U.S. $99.95.

Increasing environmental awareness has resulted often in calls for action. Action which hopefully occurs based upon facts. *World soil erosion and conservation*, a product of IUCN's Commission on Ecology, is meant to be a contribution in providing facts dealing with one of the fundamental resources — soil.

Soil data are provided with detailed studies from West Africa, Ethiopia, China, India, Australia, Argentina, United Kingdom, and Poland written by leading scientists in the corresponding geographical areas. There are also summary chapters covering the humid tropics, sustainable agricultural production and agricultural productivity. The final chapter provides a discussion of the role of Vetiver grass.

Through all the chapters there are a number of recurring themes. They include: (1) increased soil erosion with increased population, (2) insufficient support for conservation programs, and (3) the need for change in agricultural practices on lands of marginal productivity.

Areas of the book which I feel need improvement are: (1) lack of a standard monetary system — all studies quote costs in local currency creating some difficulty in understanding of economic impact and reader's ability to compare countries; (2) lack of standard terminology — in one chapter an author refers to grasses as being *Medicago sativa, Onobrychis viciaefolia,* and *Astragalus adsurgens*, all of which are members of the taxonomic family Leguminosae, not Gramineae, and remaining authors do not define what they meant by grasses; (3) detailed studies provide information covering all the continents except North America — although papers from this area are referenced and facts from North America are used in summary chapters.

The book does meet its objective of providing facts. There are plenty of facts provided for the areas discussed such as cost of soil erosion, cost of correcting problems, past and present attempts of dealing with soil erosion, reasons why soil erosion occurs. For people who require this type of information this book should be a good reference.

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The Balance of Nature: Ecological Issues in the Conservation of Species and Communities

By Stuart L. Pimm. 1991. University of Chicago Press, Chicago. 464 pp. illus. Cloth U.S $62; Paper U.S. $26.95.

As the issue and urgency of maintenance of biological diversity gains prominence in politics and policy, the need for fully understanding the linkages between population biology and community ecology grows. For decades, university biology faculties have taught separately these two aspects of the problem of conservation. The 'new' interdisciplinary science of conservation biology, complete with its own scientific journals, has become widely accepted. *The Balance of Nature* represents one of a handful of attempts to assimilate information enabling a reader to understand the connections between populations and community persistence. Pimm writes in a style that is more familiar than formal, and succeeds in making a readily readable text about an important and complex topic.

The first half of the volume (170 pages) is devoted to an understanding of population processes, including a series of rigorous definitions upon which the chapters are crafted. Pimm explains persistence, resistance, variability, resilience, and stability by exploring each word to the full depth of its meaning. The community ecology topics of food webs, assembly, structure, introductions, extinctions, and species composition are dealt with in the context of his defined terms. Summaries are given at the end of each chapter to support and oppose theoretical considerations of community ecology, based on the discussion of published studies. Pimm points out and discusses that he has indeed selected his case studies, but that he has done so with a view to illustration of various opinions. The studies chosen for review and examples meet his criterion as thoroughly controlled investigations.

Pimm attacks his topics from the perspective of a researcher asking pertinent questions through testing of hypotheses. The difficult topic of population regulation is examined through chapters on factors that influence intrinsic variability, food webs, environmental variability, non-linear dynamics, and the processes of animal extinction. The aspect that I found refreshing throughout these sections, aside from his research bent, was Pimm's use of examples from several classes within the animal kingdom in an effort to find some generality. A multi-disciplinary approach is far superior, in a book like this, to singling out a group of animals and assuming that processes are similar regardless of trophic status. The chapter on non-linear dynamics concludes with a chiding of field ecologists for assuming that the world is linear, when strong evidence exists to the contrary.

A common theme, in this and many other recent books and review articles, is that an understanding of community ecology can only be based on long-term data sets. Biologists collect data and interpret them in the light of a short-term window of what is undoubtedly a long-term continuum. The most important data sets are those that shed light on the natural variability of animal populations with respect to biotic and abiotic variables through a considerable period of time. Yet, the vast majority of research is short-term, often politically-motivated, and ultimately fails to provide the clues to population persistence so necessary in the conservation of species. Researchers find it extremely frustrating to be forced into the inability to conduct needed long-term research, because of the short-term political commitment to mission oriented industry-driven problems.

I found only two criticisms that I can make of the book. First, I would have preferred a final synthesis to draw the book together in a more complete fashion. Second, and I suspect beyond the author's control, the pages were translucent to highlighter markers and underlining in pen. I thoroughly recommend this book to all those interested in conservation biology above most other books because it provides a rigorous basis for understanding communities and bridging the gap to populations.

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MISCELLANEOUS

Dinosaur Hunters

By David A. E. Spalding. 1993. Key Porter Books, Toronto. 310 pp., illus. $29.95.

Dinosaur Hunters is a formula book. List all the major discoveries of dinosaurs found in the world, give a one or two sentence biography of the individual(s) who made the discoveries, (this may be extended), name the dinosaurs with the English translation, sprinkle in a few anecdotes, and then you have it. Simple? Maybe, but the reader may be surprised at the number of historically and scientifically important discoveries of dinosaurs there have been over the past 150 years.

The book begins historically, with the early discoveries of Mantell, Buckland, etc., the influence on Darwin and evolution, and then expands paleogeographically using the continents of the Mesozoic as a foundation for discoveries rather than today's position of the continents. Combining the globe trotting dinosaurs and the occasional globe trotting paleontologist in this framework potentially muddles the reader, yet Spalding is quick to sort out any potential confusion.

To the North American reader it is interesting to see more detail spent on work done in Asia, Africa, and South America which are often given cursory descriptions in other historical sketches. I was unaware that Louis Leakey, the great paleoanthropologist, worked with William Cutler, a Canadian, for the British Museum in east Africa collecting partial skeletons of sauropods.

I was also impressed with two other features. One was the equally important (though at times confusing) story of trace fossils, primarily footprints left by dinosaurs and their role in the early interpretation of dinosaurs. I was also surprised by Spalding's account of the development of new collecting techniques (I had had the parochial impression that the plaster of Paris method of removal of fossils was an American invention; not so, as it was independently "discovered" several times before, elsewhere.) These two features are often underplayed in the history of paleontology. In order for the public to enjoy the skeletons on display in some museum the scientist often has to travel great distances in sparsely populated regions to retrieve multi-ton animals from surrounding rock, without further damaging the fossil. Talents in logistics, engineering, brawn, and pure luck have led to the skeletons we see today.

There are many popular and technical treatises on the history of paleontology and/or dinosaurology, yet most of these are lacking in global scope. This is not the case in *Dinosaur Hunters*. There is much information in this book that both the historian and general reader will find useful, regardless of the formularization.

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Science and the Canadian Arctic: A Century of Exploration, 1818–1918

By Trevor H. Levere. 1993. Cambridge University Press, Cambridge and New York. x+438 pp., illus. Cloth. U.S. $49.95.

In recent years, discoveries of bodies frozen in ice and new theories about the fate of the last Franklin expedition revived interest in 19th century explorations in the Arctic. Trevor H. Levere's book, about a decade in the making, provides both context and detail of the various military, expansionist, and scientific explorations, most of them British, in the large geographic area now referred to as the Canadian Arctic.

The story begins in the 18th century when the colony of Canada was part of the British Empire. We learn that although science "featured prominently in arctic exploration," in most cases it was a by-product of the political and economic aims of discovery, such as the search for the Northwest Passage. We learn about personalities, nepotism, and how much of the scientific information was painstakingly obtained under difficult conditions.

The book consists of ten chapters plus an Introduction and an Afterword. Chapter 1 discusses the historical background, and the importance of the Royal Society and of explorers, such as Captain James Cook, in the second half of the 18th century. Chapter 2 details the role of the Navy in the quest for the Northwest Passage after the Napoleonic wars; the activities of Joseph Banks, John Barrow, and Edward Sabine; the various Parry and Rose expeditions and the attention paid to the geophysical sciences, such as hydrography, meteorology, and geomagnetism. Chapter 3 traces the paths of naturalists, such as Samuel Hearne, John Richardson, and Thomas Drummond, and discusses the natural history publications resulting from Sir John Franklin's first and second expeditions.

Chapter 4, a pivotal one in the book, provides the background to and need for the mid-19th century

Admiralty Manual, published for naval officers "who were expected to be accurate observers and reporters," (p.144) Chapter 5 concentrates on the British Navy and the Hudson's Bay Company during the 1837-1859 period, including the last John Franklin expedition and subsequent search expeditions after 1848. Chapter 6, "The Arctic Crusade: National Pride, International Affairs, and Science," centres on science and politics, including the reluctance of the Admiralty to support British involvement in the International Polar Year of 1882-83. Chapter 7 details the mandate and experiences of the British Arctic Expedition of 1875-76, the work at the polar magnetic observatories, and studies in geology and natural history.

Chapter 8 follows the trend from nationalism to a broader international cooperation in science before and during the International Polar Year. The only significant expedition in the Canadian Arctic was "The Lady Franklin Bay expedition" organized by the United States. Chapter 9 highlights the continuing role of the Hudson's Bay Company in supporting scientific work, including that of the Smithsonian Institution, in the Arctic. Chapter 10, "Stefansson: Science, Territory, Politics," deals with the Vilhjamur Stefansson — R. M. Anderson Arctic Expedition of 1908-1912, and the subsequent Canadian Arctic Expedition in 1913-1918.

The book is printed on good quality paper and is beautifully illustrated. It is carefully researched and well written. I liked having foot notes rather than end notes, but would have appreciated more explanatory notes.

This is not a book for the armchair traveller. The reader needs time to take in and reflect upon the innumerable details and complex background of the history of *Science and the Canadian Arctic*. The sections on the various geophysical studies can no doubt be appreciated more by those trained in these fields. Certainly, the rationale for conducting certain observations and experiments was not always clear to me. Its thorough scholarship and great detail would make this volume suitable for university courses. In fact, one could build an advanced seminar in Canadian history/history of science around it.

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NEW TITLES

Zoology

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Cover: John Erskine collecting on Margaree Island, Nova Scotia, 22 July 1965. Photograph taken by, and courtesy of, A. J. Erskine. See remembrance pages 248–254.

The Canadian Field-Naturalist

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Status of the Harbour Seal, *Phoca vitulina*, in Greenland

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Teilmann, Jonas, and Rune Dietz. 1994. Status of the Harbour Seal, *Phoca vitulina*, in Greenland. Canadian Field-Naturalist 108(2): 139–155.

The Harbour Seal (*Phoca vitulina*) has never been as abundant in Greenland as other species of seals, therefore it is of minor economic and nutritional importance. The Harbour Seal has been a highly prized prey due to its fine, silky hair, which is part of the Greenlandic national costume. The meat is claimed to be the most tasty of any of the seal species in Greenland. The Harbour Seal is the only seal that hauls out on land in Greenland, where from late May to August it breeds and moults on land in certain fjords and on some remote skerries. This behaviour makes the species particularly vulnerable to hunting, disturbance, oil spills etc. The Harbour Seal has been observed from Avanersuaq in Northwest Greenland, all the way round South Greenland, to Ittoqqortormiit on the east coast. The main historical distribution lies between Nunap Isua in South Greenland and Sisimiut in Central West Greenland. The present distribution is roughly believed to be the same, but at least 9 out of 23 previously known breeding places have now been abandoned. Harbour Seals are caught mainly between June and August, when the seals are hauled out on land. In the past decades the catch has decreased in all municipalities except for the southernmost, Nanortalik. Since the end of the 1940s, where the annual catch was about 300 animals, a significant decline of 5% per year has reduced the annual catches to approximately 40 animals in the recent years. Since 1960 adult seals have been protected from May through September, and certain municipalities have local sanctuaries and further hunting regulations. The hunting of subadults and pups has a negative effect on the rest of the population because of disturbance during the reproductive period. An aerial survey conducted in 1992 indicated that seven of 14 known Harbour Seal localities may still be in use. No seals were observed on land, but 12 Harbour seals were observed in the water close to four of these haulout localities. Severe ice conditions may have biased the results and no reliable figures on stock size are available at present. The remote geographical position of Greenland may cause limited possibilities for immigration, should the Harbour Seal be extirpated in Greenland waters.

Key Words: Harbour Seal, *Phoca vitulina*, Greenland, distribution, catch statistics, hunting, historical records, orthography.

Since the first settlements, the Harbour Seal (*Phoca vitulina* Linnaeus, 1758) [Figure 1] has been subjected to hunting in Greenland. It has the finest and most silky hair of the Greenlandic seals and is therefore a much coveted quarry. The skins are used in the Greenlandic national costume. Harbour Seals congregate on land for whelping, suckling and moulting in groups during summer. The easy access to such congregations, and the fact that seals are easier to shoot on land than in water, make them more vulnerable than the other seal species in Greenland. The Harbour Seal have probably always been the least numerous seal species in Greenland, which may be the reason for the limited written accounts of it from Greenland.

In April 1992 the Danish/Greenlandic authorities announced hydrocarbon exploration licensing for areas off West Greenland south of 66°N. In connection with this licensing process, Boertmann et al. (1992*, see Documents Cited section preceeding Literature Cited) reviewed biological data in relation to mapping of oil spill sensitivity, and identified data gaps. One of the identified gaps was the lack of information on the distribution and abundance of Harbour Seals with emphasis on breeding and moulting concentrations. The present report summarizes our knowledge and identifies the need for further research.

Materials and Methods

Published and unpublished records of observations and catches from the 20th century were reviewed, and references from last century, reviewed by Winge (1902), resummarized in this study. Recent information on Harbour Seals was mainly obtained through interviews of hunters along the coast of West Greenland (GTO 1976*; Glahder 1992*; Siegstad 1992*; Boertmann and Mosbech 1992*). Place names relating to the name of the Harbour Seal in the different Greenlandic dialects (Qasigiak, Qittalivaq and Qasiiaq) were extracted from a database containing names and positions of more than 25 000 localities in Greenland. This information is presented in tables and maps, but no further verification was conducted. Finally, we include some information from a pilot project on the feasibility of using aerial surveys to locate and census Harbour Seals in Greenland (Teilmann 1993*).

Results

Distribution

The Harbour Seal is widely distributed in the North Atlantic and North Pacific, between 30° N and 75° N. The Harbour Seals in Greenland are attributed by Bigg (1981) to the nominal subspecies *Phoca vitulina concolor*. Historically, the Harbour Seal ranged from Avanersuaq (Thule) on the west coast to the southernmost tip of Greenland, Nunap Isua (Kap Farvel), and north to Ittoqqortormiit (Scoresby Sund) on the east coast of Greenland, while the present distribution is uncertain (Figure 2).

Occurrence

Occurrence by season

Sightings from all seasons indicate that some or all Harbour Seals remain in the coastal areas of Greenland throughout the year (Winge 1902; Jensen 1909; Jensen 1928; Degerbøl 1936; Kapel 1971). Harbour Seals prefer shallow water or rocky areas and have been observed during summer in freshwater streams, where they reportedly feed on Arctic Char (*Salvelinus alpinus*), and along the outermost islands, but never offshore (Winge 1902; Müller 1906; Birket-Smith 1924; Vibe 1990; Malmquist, S., Viceairport manager in Kangerlussuaq, Greenland, personal communication). From May to September they gather on certain breeding grounds to give birth, nurse, mate and moult (Winge 1902; Engell 1909; Jensen 1909; Bendixen 1921; Degerbøl 1936; Vibe 1990; Malmquist, personal communication; Boertmann and Mosbech 1992*). They seem to avoid solid ice and are therefore rarely seen in fjords with fast ice and in the northern municipalities during winter time (Winge 1902; Müller 1906; Vibe 1990).

Occurrence by municipality

Greenland is divided into 17 municipalities (administrative divisions). The following information is summarized in Table 1 and Figure 2.

Northern Greenland municipalities

The Harbour Seal is rarely seen in the Thule municipality. A few individuals were apparently observed off Igannapaluk in Booth Sund south of Kap Parry in about 1935 (Vibe 1950). According to the catch statistics 16 Harbour Seals were caught in Thule in 1961, three of them reported as shot and the remaining 13 estimated from unreported catches. The reported catches were verified, and the fact that the Ringed Seal (*Phoca hispida*) and Harbour Seal columns were adjacent in the hunters' diaries, could have led to mistakes. By the beginning of the 20th century the Harbour Seal was already considered rare in Upernavik, where only a few or none were shot annually (Bryder et al. 1921). In the 1920s, Harbour Seals were still observed at Qasigialigssuaq and Qasigiarssuit on the north coast of Nuussuaq, Upernavik. But within this decade they were extirpated (N. Jensen, Inuit hunter in Kuvdlorssuaq, Upernavik, personal communication). In Uummannaq the Harbour Seal was very rare, and was only occasionally seen at Nuussuaq or on Hareøen (Bertelsen et al. 1921). From 1980-1990 an average catch of one Harbour Seal per year has been reported from Upernavik and Uummannaq (Hunters' Lists of Game 1938-1990*).

Diskobay area municipalities

In 1807 the Harbour Seal was common around Qeqertarsuaq (Disko Island) (Winge 1902). Every year the Inuit hunted Harbour Seals on rocks in the fjords on the west coast of Qeqertarsuaq (Winge 1902). Porsild and Ostermann (1921) described the Harbour Seal as numerous on remote places, especially in Nordfjord and around Avatarpait. According to interviews with local hunters, Harbour Seals occurred on the rocks around Avatarpait and were breeding in the bay of Qasigissat on the west coast of Qeqertarsuaq (GTO 1976*). However, Siegstad (1992*) was told that Harbour Seals no longer breed in Qasigissat, and that only a few individuals occasionally occur. On 12 September 1986 two Harbour Seals — one small and one big — were observed in the river delta in Mellemfjord on the west coast of Disko Island (Heide-Jørgensen 1986*). In Nordre Laksefjord north of Mellemfjord two Harbour Seals were shot in April 1980 and a few groups of 20-30 individuals were seen (Heide-Jørgensen 1986*). According to Engell (1909) Harbour Seals were fairly common in Torsukatak Fjord north of Ritenbenk in the Disko Bay area.

By 1921 the Harbour Seal population had decreased and was described as being rare in Qasigiannguit (Christianshåb) municipality. The name of the municipality is derived of the Inuit name of the Harbour Seal, Qasigiak. Only a few Harbour Seals were shot annually around Grønne Ejland and in Ata Sund (Porsild 1921). The river delta in the fjord Qinuua Avannaleq was a breeding site for Harbour Seals in the 1960s (Siegstad 1992*).

In Aasiaat (Egedesminde) municipality the Harbour Seal was caught around the island of Simiutarsuaq, but always in low numbers (Birket-Smith 1924). Ostermann and Porsild (1921) considered it "very rare" in Aasiaat municipality.

Central West Greenland municipalities

Winge (1902) and Bendixen (1921) regarded the Harbour Seal as uncommon in the municipalities of Sisimiut (Holsteinborg) and Maniitsoq (Sukkertoppen). The number of Harbour Seals was declining as early as the 1920s (Bendixen 1921).

One of the outermost rocks in "Grundene" south of Sisimiut has previously been mentioned as a breeding ground where Harbour Seals gather in large numbers. In the beginning of this century, Inuit hunted Harbour Seals at "Grundene" south of Sisimiut,

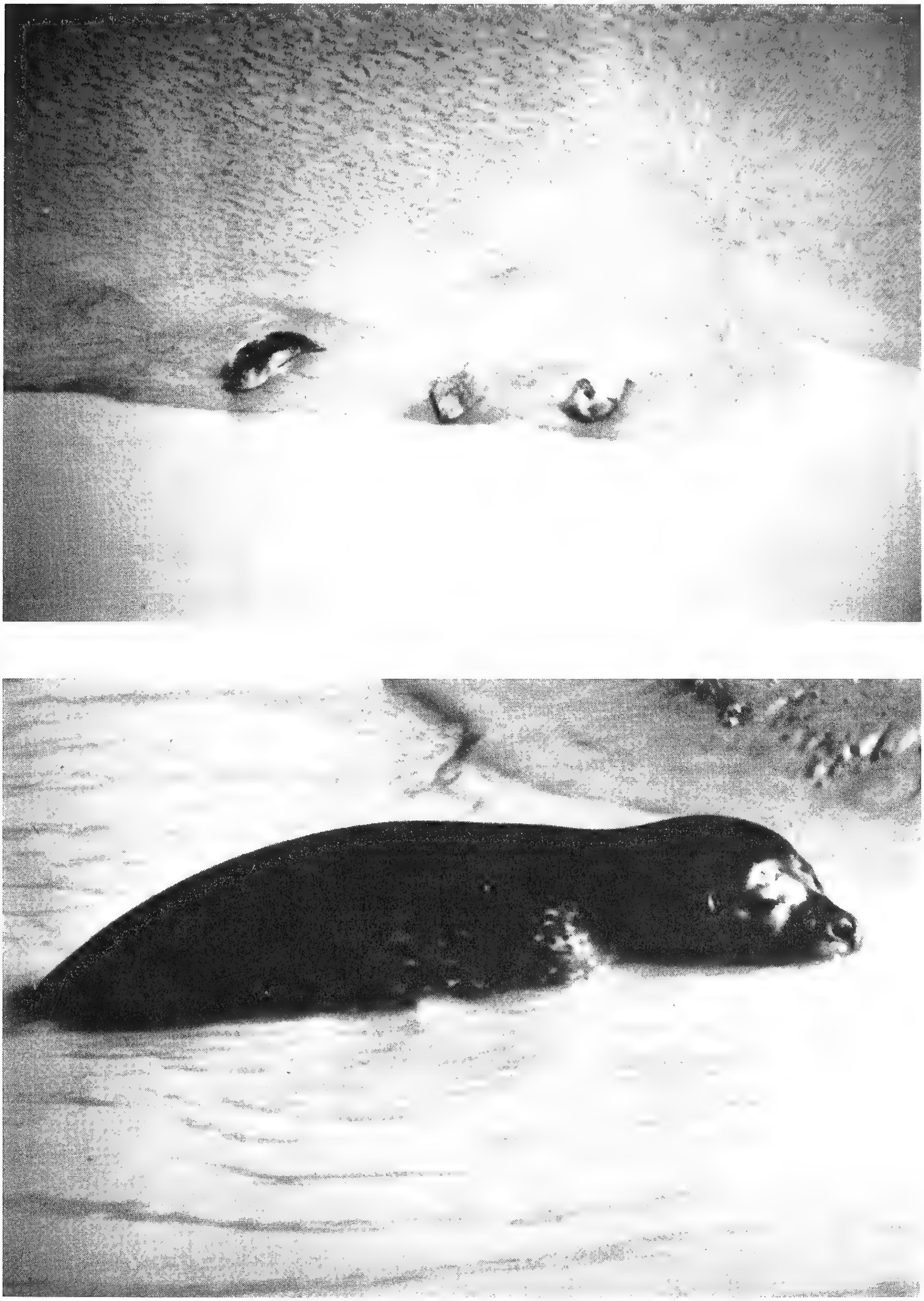

FIGURE 1. Harbour Seals on the sand banks at Kangerlussuaq (Søndre Strøfjord). Photos: Steen Malmquist.

TABLE 1. Information on Harbour Seal localities based on the literature. Numbers refer to Figure 2.

Locality no.	Name of locality	Position	Comments	Reference
1	Igannapaluk	76°47′N, 70°50′W	A few Harbour Seals presumably observed	Vibe 1950
1A	Qasigialigssuaq	74°08′N, 57°05′W	Observed in the 1920s	Jensen personal communication
1B	Qasigiarssuit	74°13′N, 56°30′W	Observed in the 1920s	Jensen personal communication
2	Nuussuaq	70°40′N, 54°40′W	Occasionally seen	Bertelsen et al. 1921
3	Hareøen	70°25′N, 55°00′W	Occasionally seen	Bertelsen et al. 1921
4	Avatarpait	70°05′N, 54°55′W	Numerous	Porsild and Ostermann 1921
4	Avatarpait	70°05′N, 54°55′W	Occurred	GTO 1976
5	Torsukatak	70°00′N, 50°40′W	Fairly common	Engell 1909
6	Nordfjord	69°53′N, 54°20′W	Numerous	Porsild and Ostermann 1921
6	Nordfjord	69°53′N, 54°20′W	1 Harbour Seal 26 August 1993	Mosbech and Boertmann 1993
7	Qasigissat	69°52′N, 54°54′W	Breeding site	GTO 1976
7	Qasigissat	69°52′N, 54°54′W	Former breeding site	Siegstad 1992
8	West coast of Disko Island	69°50′N, 55°00′W	Hunted on rocks in the fjords	Winge 1902
9	Grønne Ejland, Ata Sund	69°50′N, 51°50′W	A few shot annually	Porsild 1921
10	Mellemfjord	69°42′N, 54°30′W	2 Harbour Seals (1 pup) 12 September 1986	Heide-Jørgensen 1986
10	Mellemfjord	69°42′N, 54°30′W	2 Harbour Seals 26 August 1993	Mosbech and Boertmann 1993
11	Qinuua Avannaleq	69°33′N, 50°15′W	Former breeding site	Siegstad 1992
12A	Kuannersuit Sulluat	69°32′N, 53°20′W	1 Harbour Seal 26 August 1993	Mosbech and Boertmann 1993
12	Nordre Laksebugt	69°19′N, 53°55′W	2 Harbour Seals shot April 1980	Heide-Jørgensen 1986
12	Nordre Laksebugt	69°19′N, 53°55′W	A few groups of 20-30 Harbour Seals April 1980	Heide-Jørgensen 1986
13	Qasigiarsuit	69°16′N, 51°04′W	Possible breeding site	GTO 1976
14	Simiutarsuaq	68°11′N, 53°43′W	Caught in the neighbourhood, but always scarce	Birket-Smith 1924
15	Qarsorsaq	67°51′N, 50°50′W	Possible breeding site	GTO 1976
16	Inner part of Nordre Strømfjord	67°50′N, 51°00′W	Presumably breeding site	Anonymous 1980
17	Inner part of Nordre Isortoq	67°20′N, 52°30′W	Presumably breeding site	Anonymous 1980
18	Umivit flodleje	66°50′N, 50°48′W	Breeding site	GTO 1976
19	Achipelago south of Holsteinsborg	66°40′N, 53°50′W	Breeding site	Vibe 1981
20	Sarfartooq	66°29′N, 51°53′W	Breeding site	GTO 1976
20	Sarfartooq	66°29′N, 51°53′W	Former or present breeding site	Anonymous 1980
21	Anders Olsen Sund	66°28′N, 53°40′W	Seen	Boertmann and Mosbech 1992
22	Ikerlussuaq	66°26′N, 53°55′W	Still seen in low numbers	Boertmann and Mosbech 1992
23	Søndre Strømfjord flodleje	66°24′N, 52°30′W	500-600 Harbour Seals in the early 1960s	Malmquist 1993
23	Søndre Strømfjord flodleje	66°24′N, 52°30′W	Breeding site	GTO 1976
23	Søndre Strømfjord flodleje	66°24′N, 52°30′W	20-30 Harbour Seals in the summer	Vibe 1981
23	Søndre Strømfjord flodleje	66°24′N, 52°30′W	1 adult Harbour Seal 27 July 1988	Heide-Jørgensen 1988
23	Søndre Strømfjord flodleje	66°24′N, 52°30′W	4 Harbour Seals (2 pups) 5 August 1988	Heide-Jørgensen 1988
23	Søndre Strømfjord flodleje	66°24′N, 52°30′W	3 Harbour Seals (1 pup) 6 August 1988	Heide-Jørgensen 1988
23	Søndre Strømfjord flodleje	66°24′N, 52°30′W	Less than 20 Harbour Seals	Malmquist 1993
24	Grundene	66°20′N, 53°50′W	Breeding site	Degerbøl 1936

(Continued)

TABLE 1. *Continued*

Locality no.	Name of locality	Position	Comments	Reference
24	Grundene	66°20′N, 53°50′W	Breeding site	Vibe 1990
24	Grundene	66°20′N, 53°50′W	Probably abandoned	Boertmann and Mosbech 1992
25	Ikarllussuit/Ikardlugssuaq	65°09′N, 52°40′W	Breeding site	Bendixen 1921
25	Ikarllussuit/Ikardlugssuaq	65°09′N, 52°40′W	Breeding site	GTO 1976
25	Ikarllussuit/Ikardlugssuaq	65°09′N, 52°40′W	Former breeding site	Siegstad 1992
26	West coast of Nordlandet	64°35′N 52°15′W	Former breeding site	GTO 1976
27	Ikatua	64°35′N 52°06′W	Breeding site	Boertmann and Mosbech 1992
28	Ameragla/Naujat Kuat	64°13′N 50°15′W	Large numbers of Harbour Seals around year 1000 A.C.	Bruun 1917
28	Ameragla/Naujat Kuat	64°13′N 50°15′W	Large numbers of Harbour Seals around year 1000 A.C.	Degerbøl 1936
28	Ameragla/Naujat Kuat	64°13′N 50°15′W	Breeding site	GTO 1976
28	Ameragla/Naujat Kuat	64°13′N 50°15′W	Former breeding site	Siegstad 1992
29	Eqalungiut	64°08′N 51°56′W	Often seen	Winge 1902
30	Sermilik	63°32′N 51°15′W	Former breeding site	Siegstad 1992
30	Sermilik	63°32′N 51°15′W	Still seen	Boertmann and Mosbech 1992
31	Frederickshåb Isblink	62°20′N 50°08′W	5 Harbour Seals 10 August 1992	Teilmann 1993
	Frederickshåb Isblink	62°26′N 50°15′W	2 Harbour Seals 30 August 1993	Boertmann and Mosbech 1993
32	Tiningnertooq/Niaqornarssuaq	62°18′N 49°55′W	Breeding site	Bendixen 1921
32	Tiningnertooq/Niaqornarssuaq	62°18′N 49°55′W	Breeding site	GTO 1976
32	Tiningnertooq/Niaqornarssuaq	62°18′N 49°55′W	Breeding site	Siegstad 1992
32	Tiningnertooq/Niaqornarssuaq	62°18′N 49°55′W	Seen	Boertmann and Mosbech 1992
33	Qagssissalik	62°12′N 50°00′W	Breeding site	Degerbøl 1936
34	Kvanefjord	62°00′N 49°10′W	One Harbour Seal shot	Boertmann and Mosbech 1992
35	Sermilik	61°50′N 49°00′W	Breeding site	Bendixen 1921
35	Sermilik	61°50′N 49°00′W	Breeding site	Siegstad 1992
35	Sermilik	61°50′N 49°00′W	Breeding site	Boertmann and Mosbech 1992
36	Sermiliarsuk	61°37′N 48°20′W	Breeding site	Bendixen 1921
36	Sermiliarsuk	61°37′N 48°20′W	Breeding site	Siegstad 1992
36	Sermiliarsuk	61°37′N 48°20′W	Breeding site	Boertmann and Mosbech 1992
37	Qasigialik	61°32′N 49°00′W	Breeding site	Winge 1902
37	Qasigialik	61°32′N 49°00′W	Former breeding site	Siegstad 1992
37	Qasigialik	61°32′N 48°58′W	Important place	GTO 1976
38	Qasigiarqarfia	61°24′N, 49°00′W	Breeding site, growing stock	Siegstad 1992
39	Arsuk Fjord	61°19′N, 48°00′W	Seen	Winge 1902
40	Sermilik fjord Nordre arm	61°13′N, 45°25′W	Breeding site	GTO 1976
41	Qoroq	61°05′N, 45°05′W	Breeding site	GTO 1976
42	Igkardlugtusoq	60°57′N, 47°48′W	Protected breeding sites	Anonymous1982c
43	Siorardlit	60°55′N, 48°18′W	Protected breeding sites	Anonymous1982c
44	Tarajornitsoq	60°51′N, 47°44′W	Former breeding site	Siegstad 1992
45	Kitsisut tunordlit	60°51′N, 48°26′W	Protected breeding sites	Anonymous 1982c

(Continued)

TABLE 1. *Concluded*

Locality no.	Name of locality	Position	Comments	Reference
46	Angnikiteorssup sta	60°50′N, 48°11′W	Protected breeding sites	Anonymous 1982c
47	Uvitdlut	60°45′N, 48°10′W	Protected breeding sites	Anonymous 1982c
48	Qingortuneq	60°45′N, 48°10′W	Protected breeding sites	Anonymous 1982c
49	Qitdluakitsoq	60°45′N, 48°10′W	Protected breeding sites	Anonymous 1982c
50	Kitsisut avatdlit	60°45′N, 48°24′W	Protected breeding sites	Anonymous 1982c
50	Kitsisut avatdlit	60°45′N, 48°24′W	Former breeding site	Siegstad 1992
51	Tasiusaarsuk	60°12′N, 45°05′W	One Harbour Seal caught	Sparholt 1982
52	Prins Christians Sund	60°06′N 44°40′W	Seen 1 April 1829	Winge 1902
53	Itillip Illua	59°52′N, 43°47′W	Breeding site	Siegstad 1992
54		59°50′N, 43°32′W	1 Harbour Seal 14 August 1992	Teilmann 1993
55	Vestsiden af Saningassoq	59°51′N, 43°33′W	Breeding site	Siegstad 1992
56	Tullerunnat	59°57′N, 43°14′W	Breeding site	Siegstad 1992
56	Tullerunnat	59°57′N, 43°14′W	1 Harbour Seal 14 August 1992	Teilmann 1993
57		59°59′N, 43°11′W	1 Harbour Seal 14 August 1992	Teilmann 1993
58	Aluk	60°09′N, 43°05′W	Seen 26 April 1829	Winge 1902
59		60°28′N, 43°01′W	4 Harbour Seals 14 August 1992	Teilmann 1993
60	Kangersiuasik	60°34′N, 42°55′W	Breeding site	Siegstad 1992
61	Tinmmiarmiut	62°32′N, 42°10′W	Seen	Glahder 1992
62	Skjoldungen	63°13′N, 41°20′W	Seen	Glahder 1992
63	Angmagssalik fjord	65°40′N, 37°15′W	Fairly common	Poulsen 1900
63	Angmagssalik fjord	65°40′N, 37°15′W	Fairly common	Winge 1902
63	Angmagssalik fjord	65°40′N, 37°15′W	Fairly common	Jensen 1909
63	Angmagssalik fjord	65°40′N, 37°15′W	Common all year	Holm and Petersen 1921
64	Sermilik fjord	65°55′N, 37°55′W	Still seen	GTO 1976
65	Ikasaulaq	66°00′N, 37°30′W	Former breeding site	GTO 1976
66	Uttental Sund	68°12′N, 31°45′W	Lots of Harbour Seals in the 1940's	Glahder 1992
67	Kangerlussuaq	68°20′N, 32°10′W	One Harbour Seal caught	Anonymous 1970-89

FIGURE 2. Harbour Seal localities based on the literature. Details on locations are presented in Table 1.

during the pupping season in June. The Harbour Seals could be shot easily because of their dense concentration. The pups could be caught by hand or stabbed in a little pond on top of the rock (Müller 1906; Degerbøl 1936). Vibe (1990) also mentioned that "Grundene" and the archipelago between Maniitsoq and Nuuk were "well known" breeding grounds for Harbour Seals. However, recent interviews with local residents, indicate that "Grundene" are hardly used as a breeding area by Harbour Seals today (Boertmann and Mosbech 1992*). Local hunters say that about 25 Harbour Seals were seen regularly in the 1940s at the rock Ikerlussuaq, where they are still seen but in lower numbers. Harbour Seals are also seen in the nearby fjord, Anders Olsens Sund (Boertmann and Mosbech 1992*). Harbour Seals used to breed on the small islands and rocks in the deep fjords between Maniitsoq and Nuuk. They can still be seen in the heads of the fjords, especially between 64°30′ N and 64°38′ N the area surrounding the fjord Ikatua, and they still breed there. A few Harbour Seals are taken every year in this area (Boertmann and Mosbech 1992*).

Malmquist (personal communication) has observed Harbour Seals in Kangerlussuaq (Søndre Strømfjord) since 1963, when he remembers seeing as many as 500-600 Harbour Seals lying on the sand banks about 10 km up the river, close to the airport. He reports a dramatic decline in the numbers observed there since the 1960s and estimates that fewer than 20 Harbour Seals haul out in Kangerlussuaq today. Malmquist was not aware of any alternative haulout sites in adjacent fjords to which the seals may have moved, and suggest gill-netting for Arctic Char in the river as a possible reason for the severe decline of Harbour Seals. Hunters still occasionally go to Kangerlussuaq to shoot Harbour Seals (Boertmann and Mosbech 1992*). The recent low numbers in Kangerlussuaq are consistent with information from Vibe (1990), who estimated the number at about 30-40 animals. Heide-Jørgensen (Greenlands Fisheries Research Institute, Tagensvej 135, 2200 Copenhagen N, Denmark, personal communication) reported three observations between 27 July and 6 August 1988 involving 1-4 animals, including two small ones. Local Inuit mention the river delta at Kangerlussuaq Airbase, Umivit river delta and Sarfartooq river delta, as breeding grounds for Harbour Seals, and Qarsorsaq and Qasigiarsuit in Nordre Strømfjord as breeding grounds for seals, probably Harbour Seals (GTO 1976*). The inner parts of Nordre Strømfjord and Nordre Isortoq are presumed to be breeding sites according to Ministeriet for Grønland (1980).

Archaeological excavations at the river delta in the southern branch of Lysefjord, Ameragla, in Nuuk (Godthåb) municipality, indicate that Harbour Seals were present in large numbers, probably year round, approximately a thousand years ago (Bruun 1918; Degerbøl 1936). The Harbour Seal was described as common around Nuuk in 1823 (Winge 1902). The newborn pups were hunted until the 10 July on the island of Ikarllussuit during the early 1900s (Bendixen 1921). Local Inuit mention Ikarllussuit/ Ikarlugssuaq and Naujat Kuat, the river delta of Ameragla, as breeding grounds for Harbour Seals, and the archipelago along the Nordlandet as an area where there used to be many Harbour Seals (GTO 1976*). Ikardlugssuaq/Ikarlussuit and Naujat Kuat were identified as former breeding grounds by Siegstad (1992*). Interviews reveal that Harbour Seals are still seen in Sermilik Fjord but that breeding there has ceased (Siegstad 1992*; Boertmann and Mosbech 1992*). In 1990 the Harbour Seal occurred rarely in the municipality of Nuuk (Siegstad 1992*).

In 1828 the Harbour Seal was described as rather common in Paamiut (Frederikshåb) municipality (Winge 1902). However, at the beginning of the 20th century Bendixen (1921) referred to a drastic decline in the municipality. Qasigialik Fjord south of the village Narsalik was said to be a favorite haulout and probably breeding site for Harbour Seals early in this century (Winge 1902), and in the 1970s (GTO 1976*) it was still mentioned as an important site. However, in the 1990s Siegstad (1992*) regarded this locality to be a former breeding site and therefore only of little if any importance. According to Bendixen (1921) and interviews in the 1970s (GTO 1976*), Niaqornarssuaq/ Tiningnertooq at Paamiut Isblink was a breeding site for Harbour Seals. They are apparently still breeding there but in smaller numbers (Siegstad 1992*). Recent information from hunters indicates that Harbour Seals are still seen in Niaqornarssuaq (Boertmann and Mosbech 1992*), but no information on breeding status is available. The fjords Sermilik and Sermiliarsuk were mentioned as breeding sites by Bendixen (1921). Harbour Seals are still breeding in the fjord Sermilik and in the northern branch of Sermiliarsuk (Siegstad 1992*; Boertmann and Mosbech 1992*). One was shot in Kvanefjord in 1975 (Boertmann and Mosbech 1992*). Qasigiaqarfia, the bay south of Nordre Kangeq, is believed to have an increasing population of Harbour Seals (Siegstad 1992*).

South Greenland municipalities

According to interviews with local residents, the northern branches of Nordre Sermilik Fjord and Qoroq are breeding sites for Harbour Seals (GTO 1976*). In the hunting regulations of Qaqortoq breeding sites are indicated at Uvitdlut, Qingortuneq, Qitdluarakitsoq, Angnikitsorssûp atâ, Igkarlugtusoq, Kitsisut tunordlit, Kitsisut avatdlit and Siorardlit, which suggests that these sites were still used in the early 1980s (Anonymous 1982c). Müller (1906) mentioned Qaqortoq as the district where the Harbour Seal was most numerous. The river deltas and sandbanks in the head of Pukitsoq, Nuup Kangerlua and Nunap Isua (Kap Farvel) in Nanortalik municipality have all been designated as breeding places for Harbour Seal (GTO 1976*). The rocks called Kitsisut avatdlit (Ydre Kitsisut) are a former breeding site, and a few Harbour Seals might still be seen in the area (Siegstad 1992*). One small Harbour Seal was caught in a net in the fjord Tasiusaarsuk in Nanortalik municipality on 20 August 1982 during a biological expedition (Sparholt 1982*). In the nearby freshwater lake "Tasserssuaq" two Harbour Seals were seen by Müller (1906). The Harbour Seal has been observed in Prins Christians Sund (Winge 1902). The fjord Itillip Illua, on the west coast of the island Saningassoq, and the bays Tullerunnat and Kangersiuasik south of Kap Walløe are breeding sites for Harbour Seals (Siegstad 1992*).

East Greenland municipalities

According to Winge (1902) Harbour Seals may have been seen in the inner part of Ittoqqortormiit. Pedersen (1926) wrote about Harbour Seals in Ittoqqortormiit but later corrected those statements by noting that Ringed Seals were mistaken for Harbour Seals (Pedersen 1931). Sandell and Sandell (1991) wrote that a Harbour Seal was caught in 1985, but also cautioned that according to local informants, a few Ringed Seals with irregular markings are caught every year in Ittoqqortormiit. These latter could be mistaken for Harbour Seals. The 11 Harbour Seals reported to have been shot in Ittoqqortormiit in 1974 (Hunter's Lists of Game 1938-1990*) were most likely listed in error according to Born (1983*) and Sandell and Sandell (1991). Interviews with hunters in Kangerlussuaq, between Angmagssalik and Ittoqqortormiit, indicate that many Harbour Seals were present in Uttental Sund close to the dwellings in the 1940s. In recent times Harbour Seals have only been recorded at Skjoldungen and Tinmmiarmiut, about 500 km south of Kangerlussuaq (Glahder 1992*). According to the catch statistics one Harbour Seal was caught in 1970 in Kangerlussuaq (Anonymous 1970-89). The Harbour Seal was previously described as fairly common year round in the Angmagssalik area and north to 67°22′ N, being most common in Angmagssalik Fjord (Poulsen 1900; Winge 1902; Jensen 1909). Interviews with Inuit in Angmagssalik reveal that Harbour Seals are still seen occasionally in Sermilik Fjord, but that Ikasaulaq is no longer a breeding site (GTO 1976*).

General Biology

Time of birth

There has been some disagreement in the literature about the exact period of birth (Winge 1902; Müller 1906; Engell 1909; Jensen 1909; Bendixen 1921; Degerbøl 1936; Vibe 1990; Boertmann and Mosbech 1992*; and Malmquist, personal communication). Pups are born on beaches in late May or June followed by a suckling period of 2-3 weeks according to Winge (1902) and Vibe (1990) but interviewed hunters stated that pups were born from June to July (Boertmann and Mosbech 1992*). At Torsukatak in Disko Bay pups are born in July according to Engell (1909). In Sisimiut pups are born on certain rocks in late May or early June (Winge 1902; Müller 1906; Degerbøl 1936). Just after the ice has broken up in mid June in Kangerlussuaq (Søndre Strømfjord) the Harbour Seals arrive to give birth (Malmquist, personal communication). On one occasion near Nuuk, pups reportedly had not yet been born in the last days of May and first days of June (Winge 1902). This observation is consistent with the statement by Bendixen (1921), that June is the time of birth in this area. In Angmagssalik pups are born in June (Jensen 1909). The grey prenatal fur is lost just before or during birth (Müller 1906).

Moulting and Mating

According to Vibe (1971) moulting takes place from July through August. During this period the seal remains mainly on land and seldom feeds. It becomes thin and the fur condition deteriorates. Winge (1902) claimed that Harbour Seals moulted mainly on haulout sites in August and that moulting could continue into September. Mating and moulting take place after the suckling period, that lasts for 2-3 weeks, and is completed in July (Müller 1906; Bigg 1981; Vibe 1990).

Feeding habits

According to Winge (1902) Harbour Seals feed on a variety of prey items including Arctic Char, Redfish (*Sebastes marinus)*, Long Rough Dab *(Hippoglossoides platessoides),* Polar Cod *(Boreogadus saida)* and Uvak *(Gadus ogac).* Fabricius (1780; 1929) states that Arctic Char are the main food, but Harbour Seals also eat other fishes and various "longtailed crustaceans". The Inuit claim that they eat mussels and small crustaceans (Jensen 1909), while Stephensen (1921) suggest that Harbour Seals feed on all kind of fishes and crustaceans. Vibe (1971; 1990) includes Arctic Char, Herring (*Clupea harengus*), Cod (*Gadus morhua*), Long Rough Dab and Salmon (*Salmo salar*) in the diet of the Harbour Seal in Greenland.

Hunting

The annual catch in the last century on the west coast was approximately 1000 Harbour Seals (Winge 1902). Jensen (1928) stated that catches of Harbour Seals decreased significantly in the 1920s. Greenland-wide annual estimated catches have been given as 300 (Vibe 1971) and 500 (Vibe 1990), while Kapel and Petersen (1982) estimated an annual catch of less than 100 Harbour Seals.

Catch statistics

According to the Hunters' Lists of Game (1938-1990*) the annual catch of Harbour Seals in Greenland has decreased significantly ($R^2 = 0.82$, $P < 0.0001$) with an average of 5.0% each year from about 300 in the late 1940s to about 40 in the late 1980s. This overall decrease is evident in all municipalities except Nanortalik (Figure 3). Traditionally Sisimiut, Maniitsoq, Nuuk and Paamiut (Central West Greenland) have been the municipalities with the largest catches. However, a significant decline ($R^2 = 0.93$, $P < 0.0001$) of 9.1% per year have reduced the annual catch to about 10 Harbour Seals in these four municipalities together, compared to about 250 in the late 1940s. The same tendency is evident in the Diskobay area and in the southern municipalities Qaqortoq and Narsaq where the significant decline have been 4.7% ($R^2 = 0.60$, $P < 0.0001$) and 3.3% ($R^2 = 0.27$, $P = 0.001$) per year respectively. In Nanortalik municipality the catch has increased significantly ($R^2 = 0.56$, $P < 0.0001$) by 5.8% a year in the past decades, from an average of about five animals in the late 1940s to about 40 in the late 1980s (Figure 3). The remaining municipalities have always been of little importance in the catch statistics, with only a few Harbour Seals reported annually in each of them. Catches in these municipalities have almost ceased in the last 10 years (Hunter's Lists of Game 1938-1990*).

Harbour Seals have been caught mainly in June, July and August (Figure 4), when they haul out on land to give birth, suckle pups and moult. The seals are especially vulnerable to disturbance at this time. Bendixen (1921) stated that the recently weaned seals are hunted in July and August when they leave the fjords.

Catch regulations

Since 1960 adult Harbour Seals have been protected from 1 May through September, and the export of Harbour Seal furs was prohibited (Anonymous 1960; Anonymous 1990). In Paamiut municipality additional restrictions have been made. It is illegal to hunt adult Harbour Seals throughout the year as well as netting of any Harbour Seals is forbidden. Some haulout sites have also been protected from distur-

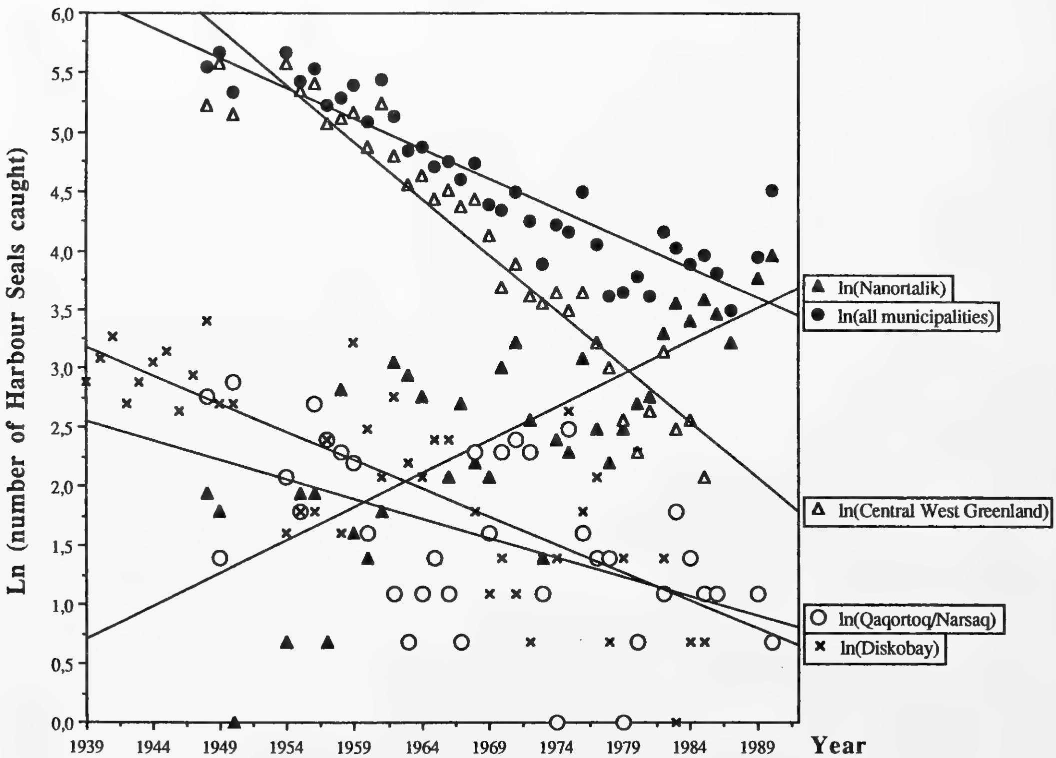

FIGURE 3. The catches of Harbour Seals between 1938 and 1990 based on information from the Hunters' Lists of Game (HLG 1938-1990). The data are pooled into four different regions and a total of all the municipalities (all Greenland). The regression line are made on the transformed data (ln).

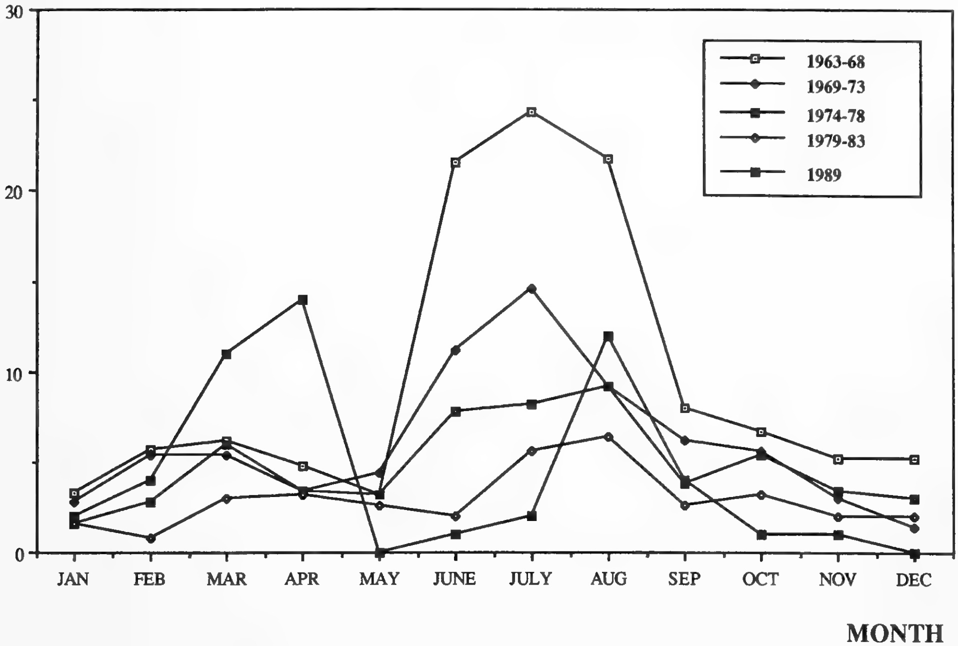

FIGURE 4. The reported catches of Harbour Seals (pooled from all Greenland), by month, based on information from the Hunters' Lists of Game (HLG 1938-90).

bance and hunting (Anonymous 1973, 1982a, 1982b). In Qaqortoq municipality eight Harbour Seal haulout sites (see Table 1, locality numbers 42-43 and 45-50) have been protected against any kind of seal hunting from 1 May through September (Anonymous 1982c).

Place names indicating presence of Harbour Seals

From a query on the Greenlandic name for Harbour Seal, qasigiak (truncated: qasigi), 89 positions were extracted from the database covering all place names in Greenland (Table 2, Figure 5). Of these the majority (85) were situated on the west coast (12 were from Upernavik, 5 from Qeqertarssuaq, 4 from Ilulissat, 3 from Qasiaanguit, 5 from Aasiaat, 14 from Kangaatsiaq, 3 from Sisimiut, 7 from Maniitsoq, 7 from Nuuk, 6 from Paamiut, 9 from Qaqortoq, 1 from Narsaq and 6 from Nanortalik) and the rest were from Ammassalik municipality. We found information in the literature on only 4 of the 89 localities. An additional 21 place names in Ammassalik were identified from a search for qittalivaq (truncated: qitta), the local Ammassalik name for Harbour Seal (Table 3, Figure 4). For Ittorqortoormiit a slightly different word, qasiiaq (truncated: qasii), was used but no place names were found. The fact that no place names were found in either Avanersuaq or Ittorqortormiit can be interpreted to indicate that the Harbour Seal has never been common in these areas.

Aerial survey

Aerial surveys was conducted in July and August 1992 (Teilmann 1993*) and August 1993 (Mosbech and Boertmann, unpublished data from aerial survey of birds, Greenland Environmental Research Institute). Nineteen known Harbour Seal haulout sites were overflown, 14 in 1992 and 5 in 1993. Seven of these were probably still used (Siegstad 1992*). No seals were observed on land, but 16 Harbour Seals were seen in shallow water close to seven of the haulout places (Table 1). Severe ice conditions in some of the fjords in the summer of 1992 may have prevented the Harbour Seals from using certain of their traditional haulout grounds at the time of the survey.

Discussion

The Harbour Seal was once widely distributed along the west coast of Greenland from Qeqertarsuaq (Disko Island) to Nanortalik and in Angmagssalik on the east coast. The present review indicates that the species has disappeared from several of its former summer haulout sites and has declined in numbers at some of the remaining sites based on statements from different sources and from the catch statistics. However, due to the lack of quantitative information, it is impossible to assess the actual extent of decline in the population.

TABLE 2. Localities containing the Greenlandic name for Harbour Seal (truncated: qasigi). Numbers refer to Figure 5.

Position no.	New Orthography	Type of locality	Municipality	Position
1	Qasigiarsuit	Fjord	Upemavik	74°14′N, 56°35′W
2	Qasigialissuaq	Fjord	Upemavik	74°09′N, 57°08′W
3	Qasiqiaqarfik	Foreland	Upemavik	73°29′N, 55°59′W
4	Qasigiararsuit	Fjord	Upemavik	73°03′N, 55°13′W
5	Qasigiarsuit	Bay	Upemavik	72°53′N, 55°23′W
6	Qasiqissat	Island	Upemavik	72°53′N, 56°23′W
7	Qasigiararsuit	Bay	Upemavik	72°52′N, 55°35′W
8	Qasigiaqarfik	Bay	Upemavik	72°40′N, 55°00′W
9	Qasigiaqarfiup Kuua	River	Upemavik	72°27′N, 55°23′W
10	Qasigiannguit	Bay	Upemavik	72°24′N, 55°08′W
11	Qasigiannguit	Foreland with ruins	Upemavik	72°11′N, 55°50′W
12	Qasigiannguit Iterlatt	Bay	Upemavik	72°11′N, 55°50′W
13	Qasigissat	Island	Uummannaq	70°01′N, 52°20′W
14	Qasigissat	Bay with harbour	Uummannaq	70°42′N, 52°11′W
15	Qasigissat Kuuat	River	Ilulissat	70°02′N, 51°54′W
16	Qasigissat	Bay	Qeqertarsuaq	69°53′N, 54°52′W
17	Qasigissat Tasinngortaa	Inlet	Qeqertarsuaq	69°53′N, 54°53′W
18	Qasigissat Kuussuat	River	Qeqertarsuaq	69°52′N, 54°30′W
19	Qasigissat Kingittuat	Mountain	Qeqertarsuaq	69°52′N, 54°52′W
20	Qasigiarsuit	Foreland	Ilulissat	69°16′N, 51°04′W
21	Qasigiarsuit Kangerlaut	Bay	Ilulissat	69°16′N, 51°04′W
22	Qasigiatsiaat	Foreland	Ilulissat	69°15′N, 51°05′W
23	Qasigiarsuit	Bay	Qeqertarsuaq	69°15′N, 53°36′W
24	Qasigiannguit :901:	Municipality	Qasigiaanguit	68°49′N, 51°11′W
25	Qasigiannguit :1575: :QAS:	Town	Qasigiaanguit	68°49′N, 51°11′W
27	Qasigiarsuaq	Island	Aasiaat	68°44′N, 52°31′W
28	Qasigiarsuup Kangilernga	Foreland	Aasiaat	68°44′N, 52°33′W
29	Qasigiarsuup Karra	Foreland	Aasiaat	68°44′N, 56°35′W
30	Qasigiarsuup Iggiaa	Sound	Aasiaat	68°44′N, 52°31′W
31	Qasigiarsuit Alanngorliit	Island	Aasiaat	68°44′N, 52°33′W
32	Qasigiaqarfik Kujalleq	Fjord arm	Kangaatsiaq	68°28′N, 50°50′W
33	Qasigiaqarfik	Cove	Kangaatsiaq	68°27′N, 52°59′W
34	Qasigiaqarfik Avabbarkeq	Bay	Kangaatsiaq	68°27′N, 56°35′W
35	Qasigiaqarfiup Nuussua	Foreland	Kangaatsiaq	68°16′N, 52°41′W
36	Qasigiaqarfik	Bay	Kangaatsiaq	68°15′N, 52°41′W
37	Qasigiaqarfia	Bay	Kangaatsiaq	68°12′N, 53°41′W
38	Qasigiatsiaat	Lake	Kangaatsiaq	68°02′N, 50°25′W
39	Qasigiaqarfik	Fjord	Kangaatsiaq	67°59′N, 53°07′W
40	Qasigiatsiaat Nuuat	Foreland	Kangaatsiaq	67°58′N, 50°35′W
41	Qasigiarsuit	Fjord	Kangaatsiaq	67°56′N, 50°33′W
42	Qasigiaqarfik	Foreland	Kangaatsiaq	67°56′N, 51°45′W
43	Qasigiaqarfik	Bay	Kangaatsiaq	67°53′N, 52°13′W
44	Qasigiaqarfik	Bay	Kangaatsiaq	67°38′N, 53°36′W
45	Qasigiaqarfiup Tasersua	Lake	Kangaatsiaq	67°38′N, 53°32′W
46	Qasigiannguit	Fjord	Sisimiut	67°08′N, 53°53′W
47	Qasigiaqarfik	Bay	Sisimiut	66°47′N, 53°18′W
48	Qasigiaqarfil	Skerries	Sisimiut	66°15′N, 53°48′W
49	Qasigiaqarfia	Fjord	Maniitsoq	66°05′N, 53°34′W
50	Qasigiaqarfia	Fjord	Maniitsoq	66°05′N, 53°30′W
51	Qasigiannguit Avannarliit	Fjord	Maniitsoq	66°04′N, 53°39′W
52	Qasigiannguit	Group of islands	Maniitsoq	66°02′N, 53°36′W
53	Qasigissat	Bay	Maniitsoq	65°53′N, 53°14′W
54	Qasigissat	Peninsula	Maniitsoq	65°53′N, 53°14′W
55	Qasigissat	Group of islands	Maniitsoq	65°48′N, 53°22′W
56	Qasigiannguit	Foreland	Nuuk	64°13′N, 52°08′W
57	Qasigiannguit	Sound	Nuuk	64°13′N, 52°08′W
58	Qasigiannguit Paaqussuat	Island	Nuuk	64°13′N, 52°08′W
59	Qasigiannguit	Island	Nuuk	64°12′N, 51°44′W
60	Qasigiannguit	Bay	Nuuk	64°12′N, 51°44′W
61	Qasigiannguit	Bay	Nuuk	64°06′N, 51°03′W

(Continued)

TABLE 2. *Continued*

Position no.	New Orthography	Type of locality	Municipality	Position
62	Qasigiaqarfik	Bay	Nuuk	63°21′N, 50°53′W
63	Qasigiaqarfia Saqqarleq	Bay	Pamiut	61°47′N, 49°35′W
64	Qasigialik	Fjord	Pamiut	61°32′N, 48°58′W
65	Qasigiallip Pulariaa	Foreland	Pamiut	61°32′N, 49°05′W
66	Qasigiaqarfia	Bay	Pamiut	61°32′N, 49°03′W
67	Qasigiaqarfia	Bay	Pamiut	61°24′N, 48°59′W
68	Qasigiaarunnerit	Bay	Pamiut	61°18′N, 48°07′W
69	Qasigiaqarfiiameq	Bay	Narsaq	61°04′N, 46°16′W
70	Qasigiannguit	Bay	Qaqortoq	60°53′N, 47°03′W
71	Qasigiannguit	Bay	Qaqortoq	60°49′N, 45°59′W
72	Qasiglik	Bay	Qaqortoq	60°46′N, 47°13′W
73	Qasigissat	Bay	Qaqortoq	60°43′N, 46°21′W
74	Qasigiaqarfik	Bay	Qaqortoq	60°41′N, 46°26′W
75	Qasigissat Nunaa	Island	Qaqortoq	60°40′N, 46°27′W
76	Qasigiannguit	Group of islands	Narsaq	60°38′N, 46°41′W
77	Qasigiannguit	Bay	Qaqortoq	60°34′N, 45°57′W
78	Qasigissamik Natsillip Nuua	Foreland	Qaqortoq	60°33′N, 45°56′W
79	Qasigissamik Natsilik	Mountain	Qaqortoq	60°33′N, 45°57′W
80	Qasigiannguit	Island	Nanortalik	60°23′N, 45°40′W
81	Qasigissat	Bay	Nanortalik	60°05′N, 44°06′W
82	Qasigissat Nuua	Foreland	Nanortalik	60°05′N, 44°07′W
83	Qasigissat Imaa	Sound	Nanortalik	60°05′N, 44°08′W
84	Qasigissat	Bay	Nanortalik	59°56′N, 43°17′W
85	Qasigissat Kangera	Foreland	Nanortalik	59°55′N, 43°18′W
86	Qasigiaqartarfia	Bay		61°14′N, 42°37′W
87	Qasigissat Immikkeertivat	Island	Angmagssalik	65°33′N, 37°41′W
88	Qasigissat	Foreland	Angmagssalik	65°34′N, 37°41′W
89	Qasigissat Qinngivat	Bay	Angmagssalik	65°34′N, 37°40′W

It has been suggested that climatic changes have contributed to the decline in Harbour Seal abundance in Greenland (Kapel and Petersen 1982). Although there has been a general lowering of the sea temperature in West Greenland since the 1950s (Hovgård and Buch 1990), no specific cause-and-effect relationship between climate and Harbour Seal abundance has been established. Porsild (1921), Bendixen (1921) and Jensen (1928) described declines in Harbour Seal numbers in Qasigiannguit, Sisimiut and Maniitsoq at the beginning of the 20th century. This suggests that a decline in the population has been occurring for a very long time, regardless of climatic fluctuations. Statements that the Harbour Seal was common in many municipalities, such as Qeqertarsuaq, Nuuk, Paamiut and Ammassalik in the last century (Winge 1902; Jensen 1909), and the fact that such statements not have been made since then, support this suggestion. However, if the increase in the catches in Nanortalik reflects an increase in the stock, this development might be explained by a movement of seals from cold northern localities to warmer localities in the south.

Other factors may have contributed to, or even accelerated, a decline. Among these are intensified hunting, increased boat traffic and entanglement of seals in nets for Arctic Char and salmon. In 1993 the Great Greenland firm may have stimulated increased hunting of Harbour Seals when they raised the price by 20% (Anonymous 1992). Harbour Seal furs are used in the Greenlandic national costume and are therefore of especially high value. Since the 20th century the demand for Harbour Seal furs has been greater than the catch (Müller 1906). Harbour Seal furs are presently being imported from Iceland to Greenland.

Declines in several Harbour Seal populations on the northern hemisphere have been discovered in the last century. In the Kattegat-Skagerrak, in northern Europe the Harbour Seal population declined from a minimum of 7000-14000 in 1890 to about 2500 in 1979 (Heide-Jørgensen and Härkönen 1988). This decline was mainly caused by hunting and various other kinds of disturbances. In areas like the Baltic and the Wadden Sea high levels of organochlorines have also affected the population negatively (e.g., Helle et al. 1976). In Denmark the Harbour Seal was totally protected from hunting in 1977, and sanctuaries were later established at a number of localities to protect the Harbour Seals against disturbances while hauled out. These regulations resulted in a rapid increase in the same populations. For example, the number of Harbour Seals in the Kattegat-Skagerrak area increased at a rate of 12% per year between 1979

TABLE 3. Localities containing the Angmagssalik name for Harbour Seal (truncuted: qitta). Numbers refer to Figure 5.

Locality no.	New Orthography	Type of locality	Municipality	Position
90	Qittalivaqartip Paava	Water area	Angmagssalik	63°07′N, 41°14′W
91	Qittalivaqartip Kangertiva	Fjord	Angmagssalik	63°08′N, 41°15′W
92	Qittalivaqartip Paavata Immikkoortua	Island	Angmagssalik	63°08′N, 41°13′W
93	Qittalivaqartip Noorajiva	Foreland	Angmagssalik	63°08′N, 41°16′W
94	Qittalivaqartip Paavata Kiataa	Coast	Angmagssalik	63°09′N, 41°14′W
95	Qittalivalik	Fjord	Angmagssalik	63°09′N, 41°18′W
96	Qittalivaqartip Immikkoortui	Group of islands	Angmagssalik	63°15′N, 41°06′W
97	Qittalivaqarteq	Bay	Angmagssalik	63°15′N, 41°06′W
98	Qittalivaqartip Umiatsialivia	Bay	Angmagssalik	63°15′N, 41°07′W
99	Qittaap Kangertiva	Fjord	Angmagssalik	65°18′N, 39°27′W
100	Qittoaq	Peninsula	Angmagssalik	65°19′N, 39°26′W
101	Qittalivaajik	Island	Angmagssalik	65°38′N, 37°20′W
102	Qittalivaajiip Tunua	Bay	Angmagssalik	65°39′N, 37°22′W
103	Qittalivaajivit	Bay	Angmagssalik	65°39′N, 38°16′W
104	Qittattit Ilinnerat	Crossing place	Angmagssalik	65°41′N, 37°07′W
105	Qittattit Immikkeertivat	Island	Angmagssalik	65°41′N, 37°10′W
106	Qittattit Nuuat	Foreland	Angmagssalik	65°41′N, 37°10′W
107	Qittattit	Coast	Angmagssalik	65°41′N, 37°09′W
108	Qittattarpik	Peninsula	Angmagssalik	65°52′N, 37°10′W
109	Qittalikkap Ernivia	Fjord	Angmagssalik	65°54′N, 38°14′W
110	Qittalivaajivit	Bay	Angmagssalik	65°58′N, 37°08′W

and 1988 (Heide-Jørgensen and Härkönen 1988). In 1988 Phocine Distemper Virus (PDV) caused 18 000 Harbour Seals to die in the North Sea, the Kattegat-Skagerrak and the southern Baltic Sea. This decline was estimated to be 60% on average of the populations (Dietz et al. 1989b). Antibodies against PDV have been found in 30% of the Harp Seals and 4% of the Ringed Seals from Greenland waters (Dietz et al. 1989a), showing that the threat from virus can be present in the Arctic region (no Harbour Seals were tested). In 1979-80 an instance of mass mortality occurred in Harbour Seals along the New England coast caused by pneumonia associated with an influenza A virus of avian origin (Geraci et al. 1982). On Tugidak Island in the Gulf of Alaska the Harbour Seal population declined by about 85% between 1976 and 1988, but the causes of the decline are not apparent (Pitcher 1990). In 1989 a great oil spill from *Exxon Valdez* took place in Prince William Sound in the Gulf of Alaska. As an effect of the spill an additional decline in the already depleted population of Harbour Seals was observed (Frost and Lowry 1993). Autopsies of many of the seals revealed brain damage particularly in the thalamus. The intramyelenic edema found in oiled seals is similar to that present in humans that die from inhaling solvents, however, if the brain damage was caused by some other sickness it could explain the decline prior to the spill (Frost and Lowry 1993; Pain 1993). Whether the causes of decline in the Greenlandic Harbour Seal population has any connections or similarities to those of decline in other Harbour Seal populations is unknown.

The present status of Harbour Seals in Greenland is only partly known, but the limited information available suggests that the population throughout Greenland, except for the southernmost municipality, has probably declined since the beginning of this century.

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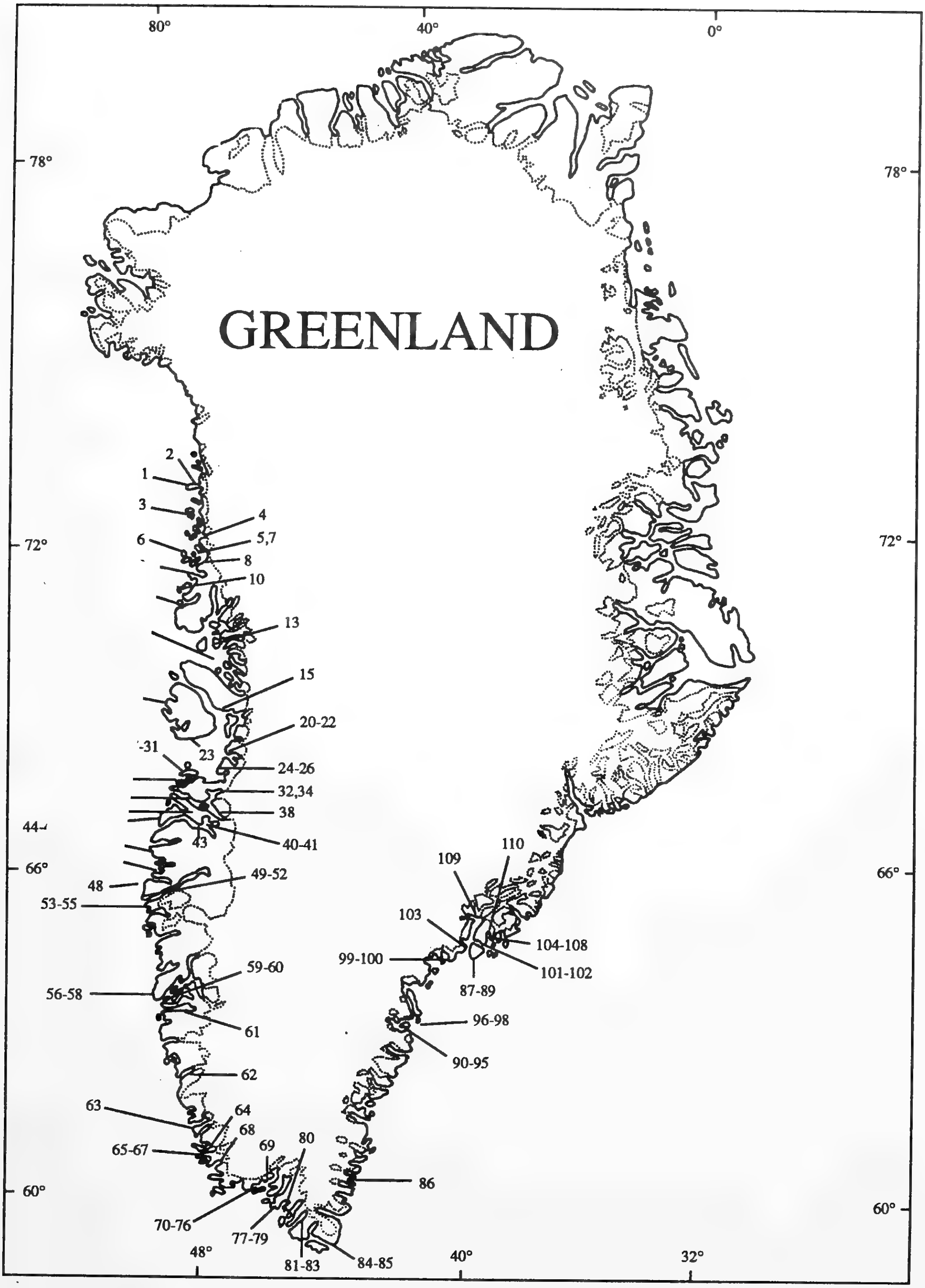

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The Density and Diversity of the Bird Populations in Three Residential Communities in Edmonton, Alberta

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Over a one-year period, bird populations were monitored in three urban residential communities in Edmonton, Alberta. The communities were approximately 35, 20, and 10 years old. The bird population density, number of species, and evenness of distribution declined from the oldest to newest area. The only bird species common to all three areas throughout was the House Sparrow, comprising between 70% and 100% of the total bird population. Except in the winter, the number of species and population density of birds were less in the urban areas than in a number of wildland studies, and also less than were found in a number of other urban bird studies.

Key Words: Urban bird communities, population density, population diversity, population gradient, Edmonton, Alberta.

A number of studies in Canada determined densities of breeding birds in urban environments. Some were breeding bird censuses on single sites; e.g., Senneterre, Quebec (Erskine 1970) and Swan River, Manitoba (Erskine 1972).

Other studies determined the density and diversity of the avifauna on multiple sites and in more than one season. Campbell and Dagg (1976) in Kitchener-Waterloo, during the breeding and winter seasons of 1974-1975, found the population density to be positively related to the degree of urbanization while the diversity was inversely related to urbanization. In Vancouver, British Columbia, Weber (1975) found that most breeding birds were cavity nesters and only a few species selected nest sites in trees. During the breeding, post-breeding, and winter seasons, on 11 types of urban habitat in Toronto, Ontario, Savard (1978) found that the density and diversity of the bird population were correlated with vegetation and varied seasonally. On eight study sites in Vancouver, B.C., Lancaster and Rees (1979), found that the density and diversity of the bird population could be related to the structure of the foliage.

In order to determine the population density and diversity of urban bird populations in Edmonton, three study sites representative of different ages were selected. These areas were studied during the breeding, post-breeding, and winter seasons between April 1990 and April 1991.

Study Areas

Edmonton (53°30′N, 113°30′W), with a population in excess of 750 000 and occupying an area of 67 000 ha (Statistics Canada 1992), is the most northerly major urban centre on the North American continent. It is located in the Aspen Parkland region of north-central Alberta which is an ecotone between the Grasslands and Boreal forest biomes (Wilkinson 1990).

The climate is typical of a mid-latitude continental location. Summer and winter have relatively stable temperature regimes. Summer begins in mid-May and lasts until early September, and winter lasts from mid-November until mid-March. The short transitional seasons are characterized by daily temperatures similar to either winter or summer values. Edmonton has, on average, 120 frost-free days (Olson 1985).

Three study areas in west Edmonton were selected as representative of different aged, but structurally similar communities forming a gradient from near the city centre to the urban fringe. Each contained only single family dwellings, was free of extensive redevelopment, and was structurally similar (Table 1).

The Parkview study area was surrounded by residential areas except on the east where a major thoroughfare separated it from another residential area, and on the north where a schoolyard, apartment building, and a small commercial development adjoined the study area.

Thorncliffe was also located within a more or less continuous residential area but was bounded on the east and south by major thoroughfares. The southern thoroughfare was separated from the study area by a berm and a noise reduction wall. Beyond part of the western margin lay a small shopping centre.

LaPerle was located on the urban fringe, with undeveloped rural land beyond the northern and western margins. Similar residential housing extended to the south and east of the study area.

Methods

The distribution and density of birds within the three study areas were determined using a belt tran-

TABLE 1. Comparison of some structural features in Parkview, Thorncliffe, and LaPerle.

	Parkview	Thorncliffe	LaPerle
Age in years	35	20	10
Area (ha)	20	21	22
Edge (m/ha)	90	77.4	97.3
Length of road (Km)	3.05	2.09	2.59
% area as Parks	10.99	14.86	8.14
# of properties	190	171	273
% single story dwellings	100	80	20

sect mapping method (Mikol 1980) similar to that employed by Emlen (1974) and Savard (1978). This technique involved a single observer moving at a more or less constant speed of 3 km h^{-1} along a fixed route which included both streets and laneways. The locations of all birds, from the centre of the transect belt to the roofline of the nearest dwelling on each side (approximately 25 m), were recorded on a 1:5000 cadastral map, which shows property boundaries in addition to laneways, and roadways. To be included in the dataset, an individual bird had to be seen or heard within the transect area. Overflying birds were not included. Counts were not conducted during periods of precipitation or when the winds exceeded 20 km h^{-1} and all counts were completed before 10:00 (the average time/count = 1.5 hrs).

Defining the "seasons" for urban birds is a somewhat subjective process. Casual observation in previous years (1987, 1988, and 1989) suggested that the number of species present was at its lowest in early April when most overwintering species had departed and most summer species had not yet arrived. The breeding season was defined as beginning when the first singing robins were heard on 13 April 1990. Week 1 of the study period began 14 April, and ended by week 15 (28 July 1990) when obvious breeding behaviour was no longer observed. The post-breeding season extended from with the end of the breeding season until the first major snowfall (11 November). The winter season began with the first major snowfall and lasted until the first singing male robin was sighted on 2 April 1991.

The average number of birds per hectare and the proportion of each species counted over the field season were calculated. The Shannon-Weaver Index of bird species diversity (MacArthur and MacArthur 1961) was used for comparing the species diversity in the three study areas. The Kruskal-Wallis H-test (Campbell 1989) was used to test for statistical differences among the count data.

All trees in the three study areas were identified as deciduous or coniferous and classified into one of four height groups. Contingency tables were used to test for significant differences between the study areas. To test for correlations between tree height and the population density km^{-2} and between tree height and the Index of Diversity linear regression analysis (Sincich 1985) was used.

Results

Tree Cover

An analysis of the data (Table 2) indicated that the proportion of deciduous to coniferous trees did not vary significantly between the three study areas (χ^2=2.814, df=2, a=0.05).

A second test, using a 3x4 contingency table, indicated that within the three study areas there was a significant difference in the distribution of the trees between the four height classes (χ^2=1272.4, df=6, p=0.05).

TABLE 2. Distribution of trees by type and height within Parkview, Thorncliffe, and LaPerle .

	Parkview	Thorncliffe	LaPerle
Coniferous			
<3m	7	187	183
3m-<6m	71	188	12
6m-<10m	174	100	6
>10m	154		
Deciduous			
<3m	6	92	159
3m-<6m	169	238	20
6m-<10m	141	74	11
>10m	101	11	3
Total	823	890	394

Avifauna

Breeding Season

Population Density and Diversity

The oldest subdivision, Parkview, contained a larger average number of birds than either of the younger areas and the Shannon-Weaver Index indicated that these individuals were more evenly distributed among the number of species present (Table 3).

Spring Migrants

Several migrating bird species were more or less common in the oldest study area, Parkview, during the breeding season. One of the earliest transients to appear was the Dark-eyed Junco (*Junco hyemalis*), which was recorded from 4 May 1990 to 13 May 1990. Three Yellow Warblers (*Dendroica petechia*) were observed singing on 20 May 1990. Swainson's Thrush (*Catharus ustulatus*) was observed on 13 May. In addition, four Yellow-rumped Warblers (*Dendroica coronata*) were observed on 5 May 1990 outside of the formal count period. Each of these species can be found nesting in the Edmonton region (Semenchuk 1992). On 21 May 1990 a single White-throated Sparrow (*Zonotrichia albicollis*) was heard to the north of the Thorncliffe study area. None of the above species were observed in the younger LaPerle study areas.

A number of overflying migrants were also seen over the city. These included Canada Geese (*Branta canadensis*), Sandhill Cranes (*Grus canadensis*), Golden Eagles (*Aquila chrysaetos*), and a number of buzzard hawks (*Buteo spp*).

Post-Breeding Season

Population Density and Diversity

This season had the highest average number of individuals/survey counted (Table 3).

A Kruskal-Wallis H-test indicated that the average number of birds/survey, in the Parkview study area, was not significantly different from the number/survey counted during the breeding season ($H'=3.67$, $df=1$, $p=0.05$).

In the newer Thorncliffe study area, the average number of birds counted increased in the post-breeding season. The Kruskal-Wallis H-test showed that the average number of birds/survey did not differ significantly from the average number/survey counted during the breeding season ($H'=1.82$, $df=1$, $p=0.05$).

The oldest subdivision contained a large average number of birds and the Shannon-Weaver Index indicated that these individuals were more evenly distributed among the number of species present.

TABLE 3. Cumulative count data for Parkview (P), Thorncliffe (T), and LaPerle (L).

	Breeding			Post Breeding			Winter		
	P	T	L	P	T	L	P	T	L
Merlin				1	1		3		
Ring-billed Gull	12			46	16		4		
Blue Jay	9			48	19		51	1	
Black-billed Magpie	16	2		49	21		71	2	
American Crow				5	4				
Black-capped Chickadee	20			98	6		40	1	
Red-breasted Nuhatch				12			10		
White-breasted Nuthatch				1			1		
Swainson's Thrush	1								
American Robin	119	29		30	5		3		
Bohemian Waxwing							37		
Cedar Waxwing	5			4	1		1		
European Starling	3	4		4	7		1		
Yellow Warbler	3			5					
Chipping Sparrow	50	39	1	2	21	5			
Savannah sparrow				29					
Dark-eyed Junco	2			61	9		3		
Common Redpoll							9		
Pine Siskin							7		
House Sparrow	359	139	22	811	302	10	1023	188	8
Total number	599	214	23	1206	412	15	1264	192	8
Number of Counts	6	4	3	11	6	3	13	4	3
Average per Count	99.8	53.5	7.7	109.6	68.7	5.0	97.2	48.0	2.7
Average Density per Km	499.2	254.7	34.9	548.2	326.9	22.8	486.2	228.5	12.1
Number of Species	12	6	2	16	12	2	15	4	1
Diversity (H')	1.31	0.98	0.18	1.34	1.08	0.64	0.76	0.12	0

Fall Migrants

The post-breeding season also included the period of fall migration and a number of species were apparent for relatively short periods at this time. The larids, particularly the Ring-billed Gull (*Larus delawarensis*), are commonly observed urban birds during the post-breeding season; however, gulls were sighted within the Parkview study area only between 20 August and 26 September. In the newer Thorncliffe study area, these gulls were seen between 9 August and 22 October. This species was not observed in the LaPerle study area. Gulls were observed in large numbers along the banks of the North Saskatchewan River until 6 November when the overnight temperature dropped to -12°C.

In the oldest study area, Parkview, Savannah Sparrows (*Passerculus sandwichensis*) were observed between 1 and 20 August. This species was not seen after 20 August and wasn't seen at all in the two younger study areas.

Dark-eyed Juncos (*Junco hyemalis*) were common in the oldest study area between 21 September and 28 October. This species was seen in Thorncliffe on 13 and 29 September. Juncos were not observed in the LaPerle study area.

Several other migrant species were observed in small numbers. From 27 August to 10 September, Yellow Warblers were observed during their fall migration, in the Parkview area. Also seen in this area were European Starlings (*Sturnus vulgaris*), Pine Siskins (*Carduelis pinus*), American Crow (*Corvus brachyrhynchos*), and a single White-breasted Nuthatch (*Sitta carolinensis*).

In the 20-year-old Thorncliffe area, only the European Starling and the American Crow appeared as migrants. No migrants were observed in the youngest study area, LaPerle.

Winter Season

Population Density and Diversity

This season was characterized by the lowest average number of birds observed during the year (Table 3).

A Kruskal-Wallis H-test indicated that, in the Parkview area, the number of birds/survey seen in the winter season did not differ significantly from the value for the post-breeding season (H'=1.08, df=1, p=0.05).

TABLE 4. Results of Regression Analysis comparing the number of trees in excess of 6 m in height with the population density and the Index of Diversity in the three study areas. In all cases p=0.01 and r_p=0.951 (Sincich).

	Density	Diversity
Breeding	0.9836	0.9015
Post-Breeding	0.9545	0.9279
Winter	0.9869	0.9864

In the Thorncliffe area, a Kruskal-Wallis H-test again indicated that the there was no significant difference between the birds/survey seen in the winter season and the post-breeding season (H'=2.93, df=1, p=0.05).

The diversity of the species was also lowest during the winter season. For all areas, there were fewer species and fewer individuals counted than at any other time of the year.

Correlation Between Tree Height and Population Density and Diversity

Linear regression showed that in all seasons there was a significant correlation between the avian population density and the number of trees which exceeded 6 m in height (Table 4).

The same test showed that during the winter season a significant correlation existed between the Index of Diversity and the number of trees which exceeded 6 m in height (Table 4).

Discussion

Breeding Season

The number of species sighted, though not necessarily breeding, in the Parkview study area (12) was similar to the numbers found in Toronto (8-23), Vancouver (6-23), Ottawa (17), Swan River, Manitoba (eight), and Senneterre, Quebec (eight) (Savard 1978; Lancaster and Rees 1979; Erskine 1975, 1970, 1972). In the Thorncliffe study area, six species were sighted, while only one species was sighted in the LaPerle study area. By comparison, Flack (1976) sighted between 12 and 22 species at three study sites within the aspen parkland of Alberta. Rukstad and Probst (1979) counted 25 species during the breeding season, within a mature aspen forest in Minnesota.

The bird population densities in the three study areas were lower than the densities found in Swan River, Manitoba (609 km^{-2}), Toronto (up to 763 km^2), Vancouver (351 to 1458 km^{-2}) (Erskine 1972; Savard 1978; Lancaster and Rees 1979). Breeding bird densities in aspen forests were also higher than the bird densities in the Edmonton study areas. Flack (1976) found densities between 1027 and 1703 km^{-2} at three sites within Alberta. Rukstad and Probst (1979) found 810 km^{-2} in a mature Minnesota aspen forest.

House Sparrows, American Robins, and Chipping Sparrows accounted for 88.3% of all observed birds in Parkview, 63.3% in Thorncliffe and 100% in LaPerle. Erskine (1972) found that these same species accounted for 87% of the birds observed in Swan River, Manitoba. By contrast, Rukstad and Probst (1979) found that robins accounted for 0.7% of the breeding birds in a mature aspen forest in Minnesota, and Flack (1976) determined that robins (House Sparrows and Chipping Sparrows were not seen) accounted for between 5.3% and 9.5% of the birds in three non-urban study sites in central Alberta.

Post-breeding Season

Although no studies have been published on urban areas with similar climate or at similar latitudes, Lancaster and Rees (1979) in Vancouver and Savard (1978) in Toronto found both the density and diversity of birds to be higher than in Edmonton.

Winter Season

A number of other urban studies have estimated winter population densities. Ralph (1982) found the population density in Ignace, Ontario to be 251 birds km^{-2}, while in five residential sites within Ottawa Erskine (1975) found the density of the winter bird population to range between 219 and 336 birds km^{-2}. Weber (fide Savard 1978) found a maximum winter population of 1241 birds km^{-2} in Vancouver, and Savard (1978) found the maximum winter population density in Toronto to be 1942 birds km^{-2}. It was apparent that the winter population density in Edmonton was near the low end of the range when compared to other urban centres in Canada. It should, however, be noted that Edmonton is located further north, has a more extreme climate, a longer winter season, and a shorter length of day than any of the other centres.

House Sparrows accounted for an average 82% of the birds counted within the Parkview study area, 98% of the winter bird population in Thorncliffe, and 100% of the birds seen in LaPerle. The high proportion of this species in Edmonton's avifauna may reflect the more limiting climactic conditions or habitat characteristics working singly or in combination. Isolating causal variables is an area for future study.

In Edmonton, Spencer (1973) inventoried the wildlife in four ravines along the North Saskatchewan River valley. In the winter of 1973 he found a total of 30 bird species in the ravines. The Parkview study area is less than 1 km from one of these study sites, Mackenzie Ravine, and less than 3 km from a second site, Whitemud Ravine. In Spencer's results, six of the species recorded in Mackenzie Ravine and nine of the species seen in Whitemud Ravine were recorded in the Parkview study area. Only the Pine Siskin and Red-breasted Nuthatch were limited to the residential area. All of the species seen in Thorncliffe were recorded in Spencer's inventory.

In wildland censuses, which were similar in habitat or latitude, the number of species was higher than in Edmonton while the population density of winter birds was less. Near Banff, Alberta, Colgan et al. (1978) found 15 species at a density of 80 km^{-2}, and Harris (1975) determined the population density near Saskatoon, Saskatchewan to be 328 km^{-2} and comprised 15 species.

Relationship between tree cover and birds

Over a 35-year period, the proportion of coniferous to deciduous trees has not changed significantly within the three study areas. The only significant difference in the tree cover was in the distribution by height. In all seasons the distribution of trees greater than 6 m in height was a significant habitat feature related to the population density of birds. The relationship between vegetation and population density is similar to results reported for Toronto and Vancouver (Savard 1978; Lancaster and Rees 1979).

A similar gradient was apparent using the Index of Diversity. However, this gradient only correlates with distribution of trees greater than 6 m during the winter season.

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Food Habits of the Black Bear, *Ursus americanus,* and Habitat Use in Gaspésie Park, Eastern Québec

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Foods habits of Black Bears (*Ursus americanus*) and their habitat use in Gaspésie Park, Québec, were determined from 169 scats and by monitoring 14 radio-tagged bears during summer 1990. Scat analysis indicated that graminoids were the most important food in early summer (1 June to 15 July) whereas Serviceberry (*Amelanchier* spp.), Wild Sarsaparilla (*Aralia nudicaulis*), Dogwood (*Cornus stolonifera*) and Raspberry (*Rubus* spp.) were the major fruit-bearing plants used in late summer (16 July to 31 August). Ants (Formicidae) were an important animal food throughout the summer. Mature forest was the commonest habitat type in the study area. It was used in proportion to its availability during early summer even though it was the poorest food-producing habitat. Clearcuts harboured the most fruit-bearing plants and were used predominantly in late summer. In general, disturbed areas, either natural (insect epidemics) or man-made (clearcuts), were the preferred habitats during the study. With the exception of one individual, none of the radio-collared bears were located in alpine tundra, the preferred habitat of a threatened Woodland Caribou (*Rangifer tarandus caribou*) population suffering heavy calf loss.

Le régime alimentaire et l'utilisation de l'habitat de l'Ours noir (*Ursus americanus*) du parc de la Gaspésie furent déterminés par l'analyse de 169 fumées et le suivi télémétrique de 14 animaux au cours de l'été 1990. L'analyse des fumées a montré que les graminoïdes constituaient la plus importante source de nourriture au début de l'été (1er juin au 15 juillet) alors que les Amélanchiers (*Amelanchier* spp.), la Salsepareille (*Aralia nudicaulis*), le Cornouiller Stolonifère (*Cornus stolonifera*) et les Framboises (*Rubus* spp.) étaient les espèces dont les fruits étaient consommés à la fin de l'été (16 juillet au 31 août). Les fourmis ont constitué une source importante de nourriture animale tout au cours de l'été. La forêt mature constituait le type d'habitat le plus commun dans l'aire d'étude et elle fut utilisée en proportion de sa disponibilité au début de l'été même si elle constituait l'habitat le plus pauvre en nourriture. Les parterres de coupe renfermaient le plus de plantes produisant des fruits et ils étaient recherchés à la fin de l'été. En général, les endroits perturbés, soit naturellement (épidémies d'insectes), soit par l'homme (coupes forestières) représentaient les habitats recherchés par l'Ours noir durant l'été. À l'exception d'un individu, aucun ours sous suivi télémétrique ne fut observé dans la toundra alpine, l'habitat préféré d'une harde menacée de Caribous (*Rangifer tarandus caribou*) souffrant de mortalité élevée chez les faons.

Key Words: Black Bear, *Ursus americanus,* Caribou, *Rangifer tarandus caribou*, feeding habits, habitat, Québec.

Since 1984, summer calf mortality of the Gaspésie Park Caribou (*Rangifer tarandus caribou*) herd has gradually increased, reaching 90% in 1988 (Crête et al. 1989). This Woodland Caribou population is the last surviving herd on the mainland in northeastern North America east of the Saint-Lawrence River, and for this reason, was classified as threatened in 1984 (J. P. Kelsall, unpublished COSEWIC report, 1984). Disease was ruled out as a possible explanation of low calf production because assays on 20 radio-tagged females examined in 1987 proved to be negative (Crête et al. 1989). Black Bear (*Ursus americanus*) and/or Coyote (*Canis latrans*) predation was suspected as the cause of calf mortality, but relative importance of mortalities due to each species was unknown.

The Black Bear is considered an opportunistic omnivore (Hatler 1972; Juniper 1978; Beeman and Pelton 1980; Graber and White 1983; Maher and Brady 1984). Although animal foods, usually colonial insects, constitute a small part of total diet, they are an important source of protein. Vertebrates are often consumed as carrion, but under certain conditions, Black Bear predation, particularly on neonates, can be an important limiting factor of Moose (*Alces alces*) (Franzmann et al. 1980; Wilton 1983; Franzmann and Schwartz 1986) and White-tailed Deer (*Odocoileus virginianus*) (Behrend and Sage 1974; Ozoga and Verme 1982; Verspoor 1983; Matthews and Porter 1988).

Little is known of Black Bear ecology in the Gaspé peninsula. Although bears and Woodland Caribou coexist in the region, we hypothesized that the closing of the park dump in 1984 could have modified bear feeding habits. Loss of that predictable and possibly important food source could have caused bears to enhance their use of alpine tundra while foraging, increasing the probability of Black Bear predation on neonate Woodland Caribou.

The objectives of our study were to describe seasonal food habits of Black Bears and their habitat use in Gaspésie Park to determine, in particular, if alpine tundra becomes a focal point of Black Bear foraging during summer.

Study Area

Gaspésie Park is located 450 km northeast of Québec City, in the Gaspé peninsula (≈49°00'N, 66°00'W). The study area (approximately 675 km^2) was located in the eastern part of the park and included portions of the Chics-Chocs Game Reserve (Figure 1). McGerrigle Mountains occupy the centre of the study area and form an elevated plateau dominated by Mont Jacques-Cartier (1270 m).

Climate is continental, but strongly influenced by altitude and proximity to the St Lawrence River. Average yearly temperature is below 0°C and mean annual precipitation is 1320 mm, 40-50% of which is snow (Gagnon 1970). Snow cover usually persists from early October to early June (Gagnon 1970).

At lower altitudes, vegetation is boreal. Mature forests are dominated by associations of Balsam Fir (*Abies balsamea*), Spruce (*Picea glauca*, *P. mariana*) and White Birch (*Betula papyrifera*). Until 1977, logging was allowed in Gaspésie Park and logging continues within Chics-Chocs Game Reserve. At higher elevations, vegetation opens up rapidly: tundra covers hilltops while Spruce and Fir krummolz grow in protected areas. Boudreau (1981) gives a complete description of alpine and subalpine flora.

The road system is relatively well developed at lower elevation, and a gravel road circles the McGerrigle massif (Figure 1). In the alpine and subalpine areas, human accessibility is restricted to a few hiking trails.

The Gaspésie Park Woodland Caribou herd is composed of 200-250 animals which are divided between the Mont Jacques-Cartier and the Mont Albert groups (Crête et al. 1989; Crête and Desrosiers 1993). Due to the precarious nature of calf survival, a local bear control plan was implemented in June and July 1990, at the same time as our study was carried out, in the hopes of protecting the calving grounds. A series of conibear-type traps, custom built to handle Black Bears, were set up at the periphery of the alpine tundra at high elevation in the centre of our study area. Thirteen bears were taken in and around Mt Jacques-Cartier during that period, and five of them were under the age of two.

Methods

Field work extended from 17 May to 31 August 1990 with additional telemetry data collected during the autumn of the same year and during the winter of 1991.

Food habits were based on 169 scats collected weekly along roadsides and opportunistically from 6 June to 27 August 1990. Scats were dated and frozen until analysed. Sampling of scat contents was based on methods described by Chamrad and Box (1964).

After initial oven-drying at 65°C for 48 hours to eliminate parasites, scats were rehydrated and then sieved. A sample of each scat was suspended on a thin film of water and distributed evenly in an enamel pan. Point-sampling was used to determine relative importance of food items. The number of sampling points was fixed at 50 items, and point distribution was systematic within the pan. Relative importance of each item was determined by dividing the number of points by 50. Food items were indentified to species whenever possible.

The study area was stratified into five habitat types using Ministère de l'Énergie et des Ressources du Québec (MER) forest cover maps (1:20 000): mature forest (MF), clearcuts less than 15 years old (C<15), clearcuts more than 15 years old (C>15), forest stands affected by insect epidemics (IE), mainly Spruce Budworm, and miscellaneous (MIS) which consisted of clearings, old burns, water areas, etc, and included alpine tundra.

In each habitat type, trees were sampled using 25 100-m^2 quadrats. Sampling plots were randomly selected along the road network, and for this reason, alpine tundra was not sampled. Diameters at breast height (DBH) were measured for all stems and percentage of canopy cover was estimated by species. Percent ground cover of shrubs and non-woody vegetation was estimated with 4 2-m long transects per stand, spaced at a right angle on one corner of the quadrat used to sample trees. Relative availability of animal species liable to be consumed by bears was estimated by recording the number of animal signs (browsed twigs, scats, foot prints) along 4 50-m transects placed at a right angle to the main plot. Detailed description of sampling procedures is provided by Boileau (1993).

Black Bears were captured in foot snares at baited sites along the main roads circling the McGerrigle massif. Techniques for immobilization, age determination, and telemetry were described in Boileau (1993). Fourteen adult bears (seven males, seven females) were fitted with radio-collars. Ages of males ranged from 4 to 9 years ($\bar{x}$ = 7.1 years) whereas ages of females ranged from 5 to 10 years ($\bar{x}$ = 6.6 years). One of the females had two yearling cubs.

Bears were located from the ground every two days when possible from 3 June to 27 August, 1990, but radio contact was often impossible due to large movements and topography. By mid-July, dispersal of bears was such that only three bears were regularly contacted from the ground. Helicopters were used to locate bears on five occasions during the study, and three additional flights were completed during late autumn and winter to locate dens. Bears were generally seen and habitat type was determined for comparison with maps of forest cover maps.

Habitat use by Black Bears was estimated from aerial locations only because they were more acurate than ground-based relocation. Habitat selection was determined with methods described by Johnson (1980) which compare rank of habitat use with rank of habitat availability. The Johnson method is an application of a multivariate paired *t*-test where the variables are habitat types and where the null hypothesis is that all habitats are used with equal intensity. Johnson recommends the use of the Waller-Duncan multiple comparison procedure to determine differentially selected habitats when a significant test statistic is obtained. MER data was used to determine habitat availability.

To evaluate seasonal trends in food habits and habitat use, data were computed for two periods: early summer, 1 June to 15 July; and late summer, 16 July to 31 August.

Results and Discussion

Foods habits

Graminoids (grasses and grass-like plants) were the major food item in the early summer diet; clover (*Trifolium* spp.) was the second largest one (Table 1). Graminoids have also been found to be a dominant food item during early summer in Wyoming (Irwin and Hammond 1985), California (Graber and White 1983), Tennessee (Beeman and Pelton 1980), and in southwestern Québec (Lachapelle et al. 1984). Jonkel and Cowan (1971) and Hatler (1972) also reported graminoids as a common food item in Montana and in Alaska.

Late summer diet was composed largely of fleshy fruits, particularly serviceberries (*Amelanchier* spp.), Wild Sarsaparilla (*Aralia nudicaulis*), Dogwood (*Cornus stolonifera*), and wild raspberries (*Rubus* spp.). In other areas in boreal habitats, blueberries (*Vaccinium* spp.) were the largest food item in late summer (Jonkel and

TABLE 1. Relative (%) importance (RI) and frequency (%) of occurrence (FO) of foods consumed by Black Bears in Gaspésie Park as revealed by the analysis of 169 scats collected from June to August 1990.

	Early Summer (n=136)[a]		Late Summer (n=33)	
Food Item	RI[b]	FO[b]	RI	FO
GREEN VEGETATION				
Betula spp.	1	19		
Equisetum spp.	2	13		
Graminoids	43	85	4	12
Hieracium spp.	3	30		
Populus spp.	1	17		
Salix spp.	T[c]	2		
Taraxacum spp	5	24		
Trifolium spp	12	57		
Unidentified	5	10	2	30
FRUITS				
Amelanchier spp.			28	49
Aralia nudicaulis	T	1	11	39
Cornus stolonifera			8	33
Fragaria americana	1	2		
Ribes spp.			1	3
Rubus spp.			7	22
Streptopus roseus			T	3
Vaccinium spp.	1	2	4	15
Viburnum edule	1	2	T	3
Unindentified	T	1	7	42
ANIMAL				
Alces alces	1	5		
Aves (feathers)	T	3	T	3
Formicidea	10	30	8	36
Ursus americanus	1	4	T	3
DEBRIS				
(stones, wood, etc.)	14	100	17	97

[a] Number of scats in sample.
[b] Percentage values are rounded to the nearest number.
[c] Trace (%<0.5).

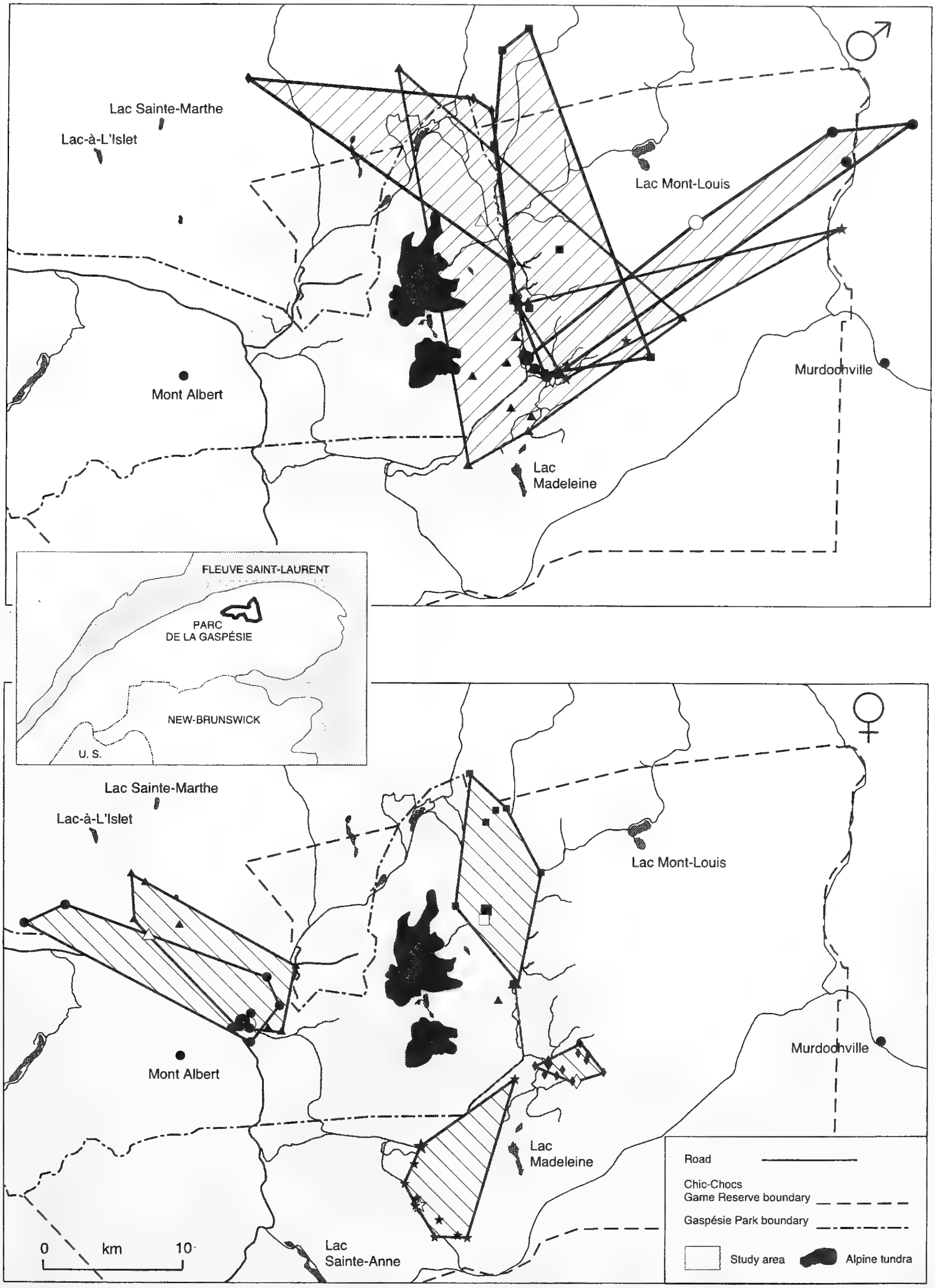

FIGURE 1. Location of Gaspésie Park in eastern Québec and home range of 10 radio-tagged Black Bears monitored from spring to denning according to their sex. The larger closed symbol indicates the capture site and the open symbol shows the den site.

TABLE 2. Relative availability, by habitat type, of vegetation and animals liable to be consumed by Black Bear, Gaspésie Park, summer 1990. MF= mature forest, MIS= miscellaneous, C<15= clearcuts under 15 years old, C>15= clearcuts over 15 years old, and IE= stands affected by insect epidemics.

	TYPES				
SPECIES OR GROUP	MF (n=25)	MIS (n=12)	C<15 (n=25)	C>15 (n=25)	IE (n=25)
Vegetation[a]					
Aralia nudicaulis	4±5	2±4	2±3	2±4	4±5
Amelanchier spp.	3±6	3±6	1±2	3±6	1±2
Betula papyrifera	2±2	4±7	5±9	3±6	6±8
Cornus stolonifera	4±11	1±2	T[c]	T	T
Graminoids	4±13	6±8	2±10	T	T
Equisetum spp.	3±13	1±2	T	0	T
Fragaria americana	T	0	0	T	T
Hieracium spp.	0	T	1±2	1±3	0
Prunus pensylvanica	0	0	1±3	0	T
Ribes spp.	1±3	2±3	4±9	1±1	1±1
Rubus spp.	3+5	6±8	18±26	4±7	14+27
Salix spp.	0	1±3	T	0	0
Sambucus spp.	1±4	1±3	1±5	2±8	0
Sorbus americana	T	2±3	T	1±2	1±3
Streptopus roseus	1±1	T	0	0	T
Vaccinium spp.	0	T	0	0	0
Viburnum spp.	1±1	6±13	1±2	T	1±2
Animals[b]					
Alces alces	5±6	8±8	3±4	2±4	3±4
Lepus americanus	8±6	8±7	8±13	10±8	11±7
Formicidea	0	1±2	1±2	T	0

[a] Percent ground cover (± SE)
[b] Number of signs observed per 50-m transect (± SE)
[c] Trace

Cowan 1971; Hatler 1972). In southwestern Québec, bears consumed mostly wild raspberries (Lachapelle et al. 1984).

Although wild raspberry stems were abundant in the study area (Table 2), particularly in C<15, berry consumption was not related to availability. During the previous year, Melançon (1990) reported that wild raspberries dominated the diet of Black Bears during late July and August in the same area. We did not measure raspberry production in our study, but it was considered to be low in 1990; bears probably switched to other fruit-bearing plants, attesting to their opportunistic nature.

Animal items in scats represented a small portion of the summer diet (11%) and were almost entirely made up of ants (82% of animal items). The colonial nature of ants provides a concentrated food source rich in protein (Landers et al. 1979; Eagle and Pelton 1983; Hellgren et al. 1989). Moreover, Hatler (1972) and Landers et al. (1979) found that eggs and pupae of insects occurred in greater amounts in stomach contents. Therefore, the relative importance of ants was probably underestimated because eggs and pupae were rather rare in scats.

Remains of vertebrates occurred infrequently (9%). Presence of Moose was probably related to use of Moose for bait at capture sites, whereas bear hairs were probably ingested while grooming. Bird feathers occurred in trace amounts in early and late summer.

It may be impossible to assess the relative importance of vertebrates in bear food habits from scat analysis. Hatler (1972) warns that meat undergoes an important transformation in the digestive tract and quantitative changes may be great. Meat consumption can also provoke diarrhoea in bears so that such scats can go undetected, particularly in rainy areas (Ballard and Larsen 1987). In addition, bears sometimes skin their prey before eating (Wilton 1983), thus eliminating hairs as a possible clue of ingestion. Moose (*Alces alces*) density reaches 2 animals/km^2 in parts of Gaspésie Park (Crête 1989), and this cervid species was much more available to Bears than Woodland Caribou. The probability of finding Woodland Caribou hair in scats was very low and, not suprisingly, we found none. However, its absence does not rule out the possibility of bear predation on Woodland Caribou calves.

Vegetation composed 77% of the bear diet in our study. Overall for the summer, bear diet was composed of 41% green vegetation, 36% fruit, 11% animal matter and 16% debris (Figure 2). The dominance of green vegetation in the first half of summer was replaced by fruits during the second part of the season. Intensive use of vegetation and fruit is con-

TABLE 3. Black Bear habitat use in Gaspésie Park, 1990, determined from radiolocations. Habitat types underscored by the same line are not significantly different from each other in terms of preference (P>0.05) according to Johnson's method (Johnson 1980). MF= mature forest, MIS= miscellaneous, C<15= clearcuts less than 15 years old, C>15= clearcuts over 15 years old, and IE= stands affected by insect epidemics.

	Habitats				
	MF	MIS	C<15	C>15	IE
Availability (%)[a]	61	20	11	5	3

Use (%)[b]

EARLY SUMMER (n=22)					LATE SUMMER (n=24)				
MIS	MF	C<15	C>15	IE	MF	MIS	C<15	C>15	IE
4.5	45.5	27.3	13.6	9.1	8.3	25	33.3	25	8.3

[a] Percent availability of respective habitats components.
[b] Percent of radiolocations in each habitat type.

sistent with findings elsewhere in North America (Hatler 1972; Juniper 1978; Landers et al. 1979; Beeman and Pelton 1980; Maher and Brady 1984; MacHutchon 1989).

Habitat use

Radio-collared bears were relocated from the air on 46 occasions during summer and autumn of 1990. By 8 July, two bears were lost to trapping and two bears lost their radiocollars. Areas occupied during the summer averaged 125 (SE=38; N=5) for 5 males and 47 (23;5) km^2 for five females. With the exception of one female which was killed in a bear-trap set at the edge of the alpine tundra, no bears were relocated within alpine tundra (Figure 1). Moreover, as summer progressed, bears tended to leave the study area; by 12 July, half of the radiocollared bears roamed outside the study area (Boileau 1993).

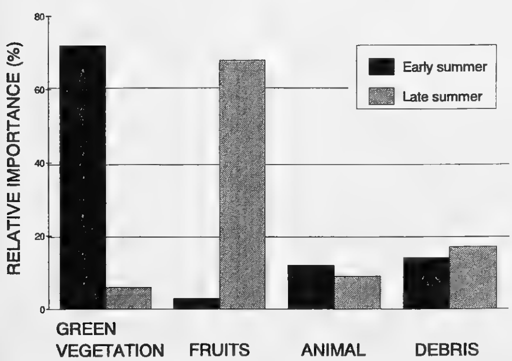

FIGURE 2. Composition of Black Bear diet in Gaspésie Park, Québec, in early (1 June to 15 July) and late (16 July to 31 August) summer, 1990, according to four broad groups, as revealed by scat analysis (*n*= 169).

Seasonal trend in habitat use was not as evident as that for food habits. Seasonal variations in habitat use reflect changes in Black Bear diet (Jonkel and Cowan 1971; Armstrup and Beecham 1976; Lindzey and Meslow 1977; Kelleyhouse 1980; Grenfell and Brody 1986; Pelchat and Ruff 1986; Young and Beecham 1986; Meddleton and Litvaitis 1990; Hellgren et al. 1991). There were significant differences (P<0.05) between habitat use and habitat availability in early summer and in late summer.

Early summer: Although 45% of radio locations were in MF stands during this period, bears did not select this habitat type in relation to availability (Table 3). IE stands were most preferred, followed by C<15 and C>15 stands. There was no significant difference in preference between MF and MIS on the one hand, and between C<15 and C>15 on the other. Preference for IE stands was significantly different than that of the other groups.

Late summer: Rank ordering of habitats was relatively the same; MF stands were now the least preferred habitat type, being nearly abandoned during this time (Table 3). There were four distinct groups of selected habitats in late summer. More than 50% of the locations were made in logged areas although they covered only 16% of the study area.

Use of clearcuts by bears became quite evident in late summer when fruit availability increased. Lindzey and Meslow (1977) also observed a strong spatial association between Black Bears and clearcuts. Jonkel and Cowan (1971) found that fruit availability was greater in selective cuts. In Michigan, fruit-bearing plant species were more abundant on sites that were clearcut (Manville 1983). Hellgren et al. (1991) found that disturbed areas were important to Black Bears and Kelleyhouse (1980) observed Bears using partial cuts in search of insects. Clearcuts and IE stands in our study area provided more fruiting and berry plant species than other habitat types; in addition, ants were more available in these clearcuts (Table 2).

Use of roads: We did not consider roads as a distinct habitat type in this study because radio locations of bears in or along roads were classified according to the habitat type they crossed. Road usage may have biased the use of some habitat types. The presence of roads can be an important factor in the quality of habitat for bears. Manville (1983) found that roads were used as travel lanes by bears and that roadsides contained many fruiting plants that were consumed by bears in summer and autumn. Hellgren et al. (1991) observed the importance of road margins for bears who used them frequently to feed on important plant foods.

Our study suggests a relationship between seasonal habitat use and food habits of bears in Gaspésie Park, Québec, which was similar to that found in other North American studies. With the exception of one individual that was captured near alpine tundra, no radio-tagged bears were relocated in this habitat type. Black Bears are diurnal (Larivière et al. 1994), so that intensive use of alpine tundra would have been detected by aerial or ground telemetry.

However, bears are present at higher elevations in Gaspésie Park, and eight individuals older than two years were trapped on the McGerrigle massif during the summer of 1990 (Crête and Desrosiers 1993). We think that, for those animals, as for the radio-tagged female that was captured, some alpine tundra habitat was included within their home range. In view of the opportunistic nature of bears, these individuals will probably kill a neonate caribou if the opportunity occurred; indeed there were three confirmed cases of bear predation on Woodland Caribou calves radio-tagged at birth among 11 cases for which the cause of death could be determined (Crête and Desrosiers 1993).

The removal of bears in the centre of our study area during the course of our telemetry work appears not to have much influenced studied animals. One could expect expansion of bear home ranges with the disappearance of neighbours, but we were unable to detect it (Figure 1). Time was maybe too short for animals to readjust home range boundaries.

Mature forest stands are the dominant habitat type in the study area and they provide few important bear foods. Logging ceased in 1977 within park boundaries; the carrying capacity for bears should diminish as stands mature, which should contribute to reduce potential for bear-caribou conflicts.

Disturbances in mature forest such as logging, burns or insect epidemics benefit Black Bears. In the Gaspé peninsula, logging practices provide quality habitat for the species. Data from this study does not allow us to infer the role played by Black Bears in the survival of Woodland Caribou in Gaspésie Park. However food habits and habitat use suggest that alpine tundra which is widely used by Woodland Caribou, is not a preferred habitat for Black Bear.

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Food Preferences of Captive Wild Raccoons, *Procyon lotor*, from East Texas

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We offered a random assortment of six foods to nine captive Raccoons (*Procyon lotor*) during 10 days in February 1991 and to 10 Raccoons during 9 days in January 1992: Persimmon, (*Diospyros virginiana*); Southern Red Oak acorn, (*Quercus falcata*); chicken egg; crayfish (*Cambarus bartoni*); corn (*Zea mays*); and Earthworm (*Lumbricus terrestris*). Foods were given preference ranks 1 - 6 corresponding to feeding sequence; we assumed that the item eaten first was most preferred. We calculated the mean of each Raccoon's preference ranks for each food item over the days of the trial period. Persimmon was the most highly favored food both years, followed by acorn. Earthworm was the least preferred of the six foods. Testing the mean rank totals for each food separately showed that the 1992 group favored egg significantly more than the 1991 group. Males showed a preference for corn more frequently than females did. The results of this study are discussed with implications for enhancing habitat and reducing crop damage.

Key Words: Raccoon, *Procyon lotor*, food habits, food preferences, feeding trials.

Reports of Raccoon (*Procyon lotor*) feeding habits have listed food items identified from the stomachs and intestines of carcasses (Greenwood 1982; Hendricks 1975; Smith et al. 1987; Tabatabai and Kennedy 1988), from analysis of scats (Greenwood 1981; Lehman 1977; Rivest and Bergeron 1981; Schoonover and Marshall 1951), from a combination of stomach and fecal samples (Baker et al. 1945; Harman and Stains 1979; Sonenshine and Winslow 1972), and also from direct observation of Raccoons and their available foods in the wild (Mech et al. 1968; Rue III 1964; Urban 1970). Seasonal analysis of Raccoon stomachs and scats reveals a few food items taken in abundance at certain times of the year in particular habitats. Kaufman (1982) summarized the current literature with regard to foods taken by Raccoons at all seasons.

Averaged over the year, the ratio of plant to animal food taken by Raccoons is about 60% to 40%, respectively (Baker et al. 1945; Hendricks 1975; Smith et al. 1987). Fleshy fruits and nuts (acorns [*Quercus* spp.], in particular) are the most important plant foods (Baker et al. 1945; Hendricks 1975; Kaufman 1982; Tabatabai and Kennedy 1988); corn is a staple in agricultural areas (Greenwood 1982; Rivest and Bergeron 1981). Crayfish is the most frequently consumed animal food (Kaufman 1982). While Raccoons are omnivorous and reportedly opportunistic (Kaufman 1982), they are selective when a variety of foods are available (Tabatabai and Kennedy 1988), favoring items high in sugar (Fleming 1983; Johnson 1970; Smith et al. 1987).

No results have been published describing systematic feeding trials on live Raccoons. The purpose of this experiment was to investigate the relative preferences of Raccoons for a selection of commonly reported natural foods. An interesting novelty in the present experimental design was the opportunity to observe the preferences of Raccoons for food items whose disjunct seasonal availability precludes comparative determinations from examination of carcasses. Smallwood and Peters (1986) suggested that food preference experiments which concurrently offer test animals a selection of foods are "flawed in their basic assumptions" that the normal foraging behavior of free-ranging animals involves similar choices from an array of available food items. We made no assumption that the present experiment simulated field conditions encountered by free-ranging Raccoons. Nevertheless, it is certainly possible that free-ranging Raccoons could be faced with a choice between potential food items, and preferences demonstrated under test conditions provide a basis for prediction of behavior in the wild. This experimental design permitted investigation of aspects of Raccoon behavior that are not easily addressed through trials on free-ranging animals. The null "opportunistic" hypothesis was that no preference would exist for any of the test foods and that selection sequence would be random.

Methods and Materials

Our sample consisted of seven males and two females in 1991 and seven males and three females in 1992. Though two Raccoons captured in 1992 appeared to be recaptured members of the 1991 group, positive identification from ear notches was not possible, and all animals were considered unique for purposes of statistical analyses. Animals used in the trials were collected under Texas Parks and Wildlife permit # SPR-0192475 to the junior author from three counties in Texas: Nacogdoches, Houston, and Cherokee (31° 20′ – 40′ N, 94° 20′ - 95° 10′ W). Collection sites described the boundaries of a geographical area of over 2000 square km. Raccoons were housed indoors in wire cage traps 36 x 48 x 91 cm (15 x 20 x 36 in). During the 3 – 4 weeks in captivity in 1991 and 3 – 7 days in 1992 before the feeding trials began, Raccoons were provided a commercial dry cat food containing 40% carbohydrate, 30% protein, 8% fat, 12% moisture, 4.0% fiber, 1% calcium, 1% phosphorus, 1.5% salt, and 0.1% magnesium. Each animal was also given a minimum of 1 liter of water each day. Dry food was withheld one day prior to the start of the trials in 1991; in 1992 Raccoons were given dry food up to the day that the experiment began. A partition was placed between cages during feeding to provide some privacy and to prevent interactions between Raccoons. These conditions of captivity and treatment are in accordance with the Animal Welfare Act of 1970 (7 U.S. Code Service § 2131).

Six food items were apportioned to the subject Raccoons on each of 10 consecutive trial nights in February 1991 and 9 nights in January 1992. We repeated trials over a 9 – 10 day period using a different randomized assortment of the food items each night in order to gain a higher confidence mean of a Raccoon's preference scores for each food item. Test foods were selected from the most abundant reported dietary constituents of Raccoons from the United States during all seasons. In addition, an effort was made to include a representative sample of the plant and animal diversity encountered by free-ranging Raccoons. Corn was the only cultivated food item offered. The other five food items were live earthworms; fresh (dead) crayfish; small chicken eggs (as a substitute for wildfowl eggs); ripe persimmon fruit; and Southern Red Oak acorns. Portions of each food were as follows:

corn — 3 to 5 cm of a cob
crayfish — 1 (or 2 if very small), with about 5 ml water
acorns — 4 to 6
earthworms — 2 or 3, with about 5 ml water
egg — 1
Persimmon — 1 or 2

Food items were placed in six baking cups mounted to a board in a single row and wired to the back of the cage. Water was included with the crayfish to make the presentation as similar as possible to a natural occurrence. Earthworms were placed in a small amount of water to prevent desiccation before the Raccoon arose to eat (sometimes three or four hours after serving).

The presentation of the foods was intended to approximate as nearly as possible the appearance and texture of the same items as encountered in the field. All items were either refrigerated or frozen until needed to preserve freshness. As needed, foods were thawed or taken from refrigeration and served at ambient temperature. Our main priorities in determining the quantity and form of food servings were: (1) to provide Raccoons with enough nutrition so that they did not physically decline during the trials, (2) to provide small enough servings to ensure that Raccoons would be hungry enough to eat at least five of the items each night, (3) to provide approximately equal mass servings of each item, and (4) to present the foods in such a way as to give the Raccoon equal access to each item in the array.

The use of whole items, in the form in which they are available to the foraging Raccoon, precluded serving each item in exactly equal mass quantities. We decided that serving foods in a consistent texture, such as powdered, in order to give exactly equal portions of each, would not produce easily interpreted information on which foods Raccoons would choose relative to others in nature. Indeed, the purpose of the experiment was to observe the selection sequence of live Raccoons for natural foods, some of which are not normally available simultaneously. The underlying causes of the selections were not investigated and are discussed only in reference to possibilities suggested by our results and available literature on Raccoon food habits.

Water was placed in the center of the cage away from the food tray. Food order was randomized each night, and each Raccoon in the group received the same selection. The data sheet consisted of a randomized block matrix with Raccoons as blocks and foods representing treatments. Cells were filled with numbers (1 – 6) corresponding to the order in which food items were eaten. An item was considered to be eaten, and a preference rank assigned, if all or part of the serving was consumed. For the purposes of this experiment, we assume that a Raccoon indicated a preference for one food item over another by selection sequence, i.e., the first food eaten was the most preferred, the last taken was the least preferred. An item was only ranked once. Therefore, instances in which an animal went back to a previously selected item were not recorded. Raccoon feeding behavior was viewed by three video cameras covering 3 – 4 cages each. Two or three observers watched monitors in an adjacent room and recorded feeding data.

We calculated each Raccoon's mean rank preference score for every food item over the trial period and used those values in comparisons of groups between years, of males with females, and in calculating combined mean preference ranks for both years. On the basis of the individual Raccoon mean rank scores we assigned pooled ranks (1 – 6) to be used in analysis of variance. We define a trial Raccoon/day as a day in which a Raccoon chose among all six food items (at least five were eaten). Incomplete trials in which two or more items were left uneaten were not included in the analyses. The pooled rank scores were totaled across years and analyzed with the Friedman two-way ANOVA by ranks (a nonparametric parallel to the repeated measures ANOVA) (McClave and Dietrich 1988) to test the hypothesis that none of the treatment totals differed from any others. After confirming that at least two preference scores differed, we tested all pairs with the multiple comparisons test (Siegel and Castellan 1988). We used the Mann-Whitney U test (McClave and Dietrich 1988) to compare groups between years and to compare mean preferences between males and females across both years (14 males and 5 females). All statistical tests, with the exception of multiple comparisons, were performed using CSS:Statistica (Statsoft c1991). An $\alpha = 0.05$ level was used for all tests.

Results

Raccoon #1 died on the ninth day of the trial in 1991; it appeared emaciated, though it ate all food items until the day of its death. All remaining Raccoons in 1991 and 1992 seemed vigorous when released at the end of the experiment. There were 88 trial Raccoon/days in 1991, 9 Raccoons tested for 8 days and 8 Raccoons for 2 days. The 10 Raccoons tested for 9 days in 1992 yielded a total of 76 Raccoon/days on which data were complete. Upon approaching the food array, as well as after consuming an item, individuals commonly sniffed over uneaten foods before selecting one. Table 1 shows the mean preference ranks for each Raccoon averaged over the trial periods in 1991 and 1992, using days in which an individual selected at least five foods.

The Friedman ANOVA showed that at least one of the treatment totals differed from the others (ANOVA chi-square = 50.66, P = 0.0000, N = 19, d.f. = 5). The multiple comparisons test of differences in mean preference rank totals for all Raccoons combined across both years showed that scores for persimmon were significantly lower (more preferred) than those for corn and earthworm, and scores for acorn were significantly lower than those for earthworm (Critical difference = 33.85; persimmon – corn = 43.80, persimmon – earthworm = 53.49, acorn – earthworm = 42.31). The mean preference ranks for each food item combined for all 19 Raccoons across both years are shown in Figure 1.

The 1992 group exhibited a greater selection preference for egg than did the 1991 group ($U = 21$, $z = -1.96$, $P = 0.05$, $N_1 = 9$, $N_2 = 10$). The mean ranks for other food items were not significantly different between years. Males showed a greater preference for corn than did females (♂$\bar{x} = 3.82$, SE = 0.32; ♀$\bar{x} = 5.46$, SE = 0.20; $U = 11.0$, $z = -2.22$, $P = 0.03$, $N_m = 14$, $N_f = 5$). Mean preference scores for other food items were not different between sexes.

Discussion

The dry cat food which Raccoons were allowed to consume ad libidum prior to the start of trials included substantial protein, fat, carbohydrate, and mineral components. Therefore, we do not believe that Raccoons were starved for any essential nutrient at the onset of the experiment. As a result, we believe that these preference results may be indicative of choices that would be made by free-ranging Raccoons in East Texas.

Based on the multiple comparisons tests of differences in mean rank totals, we may reject our null hypothesis and conclude that these groups of Raccoons favored persimmon over corn and persimmon and Southern Red Oak acorns over earthworm. The similarity in the rank totals for egg, corn, and crayfish, preclude a clear distinction between test animals' preferences for those items.

While the remains of earthworms in Raccoon feces may be determined indirectly by soil volume (Greenwood 1981), the lack of durable structures makes an estimation of the importance of earthworms in Raccoon diet problematic (Yeager and Rennels 1943). These results showing Earthworm to be ranked significantly higher (eaten later) than both persimmon and Southern Red Oak acorns give the first indication of the relative preference of Raccoons for earthworms in comparison to at least these two other common foods.

The preference scores for persimmon and acorn shown by test animals compliment other studies reporting foods frequently taken by Raccoons. Fleshy fruits and acorns are similar in nutrient and digestibility values (Short and Epps 1976), both containing high levels of carbohydrates important in the formation of needed fat reserves (Goodrum et al. 1971; Harman and Stains 1979). In addition, Short and Epps (1976) found that acorns and fleshy fruits had "greater usefulness" to wildlife than seeds and dried fruit due to a combination of their nutrition, digestibility, palatability, and seasonal abundance.

It might be argued that the high preference scores received by acorns in this study were related to seasonal habituation, since acorns are a staple of the winter Raccoon diet (Baker et al. 1945; Harman and Stains 1979, Hendricks 1975; Tabatabai and Kennedy 1988). We doubt that season exerted a significant influence on Raccoon preferences, however, since persimmon was the most favored food item but had been unavailable in the woods of East Texas for four

TABLE 1. Mean and [SE] of rank preference scores for each Raccoon for each offered food item during the trial periods in 1991 and 1992, averaged over the number of days in which Raccoons chose among at least five foods. Treatment rank totals used in multiple comparison tests shown at bottom of table. A total score is significantly different from others which are not followed by at least one common letter.

		Food						
Year	Raccoon	Persimmon	Acorn	Egg	Crayfish	Corn	Worm	Trial Days
1991	1	3.00 [0.66]	2.88 [0.67]	4.88 [0.58]	3.13 [0.58]	3.88 [0.55]	3.25 [0.49]	8
1991	2	2.20 [0.49]	2.60 [0.48]	4.40 [0.31]	3.20 [0.53]	3.30 [0.39]	5.60 [0.22]	10
1991	3	1.60 [0.31]	2.50 [0.40]	4.30 [0.21]	4.00 [0.60]	3.10 [0.35]	5.50 [0.31]	10
1991	4	1.50 [0.31]	2.00 [0.26]	3.70 [0.45]	4.30 [0.40]	5.00 [0.37]	4.50 [0.40]	10
1991	5	1.60 [0.43]	3.10 [0.38]	2.50 [0.27]	3.10 [0.35]	5.90 [0.10]	4.80 [0.20]	10
1991	6	1.60 [0.50]	3.30 [0.30]	3.50 [0.27]	4.80 [0.47]	2.30 [0.26]	5.50 [0.22]	10
1991	7	1.40 [0.16]	1.70 [0.21]	4.30 [0.21]	3.90 [0.35]	3.70 [0.26]	6.00 [0.00]	10
1991	8	3.40 [0.58]	2.20 [0.55]	5.10 [0.38]	4.00 [0.47]	3.70 [0.30]	2.60 [0.50]	10
1991	9	2.30 [0.52]	2.00 [0.30]	4.70 [0.26]	2.80 [0.47]	3.40 [0.27]	5.80 [0.13]	10
1992	10	1.14 [0.14]	2.86 [0.40]	2.86 [0.26]	5.00 [0.00]	3.14 [0.54]	6.00 [0.00]	7
1992	11	2.10 [0.59]	2.80 [0.29]	4.80 [0.29]	4.30 [0.45]	2.30 [0.37]	4.70 [0.50]	10
1992	12	1.63 [0.42]	2.50 [0.33]	4.00 [0.68]	3.63 [0.53]	5.00 [0.27]	4.25 [0.56]	8
1992	13	1.71 [0.42]	2.71 [0.61]	2.43 [0.53]	3.71 [0.18]	5.86 [0.14]	4.57 [0.30]	7
1992	14	1.00 [0.00]	2.83 [0.17]	2.17 [0.17]	4.67 [0.53]	5.33 [0.33]	5.00 [0.26]	6
1992	15	1.78 [0.47]	3.33 [0.50]	4.78 [0.40]	2.78 [0.57]	3.22 [0.32]	5.11 [0.39]	9
1992	16	1.44 [0.29]	2.89 [0.31]	3.11 [0.31]	4.00 [0.47]	5.22 [0.43]	4.33 [0.65]	9
1992	17	2.44 [0.29]	2.56 [0.38]	1.56 [0.34]	4.56 [0.38]	5.22 [0.28]	4.67 [0.47]	9
1992	18	4.00 [1.00]	2.50 [1.50]	2.00 [0.00]	2.00 [1.00]	6.00 [0.00]	4.50 [0.50]	2
1992	19	2.00 [0.50]	1.89 [0.26]	3.33 [0.41]	3.33 [0.29]	5.56 [0.18]	4.89 [0.46]	9
Totals		37.94 A	49.12 AB	68.62 ABC	71.11 ABC	80.74 BC	91.43 C	164 $\bar{x} = 8.63$ SE = 0.47

months prior to our experiment. It would be interesting to repeat this experiment in agricultural areas where corn replaces oaks in the Raccoon's range in order to see if local animals would show an acquired preference for corn on the basis of its availability or if persimmons and acorns would still be favored.

Our results showing a greater male preference for corn than that shown by females support data on the frequency and volume of food items collected from Raccoon carcasses by Tabatabai and Kennedy (1988). Examination of 111 male and 96 female Raccoons from three regions in Tennessee revealed

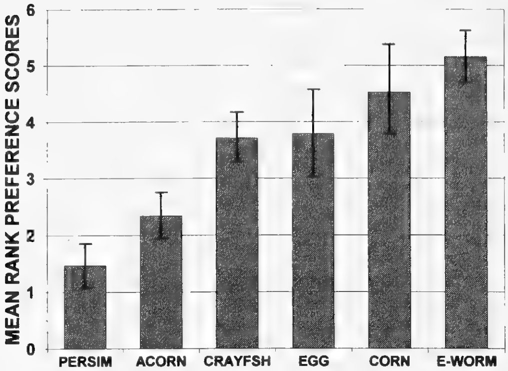

FIGURE 1. Mean rank preference scores for all Raccoons combined for both years (88 Raccoon/days, 1991; 76 Raccoon/days, 1992). Lower scores indicate more preferred items. Whiskers overlain onto bars represent ± 2 standard errors.

corn in males more often than in females in all regions. While the differences we observed in food preferences between the sexes are interesting, the small sample size in this experiment (particularly females) precludes definitive conclusions.

We recommend the elimination of incomplete trials in experiments such as this one in order to ensure that results from different studies measure the same degree of choice made by test animals. Experiments in which incomplete feeding trials are filled out with assigned ties (1) presume food choices not actually demonstrated by test animals and (2) hide possible deficiencies in procedures that make comparisons with this and other similar experiments invalid.

Tests of the optimal diet theory normally rank foods based on calorie or mass units, associated handling time, and searching effort. The optimum diet is then determined by listing ranked foods in order from the highest down, until the ratio of a subsequent food's value to its handling time becomes less than the net rate of consumption for all previously listed foods (Pyke et al. 1977). However, in addition to energy content, the currency used in dietary analyses should also include consideration of important constraints such as protein, mineral, and cellulose composition, as well as the presence of toxins and digestive inhibitors (Robbins 1983). While it would be interesting to calculate a predictive rank order for the foods used in this experiment based on optimal diet theory and compare that with observed results, nutritional assays of food items were beyond the scope of this investigation.

Results presented here suggest that Raccoons are not purely opportunistic foragers when a variety of foods is available. An understanding of seasonal food habits, together with a knowledge of preferred food items, can be useful in managing Raccoon populations and their habitat. For example, Rivest and Bergeron (1981) found that Raccoons foraged in fields of sweet corn, bypassing adjacent stands of field corn. They recommended that farmers sustaining crop damage in sweet corn fields plant small patches of sweet corn near wood margins or along streams in order to provide Raccoons with a preferred food source nearer their nesting sites. McComb (1981) also advocated using a knowledge of Raccoon food preferences as a tool in management. He suggested that by preserving oaks and fruit trees and removing den trees near corn fields, crop damage by Raccoons might be reduced. Our results reinforce these management strategies and support Goodrum's (1971) assertion of the importance of forests with mast-producing hardwoods to Raccoon populations.

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Croissance et structure d'âge de deux populations du pélécypode *Elliptio complanata* (Lightfoot) dans l'estuaire d'eau douce du fleuve Saint-Laurent

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Nous avons comparé la croissance et la structure d'âge du pélécypode d'eau douce *Elliptio complanata* (Lightfoot) entre deux stations situées respectivement dans le haut estuaire supérieur du fleuve Saint-Laurent (battures de Gentilly) et dans le haut estuaire inférieur (Deschambault), ou l'amplitude de la marée est respectivement de 1,0 m et de 3,8 m. La croissance des moules a été évaluée en utilisant le modèle de Walford et celui de von Bertalanffy. Les résultats ont démontré que la croissance relative et absolue du pélécypode sont statistiquement semblables entre les deux stations. L'âge moyen des moules ne diffère pas entre le haut estuaire supérieur et inférieur. Les distributions de fréquence de l'âge des individus indiquent que la population de moules aux deux stations est dominée par des spécimens de 6 à 10 ans. La différence du niveau d'eau au flux et au reflux n'influencerait pas la croissance de ces mollusques.

Mots-Clé: Pélécypode, moule, *Elliptio complanata*, croissance, structure, âge, fleuve Saint-Laurent.

A comparison study of the growth rate and the age-structure was conducted on the freshwater pelecypod *Elliptio complanata* (Lightfoot) at two stations, one in the upper section of the upper St. Lawrence river estuary (Gentilly) and the other in the lower section (Deschambault), where the amplitude of the tide is respectively 1,0 m and 3,8 m. Growth of the clams was assessed by using the Walford Plot model and the von Bertalanffy growth curve model. Results have demonstrated that the relative and absolute growth rates are statistically similar at the two sites. Mean age of clams does not differ between the upper and lower sections of the upper estuary. Age-frequency distributions indicated that clam populations at the two sites are dominated by individuals of 6-10 years old. The difference in the tide oscillation between the two localities does not seem to influence the growth of these molluscs.

Key Words: Pelecypod, clam, *Elliptio complanata*, growth, age-structure, St. Lawrence River.

L'évaluation de la croissance des moules d'eau douce (Unionidae) en relation avec l'habitat dans lequel elles vivent a été largement étudiée au niveau des Grands Lacs (Stansbery 1970; McCuaig et Green 1983; Hinch et al. 1986; Bailey et Green 1988; Nalepa et Gauvin 1988). De nombreuses recherches ont été rapportées dans la littérature sur les structures d'âge et la croissance du pélécypode *Elliptio complanata* (Lightfoot) en fonction des caractéristiques du milieu (Ghent et al. 1978; Strayer et al. 1981; Kat 1982; Mitchell et Collins 1984).

Au Québec, les seules données disponibles sur la croissance de ce pélécypode reposent sur les études de Magnin (1970) et Magnin et Stanczykowska (1971). À l'exception des travaux de Amyot et Downing (1991) qui ont évalué, en milieu lacustre, la distribution endo- et épibenthique de ce mollusque sans toutefois traiter de la croissance des individus, il n'existe aucune étude exhaustive concernant la croissance du pélécypode *E. complanata* dans le fleuve Saint-Laurent.

Le but de cette présente recherche est de comparer les structures d'âge et la croissance de deux populations d'*E. complanata* dans le haut estuaire du fleuve Saint-Laurent, en fonction de l'habitat dans lequel vivent ces bivalves. L'âge des individus peut être évalué en fonction des anneaux de croissance présents sur la coquille des moules (Strayer et al. 1981; McCuaig et Green 1983; Hinch et al. 1986; Bailey et Green 1988; Nalepa et Gauvin 1988).

Matériel et méthodes

Lieux d'échantillonage

Les moules ont été récoltées à deux stations situées dans le haut estuaire supérieur et inférieur du fleuve Saint-Laurent (Dionne 1963). Dans la région du haut estuaire supérieur, les pélécypodes ont été échantillonnés sur le côté sud de la batture de Gentilly (juillet 1990) qui sépare le chenal nord où passe la voie maritime, du chenal sud (Long. 72°20′30″; Lat. 46°25′25″). Dans la zone du haut estuaire inférieur, les individus ont été recueillis en milieu littoral près de la municipalité de Deschambault (août 1991), située à 30 km à l'est de la batture de Gentilly (Long. 71°59′05″; Lat. 46°37′28″). L'amplitude de la marée d'eau douce atteint un maximum de 1,0 m à Gentilly et de 3,8 m à Deschambault (Canada 1979). À la batture de

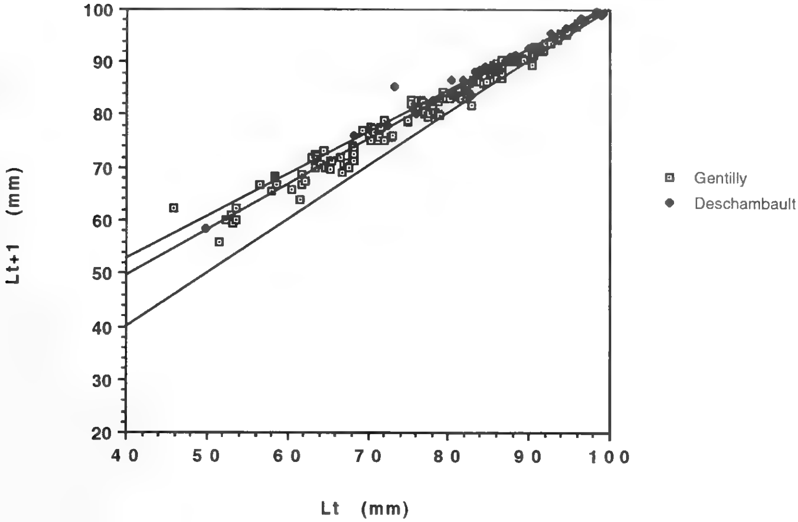

FIGURE 1. Illustration du modèle de Walford ajusté pour chaque population d'*Elliptio complanata* échantillonnée dans le haut estuaire du fleuve Saint-Laurent.

Gentilly, 48 moules ont été récoltées dans les sédiments au moyen d'une benne Peterson de 0,1 m^2. Le tamissage des échantillons a été fait sur le terrain à l'aide d'un treillis de 500 μm de vide de mailles. Au total 30 coups de benne ont été réalisés sur une superficie de 0,1 km^2. Dans la région de Deschambault, 150 pélécypodes ont été récoltés à la main sur une superficie équivalente à celle de Gentilly. L'identification de l'espèce a été réalisée au laboratoire à partir de la clé taxonomique de Clarke (1973).

La physico-chimie de l'eau (température, pH, oxygène dissous, conductivité, potentiel redox) a été mesurée à l'aide d'un Hydrolab Surveyor II (modèle SVR2), et l'alcalinité avec une trousse de Hach. Des échantillons de sédiments ont aussi été prélevés pour une analyse granulométrique du substrat des deux sites. La description des deux habitats est présentée au Tableau 1.

Comparaison de la croissance

Le modèle de Walford (Walford Plot) a été utilisé pour déterminer la croissance à long terme des deux populations de moules (McCuaig et Green 1983; Hinch et al. 1986). Celui-ci repose sur l'établissement d'une droite de régression entre la longueur d'un anneau de croissance annuel à une année "t" (L_t) en fonction de la longueur de l'anneau l'année

TABLEAU 1. Moyenne et écart-type (entre parenthèses) des paramètres environnementaux mesurés aux deux stations d'échantillonnage.

Variable	Deschambault (Août 1991) n=5	Gentilly (Juillet 1990) n=5
Température (°C):	20,6 (0,98)	24,2 (0,86)
pH:	7,5 (0,02)	8,1 (0,09)
Oxygène dissous (%):	93,7 (1,6)	100,0 (2,2)
Conductivité (μS•cm^{-1}):	206,0 (12,2)	279,0 (23,4)
Alcalinité (mg $CaCO_3$•L^{-1}):	98,8 (3,3)	85,1 (4,7)
Potentiel Redox (volts):	0,294 (0,021)	0,282 (0,012)
Profondeur (m):	0,5 (0,03)	0,8 (0,04)
Végétation dominante:	*Potamogeton bupleuroides*	*Myriophylium exalbescens*
	Vallisneria americana	*Scirpus americanus*
	Myriophylium sibiricum	*Scirpus acutus*
	Elodea canadensis	*Vallisneria americana*
Substrat:	Sablo-vaseux	Sablo-vaseux
Marée moyenne:	3,8 m	1,0 m

TABLEAU 2. Résultats des régressions linéaires évaluées à partir du modèle de Walford, en fonction des données de Deschambault, Gentilly et des deux stations d'échantillonnage combinées.

Station	Equation	R^2	n
Deschambault:	$L_{t+1}=0,796•L_t + 20,9$	0,97	150
Gentilly:	$L_{t+1}=0,859•L_t + 14,9$	0,94	48
Deschambault et Gentilly:	$L_{t+1}=0,852•L_t + 15,6$	0,95	198

suivante (L_{t+1}). La longueur des deux anneaux de croissance consécutifs les plus lisibles sur chaque moule a été mesurée à l'aide d'un vernier Manostat (Hinch et al, 1986). Une analyse de covariance (ANCOVA) a été appliquée pour comparer la croissance du pélécypode entre les deux stations. La croissance relative a été comparée en fonction des pentes des droites de régression alors que la croissance absolue a été comparée à partir des ordonnées à l'origine (Bailey et Green 1988). Le modèle de von Bertalanffy a ensuite été utilisé pour déterminer l'évolution de la longueur de la coquille des moules en fonction de l'âge des individus (McCuaig et Green 1983).

Comparaison des structures d'âge

L'âge des individus a été déterminé en comptant le nombre d'anneaux de croissance annuels sur chaque coquille. Les annulis de croissance du pélécypode *E. complanata* étant difficiles à identifier (Ghent et al. 1978; Strayer et al. 1981), les annulis dont l'identification était ambiguë n'ont pas été considérées comme de véritables anneaux de croissance (Nalepa et Gauvin 1988). Des distributions de fréquence du nombre d'individus récolté par station en fonction de l'âge ont été schématisées sous forme d'histogramme. L'âge moyen des moules entre les deux stations a été comparée à l'aide d'un test de Student.

Résultats

Les équations des droites de régression évaluées selon le modèle de Walford ($L_{t+1} = b•L_t + a$) sont présentées au Tableau 2. L'analyse de covariance réalisée sur les pentes des deux droites de régressions obtenues selon le modèle de Walford (Figure 1), a démontrée que la croissance relative des deux populations de moules est statistiquement similaire ($F = 2,468$; $p > 0,05$). Les pélécypodes atteignent donc leur taille asymptotique vers le même âge. En ce qui concerne la croissance absolue, l'analyse de covariance ne décèle pas de différence significative entre l'ordonnée à l'origine des deux sites d'échantillonnage ($F = 2,411$; $p > 0,05$). Ainsi les individus provenant des deux populations d'*E. complanata* croissent jusqu'à une même taille maximale (Figure 1). Les croissances relatives et absolues étant similaires entre les deux populations, l'ensemble des données a donc été intégré pour former une unique droite de Walford dont l'équation est:

$$L_{t+1} = 0,852•L_t + 15,6$$

Ainsi la croissance relative d'*E. complanata* provenant du haut estuaire du fleuve Saint-Laurent est de 0,852 et la croissance absolue est de 15,6 mm. Cette dernière valeur représente la croissance des individus de la première année. La valeur de la croissance relative étant inférieur à 1 (0,852; croissance théorique) indique que le taux de croissance des moules diminue en fonction du temps. Cette observation suppose que les données se distribuent selon le modèle de von Bertalanffy. Ce modèle, dérivé à partir des données du postulat de Walford (McCuaig et Green 1983), est illustré à la Figure 2. L'équation de cette courbe de croissance est:

$$L_t = 105,5•(1-e^{-0,160•t})$$

La taille asymptotique finale des moules est donc de 105,5 mm (longueur totale de la coquille), et le taux de croissance instantané au temps t = 0 est de 0,160. La valeur de la taille asymptotique finale et celle du taux de croissance des individus de première année nous indiquent que 14,8% de la taille totale du pélécypode est atteint la première année ((15,6/105,5)•100).

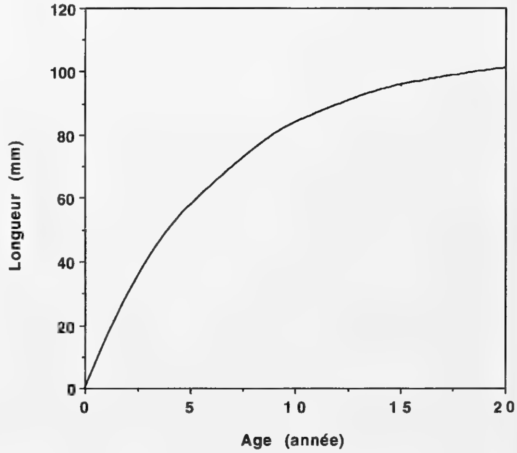

FIGURE 2. Illustration du modèle de von Bertalanffy ajusté pour l'ensemble des deux populations d'*Elliptio complanata* échantillonnées dans le haut estuaire du fleuve Saint-Laurent.

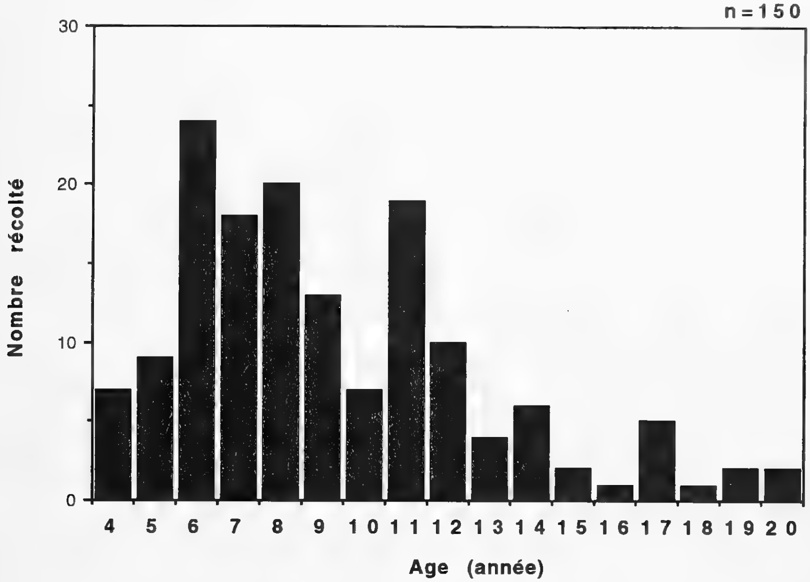

FIGURE 3. Distribution de fréquence de l'âge des spécimens récoltés dans la région de Deschambault.

L'âge moyen des moules récoltées à la batture de Gentilly est de 8,9 ± 3,1 ans (Sx) alors que celle des individus échantillonnés à Deschambault est de 9,2 ± 3,6 ans. Ces moyennes ne sont pas statistiquement différentes ($t = 0{,}507$; $p > 0{,}05$). Les distributions de fréquence de l'âge d'*E. complanata* révèlent que la population de Gentilly de même que celle de Deschambault sont dominées par des spécimens de 6 à 10 ans (Figure 3 et 4) mais aussi par un nombre appréciable de spécimens de 11 et 12 ans dans la population de Deschambault (Figure 3). Dans les deux régions nous avons échantillonné des moules dont l'âge varie entre 3 et 20 ans.

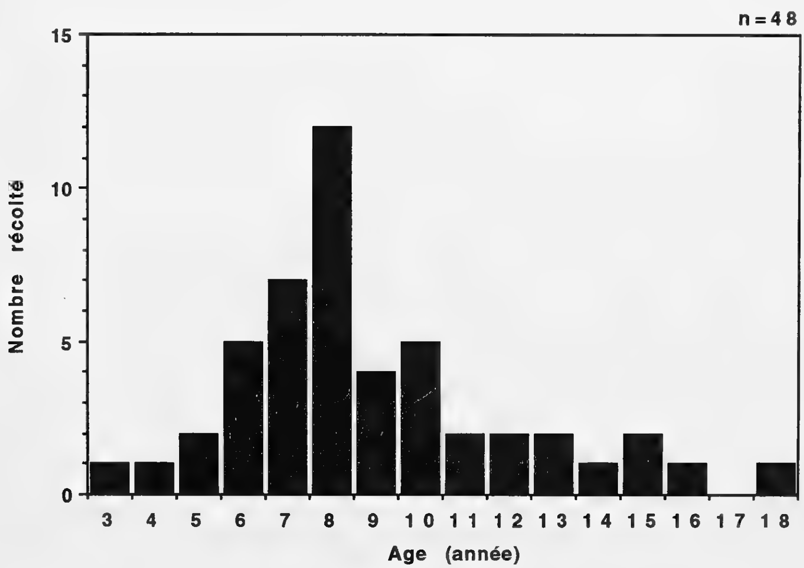

FIGURE 4. Distribution de fréquence de l'âge des spécimens récoltés dans les battures de Gentilly.

Discussion

À l'exception de l'amplitude des marées, l'homogénéité des paramètres environnementaux aux deux stations expliquerait le peu de différence observée dans la croissance des mollusques au niveau des secteurs étudiés. Néanmoins, nos résultats sont différents de ceux publiés par Mitchell et Collins (1984), où des différences significatives au niveau de la croissance de la coquille ont été observées entre deux populations d'*E. complanata* provenant du même bassin.

En comparant les valeurs de croissance mesurées pour l'ensemble des deux populations avec ceux rapportées dans la littérature pour d'autres espèces, on observe que la croissance relative d'*Elliptio complanata* est légèrement inférieure à celle d'*Anodonta grandis* (McCuaig et Green 1983), de *Lampsilis radiata* (McCuaig et Green 1983; Hinch et al. 1986), et de *Lampsilis radiata siliquoidea* (Bailey et Green 1988). La différence observée entre ces espèces, concernant la croissance relative, pourrait être reliée au métabolisme des individus; en effet, *E. complanata*, *Lampsilis sp.* et *A. grandis* possèdent des rapports surface-volume différents, ce qui impliquent des particularités métaboliques propres à chaque espèce, et par le fait même, des différences au niveau de la croissance des individus (Wilbur et Owen 1964). Le type de substrat peut aussi influencer les phénomènes de croissance (Hinch et al. 1986). La composition des sédiments des stations étudiées étant similaire à celle décrite par les auteurs cités précédemment, l'influence du substrat est probablement négligeable.

La longévité du pélécypode *E. complanata* récolté dans le haut estuaire du fleuve Saint-Laurent est relativement grande, soit 20 ans environ. Cette valeur est supérieure à celle évaluée par Strayer et al. (1981) au lac Mirror (New Hampshire) où la longévité se situait entre 16 et 18 ans.

L'absence d'individus âgés de moins de 3-4 ans dans les deux populations étudiées est fréquemment mentionnée dans la littérature (e.g., Nalepa et Gauvin 1988). À cause de leur faible taille, les moules juvéniles sont généralement difficiles à récolter, celles-ci se réfugiant plus profondément dans les sédiments (Nalepa et Gauvin 1988). D'autres phénomènes pourraient aussi expliquer cette absence: (1) un déclin du recrutement des juvéniles durant les années 1986-1987, (2), l'habitat des jeunes individus peut différer de celui des adultes, (3), la dispersion des juvéniles est trop diffuse pour permettre un échantillonnage représentatif de la zone étudiée (Nalepa et Gauvin 1988; Amyot et Downing 1991).

L'âge moyen des pélécypodes du haut estuaire du fleuve Saint-Laurent est d'environ 9 ans. Cette valeur est supérieure à celle publiée par Hinch et Green (1989) chez trois populations d'*E. complanata* récoltées dans les lacs Beech, Bark et Tock (Ontario), où l'âge moyen variait entre 4 et 6 ans.

Le secteur estuarien du fleuve Saint-Laurent semble procurer des habitats adéquats favorisant une croissance optimale pour le pélécypode *E. complanata*, malgré la présence d'une marée dynamique importante dans le haut estuaire inférieur. La forte longévité et l'âge moyen élevé observés dans la présente étude, démontrent le potentiel appréciable qu'offre les zones estuariennes pour la colonisation, la croissance et la reproduction de la faune malacologique.

L'interprétation des résultats repose sur l'hypothèse que la distance entre deux anneaux de croissance les plus lisibles sur la coquille représente exactement une année. Plusieurs auteurs ont démontré cette relation chez des unioniés d'eau douce (McCuaig et Green 1983; Hinch et al. 1986; Bailey et Green 1988). Toutefois Bérard et al. (1992) ont observé aucune concordance entre les patrons individuels de stries de croissance à petite échelle chez la moule *Mytilus edulis*. Ainsi la validité des modèles de Walford et de von Bertalanffy peut être biaisée par les sources d'erreurs associées à l'interprétation des anneaux de croissance que l'on retrouve sur la coquille des mollusques.

Dans le cadre de travaux futurs, il serait préférable d'accentuer les recherches sur plusieurs stations réparties à la fois dans le couloir fluvial, caractérisé par l'absence de marée et vecteur de fortes pollutions, et sur l'ensemble du secteur estuarien d'eau douce.

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New Records of a Sludge Worm *Teneridrilus flexus* Erséus & Hiltunen (Oligochaeta: Tubificidae) from Lake Huron

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Stacey, Donald F., and Brad R. Hubley. 1994. New records of a sludge worm *Teneridrilus flexus* Erséus & Hiltunen (Oligochaeta: Tubificidae) from Lake Huron. Canadian Field-Naturalist 108(2): 182–185.

Characteristics that positively identify *Teneridrilus flexus* Erséus & Hiltunen, 1990 include: short stout setae in segment II with distal teeth shorter and thinner than proximal, an enlarged eversible pharynx, and long tapering penes. Identification of this freshwater oligochaete and others is enhanced by complete species distribution records. *T. flexus* was previously known only from its type locality (St. Mary's River, exit channel from Lake Superior, Chippewa Co., Michigan, USA). New distribution records from northern Lake Huron, Ontario are reported here.

Key Words: *Teneridrilus flexus,* sludge worm, freshwater oligochaetes, Ontario, new records.

Benthic macroinvertebrates exhibit varying levels of tolerance to physical and chemical changes in their environment. Effective monitoring of environmental change in a freshwater ecosystem therefore requires close examination of its benthic infauna. Oligochaetes often form a major component of these communities both in abundance and in species diversity.

As part of a 1990-1992 "Long Term Sensing Survey", the Ontario Ministry of the Environment collected benthic samples from nearshore locations in the Great Lakes. The purpose of this survey was to monitor changes in water and sediment quality and the effects of these changes on the associated benthic invertebrate community. During identification of the infaunal invertebrates, a number of mature oligochaetes were identified as *Teneridrilus flexus* Erséus & Hiltunen, 1990. The only published records for this species were from St. Mary's River, Chippewa Co., Michigan, USA. New distribution records are reported here as, to date, this is a poorly known species. The absence of other published records may indicate that the species is scarce and has a very limited distribution, that it has been misidentified, or that substantial information has just not been published. In any case, we are reporting our records as complete distribution information is important to environmental, systematic and biogeographic studies.

The setal and penial structures of these worms must be carefully observed and interpreted for correct species identification. Line drawings of these are available in the original description of *T. flexus* Erséus & Hiltunen and fit the written description as well as our observations. However, setae and penes can be difficult to draw accurately and photographs are closer to what is observed during identification. We include here photographs of taxonomically important structures as a complement and addition to information that is currently available. Such information would be useful in the identification of many common freshwater oligochaetes.

Materials and Methods

Samples were collected by Ponar grabs. They were then washed through 600 μm into 200 μm mesh bags, called inner and outer samples respectively. Macroinvertebrates were removed from each sample under a dissecting microscope and then each taxon treated as required for identification. Oligochaetes were mounted in CMCP-9 on slides. The slides were allowed to dry at approximately 35°C for three to four days before examination. During drying, CMCP-9 was periodically added to counteract shrinkage of the medium. Identifications were based on some or all of epidermal, setal, and cuticular reproductive structures in mature specimens. Whole-mounted specimens were observed using differential interference contrast light-microscopy and videomicroscopy. Photography was done with a Wild MPS46 Photoautomat on Kodak Technical Pan film at ASA 100. The photographs appearing in this paper are the first to be published for *T. flexus*. Specimens were measured using Jandal Video Analysis Software (JAVA). Setal measurements were made according to the standards given by Sperber (1948).

Results

Specimens exhibited the diagnostic characteristics given in the original description (Figure 1). Measurements are included for comparison to that description. All specimens, but one, were missing the pygidium, therefore the total length of the worms could not be accurately determined. The single whole

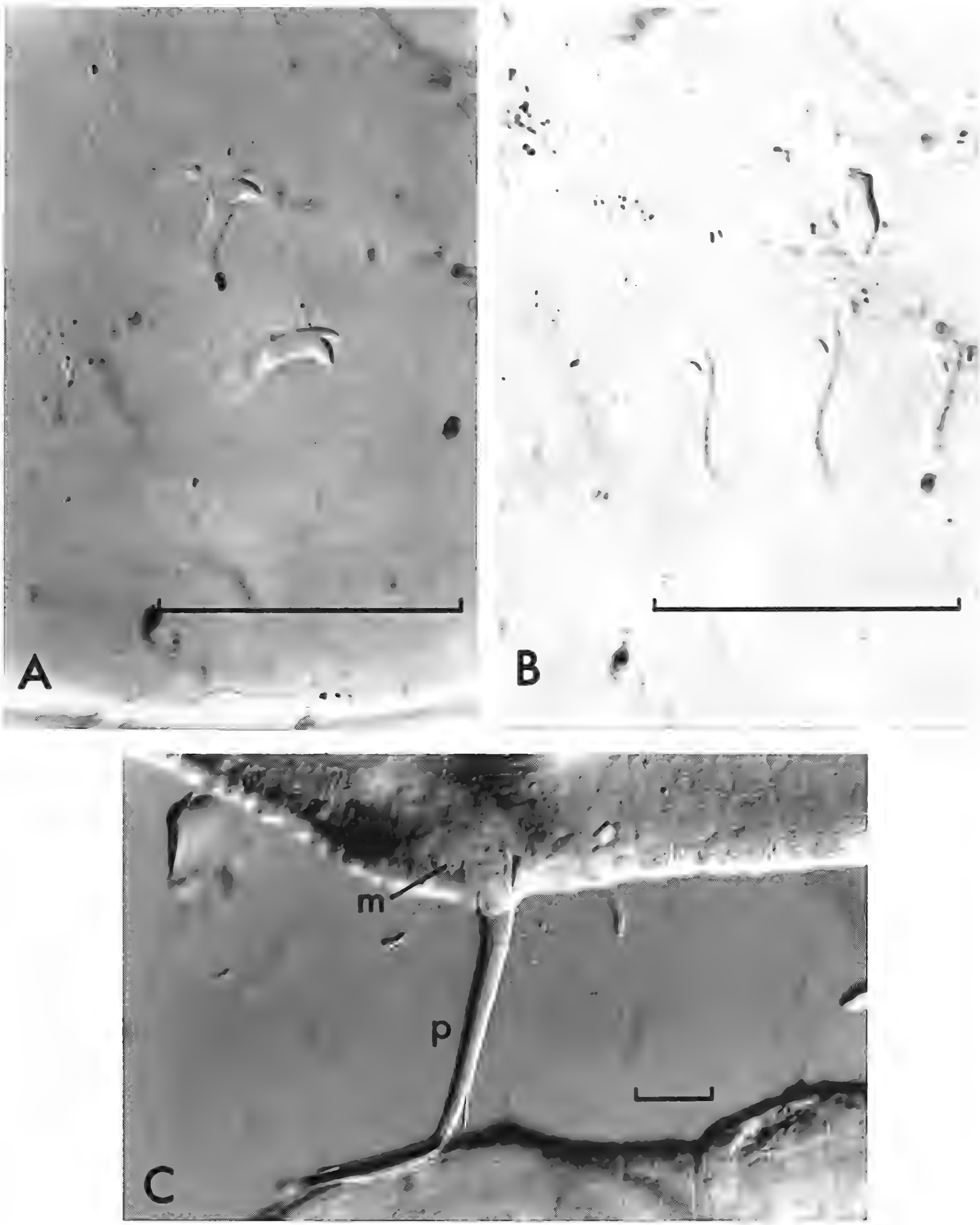

FIGURE 1. *Teneridrilus flexus*. A. Setae from segment II. B. Setae from segment IV. C. Penis. Setae shown represent individual "bundles" and only the ectal tips that protrude beyond the cuticle are visible. Abbreviations: m = muscular bulb; p = penis. All scale bars equal 25 μm.

specimen was 3.85 mm long and had about 28 segments. Setal measurements were: segment II, 26.9-35.1 μm (n=15, $\bar{x}$=30.9, s=2.1); segments III-VI, 40.1-48.8 μm (n=16, $\bar{x}$=43.8, s=2.7); mid-body to posterior segments, 31.1-40.3 μm (n=15, $\bar{x}$=36.4, s=2.5). Penes measurements were: penis length, 0.10-0.21 mm (n=13, $\bar{x}$=0.15, s=0.029); penis width at base, 12.6-26.4 μm (n=17, $\bar{x}$=19.0, s=4.0); penis width at tip,

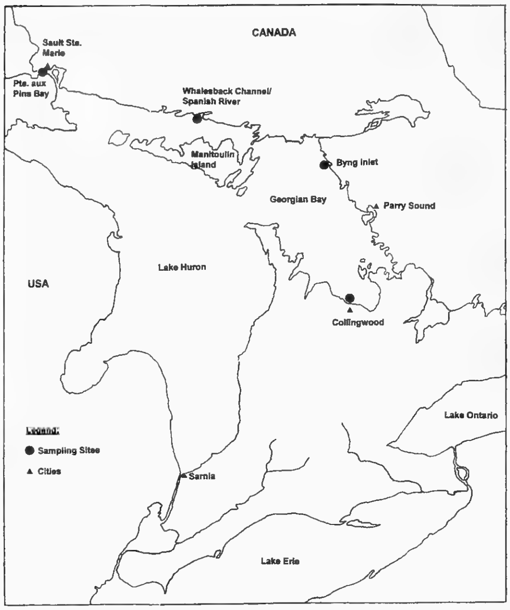

FIGURE 2. New locations of *Teneridrilus flexus* within the Great Lakes.

1.50-3.88 µm (n=12, x̄=2.83, s=0.7). Specimen and setal widths were not measured for comparison due to swelling of the body and setae in the mounting medium. The mounting medium also prevented a thorough examination of internal structures.

Distribution and Habitiat

Specimens of *T. flexus* were collected at Collingwood (Georgian Bay, 44°32′31″N, 80°14′10″W), Byng Inlet (Georgian Bay, 45°46′66″N, 80°38′88″W), Whalesback Channel/ Spanish River (North Channel, 46°10′24″N, 82°23′32″W), and Pte. aux Pins Bay (St. Mary's River, 49°29′34″N, 84°27′57″W) (Figure 2). Sediment samples collected from these sites consisted of silty sand and/or organic ooze with bark chips and wood fibers. Depth of samples ranged from 4.3 metres at Pte. aux Pins Bay to 20 metres at Collingwood (Table 1).

Discussion

Other species of *Teneridrilus* reported from North America are: *Teneridrilus mastix* (Brinkhurst, 1978), *Teneridrilus columbiensis* (Brinkhurst & Diaz, 1985), and *Teneridrilus calvus* Erséus & Brinkhurst, 1990 (Erséus et al. 1990; Brinkhurst 1986). The species can be distinguished by setal and penial forms. *T. mastix*, unlike the other three species, has both hair and bifid setae in the dorsal bundles. It has simple penes that lack penis sheaths. *T. columbiensis* is a more typical member of the genus. Setae of segment II are modified, having reduced upper teeth and recurved thick lower teeth. The penes bear short, rounded to blunt-ended penis sheaths. *T. calvus* has stout, short setae in segment II with distal teeth distinctly thinner and shorter than proximal, as *T. flexus*. *T. calvus*, however, has much shorter penes ranging from 60-95 µm with thin but distinct cuticular lining. *T. flexus* possesses very long tapering penes. The penes examined ranged from 100-210 µm with a mean length of 150 µm. The penes were found either coiled within the body or protruding from the male pore and appeared cuticularized.

The species are also distinguished by their distribution ranges and habitats. *T. mastix* is found in British Columbia, California and southern China within fine sediments of rivers. *T. columbiensis* is known only from Columbia River, Oregon. The site is described as a tidal freshwater marsh with muddy sediment. *T. calvus* is also restricted to a single locality. It is found only in the Sacramento-San Joaquin Delta in California within muddy sediments. *T. flexus*, originally described from St. Mary's River,

TABLE 1. Locality and habitat data for *Teneridrilus flexus* Erséus and Hiltunen.

Location	Latitude	Longitude	Collecting Date	Collecting Depth (m)	Substrate Type
Whalesback Channel / Spanish River (North Channel) Station 39	46°10′24″N	82°23′32″W	23 July 1991	10	grey organic ooze
Pte. aux Pins Bay (St. Mary's River) Station 52-P	46°29′34″N	84°27′57″W	19 May 1991 20 July 1991 1 October 1991	4.3	organic ooze, bark chips, wood fibre
Collingwood (Georgian Bay) Station 601	44°32′31″N	80°14′10″W	24 September 1991	20	silty sand, wood debris
Byng Inlet (Georgian Bay) Station 603	45°46′66″N	80°38′88″W	15 May 1991	5.5	organic ooze, silty sand with bark debris

exit channel from Lake Superior, Michigan, is now reported from four additional sites within the Great Lakes. These include the eastern end of Lake Superior, northern Lake Huron, and two locations in Georgian Bay. All of the specimens were found in silty or organic substrates.

Freshwater oligochaetes form important natural and invasive components of North American aquatic ecosystems. Their accurate identification is important to environmental studies as is complete information about their geographic distributions.

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Cattle and Cervid Interactions on a Foothills Watershed in Southwestern Alberta

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Interaction of cattle (*Bos taurus*) with Moose (*Alces alces*), Elk (*Cervus elaphus*), Mule Deer (*Odocoileus hemionus*), and White-tailed Deer (*O. virginianus*) was studied over 14 winters. Use of habitat was measured by fecal pile counts; food habits were estimated in one year by fecal analysis and forage consumption by comparison of biomass on caged plots with that on uncaged plots. Direct observation of wild ungulates recorded seasonal use. In autumn and winter cattle selected grassland on lower slopes with sunny aspects and slopes less than 20%. Wild ungulates selected shrubland, upper slopes, and shaded aspects. Cattle used, on the average, 53.4% of survey plots, while Elk used 16%, Moose 34%, and deer 36%. Only 31% of cattle feces were on plots jointly used by cattle and ungulates compared to 34% for Moose, 41% for deer, and 43% for Elk. Elk and cattle ate primarily herbaceous material while moose and deer consumed mainly browse. However, even though browse was a small proportion of the cattle diet, they ate as much biomass as the Moose. Utilization of herbage left a satisfactory carryover of 48–53% in the year of greatest total ungulate use. Resources of the area were heavily utilized during years of peak use but subsequent decreases in cattle stocking did not result in increased use by wild ungulates.

Key Words: Cattle, *Bos taurus,* Mule Deer, *Odocoileus hemionus,* White-tailed Deer, *Odocoileus virginianus,* Moose, *Alces alces,* Elk, *Cervus elaphus,* deer, habitat use, forage yield.

The interaction of range cattle, *Bos taurus,* with wild ungulates has been a subject of continuing interest and some controversy throughout western North America. It has been argued that the presence of cattle and the activities necessary for their management have a negative impact on wild ungulates. However, the extent of interactions between the species at different seasons varies with local conditions. Most studies of cattle and wild ungulate interactions have focussed on the summer season (Julander and Jeffery 1964; Blood 1966). Mackie (1970) studied relationship year-round in a semi-arid shortgrass environment.

In the present study, cattle grazing was largely in the fall and winter in a portion of the montane aspen region adjacent to the Rocky Mountain foothills in Alberta. The objective of the study was to explore the interaction between cattle and wild ungulates (four species of cervids) and evaluate the potential for competition. The fieldwork was conducted on the Streeter Basin Experimental Watershed and was part of the Alberta Watershed Research Program, a joint multidisciplinary research program of the governments of Canada and the province of Alberta.

Study Area

The Streeter Basin Experimental Watershed is located in the Porcupine Hills 100 km south of Calgary, Alberta at latitude 50°07′N and longitude 114°03′W. Elevations vary from 1325 to 1660 m. The total area of the Basin is 5.98 km² and consists of two sub-basins.

The climate is dry continental. However, in winter strong foehn or chinook winds blow and are accompanied by rises in temperature to above freezing levels. These phenomena cause redistribution and melting of snow and result in snow-free conditions over much of the area during a considerable portion of most winters. Ungulates are able to travel freely much of the time and the forage is available to ungulates during extensive periods, especially in early winter.

The vegetation in Streeter Basin has been assigned to the Douglas Fir-Aspen District of the Montane Forest Region (Jeffrey 1965; Rowe 1972) and by Strong and Leggat (1981) to their Montane Ecoregion.

The Montane Ecoregion is a transition zone between prairie and forest and contains stands of cover-types characteristic of both. Three cover types occur in Streeter Basin:

Herbland, (*sensu* Duvall and Blair 1962) mixed grass and forb vegetation (40% of the area). Principal grass species are Idaho Fescue (*Festuca idahoensis*), Parry Oat Grass (*Danthonia parryi*), and Timothy (*Phleum pratense*). Important forbs include Sticky Geranium (*Geranium viscosissium*), lupine (*Lupinus* spp.), Dandelion (*Taraxacum officinale*), Wild Bergamot (*Monarda fistulosa*), and Hedysarum (*Hedysarum sulpherescens*).

Shrubland, (18% of the area) a mixture of willows (*Salix* spp.) and Water Birch (*Betula occidentalis*) with small, interspersed patches of herbland dominated by the same grass and forb species as in the larger herbland stands.

Aspen forest, (42% of the area) composed of Trembling Aspen (*Populus tremuloides*) and Balsam Poplar (*P. balsamifera*) with a shrub understory of Saskatoon (Serviceberry, *Amelanchier alnifolia*), rose (*Rosa acicularis*), and aspen saplings; and forbs including Fireweed (*Epilobium angustifolium*) and aster (*Aster conspicuus*) and Pine Grass (*Calamagrostis canadensis*).

Moose (*Alces alces shirasi*) are the principal wild ungulates in Streeter Basin and are present at all seasons. Other wild ungulates are Elk (*Cervus elaphus nelsoni*), Mule Deer (*Odocoileus hemionus hemionus*), and a few White-tailed Deer (*O. virginianus dacotensis*).

The Basin was divided into three pastures. The southern two-thirds of the area, which is Crown land, was contained in a separate pasture fenced around the perimeter of the experimental area. The northern third was included in two large pastures, the east and west, of which only small portions were in Streeter Basin. The Crown pasture was grazed from approximately November to late December or early January. The East and West pastures were subject to fall and winter grazing while the former was grazed to some extent during spring and summer as well. In the early years of this study the Crown pasture was stocked with 200 cattle for approximately two months each winter, for a stocking rate of 400 animal unit months (AUMs). (An "animal unit month" is one adult cow grazing for one month, Heady 1975). Stocking level on the Crown pasture was regulated by the then Alberta Department of Forestry Lands and Wildlife and, on the private land, by the ranch owners. Stocking was considerably less in the last six years of the study. Use of the East and West Pastures was at a similar level as on the Crown Pasture.

Methods

Cole (1958) recommended four criteria for evaluating degree of interaction between livestock and wild ungulates. They are: (1) wild species and livestock use the same range areas, (2) wild species and livestock use the same forage plants, (3) the forage plants are an important source of forage for either wildlife or livestock, and (4) the forage plants are in limited supply or deteriorating as a result of combined use. In the present study distribution and habitat use by cervids and cattle were compared by fecal group surveys and by direct observations during spring and summer. Forage plant use was compared by analysis of fecal fragments while forage biomass consumption was evaluated by comparing biomass on plots caged against grazing over winter with grazed plots.

Pellet group surveys

To determine the distribution of cervid and cattle use, a system of parallel transects was established across Streeter Basin. Permanent sample sites were systematically placed along the transects, with the first site randomly located. A total of 112 points were established and permanently marked. At each point, four 10 m^2 circular plots were established for counting ungulate feces piles. Plot centres were 15 m from the sample point. The vegetative type, topographic position, aspect, direction of exposure, and slope steepness were recorded for each site.

Plots were searched for feces each spring from 1970 to 1983. Cattle feces presented a special problem. Cattle frequently defecate while walking, leaving several piles per defecation. When it appeared that several piles were part of a single defecation they were recorded as one.

Proportions of the 112 sample sites in each habitat category served as expected values against which counts of ungulate feces piles were compared by Bonferroni 90% confidence intervals (Neu et al. 1974). The use of fecal pile surveys to estimate ungulate use of habitat categories has been controversial (Edge and Marcum 1989). However, comparisons of pellet-group counts with radio telemetry data for Elk (Edge and Marcum 1989) and for Mule Deer by Loft and Kie (1988) found that such counts are reasonable predictors of habitat use over seasons. Although similar comparisons have not been made for cattle, the technique was employed by Julander and Jeffery (1964) to determine habitat selection by that species.

Direct observation

Several other studies were conducted in Streeter Basin that involved systematic coverage of all habitats in the Watershed during spring and summer of the years 1970, 1971, and 1972. All cervids seen were recorded. Winter surveys covered 100% of Streeter Basin in six years, in March 1972 by helicopter and 1977-1978 to 1983-1984 by ground counts in late winter. The lack of evergreen cover and the possibility for viewing from ridge-top vantage points provided a unique opportunity to obtain complete counts of cervids present in the basin by repeated ground observation.

Forage resources

In 1971/1972, during the period of heaviest ungulate use, a study of production and overwinter disappearance of forage biomass was conducted. Four stands each of herbland, shrubland, and aspen forest were selected for sampling. One sample transect was established in each stand with the first sample location on each transect placed at a randomly-selected number of metres into the stand. Thereafter 10 locations were established at 10 m intervals. At each location, three 1-m^2 circular plots were subjectively located within a radius of 5 m on sites with similar micro-topography, plant community, and biomass. One plot of each set of three was selected by use of a table of random numbers and clipped to obtain net total yield. Another was similarly selected to be covered with a wire mesh cage to exclude ungulates while the third was left open to winter grazing. In April 1972, the caged plot and the plot left open to grazing were also clipped. All herbage was weighed after oven-drying at 70°C for 24 hours.

Food habits

In 1972 samples of feces of cattle, Moose, Elk, and deer were collected from permanent plots in the course of the spring feces counts. Since White-tailed Deer were rarely encountered in the basin at that time, the samples were almost certainly all from Mule Deer. Samples were air-dried, then ground and composite samples prepared for each ungulate species. Sub-samples were mounted on microscope slides and oven-dried following techniques described by Hansen (1971). On each slide 25 systematically located fields of view were selected by moving the microscope a fixed distance between fields. In each field the fragment nearest the centre of the field was selected for study at 100 x magnification. Only 34% of the fragments were identifiable but those that were recognizable by cell pattern through comparison with a reference collection were recorded by major taxon and to species where possible. Because we could not definitely separate Saskatoon and Trembling Aspen, data for those species were grouped.

Results

Sample site location

Sampling sites were well distributed over the various landforms and vegetation type categories in the Basin (Table 1). Because of the systematic location of sites the proportion of sites in each category provides an estimate of the proportion of the land area of the Basin in that category.

Herbland sites were concentrated on mid to lower slopes with sunny aspects (Table 1). Shrubland sites occurred largely on upper slopes with only two sites on lower slopes and were evenly distributed across aspect and slope categories. Aspen forest site locations showed that that type usually occurred on middle slopes with shaded exposures.

Pellet group surveys

In most habitat categories cattle use of habitat differed strongly from that of cervids, especially Moose (Table 2). Cervids differed also from each other, with Moose and Elk mean use being similar in 7 of the 10 categories, Elk and deer in 5 but deer and Moose in only 4.

Cattle strongly selected herbland while cervids significantly avoided herbland. Moose and Elk selected shrubland to a significant degree and Moose also significantly selected aspen forest. Cattle used middle slopes to the extent expected (as did cervids), and selected lower slopes. Cattle strongly selected sunny aspects while deer and Elk were indifferent to aspect. Moose selected aspects that were shaded. Elk and Moose were indifferent to slope steepness while cattle selected slopes of less than 20% and deer selected steep slopes.

There were some variations between years in distribution of use (Table 3). Elk exhibited significant (Bonferroni $p < 0.1$) positive and negative departures from expected use of the 10 habitat categories in different winters, suggesting that they are the most ready to shift habitat use in response to factors like weather, forage condition, and disturbance during the fall and winter seasons. Neither cattle nor Moose exhibited both positive and negative departures from expected use of any category in different winters although deer did so in 3 of the 10 categories.

Cattle feces occurred on a higher proportion of plots (14 year mean of 53%) than did those of cervids while cattle and cervids shared 24% of the plots (Table 4). Large numbers of cattle were present compared to the numbers of cervids in the early years of the study (Table 5). Where plots were used jointly by cattle and cervids a higher proportion of the total count of feces of Elk, Moose, and deer were found on those jointly used plots than was the case for cattle (Table 4).

TABLE 1. Distribution of sampling sites for feces piles in three vegetation types in relation to three landform categories on the Streeter Basin Experimental Watershed, Alberta.[1]

	Topographic position			Aspect		Slopes (%)	
Vegetation type	Upper slope	Mid slope	Lower slope	Sunny	Shaded	<20%	>20%
Herbland	11	16	17	33	11	24	19
Shrubland	12	7	2	10	11	9	10
Aspen	12	24	11	17	30	20	27
		n=112		n=112		n=109	

n=112 for vegetation type, topographic position and aspect. Three sites were not rated for slope %, reducing n to 109 for that variable. Sites were located systematically along parallel transects by a system of multiple random starts (see text for further description of methods).

TABLE 2. Mean proportions of cervid and cattle feces pile counts in various habitat categories on the Streeter Basin Experimental Watershed, Alberta, for 14 winters from 1969-1970 to 1982-1983.

	Vegetative type			Topographic location			Aspect		Slopes (%)	
Species	Aspen	Shrub land	Herb Land	Upper slope	Middle slope	Lower slope	Sun[2]	Shade	<20%	>20%
Elk	0.43	0.38+[1]	0.20-	0.47+	0.30	0.15	0.50	0.50	0.52	0.48
Deer	0.51	0.24	0.24-	0.42	0.48	0.10-	0.54	0.46	0.35-	0.65+
Moose[3]	0.53+	0.40+	0.07-	0.47+	0.37	0.16-	0.32-	0.68+	0.51	0.49
Cattle	0.13-	0.09-	0.77+	0.25-	0.36	0.40+	0.65+	0.35-	0.70+	0.30-
Plots										
Proportion	0.42	0.18	0.40	0.35	0.39	0.26	0.55	0.46	0.52	0.48
Upper CL[4]	0.52	0.25	0.50	0.44	0.49	0.35	0.64	0.55	0.61	0.58
Lower CL	0.32	0.10	0.30	0.25	0.29	0.17	0.45	0.36	0.43	0.39

[1]"+" and "-" indicate that the values are above or below the 90% Bonferroni confidence intervals on the proportion of plots in the category.
[2]Aspects were divided into "sunny" (southeast through south to northwest) and "shaded" (northwest through north to southeast).
[3]Data from Telfer 1988.
[4]Upper 90% Bonferroni confidence interval on the proportion of total plots in the various habitat categories.

Direct observation

Late winter counts of cervids in Streeter Basin showed Moose to be present each year. Mean number of Moose observed per year was 12 animals. Elk were found in only one winter while Mule and White-tailed deer were observed in four winters. Casual observations of wild ungulates during spring and summer, however, showed Elk and Mule Deer outnumbering Moose. In the three winters from 1969-1970 through 1971-1972 there were 0.5 Elk pellet groups per Moose pellet group. Spring use was much higher with 2.2 Elk directly observed for each Moose while in summer the ratio dropped again to 1.4. Deer observations in the spring were 3.2 per Moose but were down to 1.7 in summer. There were 1.1 deer pellet groups per group of Moose pellets in autumn and winter. Assuming that rates of defecation are similiar for cervids the data imply that Elk were present in Streeter Basin to some extent during all seasons but least during late winter. Deer use was more even throughout the year but their use of the area in late winter also fluctuated. It is noteworthy

TABLE 3. Number of winters between 1969-1970 and 1982-1983 when proportion of cattle and wild ungulate feces piles differed significantly from proportion of plots in habitat catagories on the Streeter Basin Experimental Watershed, Alberta.

	Elk		Deer		Moose[2]		Cattle	
Habitat category	+[1]	-	+	-	+	-	+	-
Vegetative type								
Aspen	3	2	4	1	9	0	0	14
Shrubland	10	0	8	0	14	0	0	10
Herbland	0	13	0	12	0	14	14	0
Topographic location								
Upper slope	7	3	6	0	8	0	0	14
Middle slope	5	4	6	0	0	1	0	2
Lower slope	1	9	0	14	0	11	12	0
Aspect								
Sunny	3	4	1	2	0	14	9	0
Shaded	4	3	2	1	14	0	0	9
Slope percent								
<20%	3	3	0	13	1	0	14	0
>20%	3	3	13	0	0	-	0	14

[1]"+" and "-" indicate occurrence of feces piles was greater or less than the 90% Bonferroni confidence interval on the proportion of plots in the category.
[2]Moose data from Telfer 1988.

TABLE 4. Mean percentage of plot clusters (n=112) containing cervid and cattle feces, and the percentage of feces piles on those plot clusters, in the Streeter Basin Experimental Watershed, Alberta, winters from 1969-1970 to 1982-1983.

	Species			
	Elk	Deer	Moose	Cattle
Percentage of plots with feces:				
Mean	16%	36%	34%	53%
(Standard error)	(1.9%)	(3.5%)	(1.6%)	(1.8%)
Percentage of plots with both cattle and cervid feces:				
Mean	7%	14%	12%	24%
(Standard error)	(1.1%)	(2.0%)	(0.7%)	(1.8%)
Percentage of feces piles:				
Mean	43%	41%	34%	–
(Standard error)	(4.1%)	(3.1%)	(2.7%)	–
Percentage of plots with cattle only:				
Mean	–	–	–	29%
(Standard error)	–	–	–	(1.6%)
Percentage of cattle feces piles:				
Mean	–	–	–	31%
(Standard error)	–	–	–	(1.8%)

TABLE 5. Counts of cattle and cervid feces piles on permanent sample plots in the Streeter Basin Experimental Watershed, Alberta, winters from 1969-1970 to 1982-1983 (Feces piles / hectare).

	Species				
Year	Cattle	Moose	Elk	Deer	Total cervids
1969-1970	696	103	76	51	222
1970-1971	1147	165	141	100	406
1971-1972	1129	212	118	446	777
1972-1973	960	156	67	301	525
1973-1974	741	165	80	69	315
1974-1975	712	163	38	105	306
1975-1976	558	199	60	98	357
1976-1977	592	174	36	125	335
1977-1978	308	145	63	196	404
1978-1979	397	223	18	214	455
1979-1980	391	145	27	225	397
1980-1981	383	196	38	199	429
1981-1982	408	132	27	201	359
1982-1983	232	201	27	397	625

that cattle were moved into the Forest Reserve pasture in mid-November and were removed in January.

Forage resources

Comparison of biomass remaining on plots grazed overwinter in 1971-1972, the winter of greatest ungulate densities, showed a disappearance of 47 to 53% of net forage yield (Table 6). That value represents a maximum overwinter removal by grazing ungulates. However, there was also a substantial reduction in biomass on plots caged to prevent grazing, leaving only between 14.6% and 16.2% of the yield as definitely removed by ungulates. The additional reduction was the result of leaching, decomposition and small mammal feeding. However, if ungulates had had access to the ungrazed plots in autumn they could have removed most of the biomass before it had a chance to decay.

Food habits

Food habits of ungulates estimated from fecal analysis showed that in the winter of 1971-1972, the winter with the second highest snowfall of the 14 years of the study (Telfer 1986), 88.6% of the cattle diet consisted of herbaceous material while the remaining 11.4% was woody browse (Table 4). No herbaceous material was found in Moose feces and only 6.4% of material from deer feces was herbaceous but the Elk

TABLE 6. Overwinter carryover of forage, and loss of forage due to grazing, decomposition, leaching and small mammal feeding on the Streeter Basin Experimental Watershed, Alberta, 1971-1972.

	Vegetative type		
	Herbland	Shrubland	Aspen forest
Autumn biomass yield:			
Mean (kg/ha)	2564	2192	1450
(Standard error)	(126)	(109)	(66)
Biomass remaining in spring on caged plots:			
Mean (kg/ha)	1614	1435	906
(Standard error)	(132)	(97)	(105)
Biomass remaining in spring on grazed plots:			
Mean (kg/ha)	1217	1161	694
(Standard error)	(124)	(64)	(64)
Loss due to grazing, decomposition and leaching as per cent of yield:	53	47	52
Loss due to decomposition, leaching and small mammal feeding, per cent of yield:	36	35	38
Loss attributable to ungulates only as per cent of yield:	16	12	15
Potential percentage removal by ungulates:	16–52	12–47	15–53
Forage carryover as per cent of yield:	48	53	48

diet was 70.9% herbaceous — 65% grasses, comparable to cattle (69.5%). The Moose diet was 75% willows, a group that also formed 24% of Elk and of deer diets. Deer concentrated on the Saskatoon/Trembling Aspen group, taking 43% of their diet from there.

Mean use of all woody plant species was 37% of annual twig growth in Streeter Basin during the winters from 1971 to 1983 while use of willows averaged 96%, and use of Saskatoon was 72% (Telfer 1986). In some years utilization went substantially higher than 100% as browsing ungulates ate material produced in previous years as well as of the current year. In 1970-1971 and 1971-1972, use of all browse species was 22% and 40%, respectively, of the biomass yield of twigs. In those years utilization of willows was 49% and 114%, respectively (Telfer 1986).

Discussion

Results of the present study showed that wild ungulates and cattle usually selected different vegetative types, topographic positions, aspects, and slope steepness categories. Cattle selected herbland and avoided aspen and shrubland as might be expected from their preference for herbaceous forage (Table 7) and the greater forage biomass on herbland (Table 6). Their use of sunny exposures, lower slopes and slopes of less than 20% reflect the greater occurrence of herbland on those sites (Table 1). Cattle are widely reported to avoid steep slopes (Heady 1975; Mackie 1970). Moose selected the habitats that produce their principal forage, woody browse, including aspen forest and shrubland which occurred more often on the shaded aspect and on upper slopes. Deer selected the forest cover and browse resources of steep middle slopes, avoiding open herbland and its lower slope locations. Elk, like deer, avoided herbland, choosing shrublands and upper slopes although their diet was herbaceous plants. With Elk, avoidance of human disturbance appears to have been an important factor (Telfer 1978).

Overlaps in diet (Table 7) may have also been important determinants of species distribution, the large numbers of cattle on the area during late autumn and early winter had a substantial impact even on sites used by a small proportion of their numbers. Thirty-one percent of the cattle feces counted were on plots shared with wild ungulates. Although wild ungulates species shared only 7% to 14% of the total plots with cattle 34% to 43% of their feces counts occurred on those plots, showing that they were attracted to the same sites as cattle, probably because the resources found there were important to them.

Moose differed most strongly from cattle in their choice of habitat. However, the food habits data showed that the cattle diet consisted of 11.4% woody browse, mostly willows, Saskatoon and aspen (Table 7). Those species provided 91.5% of

TABLE 7. Winter food habits of ungulates on the Streeter Basin Experimental Watershed, Alberta, from microscopic analysis of fecal material collected in spring of 1972.

Plant species groups	Cattle	Moose	Elk	Deer
Grasses (Graminae)	69.5%	–	65.0%	2.1%
Sedges (*Carex* spp.)	16.9%	–	2.2%	–
Forbs	2.2%	–	3.7%	4.3%
Total herbaceous	88.6%	–	70.9%	6.4%
Willows (*Salix* spp.)	2.3%	75.0%	24.0%	24.0%
Aspen and Saskatoon (*Populus tremuloides* and *Amelanchier alnifolia*)	6.2%	16.5%	0.7%	43.0%
Balsam Poplar (*Populus balsamifera*)	0.6%	2.1%	4.5%	5.7%
Waterbirch (*Betula occidentalis*)	1.7%	6.4%	–	20.9%
Buffaloberry (*Sheperdia canadensis*)	0.6%	–	–	–
Total woody plants	11.4%	100.0%	29.1%	93.6%
Total microscopic fields examined	500	500	500	500
Total fragments identified	177	236	132	130

the Moose diet. Although the small proportion of browse eaten by cattle was of limited importance to them, it may well have equalled the browse biomass removed by Moose because of the numbers of cattle present. In 1971-1972 cattle use was estimated to have totalled 500 AUMs (400 on the Crown pasture and 100 on those parts of the East and West Pastures within the Basin, based on information supplied by ranch staff and from personal observation). Nine moose were counted in the basin in late winter of 1972 and were probably present throughout the fall and winter, for seven months or 63 moose-months, of feeding. If Moose average 0.75 of an animal unit (cf. Heady 1975), then Moose stocking in 1971-1972 would have been 47 AUMs, about one-tenth of the cattle stocking rate. Because the Moose diet was 100% woody browse, both species would have used about the same amount of that forage. Therefore, cattle may have reduced the supply of preferred Moose forage.

Cattle feeding overlapped even more strongly with Elk and deer. Deer depended heavily on browse but also ate some grasses and forbs while 70.9% of the Elk diet was herbaceous material.

Ungulate use of Streeter Basin varied with the season. Cattle were put in the Crown pasture in autumn and early winter but were usually removed in January. Moose use was relatively consistent throughout the year but was influenced by thick snow cover (Telfer 1986*). Deer and Elk use occurred in spring, summer, and autumn when cattle use was negligible. Elk use in proportion to Moose was low in autumn and winter but high in spring and summer. Because Moose were sedentary year around, this suggests that Elk moved out in autumn when cattle were introduced, as discussed below. Deer, on the other hand, were observed to remain in the Basin until the occurrence of heavy snowfalls (Telfer 1986*). Once the growing season ended in late summer all ungulates were depending on the same stock of forage until the onset of new growth the following May. Thus, feeding by one ungulate species at any time during the autumn and winter period was potential competition with other species requiring that forage later in the winter.

Herbage utilization combined with leaching of decomposing material as measured in 1971-1972 left a carryover of 48 to 53% of biomass (Table 6). Such a level is usually considered adequate and evidence of appropriate levels of ungulate stocking (Hedrick 1958). Total utilization of browse species was 40% in 1971-1972. However, 114% of the biomass of willow twigs was used, a level at which some decrease in productivity might be expected.

Number of piles of cattle feces counted in 1972 were second highest in the 14 years of the study, suggesting that, if herbage use was not excessive that year, it would have been below a critical level in the other years. There was a substantial overlap in habitat, forage, and site use between wild ungulates and cattle in Streeter Basin. Overlapping use of range areas and forage plants may affect the available food for one or more of the herbivore species involved. With regard to Cole's (1958) criteria for interaction among livestock and wild ungulates listed above, there were partial overlaps on range areas and on

*See Documents Cited preceeding Literature Cited section.

forage plants at Streeter Basin. The forage plant groups on which overlapping use occurred were also important to cattle and at least one cervid species. However, there may have been resource partitioning within plant groups. Other studies of cattle and wild ungulates (Mackie 1970; Berg and Hudson 1982; Lyon 1982) have reported similiar partial overlaps affecting forage use.

The adequate level of forage biomass carryover during 1972, a year of high total ungulate stocking in Streeter Basin, and the fact that the percentage of plots with feces averaged less than 50% for cervids and only 53% for cattle (Table 4), suggests that Cole's fourth criterion - that forage plants be limited in supply and deteriorating — was not met with the possible exception of willows. Otherwise, use of a higher percentage of the sample sites would have been expected. Also, field observation of the vegetation left the impression that, while heavily grazed and browsed, it was not being destroyed. Few examples of denuded soil patches or dying shrub clumps were observed.

Another parameter affecting the joint use of areas by cattle and wild ungulates is broadly described as interference competition (Odum 1971). No direct instance of wild ungulate avoidance of cattle was observed. However, cattle management did create disturbance by bringing people into the basin on a regular basis. contributing to man-caused disturbance. There was a strong relationship between use of survey quarter-sections (64 ha blocks) by Elk with the degree of security from man-caused disturbance provided by the blocks (Telfer 1978). Cattle introductions in autumn followed on the most intensive period of hunting for Elk and Mule Deer which would sensitize Elk to human disturbance.

Moose, on the other hand, selected quarter-sections in direct proportion to browse biomass regardless of the presence of humans (Telfer 1978). Moose selection of habitats in the Porcupine Hills with large browse biomasses has been supported by another study (Westworth et al. 1983*). Deer distribution was not explained by either browse biomass or degree of security (Telfer 1978).

The present study showed that wild ungulates selected different habitats than cattle to a significant degree. However, the sheer numbers of cattle, particularly in the early years of the study, and their use of a high proportion of the basin, plus the human disturbance associated with their presence probably caused some displacement of Elk from important habitats such as herbland on lower slopes. Cattle and associated human activity were putting pressure on wild ungulates in 1971 and 1972 when cattle use was at its peak. As cattle stocking declined over the last decade of the study one would have expected to see an increase in cervid use. That did not happen (Table 5), suggesting that other limiting factors, including hunting, were operating as well.

In summary, based on the data from the present study, no definite conclusion can be drawn as to whether cattle and cervids were actually in competition on the study area. However, their use of space, habitat and forage resources overlapped extensively and removal of forage biomass by the combined feeding of all species was at the maximum for reasonable range management. Control of the cattle stocking combined with heavy hunting pressure on the cervids probably prevented serious overuse of the range in 1971-1972 and 1972-1973.

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Natural Hybrids between the Common Goldeneye, *Bucephala clangula*, and Barrow's Goldeneye, *B. islandica*

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Most records of hybrid Common x Barrow's goldeneyes are of male alternate-plumaged birds, probably reflecting bias with respect to identification and possibly a greater abundance of hybrids in this plumage. The male alternate plumage is the only hybrid plumage to be acceptably described. Hybrids in this plumage appear fairly uniform as a group, exhibiting intermediate characteristics between the two parent species. Hybrid records are geographically widespread, originating from all three distinct regions of overlap. An increase in the number of hybrid records in the past 40 years is obscured by an increase in the number of observers in the field, as well as improved optical equipment. Despite these biases, a recent increase in the incidences of hybridization in British Columbia may exist.

Key Words: Common Goldeneye, *Bucephala clangula*, Barrow's Goldeneye, *B. islandica*, Anseriformes, Anatidae, natural hybridization.

The occurrence of widespread hybridization between bird species is supported by evidence for almost 10% of all species hybridizing in the wild (Grant and Grant 1992). This may reflect the large degree of genetic compatibility between species; however, it provides no information on the importance of hybridization from the perspective of the individual species. Differentiating between occasional incidences of hybridization, and hybridization that may threaten the genetic identity of a species or population is therefore important, especially from the perspective of conservation (see Cade 1983). Species whose ranges are altered due to human influences are especially vulnerable to increased incidences of hybridization which may threaten the genetic integrity of a species (Cade 1983; Boag 1988). Thus, documentation of hybrid records and descriptions or patterns in these records provide important groundwork for the monitoring of hybridization and its subsequent assessment relative to conservation.

Natural hybrids between the Common Goldeneye, *Bucephala clangula*, and the Barrow's Goldeneye, *B. islandica*, have been reported at least since 1951 (Snyder 1953). A recent review of avian hybrids by Panov (1989) listed five references describing six possible records of natural hybrids occurring in the wild. The present paper provides information on at least ten other instances of reported natural hybrids (Table 1), as well as recent occurrences of cross-species pairing and suspected broods of hybrid goldeneyes.

Hybridization between the two goldeneye species has been described in the literature on the basis of specimens and sight records of individuals intermediate between the two species in morphological characteristics. Descriptions of such intermediate hybrids have been relatively consistent (see Martin and Di Labio 1994), with the exception of head iridescence of male alternate-plumaged hybrids, which may be variable in colour. Validity of presumed male alternate-plumaged hybrids from the wild is supported by similar morphology of known hybrid males from captivity (e.g. Gochfeld and Tudor 1976); however, much less is known about the morphology of hybrid females and first-year birds.

Of the seventeen records of hybrids, thirteen represent male alternate-plumaged goldeneyes. Hybrids with this plumage are more frequently reported due to their distinctive characteristics, especially in comparison with the very similar female, yearling, and basic male goldeneye plumages. Males may also represent a greater percentage of all hybrids due to a higher prehatching mortality suffered by hybrid females (the heterozygous sex) (Haldane 1922; Gray 1958).

The only two female hybrid specimens recorded to date, an adult and a juvenile reported by Fjeldså (1973), were specimens identified on the basis of various bill measurements. Although goldeneyes are distinguishable between species by bill measurements from nestling stages onwards (Gardarsson 1967; C. Nelson, personal communication 1991), the bill is still developing until skull ossification is complete when adult plumage is attained (Palmer 1976). Taking into account individual variation in bill measurements, it would seem very difficult to positively identify female hybrids based on bill measurements alone, especially in hatching-year birds. As all plumage characteristics of these described specimens fit the species most commonly found at the site of

TABLE 1. Records of hybrids between the Common Goldeneye, *Bucephala clangula,* and the Barrow's Goldeneye, *B. islandica,* in the wild.

Date	Location	Plumage	Record	Reference
27 June 1907	Lake Myvatn, Iceland 65°38′N, 17°00′W	female-alternate	specimen ZMUC 59275	Fjeldså 1973
30 October 1922	Merrymeeting Bay, Maine 44°00′N, 69°54′W	female-1st basic	specimen ZMUC 69022	Fjeldså 1973
14 April 1951	Petitcodiac, New Brunswick 45°56′N, 65°10′W	male-alternate	specimen ROM 78916	Snyder 1953
13 May 1954	Westwick Lake British Columbia 52°00′N, 122°10′W	male-alternate	specimen MZ UBC 4472	Jackson 1959
20 December 1956	Niagara River, Ontario 43°16′N, 79°03′W	male-alternate	specimen ROM 76662	Beardslee and Mitchell 1965
26 March 1957	Alki, Seattle, Washington 47°35′N, 122°25′W	male-alternate	sight record	Schultz 1958
3 March 1963	Perkins Cove, York Co., Maine 43°35′N, 70°36′W	male-alternate	sight record	Gochfeld and Tudor 1976
20 June 1970	Lake Myvatn Iceland 65°38′N, 17°00′W	male-alternate	sight record	Bengtson 1972
11 March 1976	Peterborough, Ontario 44°8′N, 78°19′W	male-alternate	sight record	Goodwin 1976
13 April 1978	Iles-des-Soeurs, Québec 45°28′N, 73°33′W	male-alternate	sight record	Bannon 1978
November-March 1984-1989 estimated 4 different individuals	Vancouver, British Columbia 49°55′N, 123°07′W	all male-alternate alternate	sight records	J.-P. Savard, personal communication 1993
breeding season 1984-1992	100 Mile House, British Columbia 51°39′N, 121°17′W	females	examined in the hand	J. Eadie, personal communication 1992
May 1985[1]	Riske Creek, British Columbia 51°58′N, 122°31′W	male-alternate	sight record	J.-P. Savard, personal communication 1993
27 November 1988	Cornwall, Ontario/New York 45°00′N, 74°46′W	male-alternate	sight record	Martin and Di Labio 1991
17 March 1991	Aylmer, Québec 45°23′N, 75°48′W	male-alternate	sight record	Yank et al. 1991
31 March 1991	Baie Comeau, Québec 49°13′N, 68°09′W	male-alternate	sight record	personal observation PRM
11 January 1992	Larchmont, New York 40°56′N, 73°45′W	male-alternate	sight record	Boyle et al. 1992
26 January 1992	Cornwall Ontario/New York 45°00′N, 74°46′W	male-alternate	sight record	Boyle et al. 1992

[1]estimated year
ZMUC: Zoological Museum of the University of Copenhagen
ROM: Royal Ontario Museum
MZ UBC: Museum of Zoology, University of British Columbia

collection, it seems possible to us that these two specimens especially the first-year female, may be extreme variations of their respective species (based on plumage). The possibility that these specimens are backcrosses (F_2 hybrids) as opposed to first generation (F_1) hybrids, as suggested by Fjeldså (1973), also exists.

Other suspected female hybrid goldeneyes were examined in the hand near 100 Mile House, British Columbia, by John Eadie (personal communication 1992) during the breeding seasons of 1984 through to 1992. These individuals were suspected of being hybrids based on intermediate characteristics for several of the following traits: weight, culmen length, wing pattern, and head shape.

The majority of hybrid goldeneye records are from the latter half of this century. Difficulty in identifying such hybrids, especially in the field prior to improved modern optical equipment, as well as an increase in observers in the field, may be responsible for the prior scarcity of hybrid records. Increased work on breeding goldeneyes in British Columbia and Iceland in the latter half of this century may also account for the temporal pattern of hybrid records in these areas. In addition, some records may not represent new individuals, especially in cases where recurring wintering birds are involved. Winter site fidelity has been described in the genus *Bucephala* (Erskine 1961; Limpert 1980; Savard 1985), so wintering hybrids may return to the same locality in subsequent years. Goldeneyes are also suspected to move locally, dependent on conditions of open water (personal observations from eastern Ontario and adjacent Québec and New York state), and an individual hybrid moving around may result in more than one record.

The six records of cross-pairing in goldeneyes all come from British Columbia, and all involve female Common Goldeneyes pairing with male Barrow's (J. Eadie, personal communication 1992). Five records were from 1985, when populations of goldeneyes were abnormally high (J. Eadie, personal communication 1992), with the sixth from 1992 (D. Anstey, personal communication 1992). These records suggest an increase in the incidence of hybridization, however, evidence to support this hypothesis is inconclusive.

Hybridization between goldeneye species is not confined to one geographic region. In fact, records of hybrids span all three areas of co-occurrence of the two goldeneye species: Iceland (two records), northeastern North America (eleven records), and western North America (over eight records). The observations of mixed pairing, noted above, are restricted to western North America. Together, these records of hybrids and mixed pairing illustrate the geographically widespread nature of hybridization between the goldeneyes. Biases in the distribution of observers and factors confounding the precise number of individuals represented by the records (as noted above), however, obscure the relative importance of hybridization among geographic areas.

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Observations of Basking Sharks, *Cetorhinus maximus*, in Clayoquot Sound, British Columbia

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Darling, James D., and Kathleen E. Keogh. 1994. Observations of Basking Sharks, *Cetorhinus maximus*, in Clayoquot Sound, British Columbia. Canadian Field-Naturalist 108(2): 199–210.

The distribution, abundance and behavior of Basking Sharks (*Cetorhinus maximus*) in Clayoquot Sound, Vancouver Island, British Columbia was investigated with sightings made from 1973-1992. A field study based on identification of individual sharks by photographs of dorsal fins was conducted on 23 days between June and August 1992. Sharks were sighted in the Sydney and Shelter Inlets and Millar Channel from March to October, 1973-1992. Twenty-seven individuals were photo-identified through scars, cuts or other irregularities in dorsal fins. The rate of discovery of new sharks declined near the end of the study period suggesting the population present in the study area is not large. Six sharks were identified on more than one occasion; duration between sightings of individuals ranged to 45 days. Observations suggest the sharks are more likely to be seen in sunny, calm weather, and in early morning or late afternoon/evening. Sharks were observed leaping from the water. Plankton tows indicated a variety of organisms, including copepods and crustacean larvae, which are likely food species. Male sharks were identified by their claspers. Some sharks had wounds on dorsal fins apparently caused by boat propellers. There are three records of sharks found entangled in fishing gear. The observations of Basking Sharks in Clayoquot Sound seem to support the descriptions of seasonal appearance, discrete populations, weather dependent behavior and propensity to become entangled in fishing gear described in the literature. This is the only known aggregation of Basking Sharks remaining on Vancouver Island, and possibly the only one in British Columbia, and may warrant conservation measures.

Key Words: Basking Shark, *Cetorhinus maximus*, Clayoquot Sound, Vancouver Island, British Columbia.

Basking Sharks *(Cetorhinus maximus)* inhabit temperate and subpolar seas throughout the world (Campagno 1984). Along the western coast of North America they range from the Gulf of Alaska to Baja, Mexico (Hart 1973, pages 34–35; Horsman 1987). The only published accounts in the scientific literature of these fish in British Columbia waters are by Green (1891) who notes the presence of Basking Sharks off the Queen Charlotte Islands and Clemans and Wilby (1961) who state this species is common along the British Columbia coast. Traditional native knowledge, complaints by fishermen, a Fisheries Department eradication program, and newspaper accounts further indicate this species to have been abundant, at least in some locations, along the British Columbia coast from Victoria to the Queen Charlotte Islands.

Accounts of Basking Sharks are common in the traditional knowledge of the Hesquiat and Ahousat people along the central west coast of Vancouver Island (Bouchard and Kennedy 1990*). Beside Green (1891) and Clemans and Wilby (1961), the only written accounts of Basking Sharks in British Columbia are found in newspaper and magazine stories in the 1940s and 1950s. These stories describe the problems fishermen had with animals getting caught in nets in Barkley Sound, Vancouver Island, and the subsequent shark eradication program of the Department of Fisheries and Oceans. A large blade was placed on the bow of a Fisheries vessel and the sharks were rammed and sliced in two. (Anonymous 1947, 1948, 1955, 1956b, 1956c, 1956d).

Since the 1950s, and the apparently successful eradication program, Basking Sharks have been given little public or scientific attention. Its current status in British Columbia waters is completely unknown.

The purpose of this study was to investigate the occurrence of Basking Sharks in a particular region of Clayoquot Sound on the west coast of Vancouver Island (approximately 49°25'N, 126°10'W). Observations of abundance, distribution and behavior were made to determine the feasibility of a long-term study in the area, and the potential for basing this study on the photographic identification of individual sharks. The program was part of a larger study of the Clayoquot Sound ecosystem.

Methods

Study area

The study was centered in the northwestern portion of Clayoquot Sound in the confluence of Shelter and Sydney inlets, a region where shark sightings were regularly reported (Figures 1 and 2). The area is approximately 16 sq km in size and included the confluence of the two inlets, and several kilometers in each direction. Almost all the surveys were conduct-

*See Documents Cited preceeding Literature Cited.

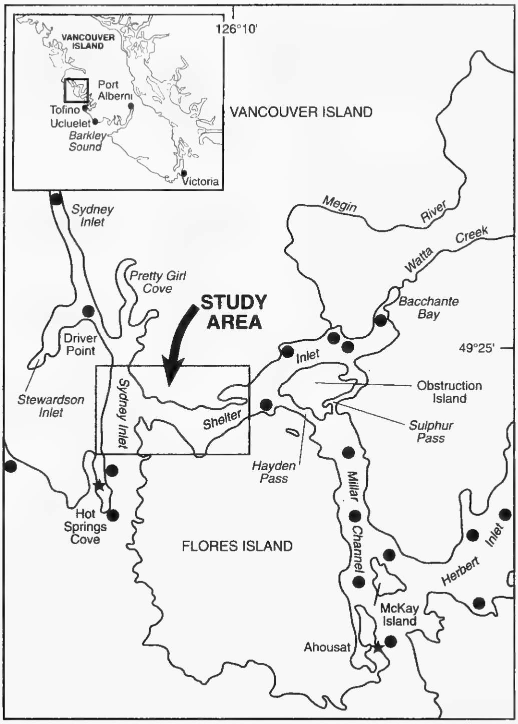

FIGURE 1. Northwestern Clayoquot Sound, the study area, and Basking Shark sightings outside the primary study area (listed in Tables 1-3).

ed within this area, although occasional trips were made to the head of Shelter and Sydney inlets. Shelter Inlet is completely protected from the open ocean by Flores and Obstruction islands. Sydney Inlet is open to the Pacific. The inlets are characterized by steep cliffs and shorelines dropping into 50–160 meters of water. Relatively strong tidal currents characteristic of the region meet at the confluence. There are a few shallow benches, including the Sydney and Megin River estuaries and several small bays on Flores and Vancouver Island shores. A camp was established on the Vancouver Island shore just northwest of Dixon Point. Sharks in adjacent Shelter Inlet waters could easily be seen from the camp.

Data collection

The main field study was conducted during the period from 4 June – 6 August 1992. Sightings by the authors and from other experienced local observers, including charter boat operators and pilots, were collected throughout the season. Written records of sightings by local naturalists and skippers in years previous to 1992 were also gathered. These include flight logs by pilot D. Banks (Box 99, Tofino, British Columbia V0R 2Z0) during year-round work in Clayoquot Sound.

Days on which sharks were sighted and photo-identified in the directed field study are given in Figure 3. Sharks were sought on 23 days and sighted on 21 between 4 June and 6 August 1992. Effort and route per survey day were inconsistent. The survey day generally consisted of 3-4 hours of searching, between approximately 0700-1000 hrs and/or 1700-2100 hrs. This schedule was followed because these seemed to be the times sharks were more likely to be seen. Several all-day boat searches were conducted, from approximately 0800-1700 hrs. When

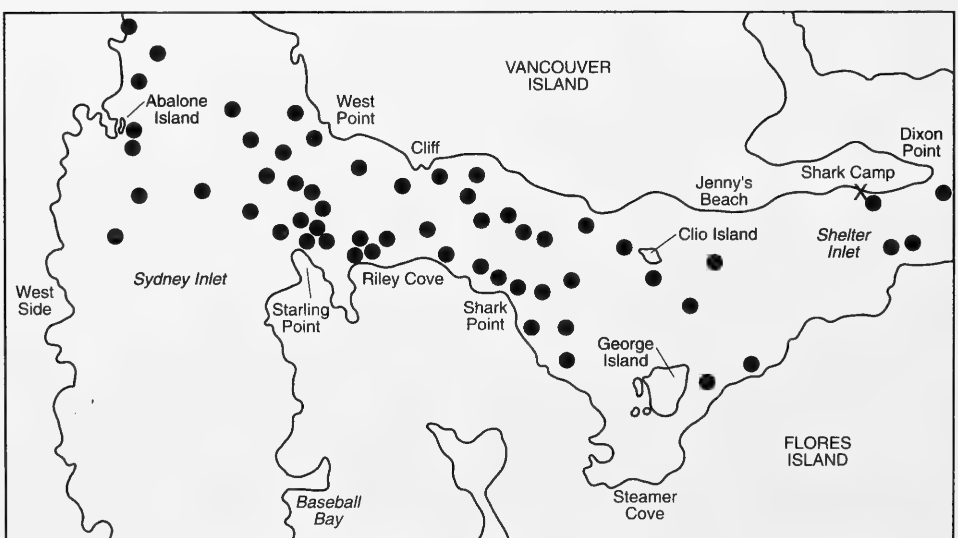

FIGURE 2. Locations of Basking Sharks sighted by the authors in the primary study area in June-August 1992.

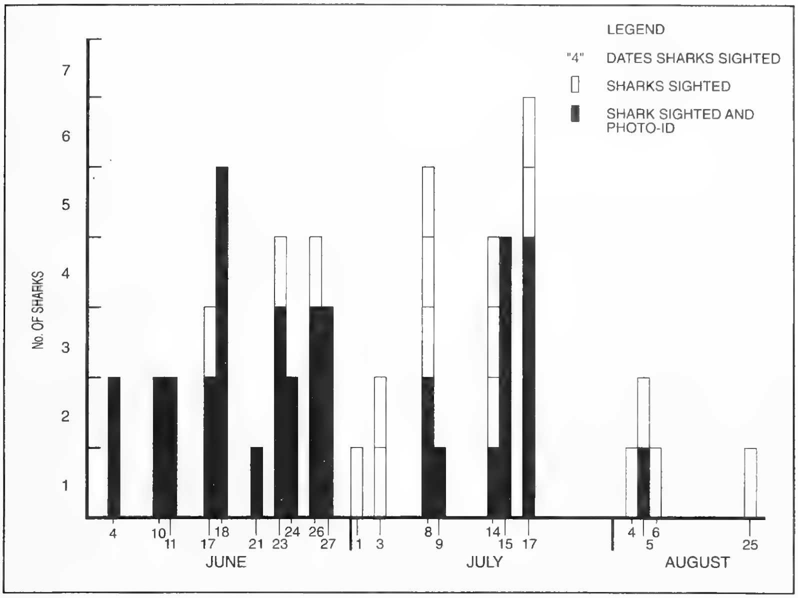

FIGURE 3. Survey effort in 1992. On 2 and 4 July sharks were sought but not sighted.

camped in the region a watch was kept on the water throughout the day.

The area was surveyed in 5-6 m boats. When a shark was sighted the time and location were recorded, and the animal was approached to obtain photographs of both sides of the dorsal fin whenever possible. Occasionally, a color sonar system was used to determine the depth of the scattering layer in the study area. Ocean surface temperature readings were obtained from a salmon farm within 1 km of the study site.

Photographic identification

Identification of individual animals using photographs of the irregularities in dorsal fins is a well-tested technique used in the study of wild whales and dolphins (e.g., Bigg et al. 1987). Photo-identification enables repeat sightings of individuals which, in turn, allows the determination of abundance estimates, length of stay, movements, site-fidelity, and associations between individuals. The feasibility of using this technique for the study of Basking Sharks was tested by photographing both sides of the dorsal fin. Ilford black and white film, pushed to 1600 ASA, and a shutter speed of 1000th of a second, and Kodachrome 64 film were used. The photographs were processed and compared to determine identifiable individuals.

Results

Sightings and distribution

Basking Shark sightings documented by a local commercial pilot, Doug Banks, from 1973-1992* are given in Table 1. Other sightings recorded prior to the study period are given in Table 2. These sightings indicate the long-time presence of sharks in the region, and extend the documented range of sharks beyond the 1992 sightings. Figure 1 indicates sightings made outside the primary 1992 study area. The majority of sightings center on the Shelter and Sydney inlets and Millar Channel, although occasional sightings occur outside of these areas.

All sightings made in 1992 are listed in Table 3 and illustrated in Figure 2. Eighty-five sightings (including two dead sharks) were reported in 1992 between March and September. The majority of sightings were during June-August likely due to increased observer effort during that period.

Figure 4 plots all the sightings available from 1973 to 1992. It provides a useful picture of when sharks are sighted in the area; however, it should be noted there was no consistency of sighting effort/month (e.g., the increased numbers of sightings in June was probably a result of this study). This plot of sightings suggests the sharks appear on the surface from March to October, and are not seen in the winter.

Photographic identification

During the study, 27 individuals were photographically identified, and examples of photo-identified animals are given in Figure 5. These 27 sharks were sufficiently marked (deformities, irregularities, scars) such that re-identification was possible. Another 10

TABLE 1. Basking Shark sightings noted in flight logs of commercial flights in Clayoquot Sound 1973-1992 (D. Banks, 1972-1992*). Specific locations were not usually noted, however all sightings were in the Herbert Inlet, Millar Channel, Shelter and Sydney Inlet region.

Year	Date
1973	15 September
1974	8 August, 11 September
1975	11 September, 22 September, 6 November[1]
1976	21 April, 28 April[2], 5 May, 14 May[3], 28 June
1981	15 May, 17 September
1982	15 May, 17 September
1984	17 May, 20 June, 22 June, 2 August
1985	16 May, 28 May, 29 May, 31 May[4], 17 June, 6 July
1986	15 May, 16 May, 30 May, 4 June, 9 June[5], 11 June, 5 September
1987	30 June, 5 September, 11 October, 23 October, 28 October
1988	19 April, 8 May, 11 June, 15 August, 17 August, 29 August
1989	5 May, 4 June, 8 August
1990	17 May, 3 July, 10 August
1991	21 May
1992	23 May, 24 May, 21 July, 27 July, 22 September, 9 October

Notes (see Figures 1 and 2 for locations):
[1]dead on beach Ahousat.
[2]shark? jumped near Steamer Cove - huge splash.
[3]Herbert Arm.
[4]Herbert Arm.
[5]dead on beach - Megin.

photo-identifications were not used in the analysis as they were considered marginal due to lack of markings and/or poor quality photographs. Many of the sharks had scars, cuts or deformities on dorsal fins that apparently came from contact with boat propellers. This allowed fairly easy identification of individuals. Other animals had relatively small irregularities in the trailing edge of dorsal fin, but with good photographs could be identified with certainty.

Abundance

The 27 individuals identified provide a minimum population size of the Clayoquot Sound Basking Shark population.

The rate of discovery of "new" sharks is given in Figure 6. This graph plots the number of identifications against the number of individuals, with the line becoming horizontal as all the sharks in the population are identified. If the total number of identifications, 36, is divided into halves, the first 18 sharks identified were all "new", or previously unidentified; and of the last 18, 9 were "new" and 9 previously identified. That is, in the latter half of this study period, on the average, one of every two sharks were "new". This rate of discovery at the end of the study period indicates the population is larger than the 27 animals identified. The increased number of repeat sightings near the end of the study may suggest the population is not huge, or, there may be some behavior pattern that increases the sightings of some individuals in July-August. It is important to note that this early insight into population size only applies to the sharks in the primary study area between June and August 1992. However, since the population has not been defined and movement patterns are unknown, it is of limited value.

Repeat sightings of individuals

During this study six sharks were identified on more than one occasion as shown in Figure 7. Same day repeat sightings were not included. The duration between sightings ranged from 2 to 45 days.

Other observations

The majority of sightings occurred between dawn and 1000 hrs., and 1500 hrs and dark. Some notable exceptions (e.g., a 2 August 1993 observation of a leaping shark, Table 4) occurred in midday. Sharks were sighted more often on calm, sunny days. Of the 11 searches (a several hour-long morning or afternoon survey) conducted when sharks were not sighted, all were during overcast and/or windy conditions. These observations have not been quantified to determine if the difference in sightings between time of day or weather conditions is statistically significant.

Stories of sharks leaping clear of the water exist in local lore. In Table 4 first-hand observations and credible second-hand reports of sharks and probable sharks leaping are listed. The most detailed observa-

TABLE 2. Other Basking Shark sightings prior to 1992.

Date	No. Sharks	Location	Observer
June 1988	3-4	Sydney Inlet estuary	JD
1988	1	Off Hisnit	R. Beaupied[1]
August 1989	1	Shelter Inlet (Sulphur Pass)	JD
Summer 1991	1	Sydney Inlet (Starling Point)	R. Beaupied
September 1991	1	Sydney Inlet (Baseball Bay)	R. Beaupied
Summer 1991	1	Millar Channel	R. Beaupied

[1]R. Beaupied. Personal communication, 1992. Box 393, Tofino, British Columbia, V0R 2Z0.

TABLE 3. Basking Shark Sightings in Clayoquot Sound - 1992. The nearest landmark to the sighting is given in parentheses (see Figures 1 and 2).

Date	No. Sharks	Location	Time	Observer
13 March	1	Bacchante Bay	–	C. Cowie
14 March	1	Shelter (Megin)	–	C. Cowie
mid-March	1	Millar (McKay)	–	E. Arnet - entangled
25 May	1	Shelter (Clio)	–	R. Beaupied
2 June	2	Sydney (Driver)	0900	E. Rochford
4 June	1	Shelter (Steamer)	1030	JD
	1	Sydney (W. side)	1645	JD
	1	Shelter (Dixon)	–	JD
6 June	1	Sydney (Pretty)	1730	D. Banks
7 June	1	Sydney (W. side)	1115	D. Banks
10 June	2	Shelter (Dixon)	1800	JD
11 June	1	Shelter (Riley)	2015	JD
	1	Shelter (Riley)	2030	JD
17 June	1	Shelter (Riley)	1940	JD
	1	Shelter (Riley)	2018	JD
	1	Shelter (Riley)	2025	JD
18 June	1	Shelter (Riley)	0740	JD
	1	Sydney (Starling)	0815	JD
	1	Sydney (W. side)	0820	JD
	1	Sydney (Abalone)	0900	JD
	1	Sydney (W. Side)	0915	JD
	1	Shelter (Shark)	1730	JD
	1	Shelter (Clio)	1730	JD
20 June	1	Shelter (Jenny's)	0620	D. Banks
21 June	1	Shelter (Steamer)	1905	JD
23 June	1	Shelter (Clio)	0745	JD
	1	Sydney (Abalone)	0810	JD
	1	Shelter (George)	0915	JD
	1	Shelter (Shark)	1910	JD
	1	Shelter (Shark)	1920	JD
24 June	1	Shelter (Camp)	0600	JD
	1	Sydney (Starling)	0750	JD
	1	Shelter (Clio)	0830	JD
26 June	1	Sydney (Starling)	0845	JD
	1	Sydney (W. Side)	0900	JD
	1	Shelter (George)	2055	JD
27 June	1	Shelter (Riley)	1915	JD
	1	Sydney (Starling)	1940	JD
	1	Sydney (Abalone)	2000	JD
1 July	1	Shelter (Riley)	1040	KK
2 July	1	Shelter (Cliff)	1945	KK
3 July	1	Shelter (Clio)	1120	KK
	1	Sydney (Abalone)	2105	KK
	1	Millar Channel	0930	E. Rochford
8 July	1	Shelter (Cliff)	1830	JD
	1	Shelter (Shark)	1850	JD
	1	Shelter (Cliff)	1930	JD
	1	Sydney (Starling)	2025	JD
9 July	1	Shelter (West Pt.)	0745	JD
14 July	1	Shelter (Cliff)	1800	JD
	1	Shelter (Riley)	1945	JD
	1	Shelter (Riley)	2000	JD
	1	Shelter (Cliff)	2015	JD
July 15	1	Shelter (Riley)	1915	JD
	1	Shelter (Cliff)	1945	JD
	1	Sydney (Starling)	2000	JD
	1	Shelter (West Pt.)	2010	JD

Continued

TABLE 3. *Continued*

Date	No. Sharks	Location	Time	Observer
17 July	1	Shelter (Cliff)	1640	JD
	1	Shelter (Shark)	1715	JD
	1	Shelter (Clio)	1815	JD
	1	Shelter (Shark)	1855	JD
	2	Shelter (Riley)	2030	JD
18 July	1	Shelter (Steamer)	–	M. Hansen
19 July	1	Sydney (Starling)	1830	D. Midavaine
21 July	1	Shelter (Clio)	early PM	R. Beaupied
22 July	1	Shelter (Clio)	1630	D. Travers
	1	Shelter (Steamer)	1630	D. Travers
27 July	2	Shelter (Clio/Riley)	0840	D. Banks
	1	Shelter (Jenny's)	1630	D. Banks
31 July	1	Shelter (Starling)	1100	R. Beaupied
	1	Shelter (Clio)	1100	R. Beaupied
1 August	1	Sydney (Starling)	1530	D. Travers
2 August	2	Sydney (Starling)	1100	B. Kingzett
	2	Sydney (Starling)	1130	B. Kingzett
	1	Shelter (Steamer)	1300	B. Kingzett
	1	Sydney (Starling)	1530	B. Conconey
4 August	1	Shelter (Clio)	1600	J. Wilson
	1	Shelter (Riley)	1600	KK
	1	Sydney (Starling)	1830	R. Beaupied
5 August	1	Shelter (Clio)	1715	KK
	1	Shelter (Megin)	2015	KK
6 August	1	Shelter (Riley)	1030	KK
24 August	1	Shelter (Riley)	0815	D. Banks
25 August	1	Shelter (Dixon)	1800	JD
22 September	1	Shelter (Megin)	–	E. Arnet - dead on beach

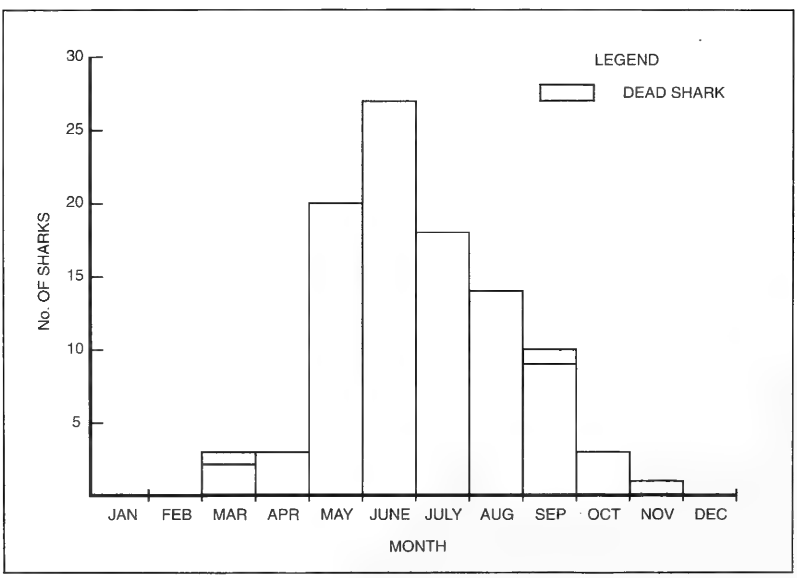

FIGURE 4. All Basking Shark sightings per month, 1973-1992 (Tables 1-3).

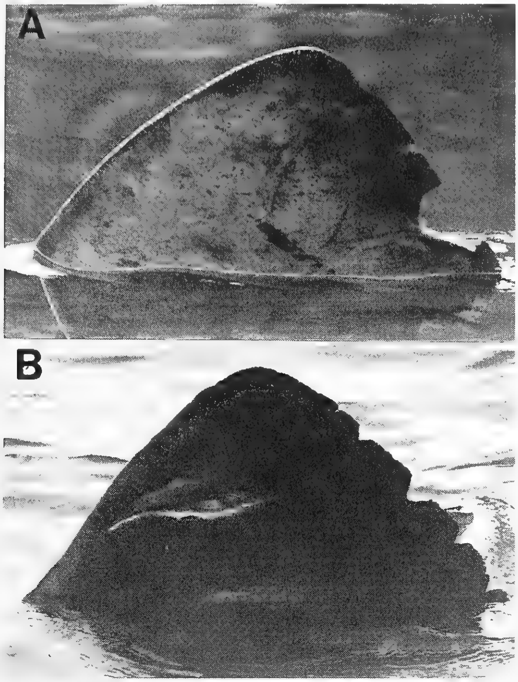

FIGURE 5. Examples of shark photo-identifications.

tion was made by B. Kingzett and C. Neville (personal communication, 1992) at approximately 1300h, 2 August 1992 in Shelter Inlet.

"We observed a fin at the entrance to Steamer Cove moving slowly for several minutes before it submerged. The fin reappeared in shallows inside Steamer Cove (intertidal area) and moved along shore slowly then submerged at the entrance to the cove. The breach occurred without warning several minutes later. The shark came out of the water at a very low angle and got approximately 1-1.5 meters into the air. At this point the shark was completely horizontal and completely out of the water. We distinctly remember the tail lashing side to side before it fell back into the water on its left side. The underside was orange with a wavy border where it came up on the sides. The shark did not seem to have much forward momentum as it hit the water. It submerged immediately and did not re-surface."

With the exception of this, and the June 1988 observation, observers in Table 4 were uncertain as to cause of the huge splash they saw. However, Basking Sharks were the only large marine animals in the area at the time of the observations, and considering the positive identification above, it is likely all were leaping sharks.

Several plankton tows conducted in the vicinity of the sharks produced a variety of organisms including copepods, crustacean larvae, medusae, and ctenophores. None were found in especially dense concentrations. A color depth sounder revealed scattering layers ranging from the surface to approximately 7 meters.

On two occasions, 18 June and 17 July, sharks were identified as males by the large white claspers hanging from their pelvic region. The sharks were swimming very close to or under the boat at the time and the claspers could be clearly seen through the water.

One brief observation made by Chris Neville and Brian Kingzett (personal communication, 1992) as

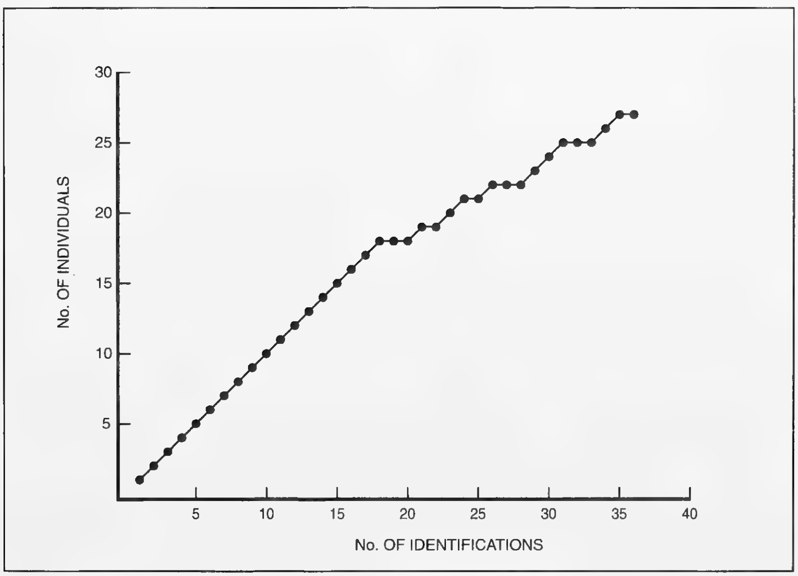

FIGURE 6. Rate of discovery of previously unidentified individual sharks in 1992.

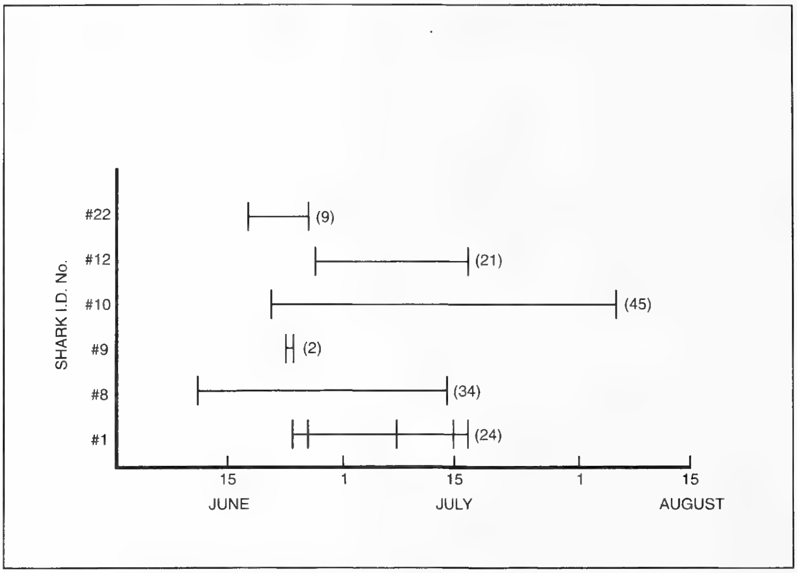

FIGURE 7. Repeat sightings of individual sharks in 1992. The numbers beside the last sighting are the number of days between the first and last sighting. Vertical lines indicate sightings.

they were passing through the study area on 2 August 1992 may be significant. Two sharks were on the surface near Starling Point circling each other, nose to tail, fins tipped to the sides. This activity appeared to be interrupted by a passing boat after about five minutes of observation.

We noticed that many of the sharks had white scars on fins and noses, and as noted above, the dorsal fins were often cut or mangled. The scars ranged from apparently recent, and pink or bloody, to almost completely healed over. On occasion the sharks changed course to approach the propeller area of our boat. The approach ranged from a "charge" with the animal moving at speed on the surface with dorsal fin and tail out of the water, to a simple change of course to swim slowly under the propeller. This apparent attraction of the sharks to the propeller would supply an explanation for the number of mutilated dorsal fins.

Several recent records of sharks entangled in commercial fishing gear are given in Table 5. The fishing gear that trapped the sharks included prawn traps, a salmon gill net, and a herring seine net.

The sea surface temperatures at Dixon Bay fish farm, approximately 1 km from the study area, ranged from 14-18.5°C (mean 15.6°C) from June to August 1993. June temperatures ranged from 14-15°C (unpublished data, Pacific AquaSalmon Farming Pártners, Tofino*).

Discussion

Seasonal aggregations and behavior

All investigations to date indicate that Basking Sharks appear at the surface only during certain seasons of the year. On the west coast of the British Isles, along the Norwegian coast, around Newfoundland, and along the northeast United States, the sharks generally appear during spring through summer (Matthews 1950, 1962; Priede 1984; Stott 1982; Kenney et al. 1985; Lien and Fawcett 1986; Kunzlik 1988). In contrast, in Monterey Bay, California the sharks are primarily seen during the winter months from October to May, with occasional summer sightings (Philips 1948; Hallacher 1977; Squire 1990). In Clayoquot Sound, the sharks may appear at the surface from March through October, a pattern similar to the other more northern locations mentioned above.

Little is known about the location and behavior of sharks during the periods they are not seen at the surface. Migrations from colder to warmer water during the winter, similar to some plankton feeding whales, have been suggested (Parker and Stott 1965; Stott 1982). However, the presiding hypothesis is that the fish move into deeper (possibly offshore) waters and may settle to the bottom and "hibernate" during the winter, losing their food-gathering gill rakers until new ones regenerate the following spring (Matthews 1950; Parker and Boesman 1954; Lien

TABLE 4. Observations of Basking Sharks and probable Basking Sharks leaping from the water in Clayoquot Sound.

Date	Observation	Source
28 April 1976	Shark? jumped near Steamer Cove – huge splash	D. Banks
June 1988	Shark jumping out of water at dawn in Sydney Inlet	Prawn fishermen to JD
27 June 1992	Something "breached" off camp – "large and loud" – just saw splash (in Shelter Inlet at 1000h)	K. Shaw, KK
28 June 1992	Large "something" breached – loud sound as body hit water – only saw splash from camp (in Shelter Inlet at 1135h)	K. Shaw, KK
25 July 1992	Big splash in Shelter Inlet between Clio Island and Starling Point – breaching shark?	D. Midavaine
2 August 1992	Saw shark swim into Steamer Cove, then breach 50m from boat. It twisted in air and "orange" belly seen. Huge splash. Did not see it again (1300h).	C. Neville, B. Kingzett
4 August 1992	Huge splash, not a cetacean – shark? dark in color (in Sydney Inlet at 1600h)	KK
4 August 1992	Huge splash (in Sydney Inlet at 2010h)	KK

and Fawcett 1986). The location and behavior of the Clayoquot Sound sharks in the winter is unknown. Some of the deepest water (50-160m) in the region is located in the same area the sharks are sighted in the summer, suggesting that if the sharks are seeking deep water they do not have to migrate anywhere. The stranding reported in November (Table 1) suggests that some Basking Sharks may be present in the region in early winter.

Observations in Newfoundland and California indicates the sharks' appearance at the surface is correlated with sea surface temperature (Lien and Fawcett 1986; Squire 1990). In Newfoundland 90% of Basking Shark entanglements in nets occurred when ocean surface temperatures were 8-12°C, and researchers concluded that variations in the numbers and location of captures was a function of sea water temperature (Lien and Fawcett 1986). Squire (1990) reports that Basking Sharks in Monterey Bay were least abundant in surface water over 14°C. Typical Clayoquot Sound temperatures range from 10-14°C with several degree fluctuations during El Niño years (D. Bancroft, Naval Meterological and Oceanography Centre, personal communication 1993). The 1992 study season was considered an El Niño year and the mean temperature in the area of 15.6°C probably reflects this influence.

Population characteristics and distribution

The examination of Basking Shark fishery records, and the slow recovery of populations that have been fished, suggest that these fish live in local, discrete populations and are a slow breeding species (Matthews 1950; Parker and Stott 1965; Horsman 1987; Kunzlik 1988). Several field observations support the view that these sharks maintain some level of site fidelity, at least during the season they are sighted at the surface. Priede (1984) tracked a Basking Shark using a satellite transmitter for 17 days during which time the shark stayed within the local area of the Firth of Clyde, Scotland. This suggests that it was a member of a population continually resident there during the summer months. During winter of 1990/91, 38 sharks were tagged in Monterey Bay, California. Several tagged in November-December off Santa Cruz, were seen during February off Moss Landing and Monterey suggesting some degree of residency in Monterey Bay over the winter (Black 1991*). During the winter of 1991/92, six of the sharks tagged the previous year were resighted indicating some year to year fidelity in the area (Sean Van Sommeren, personal communication 1993). In Clayoquot Sound, repeated sightings of photo-identified individuals over periods up to 45 days in the study area indicate these animals remain in, or revisit, specific areas over extended periods. This, combined with the observation that the sharks have not recovered to any extent in the Barkley Sound area approximately 80 km to the south where they were subject to the Fisheries eradication program in the 1950s, contributes to the view that these fish live in discrete, slow breeding populations.

Records from Victoria and Saanich Inlet on southern Vancouver Island, Barkley Sound mid-way up the west coast of Vancouver Island, and from the Queen Charlotte Islands, suggest a wider distribution of sharks than observed today (Green 1891; Anonymous 1947, 1948, 1955, 1956abcd, 1959; Clemens and Wilby 1961). It appears the Clayoquot Sound sharks may be a remnant population, only inhabiting a specific region of northwestern Clayoquot Sound. Without ruling out the importance

TABLE 5. Recent records of sharks entangled and killed in fishing gear in Clayoquot Sound.

June 1988	Prawn fishermen called JD to report "a whale" caught in their prawn gear at the head of Sydney Inlet. It was a Basking Shark.
mid-March 1992	The vessel Hayden Pass caught shark in herring seine net near McKay Island in Millar Channel.
22 September 1992	A Basking Shark was caught in a salmon gill-net stretched across the Megin River estuary in Shelter Inlet.

of adjacent locations, it is clear this is at least a portion of prime habitat for these fish.

Abundance

Basking Sharks can be seen in schools of 50 or more individuals, although are often seen alone or in groups of 2–3 (Squire 1967, 1990; Kunzlik 1988). The only information on the abundance of Basking Sharks in British Columbia arises from the reports of numbers killed by the Fisheries program in Barkley Sound. According to Victoria newspaper articles, 59 sharks were killed in the 1955 season (Anonymous 1955), and 51 or 56 (two different newspapers) in the 1956 season (Anonymous 1956bc). A 1956 report states the "biggest day" was 24 April that year, when 31 were killed (Anonymous 1956b). In total, it appears from this information that just over 100 sharks were killed in the two seasons. Clemens and Wilby (1961) state "several hundred" Basking Sharks were killed in Barkley Sound up to 1959. Basking Sharks are rarely sighted in Barkley Sound today, suggesting that the majority of the population in that area was killed. At the time, the Fisheries department did not consider the sharks to be as plentiful in Clayoquot Sound, and the eradication program was not extended beyond Barkley Sound (Ed Arnet, personal communication 1993). Long time residents of western Clayoquot Sound remember seeing many more sharks 20 or more years ago than today. With comments like, "Sydney Inlet was full of them," and "They were stacked like cord wood in Millar Channel," it is apparent sightings are less common today (Huey Clarke, personal communication 1993). This limited information suggests that the population of sharks in west coast Vancouver Island regions was not, at least recently, near the many hundreds or even thousands seen in Monterey Bay (Squire 1967, 1990). The preliminary work in Clayoquot Sound suggests the current Basking Shark population is somewhat larger than the 27 individuals identified, but any rough guess at this stage would not exceed the numbers killed in Barkley Sound. More precise estimates should be possible during the next few years of study.

Weather dependent behavior

The potential for sharks to be sighted on the surface is clearly seasonal, and several authors comment that within the "shark season" the day to day chances of seeing the fish on the surface is weather dependent. For example, in the UK, Basking Sharks are seen feeding on the surface in the summer on cloud free-bright summer days (Priede 1984). According to Scottish fishermen in the Firth of Clyde, a decrease in the number of sharks sightings is due to poor weather (Horsman 1987). This pattern appears to be documented in Priede's (1984) satellite tagging work. He found that shortly after the tag was attached "the weather changed to relatively dull cool conditions and no more Basking Sharks were seen: they were presumably deeper. The only cloud-free day during the 17-day tracking period was on 6 July and the shark seems to have been near the surface most of the day." This pattern fits the preliminary observations made in Clayoquot Sound, where the sharks seemed more likely to be seen on sunny days versus cloudy or foggy days. This observation, along with our notion that sharks were more likely to been seen at the surface in morning and evening than in mid-day, requires further investigation.

It should be noted that, in Monterey Bay, Phillips (1948) suggests there is little correlation between the time of day or kind of weather and the appearance of Basking Sharks on the surface. He states the sharks were harpooned in morning and afternoon on sunny and rainy days.

Feeding and breeding

Matthews (1950) suggested the basking habit is probably adopted when the concentration of plankton is greatest at the surface, or it may be correlated with breeding activity of the fish.

Basking Sharks are thought to be indiscriminate planktivores, their food consisting of those species abundant in the plankton at any one time (Matthews 1950). Food items reported in the stomachs of Basking Sharks include copepods, arrow worms, crustacean larvae, fish eggs, and oceanic shrimps (Matthews and Parker 1950; Parker and Boesman 1954; Mutoh and Omori 1978). The appearance of the sharks in Clayoquot Sound coincides with the season of highest plankton productivity in the region and the organisms identified in the plankton tows near surfaced Basking Sharks are likely food species for the sharks. Some observations indicate the sharks are actively feeding on plankton patches while on the surface (Priede 1984), while others indicate that the surface behavior does not correlate with the highest plankton concentrations or even, as is the case in Monterey Bay, the season of highest plankton productivity (Kunzlik 1988; Squire 1990). Whether the surface aggregations of Basking Sharks are a function of food concentrations, or simply coincide with food concentrations in some cases, remains to be determined.

Matthews (1950) suggests that females are impregnated while at the surface in coastal waters during the second half of May to June, as the six female sharks he examined in the British Isles were in breeding condition and showed signs of having recently copulated. These signs included freshly healed or open wounds caused by male claspers and spermatophores found in one female. As there are no records of pregnant females in Basking Shark fisheries, it is thought that the females must migrate either vertically or horizontally as pregnancy starts (Matthews 1950). Basking Sharks have been observed swimming in long lines nose to tail in a large circle, or following each other in small circles, and this has been interpreted as "some form of nuptual behavior" (which we assume to mean courting behavior) (Gilbert and Gilbert 1986; Matthews 1962). The short observation, reported here, of one shark circling another, nose to tail, is intriguing in the context of these earlier reports and is at this stage the only clue that some form of social activity may occur amongst sharks in Clayoquot Sound.

A combination of the observations of the sex ratio of sharks hunted in Scotland at the surface, and those entangled at depth in Newfoundland suggests that primarily females bask at the surface, and primarily males are found 10-30 meters deep (Matthews 1962; Lien and Fawcett 1986). These authors have suggested that this difference may be further evidence that the seasonal basking behavior is associated with sexual activity. The two clear observations of males at the surface during this study, suggest that this vertical division of the sexes in the water column is not a consistent pattern in our study area.

Leaping behavior

Several authors mention that Basking Sharks may jump clear out of the water (Gilbert and Gilbert 1986; Matthews and Parker 1951; Kunzlik 1988). This behavior occurs in the Clayoquot Sound shark population, at least occasionally. Its cause or function is unknown.

Interaction with vessels and entanglement

In the study area, sharks with cuts and wounds on the dorsal fin were the rule rather than the exception. The apparent attraction of sharks to our boat's propeller probably explains these injuries. The study area is moderately busy with motor boat traffic during the summer months (maximum approximately 20 boat passages a day) including speed boats, sail boats and fishing boats. It seems unlikely that speed boats are the main problem, as collisions would be serious and reported and this has not occurred. It may be that the propellers of slow-moving boats attract the sharks which are cut without the operator being aware of it.

In Newfoundland waters, Basking Sharks are often entangled in inshore fishing gear, primarily salmon gillnets and cod traps (Lien and Fawcett 1986). This species clearly has a propensity to get entangled in almost any type of fishing gear including prawn traps, salmon gill nets, and seine nets in British Columbia. Fishing activity is sporadic in the prime shark area, and this is probably fortunate for both sharks and fishermen. Limited distribution and, apparently, small numbers in these local populations probably indicate that any concentrated net or gear fishery in the Shelter and Sydney Inlet region could threaten the population. Currently there are three salmon farms in Shelter Inlet, each consisting of a series of pens with nets extending from the surface to approximately 6 m. Gilbert and Gilbert (1986) describe an Irish Basking Shark fishery that spread nets at right angles to the shore to trap sharks; this is apparently similar to the orientation of Clayoquot Sound salmon farms. There have been no reports of sharks being entangled in the farm nets that we are aware of, but this potential interaction should be a consideration in the siting of future farm sites, for the protection of the sharks and the fish farms.

Status

We can only speculate as to the current status of Basking Sharks in British Columbia. This population of sharks, in one small region of Clayoquot Sound, is the only aggregation we are aware of and preliminary indications are that the numbers are small. This may be a remnant population that warrants special consideration and protection, at least until its status, population biology, behavior and habitat requirements are better understood.

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Columbia V0R 2Z0 (1992); D. Travers, General Delivery, Tofino, British Columbia V0R 2Z0 (1992); S. Van Sommeren, Pelagic Shark Research Institute, Santa Cruz, California (1992); J. Wilson, Vessel Jerome, reporting to K. Keogh (1992). Special thanks are due Doug Banks for sharing his years of flight log-book shark sightings, D. Bancroft, Naval Meterological and Oceanography Centre, Marpac; Headquarters, FMO Victoria, British Columbia V0S 1B0; for providing water temperature information; Kara Shaw for field assistance, Josie Cleland and Alexa Klimke for help with the manuscript, Jasper Stephens for his logistical and financial support, Cheryl Baduini for her comments on early drafts of the manuscript, Spencer Evans and Pacific AquaSalmon Farming Partners for providing water temperature information. This work was supported by the Clayoquot Biosphere Project, Ecotrust, the Bullitt Foundation, and the McLean Foundation.

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Status of the Ancient Murrelet, *Synthliboramphus antiquus*, in Canada and the Effects of Introduced Predators†

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Gaston, Anthony J. 1994. Status of the Ancient Murrelet, *Synthliboramphus antiquus*, in Canada and the effects of introduced predators. Canadian Field-Naturalist 108(2): 211–222.

The Ancient Murrelet breeds on offshore islands across the northern Pacific from China to British Columbia. The total world population is in the order of half a million breeding pairs, of which about half breed in Canada, all in Haida Gwaii (the Queen Charlotte Islands), British Columbia. The formerly very large colony at Langara Island has decreased by about 90% over recent decades, and numbers occupying colonies on Lyell Island, the Limestone islands and islands in Englefield Bay have been considerably reduced. In all cases these declines seem to be related to the presence of introduced rats or Raccoons. The colonies affected by rats; Langara, Lyell and Kunghit islands, may be extirpated soon. Although rats do not appear to be spreading rapidly in the archipelago, Raccoons are threatening many seabird colonies and putting more than half the current Canadian population of Ancient Murrelets at risk. Unless rats can be eliminated, or the spread of Raccoons can be halted, a significant proportion of the population may be extirpated within a few decades. The species is designated "vulnerable" by the Committee on the Status of Endangered Wildlife in Canada (1993).

Key Words: Ancient Murrelet, *Synthliboramphus antiquus*, status, rare and endangered birds, predation, rats, *Rattus* sp., Raccoon, *Procyon lotor.*

Concern over the status of the Ancient Murrelet, *Synthliboramphus antiquus,* in its only breeding area in Canada, in Haida Gwaii (Queen Charlotte Islands), has been expressed recently by Rodway (1991), Gaston (1992) and Bailey and Kaiser (1993). This concern is based on the impact of mammalian predators introduced into the archipelago during this century. Recent surveys of several Ancient Murrelet colonies have demonstrated dramatic declines in population where introduced predators are present (Bertram 1989; Gaston and Masselink 1993). The Ancient Murrelet is an important element in the marine bird fauna of Haida Gwaii, comprising about 30% of all breeding seabirds. In addition, it is the most important species in the diet of the marine Peregrine Falcon, *Falco peregrinus pealei,* population of the area. A decline in the Ancient Murrelet population holds implications for other elements of the archipelago's ecosystems. A full description of the species and its biology is given by Gaston (1992).

Distribution

The Ancient Murrelet breeds in a thin arc, about 9 000 km in length, around the northern rim of the Pacific Ocean (Figure 1). The species becomes progressively more abundant from China to British Columbia. However, it is easily overlooked because it visits land only at night, and it is hard to census, so numbers for many breeding areas are likely to be very unreliable. Canada is the only part of its breeding range where we can be fairly confident that population estimates are correct to within less than orders of magnitude.

In Asia, Ancient Murrelets seem to be thinly distributed in small colonies separated by long distances. In the Aleutian chain the species is more common, but numbers there are poorly known. It is abundant in the Sandman Reefs and other islands south of the Alaska Peninsula, but it is an important constituent of the marine bird community only in British Columbia and adjacent parts of southeastern Alaska (Gaston 1992). In Canada, it breeds only in the Haida Gwaii, where nesting occurs on at least 30 islands (Rodway 1991).

Ancient Murrelets occur mainly in subarctic waters, where mean annual surface water temperatures are between 5° and 15°C (Kitano 1981). Its distribution was defined by Udvardy (1963) as, "subboreal, pan-pacific". In winter the species spreads south as far as California and Taiwan (Gaston 1992).

Protection

Ancient Murrelets, being defined as migratory birds under the Migratory Birds Convention Act, and being considered non-game birds, are protected throughout the year. However, native peoples can take them legally for subsistence purposes at any time.

A little less than half of the Canadian-breeding population of Ancient Murrelets nests on islands in the Gwaii Haanas/South Moresby National Park Reserve. Their breeding habitat within the park is

†Vulnerable status approved and assigned by COSEWIC, March 1993.

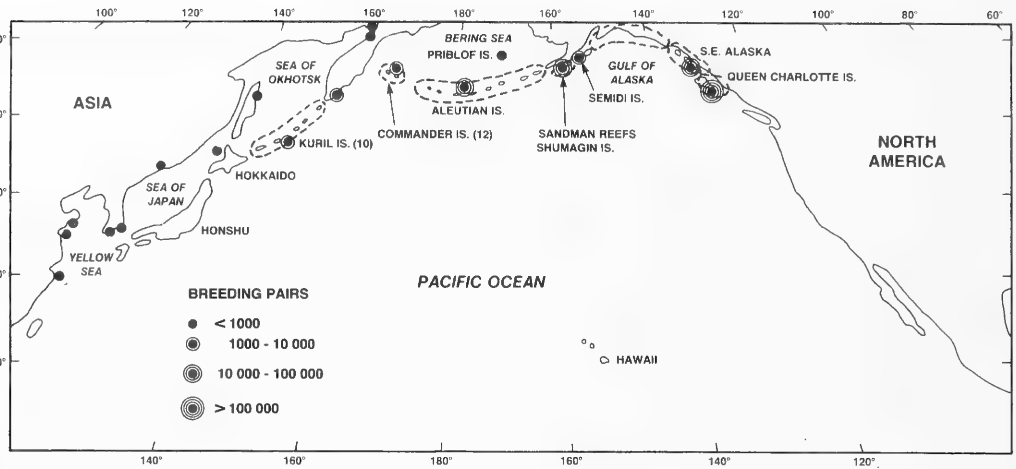

FIGURE 1. Global distribution of the Ancient Murrelet

protected from most forms of disturbance. Hippa Island, off the west coast of Graham Island, which supports a large colony, is a provincial Ecological Reserve and Frederick Island, which currently supports the largest number of Ancient Murrelets, is under consideration for provincial Park status. The small colonies on Reef Island and the Limestone Islands are protected as provincial Wildlife Management Areas. All of these protected areas should remain free of most human disturbance.

Population size and trend: Global

In China, the Ancient Murrelet breeds in Jiangsu Province (200 pairs, Chen Zhao-Qing 1988), and off the Shandong coast (Meyer de Schauensee 1984; Tso-Hsin 1987). In Korea, Ancient Murrelets were more common, though still not numerous, several decades ago (Austin 1948; Gore and Pyong-Oh 1971), nesting on a number of offshore islands; no recent information is available. The species also breeds on a few islands off the coast of Japan (Yamashina 1961; Fujimaki 1986; Hasegawa 1984).

In Russia, Ancient Murrelets breed in small numbers on islands in Peter the Great Bay, off Vladivostok, and on Sakhalin (Shibaev 1987; Litvinenko and Shibaev 1991). In the Sea of Okhotsk, Kondratiev (1991) estimated 25 000 birds spread among 18 sites, with the largest being Talan Island (5000 pairs: Springer et al. 1992). Recent estimates for the Kuril Islands suggest several thousand birds (Shuntov 1986; Litvinenko and Shibaev 1991), but populations there have probably been affected by predation from introduced rats, *Rattus norvegicus*. Evidence of rat predation on adult Ancient Murrelets was also found on Moneron Island, off the east coast of Sakhalin (Nechaev 1986; Litvinenko and Shibaev 1991).

Ancient Murrelets also breed on the east coast of Kamchatka, where Starichkov Island supports the largest population known on the Asiatic shore of the Pacific — about 6500 pairs (Vyatkin 1986). Some other smaller colonies may be extinct (Flint and Golovkin 1990). The population of the Commander Islands is poorly known, although the species occurs on both Bering and Copper islands.

The wide range of the Ancient Murrelet in Asia suggests that it may have been more common formerly. Human persecution and introduced predators, especially rats, could have drastically altered its populations before any naturalist had time to assess them. This damage probably continues.

The status of the Ancient Murrelet in Alaska is imperfectly known. In 1989, the U.S. Fish and Wildlife Service seabird colony catalogue (Catalogue of Alaskan Seabird Colonies - Computer Archives) listed 66 known and 8 probable breeding sites, with an estimated total population of just under 110 000 breeding birds. However, recent surveys at sea, and estimates taking into account the poor coverage of earlier surveys, suggested that numbers may be considerably higher (D. Forsell, V. Mendenhall, personal communications). Much more remains to be done to elucidate the status of the Ancient Murrelet in Alaska.

Ancient Murrelets occur in the Aleutians Islands, where they are most abundant in the Fox Islands, at the eastern end of the chain. They also occur on the south coast of the Alaskan Peninsula, where they breed on all the major island groups. The largest colony in this area is on Castle Rock, in the Shumagins, where Moe and Day (1977*) estimated 15 000 pairs, the largest colony reported from any treeless site. To the east of the Semidi Islands, in the Cook Inlet/Kodiak Island area, only ten sites are listed by the US Fish and Wildlife Service Catalogue between Shelikof Strait and south-east Alaska.

Numbers in Alaska must have been much higher in the past (Lensink 1984), because foxes were introduced onto most of the Aleutians from 1750 onwards to encourage fur trapping (Jones and Byrd 1979; Bailey and Kaiser 1993). Existing populations of Ancient Murrelets in the eastern Aleutians are all on fox-free islands (Nysewander et al. 1982*). Where foxes have died out, or been removed, Ancient Murrelet populations are recovering (Bailey 1978; Bailey and Faust 1980; Bailey and Kaiser 1993).

The Ancient Murrelet population in southeastern Alaska is concentrated on Forrester Island, on the north side of Dixon Entrance, where a survey by DeGange et al. (1977) gave an estimate of 30 000 pairs, making it the largest colony outside of Haida Gwaii. The only other colony of any size is on St. Lazaria Island (1000: Nelson et al. 1987).

Population size and trend: Canada

Ancient Murrelets in Haida Gwaii are concentrated in two areas: off the west coast of Graham Island, and off the east coast of Moresby Island (Figure 2). Both of these areas supported about 120 000 breeding pairs in the 1980s (Rodway 1991). The northern population is concentrated in three large colonies, on Langara (15 000 pairs in 1993), Frederick (68 000 in

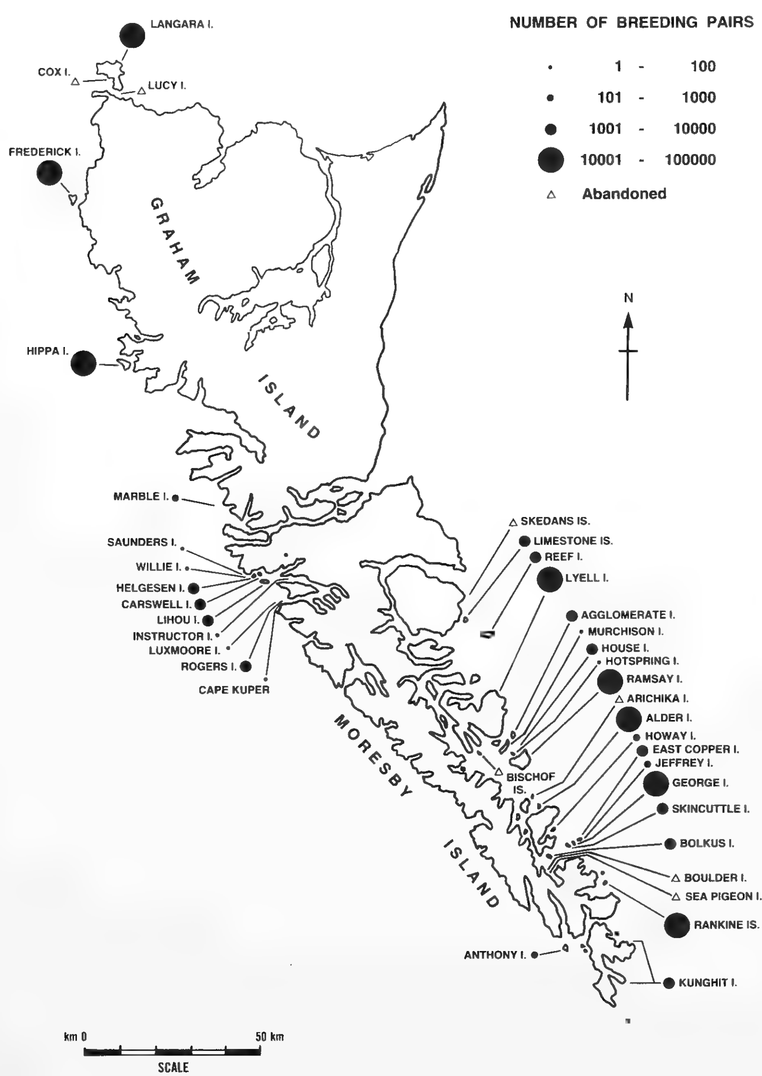

FIGURE 2. Ancient Murrelet colonies in the Queen Charlotte Islands (after Rodway 1991)

1980) and Hippa (40 000 in 1983) islands. The southern group is spread over at least 17 islands. An additional 10 smaller colonies, comprising about 20 000 breeding pairs, occur off the west side of Moresby Island (Table 1), the largest being on Lihou Island (12 000 pairs; Gaston and Masselink 1993*).

The colonies off Graham Island have been known since the early 1900s, but no attempt was made to census them until 1981. Prior to that, only general statements, such as "astronomical" (Beebe 1960), "immense numbers", or "thousands" (Drent and Guiguet 1961), were available. Consequently, we have information for only a few colonies on whether populations are increasing, stable or declining.

At Langara Island, Sealy tentatively estimated 80-90 000 breeding pairs of Ancient Murrelets in 1971 (Vermeer et al. 1984), but by then many formerly occupied areas were deserted (Nelson and Myres 1976; Sealy, personal communication). By 1981 the estimated population had fallen to 25 700 pairs (Rodway et al. 1983*). Another census in 1988 provided a similar (statistically indistinguishable) estimate, of 24 100 pairs, although the occupied area had contracted (Bertram 1989). This contraction continued, with only 23 ha occupied in 1993 and the population estimate, based on more intensive sampling than the earlier surveys, down to 15 000 pairs (A. Harfenist, in preparation). However, the density of burrows in the remaining occupied area continues to be high. Early accounts suggested that the occupied area was much more extensive than was found in the 1980s, and Rodway (1991) and Gaston (1992) independently estimated the original population at approximately 200 000 pairs.

Information for colonies other than Langara Island is less complete. Several small colonies in the southeast Moresby area disappeared during the last two decades. Murrelets were present on Low Island and the Skedans Islands in 1970, but were gone by 1983 (Summers 1974; Rodway et al. 1988). Probably neither of these sites would have supported large populations because the islands involved are very small.

On Boulder and Sea-Pigeon islands, in the inner part of Skincuttle Inlet, eggshells and the remains of dead adults were found in 1960 (Drent and Guiget 1961), but Summers (1974) found no sign of breeding in 1971. Introduced Raccoons, *Procyon lotor*, present on Boulder and Sea-Pigeon islands in 1985 (Rodway et al. 1988), may have been responsible for their abandonment by Ancient Murrelets (Rodway 1991).

Summers (1974) found abundant burrowing on Arichika Island and the Bischof Islands in 1971, estimating 500 pairs on each. By 1985 Rodway et al. (1988) could find no trace of these colonies. Although these colonies have certainly disappeared recently, the cause of their desertion is unknown.

Evidence for declines is most reliable at the East and West Limestone islands, and Lyell Island, in the South Moresby area, and at Helgesen and Instructor islands in Englefield Bay. Summers (1974), found burrows covering both the Limestone Islands, except for a small area on the east island, estimating more than 5000 pairs. In 1983, the Canadian Wildlife Service (CWS) survey team estimated about 1500 pairs on the two islands (Rodway et al. 1988), and in 1989 a similar estimate was obtained (Gaston et al. 1989*), with only a handful remaining on the west island, occupying a small portion of the northeast corner. The situation in 1993 remained similar (personal observation).

At Dodge Point, Lyell Island, in 1982 a CWS survey estimated 10 700 breeding pairs. A repeat survey in 1992 found a 25% reduction in the number of occupied burrows and a contraction of about 30% in the colony area (Lemon 1993). On Helgesen Island an estimated 7700 pairs were present in 1986, but only 1100 pairs in 1993 , while on the smaller Instructor Island the 760 pairs present in 1986 had disappeared entirely by 1993 (Rodway et al. 1990; Gaston and Masselink 1993*).

Causes of population trends

Nelson and Myres (1976) suggested that the Ancient Murrelet population declined on Langara Island because there was a reduction in the availability of food, either because of pesticide pollution, or because of changes in the marine current systems controlling local productivity. However, neither of these explanations appears likely in the light of subsequent evidence (Elliot et al. 1989; Gaston 1992).

Studies by Bertram (1989) and A. Harfenist (personal communication), showed that rats, *Rattus* spp., introduced on Langara Island some time before the 1960s, killed many adult Ancient Murrelets in their burrows. Rats collected in 1960 were *Rattus rattus*, but in 1988 *R. norvegicus* was present, presumably having displaced the former species. Evidence of rat predation on Langara had been noted earlier by Campbell (1968), Sealy (1976) and Rodway et al. (1983). Bertram found murrelet bones in 29% of all burrows searched, and they were most common in parts of the colony that had been abandoned. Bones are rarely found in burrows in colonies where rats are absent (Rodway et al. 1988; Bertram 1989; personal observation).

D. Bertram (personal communication) has suggested that fishing activity close to Langara Island may have had an effect on the Ancient Murrelet population, both through drowning in gill nets and

*For references marked * see the Documents section that preceeds the Literature Cited, all others are listed in Literature Cited.

TABLE 1. Breeding populations of Ancient Murrelets in the Queen Charlotte Islands (from Rodway 1991, amended with unpublished data from A. Harfenist and AJG).

Locality	Population (pairs)		Year	Distance to Raccoon source area (km)
WEST COAST OF GRAHAM ISLAND				
Langara Island	15 000	(R)	1993	1.0
Frederick Island	68 000		1980	0.7
Hippa Island	40 000		1983	0.7
Marble Island	1 000		1977	3.5
WEST COAST OF MORESBY ISLAND				
Saunders Island	50		1986	P
Helgesen Island	1 100		1993	P
Willie Island	10		1986	0.3
Carswell Island	1 700		1986	0.4
Instructor Island	760		1986	P
Lihou Island	12 000		1993	1.8
Luxmoore Island	1 000		1986	2.8
Rogers Island	1 700		1986	2.4
Cape Kuper, Hibben Island	10		1986	1.0
Anthony Island	200		1985	1.5
EAST COAST OF MORESBY ISLAND				
Kunghit Island	3 500	(R)	1986	P
Rankine Island	26 000		1984	1.7
Bolkus Island	9 900		1985	1.0
Skincuttle Island	2 200		1985	P
George Island	11 600		1985	P
Jeffrey Island	1 000		1985	1.0
East Copper Island	4 400		1985	1.5
Howay Island	300		1985	1.2
Alder Island	14 400		1985	0.4
Ramsay Island	18 200		1984	5.5
Hotspring Island	6		1984	5.0*
House Island	2 600		1984	5.0*
Murchison Island	20	(R)	1984	1.2*
Agglomerate Island	2 200		1985	1.2*
Dodge Point, Lyell Island	10 700	(R)	1982	1.5
Reef Island	5 000		1985	5.6
East Limestone Island	1 150		1989	P

(R) = rats present
P = Raccoons present
* = distance to nearest potential source area if Lyell Island is colonized

through birds becoming disoriented by the lights of fishing boats moored offshore. There is anecdotal evidence to suggest that many thousands of birds might have been drowned in the 1960s (C. Bellis *in* Shelford 1988*), and this seems to coincide with the period of most rapid decline of the colony. This fishery no longer operates. It is possible that, in the past, a combination of drownings and rat predation were responsible for the decline in Ancient Murrelets at Langara Island. However, rats have probably been the major cause of declines since 1981.

Rats are known to be present on at least three other islands supporting Ancient Murrelets. At Murchison Island, where *Rattus rattus* is present and common, there are only a few breeding Ancient Murrelets, although the nearby and very similar House Island supports more than 2000 pairs. The population on Murchison may have been greatly reduced by the rats.

At Dodge Point, Lyell Island, evidence of rat predation, again involving *Rattus rattus*, was found during a census in 1982. In 1992 50% of occupied burrows showed evidence of rat predation in the form of dead adult murrelets, or depredated eggs (Lemon 1993). At Kunghit Island, where *Rattus norvegicus* is present, much evidence of predation was found in 1993, including bones in burrows, but there is no baseline with which to compare the 1993 estimate of 3500 pairs. On this island, as at Langara, *R. rattus* was replaced by *R. norvegicus* between 1960 and 1993 (A. Harfenist, personal communication).

The cause of the decline observed at the Limestone Islands is almost certainly Raccoon predation. In the 1990 and 1991 breeding seasons, Raccoons were active on the east island, digging up burrows, killing adults and eating eggs. In 1991 three adult Raccoons on East Limestone Island are estimated to have killed at least 11% of breeding adult Ancient Murrelets and to have reduced the number of chicks leaving the colony by 35% (Gaston 1991*; Gaston et al. 1992*; Hartman 1993). Raccoons were removed from the island during the winter of 1991-1992 and in 1992 numbers of Ancient Murrelet chicks produced rebounded by 20%, while adult mortality was reduced by nearly 80% (Gaston and Lawrence 1993*). However, in 1993 at least one Raccoon was present and predation returned to its former level (Laskeek Bay Conservation Society, unpublished).

At Helgesen Island, seven Raccoons were counted in 1991 during a single spotlight survey at night. In November 1993, at least nine and possibly more than 12 were present. Evidence was found of heavy predation by Raccoons on seabirds. In parts of the colony where Ancient Murrelets and Rhinoceros Auklets, *Cerorhinca monocerata,* were still numerous, all fresh Raccoon scats contained feathers, suggesting that seabirds made up a major portion of the diet. Many burrows had been excavated and at some excavations Raccoon tracks and hairs were found. The area closest to Moresby Island, presumably the source area for the Raccoons, had been entirely deserted, with most birds concentrated at the south end of the island (Gaston and Masselink 1993*). Little evidence of Raccoon activity was found on Instructor Island but, like Helgesen Island, it is less than 250 m from Moresby Island at the closest point and hence visits by Raccoons are very likely (Masselink and Van den Brink 1992*).

In addition to the disappearance of murrelets from Boulder and Sea Pigeon islands, referred to above, colonies of burrow nesting Rhinoceros Auklets and Cassin's Auklets on Saunders Island, on the west coast of Haida Gwaii, have also been deserted (Rodway et al. 1990). In all cases the deserted islands showed evidence of Raccoon activity (Rodway 1991). Leaving aside the marginal colonies on Low and Skedans islands, five out of seven colony abandonments that we know of involve islands where Raccoons are, or have been, present (Rodway 1991). Raccoons are known to coexist with burrow-nesting seabirds at present only on the Limestone Islands (until removed in 1991), on Helgesen Island and possibly on Kunghit Island, where the presence of Raccoons has not been confirmed, and Skincuttle and George islands where they are believed to have just arrived. Surveys of most islands in the southern half of the archipelago in 1991 and 1992 suggested that Raccoons may be continuing to spread to the more remote islands (M. Van den Brink, personal communication).

Possible effects on Peregrine Falcon populations

The decline in the number of murrelets on Langara Island has been accompanied by a dramatic decline in the numbers of Peregrine Falcons breeding there, which fell from about 20 pairs in the 1950s to 5 or 6 pairs during 1968-1973, remaining stable since then (Nelson and Myres 1976; Nelson 1990). The Ancient Murrelet is the main prey of the peregrine at Langara Island (Beebe 1960; Nelson 1977). A possible explanation for the available observations is that peregrines declined because of pesticide contamination and that the reduction in the Ancient Murrelet population has prevented any recovery since the banning of chlorinated hydrocarbon pesticides (Gaston 1992).

Because the resident peregrines in Haida Gwaii depend heavily on small burrow-nesting seabirds, especially the Ancient Murrelet, for food (Nelson 1977; Gaston 1992), the recent declines in seabird populations must cause concern for the peregrine population, currently 50-70 pairs (British Columbia Department of the Environment). Haida Gwaii is the main breeding area in Canada for the race *Falco peregrinus pealei.*

Habitat

Most islands on which Ancient Murrelets breed are between 20-2000 ha in area. Breeding sites are situated up to 300 m, exceptionally 400 m, from the sea. They do not coexist naturally with any mammalian terrestrial predators except river otters (Gaston 1992). In Haida Gwaii, in south-east Alaska, in some places in Peter the Great Bay, and probably also in the Kuril Islands, Ancient Murrelets nest under forest. However, from Kamchatka through the Commander and Aleutian islands, and as far east as the Gulf of Alaska, most of the islands on which they breed are treeless (Gaston 1992). Where forest is available, it appears to be the species' preferred breeding habitat (Vermeer et al. 1984). Where it is absent, Ancient Murrelets usually pick the most densely vegetated area available, provided that it is not too wet. On Buldir Island, they occupy the lowland tall-plant complex, which grows about 1 m high (Byrd and Day 1986). In the eastern Aleutians they are found in *Elymus/Calamagrostis* grassland and mixed *Elymus* and Umbelliferae. Tussock grassland is probably their main breeding habitat throughout much of their

Alaskan range (Bendire 1895; Nysewander et al. 1982*), but they also breed on some small islands practically devoid of vegetation, and there they must make do with cracks in the rocks; they are common in such habitat on islands off the Alaska Peninsula (E. Bailey, personal communication).

Burrows dug by the birds themselves seem to be the most typical nest sites where there is a sufficient depth of soil. In forest habitat, in Haida Gwaii, burrows are tunnelled under the base of trees, stumps, or fallen logs, and may penetrate fissures in the underlying rocks (Drent and Guiguet 1961). Outside forest they make use of rock crevices, or burrows made among the roots of grass tussocks (Bendire 1895).

Breeding habitat quality and availability

The breeding habitat of the Ancient Murrelet in Haida Gwaii allows them to take advantage of all but the largest islands of the archipelago, as most support coastal rainforest. Some colony islands are densely burrowed throughout (e.g., Rankine Island, most of coastal Frederick Island: Rodway et al. 1988; personal observation), whereas others have large areas of apparently suitable habitat which is either unused or supports only a low density of burrows (e.g., Ramsay and Reef islands). The density of burrowing decreases from south to north among the islands of south-east Moresby. There is no evidence that the population is limited by the availability of breeding habitat, except possibly on a few very densely burrowed islands. Competition for burrowing space with Cassin's Auklets is possible in a few places where their respective breeding habitats overlap (Vermeer et al. 1984).

General Biology

Ancient Murrelets almost invariably lay two eggs. There is only one clutch per year and no replacements are laid. Where there are no introduced predators, breeding pairs rear an average of 1.5 young per year to the stage of colony departure, which takes place 2-3 days after hatching (Sealy 1976; Vermeer and Lemon 1986; Gaston 1992). Most family parties seen at sea soon after departure from their colonies consist of two adults and two chicks, so despite the precocial departure, survival of young during the first few days appears to be high (Gaston 1992).

The only information available on other aspects of population dynamics comes from studies by Gaston (1990) at Reef Island in Haida Gwaii. Birds begin to prospect for breeding sites occasionally in their first summer, but more typically in the second summer. Some, perhaps many, birds begin to breed at three and probably most do so by four. In the absence of introduced predators, the annual survival of breeding adults is about 77%, which is relatively low for an auk (Gaston 1990). The annual survival of pre-breeders may be a little higher.

Ancient Murrelets breed in Haida Gwaii in April-June. Although they are scattered while feeding, they concentrate on "gathering grounds", usually 1-3 km from their colonies, for several hours prior to going ashore (Gaston 1992). These aggregations which seem to have an important social function for the species could make Ancient Murrelets especially vulnerable to oil spills in the vicinity of their breeding sites.

Ancient Murrelets leave the vicinity of their colonies soon after the end of breeding. Family parties originating from colonies in Hecate Strait remain in the area for several weeks (Duncan and Gaston 1990) and some appear off the Goose Islands in Queen Charlotte Sound at the same period (Guiguet 1953). By August, Ancient Murrelets are uncommon in Hecate Strait, and in September they virtually disappear from British Columbia waters (Gaston 1992). Their whereabouts at this season is unknown.

Large numbers of Ancient Murrelets reappear in inshore waters off Vancouver island by late October, where they remain until mid-February (Wahl et al. 1981; Campbell et al. 1990). Smaller numbers occur at the same season in waters out to the edge of the continental shelf off Washington, Oregon and California (Ainley 1976; Balz and Morejohn 1977; Briggs et al. 1987). By March they appear in large numbers in Hecate Strait and begin visiting their colonies prior to laying which begins in early April (Sealy 1976; Gaston 1992).

Only one banding recovery of a Canadian Ancient Murrelet has been reported away from Haida Gwaii; a pre-breeder found dead in winter on a beach in Washington State. We do not know for sure that the birds that occur in winter off southern British Columbia originate from Haida Gwaii, but as the numbers involved are large and Haida Gwaii is the main breeding area in the eastern Pacific, it seems probable.

Natural changes in breeding habitat created by windthrow and by subsequent regeneration of trees seem to have little effect on Ancient Murrelets, as birds can be found breeding in all types of forest. At Limestone Island a large area cleared by a wildfire more than 20 years ago is not being used by murrelets although alder has regenerated strongly. This suggests that recolonisation following forest destruction may take a long time, although the decline of the Limestone Island population may also be involved in the lack of recolonization.

The contraction in the area occupied by the declining Ancient Murrelet colonies at Langara and Lyell islands seems to be a response to the heavy predation pressure being exerted by rats. This may indicate that birds recruiting to the colony prefer to join areas with many active burrows. Whether the consequent concentration of burrows acts to reduce or enhance the chance of predation is not known.

Pre-breeding birds have been trapped on islands other than the one where they were reared, leading Gaston (1990) to suggest that many birds disperse from their natal colony to breed. This suggestion is unproven as yet, although the rate of return of chicks banded in 1990 at East Limestone Island (only 3% of pre-breeders trapped in 1992 had been banded as chicks, although about 50% of departing chicks were banded) further supports the idea. If many recruits at Ancient Murrelet colonies were hatched elsewhere then colonies may continue to receive recruits despite experiencing low reproduction due to predation. This might explain the remarkable resilience of the Limestone Islands population and the persistence of the populations at Langara and Kunghit islands. As long as colonies subject to predation make up only a small proportion of the total regional population they may be maintained partly by recruitment from elsewhere. However, if predators spread to more colonies, a point will be reached when production at unaffected colonies can no longer compensate for losses at affected colonies. At that point we can expect the population to suffer a very steep decline, not only at affected colonies, but throughout the entire archipelago.

Limiting factors

Evidence from many parts of the Ancient Murrelets breeding range suggests that the main factor responsible for population declines in the past century has been the introduction of exotic mammals to colony islands; rats in Asia, foxes in Alaska and rats and Raccoons in British Columbia.

Before the arrival of Europeans in the 18th century, Haida Gwaii supported several mammals liable to take seabirds: the deer mice *Peromyscus sitkensis* and *P. maniculatus*, which are allopatric within the archipelago and which take eggs on occasions, the Marten *Martes americana*, the Ermine, *Mustela erminea*, and the River Otter *Lutra canadensis*, all of which might be capable of taking adult birds. At present, only the deer mice and the River Otter occur on islands occupied by seabirds. Mammals introduced since the arrival of Europeans and which occur on at least some seabird islands include the Black-tailed Deer, *Odocoileus hemionus*, the two rat species, the Raccoon and the Red Squirrel, *Tamiasciurus hudsonicus* (McTaggart-Cowan 1989). Of these, only the rats and the Raccoon have been shown to have an adverse impact on seabirds. However, some impact of squirrels can also be expected, as they are significant predators on songbird nests (J. L. Martin, personal communication)

In Haida Gwaii, numbers at Langara Island, probably the largest colony prior to this century, have fallen by more than 90%, in part due to rat predation. Several smaller colonies have been extirpated, probably by Raccoons. Populations at Helgesen and the Limestone islands have also been severely affected by Raccoons. The colony at Dodge Point is dwindling in the face of rat predation and probably also that at Kunghit Island. If we accept the conservative figure of 200 000 pairs for the original population of Langara Island, the present Ancient Murrelet population of British Columbia has probably fallen by about 50% over the past 50 years.

Rats do not appear to have spread to new islands in Haida Gwaii during the past decade, although we do not know when or how *Rattus norvegicus* arrived on Langara and Kunghit islands. Their absence from many seabird islands known to have been inhabited by non-native people for varying lengths of time in the past (e.g., Burnaby, East Copper) suggests that special circumstances may be necessary for rats to persist. However, the possibility of further introductions remains and may be exacerbated by the increased boat traffic occurring within the area of the Gwaii Haanas Park Reserve.

Hartman (1993) showed that most islands in the Haida Gwaii within a maximum water-crossing distance of 600 m from a source area now support Raccoons. However, Raccoons have also been observed on Ramsay, Skincuttle and Kunghit islands, all more than 1 km from potential source areas (Table 1). All but the furthest colonies (Langara, Marble, Reef) must be considered vulnerable to invasion by Raccoons within the next decade. Evidence obtained so far suggests that Ancient Murrelets cannot coexist indefinitely with Raccoons and that once they are established on colony islands the murrelets will eventually be extirpated.

Compared to the impact of introduced mammalian predators, other possible causes of Ancient Murrelet declines seem fairly trivial. Disturbance by tourists at breeding colonies may cause some reproductive failures in a species which is extremely sensitive to disturbance (Gaston et al. 1988a). Some disruption of family departures may be caused by artificial lights around camps, or on fishing boats or fishing lodges, because the chicks are very strongly attracted to light when leaving the colony (Gaston et al. 1988b). In the past, drowning in gill nets, especially off Langara Island, may have had a significant impact (D. Bertram, personal communication).

Ancient Murrelets, like all auks, are very vulnerable to oiling at sea. The Ancient Murrelet was one of the commonest birds killed in oil spills in the Sea of Japan (Kazama 1971). However, it has not occurred in great numbers in any spill on the west coast of North America. Ancient Murrelets comprised only 2.4% of avian corpses found on the west coast of Vancouver Island as a result of the Nestucca spill in early 1989 (Rodway et al. 1989).

Although not imminent, there is a possibility of oil exploration and development in Hecate Strait. If this took place incidental spills associated with drilling could create significant additional mortality for Ancient Murrelets. In addition, Hecate Strait and Dixon Entrance are important shipping lanes. A major spill near important colonies during the breeding season could have a significant impact on the population. The potential for damage from oil is likely to increase if the number of occupied colonies contracts further and especially if a large proportion of the population becomes concentrated on Frederick and Hippa islands.

Logging does not appear to pose a threat to Ancient Murrelets. Most of the colony islands are too small or too exposed to attract the attention of logging companies.

Although it is possible that levels of chlorinated hydrocarbons in Ancient Murrelets were high enough in the 1960s to have had an impact on the reproduction of peregrines that fed on them, no levels have been identified that suggest the murrelets themselves might be affected (Elliot et al. 1989).

To summarise, it appears unlikely that anything other than the impact of introduced mammals can have caused the recent and continuing decline of the Ancient Murrelet population in Haida Gwaii.

Special significance of the species

The Ancient Murrelet is the most numerous member of its genus. The other three congeners all have very small ranges (Craveri's Murrelet, *Synthliboramphus craveri*, Baja California; Xantus' Murrelet, California; Japanese Murrelet, *S. wumizusume*, Japan). The Ancient Murrelet's closest relative, the Japanese Murrelet, is severely endangered (Collar and Andrews 1988; Piatt and Ford 1993). The genus is unique, among seabirds, in having chicks that are fully precocial and which go to sea at 2-3 days old, never having been fed in the nest. Many interesting physiological adaptations are associated with this precocial strategy (Duncan and Gaston 1988, 1990; Gaston 1992).

Rodway (1991) considered that 74% of the world population bred in Haida Gwaii. However, this was based on the very low estimate for Alaska given by the U.S. Fish and Wildlife Service (1988). Assuming that Alaska supports at least 200 000 pairs at present, and that there are a further 25 000 pairs in Asia (Gaston 1992) it appears that the population of Haida Gwaii constitutes about half the world total. If V. Mendenhall's guess (personal communication) that the Alaska population could be as high as 800 000 birds (400 000 pairs) is correct, the proportion in British Columbia would be a little over 30%. For the moment, pending better information from Alaska, it is probably best to consider that Canada supports about half the world population.

Ancient Murrelets were harvested in the past by the natives of Haida Gwaii, a practice that persisted into the 1960s (R. W. Campbell, personal communication). Many of the older Haida remember eating them. Hence the birds have some cultural significance. The Masset band council has expressed concern about the declining population at Langara Island (*per* G. Kaiser).

The Ancient Murrelet has become the "flagship" of conservation efforts in Haida Gwaii, especially by the Laskeek Bay Conservation Society, which is trying to encourage the control of introduced animals in the archipelago. Locally and in the Canadian Park Service, there is a lot of concern about the more cryptic impacts of Raccoons, especially on the intertidal fauna. Protecting Ancient Murrelets can help to focus attention on the whole issue of the ecosystem effects of introduced animals.

Evaluation

Although there are currently about 200 000 pairs of Ancient Murrelets breeding in Canada, this is well below numbers a few decades ago. The declines at the rat-affected colonies on Langara, Lyell and Kunghit islands could result in extirpation fairly soon unless rats can be controlled. Rats are known to have extirpated the very similar Japanese Murrelet from at least one colony in the past decade (Takeishi 1987). They are a worldwide scourge of insular avifaunas (Atkinson 1985).

Raccoons threaten most of the other colonies, of which Helgesen Island (formerly 7700 pairs), Alder Island (14 400 pairs) and the Copper islands (aggregate of nearly 30 000 pairs) seem to be the most immediately at risk. The two largest colonies, Frederick and Hippa islands, are separated from the mainland of Graham Island by less than 1 km and must be vulnerable to invasion by Raccoons. Both are large islands with substantial intertidal areas and hence could support large Raccoon populations through the non-breeding season.

Given the difficulty inherent in trying to eradicate rats from large, wooded islands, and the fact that Raccoons seem likely to spread to other Ancient Murrelet colonies soon, the long term outlook for the species is not good. With several colonies on islands that are far offshore (Rankine, Ramsay, Reef with approximately 50 000 pairs between them), the total extirpation of the species seems unlikely in the near term. However, if all colonies within 1 km of possible Raccoon source areas were to be extirpated and the populations on Langara and Lyell were wiped out by rats, the remaining population would be less than 80 000 pairs. In addition, a Raccoon has been sighted on Ramsay Island, more than 6 km from a source area, so there is no guarantee that even the remotest islands will not be colonized eventually. If Lyell Island is colonized, which seems probable considering its size, and the fact that the waters of Darwin Sound, which separate it from Moresby Island, are relatively sheltered, House, Hotspring and Ramsay islands will be vulnerable via the "stepping stones" of Faraday and Murchison islands. Ultimately, without constant monitoring and control of Raccoons in the archipelago, Ancient Murrelets could be totally extirpated from the islands, along with tens of thousands of other burrow-nesting seabirds.

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Notes

A Southern Breeding Range Extension of the Lesser Snow Goose, *Chen caerulescens caerulescens*, James Bay, Ontario

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McRae, Doug, Robert Stitt, and Nancy C. Wilson. 1994. A southern breeding range extension of the Lesser Snow Goose, *Chen caerulescens caerulescens*, James Bay, Ontario. Canadian Field-Naturalist 108(2): 223.

Breeding evidence for a pair of blue phase Lesser Snow Geese was documented over two consecutive years (1990, 1991) at Longridge Point in southwestern James Bay, 165 km south of the nearest regular breeding colony.

Key Words: Lesser Snow Goose, *Chen caerulescens caerulescens*, breeding, extralimital.

In 1990 and 1991 one pair of Lesser Snow Geese (*Chen caerulescens caerulescens*) bred at Longridge Point (51°50'N, 80°42'W) on the south-west shore of James Bay. This site is 85 km south of an extralimital nesting at the mouth of the Opistokwayau River (52°21'N, 81°35'W) in 1969 (Hanson et al. 1972), and is 165 km south of the nearest known regular breeding colony on the north shore of Akimiski Island, NWT (53°13'N, 81°20'W).

Breeding at Longridge Point was first recognized on 11 July 1990 during a Canada Goose (*Branta canadensis*) banding operation when two flightless adult "Blue" geese, accompanied by five flightless juveniles were located. The adults and two young were banded with standard US Fish and Wildlife Service bands and released. On 6 June 1991, a nest containing five eggs was located during a wildlife habitat assessment project. The nest was located at the edge of a small tidal creek running through the same large supertidal meadow where the 1990 observations were made. Both adults were banded blue-phase individuals, suggesting they were the same pair encountered the previous year. On 8 June, the nest was next checked but was found destroyed by an unknown predator. Photographs of the destroyed nest were taken and eggshell fragments were deposited in the Royal Ontario Museum (Catalogue Number 13273). No intensive search of the area was made in 1992, but a low pass by helicopter on 31 May revealed no Snow Geese.

Although the Longridge Point breedings appear extralimital in nature, they may be suggestive of similar events in the future. Lesser Snow Goose populations have increased dramatically in recent decades, causing considerable habitat stress at existing colonies (Kerbes et al. 1990). This habitat degradation appears to be forcing geese to expand to new breeding areas, possibly accounting for the record presented here.

Acknowledgments

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Recent Confirmation of a Cougar, *Felis concolor*, in New Brunswick

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Cumberland, Roderick E., and Jeffrey A. Dempsey. 1994. Recent confirmation of a Cougar, *Felis concolor*, in New Brunswick. Canadian Field-Naturalist 108(2): 224–226.

The presence of Cougar (*Felis concolor*) in the northeast, specifically New Brunswick, has been a controversial topic for decades, due primarily to an abundance of reports and sightings confounded by a lack of physical evidence. However, on 16 November, 1992, characteristics and measurements of tracks and identification of hair from a scat found near Deersdale New Brunswick were determined to be that of a Cougar. Confirmation of the endangered subspecies, the eastern Cougar (*Felis concolor couguar*) is not possible with the collected data.

Key Words: Cougar, *Felis concolor*, Eastern Cougar, *F.c. couguar*, New Brunswick.

The existence of the Eastern Cougar (*Felis concolor couguar*) has long been a controversial topic of discussion in eastern Canada and the United States. Allen (1894), and Boardman (1899) felt that the presence of the Cougar was well authenticated, while Gesner (1847) and Ganong (1903) suggested that there was no authentic evidence of the Cougar's existence in New Brunswick. Another advocate of the Eastern Cougar throughout the mid 1900s was the late Bruce Wright (1948, 1953, 1959, 1961, 1965, 1972), who compiled accounts and reports that he felt substantiated the animals, existence. Despite his conclusions, Van Zyll de Jong and van Ingen (Status of the Eastern Cougar in Canada, National Museum of Natural Sciences, Ottawa, Canada Unpublished Report 1978) reviewed data on the eastern subspecies in the Maritimes over this same time period and concluded that no reliable estimates of the number of Cougar could be made.

In the spring of 1990, a tawny cat was taped on home video at the edge of field near Fredericton, New Brunswick. Tischendorf (1990) investigated the poor quality videotape and concluded that it was a young Cougar, although not all officials shared his conclusion. Rainer Brocke, a professor at the State University of New York in Syracuse, states that there is no viable breeding population of Cougars in the northeast. He believes that only 5% of sightings are reliable and these may only be of escaped captive animals (Hansen 1992).

Although sightings of the animal in New Brunswick are frequent, actual physical evidence of animals has been lacking for over 50 years, since the last reported Cougar was killed at the Maine, USA/Quebec/New Brunswick border in 1938. This specimen is now in the collections of the New Brunswick Museum Catalogue Number NBM 5678. The only other catalogued evidence of a Cougar in New Brunswick was a 1932 photograph of a skin from a Cougar shot in Kent County (Wright 1972).

The Eastern Cougar is listed as a nationally endangered species by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). In New Brunswick, the Eastern Cougar has been protected under the Endangered Species Act since the Act was proclaimed in 1976. However, lack of concrete evidence of a viable population has made it difficult to validate its status as endangered. The Canada Lynx (*Lynx canadensis*) is also listed as endangered in New Brunswick and are occasionally trapped incidentally during the Coyote (*Canis latrans*) and Bobcat (*Lynx rufus*) seasons (four incidental Lynx were reported in the 1992-1993 fur harvesting season alone). In comparison, Cougar have never been reported to be trapped, shot or found dead in New Brunswick over the last 50 years. This note reports on field observations and laboratory analysis that confirm the first indisputable evidence of the presence of a Cougar in New Brunswick.

Materials and Methods

Data were gathered approximately 5 km north of McKiel Lake, west-central New Brunswick (43'22" N and 67'00" W). The area, a one million acre tract of land belonging to J. D. Irving Woodlands (Deersdale Division), is high, cool temperate forest characterized by a predominance of Balsam Fir (*Abies balsamea*) and spruce (*Picea* spp.) in lowlands and dominant hardwoods on more upland sites. It is classified as Miramichi highlands with elevations up to 800 m, annual snowfall over 400 cm and mean annual precipitation over 1200 mm (S. L. Lusk, 1990, Wildlife Management Zones. Unpublished New Brunswick Department of Natural Resources and Energy Report). Timber harvesting has produced a mosaic of clearcuts and conifer plantations of various ages interspersed with hardwood, mixedwood and softwood stands.

On 16 November 1992, Tom O'Blenis of the J. D. Irving Woodland's Deersdale Division reported large cat-like tracks along a woods road on their freehold land. Tracks were visible in snow that had fallen one day prior to the report, resulting in a light, fluffy snow accumulation of 10 cm. Daily maximum temperatures at the Juniper, New Brunswick weather office did not exceed -2° Celsius before we investigated the tracks, reducing the likelihood of enlarged or distorted tracks.

We followed the tracks for over 2.5 km along a skidder trail, then into hardwood saplings which led to a dominant hardwood stand. From here the tracks meandered down a ridge and passed through balsam fir thickets. Stride was measured where the same foot touched the ground twice, measuring from the front of both tracks. Stride, plus length and width of the tracks, were measured in the shade and through all habitat types encountered along the trail. Careful observation was made of every tree/branch that the animal might have contacted. Only one sample of hair was collected along the animal's trail and identified by the observers using cuticular scale patterns (Adorjan and Kolenosky 1969; Carter and Dilworth 1971).

Scat was found approximately 400 meters along the trail in association with the tracks. The scat was on top of a rock and not covered by debris, a characteristic of the cat family. The size of the scat suggested its origin could have been Bobcat, Lynx, Coyote or Red Fox (*Vulpes vulpes*). Hairs from the scat were analyzed by Dr. C. G. Van Zyll de Jong then at the Canadian Museum of Nature in Ottawa, by using reference specimens with respect to pigmentation, shape, length and width dimensions, cuticular scale patterns and nature of the medulla.

Results and Discussion

A total of 30 stride measurements were recorded along the length of the trail and resulted in an average stride of 109.4 cm (43.8 inches). Eighteen individual measurements of track length and width resulted in average dimensions of 9.72 cm wide by 9.62 cm long (3.9 by 3.8 inches). In addition, we measured a 15.9 cm straddle (width from outside of left foot to outside of right foot), a leap 5.25 m long and 1 m high over balsam fir saplings without disturbing snow on top of the saplings, tracks along two logs for over 3 m and measurements where the animal had sat on its haunches (34.4 cm long including heel impression).

The tracks revealed strong feline characteristics, including width equal to or greater than the length, deeper impression of the front of the plantar pad, tear-drop shaped toes, non-symmetrical pattern to the toes and lack of claw marks. Balance required to walk along logs several feet above the ground over a considerable distance is also typical of felines and not indicative of canines.

Stride changed little throughout the different forest covertypes. The 110 cm average stride is double the typical Bobcat and Lynx stride (Murie 1974; Dixon 1982).

Microscopic analysis of the hair sample found on a Balsam Fir sapling along the track trail was identified as underfur from a Coyote. All characteristics of the hair found in the scat were consistent with that of Cougar.

There have been over 100 credible sightings of "Cougar" over the last 16 years in the Maritimes (R. F. Stocek, personal communcation 24 September 1990. Eastern Cougar sightings in the Maritime provinces, Atlantic Society of Fish and Wildlife Biologists Annual Meeting, Mill River, Prince Edward Island). Tracks reported from previous cougar sightings have been identified as Coyote, Fisher (*Martes pennati*), Bobcat, housecats (*Felis* spp.) or occasionally Lynx. Robert Downing, after five years of tracking Cougar in the eastern United States, found that sighting reports were generally unreliable (Hansen 1992).

Although we present indisputable evidence of a Cougar in New Brunswick, we cannot distinguish subspecies from these data. Therefore, these data lend little support to the existence of a remnant Eastern Cougar population. It is possible that the animal responsible for the tracks could have been an escaped or released animal. Photographs of the tracks, slides of the hair from the scat as well as a portion of the scat itself are on collection with the New Brunswick Museum in Saint John, New Brunswick.

Acknowledgments

We acknowledge L. Stone, JDI Woodlands Division, for notifying our Department about the tracks, L. Grant for accompanying us, C. G. Van Zyll de Jong for his scat analysis, and R. Stocek, D. McAlpine, and G. Redmond for their review of this manuscript.

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Range Extension and First Holocene Record of the Arctic Shrew, *Sorex arcticus*, from the Driftless Area, Southeastern Minnesota

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Jannett, Frederick J., Jr., and Ronald L. Huber. 1994. Range extension and first Holocene record of the Arctic Shrew, *Sorex arcticus*, from the Driftless Area, southeastern Minnesota. Canadian Field-Naturalist 108(2): 226–228.

A specimen of the Arctic Shrew, *Sorex arcticus*, was secured in extreme southeastern Minnesota, at a locality within the late Pleistocene Driftless Area. This new record extends the known range approximately 198 km and is discussed in the context of the Pleistocene distribution of the Arctic Shrew.

Key Words: Arctic Shrew, *Sorex arcticus*, Driftless Area.

Sorex arcticus is a boreal species with large geographic and broad ecological ranges across Canada (van Zyll de Jong 1983). In the United States, the species reaches the southern limit of its distribution in Wisconsin and Minnesota (Hall 1981). Heaney and Birney (1975) reported it to be common in a grass-sedge meadow and at the edges of a marsh near what was thought to be that limit, Anoka County, Minnesota. Hazard (1982) depicted the known localities in Minnesota as extending south only as far as the Minnesota River and the Mississippi River east of its confluence with the Minnesota River.

We report finding a *S. arcticus* dead on a road in Beaver Creek Valley State Park, Houston Co., the most southeastern county in Minnesota, on 3 May 1980. The specimen was a parous female with seven embryos. The standard measurements (total, tail, hindfoot, and ear(n) lengths, in mm; weight, in g) were, respectively, about 105 (the rostrum was broken off cleanly), 39, 13.5, 7, and 8.8. Identification was made on the basis of cranial and mandibular characters, and the tricoloration typical of this species (Junge and Hoffmann 1981).

Beaver Creek Valley is narrow (about 650 m wide at the top) and deep cut (about 90 m maximum depth). The forest canopy was originally Boxelder (*Acer negundo*), Cottonwood (*Populus deltoides*), American Elm (*Ulmus americana*), maple (*Acer* spp.), Basswood (*Tilia americana*), and oaks (*Quercus* spp.), much of which persists today with an assemblage of at least eight plant species officially recognized by the state of Minnesota as endangered, threatened, or of special concern (K. Bolin, personal communication). Surrounding land is intensively and extensively cultivated. Attempts to secure additional specimens here and elsewhere in the area failed in 1990 and 1991, although the effort was hampered by flash floods and, presumably, Raccoons (*Procyon lotor*). Nor was *S. arcticus* secured on algific (cold air producing) talus slides elsewhere in southeastern Minnesota in 1984.

The historic and geographic patterns of this species in Minnesota are uncertain. First, it is possible that the species distribution is currently and historically continuous between the more northern localities (Hazard 1982) and the one in Houston Co., and that it is simply not documented in the hiatus of approximately 198 km. This is not likely considering extensive collecting in this region of the state. Secondly, the species may be expanding its range. Frey (1992) correlated the southward expansion of the range limits of four species of boreal small mammals with recent cool, mesic climatic

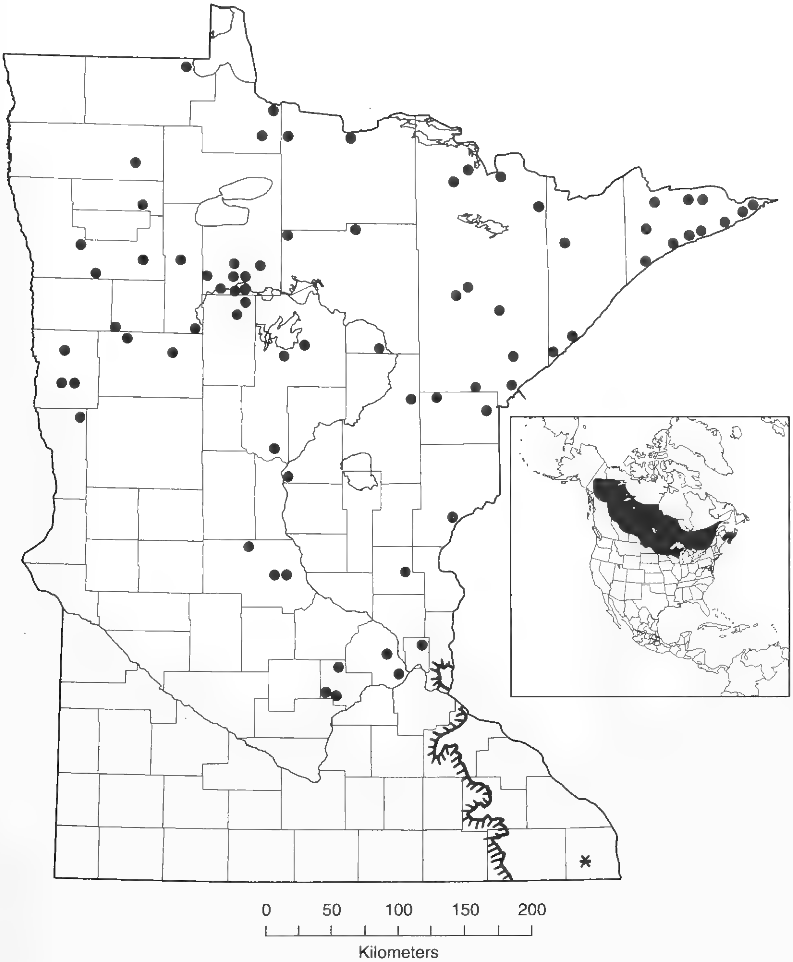

FIGURE 1. Range of *Sorex arcticus* [after Hall (1981)], extent of the Driftless Area in Minnesota [hachured line after Hobbs and Goebel (1982)], previous specimen localities in Minnesota [after Hazard (1982)], and new locality (*).

patterns. The southward range extension of *S. arcticus* reported here may be another example of this phenomenon. Lastly, the range of *S. arcticus* in Minnesota may be disjunct and the population in Houston Co. may be relictual. *Sorex arcticus* occurred on the Great Plains during the Pleistocene (Stewart 1987; Wells and Stewart 1987). Extreme southeastern Minnesota was part of the Driftless Area, which included contiguous parts of Wisconsin, Iowa, and Illinois and which is generally recognized as having been free of the late Wisconsin ice sheet (e.g., Mickelson et al. 1983). *Sorex arcticus* is documented from the late Pleistocene Driftless Area of Wisconsin (Foley 1984). This region is known for other relict species, including, for example, an assemblage of land snails (Frest 1991). It has been suggested (Rand 1954; Youngman 1975; Junge et al. 1983) that *S. arcticus* has expanded its range northward into Canada since glacial retreat. If so, one explanation of the relict population in southeastern Minnesota is that the range there may have been continuous with that of more northerly populations until the species disappeared from what is now the intervening hiatus during a Holocene warming period (Dorale et al. 1992).

This specimen is Science Museum of Minnesota (SMM) number Z82:1:10.

Acknowledgments

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Yearling Black Bear, *Ursus americanus,* Gives Right-of-Way to Adult Coyote, *Canis latrans*

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Proulx, Gilbert, Pauline Proulx, James M. Groenewegen, and Lene Groenewegen. 1994. Yearling Black Bear, *Ursus americanus,* gives right-of-way to adult Coyote, *Canis latrans,* Canadian Field-Naturalist 108(2): 229.

In July 1993, we observed a yearling Black Bear (*Ursus americanus*) giving the right of way to an adult Coyote (*Canis latrans*), 20 m away. There is no evidence in the literature that yearling Black Bears should fear adult Coyotes.

Key Words: Black Bear, *Ursus americanus*, Coyote, *Canis latrans*, Peter Lougheed Provincial Park, Alberta.

Accounts of Wolf (*Canis lupus*) and Black Bear (*Ursus americanus*) interactions have been reported during recent years (Rogers and Mech 1981; Horejsi et al. 1984; Paquet and Carbyn 1986). However, published records of interactions between Black Bears and Coyotes (*Canis latrans*) are scarce. Cahalane (1961: 251) reported seeing a Coyote sauntering behind a bear that was after rodents. Sometimes, the Coyote nipped at the bear; when the bear dropped its food to turn around and charge, the Coyote stole the prey and ran away. Bowen (1981) reported, without interpretation, the presence of Black Bear (*Ursus americanus*) remains in eight Coyotes' summer feces. Cahalane (1961: 250) also reported Black Bear hair in the fall stomach contents of three Coyotes in Yellowstone. He concluded that this was the result of scavenging. Conversely, Coyote remains were found in four late summer Black Bear scats in Alberta (Holcroft and Herrero 1991).

On 2 July 1993, we were hiking along the eastern shore of the Lower Kananaskis Lake, in Peter Lougheed Provincial Park, Alberta. At 10:00 h, we observed a Black Bear about the size of a yearling ambling on the west shore of the lake, approximately 0.5 km away from us. The bear headed south and we followed its regular but leisurely pace for > 200 m. Suddenly, the bear ran toward the forest cover with its head turned toward an adult Coyote. The Coyote was approximately 20 m away from the bear and was slowly moving north. The Coyote then investigated grass patches along the shore, about 20 m north of where the bear had fled. Approximately 1 km to the south, the bear reappeared on the shore to continue south. Our observation suggests that the Black Bear fled from the Coyote. Knowing that single Wolves tend to flee from bears (Rogers and Mech 1981), the bear's reaction may appear strange. However, at the time of our observation, this yearling bear had probably recently broken up from its family (Rogers 1987; Schwartz and Franzmann 1992) and its get-away may be indicative of some level of temporal insecurity.

Acknowledgments

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Skeletal Injuries of an Adult Timber Wolf, *Canis lupus*, in Northern Ontario

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Mallory, Frank F., T. L. Hillis, C. G. Blomme, and W. G. Hurst. 1994. Skeletal injuries of an adult Timber Wolf, *Canis lupus*, in northern Ontario. Canadian Field-Naturalist 108(2): 230–232.

The carcass of an adult male Wolf (*Canis lupus*), snared in late December in Waldey Township, was recovered and the skull cleaned. Upon examination it was evident that the animal had suffered a comminuted fracture of the left mandible. Upon further examination other injuries were noted. All injuries were in the process of healing.

Key Words : Timber Wolf, *Canis lupus*, skull injuries, northern Ontario.

Any time a wolf attempts to capture prey larger than itself, it places itself in a hazardous position. Reports of nonfatal injury to wolves by prey are infrequent because of the inability to observe such occurrences (Mech 1970; Mech and Nelson 1989). Some incidents of injury as a result of prey encounters have been observed (Stanwell-Fletcher and Stanwell-Fletcher 1942; Mech 1970; Frijlink 1977; Gray 1987; Mech and Nelson 1989) or are reported from collection of carcasses for other purposes (Young and Goldman 1944; Rausch 1967; Nelson and Mech 1985; Mech and Nelson 1989; Pasitschniak-Arts et al. 1988; Hillis 1990). Traumatic injuries to the lower jaw may result from bullet wounds, physical injuries or hunting confrontation with big game. These injuries may be seen in a healed state well after the initial impact has occurred (Pasitschniak-Arts et al. 1988). This note reports on an incident of a wolf injured by a severe impact, by the nature of the injury, suspected as a blow by a Moose, *Alces alces,* in northern Ontario.

An adult male wolf was snared in late December in Waldey Township, approximately 90 km southwest of Sudbury, Ontario. Observations at the site indicated that it was a member of a pack frequently seen at a bait-set and that it was having difficulty feeding. Tracks other than its own were observed at the snare site and the animal appeared in good condition (W. G. Hurst, personal communication). A post mortem examination showed that although lacking subcutaneous fat reserves (visual fat index = 2; Kirkpatrick 1980) both the marrow and fur were in good condition

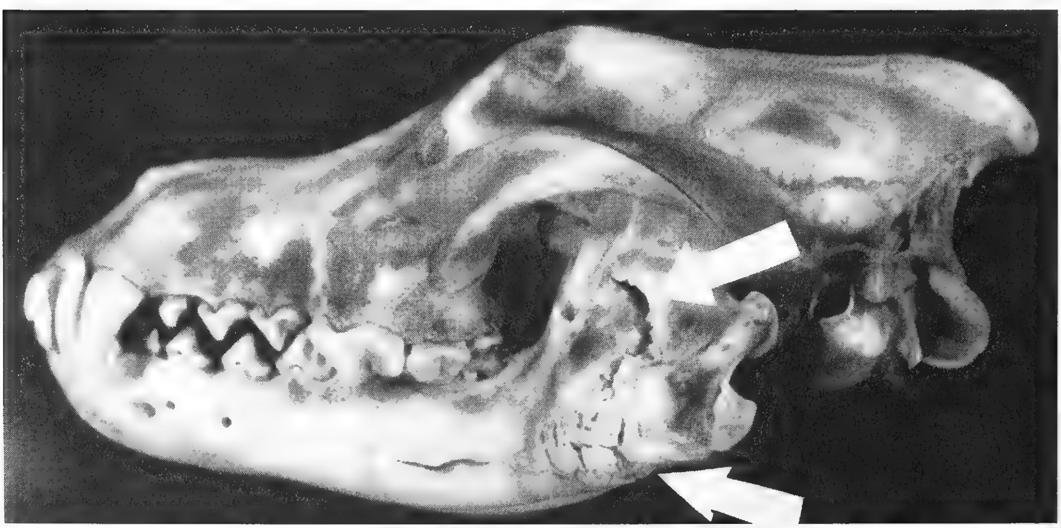

FIGURE 1. Skull of wolf showing comminuted fracture of the left mandible with the major fracture line travelling through the ramus cranial to the coronoid process.

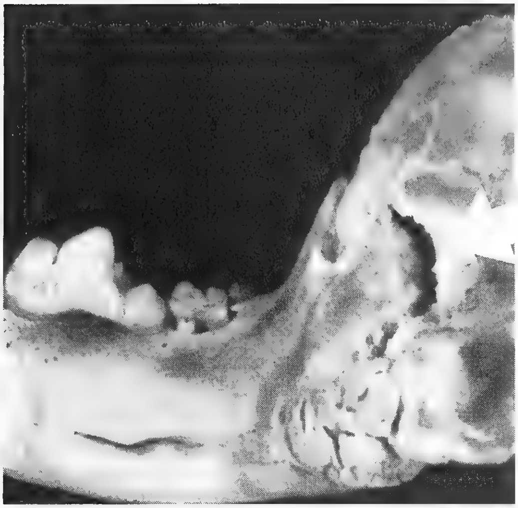

FIGURE 2. Angle showing oblique fracture travelling cranially along the body of the mandible to the level of the third premolar tooth and then travelling dorsal and ventral at the level of the carnassial tooth .

(W. G. Hurst, personal communication) ruling out any indication of starvation at this point.

A post-mortem inspection of the wolf's skull was conducted by R. H. Jouppi at the Walden Animal Clinic in Lively, Ontario. Results of the examination indicated that the animal had suffered a comminuted fracture of the left mandible with the major fracture line travelling through the ramus cranial to the coronoid process (Figure 1). This fracture site appears to have occurred at least four weeks prior to death because of the extensive osteophyte production and the formation of a large periosteal callus. The fracture site was, however, probably less than four weeks of age since the fracture line was still not fully healed with new bone and much of the fixation consisted of cartilage: nous and cancellous type bone.

There was also an oblique fracture travelling cranially along the body of the mandible to the level of the third premolar tooth and then travelling dorsal and ventral at the level of the carnassial tooth (Figure 2). These lines were healing with a minimum of periosteal callus, showing that they were being held more rigidly than the main fracture through the ramus.

The large fracture through the ramus may have had some infection (osteomyelitis) present. The fracture was healing with a minimum of mediolateral overriding and alignment seems conducive to appropriate function. The cranial root of the second molar was also fractured, which may have occurred at the time of the initial injury.

Whether or not the animal may have recovered fully cannot be disclosed from information provided; however, the fractures were healing and alignment of the lower jaw was evident. Such damage to skulls is relatively high; Phillips (1984) reported a frequency of 22 % cranial injuries due to blows by hooves of prey; Rausch (1967) also reported numerous skulls (25%) with compression fractures . Mech (1970) hypothesized that inexperienced pups would stand a higher chance of being injured; however, from the reported incidences of wolf injuries it appears that adults (specifically adult males) have a higher chance of injury (Pasitschniak-Arts et al. 1988; Mech and Nelson 1989; Weaver et al. 1992; L. D. Mech, personal communication). This may further support the theory that males have first contact with prey, being, therefore at higher risk (Hillis and Mallory *in press*; L. D. Mech, personal communication). The observations made in this report may further support the theory that during the critical period following a severe injury wolves are dependent on other pack members for food and the social nature of wolves facilitates the survival of wounded individuals (Rausch 1967; Pasitschniak-Arts et al. 1988).

Acknowledgments

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Problem-solving by a Foraging Wild Red Fox, *Vulpes vulpes*

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Ommundsen, Peter D. 1994. Problem-solving by a foraging wild Red Fox, *Vulpes vulpes*. Canadian Field-Naturalist 108(2): 232–233.

Problem-solving by the Red Fox (*Vulpes vulpes*) has been demonstrated in the laboratory but has rarely been observed in the wild. I describe here an example of problem-solving behaviour in a wild Red Fox foraging for Arctic Ground Squirrels (*Spermophilus parryii*) in a natural environment.

Key Words: Red Fox, *Vulpes vulpes*, behaviour, foraging, problem-solving, reasoning.

Knowledge of food procurement adaptations of carnivores is important to the study of community ecology and optimal foraging theory. Species-specific foraging strategies may determine competitive interactions in resource-limited environments (Pyke 1984; Hanson 1987; Theberge and Wedeles 1989; Paquet 1992). The Red Fox (*Vulpes vulpes*) commonly hunts by stalking and pouncing, but may execute a high-speed charge (Dekker 1983; Henry 1986). A typical predator kill may be characterized as a stimulus-response-reinforcement sequence (Cheney 1982). However, the Red Fox and other canids also occasionally exhibit problem-solving behaviour. Problem-solving refers to novel and extrapolative behaviour, also termed elementary reasoning, means-end reasoning, high-order behaviour, purposeful behaviour, insight behaviour, foresight behaviour, and cognitive vs. instinctive behaviour (Fox 1971; Molodkina et al. 1978; Frank and Frank 1982).

Although there exists laboratory evidence for problem-solving by the Red Fox (Molodkina et al. 1978), field evidence is scarce. Henry (1986) witnessed several episodes of predation in which a fox, after a failed pursuit, "waited", presumably sleeping or feigning sleep, until its prey ventured forth again. One wait lasted 12 minutes. He termed this manoeuvre the slumbering strategy. I report here a rarely observed foraging behaviour of the Red Fox which is a different example of problem-solving by a fox in a natural environment.

I observed the behaviour of a wild Red Fox hunting Arctic Ground Squirrels (*Spermophilus parryii*) in Denali National Park, Alaska. The sequence of events described occurred within a ten minute period beginning at 1220 h on 24 June 1973. The habitat was gently sloping tundra at 1200 m elevation, with a southern exposure (63°26′N, 150 17′W).

An adult Arctic Ground Squirrel was feeding on vegetation when a Red Fox approached the squirrel colony from afar. The fox charged the squirrel, which evaded the fox by running to a tunnel in the ground (hereafter termed the "entrance"). The fox stopped at the entrance and scanned the tundra. Within one minute the squirrel reappeared at another opening in the ground (hereafter termed the "exit") seven m from the entrance and within view of the fox. The fox retreated, and the squirrel emerged and returned to its feeding site. The fox rushed the squirrel a second time, with the same results. The squirrel safely reached the entrance, soon reappeared at the exit, emerged, and resumed feeding. The fox then rushed the squirrel a third time, but when the squirrel disappeared into the entrance, the fox altered course and ran directly to the exit, where it waited with mouth open. The squirrel promptly appeared at the exit, as it had on the two previous occasions, and was immediately captured by the fox. It appears as though the fox, unable to capture the squirrel by rushing it, solved the problem by devising a new strategy (interception) based upon observation of the squirrel's past behaviour.

Skinner (1953) describes four requirements necessary to demonstrate problem-solving behaviour. (1) A problem must exist. The nature of the problem can be inferred by the behaviour of the organism trying to solve it, and can be confirmed retrospectively once the problem is solved. In this instance, the problem facing the fox was its inability to capture the ground squirrel. The nature of the problem is evident by the pursuit and is confirmed by the capture. (2) Immediate or trivial solutions must be unavailable. In this situation, the initial behaviours (repeated charging) did not solve the problem. An immediate solution was not available to the fox; a different tactic was required in order to solve the problem. (3) The problem must be solved by manipulation of the variables. This occurred. The fox repositioned itself in space and time relative to the anticipated behaviour of the ground squirrel. It was this change in strategy that solved the problem. (4) Accidental solutions must be ruled out. It was hardly coincidental that the fox ran directly to the burrow exit, opened its mouth, and waited, moments before the squirrel was to emerge. The fox had an opportunity to witness the movement patterns of the squirrel, then intercepted it at precisely the appropriate time and location.

Molodkina et al. (1978) have demonstrated that the Red Fox is capable of novel extrapolative behaviour in locating a food stimulus that is moved out of sight by an experimenter. These investigators found that individual foxes differed in their problem-solving abilities and speculated that this trait was subject to selection in the wild. They also documented differences in problem-solving ability among canid species, as did Krushinsky (1980), and Frank and Frank (1982).

In conclusion, I suggest that the incident described in this report is an example of problem-solving resulting in improved foraging efficiency. Problem-solving phenotypes within a population may confer behavioral plasticity of competitive and selective advantage.

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Breeding Site Fidelity in Harris' Sparrows, *Zonotrichia querula*, in the Northwest Territories

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Norment, Christopher J. 1994. Breeding site fidelity in Harris' Sparrows, *Zonotrichia querula*, in the Northwest Territories. Canadian Field-Naturalist 108(2): 234–236.

I studied site fidelity of Harris' Sparrows (*Zonotrichia querula*) in the Northwest Territories, Canada, in 1989-1990. Return rate for adults in the first year following banding was 34% (n = 44). Return rates for males (nine of 22) and females (six of 22) in the year following banding did not differ significantly. Banded male and female Harris' Sparrows that bred successfully returned at a higher rate the following year than did birds that bred unsuccessfully (males: 86% vs. 40%; females 86% vs. 10%), although small sample sizes make any conclusions about a cause-effect relationship tentative. Returning males often occupied the same territories in successive years, but returning females always moved their nest sites. No banded Harris' Sparrow nestlings were resighted the year following banding.

Key Words: Harris' Sparrow, *Zonotrichia querula*, site fidelity, Northwest Territories, philopatry.

The Harris' Sparrow, *Zonotrichia querula*, is a medium-distance intracontinental migrant that winters in the central United States (Root 1988) and breeds only in the forest-tundra ecotone of northern Canada (Norment and Shackelton 1993). Breeding site fidelity has not been studied previously in Harris' Sparrows, and there are few published data on the topic for passerines breeding at high latitudes in North America. In this note I report on site fidelity in Harris' Sparrows breeding in the Northwest Territories, Canada.

Study Site and Methods

The study was conducted at Warden's Grove (WG), Thelon Game Sanctuary, Northwest Territories, Canada (63°41′N, 104°26′W) during the summers of 1989, 1990, and 1991. The 2.0 km^2 study site was located adjacent to the Thelon River, near the southern border of the Low Arctic (Bliss 1981), and contains a mosaic of isolated spruce (*Picea* spp.) stands and extensive tundra vegetation. Detailed descriptions of the study site were given by Norment (1985, 1992).

Data on Harris' Sparrow return rates were collected during field work on the breeding ecology of the species (Norment 1992). Adults were individually marked with aluminum and colored plastic leg bands. Nests were located by searching breeding habitat or following birds to nests. The study area was traversed daily during nest checks, and areas up to 2 km from the boundaries of the study area were searched for marked birds throughout the breeding season.

Results

During 1989–1991 81 adult Harris' Sparrows were banded. Sixty-four Harris' Sparrow nests were found; 53.3% of the known nests had at least one marked bird present.

Annual return rate of adults

The overall return rate (males and females resighted on the study area) for adults banded in 1989 and 1990 was 38%; return rates in 1990 and 1991 were similar (Table 1). First-year return rates for birds banded in 1989 and 1990 was 34% (n = 44). Four adults banded in 1989 (three males and one female) also were found on the area in 1991, a second-year return rate of 31%. First-year return rates for males (nine of 22) and females (six of 22) did not differ significantly (χ^2 test with Yate's correction, P > 0.05). First-year return rates for a small sample of sympatric White-crowned Sparrows (*Zonotrichia leucophrys*) (n = 16) was higher for males (three of eight; 37.5%) than for females (one of eight; 12.5%).

Nest success and return of males

In 1989 and 1990 seven of 12 nesting attempts involving banded males were successful. Six of seven successful males (86%) returned the following year, while only two of five unsuccessful males (40%) returned. In 1990, two males returned to the same territories that they occupied in 1989. Of these birds, one participated in raising a successful brood in 1989. In 1991, the breeding status of seven returned male Harris' Sparrows was known; six had raised successful broods in 1990. Four of these males occupied the same territories as in 1990, including one that also had occupied the same territory in 1989. Two others established territories ca. 150m and 750m from the territories they held in 1990. One male that bred in both 1989 and 1990 returned to the study area in 1991 but apparently did not mate.

Nest success and return of females

In 1989 and 1990 seven of 17 nesting attempts involving banded females were successful. Six of seven successful females (86%) returned the follow-

TABLE 1. Adult male (M) and female (F) Harris' Sparrows recaptured in subsequent years at Warden's Grove, Northwest Territories, Canada.

	Total banded birds present		Returned from 1989		Returned from 1990		Percent previously banded
	M	F	M	F	M	F	T[a]
1989	8	5					
1990	17	19	3	2			38.5
1991	27	24	3	1	6	4	38.9
Average ($\bar{x}$ ± SD)							38.7 ± 0.3

[a]Percent of total banded birds present (male plus female) in previous year.

ing year, while only one of 10 unsuccessful females (10%) returned. No banded females returned to the same territory that they had occupied during the previous breeding season. In 1990, the only returned female whose breeding status was known from 1989 moved her nest 250 m following an unsuccessful nesting attempt in 1989. She returned in 1991 following a successful nesting attempt in 1990, and again moved her nest 250 m. A second female that nested successfully in 1990 also returned in 1991, and moved her nest 75m. Another female that nested successfully in 1990 returned to the study area in 1991 but was killed by a Northern Shrike (*Lanius excubitor*) before she nested. Both members of three pairs of Harris' Sparrows that mated in one year were known to return the following year, but none of these birds retained the same mates.

Site fidelity of nestlings

Among 62 Harris' Sparrow nestlings banded in 1989 and 1990, none were resighted on the study site the following year.

Discussion

There are few published data on return rates and site fidelity for passerines breeding at high latitudes, particularly in North America. Return rates for Harris' Sparrows at WG were greater than overall return rates for Lapland Longspurs (*Calcarius lapponicus*) at Barrow, Alaska, which were 12% and 24% for males and females, respectively (Custer and Pitelka 1977). However, cumulative return rates for longspur adults aged 2-5 years were 43% for males and 45% for females (Custer and Pitelka 1977). Harris' Sparrow return rates were higher than for Pied Flycatchers (*Ficedula hypoleuca*) in Swedish Lapland (Nyholm and Myhrberg 1983), but similar to those for Chaffinches (*Fringilla coelebs*) in northern Finland (Mikkonen 1983).

The absence of observed philopatry for Harris' Sparrow nestlings banded at WG supports conclusions that natal dispersal is more extensive than dispersal of breeding adults (Greenwood and Harvey 1982). First-year migratory White-crowned Sparrows in temperate latitudes occasionally return to their natal site the following year, but return rates are 10 % (Hubbard 1978; Morton et al. 1991), and very few Lapland Longspurs returned to their natal site at Barrow, Alaska (Custer and Pitelka 1977).

The factor that appears to most influence return rates of Harris' Sparrows to the study site is breeding success during the previous year. Although sample sizes were small, both banded male and female Harris' Sparrows that bred successfully one year appeared more likely to return to the study site the following year than birds that bred unsuccessfully. Poor or unsuccessful breeding also increased dispersal to new breeding sites during the following year, and thus lowered return rates, in a number of other birds (Catchpole 1972; Brooke 1979; Harvey et al. 1979; Newton and Marquiss 1982).

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Evidence for a Black Bear, *Ursus americanus*, killing an Adult Moose, *Alces alces*

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Observations of Black Bears (*Ursus americanus*) feeding on adult Moose (*Alces alces*) are rare. Black Bears prey on Moose calves and have been reported to scavenge on adult Moose, but there has been no documentation to suggest that adult Moose are preyed on by Black Bears. We report evidence for one radio-collared adult male Black Bear killing and consuming an adult female Moose in the Chapleau Crown Game Preserve, Ontario, during May 1992.

Key Words: Black Bear, *Ursus americanus*, Moose, *Alces alces*, predation, Ontario.

The Black Bear (*Ursus americanus*) has been implicated as a predator of young cervids, including Moose (*Alces alces*) (Schlegel 1976; Ballard et al. 1979; Franzmann et al. 1980; Ozoga and Verme 1982; Stewart et al. 1985), but is not considered a predator of adult Moose (Ballard et al. 1990; Ballard 1992). In contrast, Brown Bears (*Ursus arctos*) are regular, successful predators of adult Moose (Boertje et al. 1988) as are Wolves (*Canis lupus*) (Mech 1970; Gasaway et al. 1983; Peterson et al. 1984).

Our observations were made during an investigation of possible effects of Black Bears preying upon and scavenging Moose in the Chapleau Crown Game Preserve, Ontario (48°N, 83°W) during the summer of 1992. This was part of a larger population dynamics study of Black Bears in which between 30 and 50 radio-collared adult Black Bears were monitored at any one time (30-40 females, 1-10 males).

Adult male bear #036 (18 years old) was radiolocated at the same site (± 250 m) on 6, 9, 10 and 12 May, 1992. Average error of radio-fixes in the radiotracking study was determined to be about 250 m (Kolenosky and Obbard, unpublished data). We investigated the site on 12 May and the bear was found beside the carcass of an adult female Moose. The hide was everted and the skeleton strewn around an area of about 3 m radius except for one rib about 5 m away. All organs and muscle had been consumed with the exception of the upper portion of the hind legs. Most of the skeleton remained articulated except for the lower jaw, left scapula, pelvic girdle, two ribs and skull, (which remained attached to the hide). The vertebral column was separated anterior and posterior to the ribs. There were signs of chewing on all ribs and the scapulae. Two bear beds were located within 4 m of the carcass. Numerous bear scats containing Moose hair and bone were collected. Wear class aging (Passmore et al. 1955) placed the Moose in Wear Class VIII (i.e., from $10^{1/2}$ to $15^{1/2}$ years old), but the bone marrow of the femur was white and firm indicating that the animal was not near death due to starvation (W. Ballard, University of New Brunswick, personal communication).

The neck region of the Moose contained punctures, scratch marks and subcutaneous haemorrhaging indicative of an attack by a predator (Ballard et al. 1979; Wade and Bowns 1984). There were two puncture wounds, 5 cm apart, on the right side of the lower jaw 15 cm anterior to the bell. On the right side of the neck, 8 cm posterior to the bell, there was a 10-cm diameter contusion and 5 smaller contusions of 2 cm diameter arranged in a manner consistent with the pattern of a bear forepaw. There were several scratches on the throat and chest.

An examination of the site indicated that the Moose had taken an erratic path from a bedding site 26 m away. The bedding site contained a large quantity of Moose hair scattered in small clumps in a circle of approximately 3 m diameter. The ground was muddy and had been disturbed by Moose tracks. Some of the hoofprints on the path between the bed and the carcass were deep and splayed suggesting that the animal was running and probably bearing additional weight.

The path was marked by changes in direction of up to 90° every 2-4 m. Moose hair and Black Bear hair was present on numerous trees along the path including many that appeared to have been knocked down by the cow. At the 9 m point along the path from the bedding site to the carcass, a dead Balsam Fir (*Abies balsamea*) about 15 – 20 cm dbh was freshly broken off at a height of about 1 m above the ground. Moose hair on the tree indicated the Moose had collided with the tree. At this point, the path veered sharply to the right, and about 3 m away was a 25 cm dbh White Spruce (*Picea glauca*) with a 10 cm long nearly vertical gash in the bark about 60 cm above the ground that appeared to have been made by a bear claw. Bark had been knocked off the side of the tree facing the Moose's path and Moose hair was found on the tree.

The contusions and punctures on the neck of the Moose, the sign along the path from the bedding site, the bear scats, beds and hair at the site, and the manner in which the Moose was consumed (i.e., hide everted and largely intact, skeleton not scattered extensively) indicate (Wade and Bowns 1984) that a Black Bear killed the Moose. The fact that bear #036 was present at the site on 12 May and was located there (within radio-tracking error) on 6, 9 and 10 May suggest that #036 was the predator. When bear #036 was recaptured on 25 May 1992, (at which time he weighed 138 kg), his lower canines were measured to be 5 cm apart further supporting our conclusion that #036 killed the Moose.

We suggest that Black Bear #036 attacked the Moose at the bedding site possibly while the cow was lying down. The bear probably bit the neck or muzzle of the cow and held on, perhaps at least partially on the cow's back. The cow attempted to run but was slowed by the weight of the bear. The cow then collided with the Balsam Fir, veered to the right, and ran into the White Spruce possibly in an attempt to dislodge the bear. The bear pushed off the tree with a rear paw leaving the mark in the tree. The cow continued for another 15 m and collapsed or stumbled and was killed by the bear. From the placement of the punctures below the lower jaw the bear may have pulled on the head of the Moose to break its neck or may have at least partially covered the muzzle of the moose and suffocated it.

No differences in predation rates have been reported among sexes or age classes of Black Bears preying on Moose calves (Ballard et al. 1990), but certain Black Bears such as large males may prey on adult Moose more frequently than previously thought. The lack of documented cases of Black Bears preying on adult Moose may be due to the fact that most detailed studies of Black Bears as predators have been conducted in areas where they are sympatric with Brown Bears (Ballard et al. 1990; Schwartz and Franzmann 1991; Ballard 1992). In areas unoccupied by Brown Bears or where Brown Bears occur at low densities, Black Bears may occasionally prey on adult Moose when the chances of having the prey carcass usurped, or of being injured or killed by a Brown Bear are much reduced. To date, few studies have investigated causes of mortality in adult Moose in areas where Black Bears are common but Brown Bears are rare or absent (Messier and Crete 1985; Stewart et al. 1985; Ballard et al. 1990; Ballard et al. 1991; Schwartz and Franzmann 1991).

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Adoption of a White-tailed Deer, *Odocoileus virginianus*, Fawn by a Captive Doe

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A wild male orphan White-tailed Deer (*Odocoileus virginianus*) was adopted by a captive doe when the hide of her own still-born fawn was tied around the body of the orphan.

Key Words: White-tailed Deer, *Odocoileus virginianus*, orphan, adoption.

The willingness of deer to adopt strange fawns was observed by Severinghaus (1949). In the four cases he observed adoption attempts were a success in only two. We report on the successful adoption by a captive doe of a wild orphan fawn when the hide of its own still-born fawn was attached to the orphan.

On 9 June 1993, a White-tailed Deer fawn (*Odocoileus virginianus*) was brought to the New Brunswick Department of Natural Resources in St. Louis de Kent, New Brunswick. We picked up the fawn to include it in parasitological studies involving captive White-tailed Deer. The fawn was approximately one week old when obtained and was maintained on a diet of a mixture of: one litre whole milk, one egg, 15 ml cod liver oil, and 15 ml sucrose. The fawn was fed 150 ml of this diet every four hours following the method described by Buckland et al. (1975) for one week while being kept at the home of one of the authors. On 13 June 1993, one of our captive White-tailed Deer dropped a dead fawn. On 14 June 1993, the orphan was placed in the pen with this doe and their interaction was monitored using a video camera. Viewing of the video tape revealed that the orphan was ignored by the doe and discouraged from nursing when it tried to do so. The four-hour feedings were maintained while the fawn remained in the pen with the doe. On 15 June 1993, the hide of the still-born fawn, which had been frozen for two days, was securely tied around the body of the orphan. This is an old shepherd's trick long practised with sheep with some success (Ensminger 1970: page 196; Cooper and Thomas 1975: page 49). The interaction of the doe and fawn was again monitored with a video camera. It was revealed that almost immediately the doe began a vigorous licking of the attached hide. After about 30 minutes the fawn nursed. Despite the hide being removed after about five hours, due to vigorous licking by the doe, the orphan continued to be accepted by the doe.

Severinghaus (1949) found that two of four does would adopt a strange fawn after the death of their own and he suggested that sex of the fawn played a role in the adoption process. In this case the doe's own fawn had been female and she totally ignored the male orphan until the hide of her fawn had been placed on it.

This procedure may have limited use but in a situation dealing with captive White-tailed Deer it may enhance the odds of adoption and provide an alternative to the labour intensive bottle feeding every few hours.

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Larder Hoarding in the Cougar, *Felis concolor*

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Holt, Denver W. 1994. Larder hoarding in the Cougar, *Felis concolor*. Canadian Field-Naturalist 108(2): 240–241.

A Mountain Sheep (*Ovis canadensis*), and two Mule Deer (*Odocoileus hemionus*) were killed, and hoarded by a Cougar (*Felis concolor*). The prey were hoarded within 19 m of a game trail, and 22 m of an open hillside. The carcasses lay within 5 m of each other, and were all less than one month old. The sheep was 9.5 years old, and the deer were 2.5 and 3.5 years old.

Key Words: Cougar, *Felis concolor,* Mountain Sheep, *Ovis canadensis,* Mule Deer, *Odocoileus hemionus,* larder hoarding, kill characteristics, larder site characteristics.

Food hoarding is thought to be a behavioral, and ecological strategy for coping with unpredictable environments (see Vander Wall 1990). Food hoarding (i.e., caching and storing) is the handling and preservation of food for future use (Vander Wall 1990). Vander Wall separated food hoarding into two categories: (1) larder hoarding — the concentration of all or most food at one or few sites; and (2) scatter hoarding - one or few food items stored at many sites. Food hoarders may gain advantages over non-hoarders because excess food can be used when prey is scarce.

Within the order Carnivora, species of several families are known to hoard food (Vander Wall 1990). Within the family Felidae, most species, including the Cougar (*Felis concolor*) scatter hoard single prey items (Vander Wall 1990). Wright (1934) flushed a Cougar off the carcasses of two Mule Deer (*Odocoileus hemionus*) fawns which were buried in leaf litter. Jamie Jonkel and Bart O'Gara (personal communication) discovered carcasses of two Coyotes (*Canis latrans*) and four Mountain Sheep (*Ovis canadensis*) killed and larder hoarded by Cougars, respectively.

Predatory species exhibit differential characteristics of their kills, and feeding techniques (O'Gara 1978). These characteristics, accompanied by subcutaneous hemorrhages observed during necropsies, can be considered proof of a kill (O'Gara 1978). Herein, I report my findings which indicate a Cougar killed three adult ungulates in the same location. I suggest the proximity of the kills to each other is proof of larder hoarding.

Area and Methods

On 26 November 1991, I discovered the carcasses of 2 adult Mule Deer and 1 adult Mountain Sheep near Mittower Creek, East Missoula, Missoula County, Montana. I determined these kills were made by a Cougar based on; (1) the physical evidence at the site; (2) knowledge of the local fauna; and (3) descriptions of predator kills reported from the literature (Hornocker 1970; Acorn and Dorrance 1990; Vander Wall 1990). The carcasses were dragged into a dense stand of Douglas-fir (*Pseudotsuga menziesii*) trees with an under-story of Mountain Maple (*Acer glabrum*), Serviceberry (*Amelanchier alnifolia*), and Ninebark (*Physocarpus malvaceus*) shrubs. The carcasses laid on the ground and were partially covered with dirt, deciduous and coniferous leaf litter, and their own hair. The area was steep, interspersed with rocky outcrops, and had a west/southwest aspect. Bunchgrasses dominated the open slopes, and game trails were abundant. The draws between slopes were shallow and narrow, but densely forested. Mule Deer inhabit the area at all seasons.

I recorded and sketched my observations at the site. I returned the next day to make more detailed notes. I used a meter tape to record distances between kills, the Cougar bed, a game trail, and an open hillside. I recorded topographic compass directions, and general habitat description. I used a diameter tape measure to record diameter at breast height (1.4 m) over the bark (DBH) of trees where the caches and Cougar bed were located. I used a spherical densiometer to record vegetation canopy cover, and a clinometer to measure tree height. I skinned the carcasses where possible, and examined for subcutaneous hemorrhages, tooth, and claw holes. I measured diameter and distances of these holes to the nearest cm. I sexed the animals using secondary sexual characteristics (i.e., antlers and horn size, and shape), and aged them using molar wear for the deer, and horn annuli for the sheep.

Results

Larder site: Broken branches on low lying shrubs, and matted vegetation, indicated where prey was dragged from the open hillside to the larder site. It was 19 m from the larder area to the nearest game trail through the forest, and 22 m to where the game trail swung into the open hill. The sheep was 1 m north of the female deer, and the male deer was 4.5 m west of the other carcasses. Both the female deer and female sheep were under a 15 m Douglas-fir tree. The tree had a 22.6 cm DBH, and 76.0% canopy cover. The male deer was under Serviceberry and Ninebark bushes with 65.0% canopy cover.

The Cougars bed was under a Douglas-fir tree 15 m in height, 41.6 cm DBH, and 77.0% canopy cover. The bed was north of the kills on the uphill side of the tree. The bed was 4 m from the female deer and sheep, and 3.5 m from the male deer. I did not locate any predator scat.

Kill Characteristics: The sheep carcass was partially covered with deciduous and coniferous leaf litter, and dirt. I estimated this kill to be about three weeks old. Some hide was removed from part of the back, and rump. The meat of the upper torso had been eaten, but the hindquarters remained largely intact. I located two punctures 3 cm apart and 1 cm each in diameter on the left side of the neck, 15 cm from the base of the left horn. Subcutaneous hemorrhages were associated with each hole. The left hind quarter was punctured with elongate holes, likely from the Cougar's claws. The sheep was 9.5 years old.

The male deer was also partially covered with deciduous and coniferous leaf litter, and dirt. Some of its own hide was mixed in with the coverings. This carcass was the freshest kill and less than 14 days old. There was subcutaneous hemorrhages associated with three holes in the dorsal area of the neck. The atlas bone was partially punctured by the Cougar's tooth, and the hole measured 0.5 cm wide. There was one 3 cm elongated claw hole under the neck. All meat on the torso and much of the hindquarters had been eaten. The deer was 2.5 years old.

The female deer was partially covered with leaf litter, and dirt. This carcass was further decayed than the others and perhaps three weeks to a month old. I could detect no puncture holes. All the meat was gone and the bones had been picked clean by birds. The deer was 3.5 years old.

Discussion

Predators kill and consume prey in distinctive patterns, and these may be used to identify the predator (O'Gara 1978). Given the author's knowledge of the local fauna, and the fact that these kills did not have characteristic techniques used by other larger carnivores (see O'Gara 1978; Acorn and Dorrance 1990; Vander Wall 1990), I am confident these were Cougar kills.

The kills described here were similar to Cougar kills reported by O'Gara (1978), Boyd and O'Gara (1985). Boyd and O'Gara (1985) reported puncture holes from the canines of young Cougars to be 2 to 4 mm in diameter. These however, are less than half the diameter of puncture wounds reported here.

The proximity of a game trail to the larder site, suggested the Cougar may have ambushed prey there. The broken bushes, trampled vegetation, and drag marks indicated the Cougar dragged the kills to the site. O'Gara (1978) reported that Cougars usually bring down deer sized prey within a few meters of first contact, except on steep hills. In this area the steep hills are open, and a Cougar would need to drag the prey into the draws for cover.

Larder hoarding in Cougars may be more common than the literature indicates. Food storing in Cougars remains little studied, particularly, as an evolutionary strategy for survival (i.e., food buffer, kleptoparasitism). Future studies should evaluate and quantify this behavior in terms of shifting resources, changing prey densities, spatial memory, and Cougar survival. Vegetation characteristics at larder or kill sites also need quantification to determine if specific habitat features are important.

Acknowledgments

I thank Diane Boyd, Kerry Murphy, and Michael T. Maples for conversation, and helpful suggestions on the manuscript. I thank Jack Hogg for helping age the sheep, and John Firebaugh for providing data on the sheep relocation.

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News and Comment

The Ottawa Field-Naturalists' Club 1993 Awards

Awards are given each year to acknowledge and encourage contributions towards Club goals by individual members. The 1993 awards were presented at the annual Soirée on 29 April, 1994.

No Honorary Membership was conferred this year as the Club has at present the full complement of twenty-five. Frank Pope, President, hosted the evening, and awards were presented by members of the Awards Committee, and appropriate members of the Club.

Members of the Macoun Club set up their usual array of interesting exhibits. Rebecca Danard, William Godsol and Sarah Bonie won prizes for their exhibits. Representatives of the three Macoun groups reported on their activities during the past year.

1993 Conservation Award (non-member) - Donna Wilson

Through a program called "Adopt-a-Pond" sponsored by the Toronto Metro Zoo, Donna Wilson organized the pupils of two schools to be 'custodians' of Mud Lake in the Britannia Conservation Area in the west end of Ottawa. She managed to arouse the interest and enthusiasm of the students in protecting this unique and perpetually threatened area that is the last of its kind within the city boundaries.

To launch this session of study and field trips she organized a ceremony of dedication to receive the adoption certificate from the Metro Zoo. She involved a number of influential people including the Member of Parliament and City Councillor, local naturalists and other interested members of the community willing to lend their support to such a worthwhile enterprise.

Recently, with her usual persistence and some cajolery, she persuaded the National Capital Commission to install two prominent and attractive signs at entrances to trails leading to Mud Lake. The signs read:

> *We the students of F.J. MacDonald and Regina Street Schools have taken on the responsibility to care for Mud Lake and the animals that live there.*

Donna is to be commended for her initiative for starting the programme, for her skill in keeping interest and enthusiasm high, for awakening young minds to their responsibility for the environment, and for procuring their commitment to appreciate and cherish what remains of it. This also provides important support for the continued protection of an area which has long been considered a conservation priority by the OFNC.

For the reasons stated, Donna Wilson is a worthy recipient of the non-Member Conservation Award for 1993.

1993 Conservation Award (OFNC member) - Jacques Cayouette

The undertaking of conservation action in the Outaouais section of the Ottawa District has lagged behind that in the Regional Municipality of Ottawa-Carleton. As residential development accelerates across this area of western Quebec, however, the need has never been greater. It seems particularly encouraging, then, that we can highlight this need by awarding the OFNC member's Conservation Award to Jacques Cayouette for his recent work in the Aylmer area.

Although an established authority on the flora of Quebec through his professional activities, Cayouette is relatively new to the Ottawa District and has only recently begun more systematic botanical investigations in the Outaouais. In the course of these field studies he discovered a series of alvars in Aylmer in 1992 and 1993. While these exceptional and sensitive habitats (spring-flooded, summer-droughted, thinly buried limestone plain which support rich and virtually unique floristic associations) have been examined in some detail in Ontario (e.g., at the Burnt lands near Almonte) and elsewhere in southern Ontario, none had previously been discovered in Quebec.

With the help of 1992 OFNC Conservation Award recipient Ian Huggett, Cayouette publicized the existence and significance of these sites. He also continued his field investigations, documenting a number of provincially rare species in the habitat. In due course, he alerted the appropriate provincial authorities in Quebec City. This has resulted in a provincial initiative to secure formal protection for some of the most biologically important areas of the Aylmer alvars.

As is usually the case in conservation matters, the question is not yet settled. The precise provincial conservation measures have not been defined. Further, the new municipal Official Plan has yet to reflect the sensitive nature of these places. The independent and co-operative actions of Jacques Cayouette, however, have ensured that these biologically important sites will not be overlooked. He has provided a fine example of the effective conservation action that is possible through the careful field investigations by a single individual – even in our own back-yards.

1993 Anne Hanes Natural History Award - Mary I. Moore

The flora and landscape of the upper Ottawa Valley reflects an intricate complex of Canadian Shield forest, limestone plain, peatlands, massive cliffs, emergent shores, sand dunes and extensive swamp forest habitats where southern temperate hardwood regions mix with northern boreal conifers. Add to the ecological mix a period of partial inundation by the post-glacial Champlain Sea and a period in which the entire Great Lakes drained through this area. A complex area indeed. Although extending over a vast area, few of us have more than a passing familiarity with the marvellous diversity expressed in its vegetation and flora of this part of eastern Ontario/western Quebec. Few of us, perhaps, but certainly not the 1993 recipient of the Anne Hanes Natural History Award, Mary I. Moore.

Mary Moore has spent most of her adult life in the Ottawa Valley, based in Deep River. From here she has explored the rivers, forests and wetlands of both provinces by canoe, on foot and by skis. One of the first botanists to explore eastern Algonquin Park, Mary documented the remarkable complex of northern relics found in the spectacular Barron Canyon. There she also discovered and documented a bizarre form of White Cedar found nowhere else in the world. Relict communities remain a particular interest of hers and there is hardly a cliff face, sand dune or rocky slope between eastern Algonquin Park and western Pontiac County that has not received her careful scrutiny. Her keen knowledge and interest in aquatic systems uncovered a myriad of rare and previously unsuspected floristic characteristics of the Ottawa River and environs during the course of more traditional upland investigations.

Edible wild subjects are another expertise of hers, as anyone who has tasted her elderberry pancakes will attest. It sometimes can be difficult in the field to know if that specimen she has just secured is a scientifically critical voucher specimen – or lunch!

Mary Moore is probably best known beyond the Ottawa Valley for her publication "*Vascular Plants of the Middle Ottawa Valley and Northeastern Algonquin Park*". Produced in 1972 and up-dated in 1978, the publication provides an individual distributional status statement for almost 1000 plant species in three distinct areas, 1) eastern Algonquin Park, 2) northern Renfrew County, and 3) northwestern Pontiac County This remarkable compendium of almost 3000 annotations is almost totally the product of Mary Moore's personal field investigations. Her citations are virtually all supported by well-processed, well-documented voucher specimens which are maintained in major public herbaria. The depth and accuracy of her work has resulted in this document remaining the definitive Ottawa Valley floristic publication over 20 years after it was first produced.

Mary delights, she will agree, in sharing her information and discoveries with others. Would that more of us had this calling. She is a prolific author, having penned many an article on individual species and/or interesting places, particularly for Federation of Ontario Naturalist publications. A number of popular and scientific contributions to *Trail & Landscape* and *The Canadian Field-Naturalist* have been offered over the years. She also remains an enthusiastic and expert field excursion leader for various natural history organizations.

Mary Moore demonstrates most of the attributes of the ideal field naturalist; she is a perceptive field investigator with a scientific concern for the appropriate documentation of her results and an enthusiastic enjoyment in sharing her love of the natural world with others. In the final analysis, this latter asset many count for as much as any; many of us are quick to acknowledge our debt to Mary's inspiration, enthusiasm and patience. She is, in other words, precisely Anne Hanes' sort of naturalist.

1993 George McGee Service Award - Bill Holland

The George McGee Service Award is presented "*in recognition of the member who has contributed significantly to the smooth running of the Ottawa Field-Naturalists' Club over several years*". This year the service award has been bestowed posthumously upon Bill Holland, a long-time member, friend and supporter of the Ottawa Field-Naturalists.

Since emigrating to Canada from England in 1946 until his death late last year, Bill was an active birder. In the 1970s and 1980s he would often be found in local birding areas such as the Britannia Conservation Area and Vincent Massey Park, often accompanied by his favorite birding partner, George McGee. More recently, Bill was working on a sighting list at the Fletcher Wildlife Garden, with over 90 bird species tabulated.

Through the years he was instrumental in bringing many new young members into the club. He also had a unique ability to kindle and rekindle an interest in nature in our more mature members. Through his leadership on countless field trips, his efforts and dedication in planning, promoting, and fund raising for the Fletcher Garden, and his participation in the organizational aspects of the OFNC, Bill Holland has always been a fine example of what an OFN member can be. He is therefore a most fitting and deserving recipient of this award.

1993 Member of the Year Award - David Moore

Although it is a truism that no-one is indispensable, David Moore is one of those rare people whose actions could almost refute such a statement. He had been a Council member for only a short time when it became apparent that he had a great deal to contribute.

He has been an effective chairman of the Education and Publicity Committee. He has attended many functions to display Club materials that are for sale and to make Club information available. In this capacity he has increased interest in the Club and with his persuasiveness, and has managed to line up new members.

He was actively involved in the organization of the 1993 FON Conference hosted by the OFNC. He organized the publicity, prepared a superb programme booklet and made himself available to help out in many ways.

David is always a good public relations representative for the Club. At meetings and on field trips he is able to make new members feel welcome and to add to the cohesiveness of the group. He carries out any responsibility he takes on with cheerfulness and assurance.

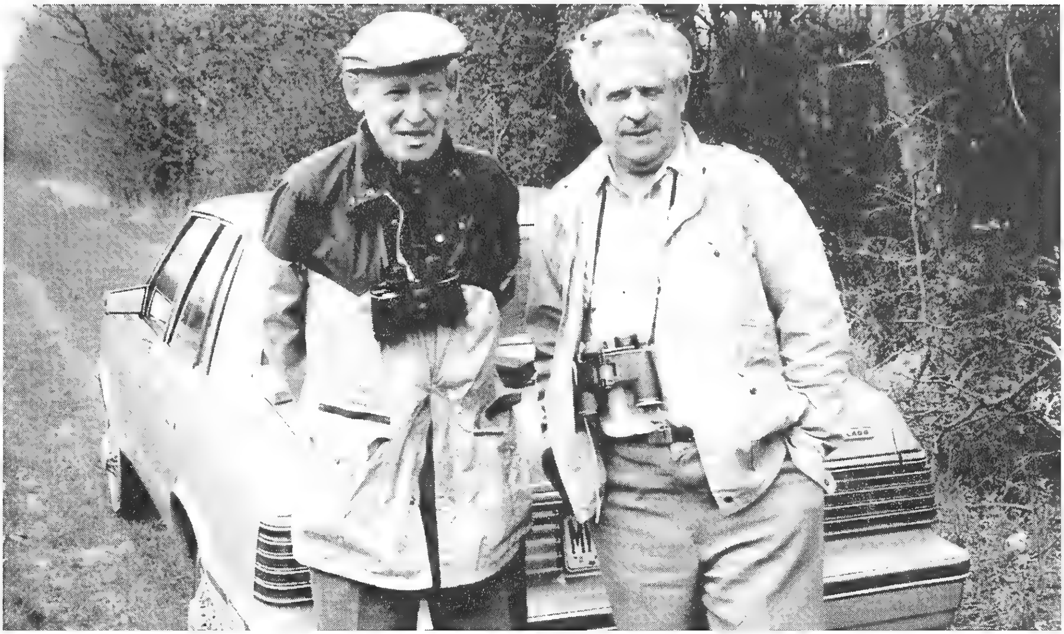
It seems most fitting that he receive the Member of the Year Award for 1993.

Presidents' Prize - Eileen Evans

The President's Prize was awarded by Frank Pope to Eileen Evans. This was in recognition of her loyal and tireless support of the Club over many years in various capacities. Her role in handling the exhibits for the 1993 FON Conference was noted, and appreciation of her quiet efficiency was expressed.

ENID FRANKTON
Chair, Awards Committee

News and Comment



George McGee (left) and Bill Holland at Bill Gummer's farm near Burritts Rapids, Ottawa-Carleton Regional Municipality, Ontario, May 1990. Photo courtesy Bill Gummer and *Trail & Landscape*.

George Hazen McGee, 1909-1991

George McGee died in hospital in Ottawa 1 December 1991 at age 82. To members of The Ottawa Field-Naturalists' Club, his leadership, infectious warmth, humour, and gentle but boundless enthusiasm are etched in the memories of all who worked with, talked or listened to him. Humble and unassuming, he simply did what came so easily to him, talking to everyone, hoping to instill his own deep interest in natural history, especially birding, in everyone he met. Whenever George entered a group its collective spirits and involvement in whatever the objective was at the time invariably soon rose perceptively.

George was born 18 February 1909 in St. George, New Brunswick, the youngest (and only boy) of four children of Charles Hazen and Bessie (Parks) McGee, of United Empire Loyalist stock. He graduated from the University of New Brunswick in Forest Engineering in 1931 and subsequently joined the New Brunswick Forest Service where in time he was put in charge of logging and reforestation and organized crews for fire control. During this period he was also with the Militia, and earned the rank of Major. When World War II broke out in 1939 and his army unit was not sent overseas, he transferred to the Royal Canadian Air Force intent on becoming a pilot. However, because of a need for university graduates to train as navigation instructors he was soom shifted to this area. His first posting was to Trenton, but in the fall of 1940 he was sent to Edmonton. There he met Doreen Kavanagh and they were married in September 1941. George subsequently served at many RCAF stations across Canada before he finally received an overseas posting in 1943. After discharge in 1946, he joined the Federal Government in the Forestry Division of the Department of Labour and settled in Ottawa. A great deal of his time, however, was spent in Germany and Italy as the officer in charge of the selection of immigrants for work in Canada's forestry and prime industrial programmes. About 1949, he transferred to the Ministry of Transport and was in charge of their examination branch for all flying personnel. He retired in 1973. During the 1950s to 1970s, he also devoted many hours to teaching and running ground schools at the Ottawa Flying Club, Mary Carson's Flying Schools and the Ottawa Airport.

George was an ardent and active supporter of The Ottawa Field-Naturalists' Club's objective "to promote the appreciation, preservation, and conservation of Canada's natural heritage", throughout his 31 years as member and before formally joining. During the 10 years he served on Council he worked on most Club committees and was Club President during 1964-1966. When he first joined the Club in 1960, George became editor of the club *Newsletter*, the forerunner of *Trail & Landscape* which replaced it in 1967. He also played a major part in the organization of birding field-trips to Mer Bleue in spring and Shirleys Bay in fall; often these were titled simply "Birding with George". His last were in 1988, and included a "Duck Waddle for Beginners". His 1968 pamphlet *Birds, Botony, Geology, Ottawa, Canada* was published by the Ottawa Tourist and Convention Bureau, and widely distributed to visitors, and to all new OFNC members, until supplies ran out. It had been developed in collaboration with Dr. Alex S. MacLaren of the Geological Survey of Canada but MacLaren had died suddenly before its completion.

George's talent as an instructor led to lectures in natural history far beyond his contributions to The Ottawa Field-Naturalists' Club. His family was always involved in field outings and nature photography and he contributed to many special interest groups, among them a senior citizens home, home for the blind, Boy Scouts, Girl Guides, science classes at Public and High Schools and field trips and camps aimed at youth. He appeared on cable television and CBC radio in Ottawa to promote natural history. His lectures during the 1960s, and 1970s and into the 1980s on bird identification (illustrated with his own slides and photographic enlargements), first at the National Museum of Canada and later using facilities at the Ottawa Board of Education, helped countless naturalists to begin this activity or hone their skills in it, and prepared them to better appreciate field outings. In these he emphasized not just visual identification, but how to listen for bird language, bird life, and the role of birds in the ecosystem. He also tought the blind how to identify birds by sound. He contributed to the Ottawa newspaper columns of John Bird and Wilf Bell, and wrote them in periods of illness or vacation of the nominal authors. An active promotor of bird feeders, George built and distributed a hundred, and contributed his plans to both Lee Valley Tools and the National Capital Commission. In his early years in Ottawa he teamed in many projects with his long-time mentor in natural history, Duncan McLulich. In later years, his friendship with Bill Holland resulted in significant contributions to the beginning of the Fletcher Wildlife Garden at Agriculture Canada's Central Experimental Farm in Ottawa.

In 1980, The Ottawa Field-Naturalists' Club made George an Honorary Member for his contribution to conservation and natural history education, and, in 1992, formally named its *Service Award* in his honour. The latter was first presented under his name in May 1992, but George had been informed before his death four months earlier that this continuing recognition of his contribution to the Club would be inaugurated at the next annual award presentations.

George is survived by his wife Doreen, sons Rick and Randy, and four grandchildren. After his death, his family received cards and letters from young (and no longer so young) biological professionals from across Canada who remembered George as an important and positive influence in their eventual career choice. As Dan Brunton has pointed out (personal communication to FRC 6 March 1992), "his love of the natural world was truly inspirational to us whipper-snappers at a time when most 'grown-ups' saw nature as a trivial frill or, worse, a force to be beaten back. George helped us realize that such an appreciation was, for its own sake, both legitimate and worthwhile."

BILL GUMMER AND FRANCIS R. COOK

Acknowledgment: Published sources for this tribute were: *The Ottawa Citizen*, 2 December 1991, page D10; The Ottawa Field-Naturalists' Club tribute in May 1980 at George's induction as an Honorary Member (Awards Committee, 1980, *Canadian Field-Naturalist* 94: 545-546); and, especially, the "A Special Tribute to George H. McGee" by Bill Gummer (1992, *Trail & Landscape* 26(2): 36-37). Doreen K. McGee graciously responded to our enquiries and added many details, and Dan Brunton read, corrected, and augmented early drafts. The accompanying photograph of George and Bill Holland first appeared in *Trail & Landscape* 26(2): 36.

WILLIAM ARTHUR HOLLAND, 1921-1993

Bill Holland died suddenly at the age of 72 in Ottawa of a heart attack, 25 November 1993, while he was carrying out his bird inventory at the Fletcher Wildlife Garden, Central Experimental Farm. His death has deprived The Ottawa Field-Naturalists' Club of one of its most ardent supporters, an enormous ongoing contribution to the Fletcher Wildlife Garden, and a deep sense of humour which never failed to spur any Club function to a greater effort.

Bill was born in Woodville, a suburb of Bournemouth, England, 21 September 1921, and developed an interest in birding from his father on walking trips in the Dorset countryside. At 17, he entered the Portsmouth Naval Academy where he was a classmate of Philip Mountbatten, later to become Prince Philip as husband of Queen Elizabeth II. His navel training brought assignment to West Africa where the colourful tropical species brought back his youthful interest in birds, but when the Second World War began he drew a posting to the British Submarine Service and duty on convoy protection and German U-boat engagement off the east coast of Canada. In 1943 he became a instructor at HMCS St. Hyacinthe and, later, HMCS Stadacona. While stationed at St. Hyacinthe he met Margaret Ducross and they were married in 1944. He returned to Britain in 1944 but came back to Canada in 1946. He was initially employed as a travelling salesman selling coal to industrial clients, first in Montreal and later based in Ottawa. With the decline in the coal business, Bill moved to real estate in 1968 and worked first in the office of Teron Construction and later with Aselford Martin, until retirement.

Bill first met George McGee about 1964 while birdwatching at Mer Bleue and joined The Ottawa Field-Naturalists' Club in 1966. He remained a member for 27 years, serving actively on Council (1968-1972) with a term as Vice-President (1969-1970). Once he and George started birding together in the mid-1970s they were inseparable. They shared a positive outlook on life and a wry sense of humour, as well as being complementary opposites in other traits - George flamboyant and outgoing, Bill steady and reserved. As well as ranging widely over the Ottawa District, together they started the regular bird inventory of the Fletcher Wildlife Garden. After George's death, Bill carried this on alone and with passion, going almost every morning to listen for, and tabulate, the birds present.

When the Backyard Garden Certificate was initiated, Bill brought his formidable sales skills to bear on the task, selling them to everyone he met. He often manned the Club exhibit at events like the Ottawa Home Show for ten hours at a stretch.

The Awards Committee of The Ottawa Field Naturalists' Club chose Bill as recipient of the George McGee Service Award for 1993, and this was announced posthumously at the Soiree in May 1994. The Fletcher Wildlife Garden Management Committee intends to commemorate his dedication and will accept donations on his behalf to the Gardens through the Club address. Bill had joined George in designing and building bird feeders that were widely used throughout the Ottawa District. One of these will be put up in the Fletcher Wildlife Garden with an appropriate permanent plaque commerating their contributions.

Bill is survived by his wife Margaret, five children (Tim, Nancy, Diana, John and Christina), and four grandchildren.

JEFF HARRISON

Editor's Note: In a more detailed form, this text first appeared as "A Special Tribute to Bill Holland" by Jeff Harrison (1994, *Trail & Landscape* 28(2): 38-40). A reminiscent "Thank You" on behalf of Bill Holland's family for the George McGee Service Award by Bill's son, Tim Holland, subsequently appeared in *Trail & Landscape* (1994, 28(3): 73).

A Remembrance of John Steuart Erskine, 1900-1981

Anthony J. Erskine

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Erskine, Anthony J. 1994. A remembrance of John Steuart Erskine, 1900-1981. Canadian Field-Naturalist 108(2): 248–254.

John Erskine was born in Chicago 8 November 1900, the youngest of five children of British parents, Thomas Edward Erskine (1859-1916) and Amy Gertrude (nee Bruce; 1865-1939), who had settled in California about 1890. His father's health was poor after he was beaten-up by a drunken ranch-hand who ran amok there around 1895, and he had to give up ranching. He died aged 57 while (British) Consul-General at New Orleans. Although Scottish titles lurked in his distant ancestry, descent through a chain of younger sons meant that members of this genteel but in no way affluent family had to work for a living. John's sisters measured up to the families' traditions: Marjory, a nun and a Ph.D., became in turn Mother Superior of a convent and President of Marysville College (nr. St. Louis); Diana and Violet, after working in British government offices, married respectively an English baronet and a British foreign-service official. Only Violet had children. John's only brother Thomas served in World War I, and lived modestly in California for the rest of his life. Although John's life-style and career, both before and after he came to Canada, would have been viewed as "modest" by his relatives and contemporaries, his was a full life that contributed much in many fields.

Among John's best-remembered characteristics were his curiosity, his memory, and his urge to teach. He recognized his "flypaper memory", and some of its advantages, while still in school. A retentive memory contributed to his facility with languages, which went far beyond what was then usual among the educated English - and even farther beyond the North American standard; when he moved to Canada in 1936, he could communicate, effectively if not always correctly, in French, Spanish, Portugese, Italian, German, and Swedish, with some reading knowledge of Latin and Arabic. His memory also retained much from his wide-ranging and voracious reading, which continued throughout his life and prepared him to answer questions on almost any subject, if not always in depth. This also helped in teaching, which came naturally to him. During his 24 years service in Nova Scotia he taught every academic subject offered in the high schools, without having taken a university course in most of them and with almost no formal schooling in the sciences.

His childhood remembrances began with schools in Chicago and St. Louis, punctuated by summer holidays in rural Michigan and Wisconsin. His mother early instilled in him her love of birds and flowers, but his subsequent attempts to keep wild animals as pets or for study were quietly deflected. He devoured Seton's and Roberts' wild animal stories as soon as he could read. The father of a school friend in Portland, Oregon, where the family moved in 1911-12, when asked what career John might aspire to, suggested, "A professor of biology." By then he knew most of the common birds, and his recollections of their train journey across the southwest, early in World War I when they moved to Louisiana, show that he already observed peoples and landscapes with understanding. In New Orleans a hurricane shortly after their arrival left John with vivid memories. His interests in natural and human history received no encouragement (beyond childhood) from his parents, who saw no prospects for livelihood in such activities. Precocious, he finished high school at 14, but he declined to pursue beyond the first few months his mother's suggestion of studies towards the Roman Catholic priesthood. He worked in a bank, and then helped in the consular office until his father's death in 1916.

By then the family had dispersed, and he alone accompanied his mother to wartime England. He noted a strange beauty in the landscape there, but his formative years had been spent in the United States; England became "home" to him, but he had few "roots" there other than family. Then too young for the armed forces, he gravitated into farm-work after his idea of becoming a doctor was rejected by his relatives. A later move towards an army commission was ended by the Armistice, which arrived three days after his 18th birthday. He worked in an office thereafter, but was laid low by the infamous flu epidemic of 1918-19. His recovery was slow, and for a time he was thought unlikely to live long in England's damp and chilly climate. While recuperating on a farm in Devon, he again became aware of wild flowers, and also - from reading - with geology, and he wondered why such fascinating subjects had not been taught in his schools.

With his health partly in mind, and in the absence of post-war jobs in Britain except for war veterans, he was directed to Jamaica in 1920, and he worked there on cattle ranches for nearly two years. He then

John Steuart Erskine, about 1960.

moved on to the United Fruit Company in Honduras, where he worked on banana plantations for three years, broken by a six-week holiday tour of Central America and a longer visit to England and the Continent when his mother returned there from India. Jamaica and Honduras gave him many opportunities for observing the natural and people-altered world around him. He became increasingly exasperated by obstruction of his work with the fruit company, and he resigned, leaving as a parting shot his libretto for an opera that lampooned the company managers.

A book of travel and study in the Himalayas, given by his mother, stimulated him to explore conditions and languages of the surviving native peoples during a three-month trip around Honduras in 1926, on foot and by raft and canoe. On his return to England, he supported himself (in part) by writing and selling stories and articles based on his observations in the tropics. Nature featured in these writings but seldom dominated them. His first novels *The Fall in Sugar* and *The Dispossessed* (both unpublished) apparently dated from that period.

After he met, and then in 1928 married, Rachel (Rickman), who became his devoted companion for over 50 years, more income was needed to supplement the little from his writing. A further period of tropical work followed, helping to open up citrus plantations in Brazil (near Sao Paolo), but he was prostrated by concurrent attacks of jaundice and malaria which kept him in hospital for several months. With Rachel, he was sent back to England, where their first child, David Steuart, was born six weeks after their return in autumn 1929.

John and Rachel, with their family soon enlarged by sons Anthony John (b. 1931) and Roger Thomas (1933-1975), settled for several years near England's Lake District, where John continued writing. A cottage garden, with goats and hens and the usual vegetables, plus subsidies from relatives and a lieutenant's commission in the militia, helped them through those Depression years. John continued to travel, by bicycle, exploring the local area which Rachel had known as a teen-ager, and expanding to Wales, Ireland, and many countries on the Continent. As always, he observed nature and people, and his articles about it supplemented their income. A travel book manuscript titled *Wayside Europe* (never published) and albums of photographs recorded some of his impressions. His return trips across Germany, where Hitler's imperialism was rampant, convinced him that another European war was coming soon, and in spring 1935 he journeyed to Canada to find a safer place for his family. He planned to proceed to Ontario, but recurrence of his malaria on the ship resulted in his recuperating in Wolfville, at a boarding house run by Miss Harwood whom he had met on the ship. Moving his family to Nova Scotia was delayed for over a year by his pessimism over the dismal farming economy there and by Rachel's distaste for the prospects he described, but they came to the Annapolis Valley late in 1936. Although John had never spent longer than six years in one house before, he lived in Wolfville for the rest of his life.

His writing continued, with at least one unpublished book manuscript (a history of civilization) dating from his first year in Canada, but no substantial income emerged from these efforts. Farming provided some of the family's food, but obtaining sufficient income from that source demanded more capital than was available to him. So he secured university degrees, B.A. in Romance Languages (Acadia) and M.A. in French (McGill), and emerged as a school-teacher in 1940. In 1941-1965 he taught at Nova Scotia high schools in Windsor, Kentville, Berwick, Cambridge, and Canning, though never in Wolfville, with biology moving gradually to the fore. Teaching was surely his greatest strength, only in part complemented by his role as a naturalist. Nova Scotia teaching salaries were then among the lowest in the country, but frugality and careful management by John and Rachel sufficed to allow all their children to graduate from Acadia University and to continue to studies elsewhere.

His sons (and others) learned much from him that schools never offered. His enthusiasm for learning came through at every turn, and his aptitude for description and his story-telling ability, honed through his writing, helped to hold the interest of his students. In later years, he made a practice of eating his lunches in the classroom where he would be available to students for questioning or discussions. Many former students refer to his teaching as a highlight of their schooldays, and those of us - including the present CFN Editor - who had the opportunity for more and wider contacts with him benefited immeasurably.

Birds had attracted him from childhood, and this interest was maintained in the tropics and in Europe. He became involved in bird study in Nova Scotia too, joining Robie Tufts on the Wolfville Christmas Bird Counts (begun ca. 1920) soon after our arrival. John revived the local count in 1952 after Robie's retirement had ended it temporarily. A supplementary concept, to remedy what he perceived as the unrepresentativeness of those single-day counts, was his series of standardized bird walks, carried out several times each winter from 1944, at first around Windsor where he was then teaching, and for 25 years around Wolfville. His sons sometimes accompanied him on these walks, and after their departure to studies elsewhere other younger boys sometimes took their turn as John's companions. A brief summary of the Wolfville bird walks was published in 1968. He and Rachel also took part, as charter members, in the Nova Scotia Bird Society, in the Nova

Scotia Institute of Science - Valley Chapter, and finally in the Blomidon Naturalists Society, and John also held memberships in several "learned societies". He was involved in the Maritimes Nest Records Scheme from 1960 and the Breeding Bird Survey from 1966, both volunteer projects started in the area by his son Tony, by then an ornithologist in the regional Canadian Wildlife Service office.

John's budding interest in botany had grown with his marriage, as Rachel taught him flowers while he taught her the birds. During his Windsor years (1941-1948), encouraged by fellow-teacher Herbert Habeeb, he began a study of mosses which continued through the publication of his provincial moss flora 25 years later. John and Rachel actively encouraged and supported the botanical interests of their son David, building from a leaf collection in Grade 5 through his (Honours) thesis on the local flora (1948) to *Plants of Prince Edward Island* (1961). Through David's work there, John and Rachel developed a lasting association with the Acadia University herbarium, and friendship with its curator (later department head), Dr. Chalmers Smith and his family.

Starting in 1950, John was employed each summer by the Nova Scotia Museum to build up their plant collections. He explored particularly islands all around the Nova Scotia coastline, looking in part for refugia where plants might have survived since preglacial times. His island visits resulted in a series of popular articles in the Nova Scotia Journal of Education. These, with other articles focussed by subject rather than location, described various aspects of the natural history of this province readably and informatively. Six of the more general articles were reprinted in 1971 by the Nova Scotia Museum as a popular booklet, and his other articles also might warrant re-circulation. He also published short botanical articles in various scientific and popular outlets.

When the island botany lode petered out, John in 1957 returned to his earlier interest in human history. He explored the archaeology of Indian shell-heaps and other campsites in Nova Scotia, with support from the Nova Scotia and National museums, for the next decade. He was possibly the first archaeologist in Nova Scotia to collect his data with strict attention to stratification, thus allowing time-sequencing of the cultures, soon confirmed by carbon-14 dating. This study too took him to many parts of the province, with a new circle of contacts, many of whom later remarked on his seemingly intuitive ability to visualize likely places to search for previously unknown Indian sites. Such "intuition" was founded on his knowledge of natural history and the relations of native and other peoples with their environment. The result was several preliminary publications, with a much larger body of unpublished reports. These were later drawn together by Mike Deal, then of St. Mary's University, into a major manuscript on Nova Scotia's pre-history which has not yet found a publisher.

Natural history was enlarged through this work too, his archaeological findings including the first evidence of the Common Periwinkle (*Littorina littorea*, a small marine snail) in North America before Columbus; earlier it was thought to have arrived in the 1800s. The first specimen evidence (bones) in Nova Scotia of the now-extinct Great Auk, *Alca impennis,* was another of his finds. He also first reported "Indian orchards", the coincidence of various fruit-bearing trees and shrubs around former campsites where seeds had been discarded after eating. An extension of the study of Indian archaeology led him also to examine sites of early Acadian settlements, for what could be learned about their human occupation and to document plants that had been thus introduced to those areas. His pamphlets on the Acadian period are still in regular demand at National Historic Parks in Nova Scotia. In his later years, he often lectured to groups, his pre-history of Nova Scotia being always a popular topic.

Although much of his later writing effort went into his second professional life, beyond his teaching, John's production in other lines continued. He regularly contributed stories and essays, often drawn from his unpublished manuscripts, and book reviews, on a wide variety of subjects including natural and human history, to the *Dalhousie Review*. Soon after his retirement from teaching, his historical novel titled *The Rightful King* (Longmans 1966) was published, based on the Lambert Simnel rebellion of 1487 and set mainly in northern England where John had lived in the 1930s (when the manuscript was drafted). Many other fictional works from his later years, including three more novels and translations of four Spanish plays, remain unpublished.

John's last years were increasingly frustrating for him. Arteriosclerosis, first diagnosed in 1971, led to his gradual loss of memory and vocabulary, a discouraging loss for one so noted for his knowledge and use of words. Progressive debility followed, with hospitalization from 1976. He died on 19 September 1981 in Wolfville, where he is still fondly remembered by many people. The book *A Natural History of Kings County*, published in 1992, was dedicated to John and Rachel Erskine, as among the most devoted members of the Blomidon Naturalists Society.

John Erskine was a philosopher as well as a naturalist, of a type more familiar in the pioneering years of the 19th Century, one who found all nature fascinating and whose thoughts and writings ranged across all branches of natural and human history and beyond them. He broke little really new ground in science, but his contributions to the never-ending task of filling gaps and organizing accumulated information were not negligible. His activity cannot easily be pigeon-holed: although he worked more intensively in botany and archaeology, he was involved in bird study before and throughout his 35 active years in Nova Scotia, and his teaching and writings touched on, and stimulated work in, many fields far beyond natural history. A polymath in what was rapidly becoming a world of specialists, he was known and is still remembered for his enthusiasm as much as for his knowledge, by his former colleagues, associates, and students all over the province, and far beyond it.

Acknowledgments

I thank Rachel Erskine, David Erskine, and Wilfred Schofield for comments on drafts of this account, to which many details not previously known to us were added from my father's voluminous unpublished autobiographical notes. The cover photograph was previously published in "Not Strictly for the birds" by A.J. Erskine in the *Nova Scotia Bird Society Newsletter* 8(1):29 (1966) as well as "John Erskine (1900–1981), a Naturalist in Nova Scotia" by A. J. Erskine, *Federation of Nova Scotia Naturalists News* 3(4):3–6 (1993). The portrait also appeared in the latter publication and in the *Natural History of Kings County,* Blomidon Naturalists' Society (1992). The Editor of *The Canadian Field-Naturalist* instigated this remembrance, but any errors of commission are the fault of its compiler, who also deliberately omitted much that might have been of interest to *The Canadian Field-Naturalist* readers. A book could be written...

Selected publications and other writings by John Steuart Erskine.

Note: John Erskine wrote on a wide variety of subjects; many items, including fiction, having no bearing on natural history were omitted here. His writing ranged freely across the "gray" area shared by natural history, geography, and human history (including ethnology, anthropology and archaeology), and most of his known publications touching on these subjects were included.

Published

1931a. Brambles. Christian Science Monitor, 10 November 1931.
1931b. Roads and the seeing eye. Christian Science Monitor, 31 December 1931.
1932a. The last hill. Christian Science Monitor, 12 January 1932.
1932b. Islands unvisited. Christian Science Monitor, 15 January 1932.
1932c. The railway out of the clouds. Christian Science Monitor, 2 February 1932.
1932d. A day at Copan. Christian Science Monitor, 15 February 1932.
1932e. Literary birds. Christian Science Monitor, 13 May 1932.
1932f. Solitude. Christian Science Monitor, 28 June 1932.
1932g. Majorcan memories. Christian Science Monitor, 23 August 1932.
1932h. The greatest bird sanctuary of all. Christian Science Monitor, 28 September 1932.
1932j. By the light of the moon. Christian Science Monitor, 7 October 1932.
1932k. The Harz Mountains at dawn. Christian Science Monitor, 1 November 1932.
1932l. Down to the sea. Christian Science Monitor, 31 December 1932.
1933a. Out of the east wind. Christian Science Monitor, 25 February 1933.
1933b. "Unexplored forests". Christian Science Monitor, 30 March 1933.
1933c. Duddon valley. Christian Science Monitor, 2 June 1933.
1933d. The clouds of Old Castile. Christian Science Monitor, 16 June 1933.
1933e. Jamaican year. Christian Science Monitor, 26 August 1933.
1933f. The butterflies pass. Christian Science Monitor, 22 September 1933.
1933g. The cave of Altamira. Christian Science Monitor, 13 October 1933.
1933h. The gull-ringing. Christian Science Monitor, 28 October 1933.
1934a. The eternal gardens. Christian Science Monitor, 4 January 1934.
1934b. Spring in the Dales. Christian Science Monitor, 7 March 1934.
1934c. The kingdom of Valencia. Christian Science Monitor, 14 March 1934.
1934d. Winding river. Christian Science Monitor, 24 April 1934.
1934e. Lost colonies. Christian Science Monitor, 11 May 1934.
1934f. Mine host in Honduras. [published, but not in Christian Science Monitor, possibly Manchester Guardian?] 26 June 1934.
1934g. View from a Welsh hilltop. Christian Science Monitor, 29 June 1934.
1934h. Wayside nights. Christian Science Monitor, 2 August 1934.
1934j. Sunset in Donegal. Christian Science Monitor [no date, probably autumn 1934].
1934k. Book review of *Bessarabia and beyond*, by Henry Baerlein, and of *The lure of unknown lands*, by Major F.G. Jackson. Christian Science Monitor [no date, probably 1934].
1934l. The Roman wall. Christian Science Monitor, 2 October 1934.
1935a. I was entering Andalusia. Christian Science Monitor, 25 January 1935.
1935b. High tide in Connemara. Christian Science Monitor [no date, probably 1935].
1935c. This was France. Christian Science Monitor, 1 April 1935.
1935d. The land of strangers. Christian Science Monitor, 14 May 1935.
1935e. The old places. Christian Science Monitor, 28 June 1935.
1935f. Unplanted flowers. Christian Science Monitor [no date, probably summer 1935].

1935g. The land of lost causes. Christian Science Monitor, 18 October 1935.
1935h. The Greek coast. Christian Science Monitor, 16 November 1935.
1935j. Cross section of Germany. Christian Science Monitor, 18 December 1935.
1936a. Over Gotthard. Christian Science Monitor [no date, probably 1936].
1936b. Last of the Italian republics. Christian Science Monitor, 17 January 1936.
1936c. In the southern Apennines. Christian Science Monitor [no date, probably 1936].
1936d. Roman Germany. Christian Science Monitor, 29 April 1936.
1936e. The Lombard plain. Christian Science Monitor, 13 June 1936.
1936f. Lapp country. Christian Science Monitor, 14 August 1936.
1936h. The harvests of Arretium. Christian Science Monitor, 21 September 1936.
1936j. Dovrefjell. Christian Science Monitor, 20 October 1936.
1936k. White winter. Christian Science Monitor, 28 November 1936.
1936l. The land of storks. Christian Science Monitor, 21 December 1936.
1936m. Moorish Spain. Christian Science Monitor, 31 December 1936.
1936n. (with **J. Wood.** A. Birkrigg burial. Transactions of the Cumberland and Westmoreland Antiguarian and Archaeological Society 36 (new series) 50–52.
1937a. The road to Riga. Christian Science Monitor, 13 January 1937.
1937b. Knoc Sumark. Christian Science Monitor [no date, apparently 1937].
1937 or 1938a. Weeds in their glory. Christian Science Monitor [no date, after 1936].
1937 or 1938b. The wind bloweth. Christian Science Monitor [no date, spring 1937 or later].
1939. Acadian spring. Christian Science Monitor, 17 June 1939.
1941. Swift winter on the Mountain. Christian Science Monitor, 10 April 1941.
1943. List of introduced flora of the neighborhood of Windsor. Acadian Naturalist 1(2): 51–58.
1944. Winter birds in Windsor, N.S. Acadian Naturalist, 1(3): 125–126.
1945. Avon tides. Christian Science Monitor, 27 February 1945.
1947. Minute mosses of Windsor, Nova Scotia. Bryologist 50: 276–278.
1949. Mosses as a nature study. (Nova Scotia) Journal of Education Series 4, 20(1): 61–63.
1950. More minute mosses in Nova Scotia. Bryologist, 53: 54–56.
1953a. Additions and extensions to the flora of Nova Scotia. Rhodora 55: 17–20.
1953b. New Bryophytes in Nova Scotia. Bryologist 56: 177–179.
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1954b. *Cypripedium arietinum* R.Br. in Nova Scotia. Rhodora 56: 669.
1954c. The ecology of Sable Island. Proceedings Nova Scotian Institute of Science 23: 120–145.
1955a. Sable Island. (Nova Scotia) Journal of Education Series 5, 4(2): 3–16.
1955b. St. Paul Island. (Nova Scotia) Journal of Education Series 5, 4(3): 18–28.
1955c. Seal Island. (Nova Scotia) Journal of Education Series 5, 5(1): 26–36.
1956a. Ile Haute. (Nova Scotia) Journal of Education Series 5, 6(1): 39–45.
1956b. (with **W. B. Schofield**) An introduction to Nova Scotia mosses. (Nova Scotia) Journal of Education Seroes 5, 6(1): 53–60.
1956c. Additions to the flora of St. Paul Island, Nova Scotia. Rhodora 58: 245–249.
1957a. (with **Jane McNeill**) Common lichens. (Nova Scotia) Journal of Education Series 5, 6(2): 29–34.
1957b. Mud Island. (Nova Scotia) Journal of Education Series 5, 6(2): 40–46.
1957c. The land of moss. (Nova Scotia) Journal of Education Series 5, 6(3): 22–27. ["Irish moss"}
1957d. (with **W. B. Schofield**) Bogs and their plants. (Nova Scotia) Journal of Education Series 5, 6(3): 40–49.
1957e. Small fishes. (Nova Scotia) Journal of Education Series 5, 7(1): 21–31.
1957f. A study of the Tusket Islands. Proceedings Nova Scotian Institute of Science 24(3): 271–296.
1958a. (with **W. B. Schofield**) Plaster rock. (Nova Scotia) Journal of Education Series 5, 7(3): 21–28.
1958b. Pollock fishing. (Nova Scotia) Journal of Education Series 5, 7(3): 36–39.
1958c. (with **W. B. Schofield**) Along the dykes. (Nova Scotia) Journal of Education Series 5, 8(1): 42–52.
1959a. Some ancient Nova Scotians. (Nova Scotia) Journal of Education Series 5, 8(2–3): 33–37.
1959b. Sparrows. (Nova Scotia) Journal of Education Series 5, 8(2–3): 60–65.
1959c. Under the forest. (Nova Scotia) Journal of Education Series 5, 9(1): 15–21.
1959d. Blomidon. (Nova Scotia) Journal of Education Series 5, 9(1): 44–48.
1960a. Before Jacques Cartier. (Nova Scotia) Journal of Education Series 5, 9(2): 65–70.
1960b. Shell-heap archaeology of southwestern Nova Scotia. Proceedings Nova Scotian Institute of Science, 24(4): 339–375.
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1961-62. Book review of *My other islands*, by Evelyn Richardson. Dalhousie Review 41(4): 562.
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1964. A school aquarium. (Nova Scotia) Journal of Education Series 5, 13(2): 50–52.
1964-65. Book review of *The Norse Atlantic saga*, by Gwyn Jones, and of *Early voyages and northern*

approaches, by Tryggvi J. Olsen. Dalhousie Review 44(2): 236–241.

1965a. A sandpit in August. (Nova Scotia) Journal of Education Series 5, 14(4): 29–31.

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1965-66b. Book review of *The Vinland map and the Tartar relation*, by Thomas E. Marston, and of *Westviking*, by Farley Mowat. Dalhousie Review 45(4): 518–522.

1966. Birds of yesterday. Nova Scotia Bird Society Newsletter 8(3): 27–29.

1966-67a. Book review of *Black Duck spring*, by Bruce S. Wright. Dalhousie Review 46(3): 419–421.

1966-67b. Book review of *Conquest of the last frontier*, by L. H. Neatby. Dalhousie Review 46(4): 547–549.

1967-68. Book review of *Thomas Nuttall, Naturalist: Explorations in America, 1808-1841*, by Jeannette Graustein. Dalhousie Review 47: 251–252.

1968a. An introductory moss flora of Nova Scotia. Nova Scotia Museum Occasional Paper 6, Science Series 4, 110 pages.

1968b. Winter birds of Wolfville, Nova Scotia. Nova Scotia Museum Occasional Paper 7, Science Series 5. 15 pages.

1968-69. Book review of *Canada's north*, by R. A. J. Phillips. Dalhousie Review 48(3): 427–429.

1969a. Early cultures of Nova Scotia. A preliminary prehistory. (Nova Scotia) Journal of Education Series 5, 18(2): 19–25.

1969b. Early cultures of Nova Scotia. II. The Laurentian period, 4000-1000BC. (Nova Scotia) Journal of Education Series 5, 19(1): 18–26.

1969-70a. Book review of *Acadia. The geography of early Nova Scotia to 1760*, by Andrew Hill Clark. Dalhousie Review 49(1): 132–135.

1969-70b. Book review of *The Palliser papers. 1857-60*, edited by Irene Spry. Dalhousie Review 49(4): 577–579.

1970a. Early cultures of Nova Scotia. III. The transitional period, 1000BC-AD600. (Nova Scotia) Journal of Education Series 5, 19(2): 17–24.

1970b. Early cultures of Nova Scotia. IV. The bow and arrow people. (Nova Scotia) Journal of Education Series 5, 19(3): 50–56.

1970c. Early cultures of Nova Scotia. V. Cape Breton. (Nova Scotia) Journal of Education Series 5, 19(4): 34–36.

1970-71. Book review of *Andrew Graham's observations on Hudson Bay, 1767-1791*, edited by Glendyr Williams. Dalhousie Review 50(1): 147–150.

1971a. In forest and field. Nova Scotia Museum. [Note: Reprinting, with consecutive pagination, of six of the above references: 1956b, 1957a, 1957d, 1958a, 1958c, 1959c.]

1971b. The archaeology of some Nova Scotian Indian campsites. Proceedings Nova Scotian Institute of Science 27(1): 1–10.

1971-72a. Book review of *Voyages to New France, 1615-1618*, by Samuel de Champlain (translation). Dalhousie Review 51(1): 117–118.

1971-72b. Book review of *Voyages to New France, 1599-1603*, by Samuel de Champlain (translation). Dalhousie Review 51(4): 601–602.

1972. On the history of Nova Scotia plants. Part I. Plants from the distant past. (Nova Scotia) Journal of Education Series 5, 22(2): 46–51.

1972-73. On the history of Nova Scotia plants. Part II. Through Indian times. (Nova Scotia) Journal of Education Series 5, 22(3): 43–46.

1973. On the history of Nova Scotia plants. Part III. Modern times. (Nova Scotia) Journal of Education Series 5, 22(4): 55–59.

Unpublished

Living history. A synthesis of biology, history, and sociology. ca. 200 manuscript pages (drafted in mid-1930s).

Wayside Europe. Countryside and people in Europe, as seen by a cyclist in 1932-36. ca. 200 manuscript pages (drafted in mid-1930s).

The Indian period of Nova Scotia. 14,000 B.C. - A.D. 1500. circulated as typed MS, through Nova Scotia Museum. 27 manuscript pages (drafted in 1960s).

The Hepatics of Nova Scotia. circulated as typed MS, through Nova Scotia Museum (compiled in late 1960s).

The French period in Nova Scotia, A.D. 1500-1758, and present remains. A historical, archaeological and botanical survey. 55 manuscript pages. Circulated as typed manuscript, through National Historic Parks. (drafted ca. 1970).

Memoirs on the prehistory of Nova Scotia, 1957-1967. 153 manuscript pages. Edited by Michael Deal ca. 1980, from published and unpublished manuscripts by J. S. E. (all listed in appendix).

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Editor's Report for Volume 107 (1993): *The Canadian Field-Naturalist*

Eighty-seven reseach, observation, major comment, or tribute manuscripts were submitted to *The Canadian Field-Naturalist* in 1993. Issue mailing dates for issues in volume 107 were: (1) 15 February 1994, (2) 31 May 1994, (3) 22 June 1994, and (4) 21 August 1994. Volume 107 totalled 590 pages; the largest single issue (4) was 196 pages. The number of articles and notes is summarized in Table 1 by topic, the totals for Book Reviews and New Titles in Table 2, and the distribution of published pages among issues in Table 3.

M.O.M. Printers, Ottawa, set and printed the journal and special thanks are due Emile Holst and Eddie Finnigan and their staff. Wanda J. Cook proof-read the galleys for the volume. Mickey Narraway remained on call for any additional assistance to the Editor. Bill Cody continued as Business Manager, assisted by Lois Cody. Bill also oversaw the compilation, and proof-read and edited the Index for volume 107 which was painstakingly prepared by Leslie Cody. Wilson Eedy continued as Book Review Editor and compiled the lists of New Titles (see Book Review Editor's Annual Report, page 256). Status Reports reviewed by the COSEWIC Fish and Marine Mammals Subcomittee were provided by Bob Campbell with financial support provided by Environment Canada.

C. D. Bird, R. R. Campbell, B. W. Coad, A. J. Erskine, W. E. Godfrey, D. Laubitz, and W. O. Pruitt, Jr., continued to serve as Associate Editors in 1993. Two additional Associate Editors, Warren Ballard, and Robert Anderson, University of New Brunswick, Fredericton, Canadian Museum of Nature, Ottawa, have accepted appointments for 1994. George La Roi continued as Coordinator of the Biological Flora of Canada series. The following reviewers also evaluated one or more manuscripts either submitted or returned in 1993: R. Anderson, George W. Argus, C. Davison Ankney, Warren Ballard, Robin W. Baird, Jean-Marie Bergeron, J. Roger Bider, David M. Bird, D. A. Boag, W. Bond, R. Boonstra, E. L. Bousfield, Thomas E. Bowman, Diane K. Boyd, Ralph Brinkhurst, Ronald J. Brooks, Daniel F. Brunton, Harold N. Bryant, R. Wayne Campbell, Lu N. Carbyn, Paul M. Catling, Jacques Cinq-Mars, C. S. Churcher, W. J. Cody, Pierre Compere, Peter Ross Croskery, E. J. Crossman, Jeff Cummings, Les Cwynar, Frederick Dean, Dirk V. Derksen, D. Lynne Dickson, Craig Ely, Rejean Fortin, Glen Fox, Valerius Geist, Frederick F. Gilbert, John Gilhen, J. Ginns, R. Ian Goudie, Graham Griffiths, Erich Haber, Vernon L. Harms, Fred Harrington, Michel Henault, J. Holsinger, C. Stuart Houston, Derrick Iles, Ross D. James, Robert E. Jenkins, Richard B. King, Gordon L. Kirkland, Jr., Richard W. Knapton, George Kolenosky, John L. Koprowski, Richard I. Knight, Anthony Lang, Jon Lien, H. G. Lumsden, G. L. Mackie, Ross D. MacCulloch, Donald F. McAlpine, Ian McLaren, Martin K. McNicholl, L. David Mech, Wayne E. Melquist, F. Messier, Eric L. Mills, W. T. Momot, Ralph D. Morris, Elizabeth Morton, David Nagorsen, Robert W. Nero, Martyn E. Obbard, Lynn Oliphant, G. L. Parker, R. H. Peters, Jaroslav Picman, Eva Pip, Iola M. Price, Gilbert Proulx, Scott Redhead, Randall R. Reeves, James D. Rising, A. A. Reznicek, Raleigh J. Robertson, W. B. Scott, Fred Scott, G. G. E. Scudder, Kevin Seymour, Norman R. Seymour, Joseph Shepstone, John Stelfox, Majorie A. Strickland, John B. Theberge, Robert Trost, Guillermo Tell, Guy Vaillancourt, C. G. van Zyll de Jong, Steve Wendt, Paul Watts, Walter Wilms, Robert E. Wrigley, and R. G. Zweifel.

TABLE 1. Number of articles and notes published in *The Canadian Field-Naturalist* Volume 107 (1993) by major field of study.

Subject	Articles	Notes	Total
Mammals	16*	24	30*
Birds	13*	10	23*
Amphibians and reptiles	0	0	0
Fish	10*	3	13*
Invertebrates	4	0	4
Plants	5	1	6
Other	1	0	1
Totals	49	38	87

*Includes COSEWIC Status Reports for 7 mammals and 7 fish, one mammal and one bird News and Comment feature article.

TABLE 2. Number of reviews and new titles published in Book Review section of *The Canadian Field-Naturalist* Volume 107 by topic.

	Reviews	New Titles
Zoology	26	119
Botany	8	50
Environment	20	89
Miscellaneous	8	24
Young Naturalists	0	120
Totals	62	402

TABLE 3. Number of pages published in *The Canadian Field-Naturalist* Volume 107 (1993) by section (number of manuscripts in parenthesis).

Issue number:	- 1 -	- 2 -	- 3 -	- 4 -	Total
Articles	91(11)	83(10)	82(11)	152(15)	308(47)
Notes	25(11)	25(13)	26(14)	0 (0)	76(38)
News and Comment	11 (2)	9 (5)	1 (1)	0 (0)	21 (8)
Book Reviews*	11(15)	10(12)	18(18)	17(17)	56(62)
Index	–	–	–	26 (1)	26 (1)
Advice to Contributors	0 (0)	1 (1)	1 (1)	1 (1)	3 (3)
Total pages:	138	128	128	196	590

*Total pages for book review section include both reviews and new titles listings but parenthesis figures include only the number of reviews.

In addition, special assistance was provided by Claude Renaud, Canadian Museum of Nature, who edited the French abstracts for COSEWIC reports, and Arch Stewart, Chief of Libary and Archives, Canadian Museum of Nature, and members of his staff, Jean-Guy Brisson, Pauline Maxwell and Mireille Boudreau, who speedily provided bibliographic help at various critical times through the year.

I continue to be indebted to Frank Pope, President of the Ottawa Field-Naturalists' Club, the Club Council, Chairman Ron Bedford and the Publications Committee of the OFNC for their support throughout the past year. The Canadian Museum of Nature provided time to carry out editing and many facilities. Joyce provided consistant encouragement through the year.

FRANCIS R. COOK
Editor

Book-review Editor's Annual Report, Volume 107

With the speed that *The Canadian Field-Naturalist* has published issues in 1994 (Volume, 107 - 1993), this has resulted in The Book-review Editor being pressed to submit New Titles and Reviews. The lag period will result in this mostly affecting Volume 108, but should be of great benefit to listing New Titles and publishing reviews while these titles are still new. It also means we have ever increasing needs for new reviewers and keeping in touch with those who have helped provide these reviews in the past. I find it difficult to keep up with everyone, so will again extend my annual plea: do not wait for me, please volunteer whenever you see a book of interest that should be brought to the attention of our readers. We need reviewers for those which are listed as available (†), but will also request books from publishers if they are recent and relevant.

I would like to send my thanks to the many reviewers who work hard to provide timely and informative reviews. It is a great service to provide to our readers. Reviewers also receive the complimentary copy of the book that they review. A special thanks to former Ottawa Field-Naturalist Club president, Roy John, who has set the record with over 75 reviews published to date, covering various fields from birds to marine mammals. Our Business Manager, Bill Cody must be close to this, and deserving of similar credit for keeping us informed in the field of botany.

Due to the shortened time span for Volume 107, the numbers of books received and sent to reviewers were both reduced. We did manage to publish 62 reviews and list 402 new titles. It is interesting to note that close to 15% of the journal pages are occupied by reviews and new titles. In volume 107, almost 30% (120) of the new titles were for young naturalists, and yet none of these were reviewed. It is also interesting that almost all of these are from United States publishers. I believe that the future of Naturalists' clubs and movements is dependant on the knowledge and interest we pass to our young naturalists. A similar percentage of new titles and the highest number of reviews published (26) were in the zoology category, followed by environment and then botany and miscellaneous categories.

The Book-review Editor has had an interesting introduction to the information superhighway this year. I have corresponded with both reviewers and publishers, received reviews and publications listings, and even received one book electronically over internet. For anyone interested, my address is <eedy@ geomatics. on.ca>. For those who must still rely on our postal service, please contact me at the address below if you are interested in reviewing recent publications of interest to the readers of the Canadian Field-Naturalist.

WILSON EEDY

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Amphipacifica: Journal of Systematic Biology

The first three issues of this new publication primarily for monographic papers in systematic invertebrate zoology for the Pacific region (see notice in *The Canadian Field-Naturalist* 107(3): 252) have appeared in 1994.

Volume 1, number 1, dated 7 January 1994, was 140 pages and contained an introduction to the journal by Ed Bousfield, Craig Staude, and Phil Lambert (page 1); an introduction to the authors of the papers in the issue (page 2); a Tribute to J. L. Barnard by E. L. Bousfield and C. P. Staude (pages 5-16); and two major research papers: A revision of the Family Pleustidae (Crustacea: Amphipoda: Leucothoidea). Part 1. Systematics and Biogeography of Component Subfamilies by E. L. Bousfield and E. A. Hendrycks (pages 17-57); and The Amphipod Superfamily Phoxocephaloidea on the Pacific Coast of North America. Family Phoxocephalidae. Part 1. Metharpiniinae, New Subfamily by Norma E. Jarrett and E. L. Bousfield (pages 58-140).

Volume 1, number 2, dated 24 May 1994, was 150 pages and contains an lead-off editorial (page 1); an introduction to the journal's artist, Susan Laurie-Bourque (page 2); and two major research papers: The Amphipod Superfamily Leucothoidea on the Pacific Coast of North America. Family Pleustidae: Subfamily Pleustinae. Systematics and Biogeography by E. L. Bousfield and E. A. Hendrycks (pages 3-69); and The Amphipod Superfamily Phoxocephaloidea on the Pacific Coast of North America. Family Phoxocephalidae. Part II. Subfamilies Pontharpiniinae, Parharpiniinae, Brolginae, Phoxocephalinae, and Harpiniinae. Systematics and Distributional Ecology by Norma E. Jarrett and E. L. Bousfield (pages 71–150).

Volume 1, number 3, dated 15 October 1994, was 134 pages and contains an introductory editorial and background on authors Jane Kendall, Kathleen E. Conlan and Chiang-tai Shih (pages 1-2) and three research papers: The Amphipod Superfamily Dexaminoidea on the North American Pacific Coast; Families Atylidae and Dexaminidae: Systematics and Distributional Ecology by E. L. Bousfield and J. A. Kendall (pages 3-66); New Species of the Amphipod Crustacean Genera *Photis* and *Gammaropsis* (Corophioidea: Isaeidae) from California (pages 67–74); The Phyletic Classification of Amphipod Crustaceans: Problems in Resolution by E.L. Bousfield and C.-t. Shih (pages 76–134).

Amphipacifica is published quarterly and annual subscription rates are $50 Canadian or $40 U.S. Further information can be obtained from: Dr. E.L. Bousfield, Managing Editor, Amphipacifica, c/o Royal British Columbia Museum, 675 Belleville Street, Victoria, British Columbia V8V 1X4.

Errata: The Canadian Field-Naturalist 108(1)

Daury, Richard W., Francis E. Schwab, and **Myrtle Bateman.** 1994. Prevalence of ingested lead shot in American Black Duck, Anas *rubripes*, and Ring-necked Duck, *Aythya collaris*, gizzards from Nova Scotia and Prince Edward Island. Canadian Field Naturalist 108(1):26–30.

On page 27, Figure 1, the scale 1 cm: 26 km is in error due to reduction of size from the original.

On page 27, Table 1, "*Anas platyrhynos*" should read "*Anas platyrhychos*".

On page 28, Table 2, "Glefinnan River" should read "Glenfinnan River".

On page 29, night column line 4, "following" should read "foraging".

Book Reviews

Zoology

The Fishes of Alberta

By Joseph S. Nelson and Martin J. Paetz. 1992. University of Alberta Press, Edmonton and University of Calgary Press, Calgary. 2nd edition. xxvi + 438 pp., illus. Cloth $34.95; paper $24.95.

More than twenty years have passed since the first edition of *The Fishes of Alberta* (M. J. Paetz and J. S. Nelson. 1970. The Queen's Printer, Edmonton, Alberta). The enormous amount of new information gathered since on the 59 species of fish found in Alberta makes this second edition justified, if not overdue.

This is primarily a guide to help everyone with an interest in fishes to identify them properly. But this book goes beyond identification: the first 80 pages cover a broad range of fishy topics, including fishing and management practices in Alberta, general fish ecology, and more esoteric subjects such as speciation. Some sections may be too simplistic for specialists but I think that the level of explanation is about right for most readers interested in fishes.

The rest of the book is a guide to fish identification. It begins with a very straight forward key to identify the 15 families found in Alberta. In addition, a one-page pictorial guide, showing outlines of typical members of Alberta's fish families, is provided. This pictorial guide is very effective, and very user-friendly to the novice who may find the technical terms in the key a bit daunting.

The 15 families are then treated in separate chapters. A general description of each family is followed by a key to identify species. Pictorial guides are also given for species within each family, but in this case they do not allow positive identification without referring to the key.

All the species are treated with the same format, which makes it easy to find information once one is used to the book. The descriptions of colour, body characteristics and size seem to be accurate and do not contain too many relative criteria (e.g., scales bigger than in species X but smaller than in species Y), which are useless when one is not familiar with many species. Characteristics that apply specifically to Alberta populations are outlined in a separate paragraph. Each species' distribution is described, both in Alberta and worldwide. The range of each species in Alberta is also depicted on full-page, easy-to-read maps that show locality records clearly.

General natural history is contained under the heading "Biology". However, the authors warn the reader from the onset that they have included information stemming mostly from studies of the fish in Alberta waters. Much more information may be found in *Freshwater Fishes of Canada* (W. B. Scott and E. J. Crossman. 1973. Fisheries Research Board of Canada Bulletin 184), but the shear size of this latter 'bible' makes it awkward as a field companion, whereas Nelson and Paetz will fit nicely (and lightly) in any backpack.

Each species section concludes with comments on angling value, when applicable, and interesting historical notes detailing early records for the province and name changes.

My only disappointment was with the illustrations in the species sections. They are a mixture of black-and-white and colour photographs, often of dead, or even pickled, specimens. A few are of live specimens in aquaria, but most of these are dark or blurry, obscuring characteristics important for identification. The few line drawings present are excellent and it is a shame that not all species were depicted in this way, with clear photographs as back-ups.

On the whole, this book will be valuable to naturalists, anglers, and professional biologists alike. Its apparent regionalism belies the fact that it does cover nearly one-third of all freshwater fishes found in Canada, making it a useful general reference. Alberta is fortunate to have two distinguished ichthyologists who have devoted their talents to cataloguing the province's fish fauna. It would be nice to see other provinces do the same.

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Raptors: Birds of Prey

By John Hendrickson. 1992. Chronicle Books, San Francisco. 85 pp., illus. U.S. $24.95.

John Hendrickson, a gifted photographer and a good writer, has produced a beautiful book. Roughly equal space is devoted to photographs and to text. The photographs alone are easily worth the price.

The text presents an unusual amount of interesting scientific information about raptors, most of it true, but sadly the author could not have had the manuscript checked by an expert raptor biologist. Over-generalizations and over-simplifications pop up here and there where you least expect them, sometimes, as in the case of the relationship of hollow wing bones to air sacs as regards respiration, so poorly worded as to constitute misrepresentation.

Hendrickson misses some golden opportunities; for example, he tells how vultures defecate onto their own legs, but doesn't tell how this excreta can form a rock-solid mass around an aluminum leg band and ulcerate the leg, so seriously that leg banding of vultures is now forbidden. It is not only the Flammulated and Screech Owls that migrate regularly, the Short-eared, Long-eared, and Snowy Owls are additional examples. The threat to the Spotted Owl from Great Horned Owl predation and Barred Owl displacement is nowhere mentioned. The oldest Red-tailed Hawk known in the wild from banding records through 1989 was 21 years old, not 16 as stated. He mentions the awarding of a Nobel Prize for the discovery of DDT, but fails to name the recipient, Paul Hermann Müller. He doesn't mention the mechanism of electrocution of many raptors, when the prey they are carrying touches a ground wire. Golden eagles leave their nests when a human intruder appears, not in any way "confident that the young can defend themselves" (they cannot), but to allow survival of the adults who live to breed again another year.

Because the text is not fully reliable in the above and other areas, I find it difficult to follow my heart and give this book my unstinting praise. On the other hand, even though some of the facts are incorrect or misleading, the dangers faced by raptors and the "truth" of the need for greater conservation effort shine through clearly. If you buy it, take the facts with a grain of salt.

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In Search of Arctic Birds

By Richard Vaughan. 1992. T. & A. D. Poyser, London. xiv + 431 pp., illus. U.S. $39.95.

Historians are usually handicapped by their lack of knowledge of ornithology and ornithologists by their lack of a historical perspective. Those who write in English rarely have the skills in foreign languages to tap the German, French, and Russian literature; even if they do, they may write of areas they have not visited. This book is the rare exception. Richard Vaughan, a teacher of medieval history in a Dutch university, is an Englishman, an accomplished linguist, an arctic historian, and a talented birder who has visited remote sites such as Cambridge Bay in Arctic Canada. The result is a book which provides a magnificent overview of the history of ornithology across all of the circumpolar arctic regions. It is clearly a labour of love. Excellent photographs, some taken on site by Vaughan, and well-chosen quotations from other writers add greatly to the interest. There are 38 helpful maps and a thorough index.

Vaughan tells exciting stories from a historical perspective. The search for the first nest of a species, such as the Little Stint and Red Knot, often unfolds like a well-told detective story. Nowhere outside Antarctica have naturalists faced such difficulties in living, much less in travelling. North of the Arctic Circle there is total darkness in mid-winter. The summer season is extremely short; open land and water may last less than six weeks.

Birds adapt in wonderful ways. Some flightless young Brunnich's Guillemots must swim 500 km to keep ahead of the ice, and downy Ross's Gulls from the Kolmya River must walk 50 km to reach the ocean before they learn to fly. Food supplies for arctic birds can be precarious, especially at the bottom of the lemming cycle, or in cold seasons; some years no breeding can be attempted. On the other hand, incredibly large seabird colonies occur in select locations, including Canadian waters.

Vaughan shows great respect for the skills and knowledge of the native people living in arctic regions, who must use birds for food, clothing, and bedding, and are skilful observers and nest-finders. Greenlanders were enlisted by Finn Salomonsen to carry out large bird-ringing projects. The Norse settlers of Greenland between 1000 and 1400 A.D. and Dutch whalers in Spitsbergen also exploited northern birds for food, as Vaughan tells in some detail.

An interesting chapter on falconry tells how seventeenth-century tsar Alexei Mikhailovich had 200 gyrfalcons brought to Moscow each year.

Inevitably, there are a few omissions. Vaughan was unaware of the publication of *Andrew Graham's Observations* by the Hudson's Bay Record Society in 1969. Alexandr Middendorf's Taimyr peninsula studies in 1843 merit more attention than Vaughan has given them. Equally understandable are the few errors that have crept into this wide-ranging work. The first Franklin expedition's arctic exploration resulted in the loss of 11 of its 20 members, more than "nearly half"; the entomologist William Kirby did not assist in preparing *The Mammals* for the four-volume *Fauna Boreali-Americana*. British names for birds will be confusing to any North American reader who fails to consult Vaughan's glossary at the end of the book; our White-winged Crossbill is called the Two-barred Crossbill; and the Black-bellied Plover is called the Grey Plover.

The book concludes with a chapter on tourism for bird-finding in the various arctic regions and a chapter on conservation. The sensitive arctic ecosystem is threatened in a great many ways, especially since the arctic tundra is extremely fragile. One can best plan for the future by knowing the past, ably summarized in this readable and highly-recommended book.

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Threatened Birds of the Americas: The ICBP/IUCN Red Data Book. Third Edition, Part 2

By N. J. Collar, L. P. Gonzaga, N. Krabbe, A. Madrono Nieto, L. G. Naranjo, T. A. Parker III, and D. C. Wege. 1992. Smithsonian Institution Press, Washington. 1150 pp., illus. U.S. $75.

South America has an enormous variety of different habitats and, in consequence, a vast diversity of wildlife. Unfortunately it does not have an equivalent horde of observers to document the vital details necessary for the conservation of that wildlife. That being said, this book represents the compiled work of an army of contributors; probably in the order of 500. However, this is but a small number in comparison to the work needed to fully document and evaluate the conservation problems and a significant portion of these people are non-residents. This book covers over three hundred species of birds whose populations are in some way in jeopardy. Depending on the species, the information provided varies from vague to detailed and compiles whatever is known about distribution, population, ecology, and the current status.

This book is intended as a reference to any person studying birds in South America. As the text is arranged by species, serious researchers will be able to access the summarized data and references for the species (or genera) of interest. One of the appendices lists the bird by country, so with a little extra effort the data can be used for study of a particular region. An ecological study would require a more intensive search but could still be done.

Judging the quality of the data is difficult and there is much variability. This is not a reflection on the authors but on the difficulties of obtaining good data in this region. This is due to the terrain, the scarcity of most of the subjects, confusion with other species, incorrect recording of specimens, and the lack of observers. In addition, smugglers will release their catch as soon as they suspect detection. The illegal bird trade not only results in a loss of birds, but release away from their home territory will result in confusing distribution patterns.

There is one point on which there is limited variability; the reason these birds are declining in numbers. Loss of habitat is the key threat identified in many of the accounts. This may be aggravated by other pressures such as capture for the cage-bird trade, but some form of habitat change is implicated in the majority of species. The news is not entirely bad however. The authors identify what preservation actions are being taken, and the measures proposed for conservation.

Accepting that this is the best data obtainable, how can it be used? The options are large. Any researcher studying birds in any part of South America will find this a useful source book, providing information on the population size and distribution, the ecology, the threats, and the measures taken or proposed to mitigate problems. The researcher can go from the synopsis provided by the book into more detail by using the over 2500 references given. The point at which a bird was eligible for inclusion (that is when it is "threatened") is open to some debate. The authors have made rational choices where required, but have left the door open for change.

Visiting birders may not want to purchase a copy for themselves but should review the status of birds they hope to see. In this way they will benefit by being better informed and they will know which information is important and should be documented.

In summary this well organized and written book is a major contribution to ornithology. The authors deserve credit for tackling such a daunting task. They say "Books like this get abandoned, not completed" and the reader can understand why. They have, however, abandoned it in fine style.

ROY JOHN

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Fish: An Enthusiast's Guide

By Peter B. Moyle. 1993. University of California Press, Berkeley. 272+xi pp. U.S. $25.00; CDN $30.15.

By all major measures fish are the most diverse group of vertebrates, and in this book Moyle is eager to share his enthusiasm with a broad audience including aquarists and anglers. The opening chapters introduce the aquatic environment, associated physiological systems, evolutionary history, behaviour, and external and internal anatomy. The subjects of diversity (including biogeography and commercial importance) and ecological factors (physical and biotic) lead into a consideration of different habits, fresh- and salt-water. There is much good material on limnology, community dynamics, feeding patterns, and the differences between lakes and reservoirs. A fine chapter on conservation highlights problems such as introductions of species, pollution, and ethical, aesthetic, and practical aspects.

Throughout the text examples from California, of course, are abundant. With each chapter subsequent projects are usefully suggested. A final, very valuable chapter outlines further literature, both old and recent, on a diversity of topics, as well as hints for undertaking one's own explorations under the philosophy of Thinking Globally and Acting Locally. (It is good to see the publications of Fisheries and Oceans Canada recommended.) The intriguing section on gyotaku (Japanese fish printing) leaves one eager for more on the cultural, biographical, and historical impacts of ichthyology. The style is friendly and seasoned with personal anecdotes. The illustrations by Chris Mari van Dyck are very good, although size scales would have helped and the layout is occasionally odd. There are interesting tidbits, such as the abundance of bristlemouths, invalidating sonar readings, but some issues, such as why in uniparentally breeding species it is usually the male, merited further discussion. This book will be valuable for anyone wishing an introduction to both the scientific and applied sides of ichthyology.

PATRICK W. COLGAN

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The Ecology of Insect Overwintering

By S. R. Leather, K. F. A. Walters, and J. S. Bale. 1993. University of Cambridge Press, Cambridge, U.K. x + 255 pp., illus. U.S. $89.95.

Overwintering, that is the way insects overcome less than ideal temperature conditions, forms a large part of the lives of temperate and polar dwelling forms but is often neglected by researchers. The authors, stated purpose in this book is to integrate both the ecological and the physiological viewpoints of insect overwintering in an attempt to shed new light on the subject. The book is aimed at "postgraduate" entomologists but should be of particular interest to many practicing Canadian foresters, agriculturalists, and entomologists in addition to the academics.

The book contains six chapters: a short introduction to overwintering in insects and why it's important to both insects and man; overwintering location selection by insects with an emphasis on the local and regional suitability of chosen sites; control (that is the induction, maintenance, and termination) of the overwintering state; a chapter on cold-hardiness, which is largely devoted to the cold-hardiness strategies of insects; the costs and benefits of the various overwintering methods employed by insects; and a chapter on applied biology and economics of predicting and controlling insect overwintering states. The best-studied aspect of insect overwintering is plainly the physiological basis of cold-hardiness as evidenced by the amount of space devoted to this section (66 pages, nearly 32% of the written text).

Tables and figures (mostly graphs with a few maps) are interspersed throughout the text to emphasize various points made in the text. There is an extensive bibliography (33 pages, approximately 1/8 of the book) of somewhere around 650 citations up to and including 1990. The text is exceptionally well-indexed (15 pages) with both taxa and subjects combined, for example, "cryoprotectants, synthesis in *Pieris brassicae*" and "*Pieris brassicae,* cryoprotectants, synthesis of". The overall production of the book is up the usual high standards of Cambridge University Press.

This book is an extensive review of the available literature on the subject and as such is just crammed full of specific examples (well over 200 taxa are represented) for almost every possible point. But it also goes beyond being just a review volume and becomes a synthesis of all of the available information by virtue of the inclusion of some of the three authors' previously unpublished works, highlights on specific omissions in the literature requiring future research, and the insight which they bring to interpreting the results of the assembled literature by maintaining an integrated viewpoint throughout. This book should be required reading for all entomologists studying the Canadian fauna.

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BOTANY

Orchids of Indiana

By Michael A. Homoya. 1993. Indiana Academy of Science and Indiana University Press, Bloomington & Indianapolis. xix + 276 pp., illus. Cloth US $34.95 + $3.00 shipping and handling.

In perusing the floras of the various U.S. states on the shelves of any major botanical library, I often would stop for a while to leaf through the conspicuous manual of the flora of Indiana by C. C. Deam (1940), a book that attracted attention to the state. Now this same state can take pride in having produced one of the best regional orchid guides.

The book begins with a 47-page introduction covering such topics as the history of Indiana orchidology, orchid morphology and reproduction, phenology, classification, and orchid ecology and distribution. The art of good writing is still alive here. Mr. Homoya is both an orchid enthusiast and a very skilled field botanist. This combination has resulted in a first rate introduction to natural regions (with a map) as well as a comprehensive discussion of natural communities. It provides an excellent picture of how various orchid species fit into the Indiana landscape but it is valuable regardless of the orchids. The discussion of orchid environment might have contained reference to the effect of soil nutrient content (an interesting discussion of which was presented by Sheviak in 1981 and published in the proceedings of the symposium entitled *North American Terrestrial Orchids* in 1983 by the Michigan Orchid Society).

Mr. Homoya clearly has a great deal of interest in conservation, and the book is very informative in this area. The advice to horticulturalists in a section on conservation is noteworthy: "do not purchase native orchids from garden centres or mail-order nurseries, regardless of claims that their plants are nursery-grown … ." The orchids are a particularly useful group of plants to illustrate human effects on environment. The Eastern Prairie Fringed-orchid has been found in 10 counties in Indiana, and was probably once common in the extensive prairie regions of the state, but has not been seen in the state for over 50 years.

The 46 "species accounts" which cover 173 pages are preceeded by a 6-page guide with a map of Indiana counties and the key to genera. Actually 43 orchids have been found growing wild in Indiana. Two species each have two varieties accounted for separately and one hybrid is accounted for bringing the total taxa to 46. The hybrid treated separately is *Cypripedium* X *andrewsii*.

Keys which are accurate and well written are provided for each generic grouping. Minor problems include an occasional lack of parallelism and the fact that the couplets in some keys depend largely or entirely on flowering time and flower colour, both of which have some limitations with dried specimens.

Each species account includes a brief morphological description, blooming period, range, habitat, and discussion. The descriptions are adequate and accurate. Range is considered with relentless precision. The habitat descriptions are very detailed and with the lists of associated species, the habitat data is reminiscent of Sheviak's classical *Ecology of the Illinois Orchidaceae.* Incidentally, the old-field habitat of *P. leucophaea* noted by Homoya is also a phenomenon that has been recently noted in Ontario and Michigan. The discussion sections sometimes contain new and valuable information. For example the notes on recent spread of certain species such as *Corallorhiza odontorrhiza* and *Spiranthes ovalis* var. *erostellata*, and pollination of *Goodyera pubescens* by the metallic emerald bee *Augochlorella striata*. Homoya makes a number of interesting observations about disturbance. For example with regard to *Corallorhiza maculata*, he noted that it grew beside a hiking trail but not far away from the trail. He found that the geographic segregation of floral forms of *C. odontorrhiza* do not hold up in Indiana. There is a particularly good discussion of the taxonomic problem involving the varieties of *Platanthera flava.*

A shaded North American distribution map and a state distribution map with dots for each county with a verifiable record are also included for each species. North American distribution maps are definitely some of the best currently available and represent a vast improvement over corresponding maps in Luer's (1975) work. This is partly a result of the fact that more accurate information is available now than was available in the early seventies, but the author's desire to be accurate and up-to-date is also a factor. Compare maps of *Arethusa bulbosa*, *Spiranthes ovalis*, etc. Who would have imagined that some of the most accurate distribution maps for North American orchids would appear in a book about Indiana orchids?

Good quality colour photographs accompany each species account except for a few species not currently known to occur in the state, which are illustrated with line drawings. All but one of the photographs were taken in Indiana. Many of the photographs are full page (7 x 10 inches) and many of them give an interesting sense of habitat and discovery. Some are exceptional. A few of the photos contribute to design but no new information. The *Malaxis unifolia* inflorescence photo is a darker version of exactly the same image that appears on the preceding page, and the same is true for *Liparis loeselii*.

Among the special features are a figure comparing the capsules of Indiana orchids and another showing actual size comparisons of *Spiranthes* inflorescences. Both are very useful, although the latter does not well illustrate the difference between *S. cernua* and *S. ochroleuca*. The checklist of scientific and common names includes a pronunciation guide which will be appreciated by many. The book concludes with a list of scientific and common names of all plants cited in the text, a glossary, and an index.

There are some interesting opportunities for research in Indiana. For example, it would be useful to collect and analyze some data on the two varieties of *Spiranthes lacera*, which the author has effectively lumped unlike most other recent authors, but without much data to support this interesting (and possibly appropriate) decision. The possible agamospermy in *Aplectrum* and *Platanthera* is of particular interest since it is thought to be such a rare phenomenon generally in the plant kingdom. Future revision of this book may take some of these special needs for information on Indiana orchids into account, but this is not a criticism of the present work which presents an excellent current picture of systematic knowledge.

With such an excellent work, I might not have been too critical of a mediocre package, but the package is not mediocre. In fact the package is excitingly appropriate. The book has a durable hard cover of cardboard and cloth, is beautifully stitch bound in fascicles, and printed on the highest quality paper (throughout!). It has the smell of an expensive book, but by today's standards it would be a bargain at many times the selling price. It is also a well designed book, but more space between categories in species accounts, a more distinctive bold and better use of bold are potential improvements.

Because the orchid flora of Indiana has so much in common with the orchid floras of other parts of the upper midwest, Great Lakes region and eastern North America generally, this book has great value far outside Indiana. It is an essential source for any library that attempts to maintain significant contributions to knowledge of North American flora and particularly knowledge of North American orchids. For anyone who is interested in plants and at the same time would like to gain some familiarity with the natural history of Indiana, this book is a good way to do it. No "orchid nut" could stand to be without this exemplary book for long.

Obviously this reviewer is very impressed, but there are some other ways of looking at a major work. There is, for example, the question of whether or not it meets its objectives. Among the goals of the publisher, the Indiana Academy of Science, are "diffusion of scientific information, … improving education while stimulating interest in the sciences" etc. One can only say that these kinds of goals are far exceeded with a book of this kind. It creates and fuels the desire for scientific information, regardless of "diffusion" and "stimulation". Congratulations to the author and to the Indiana Academy of Sciences.

PAUL M. CATLING

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Orchids of Minnesota

By By Welby R. Smith. 1993. University of Minnesota Press, Minneapolis. ix + 172 pp., illus. Cloth US $24.95.

There are 42 species of orchids growing wild in the state of Minnesota, and the Showy Lady's-slipper is the state flower. Smith suggests that orchids are often thought of as "existing only in steamy tropical forests or in Edwardian greenhouses", but certainly there cannot be a field biologist out there who is unaware that several to many native wild orchids exist in almost all parts of North America. The reason is the tremendous increase over the past few decades in knowledge of the flora as well as the proliferation of regional orchid books. A major development in the evolution of North American orchid books was Frederick Case's *Orchids of the Great Lakes Region* published in 1964 (with a revised edition released in 1987). This book set a standard that only some of its followers have reached. Smith's book is one that measures up very well, and in fact sets a new standard in some areas.

It begins with a brief but very informative introduction. Included here is an explanation of what an orchid is, orchid ecology, and an indication of the occurrence of orchids within the major vegetation types of Minnesota. A few pages on conservation are also concise, but all the major important points are brought out. Smith notes that native lady's-slippers end up in "reputable nurseries under the misleading label of "nursery propagated", which means only that they have been held in the nursery for a minimum of one growing season." Of course Smith and others across the border do not know how lucky they are in comparison with Canadians who are without wildflower protection legislation! Smith also presents a brief but very clear account of the decline of orchid populations due to habitat destruction.

A few paragraphs at the end of the introduction explain how to use the keys and descriptions to identify orchids. The illustrated key to genera is very "user-friendly". The main body of the book includes

128 pages of species accounts and an additional 16 pages of good quality colour plates, with a colour photo of each species occurring in Minnesota. The book concludes with a valuable flowering time chart, a glossary of terms, and a list of literature cited and an index.

The very good things about the book are the concise, authoritative and accurate text, which is well referenced and contains much useful information. It is also cleverly written in such a way as to appeal to either a professional or a novice. The keys could generally be used to identify living plants or 100 year old museum specimens. They are not just for the orchid photographer.

What is special about the book is a very agreeable design. The single page of text for each species has various clearly marked categories of information including abundance, habitat, known flowering dates, description, aid to identification, and comments. The "comment" and "identification" categories contain notes on variation, unusual morphological traits, pollination, and status. The state distribution map and a shaded North American distribution map also appear on the text page. The opposite page is always a plate of line drawings. A great deal of information is thus forced into a small space, but it is predictable and optimally accessible. It took me a few minutes to realize that this efficient "field guide" design was one of the things that I found really appealing. A reader likes to be able to find things and get information easily. Our impatience these days with a so-called "slow computer" is some of the best evidence available for the importance of this efficiency seeking phenomenon.

Also special are the plates of line drawings by Vera Ming Wong. Each plate depicts an entire plant, close-up of the inflorescence and/or individual flowers as well as dissected floral parts and sometimes other plant parts. The foliar embryos of *Malaxis paludosa*, the windows in the lip of *Malaxis unifolia*, and the capsules of *Liparis liliifolia* are features rarely illustrated. So impressive are these drawings that they are approaching the level of scientific value and accuracy of the best orchid plates ever produced (*Icones Orchidacearum* — Orchids of Mexico). They require only a little more skill and fall short primarily in the lack of detailed attention to the column and pollinaria.

Another special feature is the very accurate dot distribution maps for the state based on specimens examined in various museum and university dried plant collections. The dots are small thus maximizing accuracy, and are plotted precisely rather than just in the centre of a county. To provide additional indication of status they are coded by date. The North America maps are an improvement over those currently available. The map of *Listera auriculata* for example, based on more recent information, shows twice as large an area of occurrence as the map in Luer's (1975) book.

Orchids of Minnesota is for any serious field botanist in the northeast and for anyone who wants to learn about a fascinating group of wildflowers. Its value extends far beyond Minnesota. It could be used to identify and learn about the majority of orchids found in any part of Canada. It is a must for anyone who collects the best orchid floras of the world.

Both the quality of the book and the remarkable value for the price will increase its popularity and accessibility. This is important because a fund assisting its publication is "dedicated to the publication of books that promote an understanding and conservation of botanical resources". It is difficult to imagine how this fund could have been used to better advantage.

So what is wrong with this book? The epithet of Lily-leaved Twayblade is inappropriately spelled. The compound should be formed in accordance with classical latin usage by substituting an "i" for the final vowel of the root "*lilio*" thus resulting in "*liliifolia*" (Code of Botanical Nomenclature 73G). Also the reports of *S. cernua* hybridizing with *S. romanzoffiana* alluded to on page 149 were based largely on Correll's *Spiranthes* X *steigeri* which was shown to be an unusual form of *S. ochroleuca* (Rhodora 86: 469–473. 1984.).

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Plant Partnership

By Joyce Pope. 1990. Facts on File, New York. 62 pp., illus. U.S. $15.95; $19.95 in Canada.

This book is part of the *Plant Life* series and is obviously intended for "young adults" although only the further reading list makes this clear. The format of the book is typical for its intended audience, containing 26 "chapters" consisting of open facing pages with a large colour photograph or drawing and a few smaller photos and drawings, about 1/2 to 2/3 of a page of text, and infrequent sidebars on special topics within each "chapter" or subject. Therefore, many subjects are touched on but none are dealt with in any great detail.

The subjects covered include an introduction to "the great partnerships" (the sun and photosynthesis, plant foods, and plants as animal food), plants as plant supports (vines, tendrils, roots, and epiphytes), plants as plant food (parasitic plants and symbiotes), lichens, animal partners (zooxanthellae and animal gardeners), flowers and pollination (floral structure, colour, and insect pollinators), insect traps and galls, orchids and insect pollinators, bird and mammal pollinators, seed dispersal and seed-eaters (birds, mammals, and insects), and a variety of special subjects such as insects that imitate plants, plant protectors, ants and fungi, plant galls, insectivorous plants, and uses of plants by man (future of biotechnology).

There is a two page glossary that defines some terms that are bold-faced in the text, a two page index, a 1/2 page section directing the curious to further (I would hope more in-depth) reading, and 1/2 page of photographer credits. Some of the photos seem inappropriate at best since they do not or badly illustrate what the caption intends. For example, page 26 has a photo of a butterfly nectaring on an aster and the photo caption refers to "hidden nectar in tube-shaped petals". I also found some of the obvious omissions somewhat curious and surprising. For instance no mention is made of plant chemical defenses, plant evolution or coevolution , the medicinal properties of plants, and the long-standing partnership with the human race!

However, I am not the intended audience so I asked my niece, Laura, soon-to-be 14 years old, to help me to review the book. Laura liked the pictures and found the drawings and diagrams very useful explanations of hard to grasp concepts in text. She used the glossary quite a bit but found that some words she needed, such as fungal, weren't there. She thinks that she learned a lot, said that her school did not have any books on this subject, and that they should get a copy of this one.

PHIL SCHAPPERT AND LAURA SCHAPPERT

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ENVIRONMENT

On Nature's Terms: Contemporary Voices

Edited by Thomas J. Lyon and Peter Stine. 1992. Texas A&M University Press. College Station, Texas 212 pp. Cloth U.S. $35; paper U.S. $14.95.

This collection of essays is a record of nature lovers proclaiming their love and care for the natural world which they found themselves to be contributing parts. In general the book was written from the perspectives of individuals writing of their solitary dialogue with nature or relating to the natural world with small groups of friends. Each essay is introspective and very personal to the author's experience, regional to a specific part of the United States, but very easy to read and relate to the reader's own experience.

I was happy to find that most of the writers were happy people who valued their relationship with the natural world, a relationship which gave life, nurture, and pleasure. When reading anecdotes about nature and our relationship with the natural world, I often find that writers get in the rut of bemoaning pollution, overcrowding, exploitation, government overregulation or the lack of regulation. The list goes on and on. Certainly this book is not without overtones of all of the ills which human beings have forced upon the natural world and the essay *Apologia,* by Barry Lopez, and *The Abstract Wild,* by Jack Turner, are two entries in which a lot of sadness and lamentation is expressed. In general though, this one is a book of good news by people who respect the natural world and its needs. Their spirits are fed by nature and its gifts.

We need prophets of doom and people to tell us that all is not right with the way we act in the world. Those who lament in our midst have effected a lot of change by their efforts to awaken us to our ongoing responsibilities. We also need people to tell us that the world is a blessed place and that we have a place in the unfolding of the story of our own existence. Essays like Terry Tempest Williams' *Undressing the Bear* and Gary Snider's *Woman Who Married a Bear* are both supernatural fantasies whose images teach us about our close relationship with the animals which we have been taught to fear and in context, our responsibility to protect and respect those animals. In contrast, Charles Bowden's essay *Love among the Lion Killers*, needs no help from the imagination as he shows us with cold statistics and colourful reporting the state of Mountain Lions in the Rocky Mountains and the results of the official and unofficial treatment of this species in management strategies over the last several decades.

The four corners of the Continental United States, including Alaska are represented with the exception of the southeast; obviously the authors were interested in making a book which would encompass most of the regions of the country. It is a very good read, and I recommend it for one who likes to travel and has visited many parts of the United States. I was able to identify places which I had visited and where I enjoyed the beauty of the countryside, but I do not have the depth of experience which the authors were able to bring to their narrative. I will look at these areas anew when I have the chance to visit them again. To be introduced to an area by one who has love and care for the country is to be given a gift which connects the place and the author together, a sum of parts where most of the parts are unseen but impossible to ignore.

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Newton Rules Biology: A Physical Approach to Biological Problems

By C. J. Pennycuick. 1992. Oxford University Press, Oxford; and Don Mills, Ontario. x+111 pp. Cloth U.S. $39.95; paper U.S. $19.95; Cdn. $26.95.

Biologists do not like physics. They accept chemistry, and many do arcane mathematics in investigating the genetic code, but few will admit that one can learn anything about biology from physical arguments. Colin Pennycuick, Maytag Professor of Ornithology at the University of Miami, is an exception. In this book he tries to persuade fellow biologists that simple Newtonian or classical physics constrains biological systems: plants, animals, and ecosystems; and that the response to these constraints helps us to understand the systems.

This book is too short to be a general survey of the applications of physics to biology; Steven Vogel's *Life's Devices* does that very well. Pennycuick is concerned here mainly with careful regard for units (mass, length, time, and their combinations), scaling, and allometry, or change of shape with size.

He begins by showing how careful regard for units can simplify or even answer problems, then carefully works through some familiar material on muscles as engines, making it clearer by emphasizing proper care with units.

Scaling and allometry can show us how animals change shape as they change size – an elephant's legs are disproportionately thicker than a deer's, for example. His example is the shapes of petrels' wings, over a 400-fold range of body mass.

The second half of the book is new, at least to me. First the author asks how scaling and allometric arguments are affected by the ideas of fractal geometry. Lungs and some other structures are fractal, so some apparent allometries may partially reflect a fractal dimension, not a change of shape. To do this question justice would require another book of at least this size.

Next he applies scaling ideas to ecosystems, again with proper care for dimensions, and finds the biomass density of people to be absurdly, insupportably, large. This density is propped up by our massive use of minerals, both as fertilizer and as energy. When this large flow falters, the ecosystem will crash. Our global transportation system has ensured that the resulting famine will also be global, not local, and billions of years of evolution, he argues, have ensured that we will not be able to change our behaviour enough to forestall disaster.

In the first part of the book Pennycuick points out how his hero, A. V. Hill, had made a wrong assumption in his development of scaling arguments, and so although Hill's line of reasoning is correct, the results are somewhat different. Pennycuick, too, may have made some wrong assumptions, but his line of argument is likely to remain valid. Is his predicted disaster avoidable?

Pennycuick writes carefully and clearly. I believe that this book should be able to convince a biologist that physics is as relevant to biology as is chemistry.

BRUCE WINTERBON

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Biogeography: An Ecological and Evolutionary Approach

By C. Barry Cox and Peter D. Moore. 1993. 5th Edition. Blackwell Scientific Publications, Oxford; Cambridge, Massachusetts. x+ 326 pp., illus. U.S. $34.95.

In recent years the human population has come to realize the impact it can have on the planet. With this realization has come the need to understand the interrelationships of the planet. The effort will require an understanding of the interconnectedness of several subjects for students specializing in one. This is the individual for whom this book is meant. As the authors state "implications of biogeography for our own activities and future is now central to the approach of the new edition".

The authors have developed a very readable text covering a variety of topics. *Biogeography* discusses the evolution of key theories such island biogeography. The book has been updated with new information in a number of areas, tectonics and climatology, to name a couple. New and old developments are referenced and discussed using case studies from around the globe.

This is a book to be recommended to any who have an interest in the development of the planet; past, present, or future. But the reader should be warned the book may be hard to put down once started.

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MISCELLANEOUS

Birder Extraordinaire: The Life and Legacy of James L. Baillie (1904-1970)

By Lise Anglin. Toronto Ornithological Club, 560 Blythwood Road, Toronto, Ontario M4N 1B5. 143 pp., illus. $14.60.

By publishing this tribute to Jim Baillie, Lise Anglin has reminded us how much today's birdwatchers and ornithologists owe to our predecessors – regarded in their day as (at the least!) eccentric weirdos. She has sketched a good portrait – warts and all.

Jim Baillie was born in 1904 and was an active birdwatcher and naturalist from age 15 - in the first few years by eye and sound only: he had no binoculars. He and his friends located many of the areas still renowned today for good birdwatching, and "discovered" many species not then known to occur in Ontario. He turned his hobby into his life work and joined the Royal Ontario Museum in 1922, rising to become Assistant Curator of Ornithology. For many years he was very happy in his work: cataloguing, taxonomic classification, obtaining copies of important and rare books on birds, and collecting specimens. In 1965, he was mainly responsible for raising funds to buy specimens of the Great Auk and Labrador Duck for the museum. He made distribution maps of breeding birds based on meticulous records of every field trip he made – which was about every two days. He was renowned for his generosity with both time and knowledge. For 39 years he wrote a weekly naturalist column for the Toronto Evening Telegram and never once missed a deadline.

It is refreshing to know that the Ontario Field Naturalists and the Toronto Ornithological Club honoured him for his achievements. He will be remembered by birdwatchers as long as the Baillie Birdathon is held.

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George Edwards: The Bedell and his Birds

By A. Stuart Mason. 1991. Royal College of Physicians, London. 71 pp., illus. £14.

As Sir Cyril Clarke says in his foreword, "Oh, to have been around in the 1730s – for then a third of the Fellows of the Royal College of Physicians were also Fellows of the Royal Society, all "curious men" and interested in natural history, identifying and classifying not only diseases, but monkeys, birds, fish, butterflies, and flowers..." Clarke goes on to say, "Our hero is George Edwards."

George Edwards (1694-1773) became the bedell or beadle of the Royal College of Physicians in London, England, in 1733. His duties were to administer the College, care for legal documents and the library of 8000 books, as well as to purchase items as diverse as food, candles, brooms, and chamberpots. He designed and etched the College diplomas and their printed summons, each decorated with the College's Coat of Arms. His own bookplate, inscribed "Librarian to the College of Physicians," correctly indicates where his main duties lay.

This well-written, attractively illustrated, somewhat whimsical book by Stuart Mason, gives in detail the background and activities of Edwards. Edwards had previously been employed as an artist by Sir Hans Sloane, "the foremost of all collectors," to whom specimens came from all over the world. As "a bedell who was more distinguished" than any of the eight College presidents after Sloane, Edwards had time to learn engraving and to paint and engrave pictures of unusual birds and animals. His monumental masterpiece, *A Natural History of Birds, Most of which have not been Figured or Described,* appeared in four volumes in 1743, 1747, 1750 and 1751.

Mason tells us that Edwards' skill lay in accurate representation rather than in artistic impression... He was a painstaking observer of nature, not a gifted artist..." Linnaeus wrote of Edwards' "indefatigable assiduity in collecting, delineating, and describing." Linnaeus told Edwards that his "representations were so accurate that 'nothing is wanting to the birds but their song.'" Edwards was closely connected with Mark Catesby, the man who collected and painted the South Carolina species described by Linnaeus. Indeed, Edwards brought out another edition of Catesby's book after his death.

Mason gives insufficient attention to the binomial Latin names given in 1758 by Linnaeus to most of the birds figured in Edwards' paintings. From sparsely populated Hudson Bay these included sixteen taxa of birds, thirteen of which are now recognized as full species and three as subspecies of birds, sent by a Hudson's Bay Company fur trader named James Isham. As a result, Hudson Bay was second only to South Carolina in terms of "type specimens" of North American birds.

Edwards, through his paintings of undescribed ("nondescript") species of birds, many from North America, made a permanent imprint on the scientific record. This book provides a fascinating look at the man and his times.

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NEW TITLES

Zoology

*__Animal behavior.__ 1994. Edited by T. Halliday. University of Oklahoma Press, Norman. 144 pp., illus. U.S.$ 25.95.

Birds in Europe.: their conservation status. 1994. By G. Tucker, M. Heath, L. Toialojc, and R. Grimmett. Birdlife International (distributed by Smithsonian Institute Press, Washington). 625 pp., illus. U.S.$ 40.

†**Birds to watch, 2: the world list of threatened birds.** 1994. By N.J. Collar, M.J. Crosby, and A.J. Stattersfield. Birdlife International (distributed by Smithsonian Institute Press, Washington). 320 pp. U.S.$ 25.

A birdwatching guide to the Vancouver area, British Columbia. 1994. By the Vancouver Natural History Society, P.O. Box 3031, Vancouver, B.C. V6B 3X5. $10.

†**Disturbance to waterfowl on estuaries.** 1993. Edited by N. Davidson and P. Rothwell. Royal Society for Protection of Birds, Sandy, England. 106 pp., illus. £15.

†**Fish watching: an outdoor guide to freshwater fishes.** 1994. By C.L. Smith. Cornell University Press, Ithaca. x + 216 pp., illus. + plates. Cloth U.S. $42.50; paper U.S. $19.95.

Important bird areas in the Middle East. 1994. By M.I. Evans. Birdlife International (distributed by Smithsonian Institute Press, Washington). 335 pp., illus. U.S.$ 32.

Lizard ecology: historical and experimental perspectives. 1994. Edited by L.J. Vitt and E.R. Pianka. Princeton University Press, Princeton. 403 pp., illus. U.S.$ 39.50.

Lady Grayl: owl with a mission. 1994. By R. Nero. Natural Heritage Books, Toronto. illus. $19.95.

Long-legged wading birds of the North American wetlands. 1993. By M. Riegner. Stackpole, Harrisburg, Pennsylvania. 207 pp., illus. U.S.$ 49.75.

*__The new atlas of breeding birds in Britain and Ireland: 1988-1991.__ 1993. By D.W. Gibbons, J.B. Ried, and R.A. Chapman. T. & A.D. Poyser (Harcourt Brace, London). xiv + 520 pp., illus. £40.

†**Ontario birds at risk: status and conservation needs.** 1994. By M.J.W. Austen, M.D. Cadman, and R.D. James.

Federation of Ontario Naturalists, Don Mills. 165 pp., illus. $10.25.

Physiological ecology of pacific salmon. 1994. Edited by C. Groot, L. Margolis, and W.C. Clarke. University of British Columbia Press, Vancouver. c384 pp., Illus. $95.

†**Priority areas for threatened birds in the neotropics.** 1994. By D.C. Wege and A.J. Long. Birdlife International (distributed by Smithsonian Institute Press, Washington). 370 pp., illus. U.S.$ 32.

†**The reptiles of Virginia.** 1994. By J.C. Mitchell. Smithsonian Institute Press, Washington. 384 pp., illus. U.S.$ 40.

*__Rythms in fish.__ 1992. Edited by M.A. Ali. Plenum, New York. viii + 348 pp., illus. U.S.$ 95.

†**Seabirds on islands: threats, case studies, and action plans.** 1994. Edited by D.N. Nettleship, J. Burger, and M. Gochfeld. Birdlife International (distributed by Smithsonian Institute Press, Washington). 350 pp., illus. U.S.$ 32.

Sexual selection. 1994. By M. Andersson. Princeton University Press, Princeton. 599 pp., illus. Cloth U.S.$ 65; paper U.S.$ 24.95.

*__A supplement to distribution and taxonomy of birds of the world.__ 1994. By C.G. Sibley and B.L. Munroe, Jr. Yale University Press, New Haven. 108 pp. U.S.$ 25.

†**The timber wolf in Wisconsin: the death and life of a majestic predator.** 1994. By R.P. Thiel. University of Wisconsin Press, Madison. xxiv + 253 pp., illus. Cloth U.S.$ 45; paper U.S.$ 17.95.

†**Turtles of the United States and Canada.** 1994. By C.H. Ernst, J.E. Lovich, and R.W. Barbour. Smithsonian Institute Press, Washington. 682 pp., illus. U.S.$ 60.

Whale-watching in the West Indies: a guide to cetaceans and sites of the region. 1994. By N. Gricks. Island Resources Foundation, Washington. 40 pp., illus. U.S.$ 12.50.

*__Wild wings: an introduction to birdwatching.__ 1994. By T. Fitzharris. McClelland & Stewart, Toronto. 191 pp., illus. $24.99.

Botany

*__Intermountain flora, volume five: the Asterales.__ 1994. By A. Cronquist. New York Botanical Garden, Bronx. 193 pp., illus. U.S.$ 75.

†**Plant allometry: the scaling of form and process.** 1994. By K.J. Niklas. University of Chicago Press, Chicago. c416 pp., illus. Cloth U.S.$ 60; paper U.S.$ 24.95.

Environment

†**Algonquin Park: excursions with a photographer.** 1994. By D. Taylor. Natural Heritage Books, Toronto. 208 pp., illus. $19.95.

†**Behavioral mechanisms in evolutionary ecology.** 1994. Edited by L.A. Real. University of Chicago Press, Chicago. c624 pp. Cloth U.S.$ 80; paper U.S.$ 32.95.

*__Biotic diversity in agroecosystems.__ 1992. Edited by M.G. Paoletti and D. Pimentel. Proceedings of a conference, Padova, Italy, 26-29 September, 1990. Elsevier, New York, Amsterdam. 356 pp. U.S.$ 120; Dfl 210.

The causes of tropical deforestation. 1994. Edited by K. Brown and D. Pearce. University of British Columbia Press, Vancouver. c320 pp., illus. $75.

A history of the ecosystem concept in ecology: more than the sum of the parts. 1994. By F.B. Golley. Yale University Press, New Haven. xvi + 254 pp. U.S.$ 30.

*__Large-scale ecology and conservation biology.__ 1994. Edited by P.J. Edwards, E.M. May, and N.R. Webb. 35th Symposium of the British Ecological Society. Blackwell Scientific Publications, Cambridge, Massachusetts. xi + 375 pp., illus. Cloth U.S.$ 75; paper U.S.$ 29.95.

*__A naturalist's guide to the Arctic.__ 1994. By E.C. Pielou. University of Chicago Press, Chicago. c384 pp., illus. Cloth U.S.$ 57; paper U.S.$ 19.95.

†**Quantitative genetic studies of behavioral evolution.** 1994. Edited by C.R.B. Boake. University of Chicago Press, Chicago. x + 390 pp., illus. Cloth U.S.$ 66; paper U.S.$ 24.95.

Miscellaneous

†**The coevolutionary process.** 1994. By J.N. Thompson. University of Chicago Press, Chicago. c352 pp., illus. Cloth U.S.$ 49; paper U.S.$ 19.95.

The fossils of the Burgess shale. 1994. By D.E.G. Briggs, D.H. Erwin, and F.J. Collier. Smithsonian Institute Press, Washington. 272 pp., illus. U.S.$ 39.95.

My double life: memoirs of a naturalist. 1994. By F. Hamerstrom. Wisconsin University Press, Madison. 328 pp., illus. Cloth U.S.$ 35; paper U.S.$ 16.95.

†**Think like a mountain: Aldo Leopold and the evolution of an ecological attitude toward deer, wolves, and forests.** 1994. By S.L. Flader. Wisconsin University Press, Madison. 320 pp., illus. Cloth U.S.$ 52; paper U.S.$ 14.95.

Books for Young Naturalists

Animal bandits. 1994. By R. Henno. Charlesbridge, Watertown, Massachusetts. 44 pp., illus. U.S.$ 14.95.

Birds of the night. 1994. By J. de Sart. Charlesbridge, Watertown, Massachusetts. 44 pp., illus. U.S.$ 14.95.

Entomology: high school science fair experiments. 1994. By H.S. Dashefsky. TAB, Blue Summit Ridge, Pennsylvania. 173 pp., illus. U.S.$ 12.95.

Let's investigate slippery, splendid creatures. 1993. By M.W. Carlisle. Barron's, New York. 32 pp., illus. U.S. $ 4.95.

A walk in the wild: exploring a wildlife refuge. 1994. By L.A. Ward. Charlesbridge, Watertown, Massachusetts. 32 pp., illus. Cloth U.S.$ 16; paper U.S.$ 7.95.

†available for review
*assigned for review

Advice to Contributors

Content

The Canadian Field-Naturalist is a medium for the publication of scientific papers by amateur and professional naturalists or field-biologists reporting observations and results of investigations in any field of natural history provided that they are original, significant, and relevant to Canada. All readers and other potential contributors are invited to submit for consideration their manuscripts meeting these criteria. The journal also publishes natural history news and comment items if judged by the Editor to be of interest to readers and subscribers, and book reviews. Please correspond with the Book Review Editor concerning suitability of manuscripts for this section. For further information consult: A Publication Policy for the Ottawa Field-Naturalists' Club, 1983. *The Canadian Field-Naturalist* 97(2): 231-234. Potential contributors who are neither members of *The Ottawa Field-Naturalists' Club* nor subscribers to *The Canadian Field-Naturalist* are encouraged to support the journal by becoming either members or subscribers.

Manuscripts

Please submit, **to the Editor**, in either English or French, **three** complete manuscripts **written in the journal style**. The research reported should be original. It is recommended that authors ask qualified persons to appraise the paper before it is submitted. Also authors are expected to have complied with all pertinent legislation regarding the study, disturbance, or collection of animals, plants or minerals. The place where voucher specimens have been deposited, and their catalogue numbers, should be given. Latitude and longitude should be included for all individual localities where collections or observations have been made.

Type the manuscript on standard-size paper, if possible use paper with numbered lines, **double-space throughout**, leave generous margins to allow for copy marking, and **number each page**. For Articles and Notes provide a bibliographic strip, an abstract and a list of key words. Generally words should not be abbreviated but use SI symbols for units of measure. Underline only words meant to appear in italics. The names of authors of scientific names should be omitted except in taxonomic manuscripts or other papers involving nomenclatural problems. "Standard" common names (with initial letters capitalized) should be used at least once for all species of higher animals and plants; all should also be identified by scientific name.

The names of journals in the Literature Cited should be written out in full. Unpublished reports should not be cited here but placed in the text or in a separate documents section. Next list the captions for figures (numbered in arabic numerals and typed together on a separate page) and present the tables (each titled, numbered consecutively in arabic numerals, and placed on a separate page). Mark in the margin of the text the places for the figures and tables.

Extensive tabular or other supplementary material not essential to the text, typed neatly and headed by the title of the paper and the author's name and address, should be submitted in duplicate on letter-size paper for the Editor to place in the Depository of Unpublished Data, CISTI, National Research Council of Canada, Ottawa, Canada K1A 0S2. A notation in the published text should state that the material is available, at a nominal charge, from the Depository.

The **Council of Biology Editors Style Manual**, Fourth edition (1978) available from the American Institute of Biological Sciences, and **The Canadian Style: A Guide to Writing and Editing**, Department of the Secretary of State and Dundurn Press Ltd (1985) are recommended as general guides to contributors but check recent issues (particularly in literature cited) for exceptions in journal format. Either "British" or "American" spellings are acceptable in English but should be consistent within one manuscript. **The Oxford English Dictionary, Webster's New International Dictionary** and le **Grand Larousse Encyclopédique** are the authorities for spelling.

Illustrations

Photographs should have a glossy finish and show sharp contrasts. Photographic reproduction of line drawings, **no larger than a standard page**, are preferable to large originals. Prepare line drawings with India ink on good quality paper and letter (don't type) descriptive matter. Write author's name, title of paper, and figure number on the lower left corner or on the back of each illustration.

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Cover: Black-legged Kittiwake, *Rissa tridactyla,* on Great Island, Newfoundland, photographed 21 June 1977 by Alan D. Smith. Courtesy of Alan D. Smith, Canadian Wildlife Service, P.O. Box 1590, Sackville, New Brunswick E0A 3C0. See note by F. Patrick Kehoe on a New Brunswick colony of the species, pages 375–376.

The Canadian Field-Naturalist

Volume 108, Number 3 July–September 1994

Foraging Ecology of Greater Snow Geese, *Chen caerulescens atlantica,* in Different *Scirpus* Marsh Plant Communities

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Bélanger, L., and J. Bédard. 1994. Foraging ecology of Greater Snow Geese, *Chen caerulescens atlantica*, in different *Scirpus* marsh plant communities. Canadian Field-Naturalist 108(3): 271–281.

We studied the foraging behaviour of Greater Snow Geese staging in the Montmagny sanctuary in Québec during the autumns of 1985 and 1986, and the springs of 1986 and 1987. We characterize four distinct *Scirpus* marsh plant communities and compare foraging behaviour of Greater Snow Geese when using these plant communities. We found that geese spent more time grubbing (feeding on underground parts of plants) and did so with greater success in autumn than in spring. Habitat type also influenced the activity patterns of geese; feeding success of geese was reduced in the poorest marsh communities (in terms of food availability and substrate characteristics) and they spent more time searching for food in this community than elsewhere. Search speed (number steps/minute) was also highest there. Maintenance of the primary production of *Scirpus* marshes of the St. Lawrence River above a below-ground primary production of ≤200 g/m2, within the perimeter of fall staging no-hunting Greater Snow Goose sanctuaries, should be a primary management objective. Biophysical characteristics of the marsh should be taken into account to avoid areas inappropriate for foraging geese if new bird sanctuaries are to be established.

Key Words: Greater Snow Geese, *Chen caerlescens atlantica,* foraging behaviour, *Scirpus* marsh, St. Lawrence Estuary, Quebéc.

The Greater Snow Goose, *Chen caerulescens atlantica*, is the largest race of Snow Goose in North America. The entire population (about 400 000 birds: Reed 1990) in spring and most of it in autumn (Maisonneuve and Bédard 1992) will stop for 5-7 weeks along the St. Lawrence estuary in Québec during migrations between their breeding grounds in the Canadian High Arctic and their wintering area on the mid-Atlantic coast of the United States. The 3750-ha brackish tidal *Scirpus americanus* marshes of the upper estuary represent their most important staging area (Gauthier et al. 1984; Giroux and Bédard 1988a). Snow Geese reach the St. Lawrence estuary in early April and depart for the Arctic nesting grounds around 20 May. In autumn, they return by the last week of September and remain until freeze-up in early November (Gauthier et al. 1988; Giroux and Bédard 1988a). The birds reach *Scirpus* rhizomes by breaking the marsh surface in or around shallow ice-made depressions (Bélanger and Bédard 1994); they also graze the emerging apices of growing plants in late spring and the buried white part of *Scirpus* stems in early autumn (*see* Bélanger and Bédard 1992). In the spring, Greater Snow Geese spend more than 50% of the daylight period feeding in these marshes (Gauthier et al. 1988) compared to 36% in the autumn (Giroux and Bédard 1990). Among all goose foraging activities, grubbing (feeding on underground plant parts) ranked first (>50%: Bélanger and Bédard 1992). Indeed, below- ground parts of *S. americanus* (rhizomes and the buried white stems) make up as much as 55% of the marsh diet of geese during both staging seasons (Giroux and Bédard 1988b; Bédard and Gauthier 1989). Greater Snow Geese drastically reduce (by up to 60%) the net primary production of tidal *Scirpus* marshes (Smith and Odum 1981; Giroux and Bédard 1987a; Reed 1989; Bélanger and Bédard 1994).

Giroux and Bédard (1988a) reported that various biophysical characteristics of the *Scirpus* marshes (softness of marsh surface, soil texture, abundance of rocks and subterranean biomass of *S. americanus*) determine the distribution of foraging Greater Snow Geese. Reed (1989) speculated that the mechanism by which they regulated their use of these marshes could be related to their foraging success; i.e., their efficiency in food exploitation in the different marsh plant communities.

To get a better understanding of the biophysical factors that affect the use of *Scirpus* marshes by staging Greater Snow Geese and consequently their grazing impact, we first characterized four distinct *Scirpus* marsh plant communities using hardness of the substrate, rock abundance, soil texture, below-ground primary production, and rhizome depth, and we then compared the foraging behavior of Greater Snow Geese when using these different plant communities. We also investigated for the effects of food depletion within and among seasons on goose foraging behaviour.

Study Area

We conducted our study in the brackish tidal marsh of the Montmagny bird sanctuary (47°00'N, 70°35'W), about 100 km northeast of Québec City along the St.Lawrence River (Figure 1). This no-hunting area, established in 1969, is especially important in autumn when it is used by roughly 10% of the Greater Snow Goose flock migrating through the province (Maisonneuve and Bédard 1992). Two vegetation belts can be distinguished within the sanctuary: a 15-ha uppermost, narrow (20 - 100 m wide) belt of *Spartina pectinata* and *Carex paleacea* (the upper marsh) and a 72-ha middle level zone 200 - 1000 m wide (the lower marsh). The boundary between these two coincides with the mean high water mark. A 60-ha unvegetated mudflat is found between the low tide water mark and the lower marsh. The latter is intensively used by foraging geese. It is dominated by *Scirpus americanus* associated with a cortege of other species such as *Sagittaria* spp. (mostly *S. latifolia* Wildl.), *Zizania aquatica* var *brevis, Scirpus torreyi* Olney and *Eleocharis* spp. Depending on physical conditions (submersion time, substrate characteristics, soil texture, etc.), several plant communities could be identified in the *Scirpus* lower marsh (*see* Giroux and Bédard 1988c).

Methods

Biophysical characteristics of the marsh

We made our surveys during autumn 1985, 1986 and spring 1986, 1987. Thirteen permanent transects were established systematically across the four main plant communities (named A, B, C and D) of the lower marsh as previously identified by Giroux and Bédard (1988c)(Figure 1). They were determined mainly on the basis of plant species abundance and length of time submerged by tide. Communities A and D of this study correspond, respectively, to communities 3 and 4 described by Giroux and Bédard (1988c). These plant communities are typical of all tidal *Scirpus* marshes along the St. Lawrence River (*see* Giroux and Bédard

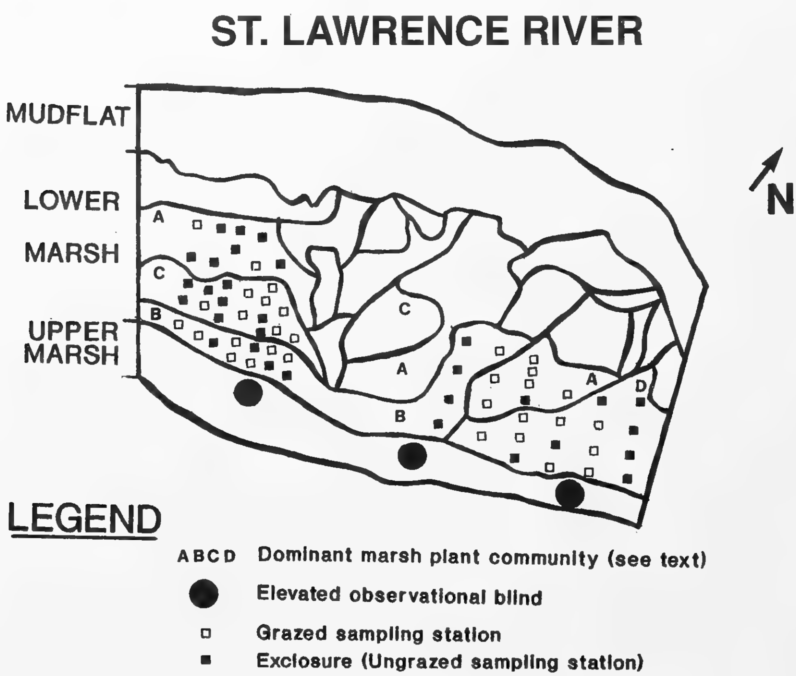

FIGURE 1. Dominant *Scirpus* marsh plant communities of the Montmagny Sanctuary, about 100 km northeast of Québec City along the St. Lawrence River.

1988c). The 350 m long transects were placed 50 to 100 m apart. Two transects were shorter (150 and 90 m). Sixty-four sampling stations, 32 grazed (open) and 32 ungrazed (fenced), were proportionally distributed throughout the four communities along the transects. Each station measured 2.3 X 2.3 m. Six 25 X 25 cm quadrats were randomly located within each station. Above-ground vegetation was measured by non-destructive double sampling technique (*see* Giroux and Bédard 1988d) in late August 1985, 1986 and 1987. For the purpose of this study and in order to detect maximum difference between grazed and ungrazed stations, only results of the third sampling year (1987) are presented. For each quadrat, the total number of stems and the height of 10 randomly-selected ones were determined for each species. We used the allometric equations developed by Giroux and Bédard (1988d) relating stem height and dry weight to derive individual stem biomass. The sum of the biomass for each species present (derived by multiplying individual stem biomass estimates by stem density) yielded the total above-ground biomass for each quadrat. In *Scirpus* marshes, peak above-ground biomass in August is considered a good predictor of net above-ground primary production (NAPP) which, in turn, is closely related to net below-ground production (NBPP)(Giroux and Bédard 1988c). In the present paper, all estimates of NBPP are presented on an ash-free dry-mass basis. Plant richness is expressed as the number of taxa, and the relative abundance of each species is based on the total biomass. During each staging week of spring 1987, we also counted the number of white emerging shoots (all species combined) within grazed and ungrazed sampling stations.

In spring 1987, to preclude trampling of the marsh along transects where grazing was measured, we determined marsh surface characteristics along two parallel transects running 15 m on each side. Sampling points were placed at each m along these lines. Penetration resistance (hardness of the substrate) was determined using a penetrometer (*see* Giroux and Bédard 1987b for a description). The distance that it penetrated substrate was used as an inverse measure of hardness. The number of times the penetrometer hit a rock was used as an index of rock abundance. We also evaluated the presence of ice-made depressions in the lower marsh by counting the number of sampling points within a depression, and evaluating their mean depth. At each 30 m along the working lines, rooting depth of *S. americanus* rhizomes was determined by taking cores 40 cm long and 10 cm in diameter and measuring the nearest distance between rhizomes and ground level. Finally, a soil sample was taken at a depth of 15 cm below ground level and analysed using the method of Bouyoucos (1962).

Behavioural observations of foraging geese

In the autumns of 1985 and 1986 and the springs of 1986 and 1987, foraging geese were observed from three elevated blinds located in the upper marsh at the rim of the sanctuary (Figure 1). Observations were conducted during 10-min periods from dawn to dusk at low tide, using the focal sampling technique (Lehner 1979) on randomly selected foraging birds. As the number of birds using the sanctuary was very large and their turnover rate was quite rapid (Maisonneuve and Bédard 1992), the likelihood of observing the same bird more than once within or between days was small.

Our observations were recorded in real time on a portable microcomputer using a modified version of the BASIC program of Hensler et al. (1986). The following behaviour categpories were recorded: walking (with head up), searching (walking head-down), grubbing (digging and ingestion of below-ground plant parts), alert (standing with head up), grazing (ingestion of the aerial part of a plant while moving or not), drinking, trampling (treading in place to break the marsh surface), washing (washing a plant part, generally a rhizome), social interactions (aggressive encounter with or without physical contacts), other activities (occasional preening, bathing, sleeping, etc.). However, only the first six behavioural categories were considered in this study, representing the main foraging behaviour of Greater Snow Geese when staging (*see* Bélanger and Bédard 1992). A separate category accounted for time when we were temporarily unable to observe the selected bird because of visual obstruction (aerial vegetation, rocks, other geese). Samples were rejected when the sum of behaviours labelled "Obstructed" and "Others" totaled >10% of all activities. We also evaluated the travel speed of geese when walking and searching by counting the number of goose steps. Finally, feeding success was expressed as the number of ingestions per minute of observation. In marsh-feeding Greater Snow Geese, ingestion of rhizomes corresponds to a particular movement of the neck and the lower mandible (Bélanger and Bédard, personal observations). Position of the observed goose in the marsh was reported using a map of the plant communities (Figure 1), both at the beginning and at the end of the observation period. This procedure was chosen because it was impossible to observe an individual bird, particularly an unmarked one, foraging among all four communities. Consequently, we deleted samples during which a goose moved from one community to another. All observation periods interrupted by human disturbance were also discarded.

The Shapiro-Wilk statistical test of the Statistical Analysis System (SAS) package was used to verify data normality. Consequently, mean percentage of time devoted by geese to the different foraging activities and biophysical features of marsh plant communities were compared using the Wilcoxon test or the Kruskal-Wallis test followed by the multiple comparisons test for unequal sample sizes (experimental error rate of 0.05). The acceptable level of statistical significance was established at 5% and means are presented ± SE throughout.

Results

Biophysical characteristics of the marsh

The four plant communities exhibited different combinations of biophysical characteristics (Table 1). Community A was characterized by a soft substrate with sparse rocks. Both the total NBPP and the *S. americanus* below-ground biomass were high whereas overall plant richness was low (Tables 1 and 2). The average depth of *S. americanus* rhizomes was greatest in this community. Community B had a hard, sandy substrate and the highest abundance of rocks (Table 1). The total NBPP, *S. americanus* biomass, and plant richness were high (Table 1 and 2). In community C, the silty substrate was relatively soft with abundant rocks. However, NBPP and *S. americanus* biomass were low (Table 2), and rhizomes were deeply buried (Table 1). Finally, community D was characterized by a hard silty substrate with few rocks. Below-ground biomass of *S. americanus* was also very low (Table 2). Moreover, ice-made depressions were shallow and rhizomes were closest to the marsh surface (Table 1).

Newly emerging stems broke the marsh surface by the end of April (Figure 2). These shoots were heavily grazed by geese, as indicated by the difference we observed in stem density between grazed and ungrazed stations ($P \leq 0.05$) except in community B ($P > 0.05$) (Figure 2). Differences were also found in stem abundance among communities ($P \leq 0.05$) (Figure 2); their density was highest in communities A and C. We also found significant differences in NBPP between grazed and ungrazed stations with the exception of Community B (Table 2). For other communities, difference varied from 30 to 50%.

TABLE 1. Biophysical characteristics of the four major plant communities of the *Scirpus* marsh of the Montmagny sanctuary in Québec, 1985-1987.

Characteristic	Plant Community A	B	C	D
Hardness[a]	6.1 ± 0.6V[4]	3.7 ± 0.2X	6.4 ± 0.4V	3.5 ± 0.1X
Rock abundance[a]	1.5 ± 0.5Y	11.2 ± 1.4V	6.4 ± 1.2X	2.0 ± 0.5Y
No. of depressions[a]	23.8 ± 1.9V	19.7 ± 2.0V	19.6 ± 2.0V	20.7 ± 0.2V
Depth of depression[a]	4.7 ± 0.4Y	3.7 ± 0.3X	6.4 ± 0.9V	2.9 ± 0.2Z
Soil texture[a]:				
- sand	21.6 ± 1.4X	30.0 ± 3.1V	13.9 ± 1.0X	17.6± 1.1Y
- clay	20.7 ± 0.7V	24.4 ± 1.1V	22.5 ± 1.7V	18.8 ± 0.7V
- silt	59.3 ± 1.4X	44.7 ± 3.2Y	64.7 ± 2.2V	64.0 ± 1.0V
NBPP[1b]	273.3 ± 41.3V	296.6 ± 26.8V	183.4 ± 20.0X	241.9 ± 20.4V
Scirpus biomass[2b]	215.5 ± 21.1X	282.7 ± 26.2V	179.9 ± 20.0Y	172.3 ± 18.9Y
Plant richness[3b]	2.4 ± 0.1X	3.3 ± 0.1V	2.0 ± 0.1X	3.0 ± 0.1V
Depth of rhizome[a]	19.2 ± 1.0V	16.1 ± 0.9V	18.1 ± 1.1V	15.7 ± 0.8X

[1]Net below-ground primary production.
[2]Belowground production of *Scirpus americanus*.
[3]Number of plant species.
[4]Means within rows with the same letter are not different ($P > 0.05$).
[a]Sample size was N=61 in community A, N=38 in community B, N=52 in community C and N=47 in community D.
[b]Sample size was N=42 in community A, N=36 in community B, N=39 in community C and N=37 in community D.

TABLE 2. Differences in net below-ground primary production (NBPP) and below-ground biomass of *S. americanus* between grazed and ungrazed stations of four major plant communities, Montmagny sanctuary, Québec, 1987.

Community	Belowground Biomass			NBPP		
	Ungrazed		Grazed	Ungrazed		Grazed
A	427.1 ± 48.0	*	215.4 ± 21.1	530.1 ± 102.8	*	273.2 ± 41.2
B	268.9 ± 25.3	NS	282.7 ± 26.2	285.7 ± 25.4	NS	296.6 ± 26.8
C	281.2 ± 27.1	*	179.9 ± 20.0	288.6 ± 27.3	*	183.4 ± 20.1
D	298.2 ± 34.2	*	172.3 ± 18.9	361.8 ± 34.5	*	241.9 ± 20.4
P	NS		*	NS		*

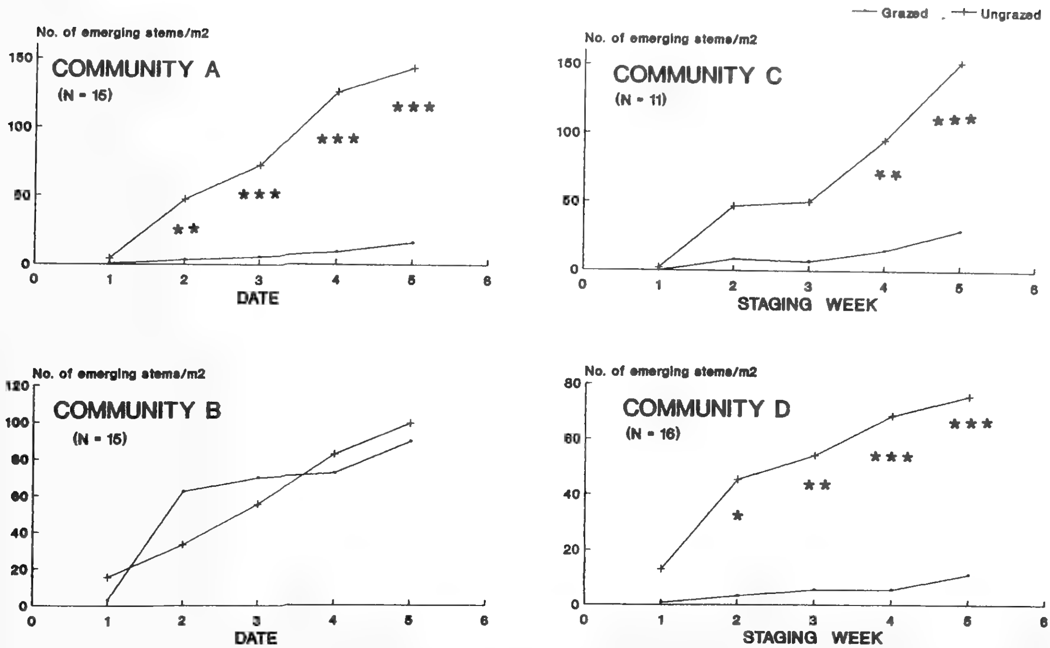

FIGURE 2. Density of emerging shoots in grazed and ungrazed stations within the different plant communities of the *Scirpus* marsh of the Montmagny sanctuary in Québec, 1985 - 1987. * = P ≤ 0.05, ** = P ≤ 0.01, *** = P ≤ 0.001.

Similar results were obtained when we considered *S. americanus* below-ground biomass solely. However, no differences were detected among ungrazed stations of all communities themselves, neither for the total NBPP nor *S. americanus* below- ground biomass taken individually (Table 2).

Habitat use by foraging geese

During our study, the length of the staging period was similar in both seasons (44.5 and 43.5 days on average in autumn and spring, respectively) although geese used the sanctuary more intensively in autumn than in spring (Giroux and Bédard 1988a; Bélanger and Bédard *in press*). The mean flock size was 1737 birds in spring compared to 7117 in autumn. This represents a mean total cumulative use of >50 000 and >290 000 goose-days, respectively.

A total of 875 10-min periods of behavioural observation have been realized. Overall, birds spent relatively more time grubbing in autumn than in spring (78% vs 59%; P≤0.05). A greater proportion of their time in spring was spent searching (27% vs 10%; P≤0.05) and grazing also was more intense in this season (4% vs <1%; P≤0.05) (Figure 3). The overall feeding success of geese was higher during the autumn staging (1.32 ± 0.13) compared to spring (1.06 ± 0.12) (P<0.05) (Table 3). However, we found no significant difference in the travel speed when searching between staging seasons (58.9 ± 5.8 and 67.3 ± 7.3 in autumn and spring respectively; P>0.05).

In autumn 1985, geese spent more time searching in community D than in community A (P≤0.05) (Figure 3). No observations were made in communities B and C during that season. Feeding success was also lower in community D (P≤0.05; Table 3) but walking and searching speeds did not differ between the two communities (P>0.05; Table 3). In autumn 1986, no difference was observed in activity patterns of foraging geese among all four communities (P>0.05; Figure 3). Feeding success and searching speed did not differ either (P>0.05).

In spring, the activity budget of foraging geese consistently differed among communities, in both 1986 and 1987 (Figure 3). Geese spent more time searching and less time grubbing in community D than in any other (P≤0.05; Figure 3). The time spent grazing and the searching speed were also highest there in spring 1986 (P≤0.05) but not in 1987 (P>0.05). Finally, feeding success did not differ among communities in 1986 (P>0.05). In 1987, however, feeding succes was highest in community B (P≤0.05).

We also investigated seasonal changes in goose activity budgets within each staging season. Each staging season was divided into three two-week periods. In autumn 1985, the activity budget of geese did not change over the season in community A. In com-

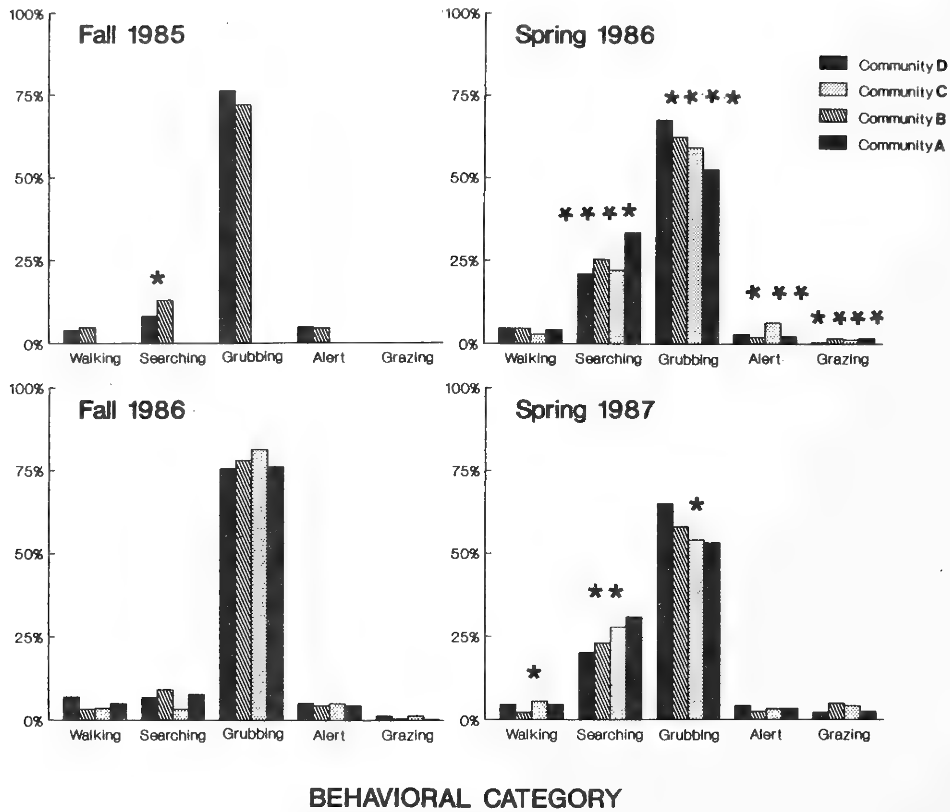

FIGURE 3. Activity budgets of foraging Greater Snow Geese during autumn and spring staging in different plant communities of the *Scirpus* marsh of the Montmagny Sanctuary, Québec, 1985-1987. No observations were made in communities B and C in autumn 1985. Behaviour accounting for less than 1% of the total activity budget are not shown (see text). * = $P \leq 0.05$, ** = $P \leq 0.01$, *** = $P \leq 0.001$, **** = $P \leq 0.0001$)

TABLE 3. Feeding success (number of ingestions/minute) and travel speed (number of steps/minute) of foraging Greater Snow Geese in the *Scirpus* marsh of the Montmagny Sanctuary in Québec, 1985-1987.

Community	Season	Year	Feeding Success	Travel Speed	
				Walking	Searching
A	Autumn	1985	1.47 ± 0.13	50.4 ± 6.5	53.6 ± 3.3
		1986	1.09 ± 0.10	59.7 ± 3.9	64.0 ± 6.4
	Spring	1986	1.05 ± 0.08	61.9 ± 3.4	67.9 ± 5.1
		1987	0.85 ± 0.11	55.1 ± 4.3	66.7 ± 7.2
B	Autumn	1985	—	—	—
		1986	1.46 ± 0.14	66.9 ± 4.7	58.6 ± 7.4
	Spring	1986	0.89 ± 0.11	64.9 ± 4.6	62.9 ± 5.8
		1987	1.47 ± 0.18	45.9 ± 9.4	73.6 ± 9.8
C	Autumn	1985	—	—	—
		1986	1.34 ± 0.22	70.4 ± 4.8	67.3 ± 7.8
	Spring	1986	1.04 ± 0.16	59.5 ± 4.7	49.1 ± 8.9
		1987	1.05 ± 0.12	56.8 ± 5.3	83.4 ± 7.0
D	Autumn	1985	1.16 ± 0.08	61.7 ± 5.4	58.1 ± 4.7
		1986	1.41 ± 0.09	58.1 ± 3.1	51.9 ± 4.9
	Spring	1986	0.99 ± 0.05	71.0 ± 2.6	66.4 ± 3.8
		1987	1.03 ± 0.07	53.0 ± 3.5	78.6 ± 4.5

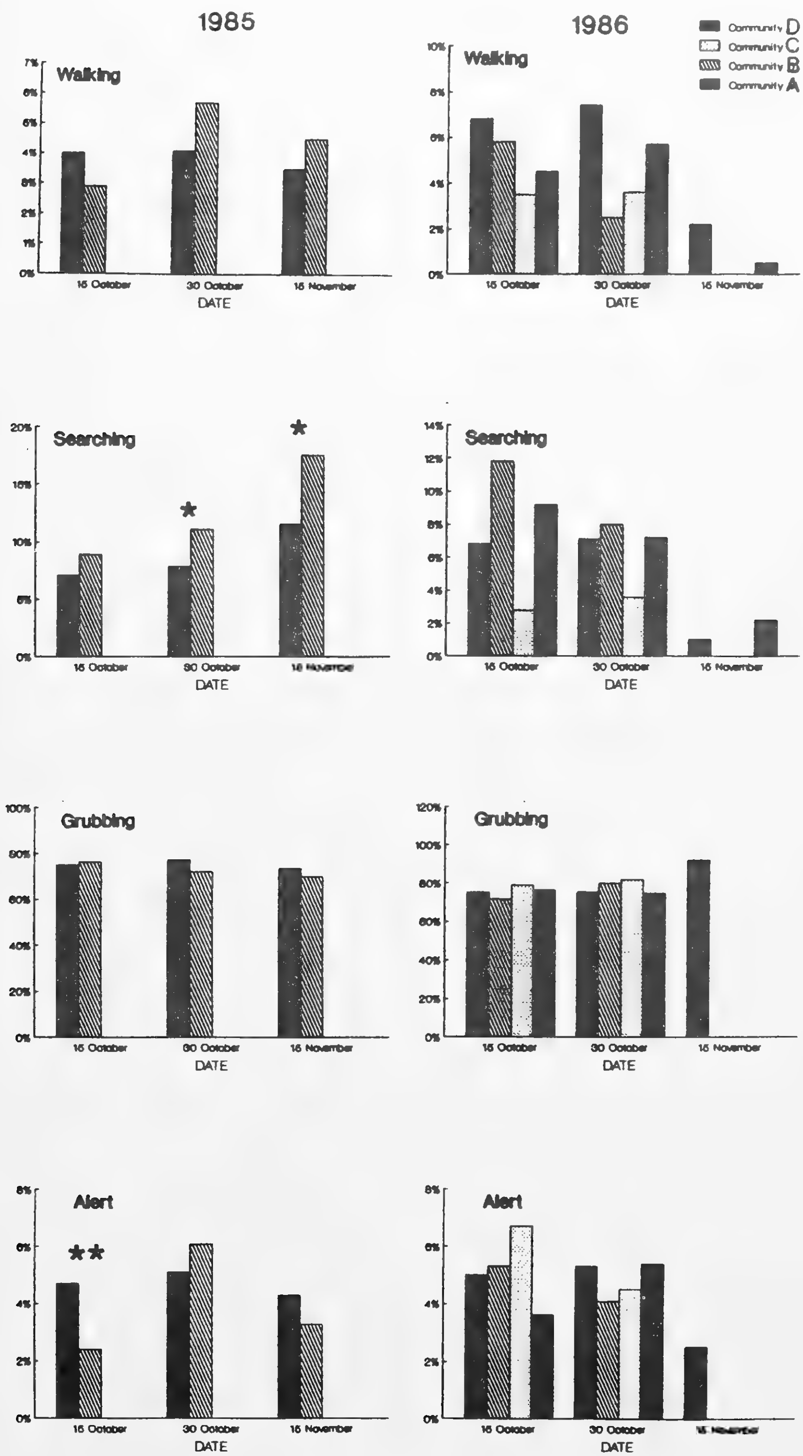

FIGURE 4. Seasonal activity budgets of foraging Greater Snow Geese staging in different plant communities of the *Scirpus* marsh of the Montmagny Sanctuary, Québec, in autumns of 1985 and 1986. The season was divided into 3 two-week periods. Behaviour accounting for less than 1% of the total activity budget are not presented (see text). * = $P \leq 0.05$, ** = $P \leq 0.01$, *** = $P \leq 0.001$.

munity D, however, searching behavior increased with date ($P \leq 0.05$; Figure 4). Both walking and searching speeds were higher in late autumn whereas feeding success decreased with date in community D ($P \leq 0.05$) (Table 3). No such changes was observed in community A ($P > 0.05$). In autumn 1986, no significant changes were observed in the activity budget of geese over the season ($P > 0.05$; Figure 4).

Early in the spring, geese foraging in *Scirpus* marshes spent more time searching and grazing in community D than in any other community, in both 1986 and 1987 ($P \leq 0.05$; Figure 5). Consequently, time devoted to grubbing in that community was less important ($P \leq 0.05$). Later on, geese still spent more time searching and grazing in community D than elsewhere, particularly in 1986 ($P \leq 0.05$) (Figure 5). Also in 1986, walking speed was highest in community D ($P \leq 0.05$) (Table 3).

Discussion

In this analysis, we were mainly interested in how staging geese coped with the different biophysical features of their main foraging marsh habitats in order to maximize food intake. Many authors have speculated that the mechanism by which Greater Snow Geese regulate their use of *Scirpus* marshes could be related to their foraging success both at small (within habitats) and large (among habitats and staging seasons) scale levels (Smith and Odum 1981; Gauthier et al. 1988; Giroux and Bédard 1988a; Reed 1989). We found that geese spent more time grubbing and did so with greater success in autumn than in spring. In the St. Lawrence River, staging geese harvest a single season's production in two episodes: one following the summer's growth and the other in the spring of the following year after ice melt. Moreover, because of hunting pressure, geese are confined to few and relatively small no-hunting areas in autumn (Giroux and Bédard 1986, 1988a). Consequently, at those sites, they have to depend in spring on food supplies already depleted in the previous fall. Thus, to maximize food intake during this latter season, they change their marsh foraging strategy, spending more time searching and grazing on newly emerging shoots rather than grubbing for rhizomes (Bélanger and Bédard 1992). These shoots are heavily grazed by geese as indicated by the difference we observed in stem density between grazed and ungrazed stations. We found differences in stem density between grazed and ungrazed stations among all communities with the exception of community B. The higher abundance of rocks in the latter compared to others (see Table 1), making grazing on emerging shoots among rocks more difficult, could explain this result. However, the real impact of goose grazing on emerging shoots during spring is not known. It is probably, however, less harmful than grubbing on overall *Scirpus* marsh production.

It has been shown that goose density within *Scirpus* marshes is positively related to the softness of the substrate and below-ground biomass of *S. americanus* (Giroux and Bédard 1988a). Based on our sampling of the biophysical characteristics of the different marsh communities, Community C and particularly Community D could be considered as poorer feeding habitats for geese whereas communities A and B represent better habitats (see Table 1). We found that feeding success of geese was lowered in community D (at least in 1985), and they spent more time searching there compared to the others. Moreover, geese greatly increased their grazing time and searching speed in this community, particularly near the end of the staging period. Such adaptations to feeding conditions have been reported for other goose species. Indeed, Charman (1979) observed that food density affected the feeding behavior of Brent Geese wintering in England; pacing rate increased while food supply decreased. Canada Goose goslings also increased their search time, while their pecking rate decreased in depleted habitats (Sedinger and Raveling 1988). Teunissen et al. (1985) reported that Dark-bellied Brent Geese during spring staging in the Netherlands fought more and walked more slowly on improved fertilized sites.

We failed to detect an effect of the mean depth of rhizomes in the substrate even if we initially thought it might determine the foraging success of geese and, consequently, their grazing impact on plant communities. It did not influence the feeding success of foraging geese among the various studied communities. In fact, we believe that the statistical difference we observed between Community D and the other ones (≤4 cm; Table 1), had no biological meaning for the birds. The mean rooting depth measured at our study site (Montmagny; 15 to 20 cm) was smaller than that reported by Reed (1989) for another Greater Snow Geese staging halt, the well-known Cap Tourmente National Wildlife Area, on the north shore of the St. Lawrence estuary. Reed observed that 28% of *Scirpus* rhizomes were more than 23 cm deep in the substrate. He argued that this would constitute an unexploitable stock of rhizomes, thus preventing overgrazing effects. We have not observed rhizomes at such a depth in our study area. Consequently, we do not believe that rooting depth could be the main factor explaining the low-level steady-state equilibrium in the primary production of the Montmagny *Scirpus* marsh as reported by Giroux and Bédard (1987a). We rather believe that annual rotation of feeding sites on a small-scale level (ice-made depressions) coupled to the dynamic geomorphological characteristics (ice scouring, sedimentation, etc.) of the marsh could be responsible for this equilibrium (Bélanger and Bédard 1994).

Many authors argued that Greater Snow Geese move to a new feeding area when food resources are

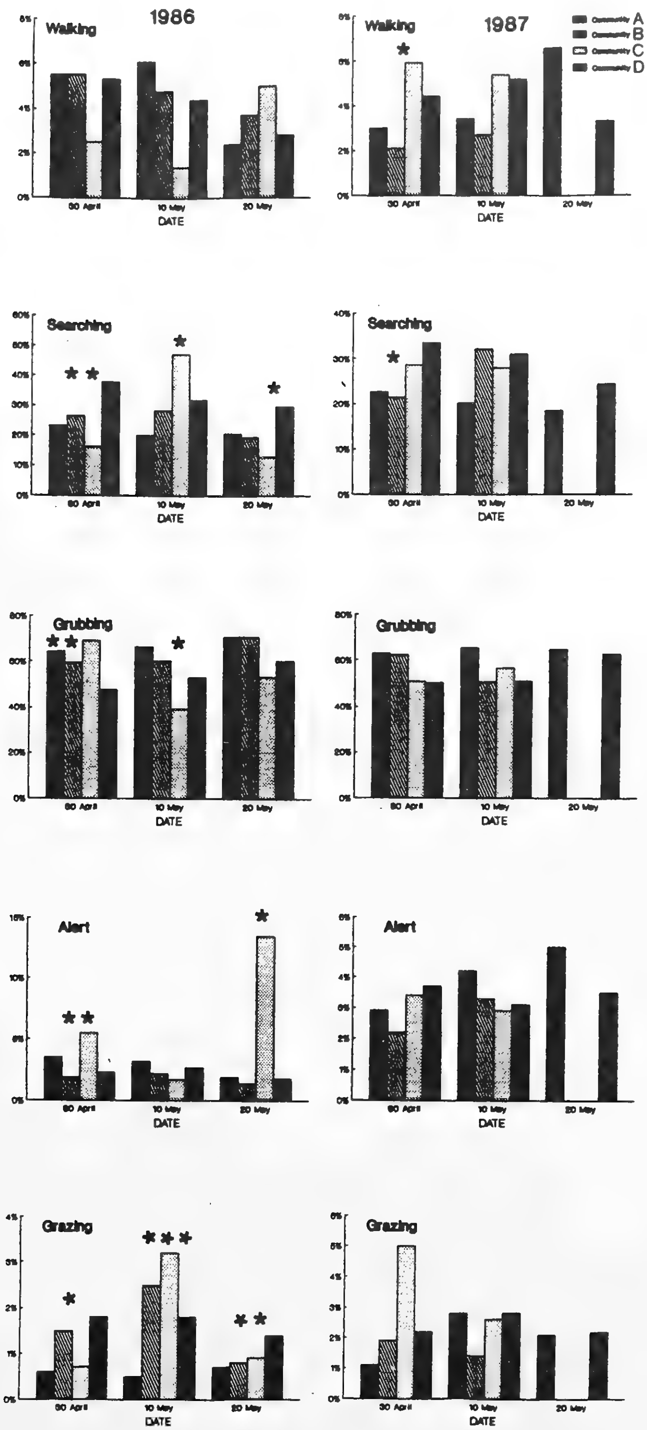

FIGURE 5. Seasonal activity budgets of foraging Greater Snow Geese staging in different plant communities of the *Scirpus* marsh of the Montmagny Sanctuary, Québec, in springs of 1986 and 1987. The season was divided into 3 two-week periods. Behaviours accounting for less than 1% of the total activity budget are not presented (see text). * = $P \leq 0.05$, ** = $P \leq 0.01$, *** = $P \leq 0.001$.

too low (Smith and Odum 1981; Giroux and Bédard 1988a; Reed 1989). However, the threshold at which this shift occurs is not known. Charman (1979) suggested that 15% leaf cover might represent a critical value below which foraging behaviour and feeding success of Brent Geese drastically changed in England. If we use this for the *Scirpus* marshes along the St. Lawrence River, it corresponds to a NBPP of approximately 220 g/m^2. Based on the present study, below-ground biomass of 200 g/m^2 (corresponding to the communities C and D of this study) seems also to be a threshold below which the foraging strategy of geese changed in response to decreased feeding success. However, this needs to be experimentally assessed.

The Greater Snow Goose population is still expanding while the area of the few no-hunting refuges to which they are confined in autumn is not. Therefore, maintaining primary production above the critical threshold should be a major management concern. *Scirpus* biomass within the heavily used sanctuaries is already critically low compared to neighbouring no-hunting marshes (Giroux and Bédard 1987a). Periodic rotation of sanctuary location, a management technique proposed by Giroux and Bédard (1988a), should be used to provide optimal foraging areas for geese at critical moments of their life cycle. Reed (1990) suggested expanding no-hunting areas to achieve a more ecologically balanced distribution of geese on their staging halts and prevent overgrazing pressure on marshes. Biophysical characteristics of the marsh should be taken into account if new bird sanctuaries are to be established, avoiding areas where hardness, soil texture, and particularly rock abundance, are inappropriate for foraging Greater Snow Geese.

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The Impact of Foraging by Columbian Ground Squirrels, *Spermophilus columbianus*, on Vegetation Growing on Patches Fertilized with Urine

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We investigated how urine fertilization (simulated urine patches) influenced the attributes of vegetation subjected to foraging, mainly by Columbian Ground Squirrels, *Spermophilus columbianus*. This form of fertilization appeared to stimulate increased foraging pressure from the ground squirrels on such patches, evident in a manifold increase in the amount of time spent foraging on the experimental plots after urine application. The vegetation responded to the application of urine by showing an increase in its nutrient content (nitrogen, phosphorus and potassium) and probably an increase in its palatability (water content). As an apparent consequence of the ground squirrel foraging activities, the vegetation on the fertilized plots changed both in canopy coverage (species composition) in mid summer and in standing crop biomass at the end of the growing season. The coverage values for both graminoids and forbs declined significantly, as did the standing crop biomass on the fertilized plots, a phenomenon not recorded on the control plots.

Key Words: Columbian Ground Squirrels, *Spermophilus columbianus*, forging, urine fertilization, Alberta.

Most grazing and browsing herbivores show a preference for certain forage species. Such preferences are developed in response to differences in plant palatability (nutrient content, including water, and plant defences, both physical and chemical) (Huntly 1991). As a consequence of these preferences, herbivores have the potential to influence the nature of the plant community through differential consumption of preferred species.

Ground-dwelling squirrels (Sciuridae) are grazers; they are often important members of the herbivore community associated with North American grasslands where they have been shown, through their grazing, to have an impact on the vegetative community (e.g., Archer et al. 1987; Mallory and Heffernan 1987). Based on a limited number of studies, it seems that within this group of rodents, depending on the species, there is a preference (species consumed in proportions greater than that predicted from their relative availability) for either forbs or grasses and a general avoidance of plants containing chemical defences. Reportedly, prairie dogs, *Cynomys* spp., prefer grasses (Hansen and Gold 1977; Archer et al. 1987; Shalaway and Slobodchikoff 1988); whereas, ground squirrels, *Spermophilus* spp., prefer forbs (Harestad 1986; Mallory and Heffernan 1987; Andrusiak and Harestad (1989), as do marmots, *Marmota* spp. (Carey 1985; Frase and Armitage 1989). One study, however, reported that, although Columbian Ground Squirrels consumed more forbs than grasses, the proportions in both the diet and the field were the same, suggesting no selection of one group over the other (Elliot and Flinders 1985). Nevertheless, this ground squirrel is reported to select an "optimal diet" that maximizes energy intake (Ritchie 1988).

During a long-term study of *S. columbianus* (Boag and Wiggett *in press*), we had cause to measure the use these rodents made of vegetation on a series of artificially-created urine patches (Day and Detling 1990a) in a stand of native grassland on the eastern slopes of the Rocky Mountains in southwestern Alberta. It was apparent that the squirrels were attracted to forage on such patches, with consequent reproductive effects (Boag and Wiggett *in press*). In this note we compare the concentration of four elements (nitrogen, phosphorus, sodium and potassium) in the vegetation on both control (no urine treatment) and experimental (urine treated) plots before and after the latter were fertilized. We also compare between years the standing crop biomass at the end of August on the two sets of plots as well as the canopy coverage and species composition at the end of July.

Methods

This study was undertaken on a 3.98-ha meadow ("MA" in Wiggett and Boag 1989), located on an elevated river terrace adjacent to the Sheep River (50°38′ N, 114°39′ W) in southwestern Alberta. This grassland supported a colony of *S. columbianus* that increased in number over the period of study from

89 animals emerging in the spring of 1988 to 110 in the spring of 1990. In addition to the squirrels, wild ungulates (Bighorn Sheep, *Ovis canadensis*, and Mule Deer, *Odocoileus hemionus*) grazed the area sporadically but lightly over the growing season, and cattle (*Bos taurus*) grazed it moderately heavily after the growing season (September and October).

In 1987 we marked out six groups of two 1-m^2 plots on that part of the grassland occupied by a colony of ground squirrels. A third plot of similar size was added in 1988. Each trio of plots was located along the territorial boundary (Festa-Bianchet and Boag 1982) between different pairs of female residents in 1987. No trio of plots was less than 25 m from the nearest neighbouring trio; individual plots within a trio were never less than 3 m from one another. One plot (experimental) in each trio was chosen randomly for later manipulation (fertilizing with urine in 1989) to simulate Bison (*Bison bison*) urine patches, shown to be attractive to grazing herbivores (Day and Detling 1990a). The remaining two plots (controls 1 and 2) in each group were left without artificial fertilization.

In late July, 1987 through 1990, we determined the species composition and coverage of the vegetation on each plot using 10 subplots (Daubenmire 1959) to cover each 1-m^2 plot. We chose late July in order to be able to include species that were both early in the phenological sequence (e.g., *Anemone patens*) as well as late in the sequence (e.g., *Solidago nemoralis*). At the end of August, 1987, through 1990, after all ground squirrels had entered hibernation, we clipped with hedge clippers the aboveground vegetation from each plot to measure the biomass of the standing crop. We separated this vegetation into two broad categories: graminoids and forbs. The samples were subsequently air dried to a constant mass. Those from 1988 and 1989 were analyzed for total nitrogen, phosphorus, sodium and potassium content in the Limnology Laboratories of the Department of Zoology, University of Alberta, using standard procedures.

After clipping the plots in 1988, we applied 70 g of pelleted commercial urea evenly over each experimental plot in early September. In 1989 and 1990 we applied weekly 1 litre of diluted male human urine (half urine and half stream water) to each experimental plot over the growing season (1 May to 15 August). The diluted urine was applied slowly and evenly over the entire plot to simulate a urine patch (Day and Detling 1990a).

We estimated the amount each of the 18 plots was used by foraging squirrels by recording the number of minutes squirrels were present on each plot over a 15-minute observation period each day. The observation periods, one per day for each trio of plots, were rotated daily so as to cover equally the entire period over which squirrels were active during the day and throughout the non-hibernating season (1 May to 15 August). Observations were made from raised platforms placed strategically so that all six sets of plots were clearly visible.

Results

In 1988, before any plot was fertilized, Columbian Ground Squirrels were recorded on them for less than 0.2% of the time the plots were observed (Table 1). Each plot represented, on average, *ca* 0.2% of an individual parous female's home range (Boag and Wiggett *in press*), suggesting that this cohort of squirrels was either attracted to or repelled from foraging on these plots. In 1989 and 1990 similar low levels of use were recorded on the two sets of control plots. By contrast, the percentage of time that squirrels were recorded foraging on the experimental plots rose to 11% in 1989 and 28% in 1990, a significant increase (G-test; $P<0.001$) in both years.

This increase in time spent foraging on the experimental plots coincided with the presence of increased levels of nitrogen, phosphorus, and potassium, but not sodium, in the vegetation on these plots (Table 2). The amounts of the first three elements nearly doubled in the graminoids, a change that was not recorded on the control plots (Table 2). Unfortunately, the standing crop biomass of forbs on the experimental plots in 1989 was reduced to such an extent (Table 3) that only a composite sample, composed largely of *Potentilla gracilis* stems, was available for analysis. This single sample, however, suggested that the nitrogen, phosphorus and potassi-

TABLE 1. Use of experimental and control plots by foraging Columbian Ground Squirrels over the active seasons (1 May to 15 August) 1988–1990. Use is expressed as a percentage (time squirrel(s) present on plots/total time plots observed X 100; $\bar{x} \pm SE$ (n)).

	Plots		
Year	Experimental	Control 1	Control 2
1988[a]	0.17 ± 0.001 (6)	0.09 ± 0.004 (6)	0.03 ± 0.001 (6)
1989[b]	10.80 ± 0.07 (6)	0.08 ± 0.03 (6)	0.37 ± 0.02 (6)
1990[b]	28.20 ± 0.24 (6)	0.58 ± 0.05 (6)	0.42 ± 0.03 (6)

[a]No plots fertilized
[b]Experimental plots urine treated

TABLE 2. Presence of four elements in vegetation growing on experimental (simulated urine patches) and control plots in a stand of native grassland in southwestern Alberta. Values are means ± 1 SE in mg/g dry weight.

Vegetation Element	Plots: Experimental (n = 6)[a] 1988	1989	Diff[d]	Control 1 (n = 6)[b] 1988	1989	Diff[d]	Control 2 (n = 6)[c] 1988	1989	Diff[d]
Graminoids									
Nitrogen	16.14 ± 1.27	30.46 ± 1.16	P < 0.001	15.82 ± 1.88	16.57 ± 1.31	P > 0.5	12.98 ± 0.53	15.63 ± 1.13	0.1 > P > 0.05
Phosphorus	1.64 ± 0.06	3.27 ± 0.15	P < 0.01	1.69 ± 0.25	1.52 ± 0.08	P > 0.5	1.49 ± 0.29	1.56 ± 0.06	P > 0.5
Sodium	0.60 ± 0.13	0.48 ± 0.05	P > 0.40	0.33 ± 0.03	0.28 ± 0.05	P > 0.2	0.34 ± 0.01	0.37 ± 0.04	P > 0.3
Potassium	12.25 ± 0.89	23.74 ± 0.99	P < 0.001	12.47 ± 1.78	14.47 ± 1.24	P > 0.3	12.08 ± 0.15	15.42 ± 1.21	P < 0.02
Forbs									
Nitrogen	21.69 ± 2.09	29.11[e]		22.16 ± 3.19	22.02 ± 2.69	P > 0.5	18.92 ± 0.82	18.70 ± 1.06	P > 0.5
Phosphorus	2.09 ± 0.16	2.43		2.31 ± 0.40	1.93 ± 0.29	P > 0.4	1.80 ± 0.10	2.02 ± 0.15	P > 0.5
Sodium	0.41 ± 0.09	0.42		0.34 ± 0.05	0.22 ± 0.04	P > 0.2	0.68 ± 0.11	0.37 ± 0.03	P > 0.1
Potassium	16.72 ± 1.22	19.77		19.09 ± 3.59	21.16 ± 1.87	P > 0.3	13.78 ± 0.44	16.62 ± 0.77	P < 0.01

[a]Received urine treatment in 1989.
[b]Standing crop biomass removed 31 August 1987.
[c]Standing crop biomass not removed in 1987.
[d]Based on paired t-tests.
[e]Single composite sample from 6 experimental plots.

um content of this vegetation had also increased (Table 2). The increased level of potassium in the vegetation on control 2 plots in 1989 (Table 2) may have reflected the increased time spent by the squirrels on these plots (possibly as the result of increased population density) in that year (Table 1), more time during which squirrel feces and urine could have been deposited on the plots.

Foraging on these plots by the squirrels had an impact on the standing crop biomass present on the various plots at the end of the active season (Table 3). This variable did not differ between years during the pre-treatment period (1987 and 1988) nor between years during the post-treatment period (1989-1990) for any of the sets of plots measured (Table 3). Yet, when pre- and post-treatment periods were compared, the standing crop biomass on the experimental plots was significantly less in 1989 and 1990 than in 1987 and 1988. Such was, however, not the case on either set of control plots (Table 3). This suggests that the increased time spent foraging on the fertilized plots reduced the standing crop biomass of vegetation present thereon at the end of August. Furthermore, this increased foraging on the experimental plots may have influenced both the coverage and species composition of the vegetation on the experimental plots. Among the graminoids, the change in coverage values between 1987 (pre-treatment) and 1989 (post-treatment), as recorded at the end of July on both the experimental and control 1 plots, was not significant (Table 4). Among the forbs, only on the experimental plots was the change in this variable significant (Table 4). Between 1989 and 1990, the decline in coverage values for both the graminoids and forbs on the experimental plots was significant, a change not recorded between these years on either set of control plots (Table 4). Coincidental with changes in coverage values of the vegetation on the experimental plots were changes in species composition (Table 4). Among the well-represented species, one species of the graminoids, *Danthonia parryi*, and one of the forbs, *Taraxacum officinale*, were eliminated from these plots. All remaining genera of forbs were reduced to remnants (< 1% coverage). Such was not recorded on the control plots where all the well-represented genera retained a relatively constant coverage value (Table 4).

Discussion

Columbian Ground Squirrels were attracted to forage on the simulated urine patches (Boag and Wiggett *in press*; Table 1) which suggests that the forage thereon may have approached an optimal state more closely than elsewhere within their home ranges. Such attraction was probably in response to the changes recorded in the state, particularly the nutritional content, of the vegetation growing on the

TABLE 3. Standing crop biomass ($\bar{x} \pm SE$), in g dry matter, of vegetation clipped between 31 August and 6 September on plots of native grassland in SW Alberta.

Plant Type[a]	Experimental (n = 6) 1987	1988	1989	1990	Control 1 (n = 6) 1987	1988	1989	1990	Control 2 (n = 6)[b] 1988	1989	1990
Graminoids	111.23 ± 24.21	64.25 ± 17.03	41.68 ± 5.76	52.31 ± 13.63	85.83 ± 20.55	77.53 ± 20.65	73.95 ± 15.62	50.33 ± 11.08	113.52 ± 13.64	93.62 ± 17.77	81.35 ± 7.06
Difference											
A[c]	P > 0.1		P > 0.4		P > 0.5		P > 0.2			P > 0.5	
B[b]		P < 0.05				P > 0.2			P > 0.1		
Forbs	48.32 ± 20.19	34.02 ± 9.87	5.72 ± 3.83	1.83 ± 1.54	23.33 ± 6.93	22.95 ± 7.61	30.72 ± 7.46	21.38 ± 4.14	48.67 ± 7.76	48.1 ± 11.06	44.70 ± 6.99
Difference											
A[c]	P > 0.5		P > 0.2		P > 0.5		P > 0.3			P > 0.5	
B[b]		P < 0.01				P > 0.5			P > 0.5		

[a]See Table 4 for genera involved.
[b]No standing crop measured in 1987.
[c]1987 vs 1988 and 1989 vs 1990, based on t-test.
[d]1987 + 1988 vs 1989 + 1990, based on t-test.

treated plots after the application of urine. Coincident with the increased time recorded foraging on the fertilized plots was an increase in the reproductive output recorded among parous female ground squirrels with access to the fertilized plots (Boag and Wiggett *in press*).

The creation of simulated urine patches resulted in both direct and indirect impacts on the vegetation. The former was evident through changes in nutrient content of the plants growing on the treated plots, a phenomenon already well documented (Day and Detling 1990a; and references therein). The increased amounts of nitrogen and phosphorus, with an assumed increase in water content (Day and Detling 1990b), were the changes most likely attracting the squirrels to forage on these plots (White 1993). There was also a change in the ratio of sodium to potassium, a phenomenon that may explain why ground squirrels were observed apparently consuming soil on the experimental plots and thereby possibly increasing their sodium intake (Weeks and Kirkpatrick 1976; Christian 1989).

The species composition of the vegetation growing on the experimental plots also changed. The relative proportion of forbs to graminoids fell, apparently as a consequence of the foraging activity of the ground squirrels. To suggest that this change, an indirect effect of fertilization, was the stimulus for foraging on the experimental plots would seem untenable since the pressure from grazing increased before the species composition of the vegetation changed. That such changed species composition could reflect any toxic effect of the diluted urine on the plants is also unlikely; the fertilized plots were readily visible at a distance because of their striking green colour. Moreover, one species, *Taraxacum officinale*, which was eliminated from the experimental plots, grew vigorously in locations subjected to frequent urine application but not to grazing (personal observations). That forbs were selected over graminoids during foraging also seems unsupported. The proportionally greater loss of forb than graminoid biomass can be more easily explained by the greater vulnerability of the former to grazing pressure because of the location of their meristematic tissue (largely at or above ground in contrast to graminoids where it is largely below ground). The only genus to show an increase in coverage values under the recorded grazing pressure was *Poa* sp., a genus of grass known to respond vigorously to urine fertilization (Day and Detling 1990a), and to be well adapted to grazing by producing many lateral tillers ("grazing lawns") in response to defoliation (McNaughton 1984). It may also divert biomass to underground rhizomes in response to grazing (Jaramillo and Detling 1988; Milchunas and Lauenroth 1989; Polly and Detling 1990). Thus, preferences, previously recorded among ground-

TABLE 4. Coverage of vegetation, expressed as a percentage (mean and range), growing on experimental plots (simulated urine patches) and control plots at the end of July in a stand of native grassland in southwestern Alberta. Data from 1988 destroyed.

	Experimental plots (n = 6)[a]			Control 1 plots (n = 6)[b]			Control 2 plots (n = 6)	
Species[d]	1987	1989	1990	1987	1989	1990	1989	1990
Graminoids								
Agropyron smithii+								
A. trachycaulum	17.3 (6.0-30.0)	12.7 (0.0-27.3)	1.0 (0.0-3.0)	19.6 (7.0-41.3)	12.1 (0.0-32.0)	12.0 (0.0-34.0)	12.9 (0.0-29.5)	11.6 (3.3-24.0)
Agrostis variabilis	9.1 (0.0-44.5)	2.9 (0.0-17.3)	0.3 (0.0-1.5)	8.5 (0.0-16.5)	1.6 (0.0-6.3)	7.3 (0.0-22.5)	3.2 (0.0-16.0)	8.7 (0.0-30.5)
Phleum pratense +								
P. alpinum	12.5 (0.0-42.0)	11.7 (0.0-56.8)	3.9 (0.0-12.3)	9.7 (0.0-43.5)	6.3 (0.0-25.0)	9.1 (0.0-33.5)	8.8 (0.0-19.5)	12.4 (0.0-22.3)
Stipa viridula	9.5 (0.0-41.5)	9.6 (0.0-26.5)	3.5 (0.0-17.8)	15.2 (0.0-58.5)	12.1 (0.0-67.5)	10.8 (0.0-35.8)	1.0 (0.0-2.3)	1.9 (0.0-7.8)
Danthonia parryi	9.2 (0.0-50.5)	0.3 (0.0-1.5)	— (0.0)	12.8 (0.0-45.5)	24.8 (0.0-76.0)	21.0 (0.0-87.8)	23.3 (0.0-62.3)	22.8 (0.0-60.5)
Poa spp.	59.8 (15.3-84.3)	74.0 (25.8-97.5)	72.1 (36.0-97.5)	46.9 (10.5-90.3)	44.0 (6.3-96.3)	45.5 (0.0-97.5)	53.6 (5.3-88.0)	63.3 (10.3-94.0)
Others[e]	24.5 (0.3-40.5)	5.5 (0.0-25.8)	5.3 (0.0-27.5)	21.1 (1.0-43.3)	14.5 (0.0-40.0)	10.9 (0.0-39.5)	19.2 (0.0-27.5)	5.1 (0.0-15.0)
Total	141.9	116.7	86.1	133.8	115.4	116.6	122.0	125.8
Difference[g]		P > 0.3	P < 0.05		P > 0.3	P > 0.5		P > 0.5
Forbs								
Fragaria virginiana	6.2 (0.0-15.5)	0.3 (0.0-1.3)	0.1 (0.0-0.3)	4.0 (0.0-11.0)	3.2 (0.0-14.5)	3.7 (0.0-13.0)	36.4 (3.5-83.0)	41.5 (9.3-85.5)
Geum triflorum	9.2 (0.0-47.0)	2.2 (0.0-11.0)	0.3 (0.0-1.8)	6.3 (0.0-17.8)	9.1 (0.0-19.5)	11.6 (0.0-38.3)	8.1 (0.0-24.0)	10.4 (0.0-28.8)
Potentilla gracilis	22.1 (4.8-45.3)	5.3 (1.3-11.3)	0.8 (0.0-3.0)	16.2 (8.3-29.8)	14.1 (6.3-24.0)	14.6 (0.0-38.3)	21.0 (9.5-42.8)	19.3 (6.5-45.0)
Trifolium repens	13.4 (0.0-52.5)	0.4 (0.0-8.5)	0.1 (0.0-0.8)	26.8 (0.0-83.0)	20.4 (0.0-69.0)	24.7 (0.0-66.5)	14.4 (0.3-73.5)	15.4 (0.0-69.0)
Achillea millefolium	4.5 (1.5-9.5)	0.5 (0.0-0.8)	0.1 (0.0-0.3)	5.8 (1.3-9.3)	5.0 (2.0-13.0)	6.7 (2.8-15.8)	11.2 (6.0-19.5)	18.9 (7.3-45.3)
Taraxacum officinale	28.3 (2.3-63.8)	0.9 (0.0-2.5)	— (0.0)	18.5 (3.0-55.5)	17.7 (1.0-34.3)	18.4 (0.0-35.8)	14.7 (3.0-30.8)	17.0 (3.0-31.0)
Others[f]	50.8 (18.6-76.5)	6.3 (1.0-15.7)	2.2 (0.0-9.0)	42.1 (12.6-69.2)	56.6 (6.0-84.1)	49.6 (8.3-83.5)	41.2 (5.1-83.2)	51.4 (1.3-80.5)
Total	134.5	15.9	3.6	119.7	126.1	129.3	147.0	173.9
Difference[g]		P > 0.2	P < 0.05		P > 0.5	P > 0.5		P > 0.5

[a]Fertilized with urine in 1989 and 1990.
[b]Standing crop biomass removed in 1987.
[c]Standing crop biomass not removed in 1987.
[d]Only those species that were recorded in ≥ 6 plots and with a coverage of ≥ 10% are listed.
[e]Included 10 species, the most frequently encountered being: *Koeleria cristata, Bromus pumpellianus, Festuca scabrella, F. idahoensis, Carex incondita, C. tolmiei, Smilicina stellata, Sisyrinchium sarmentosum.*
[f]Included 33 species, the most frequently encountered being: *Cerastium arrense, Anemone canadensis, A. patens, Thalictrum venalosum, Astragalus* sp., *Lathyrus achroleucus, Viola adunea, Gentianella crinata, Galium boreale, Agoseris glauca, Antennaria neglecta, Erigeron peregrinus, Gaillardia aristata, Solidago nemoralis.*
[g]Based on paired t-tests.

dwelling sciurids (see Introduction), may reflect only the nutrient status of the plants growing at a particular site not their taxonomic status *per se*. Our observations would seem to support the contention that "the ability to select an optimal diet can be viewed as a behavioral trait that is subject to natural selection" (Ritchie 1988: 232); in this case the "optimal diet" may have been vegetation of higher nutritional (including water) content. Such an ability could, in turn, influence population dynamics of the species (Boutin 1990; Boag and Wiggett *in press*).

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Sharp-tailed Grouse, *Tympanuchus phasianellus*, and Grasshoppers: Food is When You Find It

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Mitchell, George J., and Paul W. Riegert. 1994. Sharp-tailed Grouse, *Tympanuchus phasianellus*, and grasshoppers: food is when you find it. Canadian Field-Naturalist 108(3): 288–291.

Food items in two sets of Sharp-tailed Grouse (*Tympanuchus phasianellus jamesi*) esophageal crops collected during two annual hunting seasons in northeastern Montana, demonstrate a number of significant differences ($P < 0.05$) in the volumes, masses and frequencies of occurrence of food items consumed. Volume and mass percentages of total plant materials in the 1976 sample were significantly less than values recorded in 1979. Juniper (*Juniperus* spp.) and Wood's Rose (*Rosa woodsii*), were the most utilized plants in 1976, whereas Buffaloberry (*Shepherdia argentea*) and Skunkbush Sumach (*Rhus aromatica*) comprised the bulk of vegetation eaten in 1979. Grasshoppers occurred in 81% of the crops in 1976 and provided significantly more diet volume and mass than in 1979. This reflected the relative abundance and high availability of grasshoppers in the study area in 1976. Twenty-two species of acridid grasshoppers in three subfamilies were identified in the 1976 sample. Most of these grasshoppers (82%) were in the genus *Melanoplus*.

Key Words: Sharp-tailed Grouse, *Tympanuchus phasianellus jamesi*, fall foods, grasshoppers, northeastern Montana.

Many studies have shown that selection of food items by North American gallinaceous birds is closely dependent on the abundance and availability of those foods. With a marked reduction in availability, birds must seek out alternative foods which may provide less metabolizable energy. These diet studies have also demonstrated the importance of invertebrates to chicks in summer and to both juveniles and adults in autumn.

The objective of our study was to document and compare the foods utilized by Sharp-tailed Grouse in two mid-September collection periods in Montana, and examine the relationship between the availability and utilization of acridids by grouse.

Methods

Sharp-tailed Grouse crops were removed from hunter-harvested birds on the first two days of the annual hunting seasons in September 1976 and 1979. All birds in our sample were shot south of the Missouri River and Fort Peck Lake in an area centered on McCone, Dawson, and Garfield counties in northeastern Montana (47° 20′ N, 106° 10′ W). Descriptions of vegetation types on a portion of this semiarid mixed-grass region have been presented by Swenson (1985). Removal of crops occurred at a check-point manned by University of Regina wildlife students and the senior author. Individual crops were dried and later examined in our laboratory at Regina, Saskatchewan, where the plant and animal contents were separated, examined under a dissecting microscope, and identified to species, genus, or order, whenever possible, using plant and invertebrate reference collections. Volumes of food items in the crops were determined by the water displacement method, and masses of towel-dried food items were measured using a pan balance. Volumes less than 0.5 ml and values of mass less than 0.5 g were considered trace amounts. Measurements each year were grouped by the aggregate volume and aggregate mass methods (Martin et al. 1946). A series of Z tests was applied to ascertain if differences in the percentages of occurrence, volume, and mass of food items in the two samples were significant ($P < 0.05$). Botanical nomenclature follows Looman and Best (1979).

Results and Discussion

Thirteen species of plants, 22 species of grasshoppers, and eight additional orders of insects and other invertebrates were identified in our sample totalling 85 crops (Table 1). Grasses and forbs were minor items, and together comprised less than 10% of the diet in both years. Invertebrates and the fruits of shrubby vegetation comprised 90% or more of the volume and mass of the total diet each year, and represented the highest frequencies in the crop samples. In 1976 and 1979 the frequency of occurrence of shrubs in the crops was 83% and 94%, respectively, and that of invertebrates was 87% and 79%, respectively. The volume and mass percentages of total vegetation materials consumed by the grouse in 1976 were significantly less ($P < 0.05$) than in 1979. The two most important plant foods in the 1976 sample were Juniper (*Juniperus* spp.) cones and Wood's Rose (*Rosa woodsii*) hips which, when combined, comprised 54% and 65%, respectively, of the volume and mass of the total diet. All of the remaining eight plant species in the diet, except Wheat (*Triticum aestivum*) and Choke Cherry (*Prunus virginiana*) had volumes of 1% or less. The fruits of

TABLE 1. Percent occurrence (Occ), volume (Vol), and mass (Mass) of food items in the crops of 85 juvenile and adult Sharp-tailed Grouse shot in Montana, September 1976 and 1979[a].

Food item	Occ	1976 Percent Vol (N = 52)	Mass	Occ	1979 Percent Vol (N = 33)	Mass
Grasses						
Wheat caryopses, *Triticum aestivum*	17	3	6	6	2	3
Barley caryopses, *Hordeum vulgare*	2	1	2	–	–	–
Unidentified	2	*t*	*t*	12	*t*	*t*
Total grasses	19	4	8	18	2	3
Forbs						
Canada thistle fruits, *Cirsium arvense*	29	*t*	1	3	*t*	1
Buckwheat fruits, *Fagopyrum tartaricum*	4	*t*	*t*	–	–	–
Goat's-beard fruits, *Tragopogon dubius*	4	*t*	*t*	9	2	2
Alfalfa fruits, leaves, *Medicago sativa*	–	–	–	9	1	1
Unidentified green herbage	8	*t*	*t*	27	4	2
Total forbs	38	1	1	36	7	6
Shrubs						
Juniper cones, *Juniperus* spp.	83	46	54	21	1	1
Wood's Rose hips, *Rosa woodsii*	46	8	11	18	5	5
Snowberry fruits, *Symphoricarpos* spp.	10	1	*t*	3	1	*t*
Choke Cherry fruits, *Prunus virginiana*	4	3	3	3	1	*t*
Bush Cranberry fruits, *Viburnum* spp.	2	1	2	–	–	–
Buffaloberry fruits, *Shepherdia argentea*	–	–	–	58	42	52
Skunkbush Sumach fruits, *Rhus aromatica*	–	–	–	39	29	27
Total shrubs	83	59	70	94	79	85
Total vegetation	100	64	79	100	88	94
Insects						
Grasshoppers (Acrididae)	81	34	21	42	7	4
Beetles (Coleoptera)	35	1	*t*	61	2	1
Others[b]	38	1	*t*	39	2	1
Total insects	87	36	21	79	11	6
Other arthropods						
Spiders (Araneae)	2	*t*	*t*	15	1	*t*
Millipedes (Diplopoda)	–	–	–	3	*t*	*t*
Total animal material	87	36	21	79	12	6

[a]Volume expressed in milliliters; mass in grams.
[b]Insects in the Orders Lepidoptera, Homoptera, Hymenoptera, Diptera, and Ephemeroptera in decreasing order of percent volume and mass.
[t]Trace = less than 0.5 percent

Buffaloberry (*Shepherdia argentea*) and Skunkbush Sumach (*Rhus aromatica*), neither of which occurred in the 1976 crop sample, were the most abundant plant foods in 1979. Their combined values for volume and mass were 71% and 79%, respectively. Rose hips provided 5% of both the volume and mass of the 1979 sample, and the remaining seven species of plants in the diet had volumes of 2% or less.

Grasshoppers accounted for 34% of the volume and 21% of the mass in our 1976 sample, but were minor items in the 1979 sample (7% vol., 4% mass). In 1976, acridids of the genus *Melanoplus* comprised 82% by number of 22 species of grasshoppers ingested (Table 2). These insects normally show the largest fluctuations in numbers, and are of concern because they can inflict damage on forage and cereal crops. Those grasshoppers eaten less frequently by the grouse in our sample are species that are less common and usually confined to pasture, wasteland, or ungrazed rangeland.

We have no vegetation measurements that would account for the differences in the selection and utilization of browse food items in our two samples. It is probable, however, that the consumption of fruits of those preferred plants was a function of their relative abundance and availability in any particular year, and the preference these birds demonstrated for using shrubby vegetation for cover and roosting in fall and winter. This preference for sandhills, "breaks", creeks and upland areas supporting shrub communities consisting of Buffaloberry, Rose, Snowberry (*Symphoricarpos* spp.), Skunkbush Sumach, Choke Cherry,

TABLE 2. Species, relative masses, and numbers of grasshoppers in the crops of 42 Sharp-tailed Grouse shot in Montana, September 1976.

Subfamily and species	No.	Mass (grams)	Percent mass
Melanoplinae			
Melanoplus sanguinipes	463	38.5	37.8
M. angustipennis	206	16.4	16.1
M. femur-rubrum	120	8.5	8.3
M. keeleri	101	7.5	7.4
M. dawsoni	81	4.3	4.2
M. gladstoni	61	4.2	4.1
M. packardii	18	2.9	2.8
M. infantilis	58	2.4	2.3
Asemoplus montanus	21	2.3	2.3
M. bowditchi canus	25	1.3	1.3
Hypochlora alba	22	1.2	1.2
Phoetaliotes nebrascensis	21	0.8	0.8
Aeoloplus turnbulli	11	0.7	0.7
Total *Melanoplus*	1133	86.0	84.3
Total Melanoplinae	1208	91.0	89.3
Oedipodinae			
Spharagemon equale	14	2.2	2.2
S. collare	7	1.3	1.3
Trachyrhachys k. kiowa	10	0.8	0.8
Arphia p. pseudonietana	7	0.7	0.7
Encoptolophus sordidus costalis	7	0.6	0.6
Total Oedipodinae	45	5.6	5.6
Gomphocerinae			
Phlibostroma quadrimaculatum	60	1.8	1.8
Cordillacris crenulata	46	1.7	1.7
Ageneotettix d. deorum	27	1.5	1.5
Opeia obscura	2	0.1	0.1
Total Gomphocerinae	135	5.1	5.1
Total Grasshoppers	1388	101.7	100.0

42/52 grouse (80.8%) in the sample had consumed grasshoppers.
81.6% of the grasshoppers consumed were *Melanoplus* species.

Hawthorn (*Crataegus* spp.), Silverberry (*Elaeagnus commutata*), Saskatoon (*Amelanchier alnifolia*), Willow (*Salix* spp.), Juniper and others, has been observed by Mitchell (1959) and Moyles (1981) in Alberta, and by Nielsen and Yde (1981) and Swenson (1985) in northeastern Montana. In this region some 70-92% of the autumn sightings placed Sharp-tailed Grouse in shrub communities.

The large proportion of vegetation and the prevalence of Buffaloberry, Snowberry, Rose and Juniper in our two samples agreed with the results of Sharp-tailed Grouse food habit studies reported by Swenk and Selko (1938), Kobriger (1965), Renhowe (1968), Pepper (1972), Swenson (1985) and many others in the Northern Great Plains States and the Province of Saskatchewan. These authors, as well as Evans and Dietz (1974) and Marks and Marks (1988), refer to the positive correlation between availability of food items and their consumption by grouse.

Our study provided another example of exploitation of a food resource when it is not only preferred and nutritious but also available because of its abundance. The significant difference in consumption of grasshoppers in our two samples was related to relatively greater numbers and availability of these insects in 1976. That year in Montana, severe infestations of grasshoppers (4-8/m^2) occurred on 1.1 million acres, and grasshopper densities of that magnitude were present in McCone, Dawson, and Garfield counties (U.S.D.A. 1976). In contrast, in 1979 there was a 63.5% reduction in the acreage registering these high grasshopper densities in Montana, and there were no economic infestations of grasshoppers in our study area (U.S.D.A. 1979). That year, grasshoppers of those species present in 1976 were consumed by grouse but to a significantly ($P < 0.05$) lesser degree.

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Breeding Populations of Mallards, *Anas platyrhynchos,* on Four Urbanized Lakes in Michigan

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Among breeding Mallard (*Anas platyrhynchos*) populations on four urbanized lakes in the northern lower peninsula of Michigan, maximum numbers of indicated pairs (single males or single males with single females) per km of shoreline varied from 0.59 to 0.91, other adults from 1.65 to 5.67, females with broods from 0.19 to 0.94, and individuals in broods from 1.06 to 6.15. More males occurred than females. Males occurring singly or with single females decreased during the survey period whereas males occurring in groups showed no trend. Abundance of females with and without broods increased during the survey period. Mallard production varied significantly on the four lakes. The largest number of broods appeared on the lakes during the third week in June. Brood size reached a high of 8.6 individuals in mid-June and declined to a low of 5.3 individuals at the end of the survey period. Breeding Mallards were most abundant on gently sloped urbanized shorelines. Mallards using these lakes undertook typical fall and spring migrations and at least some individuals returned in subsequent summers.

Key Words: Mallards, *Anas platyrhynchos*, breeding populations, Michigan, forested lakes, urbanized lakes.

The Mallard (*Anas platyrhynchos*) breeds across much of North America; highest densities are in the prairie/parkland region of south-central Canada (Bellrose 1976; Pospahala et al. 1974). Mallards have considerable behavioral and ecological plasticity and a number of populations, particularly in the eastern United States and Canada (e.g., Cooper and Johnson 1977; Heusmann and Burrell 1984; Montgomery et al. 1975; Oplinger 1977), commonly occur in urban areas and may be partly dependent upon the presence of humans. Figley and VanDruff (1982) reviewed the ecology of such populations and defined "urban" Mallards as "free flying Mallards that spend at least part of a day in close company with humans in urban or suburban areas and have access to artificial food." At many locations, urban Mallards fit one of three categories (Heusmann 1981): (1) tame resident individuals that seldom leave the area; (2) less tame resident individuals that leave the area to night roost or to breed; (3) wild, migrant individuals that are found in the area only during the winter.

In 1992, the number of Mallards estimated to breed in Michigan was about 370 000 (Lake States Breeding Waterfowl Survey 1992). Some of these Mallards breed on urbanized lakes (i.e., lakes whose shorelines support short-cut lawns and human-made structures) of the northern part of the lower peninsula. These individuals represent another category of "urban" Mallards because they often receive artificial food from the humans who summer on these lakes.

There have been relatively few studies of Mallards that breed in forested areas; exceptions are studies by Donaghey (1974), Gilmer et al. (1975) and Kirby et al. (1985). Our objectives were to determine population sizes of adults and young and to characterize patterns of occurrence and habitat use in the urban Mallards of four forested lakes in northern lower Michigan.

Study Area

During the summer of 1991, we surveyed Mallards on North Lake Leelanau (NLL)(1194 ha, 26.4 km of shoreline, South Lake Leelanau (SLL)(2306 ha, 41.3 km), Lime Lake (LL)(244 ha, 7.7 km), and Little Traverse Lake (LTL)(234 ha, 8.5 km), in Leelanau County (44°50′N, 85°50′W), Michigan. These lakes are mostly surrounded by second-growth coniferous, deciduous, or mixed coniferous-deciduous forest and their shorelines support a large number of resorts and private homes, most of which are occupied only during late spring, summer, and early fall. The four lakes have sand, marl, organic, or cobble bottoms, are oligotrophic, support relatively little submergent vegetation, and include only small patches of shoreline-related, emergent (*Scirpus* spp. and *Typha* spp.) vegetation. Maximum water depths are as follows: NLL, 36.8 m; SLL, 18.8 m; LL, 20.4 m, LTL, 16.4 m.

Methods

We used a motorboat and scaled maps to determine the linear extent of urbanized shoreline on all four lakes and the extent of steeply and gently sloped shorelines on NLL and SLL. "Steeply sloped" shorelines rose vertically or nearly vertically from the water's edge.

We also used motorboats to conduct shoreline surveys of Mallard abundance. Similar approaches were used by Danell and Sjöberg (1979), Donaghey (1974), and Spindler et al. (1981). We surveyed almost every week in June and July by slowly cruising along the perimeter of the lake and recording all individual Mallards sighted in the water and on the shore. We surveyed in the morning between 06 00 and 12 00 hrs and alternated between clockwise and counterclockwise directions. The close proximity of the survey course to the shore made it impossible to scan all open-water areas in the middle of the two largest lakes. We decided not to survey those areas because Mallards were seldom encountered during cross-lake trips. For all individuals, we recorded on maps the location of sighting, sex, number of accompanying individuals, age class of broods (Gollop and Marshall 1954), and behavior at time of sighting (feeding in water, swimming but not feeding, resting/feeding on shore, resting on a dock or other structure in the water, flying).

We used drive traps, set in shallow water, to capture 410 Mallards, including 87 adult males, 59 adult females, 134 male ducklings, and 130 female ducklings. All individuals were banded with U.S. Fish and Wildlife Service aluminum leg bands.

Single-factor ANOVA and Fisher's Protected LSD procedure were used to determine if Mallard abundances on the four lakes were similar. The Wilcoxon signed-rank test (for unequal variances) was used to compare means for male and female numbers, and contingency table analyses were used to test for independence in patterns of behavior and habitat use. Relationships between time and abundance variables were examined with the use of simple linear regression. Significance was set at $P < 0.05$.

Results and Discussion

Although mean numbers of indicated pairs (single males or single males with single females) per km of shoreline on the four lakes were not different (Table 1; ANOVA, $F = 0.98$, $df = 3,26$, $P = 0.416$), there were different mean numbers of other adults ($F = 17.59$, $df = 3,26$, $P = 0.0001$), females with broods ($F = 5.83$, $df = 3,26$, $P = 0.004$), and individuals in broods ($F = 6.02$, $df = 3,26$, $P = 0.003$). Individuals in all three categories were most abundant on SLL (Table 1); numbers of individuals in these same categories for the other three lakes did not differ (Fisher's Protected LSD, $Ps > 0.05$).

For all surveys and lakes, more males were recorded than females ($\bar{x} \pm$ SE: males = 43.0 ± 11.7, n = 28; females = 19.8 ± 4.5; n = 28; $P = 0.0001$). Males comprised 85% of all birds observed at the beginning of the survey period and declined to 51% at the end. Males occurring singly or with single females (presumably, breeding males) decreased in number as the breeding season progressed (Figure 1;

TABLE 1. Minimum, mean (SE), and maximum numbers of individuals per km of shoreline for all surveys. Dates indicate when a particular minimum/maximum occurred.

Lake and group	Minimum (Date)	Mean (SE)	Maximum (Date)
N. Leelanau			
Indicated pairs[a]	0.08 (18 July)	0.37 (0.08)	0.68 (11 June)
Other adults[b]	0.34 (4 June)	0.88 (0.18)	1.48 (9 July)
Females with broods	0.00 (24 May)	0.10 (0.02)	0.19 (9 July)
Individuals in broods	0.00 (24 May)	0.60 (0.12)	1.03 (9 July)
S. Leelanau			
Indicated pairs	0.17 (17 July)	0.47 (0.08)	0.80 (14 June)
Other adults	2.20 (25 May)	3.30 (0.47)	5.67 (7 June)
Females with broods	0.05 (30 May)	0.50 (0.14)	0.94 (17 July)
Individuals in broods	0.29 (30 May)	3.23 (0.83)	6.15 (28 June)
Lime			
Indicated pairs	0.00 (11 July)	0.33 (0.12)	0.91 (12 June)
Other adults	0.00 (25 July)	0.72 (0.21)	1.69 (11 July)
Females with broods	0.00 ([c])	0.16 (0.06)	0.39 (11 July)
Individuals in broods	0.00 ([c])	1.15 (0.37)	2.86 (11 July)
Little Traverse			
Indicated pairs	0.00 ([d])	0.25 (0.08)	0.59 (5 June)
Other adults	0.12 (12 June)	0.91 (0.21)	1.65 (29 June)
Females with broods	0.00 ([e])	0.10 (0.03)	0.24 (11 July)
Individuals in broods	0.00 ([e])	0.94 (0.28)	2.00 (11 July)

[a]single male or male and female pair.
[b]males not occuring alone or with single females; females without broods or not occurring with single males.
[c]29 May and 12 June.
[d]11 July and 25 July.
[e]29 May and 5 June.

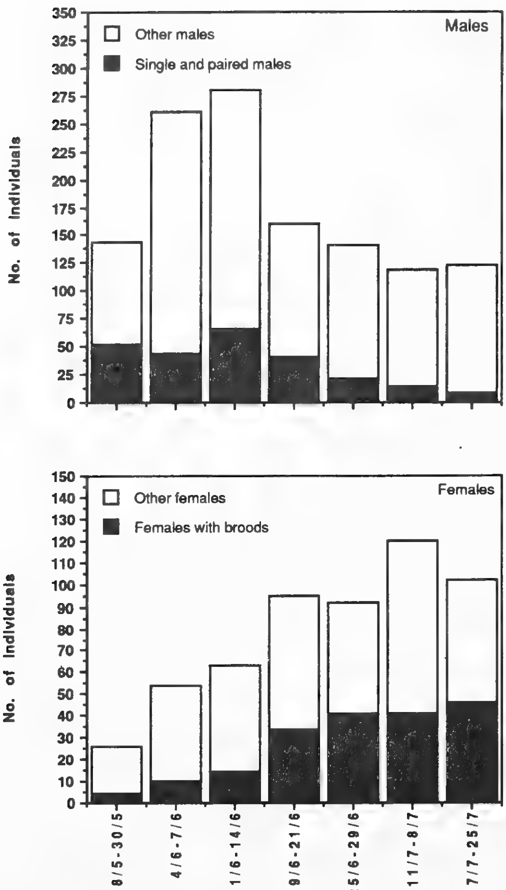

FIGURE 1. Numbers of males and females on North Leelanau Lake, South Leelanau Lake, Lime Lake, and Little Traverse Lake during the summer of 1991.

simple regression, F = 13.03, df = 1,5, P = 0.015) whereas other males showed no trend (F = 1.09, df = 1,5, P = 0.345). Most of the males recorded were in groups. On NLL and SLL, where most of the males occurred, their mean percent occurrence was 71.9 ± 6.2 SE (n = 14). Males in this category were especially abundant during the first half of June (Figure 1). Skewed sex ratios in favor of males early in the breeding season have been reported for other populations associated with humans (Figley and VanDruff 1982) and also for wild Mallard populations (Bellrose 1976; Sowls 1955: 164).

TABLE 2. Chronology of mean brood size and brood numbers (numbers in parentheses) for Mallards breeding on North Leelanau Lake, South Leelanau Lake, Lime Lake, and Little Traverse Lake during the summer of 1991. Values for each time period are based on data from all of the lakes.

	Mean brood size			
	Age group			
Date	I	II	III	Totals
28-30 May	7.7			7.7
	(3)			(3)
4-7 June	8.0	6.5		7.7
	(8)	(23)		(10)
11-14 June	8.5	8.8		8.6
	(8)	(6)		(14)
19-21 June	6.9	7.6		7.3
	(15)	(20)		(35)
25-29 June	5.5	7.9	9	6.9
	(17)	(23)	(1)	(41)
8-11 July	5.5	6.4	7.9	6.4
	(11)	(23)	(7)	(41)
17-25 July	3.1	5.6	5.8	5.3
	(7)	(19)	(21)	(47)

Female abundance increased on all four lakes as the breeding season progressed (Figure 1), both for females with broods (F = 59.83, df = 1,5, P = 0.001) and females without broods (F = 7.53, df = 1,5, P = 0.041). On NLL and SLL, females without broods comprised 71.9% ± 3.8 SE (n = 14) of total females. Some of these females occurred with single males indicating that they were late breeders or were attempting to renest.

Mallard broods first appeared late in May, showed the largest increase during the third week of June, and then slowly increased in numbers to the end of the survey period (Table 2). Mean brood size reached a peak of 8.6 at mid-June and then slowly declined to 5.3 individuals at the end of the survey period. These brood numbers indicated that a few females began to incubate as early as late April with

TABLE 3. Mallard reproduction on four Michigan lakes during the summer of 1991. Numbers are based on maximum brood counts recorded during surveys.

Lake	km of shoreline	No. of broods	No. of young	Broods/km of shoreline	Young/km of shoreline
North Leelanau	26.4	5	28	0.19	1.06
South Leelanau	41.3	37	254	0.90	6.15
Lime	7.7	3	22	0.39	2.86
Little Traverse	8.5	2	17	0.24	2.00

TABLE 4. Mallard sightings in relation to shoreline type.

	N. Leelanau Lake	S. Leelanau Lake	Lime Lake	Little Traverse L.
Shoreline type				
Urbanized (km)	16.7	24.3	4.9	5.8
Not urbanized (km)	9.7	17.0	2.8	2.7
Percent urbanized	63.3	58.8	63.6	68.2
Individuals on urbanized shoreline				
Observed	347	2279	81	93
Expected	258	1442	80	82
χ^2	83.51	1179.46	0.03	4.66
P	0.0001	0.0001	0.853	0.031

TABLE 5. Behavior of individual Mallards at the time of sighting. Numbers are percent of total sightings.

Lake	N	Feeding in water	Swimming	Rest/ feeding on shore	Resting on shore	Flying
North Leelanau	427	26	40	13	20	1
South Leelanau	2579	10	29	48	12	1
Lime	129	38	21	25	15	2
Little Traverse	124	19	38	17	21	5

the majority starting during the third week of May. Mallard production (number of broods and number of young) on SLL substantially exceeded production on the other three lakes (Table 3). NLL showed the fewest broods and ducklings.

Mallards were strongly associated with urbanized shorelines on NLL and SLL, less strongly associated with such shorelines on LTL, and located randomly with respect to this shoreline feature on LL (Table 4).

Mallard behavior, based on raw frequency data and all of the behavior categories except "flying," differed among lakes (Table 5; χ^2 = 56.45, 9 df, P = 0.0001). Mallards on SLL were sighted on the shore 48% of the time whereas only 13% of the Mallards on NLL were sighted on the shore.

One of the clearest results was that Mallard populations on NLL and SLL were strongly associated with urbanized portions of shorelines. We attribute the lack or relative weakness of such an association on the two small lakes (LL and LTL) to the need for individuals there to use all shoreline types to meet their resource requirements.

We suggest two reasons why Mallards preferred urbanized shorelines. First, Mallards are known to prefer habitats that provide convenient and predator-safe areas for resting and loafing (Gilmer et al. 1975; Kirby et al. 1985). The urbanized shorelines provided a variety of such sites, including boat docks, sandy shoreline strips, and short-grass lawns. Second, Mallards found a variety of food resources on urbanized shorelines. On many occasions we observed Mallards being fed by property owners and resort guests. In addition, Mallards were regularly observed foraging on lawns, making considerable use of terrestrial vegetation and terrestrial arthropods as food sources.

Even though the length of urbanized shoreline on SLL compared to NLL was only about 1.5 times greater, SLL supported more than 6.5 times as many Mallards (Table 4). We believe that NLL supported fewer Mallards because a much larger percentage of its shoreline was steeply sloped (50.6% as compared to 4.6% for SLL) and therefore less accessible. This conclusion is supported by the fact that Mallards on NLL were sighted most often in the water and Mallards on SLL most often on shore (Table 5).

During fall 1991, 17 Mallards banded on the study lakes were reported shot by hunters. Locations and numbers of shot individuals were as follows: Leelanau County, 8; elsewhere in Michigan, 3; Wisconsin, 3; Arkansas, 1, Mississippi, 2. Banding efforts during the summer of 1992 yielded recaptures of 61 individuals first banded in 1991. Among these individuals, there were 25 males banded as adults in 1991, 13 females banded as adults, 3 males banded as ducklings, and 17 females banded as ducklings.

Although these Mallards show a number of "urban" characteristics during the breeding season, our banding return data indicate that they undertake typical fall and spring migrations and at least some individuals returned in subsequent summers.

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The Genus *Tolypella* (Characeae) in Insular Newfoundland

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Tolypella glomerata (Desv.) Leonh. is reported for the first time in eastern Canada, on the tip of the Great Northern Peninsula in Insular Newfoundland, extending its range 1500 km northeast of previously known eastern most localities in New York State. Plants with mature oospores but still in relatively protonematal growth stage were collected 29 August 1992 and 24 August 1993 from shallow coastal pools. Newfoundland material morphologically resembles that described by European authors and possible transatlantic introduction is suggested.

Key Words: Charophyte, Characeae, *Tolypella*, Newfoundland, phytogeography.

A recent survey of the charophytes of insular Newfoundland (Mann 1989) reported ten taxa within the two genera *Chara* and *Nitella*, but also indicated that the Island has only been superficially investigated leaving vast areas yet to be thoroughly explored. Because both vascular plant botanists as well as phycologists generally ignore these macrophytes, the potential for significant new finds still exists and will continue to exist in the foreseeable future. The island of Newfoundland, especially the west coast, is part of the great Atlantic flyway seeing numerous species of ducks, geese, and shorebirds migrating northward and southward with the seasons carrying oospores on or within their bodies. Since a number of charophyte species can range into the subarctic where suitable waters exist (Langangen 1972, 1974, 1979, 1993; Wood 1965), some of those species occurring to the south of the Island will undoubtedly be located in Newfoundland as our freshwaters become better known. On the other hand, considerable floristic affinities with northern Europe also exist and should be more fully investigated. It would also be expected that the frontiers of dispersal and establishment, especially to islands, will be extended largely by monoecious species as predicted by Proctor (1980).

The present report describes the discovery of *Tolypella glomerata* (Desv.) Leonh. in northern Newfoundland where it appears to be disjunct both in terms of the nearest known North American and European populations. This is the first report of the genus *Tolypella* in Newfoundland. Voucher specimens are housed as liquid preservations in 5% formalin (5 parts commercial formalin and 95 parts water) and as dried sheets in the herbarium of the Sir Wilfred Grenfell College (Mann Numbers 143, 175, 196). Herbarium sheets (Mann Number 175) have also been deposited with the Phycological Herbarium of the Canadian Museum of Nature, Ottawa (CANA), the Phycological Herbarium of Memorial University, St. John's (NFLD), and the Newfoundland Museum, Duckworth Street, St. John's. Herbarium abbreviations used are listed in Holmgren et al (1990).

Location and Habitat

The Newfoundland discovery of *Tolypella glomerata* is located in the Strait of Belle Isle near the tip of the Great Northern Peninsula (Canadian Topographical Map 12 P/8, U.T.M. Grid Reference 402965). The site is situated two km north of the community of Eddie's Cove East on the old coastal highway no longer used as a thoroughfare (Figure 1). The general area is almost arctic tundra-like in climate and appearance, with extensive exposed limestone rock and gravel barrens. In wetter areas a thin veneer of peat produces species diverse fens with scattered patches of scrub spruce-fir thickets and tuckamoor. Numerous shallow pools and ponds occur throughout.

Meades (1991) characterizes the growing season of the area as follows: "Ice flows carried by the Labrador Current plug up the Strait of Belle Isle in December and the disintegrating pack-ice lies off the coast well into June and even early July. Consequently, the vegetative season is less than 110 days and frosts can occur at any time of the year. Annual precipitation consists of 1000 mm of rainfall and 300 cm of snowfall. Mean daily temperature varies from -8.0°C in January to 12.0°C in July." In 1992 large icebergs could still be observed grounded in the Straits on 29 August.

Two small shallow pools lie as depressions in the broad flat landward side ditch of the old coastal road only 75 m from the rocky ocean beach (Figure 2). This road was constructed in the late nineteen fifties by grading the calcareous gravels on either side into the raised central roadbed. The pools may have been newly formed at this time, but a depression could

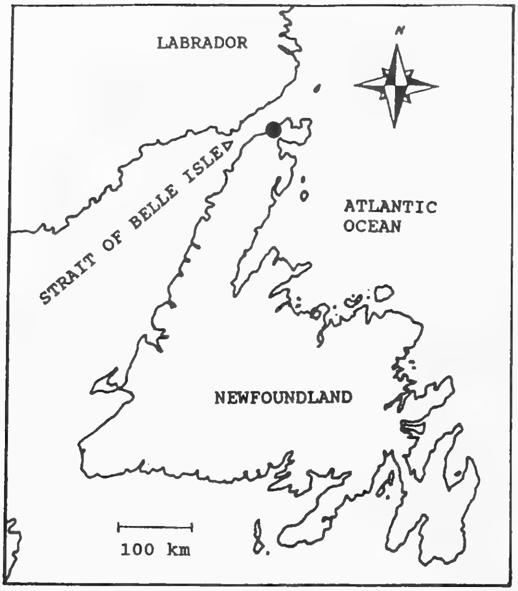

FIGURE 1. Location of *Tolypella glomerata* in insular Newfoundland, Canada.

have previously occurred receiving runoff and seepage water from the inland escarpment. It is likely, however, that the macrophytes present were introduced since the construction period.

The larger pool is approximately 200 m^2 in area whereas the smaller pool 100 m to the northeast is only one-third this size. Maximum water depth which measured 25 cm fluctuated somewhat during the summer, but never dropped drastically and the pools never dried out in the two years of observation (1992–1993) because of frequent rains and inland seepage. It is conceivable that in some years the pools might be subject to partial or total drying for a short period. The firm bed of the pools is of coarse gravel sealed by a fine pale grey calcareous mud and covered by several centimeters of loose organic ooze.

Water pH tested with a Cole-Parmer digital meter (pHep$^+$) on 29 August 1992 was 9.4 and conductivity tested with a Myron L DS Meter (Model EP-10) was 480 µmhos/cm. Both these values are among the highest measured in Newfoundland freshwaters reflecting the soluble calcareous substrate as well as the proximity of the pools to the ocean and the effect of salt spray (Kerekes 1978). The pH of inland calcareous marl ponds rarely rises above 8.0 with a conductivity of 300 µmhos/cm In areas of acid rock substrate, Newfoundland freshwaters are highly dilute producing conductance values of less than 50 µmhos/cm (often less than 25) and mostly ranging in pH from 6.0 to 6.9, but with some values falling below pH 5.0.

Besides *Tolypella*, two aquatic macrophytes occur in the pools, the pondweed *Potamogeton filiformis* Pers. and the White Water Crowfoot, *Ranunculus trichophyllus* Chaix. Both of these are readily dispersed cosmopolitan species of North America, Europe and Asia with tough seed coats resistant to waterfowl digestion. Species of the wet pond margins include *Juncus* sp., *Equisetum arvense* L., *E. variegatum* Schleich., *Triglochin palustris* L., *T. maritima* L., *Calamagrostis neglecta* (Ehrh.) Gaertn., Mey. & Scherb., and others. The surrounding vegetation is largely a grass/sedge/forb meadow with some scattered low *Salix* shrubs. Patches of sparsely vegetative gravels also occur.

Tolypella plants were not growing together in clusters, but were individually scattered throughout the pools in what appeared to be random distribution with sometimes up to a meter or more from one plant to its nearest neighbour. Similar pools and various larger ponds exist throughout the area and although only a small number have been thoroughly sampled, this species has not been located anywhere else. These observations may indicate a very recent introduction into the two adjacent pools either from a source elsewhere in the area or through long distance dispersal. On the other hand, this sparce scattered growth appears to be common also for vascular macrophytes in some of the shallow calcareous ponds and may be the result of wind and wave action coupled with patchy suitable substrate rooting microhabitat.

Growth and Morphology

Tolypella glomerata was first discovered on 28 July 1992 accidentally while collecting herbarium specimens of the white-flowering *Ranunculus*. Tiny green single "stalks" protruding one to several centimeters above the organic ooze proved to be the "terminal process" tips of the protonematal (pro-embryo) growth stage (Figure 3B). On this date protonemata were in all stages of development from tiny 1 cm long thalli having just germinated, to specimens of 8.5 cm in length as measured from the attached oospore to the tip of the elongate terminal process. Often one to four or more accessory protonemata had developed from the base of the primary thallus. All individuals collected were still attached to the blackish oospores from which they had germinated. The structure and mode of development of protonemata (pro-embryos) and the development of the sexual shoots from the protonematal whorl in charophytes is well described and illustrated in Groves and Bullock-Webster (1920).

Collections with some mature oospores were made on 29 August 1992 and 24 August 1993. Plants at this stage were still essentially enlarged protonemata with the internodal cell elongated up to 6 cm and the terminal process of up to 10 cm producing a

FIGURE 2. Pools from which *Tolypella glomerata* was collected. The edge of the road berm is visible on the left of the photograph.

total height from attached germinated oospore to the tip of the terminal process of up to 16 cm (Figure 3A). The protonematal whorl consists of unbranched sterile branchlets from among which arise axes terminating in compact elongate "heads", each head composed of 4-6 whorls of fertile branchlets. These axes producing the fertile branchlet whorls are considered to be the sexual phase of the thallus as opposed to the protonematal phase described above. Many of these sexual axes are produced at the protonematal whorl, often from six to fifteen and sometimes more. Axes of the fertile shoots were relatively short, up to 5 cm, but mostly shorter, producing a cluster of compact heads. Usually only the primary protonema undergoes rapid growth after germination, the accessory protonemata remain smaller (possibly some of them abort?) until the primary one is producing mature oospores.

In most charophytes the vegetative sexual phase grows vigorously from the protonematal node, obvious vestiges of the protonemata are soon lost, and eventually fruiting structures are produced. In at least this species of *Tolypella*, the vigorous rapid growth of the protonemata and the maturing of oospores while the sexual axes are still relatively immature reveals a neoteny adapted for rapid reproduction in temporary situations or those where favorable growth conditions are transient. Such is the habitat in which this species was located in Newfoundland and literature citations also indicate the species as one of ditches, pits, pools, semi-permanent puddles, in fresh and brackish waters, frequently coastal (Groves and Bullock-Webster 1920; Olsen 1944; Moore 1986). Moore (1986) notes that *T. glomerata* can develop rapidly from germination to oospore production in three months. For the Newfoundland population the earliest collection of 28 July 1992 suggested that germination had not occurred before late June or early July and was still occurring on the collection date whereas on 29 August 1992 the first oospores were already ripe. Olsen (1944) also noted such rapid development. This indicates that the species is capable of successful reproduction in as short a time as two months from germination, possibly less, while the thallus is still in a relatively immature state of growth.

Perhaps this species should be sought even further north in Labrador and even coastal Greenland, Iceland, and northern Europe wherever similar environmental conditions exist. Transient shallow pools are sometimes overlooked by collectors and the small stature and scattered occurrence of fruiting specimens in northern waters could also cause the species to be easily missed by traditional sampling methods. When growing in more stable conditions in larger nutrient rich lakes and in areas with longer

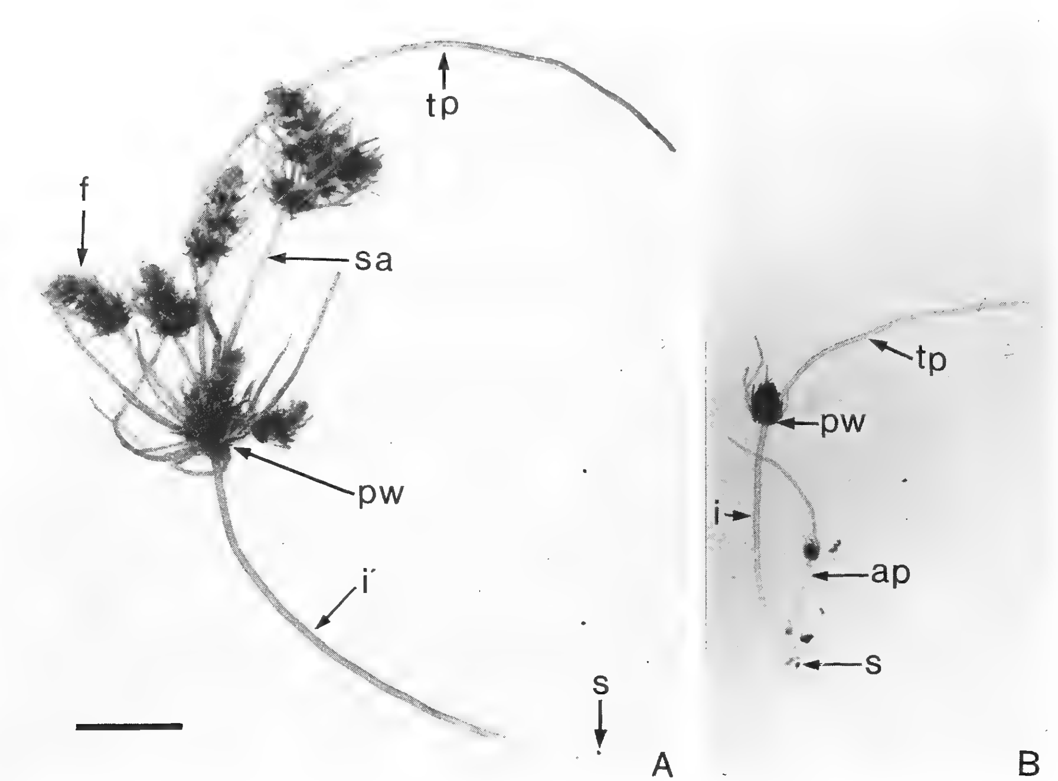

FIGURE 3. Mature (A) and immature (B) growth stages of *Tolypella glomerata*. A. Fruiting plant with mature oospores. 24 August 1993. B. Young protonema with an accessory protonema. 28 July 1992. Abbreviations: ap, accessory protonema; f, fertile head; i, protonematal internode; pw, protonematal whorl; s, germinated spore; sa, sexual axis, tp, terminal process. Scale bar = 10 mm.

growing seasons, the species does produce a large highly branched thallus, sheds its protonematal vestiges, and grows in dense stands fruiting profusely (personal observations from Crooked Lake, southern Saskatchewan). This high degree of adaptability to extremes is no doubt the reason for this species' cosmopolitan distribution.

Axes and branchlets of specimens with mature oogonia are moderately incrusted with a flocculent patchy crystalline type of incrustation. Diameters of both mature protonematal basal internodes and fertile axes of the sexual shoots measures up to 800 µm. Branchlets of the fertile whorls are commonly once divided in a monopodial fashion, only the lowest node producing three or four laterals (Figure 4). Laterals consist of two or three cells each and are conspicuously smaller than the main branchlet axis both in length and diameter. The main branchlet axis typically consists of four allantoid cells and tapers only slightly from the base to the tip, the end cell having a rounded tip and not being greatly smaller than the penultimate cell. Laterals as well as main branchlet axes often curve strongly inward to produce the compact heads characteristic of the species. Occassionally a branchlet lateral may itself be further divided monopodially like the main branchlet axis, but this condition is only rarely noted.

Gametangia occur only at the lowest branchlet node where laterals are produced or at the base of the branchlet where it joins the shoot axis. Typically gametangia are born laterally on short stalks, usually a single antheridium flanked by two oogonia, however, up to five oogonia in a cluster are not uncommon at the base of the laterals and at the base of a branchlet. At maturity antheridia are bright orange to reddish orange and have an average diameter of 403 µm (360–445 µm). Oogonia are colorless or pale orange at maturity, the egg cell being visibly engorged with starch grains. Average oogonial length including coronula is 602 µm (578–640 µm) and average maximum width (diameter) is 437 µm (413–465 µm). Coronula height averages 45 µm and coronulas often are deciduous as oospore membranes begin to color and thicken. Oogonia exhibit seven to ten spiral cell convolutions which sometimes swell near their tips.

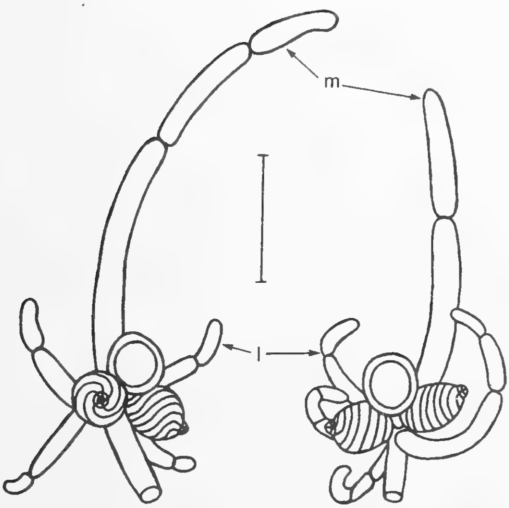

FIGURE 4. Two typical fertile branchlets exhibiting monopodial branching and each with a single antheridium flanked by two archegonia. Abbreviations: l, lateral branch; m, main branchlet axis. Scale bar = 1 mm.

Oospore length averages 390 μm (360–415 μm) and width, including ridges, 306 μm (290–330 μm). The number of ridges (striae) range from 6–8 and average maximum fossae width equals 79 μm (63–93 μm) in crushed and flattened membranes. Membranes of newly matured oospores are orange-brown whereas membranes of germinating oospres are darker dull brown in crushed and flattened material with transmitted light. Oospores which are intact appear dark brown to almost black with reflected light. Membranes are coarsely "granular" with transmitted light at 400X, the "granules" being arranged in linear rows as is well described and illustrated in Groves and Bullock-Webster (1920). In older germinating oospores the pattern becomes more linearly spongy in appearance. Curiously, Wood (1965) does not mention this coarse linear pattern from the material he examined, but describes the membrane as "minutely granulate or vermiferous, occasionally smooth" even though it appears to be a key characteristic of the species at the level of the light microscope. Frame (1977) has shown that the "granular" nature of the membrane as seen with the light microscope has been misinterpreted, the scanning electron microscope revealing a spongy or reticulate pattern. Nevertheless, his low power micrographs still reveal a linear pattern to the membrane decoration and this feature will continue to be useful as a rapid check with the light microscope.

Taxonomy and Distribution

The genus *Tolypella* is included with the genus *Nitella* in the tribe Nitelleae characterized by the presence of ten coronula cells and divided branchlets. *Tolypella* may be readily distinguished from the genus *Nitella* by its monopodial branching of the branchlets and by its terete oospores. *Tolypella* usually has antheridia located laterally at the branchlet divisions whereas in *Nitella* the antheridia are situated apically in the furcations. However, Sawa (1973) has described two new *Tolypella* species where the apical location of antheridia sometimes also occurs. The genus *Tolypella* is itself split into two sections, Acutifolia (Section Rothia in Wood 1965) and Obtusifolia (Section Tolypella in Wood 1965). Acutifolia species have branchlets ending in small, sharp-tipped conical cells while in Obtusifolia the end cells are larger and round-tipped. Acutifolia also has a single basal plate on the oospore while Obtusifolia has a basal plate of 2–3 segments (Sawa 1973). The present species *T. glomerata* belongs to Section Obtusifolia.

Tolypella glomerata has long been distinguished as a unique species by earlier European and North American scientists and a number of modern authors still adhere to this approach (Sawa 1974; Corillion 1975; Blindow and Krause 1989; Blazencic and Temniskova-Topalova 1991). Frame (1977) also supports this view showing that *T. glomerata's* oospore membrane decoration is unique and characteristic of the taxon separating it clearly from closely related forms. In his 1965 monograph, Wood combined *T. glomerata* as a variety of *T. nidifica* (O. Müll.) A. Br. (*T. nidifica* var. *glomerata* (Desv.) Wood) and Moore (1986) in Britain also follows this taxonomy. The nominate variety *nidifica* is restricted to Europe whereas the var. *glomerata* is widespread in the world (Wood 1965, p. 721 and p. 723) although Wood contradicts himself several times on this matter and indicates *T. nidifica* var. *nidifica* as also occurring in North America (Wood 1965, p. 726 and Wood 1967, p. 56). I am not aware of any var. *nidifica* from North America at present. Wood also merged the recognized North American taxa *T. longicoma* Braun and *T. comosa* T. F. Allen (T. F. Allen 1883; G. O. Allen 1954) with the var. *glomerata*. Allen (1954) notes that *T. glomerata* (as opposed to *T. comosa* and *T. longicoma*) is surprisingly rare in North America despite its cosmopolitan range through Europe, Asia, Africa and Australia, and that some of the North American material shows differences from the typical *T. glomerata*. The Newfoundland material morphologically exhibits the traditional species characteristics as described by European authors (Migula 1897; Groves and Bullock-Webster 1920; Corillion 1957, 1975). Morphological similarity does not necessarily denote conspecificity in widely separated populations as Proctor (1975, 1980) discusses; however, the possibility should not be discounted that the Newfoundland population may be of relatively recent transatlantic introduction or from a northern population which may have its origins in Europe via a North Atlantic route.

In North America, the *Tolypella nidifica* complex as defined by Wood (1965) extends in a broad belt across the northern and central United States entering Canada only in the prairies of southern Saskatchewan/Alberta and possibly in extreme southern Ontario, although I am not aware of any Ontario records. It is recorded in eastern North America only as far north as New York State. Figure 5 illustrates its American distribution as presented by Wood (1967), however, it is not possible from Wood's sources to distinguish *T. glomerata*, *T. longicoma*, and *T. comosa* in this distribution. The Newfoundland discovery extends the range of *T. glomerata* in excess of 1500 km to the northeast without any known intermediate populations. The Newfoundland collection (51° 26′ N) and the Saskatchewan record (Macoun 1879 *in* Wood 1965) are of approximately the same latitude and constitute the most northerly reports on this continent. Growing conditions are, however, quite different in these two locations, the Strait of Belle Isle site providing generally harsher conditions including a shorter, cooler growing season, less unimpeded direct sunlight, and poorer nutrient conditions.

The vascular floras of eastern North America and western Europe have a high proportion of related endemics, the "amphi-atlantic element". It appears that some migration of species has occurred in both

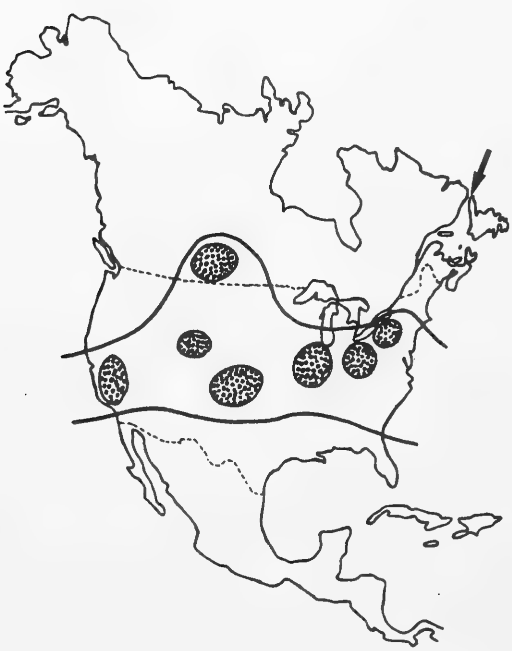

FIGURE 5. North American distribution of the *Tolypella nidifica* "complex" redrawn from Wood (1967). Arrow indicates Newfoundland location of *T. glomerata*.

directions with the predominant movement from Europe westward (Hulten 1958; Dahl 1963). In addition, many species have been introduced from Europe in historic times and are largely considered anthropophytes although direct evidence of alien invasion mechanisms and routes are only documented for a very few (Cooper 1981; Lindroth 1957). If many vascular plants have traversed the Atlantic in prehistoric and historic times, it should not be unexpected that easily dispersable propagules such as charophyte oospores could likewise occassionally cross the ocean barrier.

A number of vectors for transmission of organisms from Europe to Newfoundland have been well documented and others are very plausable based on evidence available. That waterfowl and shorebirds can and do disperse aquatic macrophytes over short and medium distances is well documented and universally accepted (Ridley 1930; Sculthorpe 1967). Their role in long distance dispersal across extensive oceanic stretches is a more contentious issue. However, it has been demonstrated by argument, observation, and by experimental means that such long distance dispersal is possible and highly likely (Proctor 1968; Vlaming and Proctor 1968; Carlquist 1974). Charophyte oospores are extremely hardy and resistant to mechanical and enzymatic digestion, can remain viable for many years, and are known to be ingested and transported by shorebirds and waterfowl (Proctor 1962, 1967, 1980). Confirmed sightings of European species of waterfowl and shorebirds as vagrants are not uncommon in Newfoundland (Montevecchi and Tuck 1987; Desbrosse and Etcheberry 1986), sometimes appearing in considerable numbers such as the 1988 spring arrival of hundreds (perhaps thousands) of Greater Golden Plovers on the Island (Burrows 1988). Both direct flights across the Atlantic on weather fronts or in shorter steps via Iceland and Greenland certainly occur with such a frequency that over time this form of transport must undoubtedly have had some significance in long distance dispersal of charophytes.

The Strait of Belle Isle has seen considerable human activity bridging the gap between the continents at least since the beginning of this millenium. The only known Viking settlement in North America dating to about 1000 AD occurs here at L'Anse aux Meadows which historically included the transport of livestock, feeds, soils, and propagules (Ingstad 1985). Basque whaling stations are also known from sites such as Red Bay dating to the early sixteenth century (Tuck and Grenier 1989) and a thriving cod fishery until modern times provided a brisk commercial link with many coastal European nations. The dumping of ballast and other such practices are implicated in the transfer of certain segments of both our flora and fauna (Lindroth 1957).

Even though one recent view suggests that our present northern species are migrants from southern areas in the Americas probably in post-glacial times (Khan and Sarma 1984), it still appears highly likely that at least some of our Newfoundland and Labrador charophytes may have arrived more recently by means discussed above. Langangen (1993) also alludes to the possibility of North Atlantic dispersal when discussing the amphi-atlantic distribution of *Tolypella canadensis* Sawa. Breeding studies such as demonstrated by Proctor (1975) and Croy (1982) could provide evidence for or against such occurrences not only for *T. glomerata*, but other northern species as well. Also, reported chromosomal variation within the *T. glomerata* "species complex" (Sawa 1974; Bhatnagar and Jori 1986; Bhatnagar 1987) suggest that comparative cytological and biochemical studies may be fruitful in this regard. Adding to the potential for further studies with *T. glomerata* are Frame's (1977) observations of a recognizable difference in oospore membrane decoration between European and North American populations and further variations among the North American populations.

Acknowledgments

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The History of Invasion and Current Status of Glossy Buckthorn, *Rhamnus frangula*, in Southern Ontario

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In southern Ontario Glossy Buckthorn, *Rhamnus frangula*, became established in three urban centres, London, Ottawa and Guelph, at the turn of the century. By 1930, it had still only been found in these three urban centres, and by 1950 it had not extended beyond 40 km from any of them. By 1970, it had spread to sites up to 150 km distant but still appeared to have a sparse and largely urban distribution in the southern part of the province. Currently *Rhamnus frangula* occurs throughout much of southern Ontario and is locally common. In some sites it comprises more than 90% of the green biomass over areas of several acres and it has become a major component of regionally and provincially significant plant communities. Berries of *Rhamnus frangula* are eaten by American Robins, Bohemian Waxwings, Cedar Waxwings, Rose-breasted Grosbeaks and Starlings. The shrub probably has a number of different avian and mammalian dispersal agents. Over the next 10-20 years, it is expected that *R. frangula* will become abundant and dominant in open and semi-open wetlands over most of the southern part of the province. While small scale management technology is available, the problem is one that requires a consideration of management on a large scale.

Key Words: *Rhamnus frangula*, Glossy Buckthorn, alien, weed, distribution, dispersal, ecology, invasion, Ontario.

Glossy Buckthorn, *Rhamnus frangula* L. is one of three species of Buckthorns occurring without cultivation in eastern Canada. The group is characterized by leaves with veins converging toward the tips and fruits that are fleshy and black when ripe (e.g., Soper and Heimburger 1982). The native Alder-leaved Buckthorn, *Rhamnus alnifolia* L'Hér and the introduced Common Buckthorn, *Rhamnus cathartica* L., both have serrated leaves, the former being a thornless shrub less than 1 m high, the latter, a large shrub or small tree to 6 m high with some branches ending in a sharp thorn. The Glossy Buckthorn is a shrub or small tree to 6 m tall, like Common Buckthorn, and is also introduced from Europe. It differs in having smooth-margined, mostly alternate leaves and in lacking thorns. In winter, it can be distinguished by its greyish, and pubescent twigs, alternate buds, and ascending branches. While the berries of Common Buckthorn are retained on the shrub until the following spring (unless eaten), those of Glossy Buckthorn have mostly fallen by early November.

Several authors have alluded to invasion and replacement of natural communities by Glossy Buckthorn (e.g., Voss 1985; Taft and Solecki 1990) and it is evidently a rapidly increasing problem in southern Ontario (e.g., Dugal 1990, 1992; White et al. 1993). Native to Europe, it was recently rated as one of the six principal invasive aliens of wetlands in Canada, and one of the four principal invasive aliens of Canadian uplands (White et al. 1993). In a national survey it was rated as second (to Purple Loosestrife, *Lythrum salicaria*) in both the extent to which it is spreading in natural habitats and its severity of impact (White et al. 1993). In addition to the threat it poses to natural plant communities, *R. frangula* is an alternative host to crown rust fungi which attack oats (e.g., Ginns 1986). Here we present information relating to the history of its invasion and current status in southern Ontario.

Methods

The identifications of herbarium material of *Rhamnus frangula* from southern Ontario herbaria (including DAO, CAN, OAC, QK, TRT, TRTE and WAT, acronyms from Holmgren et al. 1990) were verified. Collection dates and locations of confirmed specimens were recorded in dBase IV database files (1992. Ashton-Tate, Scotts Valley, California) which were later interfaced with Quikmap version 2.51 mapping software (1990. ESL Environmental Sciences Ltd., Sidney, British Columbia) so as to produce maps of collections up to various dates. Habitats were surveyed in the Ottawa area to obtain a subjective impression of abundance and threat to native vegetation. In addition the recent literature relating to *R. frangula* was reviewed.

Early Establishment

The earliest collections in Ontario were from the period around the turn of the century. It was collected at London in 1898 by J. Dearness, at Ottawa in 1899 by J. Macoun and at Guelph in 1906 by W. Scott. It was "well naturalized" in London, Ontario in 1898 (Macoun 1898). Although it is sometimes cultivated (Bailey 1949), it appears that all of these early collections were from non-cultivated plants. We base this assumption on the fact that there is no reference to cultivation on specimen labels. By 1930 Glossy Buckthorn was still known from only these localities (Figure 1A). By 1950, 50 years after initial establishment, it was still associated with these three urban areas (Figure 1B).

The early association with urban areas is not surprising for an introduced species, but what is a little surprising for a plant that aggressively invades natural habitats is the fact that it remained associated with these urban areas for so long. Even now it is primarily a dominant plant in natural communities near urban areas, although its rate of moving out into natural and agricultural landscapes has increased.

One might argue that the few early botanists restricted themselves to collecting in urban areas and that is why the plant appears to have been confined for so long to the three above mentioned centres. This notion is readily dispelled by examining a map of the distribution of the related native species

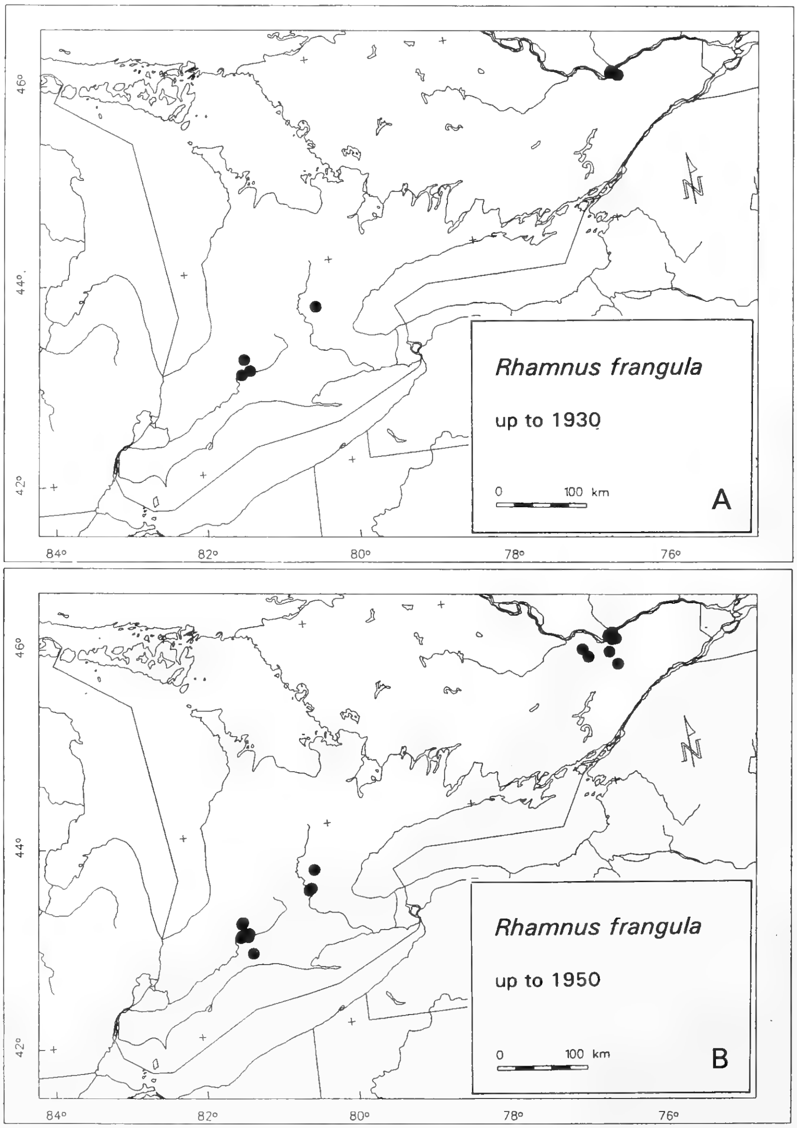

FIGURE 1. Collections of *Rhamnus frangula* in southern Ontario based on herbarium specimens examined (see methods). A, up to 1930. B, up to 1950.

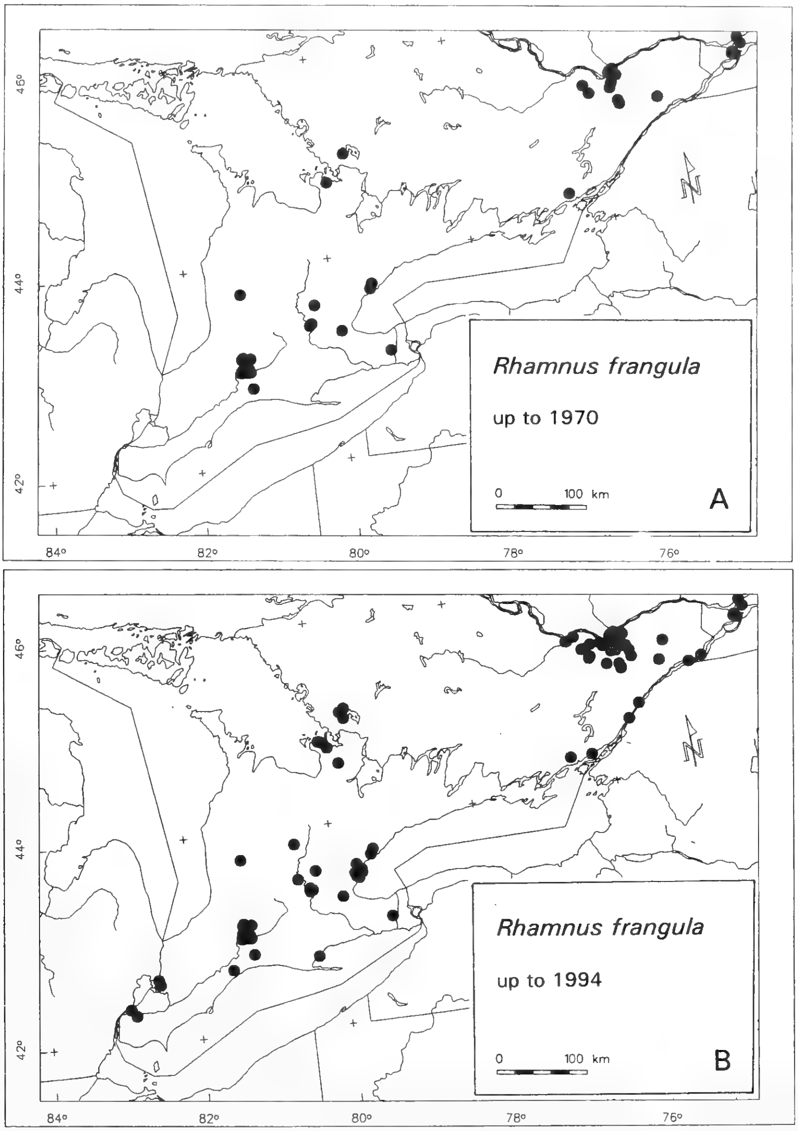

FIGURE 2. Collections of *Rhamnus frangula* in southern Ontario based on herbarium specimens examined (see methods). A, up to 1970. B, up to 1994.

Rhamnus alnifolia by 1930 (Figure 3). The edaphic tolerance of *R. frangula* appears to overlap completely with that of *R. alnifolia*, so that a habitat difference cannot be advanced as an explanation for the different distributions of these two species. By 1930, the much shorter and less conspicuous *R. alnifolia* had been collected over a broad area of southern Ontario and was not associated with urban centres, suggesting the extensive collecting of the early botanists. Thus the early confinement of *R. frangula* to the urban centres is not an artefact of collecting locations, but is an accurate picture of the first stages of its invasion.

Spread from urban centres

By 1950, *R. frangula* appears to have spread up to 40 km from initial sites of establishment in Ottawa and 20 to 30 km from initial sites of establishment in London and Guelph (Figure 1B). By 1970, it had spread to sites up to 150 km distant from the three urban centres but still appeared to have a sparse distribution in the southern part of the province (Figure 2A). In 1982, Soper and Heimburger noted that it was rather local and chiefly near cities in southern Ontario. Their 1982 map is basically the same as the "up to 1970" map (Figure 2A).

Present Distribution and Status

Currently *Rhamnus frangula* occurs throughout much of southern Ontario and is very common in some regions of the province (Figure 2B). It has clearly "escaped" major urban centres, where its early dominance in urban natural areas acted as an advance warning. Not only are more locations shown than on the 1970 map, but new regions of southern Ontario have been colonized including the St. Lawrence River region of eastern Ontario and the Lake St. Clair region of extreme southwestern Ontario. The map suggests that *R. frangula* is absent from most of the Canadian Shield region and from the Bruce Peninsula and Manitoulin Island. Its absence from the latter area is supported by the comprehensive survey of Morton and Venn (1984).

Dispersal

Howell and Blackwell (1977) implicated the introduced European Starling (*Sturnus vulgaris*) with the spread of *Rhamnus frangula* in Ohio. The basis for this was largely Ridley's (1930) report of starlings dispersing the fruit and on the fact that the starling and Glossy Buckthorn invaded Ohio at about the same time. Although Glossy Buckthorn was established at three widely separate locations in Ontario prior to 1900, starlings were not observed in the province until 1914 (Snyder 1951). They had been seen at a number of places in southern Ontario by 1920, but were not reported as breeding in Ontario until 1922 (Bowman 1987). By 1935, they were abundant in southern Ontario (Snyder 1951). Since field-naturalists with an interest in compiling regional lists of birds were numerous in the province at the time, it seems very unlikely that starlings arrived much earlier than the first report in 1914, i.e., after *R. frangula*.

With respect to Ridley's (1930) report, it was based on observations in Sweden, and while it is likely that starlings have played a role in the spread of *R. frangula* in Ontario and generally in North America, there is little evidence. Lindsey (1939) reported that the related alien, *Rhamnus cathartica* formed 8.3% of the food of starlings in New York State in November. Cramp (1988) reported Bohemian Waxwings (*Bombycilla garrulus*) feeding on *R. frangula* in Europe. In Huntley Township near Ottawa, American Robins (*Turdus migratorius*), Bohemian Waxwings, and Cedar Waxwings (*Bombycilla cedrorum*) have been observed eating the fruit of Glossy Buckthorn (S. J. Darbyshire and M. Runtz, personal communication). In Ottawa, American Robins, Rose-breasted Grosbeaks (*Pheucticus ludovicianus*) and starlings have been observed feeding on berries (M. Goselin, personal communication). It seems most likely that in North America, *R. frangula* has a number of different avian and mammalian dispersal agents.

Ridley (1930) noted that the fresh fruits of *R. frangula* were reported to be able to float for about three weeks and the dry seed floated for one week, but he noted that it was of little importance because *R. frangula* does not grow near water. Quite to the contrary in Ontario, *R. frangula* grows in and near water and in many situations where it is periodically flooded. However, ripe berries that we placed in

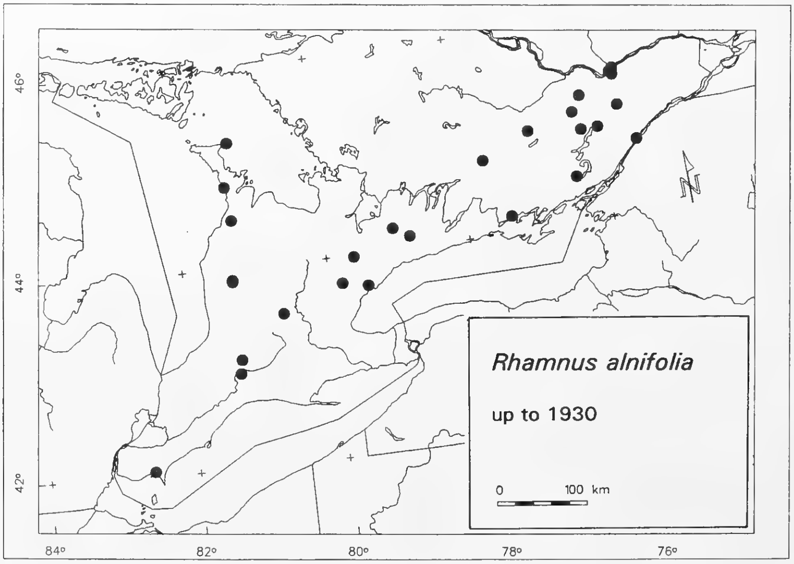

FIGURE 3. Collections of *Rhamnus alnifolia* in southern Ontario up to 1930 based on herbarium specimens examined (see methods).

water sank immediately. Since they do not dry out on the shrub over winter as in Common Buckthorn, they cannot take advantage of spring flooding. Thus, there seems to be little reason to attach much significance to dispersal by water.

Future Prospects

Based on climatic zones (Brown et al. 1980) currently occupied by Glossy Buckthorn in Ontario and observed range of habitats in the province, it may be expected to spread into the Bruce Peninsula, along the Lake Huron shore and Georgian Bay shorelines and probably to Manitoulin Island and much of the Canadian Shield. It is also expected to become abundant and dominant in open and semi-open wetlands over most of the southern part of the province.

Although *R. frangula* is a source of medicinal drugs and possibly a useful source of nectar for honey production (Risnes 1980), the problems facing natural communities as a result of its abundance seem to far outweigh the benefits. In the Ottawa area, it has become a dominant plant in moist to mesic organic soils of acid, neutral or alkaline reaction. It occurs also on sand, clay, limestone rock and pure peat (e.g., Dugal 1989). Habitats range from fields to dense woodlands but light is nevertheless a limiting factor and in dense woodland the shrubs, or small trees up to 10 cm dbh, are only dominant along the more open edges. Wetland habitats are characteristic and include open and treed fen, sedge marsh, swamps of Red Maple, ash, cedar, alder, etc., as well as shorelines. Its invasion should be of as much concern as that of Purple Loosestrife, *Lythrum salicaria*, since it appears to have a much broader habitat range than the latter species and appears to be much less dependent on human disturbance to establish and become dominant. Furthermore, it has the capacity to invade certain low nutrient wetland habitats such as fens and shores where rare and endangered native species are frequently concentrated. In the Ottawa area, it has invaded, then dominated and replaced native vegetation, especially in sedge marshes, fens, maple swamps and mesic woodland edges (Dugal 1992, personal observation). In many places, it represents more than 90% of the green biomass over areas of several acres. In some places, it has become a major component of regionally and provincially significant plant communities such as the Leitrim fen near Ottawa (e.g., Dugal 1990, 1992), the Sifton Bog near London (D. Sutherland, personal communication), and old growth pine stands in the lower Ottawa valley. *Rhamnus frangula* may have a devastating effect on many southern Ontario bogs and fens which are already a high conservation priority (e.g., Riley 1989).

A number of articles have been published on spatially limited methods of control of *R. frangula* (*e.g.*, Heidorn 1991; Post et al. 1989) and these methods will continue to be useful, but more extensive management plans may be appropriate. With the problem being in natural communities, *R. frangula* appears to be an ideal candidate for biocontrol. Some investigation has already been done on the potential for biocontrol of the related alien, *Rhamnus cathartica*, in Canada (Maw 1981; Malicky et al. 1970). Although both species are a menace to natural communities, *R. frangula* is generally considered to be a more serious problem now (e.g. White *et al.* 1993), even though it is apparently still less widespread in Ontario than *R. cathartica* (*cf.* Soper and Heimburger 1982). To some extent this could be a consequence of the recent preoccupation of environmentalists with wetlands, but regardless, both *R. frangula* and *R. cathartica* have become very serious problems which are rapidly increasing in magnitude.

If the alien domination of the natural areas of major urban centres is indicative of what can occur within extensive natural landscapes, as seems to be the case with Glossy Buckthorn, then domination by alien vegetation certainly appears likely to be a major threat to Canadian biodiversity.

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Use of a Tidal Saltmarsh and Coastal Impoundments by Sympatric Breeding and Staging American Black Ducks, *Anas rubripes,* and Mallards, *A. platyrhynchos*

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During spring, summer and fall 1988 and 1989, we documented the diurnal use of five coastal impoundments and one large tidal saltmarsh by sympatric American Black Ducks, *Anas rubripes,* and Mallards, *A. platyrhynchos,* along the lower St. Lawrence Estuary in Québec. The mean Black Duck density was higher than that of Mallards in both habitat types during all seasons. The Mallard - Black Duck ratio was highest in impoundments in the spring. Black Ducks made a greater use of the saltmarsh than impoundments in all seasons except the fall, but hunting pressure affected their use of both habitat types. Few differences in proportion of time spent feeding were observed between the two species except in the fall when Black Ducks spent less time feeding in the saltmarsh, particularly after the hunting season opened. We recommend increased efforts to restore the carrying capacity of tidal saltmarshes along the lower St. Lawrence estuary, particularly those affected by agriculture.

Key Words: American Black Duck, *Anas rubripes*, Mallard, *Anas platyrhynchos*, tidal saltmarsh, coastal impoundments, breeding, staging, St. Lawrence River, Québec.

The American Black Duck, *Anas rubripes*, (here after called the Black Duck) occurs exclusively in eastern North America. The continental breeding population has declined drastically during the last four decades, particularly in southern Québec (the St. Lawrence Valley) and Ontario (the Great Lakes region) (Grandy 1983; Feierabend 1984; Rogers and Patterson 1984). This decline has led to its designation as a species of priority concern under the North American Waterfowl Management Plan.

Increased sympatry in their distribution and interspecific competition with the Mallard *A. platyrhynchos*, has been mentioned as possible causes for the decline in Black Ducks (Rogers and Patterson 1984; Ankney et al. 1987). These species are now considered as two color morphs derived from the same Mallard-like ancestor (Ankney et al. 1986, 1987). Introgressive hybridization and competitive exclusion of the Black Duck by the Mallard have been assessed as causes of the decline during recent years (Ankney et al. 1987; Conroy et al. 1989; Seymour 1990, 1992). Although they could not conclude with certainty that their data reflect cause and effect, Merendino et al. (1993) observed that Mallards have greatly contributed to the recent decline of Black Ducks in southern Ontario via competitive exclusion from the most fertile wetlands.

The Mallard is a highly adaptable duck species and is considered a generalist at several habitat scales. In addition to deforestation (landscape change to agro-ecosystems) and releases of game-farm birds in the eastern United States (Heusmann 1987), it has been suggested that man-made wetlands might also have facilitated the recent eastward spread of Mallards into Black Duck range (Heusmann 1987; Longcore et al. 1987). It is also believed that these newly created habitats have not benefited breeding Black Ducks as much as Mallards (Rusch et al. 1989: 383). For instance, Longcore et al. (1987) found that small impoundments created in the 1960s in historical Black Duck breeding range in Maine were more productive for Mallards than for Black Ducks.

Overall benefits of coastal impoundments for wintering Black Ducks have been assessed during recent years (Conroy et al. 1987; Morton et al. 1989a, 1989b; Parker 1990) but to our knowledge, no study has compared the use of managed and unmanaged coastal wetlands by competing Black Ducks and Mallards, particularly at northern latitudes (Canada), on shared breeding and staging grounds. Our objective was to compare the differential use of five coastal impoundments and one adjacent large tidal saltmarsh by sympatric breeding and staging Black Ducks and Mallards in a long-time Black Duck stronghold in Québec, the lower St. Lawrence Estuary (*see* Reed and Moisan 1971; Reed 1975). More specifically, we compared their density and feeding activities between habitat types during the spring, summer and fall. We also looked for changes in habitat use by Black Ducks before and after the hunting season opened in the fall.

Study Area and Methods

Our study was conducted at Isle Verte, about 250 km east of Québec city along the south shore of the lower St. Lawrence Estuary (Figure 1). A detailed description of the study area is found in Reed and Moisan (1971). Seven contiguous areas from 26 to 191 ha (individual boundaries were defined by landscape features) of a large continuous coastal saltmarsh (about 2500 ha in area and >10 km long) and five artificial non tidal impoundments (4 to 53 ha), located <0.5 km from the saltmarsh, were censused. Altogether 646 ha were sampled in the saltmarsh and 154 ha in the impoundments.

Four impoundments were brackish and one was freshwater. The former were created in the mid-1970s following the establishment of a deep-water harbour near Cacouna. Several dikes or seawalls made of soil and rock were built at the mouth of the bay creating four shallow (<1 m depth) ponds with brackish water (7.0 ppm to 14.5 ppm) (Figure 1). The vegetation there is dominated by the Common Widgeongrass, *Ruppia maritima*; Saltmeadow Cordgrass, *Spartina patens*; Mackenzie Sedge, *Carex mackensie*; Maritime Bulrush, *Scirpus maritimus*; Baltic Rush, *Juncus balticus*; and Broad-leaved Cattail, *Typha latifolia*. The 20-ha rectangular freshwater pond was created in 1987 by Ducks Unlimited Canada on fallow agricultural land located at the upland-wetland interface (Figure 1). A dike was erected with excavated soil to make a 3-m wide and approximately 1-m deep channel surrounding the pond. In 1988, water was raised to a depth of about 1 m by ditching a small adjacent freshwater rivulet. At the time of our study, the vegetative cover was very sparse and mostly dominated by flooded plants of moist habitats such as Sweetgale, *Myrica gale*; Speckled Alder, *Alnus rugosa*; Bluejoint, *Calamagrostis canadensis*; and Redtop, *Agrostis alba*.

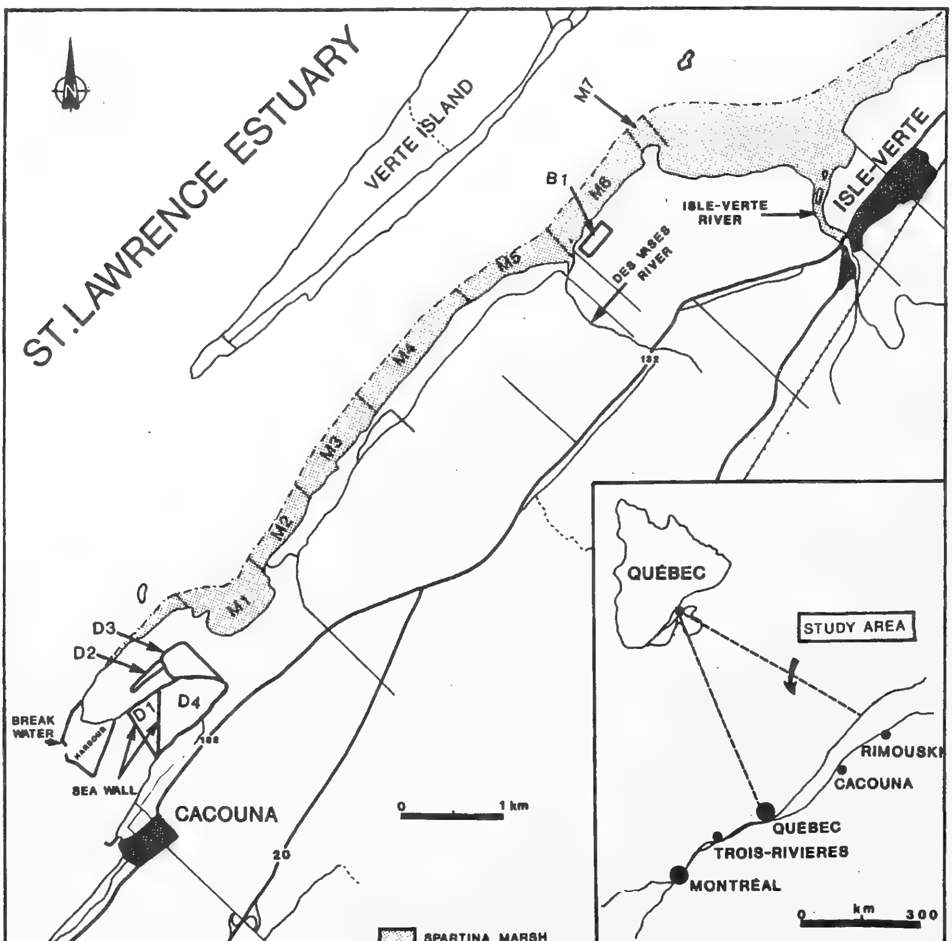

FIGURE 1. Location of the study area along the lower St. Lawrence Estuary in Québec. M1 to M7 (saltmarsh section), D1 to D4 (brackish pond), B1 (freshwater pond).

The coastal saltmarsh is subject to a semi-diurnal tide with two oscillations/day, 3 to 4 m in amplitude. Dominant plant species are Tall Cordgrass, *Spartina pectinata*; Scaly Sedge, *Carex paleacea*; Salt-meadow Cordgrass, Seaside Plantain, *Plantago jucoides*; Hastate Atriplex, *Atriplex hastata*; Glasswort, *Salicornia europea*; and Smooth Cordgrass, *Spartina pectinata*. Human disturbance is minimal at all study sites. However, during the fall, hunting activities are allowed from mid-September to the end of December in all areas with the exception of the freshwater pond.

We used the scan-sampling technique (Altmann 1974) to estimate the density of birds of each species and to document their feeding activities. In 1988, birds were censused from various vantage points on shore from 12 April to 19 May and again, from 20 August to 23 September. Each week, two bird counts/site were made at sites M1 to M7 and D1 to D4 (Figure 1). To determine the number of broods present in each habitat, we also conducted a helicopter survey on 15 June. Altogether in 1988, 22 counts were made per site. In 1989, censuses were conducted from 19 April to 16 May, from 6 June to 5 July, and from 23 August to 28 September. One day/week was randomly chosen within these periods and 12 counts/site were done exclusively at sites M7 and B1 (Figure 1). We conducted three surveys/day requiring 2 hr in the morning beginning 1/2 hr before sunset, 2 hr during mid-day; e.g., from 11:00 to 13:00, and 2 hr during evening ending 1/2 hr after sunrise. Within each period, a scan was done at 30-min intervals for a total of 12 counts/day. Therefore, we conducted 168 counts/site in 1989. We also recorded the behavior of birds during each scan, distinguishing only between feeding and non-feeding activities. Non-feeding ones included behaviors such as preening, resting, swimming and walking. Noctural use of impoundments and the saltmarsh was not addressed in this study.

Data analysis was performed using the SAS program. Data for 1988 and 1989 were pooled (*see* Discussion). We computed a Mallard - Black Duck ratio or relative index expressed as the number of Mallards/total number of Mallards and Black Ducks/100 ha. Because of the non-normal distribution of our data, Wilcoxon and Kruskal - Wallis tests were used to compare bird use and feeding activities between wetland habitats. The acceptable level of statistical significance was established at $P \leq 0.05$ through the analysis and means are presented ± SE.

Results

Black Duck and Mallard habitat use

The density of Black Ducks was significantly higher than that of Mallards in all habitats and seasons (Table 1). Black Duck density in spring was highest in the saltmarsh whereas density in impoundments was greatest during the fall. Mallards made a greater use of both the saltmarsh and the impoundments in the spring compared to other seasons. During spring, the density of Mallards was almost four times higher in impoundments than in the saltmarsh (Table 1). We observed no significant differences during other seasons.

Black Ducks made a greater use of the saltmarsh than impoundments in all seasons except the fall. The Mallard-Black Duck ratio (*see* Methods) was significantly higher during spring in impoundments than in the saltmarsh (Figure 2). This difference was not significant during summer and fall (Figure 2). Black Duck brood density was greater in impoundments ($\bar{x}$=0.14/ha) compared to the saltmarsh ($\bar{x}$=0.04/ha) ($P<0.05$). Only four broods of Mallards were observed during our study; all were using the impoundments.

There was no difference in Black Duck use of all habitats before hunting season but differences did appear after hunting began (Table 2). The mean density of Black Ducks was significantly greater in the freshwater impoundment (non-hunting area) compared to the saltmarsh and brackish impoundments (hunting areas). Black Duck use of hunting areas was greater before than after the opening of hunting season (Table 2).

TABLE 1. Densities (number of birds/100 ha) and feeding activities (% of feeding birds per scan) of Black Ducks and Mallards within a tidal saltmarsh and five coastal impoundments, Isle Verte, lower St. Lawrence Estuary, Québec, 1988-1989.

Season	Species	Bird Density			Feeding Activity		
		Saltmarsh		Impoundment	Saltmarsh		Impoundment
Spring	Black Duck	115.1 ± 23.2	***	45.3 ± 7.7	39.0 ± 3.6	NS	39.9 ± 4.1
	Mallard	3.1 ± 1.2	*	11.0 ± 3.2	40.0 ± 10.7	NS	62.1 ± 9.9
		***		***	NS		**
Summer	Black Duck	57.0 ± 7.7	***	13.9 ± 2.2	29.5 ± 5.3	NS	34.8 ± 7.4
	Mallard	1.1 ± 0.4	NS	1.2 ± 1.0	33.3 ± 21.8	–	–
		***		**	NS		–
Fall	Black Duck	73.8 ± 19.2	NS	154.9 ± 23.4	13.9 ± 2.0	*	21.1 ± 3.2
	Mallard	1.0 ± 0.4	NS	2.7 ± 0.7	62.5 ± 18.3	**	1.7 ± 1.6
		***		***	*		**

NS= $P>0.05$, * = $P\leq0.05$, ** = $P\leq0.01$, *** = $P\leq0.001$.

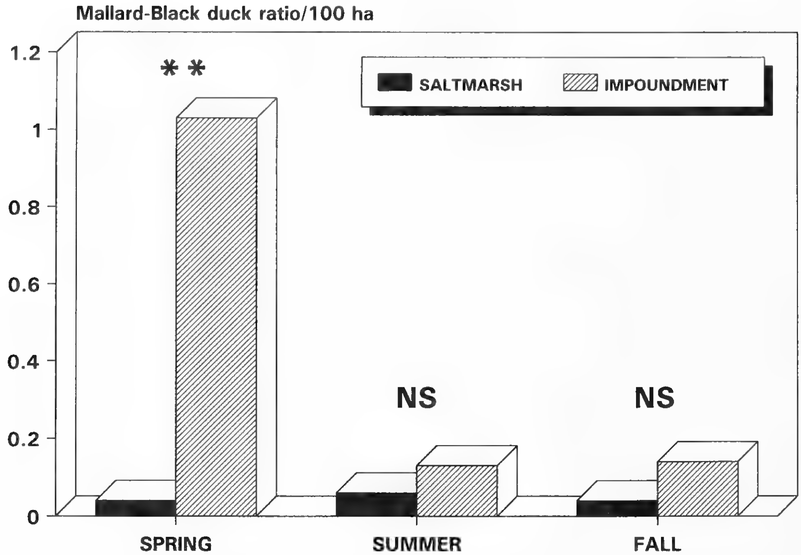

FIGURE 2. Mallard-Black Duck ratio (see text) in the saltmarsh and the impoundments along the lower St. Lawrence Estuary, Québec. NS= P>0.05, ** = P≤0.01.

Feeding activity of Black Ducks and Mallards

Few differences were observed between Black Ducks and Mallards in time spent feeding except in the fall (Table 1). Black Ducks spent more time feeding in the saltmarsh in the spring than during summer and fall (Table 1). No seasonal difference was observed for the Mallard in the saltmarsh. Mallards spent more time feeding in the spring within impoundments than during other seasons whereas proportionally fewer Black Ducks were seen there feeding in the fall compared to other seasons (Table 1). However, during fall and unlike Mallards, Black Ducks spent more time feeding there than in the saltmarsh (Table 1).

Black Ducks spent more time feeding in the saltmarsh before than after the opening of the hunting season whereas no such relation was observed for impoundments, no matter whether hunting was prohibited or not (Table 2). We observed differences in feeding time between habitat types both before and after the hunting season opened. In both cases, Black Ducks spent more time feeding within impoundments, particularly within the brackish ponds (hunting areas) (Table 2).

Discussion

In this study, we pooled bird data from two years assuming that there was no difference in use of habi-

TABLE 2. Black Duck use (number of birds/100 ha) and feeding activities (% of feeding birds per scan) in a tidal saltmarsh (hunting area) and five coastal impoundments (hunting and non-hunting areas) along the lower St.Lawrence Estuary in fall of 1988 and 1989, before and after opening of the duck hunting season.

Hunting	Saltmarsh	Impoundment		*P*
		Non-hunting	Hunting	
Bird Density				
Before	92.5 + 31.8	237.4 + 51.5	101.1 + 23.8	NS
After	49.0 + 14.3	138.5 + 28.9	4.7 + 2.9	****
P	****	NS	***	
Feeding Activity				
Before	18.5 + 3.5	20.5 + 3.2	59.0 + 8.7	****
After	0.0 + 0.0	22.7 + 8.0	25.7 + 14.3	**
P	****	NS	NS	

NS= P>0.05, * = P≤0.05, ** = P≤0.01, *** = P≤0.001, **** = P≤0.0001.

tat types between years based on our observation that bird density in the saltmarsh was not different between 1988 and 1989 (P>0.05). Although birds were easier to detect in impoundments with large open water areas than in the saltmarsh with its small tidal pools, we also believe that this has not influenced our result.

Staging and breeding Black Duck use of coastal impoundments

Results of our study indicated that staging and breeding Black Ducks made greater use (spring and summer) or at least, comparable use (fall) of the saltmarsh and the impoundments. We attribute this result to the high biological productivity of saltmarshes (*see* Chabreck 1988: 22) making them good feeding sites for ducks, and to the fact that hunting pressure did not influence bird distribution among habitats during our study until mid-fall (see above). Coastal impoundments were, therefore, not used as refuge sites in our study in contrast to those censused by Conroy et al. (1987) and Morton et al. (1989a, 1989b). Comparative studies of the use of tidal saltmarshes and coastal impoundments have been conducted recently during other periods of the annual life cycle of the Black Duck (late fall, winter and early spring; Conroy et al. 1987; Morton et al. 1989a, 1989b; Parker 1990). Their results indicated (1) that impoundments are often the most important habitat for Black Ducks; but (2) that their true benefits to birds could only be achieved in the presence of adequate amounts of tidal saltmarshes. For instance, Morton et al. (1989a, 1989b) found that wintering Black Ducks in coastal Virginia used both saltmarshes and impoundments more than they were available in the surrounding landscape in their study area but intra-seasonal as well as daily differences emerged. Human disturbance, hunting pressure, and the presence of ice-free waters helped to explain these differences. Parker (1990) reported that impoundments were intensively used by post-fledging Black Ducks in coastal Maine and New Brunswick.

Our data also revealed that Black Ducks spent most of their time engaged in non-feeding activities within impoundments. Conroy et al. (1987) also observed in New Jersey that the principal behavior of wintering Black Ducks in impoundments was loafing. Morton et al. (1989b) reported that although Black Ducks fed in coastal impoundments during winter in Maryland, they spent proportionally more time there resting than feeding; however, the proportion of their feeding time was similar in the saltmarsh (38.5%) and the impoundments (31.8%). In our study, we observed that the allocation of daylight time to feeding by Black Ducks did not differ between habitat types except in fall when birds spent more time feeding within impoundments than in the saltmarsh. Landers et al. (1976) showed that non-tidal coastal impoundments are generally very good feeding sites for ducks because of the abundance of foods that can be found there. Because of the tidal exportation process of plant materials during equinox in mid-September, foods are probably becoming less abundant in the saltmarsh at that time. This could explain why Black Ducks spent less time feeding there in late fall than in non-tidal impoundments.

Effect of hunting on habitat use and bird feeding activity

During the fall period, we observed no difference in Black Duck use of all study sites before the hunting season, but after it opened, they made greater use of impoundments, particularly the freshwater pond where hunting was prohibited. Conroy et al. (1987) observed an increase in Black Duck use of impoundments (non-hunting areas) and a corresponding decrease in the use of the New Jersey's saltmarshes (hunting areas) during the hunting season. In the latter period, birds fed mostly during non-hunting periods of the day; e.g., at night (Conroy et al. 1987) in saltmarshes. In our study, we attribute the differential late-fall habitat-use; i.e., after hunting opened, to both more abundant food resources within impoundments (see above) and to hunting pressure within the saltmarsh. We observed that Black Ducks spent more time feeding in impoundments after the opening of the hunting season whereas they did not seem to feed at all during the day in the saltmarsh. However, in reaction to hunting pressure, the birds possibly could have been feeding in the saltmarsh at night as reported by Morton et al. (1989a) and Parker (1990) elsewhere.

Role of coastal impoundments in the Black Duck-Mallard competition

Our data showed that the Mallard-Black Duck ratio (*see* Methods) was highest in the impoundments in spring. This result derived from a greater use of this habitat by Mallards rather than by solely a decrease in Black Duck use. Gordon et al. (1987) also observed that Mallards exhibited a strong preference for managed saltmarsh-bulrush marshes compared to unmanaged ones along the South Carolina coast on their wintering grounds.

However, what could be the ecological implications of the use of newly created impoundments by breeding Mallards in an area which has been a Black Duck stronghold in Québec (*see* Reed and Moisan 1971) until very recently? Ankney et al. (1987) concluded that Mallards have increased in abundance relative to Black Ducks in farmed and urbanized parts of Black Duck range. Competitive exclusion of Black Ducks by Mallards on shared breeding grounds was suggested by these authors as a cause for the long-term declines of the continental Black Duck population (for a criticism of this hypothesis, *see* Conroy et al. 1989). Seymour (1992) provided some evidence of such interspecific competitive exclusion of Black Ducks by Mallards in Nova Scotia. Recently, Merendino et al. (1993) showed that Mallards, through introgressive hybridization and competitive exclusion of Black Ducks from highly fertile wetlands, were the proximate cause of the decline of the Black Duck in southern Ontario.

Pairing by Black Ducks and Mallards normally occurs from September to March; i.e., during winter. Although many hybrid pairs form during this period (*see* Brodsky and Weatherhead 1984), the study by Ankney et al. (1987) indicated that interspecific pairing can also occur on the breeding grounds and may be an important source of hybridization between these species. Brodsky and Weatherhead (1984) and Brodsky et al. (1988) who compared mate choice and pair formation in these species both in the wild and with pen experiments, found that male Mallards were more attractive than male Black Ducks when courting female Black Ducks. Sharing breeding sites with Mallards may thus be detrimental to Black Ducks because of the male Mallard hostility and sexually motivated behaviors (e.g., intermorph forced copulation) as reported by Seymour (1990). It is believed that such behaviors could ultimately diminish the willingness of Black Duck females to use preferred breeding sites. Competition for mates by males could particularly affect renesting Black Duck females (Seymour 1990, 1992). Therefore, this may have a significant impact on reproductive fitness of Black Ducks and on overall population recruitment in a given area. Whitman and Cole (1987) reported a shift from the Black Duck as the dominant nesting species to the newcoming Mallard at several impoundments in Delaware. Longcore et al. (1987) reported that mallard broods occurred mostly on man-made impoundments in Maine. Coastal saltmarsh habitat that has been converted to residential lagoon was nearly devoid of nesting Black Ducks but populated with breeding Mallards in New Jersey (Figley and Van Druff 1982 *in* Longcore et al. 1987). Our study has shown that staging and breeding Black Duck densities were greatest in the saltmarsh whereas Mallard densities were greater in impoundments; for instance, Mallard broods were observed exclusively within impoundments. In the light of studies of Ankney et al. (1987), Seymour (1990, 1992) and Merendino et al. (1993), creation of coastal impoundments might influence Black Duck distribution in a given area considering possible competitive exclusion by the Mallard. Moreover, hunting might also have a strong impact on local breeding Black Ducks, particularly yearlings, in this habitat. Parker (1990) observed that important hunting mortality of juvenile Black Ducks occurred within coastal impoundments in New Brunswick. It is, however, difficult to predict the outcome of these local effects on overall regional or continental Black Duck populations.

Conclusion

Substantial questions remain on best management schemes of coastal impoundments for the Black Duck. There are several approaches to managing coastal wetlands, ranging from strict preservation and/or marsh restoration (the extensive or landscape approach) to large-scale habitat modifications (the intensive approach)(Whitman and Cole 1987). So far, as concluded by Kirby (1988), there are no data to show that overall production of breeding Black Ducks has increased at the regional or continental scale following the construction of coastal impoundments. Assuming that there is no lack of suitable breeding habitats in a given area, the use of impoundments by Black Ducks might therefore only represent a change in bird distribution (Kirby 1988). Furthermore, it is believed that any type of habitat management to enhance Black Duck breeding habitat (coastal impoundment for instance) in areas with historically stable populations of that species, may stimulate invasion by Mallards (Merendino et al. 1993).

Ankney et al. (1987) and Merendino et al. (1993) stated that "it may be impossible to resolve the Black Duck problem by human intervention". Besides not creating new man-made habitats in this area, we believe that something at least can be done to enhance Black Duck coastal habitats that bring no benefit to breeding Mallards. Because tidal saltmarshes represent the preferred breeding and staging habitats for Black Ducks in our study area, we recommend increased efforts to restore the carrying capacity of tidal saltmarshes along the lower St. Lawrence estuary, particularly those affected by agriculture (*see* Slavin and Shisler 1983 *or* Ferrigno et al. 1987 for examples of habitat restoration management). We believe that such an extensive landscape conservation approach would, over the long term, be beneficial to Black Ducks in this area. However, already existing coastal impoundments seem to represent good feeding habitats for Black Ducks in the fall and hunting should be prohibited there. This would minimize the possible impact of hunting activities on Black Duck recruitment in the area.

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The Response of Predators to an Erupting Bison, *Bison bison athabascae,* Population

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During the past 20 years Bison (*Bison bison athabascae*) numbers have increased and Moose (*Alces alces*) numbers appear to have decreased within the Mackenzie Bison Sanctuary. In adjacent peripheral areas near Mink Lake Moose densities were twice that in the Mackenzie Bison Sanctuary. Wolf (*Canis lupus*) activity was greater in the Mackenzie Bison Sanctuary than in the Mink Lake area. Although Bison made up a larger proportion of the Wolf diet (based upon scat analysis) in the Mackenzie Bison Sanctuary than in the Mink Lake area, Moose made up a significantly greater ($P<0.001$) proportion of the Wolf diet than expected given the availability of prey biomass in both the Mackenzie Bison Sanctuary and Mink Lake areas. Given that Moose made up a similar proportion of the diet in both areas, and that there was a two-fold difference in Moose densities between area, Wolf predation may be destabilizing and exacerbating the decline in Moose numbers.

Key Words: Bison, *Bison bison athabascae,* population eruption, Moose, *Alces alces,* Wolves, *Canis lupus,* Mackenzie Bison Sanctuary, Northwest Territories.

Bison (*Bison bison athabascae* as defined by Van Zyll de Jong (1986) but see Geist 1992 for a contrasting view on the validity of subspecies in Bison) were reintroduced into the Mackenzie Bison Sanctuary in 1963. The population has increased rapidly (Gates and Larter 1990) and the current population eruption has followed the dynamics predicted by the Caughley-Riney four-stage equilibrium model (Riney 1964; Caughley 1970) despite the presence of Wolf (*Canis lupus)* predation (Larter 1994). This four-stage equilibrium model predicts that an erupting ungulate population will go through four stages: (1) a progressive increase in population size in response to the disparity between the number of animals present and the carrying capacity of the environment, (2) a levelling off in animal numbers in response to decreasing forage availability, (3) a decline in numbers because the population has increased beyond the carrying capacity of the environment, and (4) a phase of relative stability with population density remaining lower than peak density because the carrying capacity of the environment has been reduced by the impact of peak population density. As the population passes through the four stages, food supplies are reduced and the plant community becomes increasingly dominated by more unpalatable species in response to increased grazing intensity. Beyond documenting that this model's predictions appear to hold for an indigenous ungulate population in the presence of predators, further important questions arise regarding the response of the Wolf population to an increasing prey base. Do Wolf numbers increase in response to the increasing abundance of Bison? If Wolf numbers increased, what impact could this have on the Bison population, and on Moose (*Alces alces*), the only other ungulate prey population in this study area? Gates and Larter (1990) proposed that an increasing Bison population in the Mackenzie Bison Sanctuary and adjacent areas, may not be diverting Wolf predation from Moose and Caribou by providing a substantial alternate prey source; rather it could be increasing it by maintaining high Wolf populations capable of depleting the more vulnerable prey populations.

In systems where there is an alternate prey source, and prey switching occurs, it is theoretically possible for predation rate to be either directly density-dependent or inversely density-dependent over all densities (Ricklefs 1979). Inverse density-dependent predation rates occur when predation rate increases while prey density decreases, a situation that could be destabilizing and potentially drive a prey population to extinction.

The vulnerability of the primary prey relative to an alternate prey determines the impact of predation on the abundance of primary prey (Messier 1993). Jarman and Johnson (1977) suggested that the decline in introduced hare (*Lepus europaeus*) and native rat kangaroo (*Aepyprymnus* spp.) populations in Australia may have been a result of introduced fox (*Vulpes vulpes*) populations being sustained by rabbits (*Oryctolagus cuniculus*). Consequently foxes may have been able to eliminate a less numerous and more catchable prey. A similar situation was

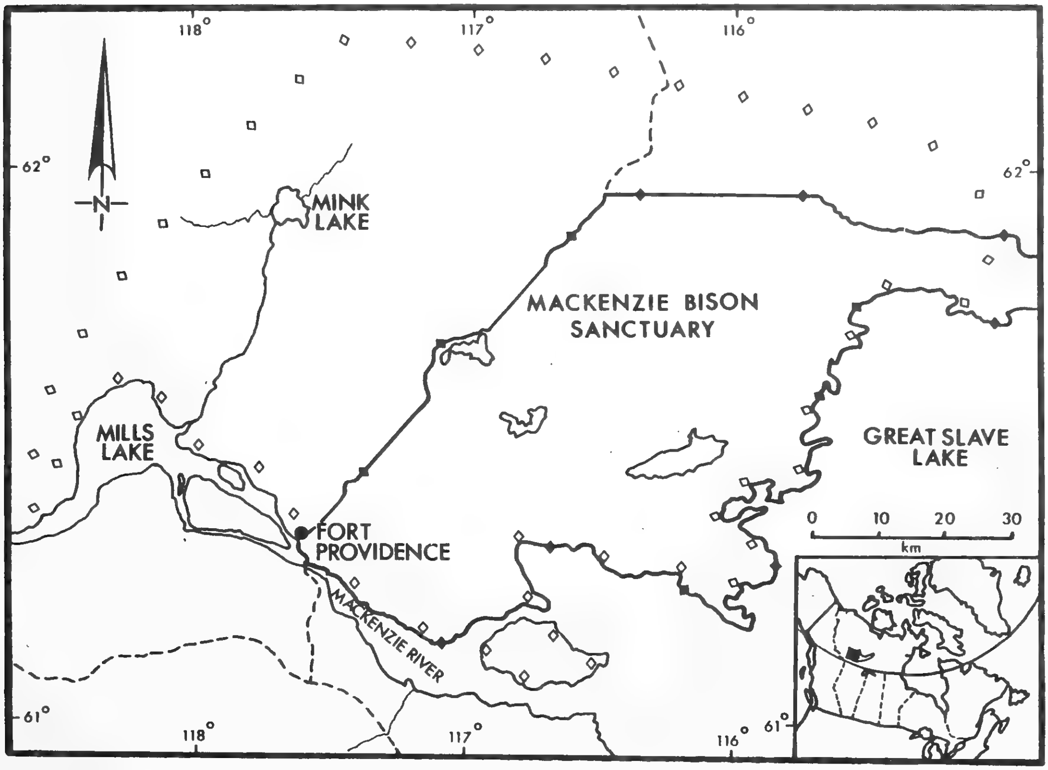

FIGURE 1. The study area, Mackenzie Bison Sanctuary and adjacent area, Northwest Territories. The current range of Bison is denoted by the open diamonds.

described in England where fox numbers were being maintained by rabbits at numbers high enough to significantly reduce breeding densities of Gray Partridge (*Perdix perdix*) (J. Reynolds, personal communication). Rock-wallaby (*Petrogale lateralis*) populations in Western Australia are being decimated by fox predation (Kinnear et al. 1988), because fox numbers are being kept high by a substantial rabbit population.

In some areas of western North America, Moose are the principal prey of Wolves which can remain at high enough population levels to deplete Caribou (*Rangifer tarandus*) populations. Seip (1992) documented that a Woodland Caribou (*R. t. caribou*) population spatially separated from Wolves and Moose during summer, and therefore less vulnerable to Wolf predation, had a lower adult mortality rate and higher calf survival than a similar Woodland Caribou population that was not spatially separated from Wolves and Moose. He believed that because the Wolf population was sustained primarily by Moose, the latter Caribou population could potentially be extirpated.

We hypothesize that predators are capable of utilizing both Moose and Bison in this system, and that Wolf numbers have increased in response to increasing Bison numbers. We predict that over a range of Moose densities Wolves will continue to utilize Moose to a greater extent than expected given Moose and Bison availabilities, thus providing the potential for local extinctions of Moose populations.

In this paper we examine Wolf-Bison-Moose dynamics in two areas by comparing Wolf diet, Wolf abundance, relative prey abundance and available prey biomass to test whether Wolf predation on Moose, in the presence of Bison, can act in a destabilizing and inversely density-dependent fashion. Because areas that have been proposed for future Bison reintroductions have low densities of Moose and Wolves, and a subsistence Moose harvest, knowledge of Wolf-Bison-Moose dynamics is becoming increasingly important.

Materials and Methods

Study area

In 1963, eighteen Bison were released into an unpopulated area of their historic range on the western side of Great Slave Lake (61°30′ N, 117° 00′ W) in the Northwest Territories of Canada (Figure 1). The population increased in an eruptive fashion

(Calef 1984), and Bison now inhabit an area exceeding 9000 km^2 (Larter and Gates 1994). Recently, the population split into two distinct subpopulations: the Mackenzie subpopulation (MBS) inhabiting the core of the range and the Mackenzie Bison Sanctuary proper, and the Mink Lake subpopulation (ML) inhabiting the more peripheral areas of the range, the Mink Lake area northwest of the Sanctuary. The study area is located in the Upper Mackenzie Section of the Boreal Forest Region (Rowe 1972) in the emerged bed of a once vast glacial lake. The undulating topography is dominated by forested habitats which include coniferous forests of Black Spruce (*Picea mariana*), White Spruce (*P. glauca*), Jack Pine (*Pinus banksiana*), and Larch (*Larix laricina*), and mixed deciduous-coniferous forests of White Spruce, Trembling Aspen (*Populus tremuloides*), and Balsam Poplar (*P. balsamifera*). Shallow lakebeds are widely dispersed throughout the area. These lakebeds are gradually filling in with sedges and grasses, while woody plants, notably willows (*Salix* spp.), are invading these lakebeds and provide most of the forage used by Bison, but represent <6% of the study area (Larter and Gates 1991a; Matthews 1991).

Predator Abundance/Activity

We calculated indices of Wolf abundance in both areas (MBS and ML) using two techniques: track counts and visual observations. Track count lines were established during winter 1989-1990 and consisted of three, 1 km transects along seismographic survey lines in each area. The start and end points of each transect were flagged for identification and track counts were made on them throughout the winter when conditions permitted. The number of track lines was increased to five and the transect length increased to 3 km during winter 1991-1992 because of the number of zero counts during 1989-1990. No data were collected during winter 1990-1991. Data were collected during three winter periods: early (November), mid- (February), and late-winter (March-April). A track-day was defined as a 24-hour period when all new tracks along the trail were made within the preceding 24-hours. Because there were different numbers of successful track-days between areas, all data were expressed as number of tracks counted per track-day. Because of reduced sample size we combined track-day data from the two winters, and used a square root transformation to normalize the data. The Student's t-test was used to determine if there were differences in the number of tracks/track-day between areas.

Wolves were observed during 25 hours of aerial reconnaissance, and ground-based travel throughout the study area. Abundance indices for both areas were calculated as the number of Wolves observed per day of field work, or the number of Wolves observed per flight-hour.

Prey Abundance and Availability

Population estimates for Bison were usually conducted on a biannual basis during 1963-1992. Prior to 1989 a total count technique was used. This was changed to a stratified strip transect technique in 1989. Sex/age composition surveys were conducted yearly from 1985-1992 (Gates et al. 1991). Because of logistic problems with the 1992 census, we used the 1989 survey data to estimate numbers of animals in the different sex and age classes. We multiplied the numbers of each sex/age class by a winter weight estimate to determine available Bison biomass. Winter weight estimates for Bison were: calves 200 kg, yearlings 360 kg, adult females 590 kg, and adult males 850 kg (Larter and Gates 1990; Gates unpublished data).

Aerial transect surveys for Moose were conducted just in the Mackenzie Bison Sanctuary in February 1965 and December 1971 (Department of Renewable Resources, Government of the Northwest Territories unpublished data). The number of Moose observed per kilometre of transect was determined. In April 1987 while conducting the Bison census of the Mackenzie Bison Sanctuary and Mink Lake area, we also calculated the number of Moose observed per kilometre of transect. During November 1991 a random stratified survey (Gasaway et al. 1986) was conducted to estimate Moose densities in both areas (Shank 1992).

Additional indices of abundance were collected from aerial- and ground-based reconnaissance of the study area by personnel during 1986 to 1992. The ground-based index was calculated as the number of Moose observed per day of field work. For convenience, this was then converted into Moose observed per week of field work. The aerial based index was calculated as the number of Moose observed per flight-hour.

Available biomass of Moose was estimated as for Bison. We used Moose sex/age ratios and population estimates collected during the 1991 census (Shank 1992). Weight estimates for Moose were: calves 160 kg, yearlings 240 kg, adult females 350 kg, and adult males 453 kg (Blood et al. 1967; Ritcey 1974; Banfield 1977; Saether 1985).

Wolf Scat Analysis

Wolf scats were collected opportunistically throughout the course of the study. Scats found near Wolf kills were not collected, because they could bias the data set. Scats collected in winter were kept frozen, while scats collected in summer were air dried prior to preparation for laboratory analysis. Scat preparation and analysis followed Kennedy and Carbyn (1981). Bone fragments, hair, and feather characteristics were used to determine the prey item(s) present in scats.

We compared the presence of prey items in Wolf scats between study areas during winter and between seasons, for the Mackenzie Bison Sanctuary (MBS) area only, using the proportion test (Zar 1984). Small sample size precluded comparing seasonal differences for the Mink Lake (ML) area. We calculated available prey biomass (Bison and Moose) for each area (see Prey Abundance and Availability). We used the log-likelihood ratio (G-test, Zar 1984) to compare the frequency of scats containing the different prey items with that available (live biomass) in each area.

We estimated relative amounts of Bison and Moose consumed following the relationship described by Floyd et al. (1978).

$$y = 0.38 + 0.02x$$

where: y = kg of prey/collectible scat
x = the average weight of individuals of each prey type.

We estimated x for each prey in each area by determining the proportion of juveniles and adults killed based on Wolf kill data, and multiplying that proportion by the average weight of juveniles and adults. Juvenile weights are an average of calf and yearling weights and adult weights are an average of male and female weights. We calculated y for each prey, and multiplied y by the number of scats in which the prey items occurred. We multiplied by frequency of scats because the majority of scats (77%) contained only one major prey item (either Bison or Moose). This calculation was done for each area and the relative amounts of each prey species was expressed as a ratio of kg of Bison consumed per kg of Moose.

Wolf Kills

Wolf kills were located opportunistically by ground-based and aerial reconnaissance. Whenever possible, kills located from the air were verified by ground observations. Evidence that an animal was killed by Wolves included obvious chase sequences in the snow and/or signs of struggle before death (i.e. extensive blood covered vegetation or snow, and broken vegetation). The sex/age class and species of prey were determined by physical examination.

Results

Predator Abundance/Activity

Overall, Wolf activity was greater in the Mackenzie Bison Sanctuary (MBS) than in the Mink Lake (ML) area during all three periods of the winter (Table 1). Differences between areas were not significant when compared at any one sampling period (P = 0.063, t = 1.58, early winter; P = 0.65, t = -0.40, mid-winter; P = 0.37, t = 0.33, late winter). However, when the data were lumped across the entire winter the difference became significant: 0.43 and 0.21 mean tracks/track-day in MBS and ML respectively (P = 0.021, t = 2.07).

TABLE 1. Comparative Wolf activity (tracks/track-day) between the Mackenzie Bison Sanctuary and Mink Lake area during three winter periods: early (November), mid (February), and late (March-April). The number in parentheses is the number of track days used to calculate tracks/track-day. ** indicates significance between areas at $p < 0.05$, * indicates significance at $p < 0.1$.

Area	Winter Early	Winter Mid	Winter Late	Lumped
MBS	0.65 (17)*	0.09 (11)	0.43 (37)	0.43 (65)**
ML	0.23 (26)*	0.14 (30)	0.27 (22)	0.21 (78)**

Ground-based and aerial observations showed a similar pattern to the track count data, but with greater disparity between areas. The aerial-based index of abundance was twice as high in MBS than ML averaging 2.2 Wolves observed/flight hour (n = 16.5 flight hours) versus 1.2 (n = 8.5 flight hours), respectively. The ground-based index was four times as high in MBS than ML averaging 0.31 Wolves observed/field day (n = 571 field days) versus 0.07 (n = 133 field days) respectively.

Prey Abundance

There were approximately three times as many Bison in MBS as at ML (1885 and 546 respectively). When these data were converted from individuals observed to number of groups (or search items) counted, there were 138 Bison versus 79 Moose groups and 48 Bison versus 190 Moose groups in the MBS and at ML respectively. The estimated available biomass of Bison per total area was 1106 tonnes for MBS (4563 km^2 area) and 343 tonnes for ML (3500 km^2 area) (Figure 2A).

The 1965 and 1971 transect surveys for Moose in the MBS gave similar results: 87 Moose along 1834 km of transect, and 82 Moose along 1496 km of transect respectively. In 1987, one Moose was observed in ML on 1075 km of transect covering both the MBS and ML. Moose densities in 1992 were 0.12 and 0.25/km^2 in MBS and ML respectively (Shank 1992). Abundance indices based upon ground and aerial reconnaissance data from 1986-1992 also indicated lower Moose numbers in MBS relative to ML: 0.21 Moose observed/field week (n = 46.7 field weeks) versus 0.63 (n = 14.3 field weeks) respectively, and 0.9 Moose observed/flight hour (n = 30.9 flight hours) versus 1.6 (n = 11.5 flight hours) respectively. The estimated available Moose biomass was 46 tonnes for MBS (4563 km^2 area) and 91 tonnes for ML (3500 km^2 area) (Figure 2A).

Predator Diet

Although Bison and Moose made up a large proportion of the diet, small mammals including mice (Cricetidae), Snowshoe Hare (*Lepus americanus*), and birds (both Gallinaceous and waterfowl) were also

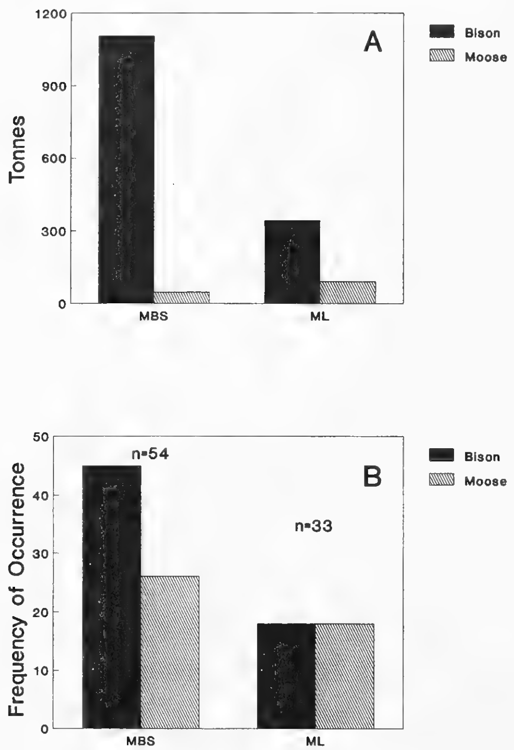

FIGURE 2. (A) Available Bison and Moose biomass in the Mackenzie Bison Sanctuary and Mink Lake area, (B) frequency of occurrence of Bison and Moose in Wolf scats (during winter) in the Mackenzie Bison Sanctuary and Mink Lake area. n = total number of scats.

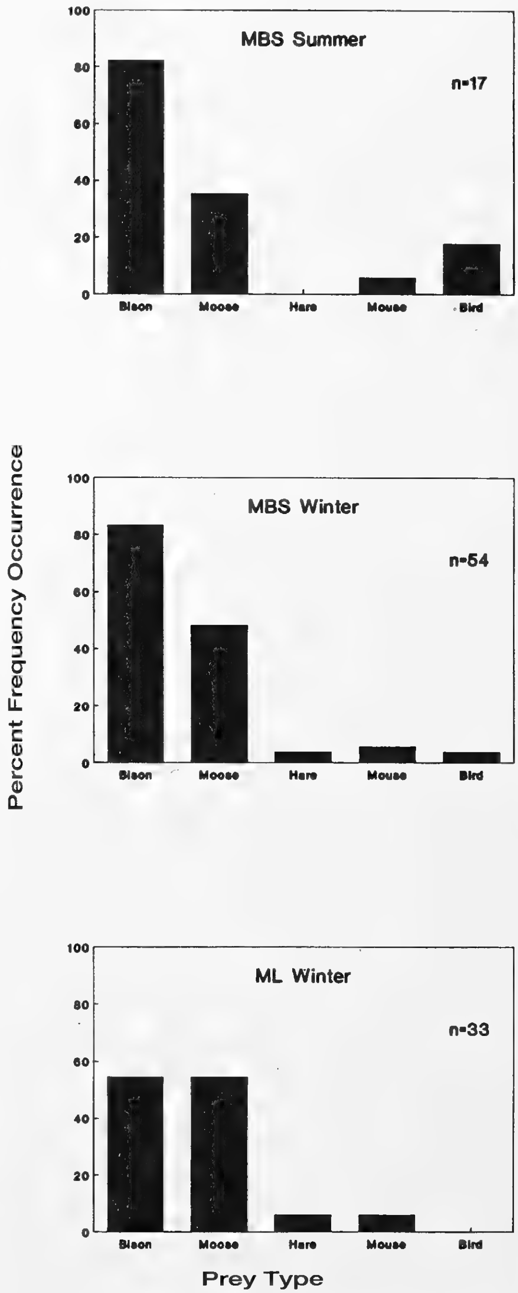

FIGURE 3. Percent frequency occurrence of various prey items found in Wolf scats during different seasons and in different areas. Values above histograms are the number of occurrences. n = number of scats.

consumed. The number of scats containing Bison and Moose was equal in ML during winter. In MBS, Bison was present in more scats than Moose (Figure 3). The proportion of scats from MBS containing Moose and Bison was similar (P>0.2) between seasons (Z = 0.93 for Moose, Z = 0.09 for Bison, snow free=summer, snow cover=winter). During winter the proportion of scats containing Bison was greater in MBS than that at ML (P<0.05, Z = 2.91); there was no difference in the proportion of scats containing Moose (P>0.3, Z = -0.58). Insufficient sample size prevented the seasonal comparison of scats found in ML. The number of scats containing Moose was significantly greater than that expected given the available biomass of Moose and Bison in both ML and MBS (G = 340.0 ML, G = 1624.3 MBS, P<0.001) (Figure 3). Wolves consumed 1.62 kg of Bison per 1 kg of Moose in MBS, compared to 1.17 kg of Bison per 1 kg of Moose in ML.

Forty-one of 46 documented Wolf kills were Bison. Of the 41 Bison kills, 31 were juveniles: 26 calves and 5 yearlings (Figure 4). The greater proportion of Bison, especially juveniles, in Wolf kills was more pronounced in MBS. Moose made up a larger proportion of kills at ML than at MBS (Figure 4).

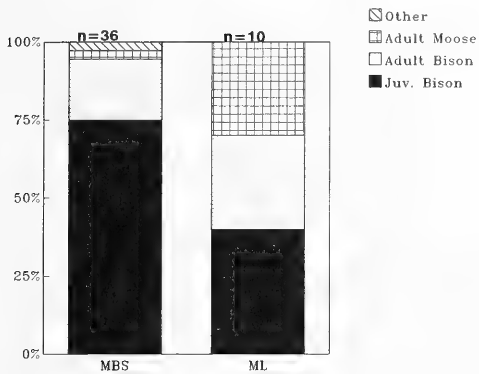

FIGURE 4. Proportion of prey types found at Wolf kills in the Mackenzie Bison Sanctuary and Mink Lake area. Juvenile Bison are yearlings and calves. Other is a Red Fox (*Vulpes vulpes*). n = number of kills.

Discussion

Whether Moose numbers have declined over the entire study area from 1971 to the present is debateable. The crude line transect surveys do not provide estimates of Moose density, and any density estimates derived from them would be underestimates (Gasaway et al. 1986). However, local hunters maintain that Moose numbers were historically much higher in the MBS in the early 1970s, and the actual numbers observed during line transect surveys in the MBS do show a decline. Currently Moose numbers and density are lower in MBS than ML, and likely have been since 1986. Bison numbers have been increasing since the 1963 reintroduction. The increase has most likely had a greater potential impact on Moose in MBS than ML based upon total numbers of resident Bison and the length of time Bison have been resident in the two areas. Decreased Moose densities could have resulted from competition between Moose and Bison for food resources, changes in habitat, or Wolf predation.

Competition for food resources is unlikely. Moose are concentrate selectors (Hofmann 1989) with diets dominated by browse species like willow, aspen, and Paper Birch (*Betula papyrifera*) (Belovsky 1978; Peek 1974; Risenhoover 1989). In contrast, Bison are classic grass/roughage eaters (Hofmann 1989) with diets dominated by graminoids (Reynolds et al. 1978; Larter and Gates 1991a, 1991b). During fall (September-October) Bison in the MSB also utilize lichen (Larter and Gates 1991a, 1991b). In exceptionally dry summers, when grass and sedge productivity is reduced, Bison have foraged on willows (Larter and Gates 1991a), but they rarely foraged on willow during winter. Consequently, any dietary overlap would be limited in duration and occur during the growing season when forage quality and quantity are highest.

Habitat changes resulting in decreased willow cover could cause declines in Moose numbers. Aerial photos indicate that over the past 30 years, willows have invaded dry meadow communities and willow cover has actually increased, although some of the willow cover may have grown out of reach for Moose browsing. Fires have occurred more recently in ML than MBS, but have been infrequent during the past 30 years. It is unlikely that habitat changes causing a reduction in browse availability are responsible for declining Moose numbers. Predation remains an alternate possibility.

Wolves have historically been present in the area (Wood Bison Recovery Team 1988; A. Look, personal communication). Local residents believe that Wolf numbers are on the rise, but unfortunately there are no data on Wolf numbers during most of this time period. Messier and Crête (1985) have provided the best evidence of Wolves regulating their prey population. They documented Wolf predation over a range of Moose densities, and concluded that Wolf predation acted in a density-dependent fashion. They found at low densities of 0.22 and 0.17 Moose/km^2, Wolves were capable of regulating Moose populations. However, at densities around 0.40 Moose/km^2, Moose numbers appear to be regulated by food. On Isle Royale, Moose numbers were regulated by food even in the presence of Wolves, and Moose densities have fluctuated between 1.6 to 2.8 Moose/km^2 (from Peterson 1977, 1992). Messier (1991) estimated that competition for food had a regulatory effect on Moose density on Isle Royale when densities were between 1–2 Moose/km^2. Crête (1989) estimated that densities greater than 2.0 Moose/km^2 were required if carrying capacity (K) (Macnab 1985) was to be reached in eastern Quebec. Messier (1984) suggested that a density of 0.2 Moose/km^2 approximated a threshold below which Wolf packs cannot subsist without an alternate ungulate prey species. Current Moose densities in the MBS are 0.12 Moose/km^2 (Shank 1992); i.e., below Messier's (1984, 1993) threshold.

Wolf predation on Moose can represent a destabilizing influence which can potentially exacerbate a Moose decline because of its antiregulatory effect (Messier 1991). Additionally, Wolf predation has a greater impact on Moose populations when the Moose population is declining (Gasaway et al. 1983). Our data support the contention that Wolf predation on Moose is destabilizing, because in areas of both low and high Moose density, predation on Moose is greater than expected given the available prey biomass.

Moose remains were found in significantly more Wolf scats than would be expected given the availability of Moose and Bison biomass in the study area (Figure 2). This was not the case for Wolf kills. The proportions of Bison to Moose kills (Figure 4) were similar to that expected given prey availability (Figure 2A). The difference between data sets may be an artefact of sampling methodology. The majority of ground-based travel was through open habitat patches and along travel corridors that connect these open habitat patches. Consequently, travel was concentrated in Bison habitat as opposed to Moose habitat. Wolf kills were generally found by ground-based travel and were much easier to spot in the more open habitats where travel was concentrated. Sightability of animals and kills in forested habitats is restricted (Larter 1988).

Wolf scats were found opportunistically, were not collected from recent kill sites, and likely represent a less biased sample of Wolf diet composition than kill data. Estimates, derived from wolf scats, of the relative amounts of each prey item consumed were 1.62 kg Bison per 1 kg Moose in MBS and 1.17 kg Bison per 1 kg Moose in ML. Given that the available biomass of Bison is 23.8 times that of Moose in MBS and 3.8 times that in ML, these data further indicate Moose as the preferred prey item.

Bison and Moose are the two largest species of North American ungulates. The typical attack success of Wolves ranges from 5% on larger prey (Haber 1977) to 40% on smaller ungulates (Kolenosky 1972). Given a choice, Wolves exhibit a preference for moderate size prey species (Murie 1944; Mech and Frenzel 1971; Van Ballenberghe et al. 1975; Carbyn 1983). Only juvenile Moose and Bison are small, and the smaller size of Moose compared to Bison may affect prey preference.

The spatial distribution of prey can alter the effective search of Wolves and, regardless of prey preference, may affect prey selectivity (Huggard 1991; 1993). Clumping of prey means a lower effective search because the group, not the individual, represents a search item (Taylor 1979; Huggard 1991). Bison are gregarious, spending much of the year in large groups dominated by females, calves, and immature animals (Larter 1988). Moose are relatively solitary animals (Geist 1963; Banfield 1977). Consequently even though available prey biomass is skewed highly toward Bison, the actual number of search items may be closer to parity. When our census data were converted from individuals to the number of search items this was the case. However, there is some evidence that hunting success is decreased for predators that stalk groups rather than solitary prey (Van Orsdol 1984), and Moose tend to be well dispersed, spatially predictable, and always part of a year-long prey base (Messier 1993). Therefore, Moose may be a more vulnerable and selected prey than Bison regardless of the number of search items.

Selectivity by the predator, especially in regard to the sex/age classes of the different species which they prefer to attack, can shape the prey populations in different ways (Huggard 1991; Mills and Shenk 1992). Consequently predation may affect Bison and Moose populations quite differently. Our data are limited, but the majority of Bison killed by Wolves were juveniles, whereas the majority of Moose killed were adults. If adults are taken in a greater proportion than juveniles, predation will have a greater impact on the prey population because it directly influences fecundity and mortality.

Wolves do not remain in areas of high prey density, they travel frequently throughout their territory (Carbyn 1983). Wolves preying upon Bison in Wood Buffalo National Park (WBNP) have a long average distance between kills suggesting that they must travel frequently between herds for kills. Although previously attacked Bison herds are more alert, Wolves will occasionally follow these herds (Oosenbrug and Carbyn 1985). Wolves may be more successful when they encounter large herds because of the higher probability of finding weak or vulnerable individuals, however vulnerability does not necessarily imply weaker or sick individuals.

Wolves attack Bison herds with calves preferentially over herds without calves (Carbyn and Trottier 1987). This preference for juveniles and especially calves would be expected because calves are generally slower, less dangerous and more inexperienced with predators. Calves are easier to kill than adults (Carbyn and Trottier 1988), however, adult Bison are still taken. Van Camp (1987) found that in the Slave River Lowlands (SRL) adjacent to WBNP, five packs of Wolves killed and consumed 15 adults (13 females and 2 males) and four calves during a nine-week period in late winter.

Calf remains in scats are indistinguishable from other age classes after three months because calves lose their red pelage. Therefore any scats collected in winter provide no information upon whether the prey was juvenile or adult. However, 26 of 41 Bison killed by Wolves were calves. Radio-collared Bison and sequential cow:calf ratios from the study area (Larter 1994) indicate that Bison calves are preyed upon year-round, but predation pressure may increase during the summer on newborn individuals. Sequential adult female:calf ratios during summer 1991 in the MBS show a decline between June and August: 46.7 ± 6.7 to 36.8 ± 11.7 calves: 100 adult females. During summer radio-collared calves were lost to Wolf predation at a rate of 1 calf/153 collar-days, but during winter the rate decreased to 1 calf/354 collar-days (Larter, unpublished data). The possible preference for more vulnerable newborn Bison calves as prey during summer may have important consequences for juvenile Wolf survival. It is during summer that pups are being reared and foraging radius is reduced.

Hunting success of Wolves generally increases in deep snow (Kolenosky 1972; Haber 1977) because deep snow hinders ungulate movements. Snow depths of 50–55 cm hinder Bison calves (Van Camp 1975), whereas depths of 80–84 cm are required to hinder Moose calves (Kelsall 1969). Adult Bison can still successfully forage at snow depths of 75–85 cm and snow densities of up to 0.2 g/cm^3 (Van Camp 1975), while adult Moose movements become hindered at 98–105 cm (Kelsall 1969). Snow levels in the study area commonly reach 50 cm by mid-winter (Larter 1988; Larter and Gates 1991a), but rarely reach 80 cm. The greatest depth recorded was 82 cm during late winter 1991. Therefore, Bison calves should be the most susceptible prey item during winter. Bison calves made up a larger proportion of Wolf kills than any other prey class (species, sex, and age).

If the Wolf population has been increasing in response to an increasing alternate prey base, then the probability of a random encounter with Moose also increases. Travel between open habitat patches (Bison habitat) necessitates travel through forested Moose habitat. If a pack of Wolves encountered Moose while actively searching for Bison it is unlikely that they would pass up the opportunity to attempt a kill, especially when the likelihood of success is higher.

In order to critically evaluate whether Wolf predation on Moose is acting in an inverse density-dependent manner it would be necessary to have a measure of Wolf numbers (i.e., the numerical response), and a measure of killing rate per predator (i.e., the functional response). Our data do not provide these definitive measurements, however they do provide a comparison of Wolf activity, prey abundance, and Wolf diet composition between two areas. The index of Wolf abundance (Wolf activity) is different between areas and consequently can be considered as an estimate of the numerical response of Wolves to an increasing Bison population over time. The Wolf diet composition in conjunction with prey (both Moose and Bison) abundance could be thought of as providing a crude estimate of the functional response. Since the frequency of Moose remains occurring in Wolf scats is similar between areas, while the availability of Moose is lower in the high Wolf density area, Wolf predation on Moose is potentially increasing as the Moose population declines. This situation could produce an inverse density-dependent relationship.

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Organochlorine Residues in Nesting Killdeer, *Charadrius vociferus*, and their Eggs in North Dakota

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Fair, Jeanne M., Lowell C. McEwen, and Patricia L. Kennedy. 1994. Organochlorine residues in nesting Killdeer, *Charadrius vociferus*, and their eggs in North Dakota. Canadian Field-Naturalist 108(3): 328–331.

Detectable concentrations of DDE were found in 88% of a nesting Killdeer sample (n = 72) collected in northwestern North Dakota. The geometric mean DDE concentration for all the Killdeers was 0.17 ppm with a range from 0.02 to 3.49 ppm. Body burden of DDE in males was significantly higher than that of the females. Adults had significantly higher residues than juveniles that had not yet migrated to wintering areas. DDE was found in 100% of the eggs collected (n = 12) but was not correlated with eggshell thickness.

Key Words: Killdeer, *Charadrius vociferus*, DDE, organochlorines, eggshell thickness, North Dakota.

Environmental applications of DDT (1,1,1 - trichloro-2,2-bis [p-chlorophenyl] ethane) were banned in the United States in 1972. Decreasing trends in DDT/DDE concentrations in birds have since been reported (Kim et al. 1985; Henny et al. 1985; Mueller et al. 1991). However, studies still detected high levels of DDE in wildlife, particularly in western migratory birds (Clark and Krynitsky 1983; DeWeese et al. 1986). Birds containing DDE concentrations ≥ 1.0 ppm can be considered high risk prey for raptors, such as Peregrine Falcons (*Falco peregrinus*) (Enderson et al. 1982) which exhibited population declines due to the DDE-induced eggshell thinning. Several studies indicate that migratory shorebirds such as the Killdeer (*Charadrius vociferus*), can possess among the highest organochlorine (OC) residues of any prey item taken by these falcons (Enderson et al. 1982; DeWeese et al. 1986; Mueller et al. 1991).

Due to the concern about impacts of pesticides on migratory upland shorebirds, we investigated the direct and indirect effects of carbaryl (a carbamate) grasshopper control on Killdeer, a common migratory shorebird in grasshopper-control areas. Killdeers were collected concurrently from areas sprayed with carbaryl Sevin-4 oil formulation and from similar unsprayed habitat. Each Killdeer was analyzed for brain acetylcholinesterase (AChE), pesticide residues (carbaryl and organochlorines), % lipids, and gizzard contents. Exposure to the grasshopper spray was assessed by carbaryl residue analysis of carcasses and gizzard contents. This provided us with the opportunity to also examine the Killdeers for organochlorine body burden. Our objectives in this paper are to : (1) present the OC residue results of the Killdeer from North Dakota by sex and age and (2) compare the relationship between OC (DDE) levels in Killdeer and their eggshell thicknesses. The results of the brain AChE activity, carbaryl residues, % lipids, and gizzard content analyses were reported by Fair et al. (*in press*).

Methods

We surveyed McHenry and Billings Counties, North Dakota by vehicle between 22 June and 29 July 1992. Killdeers were collected with a shotgun under federal and state permits (United States Department of the Interior, Fish and Wildlife Service permit number PRT-719665 and North Dakota State permit number 0125). The two areas in McHenry County (one sprayed and one unsprayed) were primarily on privately owned land northwest of Towner (48°17′ N, 100°30′ W). The mixed prairie vegetation was dominated by Western Wheatgrass (*Andropyron smithii*) and Needle-and-thread Grass (*Stipa comata*). Annual cereal grain production was the dominant cropland agricultural use; with a small percentage of the area devoted to hay production. The two areas in Billings County (one sprayed and one unsprayed) were on the Little Missouri National Grassland (LMNG), south of Medora (46°50′ N, 103°20′ W). The vegetation is a mixed-grass prairie dominated by Blue Grama (*Bouteloua gracilis*), Western Wheatgrass, Needle-and-thread Grass, Prairie Junegrass (*Koeleria pyramidata*), and Threadleaf Sedge (*Carex filifolia*). The LMNG is managed for multiple use, including grazing by livestock and extraction of fossil fuels.

We collected 72 Killdeers (59 adults [38 males, 21 females], 13 juveniles [4 chicks under 5 days old]. Birds were placed on dry ice as soon as possible after collection (5 to 10 minutes), transported from the field, and stored at –80° C. The gastrointestinal (GI) tract was removed within eight hours. Birds were sexed by internal examination and aged as either adult or juvenile by feather growth. Most birds were found around windmills, water holes, grazed pastures and short-grass habitat.

We collected 12 eggs from nests in McKenzie County where no grasshopper treatments occurred. Egg volume was measured by water displacement and greatest length and breadth were measured for each egg. Eggshells were opened, rinsed, and dried within 24 hours after collection. The contents were stored at -80°C. Eggshell thickness was also measured at four points along the equator on each half of the shell plus membrane, using a Starrett 1010M dial gauge micrometer graduated in units of 0.01 mm and then averaged for each egg. No eggs were in the advanced stages of development. A shell-thickness index (shell weight [g] x 100/length x breadth [mm]) was calculated for each eggshell (Morrison and Kiff 1979). This index was then compared to the Killdeer eggshell index calculated by Morrison and Kiff (1979) to see if eggshell thicknesses in this area differed from those of eggs collected during the pre-DDT (1910-1941) and DDT spray (1948-1977) eras.

The USDA National Monitoring and Residues Analysis Laboratory in Gulfport, Mississippi conducted the residue analyses of Killdeer carcasses. Killdeer were plucked of feathers; legs, GI tracts, and heads were also removed and not included in the carcass analyses. A 10 g aliquot of each ground carcass was mixed with anhydrous sodium sulfate and Soxhlet-extracted with hexane. The weighed lipid sample was dissolved in petroleum ether and extracted four times with acetonitrile saturated with petroleum ether. Residues were partitioned and transferred to a glass chromatographic column containing 20 g of Florisil. The column was eluted with 200 ml 6% diethyl ether and 94% petroleum ether (Fraction I) followed by 200 ml 15% diethyl ether and 85% petroleum ether (Fraction II). Fraction II was concentrated to appropriate volume for quantification of residues by packed or capillary column electron capture gas chromatography. Fraction I was concentrated and transferred to a silicic acid chromatographic column. Three fractions were eluted from the silicic acid column. Each fraction was concentrated to appropriate volume for quantification of residues by megabore column, electron capture gas chromatography.

Egg residue analyses were conducted at the Mississippi State Chemical Laboratory, Mississippi State University. Organochlorine analyses were accomplished in a similar manner as described above. PCBs were found in Fraction II in the analysis. Residue concentrations are expressed as parts per million (ppm) wet weight. The lower limit for quantification was 0.01 ppm for all OCs except toxaphene (0.05 ppm) and PCBs (0.05 ppm). The references to DDE, DDD, and DDT in this paper refer to p,p'-DDE, p,p'-DDD, and p,p' -DDT, respectively.

Statistical comparisons of residues between ages and sexes of Killdeer were made using the nonparametric Wilcoxon rank-sum test (Proc NPARWAY1; SAS Institute, Inc. 1987). Geometric means were calculated by back-transforming the mean of log-transformed DDE concentration data (Sokal and Rohlf 1981). For samples with no detectable residues, one-half the lower detection limit was included in the geometric means. Egg DDE concentrations were transformed by adding one to each value and converting to the log base 10 to provide homogeneous variances for regression tests. Regression analysis (Proc REG; SAS Institute, Inc. 1987) was then used to determine the relationship of shell thickness and DDE concentration levels.

Results

Killdeer Organochlorine Residues

Of the Killdeer collected, 88% contained detectable amounts of DDE. The geometric mean DDE concentration for all of the Killdeer was 0.17 ppm (arithmetic mean = 0.44 ppm) and DDE occurred in 90% of the adults, 100% of the eggs and chicks, and 54% of the juveniles. Adult males (geometric $\bar{x}$ = 0.36 ppm) had significantly higher DDE concentrations than did adult females ($\bar{x}$ = 0.13 ppm) (Z = -2.16, p = 0.03) (Table 1). Adults ($\bar{x}$ = 0.17 ppm) had significantly higher DDE concentrations (Z = -3.77, $p < 0.001$) than did juveniles ($\bar{x}$ = 0.06 ppm) and chicks ($\bar{x}$ = 0.11 ppm).

One adult male contained 0.17 ppm DDT. Mirex was found in 28 Killdeers and concentrations ranged from 0.02 to 0.42 ppm. Dieldrin was also detected in 17 birds and concentrations ranged from 0.02 to 0.51 ppm; heptachlor epoxide occurred in five Killdeers at concentrations ranging from 0.02 to 0.21 ppm.

Egg Residues and Eggshell Thickness

The average weight of the egg contents was 12.13 g (SD = 0.92), the average % moisture was 72% (SD = 0.98), and the average % lipid was 13% (SD = 1.40). DDE occurred in 100% of the egg samples and the geometric mean was 0.57 ppm. Two eggs, from the same nest, contained the highest DDE concentrations of 4.9 and 6.4 ppm. Nine eggs also contained <0.06 ppm of heptachlor epoxide. Six eggs contained < 0.02 ppm t-Nonachlor. Mirex occurred in six egg samples and had a geometric mean concentration of 0.02 ppm (SD = 0.20).

No cracked or crushed eggs were found. The mean thickness for the 12 Killdeer eggs was 0.167 mm (SD = 0.02) and the mean eggshell index was 0.84 (SD = 0.13). The percent difference from Morrison and Kiff's (1979) index for Killdeer from California was +3.6% from the pre-DDT era (1910-1941) and +5.9% from the DDT spray era (1948-1977). DDE concentrations were not correlated (r^2 = 0.322, p = 0.05) with shell thickness.

TABLE 1. Geometric mean[1] (range) of organochlorine insecticide concentrations in ppm wet weight[2] in carcasses and eggs of Killdeer collected in North Dakota, 1992.

		DDE	DDT	Mirex	Dieldrin	Heptachlor Epoxide
Adult						
	Males	0.36	0.17[3]	0.08	0.10	0.06
	n = 38	(0.02-3.49)		(0.02-0.42)	(0.02-0.51)	(0.02-0.21)
	Females	0.13	ND[4]	0.06	0.09	0.09[3]
	n = 21	(0.02-1.16)		(0.02-0.13)	(0.02-0.46)	
Egg	n = 12	0.57	0.01	0.02	0.03	0.01
		(0.03-6.4)	(0.01-0.02)	(0.04-0.29)	(0.02-0.26)	(0.01-0.06)
Chick < 5 d old		0.11	ND	0.27[3]	0.16	ND
	n = 4	(0.02-3.6)			(0.11-0.24)	
Juveniles[5]		0.06	ND	ND	ND	ND
	n = 16	(0.02-0.25)				

[1]Geometric mean includes Killdeer with no detectable DDE concentrations (see methods for more detail).
[2]Minimum detection limit = 0.01 ppm.
[3]Actual concentration for one sample only.
[4]No detection.
[5]Juveniles are birds > 5 days old that have not left the breeding area.

Discussion

The Killdeer collected in this study contained lower DDE concentrations than Killdeer collected in other U.S. studies. Enderson et al. (1982) collected Killdeer in New Mexico and Colorado during 1977-1979 that contained DDE concentrations ranging from 10.0 - 31.7 ppm DDE with an arithmetic average of 19.5 ppm DDE. Killdeer collected from eight western states during 1980 had concentrations ranging from 0.15 - 58.80 ppm DDE ($\overline{x}$ = 11.43 ppm) (DeWeese et al. 1986). A pooled sample of 10 individuals collected in northern New Mexico in 1985 contained 13.5 ppm DDE (Kennedy et al. *in press*). Hunt et al. (1986) collected Killdeer in California during 1980 that contained 0.020 - 27.0 ppm dry weight DDE and during 1982-1983 in Texas Killdeer pools had a geometric mean of 71 ppm dry weight DDE.

The reproductive process is an important route for elimination of OCs by females. In the wild, females frequently have lower total body burdens than males as a result of elimination in eggs. The chemical residues in eggs reflect the contaminant burden females accumulate on the wintering grounds (Somers et al. 1993). Killdeer we collected contained DDE concentrations that fit this pattern, with the females having significantly lower concentrations than the males, and detectable amounts of DDE were present in the eggs and chicks. Juveniles, that had time to eliminate DDE and had not yet left the breeding area contained the lowest levels of DDE.

Due to rapid metabolism of DDT to DDE and DDD in birds (Walley et al. 1966) and the fact that we collected only one Killdeer with detectable amounts of DDT, we conclude that it is unlikely there has been recent illegal input of DDT on our study area. The source of the DDE may be from contaminated insects consumed on the wintering area. Fyfe et al. (1990) collected Killdeers, a resident species, in Peru during the fall of 1983 and the spring of 1984. Their Killdeer pools exhibited DDE concentrations of 8.37 and 70.7 ppm wet weight, respectively. White et al. (1983) found that DDE residues increased significantly in shorebirds for about two months after they arrived on the south Texas coast from their breeding grounds. They concluded that aquatic areas near agricultural lands on the south Texas coast still pose a potential threat to waterbirds, such as Killdeer, that possibly winter in these areas, eight years after the DDT ban. More information is needed on DDT and DDE concentrations in the wintering areas of the Killdeer that breed on the Great Plains before we can conclude that the wintering area is still a source of OC exposure for Killdeer.

Another potential source of the DDE is from ingestion of prey items such as invertebrate larvae that burrow in the soil. Soils in the southwestern U.S. have an unusual persistence of DDT (Hitch and Day 1992). The DDE levels in the soils from our study areas are unknown . Hunt et al. (1986) also concluded that a significant recent source of DDE into the environment may be a metabolite of Kelthane®, a widely used miticide (Risebrough et al. 1986). The usage of Kelthane® in this study area is unknown.

Although we showed an increase in the Killdeer eggshell index from those reported by Morrison and Kiff (1979), the increase was small and could be due to variation in measurements between the two studies as well as regional differences in the thickness of Killdeer eggshells. Morrison and Kiff (1979) found a lack of substantial thinning of American shorebird eggs caused by high concentrations of DDE. Shorebirds may have a lower sensitivity to DDE-induced eggshell thinning than many higher-trophic-level species.

DDE residues in these Killdeer have evidently not reached levels that may cause eggshell thinning or adversely affect reproductive success. Although six individual birds had DDE concentrations greater than 1.0 ppm, overall the levels of DDE in Killdeer from North Dakota are not a major source of DDE for raptors such as the Peregrine Falcon. DeWeese et al. (1986) found that DDE concentrations in Killdeer increased from the Pacific Northwest southeast toward Texas. Their multiple regression equation (ppm DDE = 94.04 - 0.66 latitude - 0.52 longitude) predicted that North Dakota Killdeer would average about 10.5 ppm DDE. However, their prediction was based on data collected in 1980, only eight years after the DDT ban. In a follow-up study of the same species at the same collecting sites, DeWeese (personal communication) found a general decrease in DDE and other OCs in most of the species, including Killdeer. We lack data on Killdeer OC concentrations prior to 1992. However, the low concentrations we recorded compared to the higher concentrations consistently reported in earlier studies throughout the United States suggested a declining trend in Killdeer OC concentrations.

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Observations of Conspecific Predation by Brown Bears, *Ursus arctos*, in Alaska

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A naturally occurring concentration of Brown Bears at McNeil River has been closely monitored by Alaska Department of Fish and Game personnel for the last 19 summers. During that time, observers witnessed the killing of four cubs or young bears by adult Brown Bears of known sex and age. Adult females were the perpetrators in three of these incidents, while an adult male killed a cub in the fourth. These events add new information about infanticide among bears.

Key Words: Brown Bear, *Ursus arctos*, mortality, infancticide, McNeil River, Alaska.

Some authors have speculated that conspecific killing of unrelated immature individuals by adult males may increase male fitness if females that lose their offspring are subsequently impregnated by the male doing the killing (Hausfater and Hrdy 1984). Conspecific killing of juvenile Brown Bears (*Ursus arctos*) has been used to advance the hypothesis that subadult Brown Bear survival has a negative density-dependent relationship with adult male abundance (Stringham 1980, 1983; McCullough 1981, 1986; Young and Ruff 1982). Since bear hunters typically select for male bears over female bears (Bunnell and Tait 1980, 1981; Fraser et al. 1982), these observations and hypotheses have led to a common perception that increased hunting may be compensated by enhanced recruitment. The hypothetical and inconclusive nature of this relationship was discussed by Miller (1990), who urged biologists not to rely on such density-dependent mechanisms in developing their management strategies for hunted bear populations. These conclusions were strengthened in comparison studies by Wielgus (1993).

Although conspecific killings by bears are seldom observed, they have been reported for Brown Bear (*Ursus arctos*) (Troyer and Hensel 1962; Glenn et al. 1976; Murie 1981; Dean et al. 1986; Olsen 1993; Pearson 1975) as well as for Black and Polar bears (*U. americanus* and *U. maritimus*) (Rogers 1983; Taylor et al. 1985; LeCount 1987; Tietje et al. 1986; Elowe and Dodge 1989; Amstrup, personal communication). These observations include accounts of conspecific killing of other adults and killings of juveniles by both male and female adult bears. In some of these accounts, the sex of the bear doing the killing was unknown; in other cases the sex of the bear doing the killing was inferred based on size of the bear or size of the tracks which are often unreliable indicators of sex in bears. We report on three instances where young Brown Bears were killed by conspecific adult females and one where a cub was killed by an adult male.

Study Area

Our observations were made at McNeil River State Game Sanctuary (MRSGS). This sanctuary is located 133 km west of Homer, Alaska, on the Alaska Peninsula (59°08′30″N, 154°11′30″W). MRSGS is adjacent to Katmai National Park and Preserve. Glenn et al. (1976) previously provided a map of the 33 832 ha sanctuary which is managed by the Alaska Department of Fish and Game (ADFG). Habitat of MRSGS is low shrubs, primarily alders (*Alnus crispa* and *A. sinnata*) and open tundra (Bledsoe 1987). Topography consists primarily of low, rolling hills which are cut by McNeil River and Mikfik Creek. Both watersheds drain into a tidal lagoon which is protected from the open sea by a 0.5 km long gravel spit.

The sanctuary was created in 1967 to protect habitat and the Brown Bears which concentrate at McNeil River falls to feed on migrating Chum Salmon (*Oncorhynchus keta*) (Egbert and Stokes 1976; Bledsoe 1987). Because of this concentration of bears, the area is popular with viewers and photographers who compete for a limited number of visitor permits each year (Aumiller and Matt *in press*; Faro and Eide 1974). Bears in the area are wild, but many have become habituated to a strictly controlled human presence.

Observations

Based on markings, size, coloration, sex, and behavior, we identified more than 200 individual bears frequenting MRSGS since 1976. Individuals were sexed based on presence of offspring, observations of genitals, or of urination. The term "cub" refers to a cub of the year (<1 year-old). We gave these individuals anthropocentric names to facilitate recognition and to provide data continuity on individuals between years. These names are used here.

Our first observation was a killing of a yearling male ("WC") by an adult female accompanied by two cubs. For unknown reasons, WC separated from his family (a female and two siblings) 40 days before he was killed on 17 August 1985. We saw WC with his own family the previous year and in June 1985. After his separation from his family, we did not observe WC associating with other bears. However, from 0800-0830 h the day he was killed, we observed WC following within 40 m of a newly arrived and previously unknown female ("Idi"), accompanied by two cubs.

At midday (1230 h), Idi was on the mud at the water's edge, on the south side of the gravel spit. One cub was about 6 m behind her and the second cub about 4 m behind the first one. WC was about 2 m behind the second cub. All three bears approached Idi. The first cub ran to Idi, and they touched noses. Idi turned away from the cub to look at the lagoon, and the cub moved about 8 m back toward the other cub. WC stopped briefly when 5 m away from Idi and then slowly approached her. She was still facing the lagoon at this time. When WC was about 1 m from Idi and between her and her nearest cub, she turned slightly toward him, then swung her head around and swatted at him with a forepaw. WC turned and ran with Idi in pursuit. When WC slipped on a muddy area within 15 m of where he had first turned to run, Idi caught him by the neck and threw him onto the mud. WC struggled to rise, but Idi kept him pinned. She bit his head at least five times and shook him by the neck. At 1238 h, Idi tore at his right hind leg, and WC made his last effort to rise. At this time, Idi bit him several more times around the head. She then moved back to the leg from which she ate a small amount. She also opened WC's visceral cavity.

When Idi first pursued WC, her two cubs ran away briefly and then sat down within 10 m of where Idi killed WC. Both cubs began bawling within two minutes of the start of the altercation. Apart from raising her head several times, Idi did not appear to respond to these vocalizations. Idi stayed on or near the carcass and appeared to be eating occasionally until 1430 h, when the tide began to rise and cover the carcass. Idi and her cubs left, and we did not see them in the area again in 1985.

Examination of WC's carcass revealed that the neck was not broken, and the trachea was not damaged. The cranium had been punctured by at least two bites. WC weighed approximately 70 kg and was less than 10% consumed. Both femurs and part of the pelvic girdle were exposed. Most of the meat consumed was from the hindquarters and thighs. Although WC had been living on his own for over a month, he appeared to be in good condition. His stomach was filled with fish, fish roe, and cow parsnip (*Heracleum lanatum*) seeds. Although the visceral cavity was opened, nothing in it had been consumed.

We pulled WC's carcass to the outside of the gravel spit, but within 24 hours a subadult bear had dragged it back inside the spit. During the next week the carcass was scavenged to bones by gulls and ravens. Another female bear accompanied by a single cub was observed briefly feeding on the carcass several times.

This killing was most likely caused by WC's proximity to Idi and her cubs. Idi had not acted aggressively toward WC during earlier approaches when he was seen as close as 15 m from Idi. He was killed when he was positioned between the female and her closest cub. WC may have escaped had he not slipped on the mud. Because of this slip, he was unable to outrun Idi, or to stop, turn, and assume a submissive posture which normally defuses aggression (Egbert and Stokes 1976; Bledsoe 1987; Aumiller and Matt *in press*).

Our second observation was a killing of two cubs (accompanied by their mother), by an adult female with cubs of her own on 21 July 1986 at 1410 h. Our attention first was drawn to this interaction by loud growling and roaring that resulted from a fight between an adult female ("McBride") and another adult female ("Fossey") in the water at the mouth of Mikfik Creek.

During the fight, Fossey was accompanied by two cubs, whereas McBride's three cubs were on a bench above the lagoon, about 1 km from the fight. Fossey's cubs tried to stay close to her as she fought with McBride. McBride picked up one of Fossey's cubs by its neck, shook it, and dropped it, still alive, into the water as Fossey pressed the fight. When McBride and Fossey reached the shore, McBride ran after Fossey's cubs and caught one as they ran back toward their mother. McBride, with this cub in her mouth, disappeared from our sight behind a gravel bar for about 1 min. Once we saw this cub's body as it was tossed into the air, its hide partially separated from its body. Fossey went to the other cub and looked back at McBride (who was 30 m away). McBride ran toward her and caught the second cub. Fossey made a brief attempt to interfere, but after less than 1 min she went to the carcass of the first cub (still out of sight behind the gravel bar), lowered her head as though to sniff it, and then moved away, favoring one of her hind feet. She bedded down facing McBride and the cubs' carcasses, about 100 m away. Meanwhile, McBride fed on the second cub for less than 2 min. Both cubs were dead within 7 min of the time that we first heard roaring.

After feeding on the second cub, McBride began giving a low grunt of the type we have commonly heard from females separated from their cubs. After lifting her head from the carcass and sniffing the air several times, she left the second cub's body, now afloat on the rising tide, and started to swim across the mouth of Mikfik Creek to her cubs. At this time we saw a small unknown bear (estimated to be 2.5 years old) walking about 100 m away from McBride. McBride's three cubs followed this bear at a distance of about 5 m. When McBride was halfway to her cubs, this lone bear ran off and McBride went to her cubs.

Later on the same day (approximately 2205 h), we heard roars from the mudflats near the MRSGS campground. We saw Fossey within 3 m of McBride and her three cubs. Several times McBride and her cubs ran away a short distance; then McBride turned in an apparent effort to block Fossey from her cubs. Fossey did not make contact with the cubs, and the McBride family group eventually moved to the base of a bluff. McBride and her cubs climbed the bluff to a ledge near the top. With her cubs behind her, McBride turned to face Fossey, still at the base of the bluff. At one point, Fossey climbed a short distance up the bluff towards McBride. This apparent standoff continued for nearly an hour, after which McBride and her cubs moved over the top of the bluff into the brush. Fossey climbed to the ledge where McBride and her cubs had been, sniffed around and returned to the beach. Later she tried to climb the bluff by a different route. Our observations on this day were curtailed by darkness. The following day, Fossey again tried unsuccessfully to reach McBride's cubs while the bears were at McNeil River falls, approximately 1.5 km from the lagoon. However, we did not observe any physical contact between these bears.

We examined the carcass of the first cub killed, a male. The head had a large puncture mid-sagitally and the body had two other major wounds, both dorsal. The pancreas was exposed and the backbone was severed. A second wound was just anterior to the tail. The intestines extruded through the visceral cavity and some muscle tissue was eaten from the anterior parts of the hind legs.

We found a partial skeleton, probably belonging to the second cub, several days later on a gravel bar in the lagoon. There were not enough remains to allow us to gather any information about actual cause of death of this cub.

We do not know what precipitated the fight between McBride and Fossey, as we did not observe its initial stages. It is possible that McBride was responding to a distress call from Fossey's cubs. We have occasionally seen females with cubs responding to distress calls from cubs that belong to another family group. It is also possible that Fossey and her cubs passed too closely to the McBride group. We estimated Fossey's age at 6-7 y. This was the first litter we had observed with her. Her inexperience may have contributed to the death of her cubs. This also was the first litter we had seen with McBride. McBride was an older bear (8-9 y) and weighed approximately 50-70 kg more than Fossey. Based on our observations of other interactions of these bears with other bears in the area, McBride was generally more dominant than Fossey. We suspect that Fossey was still trying to recover "her" cubs during her subsequent interactions with McBride.

A year later, McBride, accompanied by her three yearlings, killed another cub. On 26 July 1987 at about 1030 h, a female ("Melody") with two cubs ("Cub A" and "Cub B") crossed the gravel spit in the lagoon. She began fishing on the landward side of the spit, making forays into the water up to 100 m from where her cubs were sitting on the gravel spit. She returned to her cubs and they moved nearby to a large pile of driftwood. The cubs remained here while Melody moved onto the mud flats seaward of the gravel spit. At this time, McBride and her yearlings came across the spit near Melody's cubs. Melody returned to her cubs, and all seven bears were out of view briefly. What happened next was reported to us by a group of MRSGS visitors who were present on the gravel spit.

These visitors heard growling and roaring; initially they could not see fighting. They saw Cub A run eastward down the seaward beach and out of sight. In the next 10 min, McBride's family group moved to the mud flats seaward of the spit. Cub B's location was unknown. Melody moved briefly east along the spit, sniffing the ground, apparently searching for her missing cub. Within 1 min, she ran toward McBride's group and had a brief fight with McBride. After this, she ran west, crossed the mouth of McNeil River and climbed a bluff, still apparently searching for her cub.

At about 1330 h, we inspected the fight scene. There were many scuffle marks, and we found the carcass of Cub B, a male, by the water's edge. The neck was bitten severely and appeared broken. A small amount of fur and flesh was missing from one rear leg and there were many puncture wounds over the body. We moved the carcass above the tideline and placed several logs over it.

Meanwhile, Melody continued to search the area for Cub A. At about 1440 h, she returned to the carcass of Cub B, dragged it to the top of the gravel spit, and consumed a small part of it. When examined later, the carcass was missing some meat around the pelvic girdle; some of the viscera were exposed.

Throughout the afternoon, Melody continued searching for Cub A, grunting repeatedly and walking rapidly. At about 1830 h, Cub A appeared on the beach near camp, about 0.75 km from where it was last seen. Melody, behind camp and about 0.25 km from the cub, apparently heard the cub vocalizing, and moved to it. She nursed the cub for at least 5 min, then both lay down.

We saw Melody occasionally for the next week, during which time she lost Cub A, last seen alive on 31 July. We did not see this loss, but on 17 August we found the carcass of a similarly-sized and colored male cub near the McNeil River Falls. He was found in a stand of alders Melody frequented after losing Cub A. The cub appeared to have been dead for several days. Very little meat was consumed. The carcass had only one large wound, on the right flank. We speculate that the cub received this wound from a bear at the falls and died a day or two later.

In contrast to the above three instances of conspecific killings by adult females, on 20 July 1991 we observed an adult male kill and eventually eat a cub at McNeil River Falls. At approximately 1525 h on the west side of McNeil River and opposite from the viewing pad, an 8-9 year old female ("Molly") was fishing. Her two cubs stayed in the grass along the bank when she followed another adult, which had a salmon. She was approximately 30 m from her cubs when an adult male approximately 10 years old ("PB") noticed the two cubs and approached them. They attempted to flee, but he caught one by the hindquarters and held it for several seconds before letting it drop from his mouth. The cub tried to run away again, but PB caught it before it had gone more than 6 m. He picked it up by the neck and shook it violently. The cub immediately went limp and appeared to be dead. PB carried the cub 10 m to the water's edge and put it down. He sniffed and gently pawed at the cub for a minute without opening the carcass and then left.

Molly became aware of the missing cubs while PB was still sniffing this carcass. She approached within 15 m of PB, searching for her cubs. However, she did not seem to notice the dead cub and did not approach PB or the dead cub any closer. She continued to search for the cubs, moving away from PB.

After leaving the carcass, PB moved downstream 50 m and fished cursorily for less than one minute. At 1534 h, he then returned to the carcass and opened the visceral cavity. PB alternately ate small amounts from the carcass and lay nearby until 1605 h, when he again wandered downstream. He returned again at 1615 h, continued to eat small amounts, and at 1626 h again left the carcass, this time perhaps due to pressure from other nearby bears. One of these bears, another adult male, approached the carcass, which was still more than half intact, and sniffed it. He wandered away at 1628 h without eating any of the carcass. At 1651 h, PB returned to the carcass and continued to eat everything but the head and paws. He left the carcass for the final time at 1656 h and returned to fishing.

At 1645 h, we observed Molly looking and sniffing at the area where the initial attack occurred. For the next 65 min, she searched for her cubs in several areas on both sides of the river. She was last seen within 6 m of the remains of the carcass, but did not stop to investigate closely. Molly was not seen the rest of the day.

Within 30 sec of PB's attack on the cub, Molly's second cub was seen in the mouth of another adult bear of unknown sex. This bear was approximately 80 m upstream of the initial incident and was moving away. Neither it nor the cub were seen again.

Molly was observed every day following the incident for two weeks. The day after this incident she showed no sign of searching for the cubs. On 24 July, she was followed at a distance of 100 m by an adult male, not PB. Apparently she was in estrous or false estrous. After this date, no males showed interest in her.

Discussion

The exceptionally high bear density at MRSGS may be a contributing factor in any or all bear interactions we have described here. In 1989, a minimum of 84 individual adult and subadult Brown Bears and 42 offspring in family groups (including cubs, yearlings, and 2.5 year olds) were observed using the area within 4 km of McNeil River Falls, including Mikfik Creek, McNeil Lagoon, and the surrounding grass flats and bluffs where the killings occurred (Aumiller and Matt *in press*). A small rise in the number of human visitors to the area may have slightly increased our opportunities for observing these interactions, since we spend proportionally more time travelling to bear-viewing areas and supervising the visitors remaining in camp.

Alaska Department of Fish and Game personnel have monitored bear and human activity at MRSGS for 21 years. During this period, only the four incidents reported here resulted in mortalities in which the sex of the bear that did the killing was known. However, during this same period, two cubs were killed in separate instances by bears of unknown sex, classified as adults based on size. In studies carried out by ADFG at McNeil River in the early 1960s, the loss of three cubs from unknown causes was documented (Glenn et al. 1976). In 1989, an adult male attacked and wounded a cub that was separated from its family group. This cub's mother intervened, and the cub survived the incident. In over 7000 hours of observation in 18 years of monitoring by the authors at MRSGS, this and the incident involving PB are the only documented occurrences of a known adult male attacking a cub.

We do not imply that the incidents reported here indicate that adult female brown bears are more likely than males to kill conspecific juveniles. However, our observations added to Murie's (1981) demonstration that killing of unrelated offspring by adult female Brown Bears does occur. The circumstances of these kills, as well as the small amount of tissue consumed by the bears doing the killing in three of the four instances, and the lack of defense of the carcasses, indicate that sustenance needs were not primary motives for these attacks. Our observations support the contention of Miller (1990) that biologists should be cautious about assuming density-dependent relationships between subadult recruitment and number of adult males in populations of Brown Bears. Conspecific predation of subadults by unrelated female bears may, in fact, increase female fitness if it makes more resources available to a female's own offspring (LeCount 1987). However, this may be less of a factor in a food-rich environment like MRSGS.

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Premières mentions de l'écrevisse *Orconectes immunis* au Québec

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L'écrevisse *Orconectes immunis* a été récoltée au lac Long, comté de Terrebonne, Québec, dans la municipalité de Saint-Faustin, en juillet 1991. Des recherches auprès du Musée canadien de la nature ont permis d'établir qu'il s'agit d'une troisième localité connue au Québec, les deux autres etant le lac des Îles, comté de Labelle, et le lac de la Vieille, parc de la Verendrye, comté de Pontiac.

Orconectes immunis (Hagen) was collected at Long Lake in the municipality of Saint-Faustin, Terrebonne County, Québec, in July of 1991. Two previous locality records from Québec Province are in the collections of the Canadian Museum of Nature from lac des Îles, Labelle County and lac de la Vieille, Verendrye Park, Pontiac County.

Mots clés: Écrevisse, *Orconectes immunis*, Québec, habitat, répartition, identification.

La découverte de la présence de *Orconectes immunis* dans le lac Long (46° 02′ 30″ N et 74° 32′ 30″ O), situé à la source du ruisseau Long, dans le bassin de la rivière Rouge, sur le territoire de la municipalité de Saint-Faustin, nous a amenés à vérifier si la présence de cette espèce au Québec avait déjà été rapportée. Nous n'avons trouvé aucune mention dans la littérature, mais des vérifications effectuées auprès du Musée canadien de la nature ont révélé l'existence de deux collections en provenance du Québec (Laubitz, communication personnelle, 1992). Voici tous les renseignements que possède le Musée concernant ces captures:

1) Échantillon n° NMCC1991-1157: Lac des Îles (46° 27′ 52″ N, 75° 32′ 00″ O), comté de Labelle (Québec), le 26 juillet 1971. Chalut, prof. 12 - 20 m. Une femelle. Collection: M. J. Dadswell. Identification: B. Chenoweth.

2) Échantillon n° NMCC1991-1162: Lac de la Vieille (46° 46′ 00″ N, 76° 14′ 00″ O), parc de la Vérendrye, comté de Pontiac (Québec), le 10 mai 1974 (bord du lac). Trois mâles. Collection: F. W. Schueler, N° FWS4305. Identification: B. Chenoweth.

Ces trois collections de *O. immunis* représentent à la fois les trois premières mentions pour le Québec et une extension d'aire importante pour cette espèce. Le lac Long se situe, en effet, à 225 km au nord-est du lac Opinicon (Chaffeys Locks, Leeds County) et à 300 km à l'est du lac Opeongo (parc provincial Algonquin), en Ontario, les deux stations connues pour la capture de cette espèce qui se trouvent le plus près du lieu de notre récolte (Crocker and Barr 1968: 107, figure 78). *O. immunis* a aussi été rapporté pour la localité de Fort Covington dans l'État de New York, juste au sud de la frontière canado-américaine près de Dundee, Québec, soit à 355 km au sud de Saint-Faustin (Crocker 1957 : 73, figure 4).

Les deux individus du lac Long ont été capturés à midi, le 10 juillet 1991, au moyen d'une nasse installée depuis 10 h 45 la veille. Il s'agit d'un mâle de la forme I et d'une femelle mesurant respectivement 30,50 et 30,85 mm de longueur du céphalothorax. La nasse contenait aussi 75 Ventre rouge du nord (*Phoxinus eos*) et 15 Mulet à cornes (*Semotilus atromaculatus*). L'engin mouillait tout près de l'extrémité nord-ouest du lac, à une profondeur de 1 - 1,5 m, sur un fond limoneux dans un herbier aquatique dominé par le Nénuphar à fleurs panachées (*Nuphar variegatum*) et le Nymphéa odorant (*Nymphaea odorata*). Les spécimens sont conservés dans la collection du ministère de l'Environnement et de la Faune à Montréal sous le n° 0044.

Le spécimen de M. J. Dadswell, une femelle de 39,0 mm de longueur du céphalothorax, a été capturé alors que le chalut pêchait par environ 12 m de fond; il se trouvait parmi des poissons tels le Chabot visqueux (*Cottus cognatus*), le Chabot à tête plate (*Cottus ricei*) et l'Épinoche à neuf épines (*Pungitius pungitius*). La température de l'eau était de 10°C, la teneur en oxygène dissous, de 7,0 mg/l et le pH, à 6,8 (Dadswell, communication personnelle, 1993). Bien que la présence d'une écrevisse à cette profondeur soit quelque peu inhabituelle, ce n'est pas la première fois qu'un phénomène semblable est observé chez des écrevisses femelles. En effet, Momot and Gowing (1972) mentionnent que chez *Orconectes virilis*, la migration des femelles adultes vers les eaux profondes débute tôt, qu'en août, la majorité des femelles se retrouvent à des profondeurs de 6,1 m et plus, et qu'elles s'avèrent particulièrement abondantes à 7,6 m. Fast and Momot (1973) associent cette migration à un déplacement des femelles vers les eaux profondes par les mâles, plus agressifs, qui se réservent les eaux plus chaudes.

Les trois spécimens de F. W. Schueler, des mâles de la forme II mesurant entre 18,5 et 20,0 mm au céphalothorax, proviennent du secteur nord-ouest du lac de la Vieille où ils ont été trouvés dans une zone de faible profondeur, sur un fond très sableux (Schueler, communication personnelle, 1993).

O. immunis se distingue aisément de *O. virilis*, l'écrevisse de la faune québécoise qui lui ressemble le plus, par la présence d'une encoche près de la base, sur le côté intérieur du mors mobile (dactylopodite) des pinces, caractère déjà visible chez les jeunes individus et qu'on ne rencontre chez aucune autre espèce locale. La forme du rostre est aussi différente, celui-ci étant plus effilé et présentant une dépression centrale plus prononcée chez *O. immunis*, où les épines latérales sont réduites ou absentes (Helgen 1990). Les gonopodes de la forme I s'avèrent aussi très différents (Crocker 1957: 27, figures 1 et 3; Crocker 1979: 228; Crocker and Barr 1968: 61, figures 22 et 23). Moins recourbés et plus long chez *O. virilis* (figure 1A), ils atteignent la marge postérieure de la base de la première paire de pattes thoraciques quand l'abdomen est replié, tandis qu'ils dépassent à peine la marge postérieure de la seconde paire chez *O. immunis*. Les gonopodes de la forme II et le gonopore (figure 1B) diffèrent aussi, mais à un point moindre. La fossette principale (dépression du gonopore) est déplacée vers la droite de la femelle chez *O. immunis*, ce qui fait paraître le gonopore nettement asymétrique. Ce patron peut être occasionnellement inversé, mais il est distinct même chez les jeunes femelles (Helgen 1990).

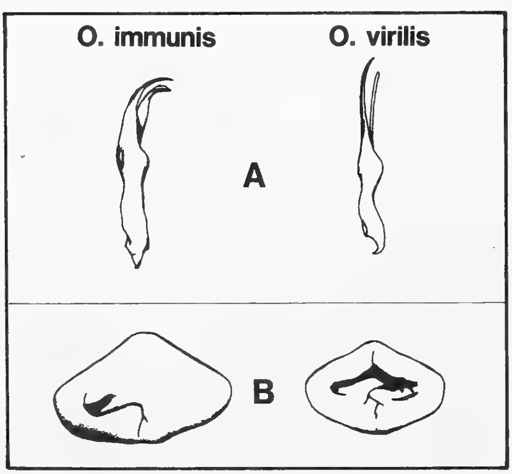

FIGURE 1. Organes génitaux externes chez Orconectes *immunis* et *O. virillis*. A: Gonopodes des mâles de la forme; B: Gonopores des femelles (d'après Helgen 1990).

O. immunis est une écrevisse indigène de l'est de l'Amérique du Nord. Son aire de répartition aux États Unis est présentée par Hobbs and Jass (1988: 52; figure 35). Elle s'étend du Colorado à la Nouvelle-Angleterre où on la rencontre dans les six états (Crocker 1979; Crocker and Barr 1968). L'espèce est aussi présente dans l'état de New York (Crocker 1957), le Michigan (Creaser 1931), le Wisconsin (Creaser 1932; Hobbs and Jass 1988) et le Minnesota (Helgen 1990); à travers l'Iowa, l'Illinois, l'Indiana (Hobbs and Jass 1988) et dans certains bassins versants du Kentucky (Rhoades 1944), du Tennessee, de l'Oklahoma (Creaser and Ortenburger 1933), du Kansas, du Nebraska, du Dakota du Nord et du Dakota du Sud (Hobbs and Jass 1988).

Au Canada, mis à part les deux régions ontariennes mentionnées plus haut, son aire de répartition connue était restreinte, dans le bassin des lacs Huron et Érié, à un triangle limité au nord-est par une droite imaginaire qui réunirait l'extrémité sud-est de la baie Georgienne à la péninsule du Niagara (Crocker and Barr 1968: 107, figure 78). Cependant, depuis 1975, *O. immunis* a été rencontré dans plusieurs localités ontariennes et manitobaines situées au-delà de cette région, notamment à Snake Bay (Schueler, communication personnelle, 1993; Karstad and Schueler, This fragile inheritance: A painter's ecology of glaciated North America, en préparation, ms page 106.). La première mention dans cette province remonte toutefois à 1969 (Popham and Hancox 1970). Bousfield (1969) n'inclut pas *O. immunis* parmi les espèces de la région d'Ottawa et nous ne l'avons rencontré dans aucune des collections examinées, en provenance de l'Estrie et de la Montérégie, au Québec. Cela tend à confirmer une hypothèse de Crocker (1979) à l'effet que *O. immunis* pourrait avoir gagné la Nouvelle-Angleterre par plus d'une voie le long des frontières entre l'état de New York et le Vermont et entre l'état de New York et le Massachussetts, si sa présence n'y résulte pas d'une introduction par l'homme.

Enfin, Crocker and Barr (1968) mentionnent qu'il semble que l'extension vers le nord de son aire de répartition soit sévèrement freinée par la limite sud du bouclier précambrien. Bien que nous ne possédions pas d'autres collections qui permettraient de déterminer si la présence de *O. immunis* au Québec est due à une extension d'aire naturelle ou à une introduction humaine, nous considérons cette dernière hypothèse comme la plus plausible, compte tenu de la discontinuité de son aire de répartition connue.

La plupart des auteurs consultés s'accordent pour décrire l'habitat de *O. immunis* comme étant les eaux peu profondes sur fond mou avec végétation abondante tel que les fossés, les étangs, les lacs et les marais. Les données de captures inédites de Schueler (communication personnelle, 1994) en Ontario et au Manitoba, de 1984 à 1986, confirment que l'espèce utilise des habitats variés: fossé et bordure de route, rive marécageuse, lac tourbeux, étang de gravelière, littoral de lac.

C'est une espèce qui peut tolérer de faibles teneurs en oxygène dissous et s'enfouir quand le milieu s'assèche. D'après Schueler (communication personnelle, 1994), les cheminées de boue érigées à l'entrée des terriers constituent généralement le meilleur indice de sa présence. Il a, en effet, observé de telles structures à toutes les stations excepté celles du Québec et du lac Crab, district de Sudbury en Ontario, à quelque 195 km à l'ouest de la frontière du Québec.

Une étude de Bovbjerg (1970), réalisée en laboratoire, tend toutefois à démontrer que *O. immunis* aurait préférer les habitats à fond rocheux de *O. virilis*, mais qu'il a été déplacé suite à la compétition avec cette dernière espèce, vers les herbiers limoneux auxquels il s'est assez bien adapté. L'habitat d'où proviennent nos captures correspond à la description livrée par la majorité des auteurs pour *O. immunis*, mais nous ne possédons pas pour le moment d'indice de la présence de *O. virilis* dans cette région.

La valeur économique de *O. immunis* n'est pas aussi élevée que celle de la plupart des autres espèces du Québec, à cause surtout de sa taille qui en diminue l'intérêt pour le consommateur. C'est cependant la seule espèce dont l'élevage était recommandé pour rentabiliser la production de poissons-appâts en étang artificiel dans l'état de New York (Forney 1956) où elle est très répandue, et sa taille est idéale pour servir d'appât pour la pêche. Encore aujourd'hui, c'est toujours la seule espèce faisant l'objet d'élevage aux États-Unis (Huner 1990), mais l'élevage de *Orconectes virilis* a fait l'objet d'évaluation (Brown et al. 1990). Au Québec, depuis 1992, des permis ont été accordés pour l'élevage expérimental de *O. virilis* et *O. limosus*.

Ces collections de *O. immunis* portent à six le nombre d'espèces d'écrevisses maintenant répertoriées au Québec, à savoir, *Cambarus bartoni*, *Orconectes propinquus*, *O. virilis* (Bousfield 1969), *O. limosus* (Couture et Savignac 1984; Crocker, communication personnelle, 1988), *C. robustus* (Dubé et Provost 1990) et *O. immunis*. Le nombre relativement élevé d'additions récentes à la faune des astacidés du Québec montre à quel point notre connaissance de ce groupe de décapode est déficiente et constitue un encouragement à continuer d'y apporter une attention particulière.

Remerciements

Nous tenons à remercier les membres des équipes techniques du Service de l'aménagement et de l'exploitation de la faune du ministère de l'Environnement et de la Faune à Saint-Faustin, sans la vigilance desquels la présence chez nous de *O. immunis* n'aurait pu être établie. Nos remerciements s'adressent aussi à MM. M. J. Dadswell (Acadia University, Faculté des sciences, Wolfville, Nouvelle-Écosse B0P 1X0) et F. W. Schueler (Musée canadien de la nature, C.P. 3443, Succ. "D", Ottawa, Ontario K1P 6P4) qui ont bien voulu contribuer à compléter nos renseignements sur leurs captures en répondant à nos demandes. Nous sommes aussi redevables à M. D. W. Crocker (118 White Street, Saratoga Springs, New York 12866) pour nous avoir transmis ses données de collection d'écrevisses au Québec en 1970. Nous remercions, enfin, Ms D. R. Laubitz, responsable de la collection de crustacés au Musée canadien de la nature, qui nous a facilité l'examen des échantillons québécois de *O. immunis* en nous consentant un prêt postal.

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A Survey of the Nematode Parasite *Parelaphostrongylus tenuis* in the White-tailed Deer, *Odocoileus virginianus*, in a Region Proposed for Caribou, *Rangifer tarandus caribou*, Re-introduction in Minnesota

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A project to restore Woodland Caribou (*Rangifer tarandus caribou*) to Minnesota commenced in 1989. A possible major limiting factor for Caribou in this region is the parasite *Parelaphostrongylus tenuis*, a nematode carried by White-tailed Deer (*Odocoileus virginianus*) that is fatal to Caribou. During 1989 and 1990 we surveyed the distribution of this parasite and deer in a region of northeastern Minnesota proposed for Caribou reintroduction. Deer are not known to winter within the proposed region but do spend summers in the area. We collected fresh deer pellets to document the frequency of *P. tenuis* and deer presence. On winter range, pellet analysis indicated that 57% of the deer could be infected with *P. tenuis*. However, the incidence of *P. tenuis* in deer spending summers within the proposed reintroduction area was 27%. Overall gastropod infection rate was ≤ 1%. Summer distribution of deer was patchy. A 500 km^2 area appears to have low deer densities with an adequately low incidence of *P. tenuis* which may allow for successful Caribou reintroduction, if *P. tenuis* was a potential significant limiting factor.

Key Words: White-tailed deer, *Odocoileus virginianus*, nematode, *Parelaphostrongylus tenuis*, Woodland Caribou, *Rangifer tarandus caribou*, Minnesota, infection incidence.

In the early 1900s, Woodland Caribou (*Rangifer tarandus caribou*) were common in northern Minnesota, but by 1942 they had disappeared from the entire state (Fashingbauer 1965; Karns and Lindquist 1986*) except for a single sighting in the extreme northeastern corner of the state during the winter of 1981-1982 (Peterson 1981; Mech et al. 1982). Four factors have been implicated in the demise of Minnesota Caribou: increased hunting, Timber Wolf (*Canis lupus*) predation, increased numbers of White-tailed Deer (*Odocoileus virginianus*) the normal host of *P. tenuis* which is fatal to Caribou, and habitat alteration (Bergerud 1974; Bergerud and Mercer 1989; Gogan et al. 1990).

Restoration of Caribou to Minnesota has been pursued several times, only one of which, between 1938-1941, involved the release of animals and was unsuccessful (Fashingbauer 1965). This study is part of a current initiative, started in 1988 by the North Central Caribou Corporation, to restore Caribou to Canadian and United States border lands of the upper Great Lakes (Gogan et al. 1990). Feasibility studies have paralled a similar analysis carried out 10 years earlier, which recommended that Caribou reintroduction was feasible but such efforts did not materialize due to lack of funding (Karns and Lindquist 1986*).

*See Documents Section.

The general objective of the present effort is to identify whether this region has potential to sustain a natural population of Woodland Caribou. Criteria for such an area include appropriate natural forage and cover for the species; a relatively low density predators (i.e., Timber Wolves, *Canis lupus*; Black Bears, *Ursus americanus*); and the absence or low density of the White-tailed Deer which are host to the nematode *P. tenuis* or the "brain worm" that are often fatal to Caribou (Bergerud and Mercer 1989). Karns and Lindquist (1986*) identified Little Saganaga Lake in the northeast corner of Minnesota as the best area for Caribou restoration effort (Figure 1). In view of the renewed interest in Caribou restoration, it is critical that this region be re-examined as a Caribou reintroduction area.

One important aspect of the evaluation process concerns determining the prevalence of *P. tenuis* in the region of the targeted site. The specific objectives of this study, carried out during the spring and summer of 1989 and 1990, were to map the extent of land area with an apparent very low deer density and to determine the *P. tenuis* infection rate in deer and gastropods in that region.

Study Area

The study area, comprised of parts of Cook, Lake, and Saint Louis counties in northeastern Minnesota. It included the Little Sagana Lake Aria lying entirely within the Boundary Waters Canoe Area Wilderness

(BWCA) of the Superior National Forest (48°N, 92°W), three major deer wintering areas, and much of the remainder of the Superior National Forest (Figure 1). While there has been no logging and relatively little fire in the Boundary Waters Canoe Area Wilderness for several decades, forests still represent various stages of intermediate and advanced maturity, with both deciduous and conifer-dominated sectors (Heinselman 1973). The vegetation offers adequate, if not ideal, habitat for both Caribou and deer (Broschart and Pastor 1994*).

The following account of population levels and movements of deer within the Superior National Forest was ascertained from discussions with Michael Nelson and L. David Mech who have been studying the topic intensively for the past 20 years and was supplemented with written accounts provided by Mech and Karns (1977) and Nelson and Mech (1981, 1987). During winter a large portion of the deer occur within three major wintering yards: Garden Lake near Ely, Isabella, and the Jonvick yard along the shore of Lake Superior southwest of Grand Marais (Figure 1). Nelson and Mech (personal communication) feel fairly confident that no deer winter in the interior part of the Boundary Waters Canoe Area Wilderness, even during mild winters. Nelson searched the zone in late November 1988 from the air specifically for deer sign; while seeing 16 Moose he found no sign of deer. Fred Thunhorst, Minnesota Department of Natural Resources (personal communication), searched during an aerial moose count during December 1988 and observed no sign of deer. In summer, deer are seen throughout the Boundary Waters Canoe Area Wilderness. Deer that summer in the area most likely come from one of the wintering yards listed above. In peripheral areas near Ely and Isabella, Nelson (unpublished) estimates the current deer density at 4–5/km^2, subsequently referred to as the known density area.

Deer were more numerous in the study area earlier in the century (Nelson and Mech 1986). During 1936–1939 the deer population was stable and density estimates were as high as 9/km^2 in peripheral areas near Ely and Isabella; however, the average density was closer to 4/km^2 (Olson 1938; Fredine 1940). Stenlund (1955) estimated 3.5 deer/km^2 during the early 1950s. Between 1969 and 1974 the deer population declined (Nelson and Mech 1986). Harsh winters and wolf predation were thought to be implicated in the decline (Nelson and Mech 1986). However, deer densities were estimated between 1975–1983 at 2 to 5/km^2 (Floyd et al. 1979; Nelson and Mech 1986).

Methods

Gastropods, deer pellets, deer tracks and evidence of deer presence (e.g., evidence of feeding, sightings) were recorded and collected during surveys in summer and deer pellets were collected from the Ely and Isabella deer yards in March. Gastropod and pellet samples were analyzed for the presence of *P. tenuis* following procedures described by Lankester and Anderson (1968) and Peterson and Lankester (1991), respectively.

There were 12 summer (June-August) collection trips (120 person-days) conducted throughout the study area in 1990, two summer collection trips (24 person-days) to the immediate area around Little Saganaga Lake in 1989, and two winter (March) collections (8 person days) in the Ely and Isabella deer yards. Transects averaging 1-2 km in length were made once every 2 km along routes following waterways from the periphery towards the center of the study area. Two observers recorded all evidence of deer sign (all pellets, tracks, visual sightings, and evidence of feeding) and fresh pellet groups were collected. An attempt was made to locate transects in areas which appeared to be more appropriate deer habitat.

Gastropods were collected during June and July, and were commonly found along the surface of decaying Paper Birch (*Betula papyrifera*) logs in contact with damp and decomposing litter. During the 1989 survey, gastropods were collected on every transect. During 1990, gastropods were collected throughout the study area but only after deer sign was observed in order to increase the probability of finding infected gastropods. A distinction was made between gastropods collected < 5 m from pellet groups and those collected randomly where deer sign was present, considering the former might have significantly higher incidence of *P. tenuis* larvae.

Due to the low deer densities in this region, and that no deer winter within the core of this region standard techniques could not be used to estimate density. Deer density was calculated by comparing number of fresh pellet groups collected per hour in known deer density near Ely (Nelson unpublished) to number of fresh pellet groups collected per hour in areas of unknown densities.

Snails and slugs were examined for *P. tenuis* in batches of 2–39 due to time constraints and the initial anticipation of a very low incidence of *P. tenuis*. All batches were from a single transect. When larvae were found, they were considered as originating from a single gastropod in the batch. Snails were crushed, then digested at 37°C for 24 hours in a pepsin solution (Lankester and Anderson 1968). The digested remains were spread in a watch glass and searched under 20× magnification for second- and third-stage *P. tenuis* larvae.

Pellets were analyzed for first-stage larvae using the Baerman technique (Anderson and Lankester 1974). The sample was weighed and placed in a 10-cm wide funnel lined with a filter of Kimwipe paper (Kimberly-Clark Corporation, Mississauga,

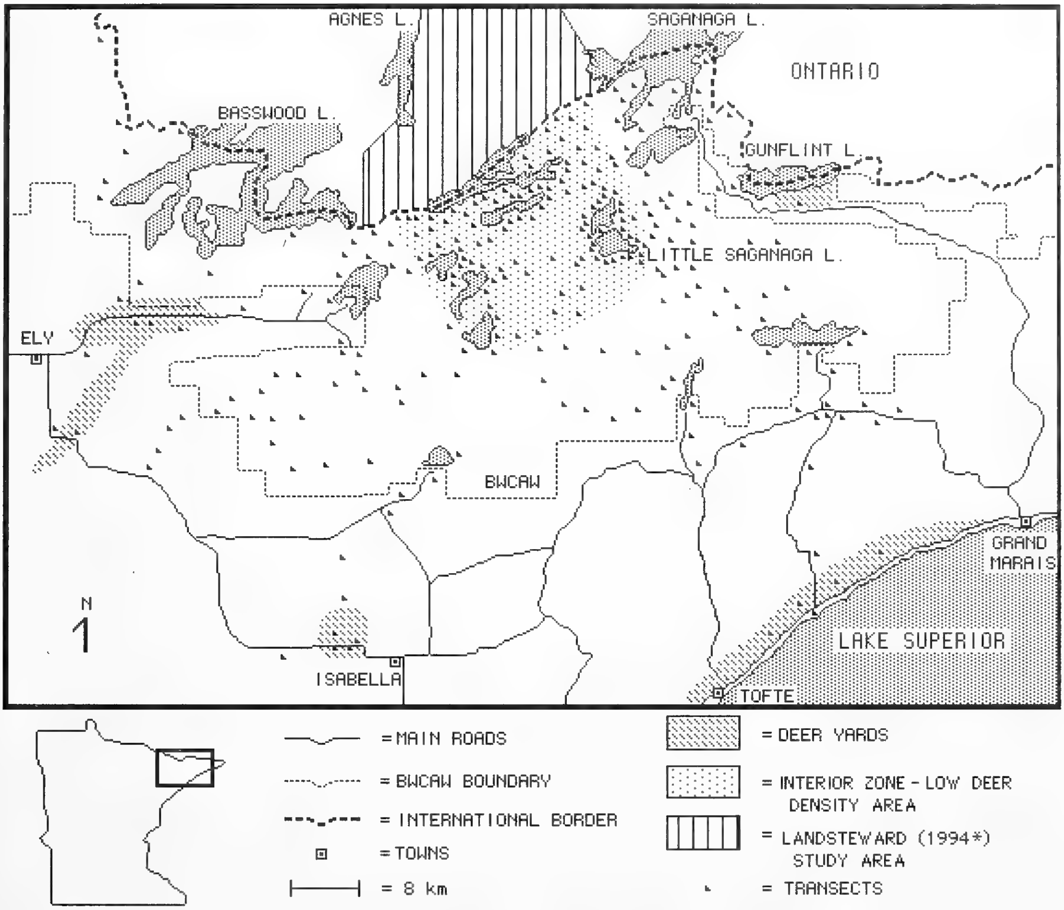

FIGURE 1. Northeastern Minnesota study area where incidence of *Parelaphostrongylus tenuis* was investigated during 1989 and 1990 in relation to proposed Woodland Caribou reintroduction.

Ontario) and closed off from below by a clamped tube fitted to the funnel stem. About 150 cc of distilled water was added to the pellets. *P. tenuis* larvae, freed from the mucus on the pellets, sink in the water and pass through the porous filter to accumulate just above the tube clamp. After 24 hours, the bottom 20 cc of water was then drawn off through the tube into a watch glass. The watch glass was illuminated from below and examined under 20× magnification. Larvae identified as *P. tenuis* were counted with the aid of a grid marked on the bottom of each watch glass.

Larval stages that were identified as *P. tenuis* possessed the following characteristics: first stage with a length of 319–490 microns, a dorsal spine, and a hooked tail; second stage larvae a granular gut and a length of 750–800 microns; and third stage with a dorsal bump and a length of 805-1085 microns (Lankester and Hauta 1989).

Results

A total of 144 person days was spent searching for snails and deer sign during 14 trips covering from 20 to 80 kilometers in length. Deer sign decreased from the periphery near the deer yards towards the center of the study area and was extremely low ≥ 32 to 38 km from the major deer yards. A 500 km^2 interior zone was identified as having extremely low deer sign. Although this area was surveyed intensively (100 transect hours), only 11 pellet groups were found. In areas with a known deer density of 5/km^2, one pellet group was found per hour searched (14 transect hours), while within the interior 0.1 pellet groups were found per hour. Based on the relationship interior deer density was 0.5/km^2. Deer sign was not uniformly distributed in the interior zone but occurred in distinct patches, leaving most of the interior zone deer free. The 11 pellet groups were found in three areas all < 5 km from the edge of the interior zone.

TABLE 1. The prevalence of *Parelaphostrongulus tenuis* in gastropods collected randomly and in areas with deer sign from northeastern Minnesota during 1989 and 1990.

Year	Area	Collection technique	Incidence %	n
1989	Little Saganaga Lake	Random	0	221
1990	Study Area	Combined	1.1	523
		Areas with deer sign	0.54	371
		< 5 m of deer pellets	2.6	152

Deer feeding was evident on Quaking Aspen (*Populus tremuloides*), Beaked Hazel (*Corylus cornuta*), Wild Sarsaparilla (*Aralia nudicaulis*), Mountain Maple (*Acer spicatum*), Bush Honeysuckle (*Diervilla lonicera*), Juneberry (*Amelanchier* spp.) and Blue Bead Lily (*Clintonia borealis*). This was evidenced by browsed twigs and leaves.

A total of 221 and 523 gastropods were collected during 1989 and 1990 respectively. Gastropods were identified using Burch (1962) as one of six species: *Anguispira alternata*, *Deroceras laeve*, *Discus cronkhitei*, *Retinella electrina*, *Stribilops labyrinthica* and *Zonitoides arboreus*, all of which are known intermediate hosts of *P. tenuis* (Lankester and Anderson 1968). Although some mixed-species batches of snails during analysis precluded listing prevalence rates by species, larvae were not found in *D. laevae* or *A. alternata*. No larvae were found in gastropods during 1989. The overall infection rate of gastropods was 1.1% in 1990; however, the majority of those infected were found in close proximity to deer pellets. When the 152 gastropods found < 5 m to pellet groups were excluded, the infection rate declines to 0.54% for 371 gastropods collected during 1990. No gastropods collected from the interior zone were infected ($n = 56$).

Gastropod infection rates varied with method of collection (Table 1). Random collecting of snails the first year of the study produced no infected snails. During the second year, gastropods collected in close proximity to pellets had a much higher infection rate (2.6%) than those collected in areas with deer sign present > 5 m from pellets (0.54%).

The infection rate was 51% for the 51 pellet groups collected throughout the study area from June through August in 1990 (Table 2). Of the 11 pellet groups found in the interior zone during 1990, 3 (27%) were infected. During 1989, 4 pellet groups were collected from the Little Saganaga Lake area and 1 was infected. In the known deer density area, 71% (10) of 14 pellet groups were infected. The prevalence of *P. tenuis* in the interior was significantly different than those collected in the known density area ($\chi^2 = 3.37$, df = 1, $p < 0.1$). Fifty-two percent (21 groups, 1990) and 53% (98 groups, 1989) of the pellet groups collected from the wintering yards in Ely and Isabella in March were infected (Table 2).

Pellet group data were arbitrarily separated into two categories, east and west, assuming pellet groups found on the west side of the study area winter near Ely and Isabella and those found on the east

TABLE 2. The prevalence of first-stage *Parelaphostrongylus tenuis* larvae in deer pellet groups from northeastern Minnesota during 1989 and 1990.

Year	Season	Location	Incidence % (% After Removal[b])	Incidence *n*	Mean Larvae/g
1977[a]	Summer	Little Saganaga Lake	4 (Unknown)	346	Unknown
1989	Summer	Little Saganaga Lake	25 (25)	4	9.98
	Winter	Deer Yards	57 (53)	98	17.69
		Ely	38 (29)	48	1.29
		Isabella	76 (66)	50	25.45
1990	Summer	Study Area	51 (41)	51	14.55
		Interior	27 (27)	11	42.33
		Intermediate	50 (42)	26	13.32
		Known Density	71 (50)	14	7.75
	Winter	Deer Yards	52 (43)	21	20.81
		Ely	53 (41)	17	11.19
		Isabella	50 (50)	4	64.06

[a]Summarized from the 1977 survey of *P. tenuis* in the Little Saganaga Lake Area (Allrect and Kanz 1977).
[b]Percent prevalence after removing pellet groups that were infected with only 1-2 larvae.

side winter near Lake Superior. Sixty-one percent of the pellets from the west side (n = 18) and 45% from the east side (n = 33) were infected but this difference was not significant ($\chi^2 = 1.14$, df = 1, $p > 0.1$). Prevalence of *P. tenuis* in deer yards was greater (74%) in Isabella than Ely (42%) and the intensity of larvae was higher in Isabella pellet groups (27.38 larvae/g) than in Ely pellet groups averaged over both years (4.59 larvae/g) (Table 2).

Discussion

The apparent low deer densities within the interior zone of the study area appear to lessen the risk of reintroduced Caribou contracting *P. tenuis*. If 27% of the deer are infected in the zone, we might predict that as many as 27% of future Caribou in the zone could become infected because they would be eating the same forage as deer. However, it is more likely that infected deer contracted *P. tenuis* in small established summer areas, and Caribou selecting different habitat would experience a lower risk of infection. The rate at which infected gastropods will be encountered by Caribou is determined by a variety of ecological factors and may be impossible to predict accurately (Lankester 1987).

Karns (1967) suggested that a Moose (*Alces alces*) could persist with a deer density up to 4.5/km^2 (10/mi^2) and this was reaffirmed by Whitlaw and Lankester (1994). As few as one or two nematodes can cause disease symptoms in Moose, however Caribou are thought to be even more susceptible to the nematode (Anderson and Strelive 1968; Gilbert 1974). Two explanations may account for this apparent difference in susceptibility: either Caribou are physiologically more vulnerable to the impacts of ingested larvae or Caribou are more susceptible to ingestion because they graze closer to the ground and are thus exposed to more infected snails than Moose that are foraging on the higher leaves of browse plants.

Parelaphostrongylus tenuis larvae cannot be distinguished from other elaphostrongyline nematodes (Prestwood 1972). However, the only other member of the group that may be present is *P. andersoni* (Lankester and Hauta 1989; Lankester 1987) and it has not been found in deer examined along the north shore of Lake Superior (Peterson and Lankester 1991). The group was distinguished from non-elaphostrongyline larvae according to the characteristics associated with the larval stage (Lankester and Hauta 1989).

It is suspected that the area of low deer density extends 15–30 km north into Canada (Figure 1). A parallel study by LandSteward (1994*) in Quetico Provincial Park obtained similar results (Figure 1). LandSteward (1994*) found 3 of 8 pellet groups infected with *P. tenuis*. Although no quantitative deer density estimates were made, LandSteward (1994*) collected 0.14 pellet groups per transect hour and concluded that the deer density was low, similar to those in the Boundary Waters Canoe Area Wilderness.

The pellet analysis results did not seem to vary greatly between years (Table 2). The level of infection is expected to vary slightly from one year to the next depending on several environmental factors (Anderson and Lankester 1968; Peterson and Lankester 1991). Our interior zone infection rate of 27% was greater than the 4% reported during a 1977 survey of the Little Saganaga Lake area (Alrecht and Kanz 1977*)(Table 2). The lower incidence of *P. tenuis* larvae in pellets during the 1977 survey may be due to collection of older pellets that may have been weathered and thus lacking larvae.

The overall low level of infection in gastropods was expected given the low deer densities within the region. Infection levels around 1% are common in randomly collected gastropods however, even in high deer density areas (Lankester and Anderson 1968). Prevalence of *P. tenuis* in gastropods would have been much lower, if snails were collected randomly throughout the study.

We suggest, to maximize the distance between Caribou and areas of higher deer densities, the initial reintroduction site should be centered at least 10 km west of Little Saganaga Lake (Figure 1). We conclude that at the present time a Caribou herd introduced into the interior zone would have a lower risk of *P. tenuis* infection than in surrounding areas. However, in the future, deer may colonize sites within the interior zone if the deer population grows substantially. This could seriously impair any restoration efforts considering the current infection rate in deer. The probability that Caribou closer to the periphery of the study area would become infected with the larvae may be as high or higher as those infection rates found in the deer population. The possible movement of Caribou into areas of higher deer densities must be considered.

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First Verified Record of the Shortfin Mako Shark, *Isurus oxyrhinchus*, and Second Records or Range Extensions for Three Additional Species, from British Columbia Waters.

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The first verifiable record of Shortfin Mako Shark, *Isurus oxyrhinchus*, from British Columbia is described. Also presented are the second Canadian records for the Pitgum Dragonfish, *Opostomias mitsuii*, and Oxeye Oreo, *Allocyttus folletti*, and southward extension of the known range of the Harlequin Rockfish, *Sebastes variegatus*.

Key Words: Shortfin Mako, Mako à Nagoires Courtes, *Isurus oxyrhinchus*, Pitgum Dragonfish, Dragon Japonais, *Opostomias mitsuii*, Oxeye Oreo, Oréo Occulé, *Allocyttus folletti*, Harlequin Rockfish, Sébaste Arlequin, *Sebastes variegatus*, distribution, British Columbia.

Several fishes were collected off the coast of British Columbia by biologists from the Pacific Biological Station or commercial fishermen and represent rare occurrences or extensions of recorded ranges for these species.

SHORTFIN MAKO SHARK, *Isurus oxyrhinchus* (Lamnidae)

A small (≈73 cm total length) Shortfin Mako Shark was captured 29 August 1992, by a tuna boat trolling at approximately 6 knots, approximately 360 km (185 nautical miles) due west of Cape St. James (51°53′N, 135°54′W). The specimen was first reported to us by a taxidermist who was unable to identify the species. Our only examination was after the specimen had been skinned, and the body and viscera discarded. The mounted specimen is stored at the Pacific Biological Station in Nanaimo, and the upper left second and third teeth were placed in the Royal British Columbia Museum (RBCM 993-00039-1).

The Shortfin Mako is distinguished by slender body and conical snout, large blade-like teeth lacking cusplets or serrations, anterior teeth considerably longer than intermediate teeth in both jaws, second dorsal and anal fin minute, origin of anal fin posterior to origin of second dorsal fin, lunate caudal fin with very small subterminal notch, first dorsal origin posterior to proximal free tips of pectoral fins, pectoral fins less than 70% of head length, and ventral surface of body white, without dark blotches found on the Salmon Shark, *Lamna ditropis* (Compagno 1984). We identified the species from the distinctive tooth structure, examination of fin shape and placement, and external coloration. External sexual characteristics of this species are evident as embryos (G. M. Cailliet, Moss Landing Marine Lab, California Department of Fish and Game, personal communication), and as the pelvic fins lack claspers, we believe the specimen to be female. Usual size at parturition is 60 to 70 cm (Compagno 1984), indicating that this was a very young fish.

The Shortfin Mako has a coastal and oceanic distribution in temperate and tropical waters worldwide. It is known in the Pacific from oceanic waters south of the Aleutian Islands to the Society Islands, including the Hawaiian Islands, and has been recorded from eastern Pacific coastal waters from central Chile to southern California and, exceptionally, from Washington State (Compagno 1984). It has been recorded, though rarely, from the Atlantic waters of Canada, to approximately 43°N (Scott and Scott 1988).

Although there have been anecdotal accounts of captures of this species in Canadian waters in the past (e.g., Bernard 1981, reported as *Isurus glaucus*, and McAllister 1990), and the species' oceanic range encompasses British Columbia, photographs and reference material from Bernard's specimen were lost. This specimen represents the first verifiable capture of the Shortfin Mako within British Columbia waters.

PITGUM DRAGONFISH, *Opostomias mitsuii* (Melanostomiidae)

Two specimens of Pitgum Dragonfish (19.6 and 18.7 cm standard length) were captured on 6 August 1991, by the R/V *W. E. Ricker*, 88 km off Vancouver Island (48°40.0′N, 126°39.3′W), with a midwater net fished at the surface. Both specimens were deposited in the Royal British Columbia Museum (RBCM 993-00031-1).

Morrow and Gibbs (1964) distinguished *Opostomias* from other members of the Melanostomiidae by the lack of an adipose fin, origin of the anal fin below that of the dorsal fin, and the first mandibular tooth fitting into a pit behind the premaxillary when the mouth is closed. The common name is a reference to this last characteristic. *Opostomias* is distinguished from other Pacific Canadian melanostomiids by the unique combination of the presence of pectoral fins and a moderately long barbel, and the placement of the pelvic fins on the ventral flanks. Counts from our specimens are: dorsal rays 23-24; anal rays 24; pectoral rays 1 + 4-5; pelvic rays 8; branchiostegal rays 10-11. The premaxillary teeth are canine, arranged in four sets—the first two single, third set double and fourth double or triple; mandibular teeth canine, arranged in four sets, the first set single or double, the second double or triple, the third and fourth single or double; and vomerine teeth, one each side. The first pectoral rays are free of the others to the base, are elongated and, like the chin barbel, possess a bulb near the tip.

Opostomias mitsuii is known from Japan (Imai 1941; Mead and Taylor 1953), California (Berry and Perkins 1966), Oregon and British Columbia (Peden 1975), where one specimen was taken off Vancouver Island (48°13.5′N, 126°26′W). The Royal British Columbia Museum has two additional specimens in their collection, both taken from the mid-Pacific near the Hawaiian Islands (RBCM 987-00198 and 987-00200).

The specimens we report represent the second verified record of the Pitgum Dragonfish in Canadian waters.

OXEYE OREO, *Allocyttus folletti* (Oreosomatidae)

An adult Oxeye Oreo, 26.2 cm standard length, was taken 28-29 October 1991, by the F/V *Arctic Ocean*, while bottom trawling in 388-540 m off Englefield Bay, Queen Charlotte Islands (approximately 53°N, 132°35′W). The specimen was placed in the Royal British Columbia Museum (RBCM 993-00033-1).

Myers (1960) distinguished adult *A. folletti* from *A. verrucosus* by the more concave predorsal profile, flatter belly, the snout profile not smoothly rounded, prominent, rugose nasal boss and the lack of two rows of enlarged scutes between the pectoral and pelvic fins. Counts from our specimen are (spines, rays) dorsal VII, 33; anal III, 31; pectoral 20; pelvic I, 6; and caudal rays i, 6, 7, i. The caudal fin was damaged during transport of the frozen specimen, and the removal of many of the lateral scales by the trawl during capture precluded precise counts of the lateral line pores.

The Oxeye Oreo has been collected from California (Myers 1960; Anderson et al. 1979) and from the Bering Sea (Cook and Long 1985). Hart (1973) reported two juvenile specimens (as *Allocyttus* sp.) taken from outside of Canadian waters, one at 50°N, 150°W, and one at Canadian Weathership Station Papa (approx. 50°N, 145°W), taken from the stomach of a Longnose Lancetfish (*Alepisaurus ferox*).

This specimen constitutes the second record of the species collected within British Columbia waters. Nagtegaal (1983) reported the first adult *A. folletti* recovered from British Columbia waters, which was captured in Hecate Strait.

HARLEQUIN ROCKFISH, *Sebastes variegatus* (Scorpaenidae)

Three Harlequin Rockfish were captured by trawl 16 May 1991 off Flores Island on the west coast of Vancouver Island (49°18.9′N, 126°36.5′W), in 86-92 m (RBCM 991-00037-1). All were mature females, with fork lengths of 17, 18 and 19 cm. A 14-cm fork length immature female was taken 19 May 1991 in a sunken gillnet set inshore, in Sidney Inlet (49°26.0′N, 126°14.5′W), in 6-15 m (RBCM 991-00038-1).

Harlequin Rockfish resemble Sharpchin Rockfish, *Sebastes zacentrus*, in possessing nasal, preocular, postocular, tympanic and parietal head spines, and having the second anal spine longer and stronger than the third (Hart 1973). The primary differences between the two are depth of body, degree of development of the symphyseal knob, and coloration. *S. variegatus* is relatively slender bodied, lacks a symphyseal knob, and is pink to deep red with darkly pigmented dorsal and caudal fin membranes with a clear red terminal band on the caudal fin, and the posterior portion of the lateral line clear of pigment. *S. zacentrus* is deeper bodied, has a strong symphyseal knob, is pinkish with dusky orange-red anal and caudal fin membranes, and has the lateral line pigmented the same as the base color of the body (Quast 1971; Hart 1973; Kramer and O'Connell 1986). Our specimens have the diagnostic complement of head spines, dorsal fin XIII, 14; anal III, 6, second spine longer and stronger than third; and pectoral 17. All four specimens lack a symphyseal knob, and have the diagnostic black membranes in the dorsal and caudal fins.

Commercial trawling on Bowie Seamount (approximately 53°16′N, 135°45′W) in May of 1993 yielded a large catch of Harlequin Rockfish (83% of a combined two-vessel catch of 46 901 kg), with small proportions of other rockfish species (G. E. Gillespie, unpublished data). Previous exploration of the seamount had not indicated that a large population of this species existed there. *S. variegatus* was not captured in 1980 (Carter and Leaman 1981), and accounted for less than 1% of the total catch in 1981 (Carter and Leaman 1982). However, these surveys used longline gear and sunken gillnets, not trawl gear. None were reported by divers in 1969 (Herlinveaux 1971). However, the species description (Quast 1971) had not been published, and the divers were likely too shallow to encounter adult Harlequin Rockfish.

Harlequin Rockfish have been encountered in small numbers off the west coast of the Queen Charlotte Islands (e.g., Lapi and Richards 1981; Leaman and Nagtegaal 1982; Gillespie and Leaman 1990). In 1993, Harlequin Rockfish were again encountered during a trawl survey off Langara Island (approximately 54°15′N, 133°W) (B. M. Leaman, Pacific Biological Station, unpublished data) and were recorded from a shrimp survey off the west coast of Vancouver Island (W. R. Harling, Pacific Biological Station, personal communication). Whether these recent reports reflect an increased abundance or extension of the distribution of *S. variegatus*, or are due to the difficulty encountered in discerning them from similar rockfish species, cannot be directly assessed. However, the scientific crews of all of the surveys are familiar with *S. variegatus*, and had not recorded them on earlier surveys in the same areas.

Harlequin Rockfish have been reported from Bowers Bank, in the Bering Sea (Allen and Smith 1988) to Goose Island Bank in Queen Charlotte Sound (Quast 1971). Allen and Smith (1988) reported unverified records from Cape Flattery, Washington, and Bodega Bay, California, but considered these questionable.

These specimens represent the southernmost verified record for the species, an extension of approximately 325 km, and represent the first inshore collection of this species. Harlequin Rockfish were previously recorded from 70-558 m (Allen and Smith 1988). These collections lend credence to the unverified record of Allen and Smith (1988), off Cape Flattery, Washington.

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Movements of Martens, *Martes americana*, in Burned and Unburned Taiga in the Mackenzie Valley, Northwest Territories

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Home range sizes and use of burned and unburned taiga by Martens (*Martes americana*) were determined in the Mackenzie Valley, Northwest Territories. Seventeen radio-marked Martens were radio-tracked an average of 8.5 (± 1.3 SE) months and relocated an average of 18 ± 3.0 times. The minimum density of Martens, including juveniles, was 1 per 6.4 km^2. Mean home range size (100% minimum convex polygon) of adults was 11.1 ± 2.5 km^2 (n = 12) and home ranges of adult males (14.2 km^2 ± 3.6, n = 7) were twice that of adult females (6.8 km^2 ± 2.3, n = 5). These ranges were large compared to those reported from other areas in North America. Eleven of 12 adult Martens had home ranges that averaged 53 ± 9% burned forest (21-year-old burn). Six adults radio-tracked for ≥ 6 months used the burn less than expected and the unburned forest more than expected; this trend held for both winter and summer.

Key Words: Marten, *Martes americana*, home range size, habitat use, Northwest Territories.

Martens (*Martes americana*) range across the entire forested region of the Northwest Territories (NWT) as far north as the Mackenzie Delta, and are the most economically important furbearing animal within the NWT. Martens have been studied across much of their North American range (*see* Strickland and Douglas 1987). However, despite the economic importance of Martens in the NWT and the need for improved management, little is known about their basic ecology in the northern boreal forest (taiga). This forest typically consists of an open canopy Black Spruce (*Picea mariana*) - terrestrial lichen (*Cladonia* spp. and *Cladina* spp.) association and is the dominant forest cover in northwestern NWT (Rowe 1972).

Forest fire is the single most important factor in the dynamics of the northern boreal forest ecosystem (Kelsall et al. 1977; Viereck 1983), but it also remains a contentious issue. The public often wishes to see greater efforts devoted to the control of fire because of the perception that all fire is deleterious to wildlife, including economically important furbearing species. Governments, however, may be faced with fixed or reduced financial and other resources. Despite the controversy, how Martens respond to forest fire in the northern boreal forest remains poorly understood. Martens were long-considered a species of mature, conifer-dominated forests (*see* Strickland and Douglas 1987), but in the northern boreal forest some evidence suggests that Martens can exploit younger, relatively open seral stages of the forest. Anecdotal information collected in Alaska (Stephenson 1984) and limited research there (Magoun and Vernam 1986) indicate that Martens occur in at least some burns, sometimes within two years of the burn event.

The objectives of this study of Martens in the Mackenzie Valley were 1) to determine their home range characteristics and 2) to determine their movements relative to a 21-year-old burn.

Study Area

The study area was 30 km^2 situated in the Mackenzie Valley (65° 15′N, 126° 49′W), approximately 20 km west of the town of Norman Wells. The climate is subarctic with annual mean temperatures in January and July of –28.9°C and +16.3°C, respectively. Mean annual snowfall and rainfall is 147 cm and 183 mm, respectively. Snow covers the area from approximately late October until early May.

Approximately half of the study area consisted of open Black Spruce-moss-lichen or Black Spruce-bog forests (Hare and Ritchie 1972). Tree height ranged from 5-10 m and trunk diameters (breast height) ranged from 4-14 cm. Tree ring counts from a random sample of cross-sectioned trunks indicated that the forest was approximately 90 years of age. The other half of the study area consisted of a 21-year-old burn (1969). This was an intense burn leaving few islands of unburned vegetation, even along watercourses. Regeneration on drier ground consisted of open to sparse deciduous vegetation (about 40% bare ground), primarily willow (*Salix* spp.)

shrub layer and a birch (*Betula* spp.) and Balsam Poplar (*Populus balsamifera*) canopy, and in wet areas a moss, lichen and Labrador-tea (*Ledum groenlandicum*) understory with sparse stunted Black Spruce. In the burn most snags were standing and any deadfall was lying directly on the ground. The study area contained several seismic exploration lines cleared over the last 10-20 years which allowed access by snowmobile in winter and by foot in summer. No fur-harvesting occurred on the study area.

Methods

Martens were captured in 75 × 20 × 20 cm Tomahawk traps (Tomahawk Live Trap Co., Tomahawk, Wisconsin) spaced at 400-600 m intervals along seismic lines for periods of 4-7 days. Traps were baited with raspberry (*Rubus* sp.) jam and sardines (*Clupea harengus*) and were checked daily, except when overnight temperatures fell below –25°C when they were checked twice per day. Trapping periods were in spring (early June), autumn (September), and periodically during the winter (December-March) from February 1990 to October 1992. Martens were run into a capture cone and immobilized with Telazol (A. H. Robbins Co., Richmond, Virginia; 0.06-0.08 mg/animal). All Martens were weighed, ear-tagged, and a pre-molar tooth was pulled for age determination by cementum analysis (Matson's Laboratory, Milltown, Montana). A 35-45 g radio transmitter (Lotek Engineering, Aurora, Ontario; Telonics, Mesa, Arizona) was affixed to each Marten by means of a neck collar. All Martens were released at the point of capture. Relocation of radio-collared Martens was attempted every 10 days using a Bell 206B helicopter. Locations were plotted on 1:50 000 topographical maps. The accuracy of aerial relocations was tested at the outset of the study by placing transmitters randomly in the study area and having personnel search for them. Aerial relocations of 10 test transmitters resulted in an average accuracy of 242 ± 100 (SE) m. Sixty per cent of these relocations were < 100 m of true. Location data were analyzed using the program HOME RANGE (Ackerman et al. 1990). Home ranges of Martens were described by 100% minimum convex polygons (Mohr 1947).

The vegetational composition of Marten home ranges was determined using SPANS Geographic Information System (GIS) analysis of stretch enhancements of satellite imagery (Landsat Thematic Mapping -30 × 30 m pixel). The following four vegetation types were used: burn, spruce forest, spruce bog, and riparian. Use of these four vegetation types relative to abundance was determined by calculating Bonferroni intervals from the expected and observed number of relocations in each vegetation type (Byers et al. 1984). The expected number of relocations in each vegetation type was calculated by multiplying the proportion of each vegetation type within the minimum convex polygon composed of the home ranges of all Marten by the total number of relocations. For seasonal analysis, the proportion of each vegetation type was that within the minimum convex polygon composed of the winter (November-April) and summer (May-October) home ranges of all Martens. All means are presented with their associated standard errors.

Results

Between March 1990 and January 1992, 17 Martens were radio-tracked an average of 8.5 ± 1.3 continuous months (range = 4-23 months). Martens were located 305 times, an average of 18 ± 3.0 relocations per animal. The mean number of locations for adult males, adult females, and juveniles was 21, 20, and 12, respectively. There was no relationship between the number of locations for each individual and the corresponding home range size ($F = 0.02$, $p > 0.05$)(Buskirk and McDonald 1989). The interval between relocations was ≥ 10 days, therefore, dependence of consecutive relocations was not a factor.

Twelve Martens were ≥ 1 yr old when initially captured while five were juveniles born in the spring and radio-tracked during their first winter only. There was a minimum of six adult Martens using an area of 54.0 km^2 (outer bounds of combined home ranges) for a density of one adult per 9.0 km^2. Including juveniles, there was a minimum of 10 Martens using 63.5 km^2, a density of one per 6.4 km^2. Although the density estimates should be considered minimum values, our saturation trapping pattern and frequent recaptures suggest that most Martens residing within the study area were captured.

One juvenile female was trapped 50 km from the study area in December 1992 after last being relocated in March 1992, and two other juveniles (one male and one female) died of unknown natural causes on the study area during their first winter. One juvenile male was caught by a trapper on the periphery of the study area in December 1992. No mortality among adult Martens was observed.

Mean home range size for 12 adult Martens was 11.1 ± 2.5 km^2. Although the mean home range of males (14.2 ± 3.6 km^2, $n = 7$) was larger than those of females (6.8 ± 2.3 km^2, $n = 5$) by a ratio of 2.1:1, the difference was not significant ($t = -1.6$, $p = 0.14$). The mean home range size for the five juveniles was 12.8 ± 6.0 km^2.

Eleven of 12 adult Martens had home ranges that incorporated 3% to 92% of the burn ($\bar{x} = 53 \pm 9\%$). Six of these were radio-tracked for ≥ 6 months and were used for habitat analysis. The burn and the unburned Black Spruce forest together comprised 94% of the total area used by these six Martens. All Marten locations were pooled since there were no differences among individuals in frequency of locations in the burn ($\chi^2 = 5.2$, df = 5, $p > 0.05$) or the unburned forest ($\chi^2 = 8.9$, df = 5, $p > 0.05$). Bonferroni analysis of the pooled data indicated that these Martens were observed in the burned portion of their ranges less, and the spruce forest more than expected based on the amounts of these vegetation types within the total area used (Table 1). The small amounts of spruce bog, riparian and unclassified vegetation types were used according to their availability. Analysis by season indicated that this pattern of habitat use held for both summer and winter (Table 1). The home ranges of four juveniles radio-tracked for six months in late summer and into winter contained greater amounts of burn (70 ± 15%) than did those of the six adults, but this difference was not significant ($Z = 0.96$, $p > 0.05$). The home ranges of one adult and one juvenile, radio-tracked for 14 and 5 months, respectively, were entirely within the burn. In addition, an adult female whose home range was partially in the burn, denned and produced young within the burn.

Discussion

Martens in this study had larger home ranges than reported in most other studies. The home range size for radio-tracked Martens averaged from studies in Wyoming, Minnesota, Wisconsin, Maine (cited in Strickland and Douglas 1987 and Buskirk and McDonald 1989), and Ontario (Thompson and Colgan 1987) was 7.5 km^2 and 3.8 km^2 for males and females, respectively, compared to the 14.2 km^2 and 6.7 km^2 in this study. Only Martens from western Newfoundland had larger home ranges (17.7 and 27.5 km^2), but this was based on only two individuals (Bateman 1986). The home ranges of Martens in the Mackenzie Valley were 35% larger than those in other northern boreal regions in the Yukon (Archibald and Jessop 1984) and Alaska (Buskirk 1983; Magoun and Vernam 1986). Body weights of adult male Martens in this study ($\bar{x} = 1319$ g) did not differ significantly ($t = -0.12$, $p = 0.9$) from the weights of male Martens in Alaska (Buskirk 1983), thus the larger home ranges in this study were likely not solely a result of differences in body size (Harestad and Bunnell 1979; Buskirk 1983). The male:female ratio of home range size in this study (2.1:1), however, was slightly larger than that reported by Buskirk (1983; 1.8:1) and Archibald and Jessop (1984; 1.3:1). As found elsewhere (Strickland and Douglas 1987), the home ranges of adults and juveniles overlapped widely.

It has been suggested that a dense complex of logs and deadfall, preferably in association with a low overstory, is important to Martens if they are to exploit open areas such as burns (Koehler and Hornocker 1977; Hargis and McCullough 1984). Deadfall and overstory provide protection from both avian and terrestrial predators (Thompson 1994). Furthermore, deadfall, if it is of sufficient height, allows access to sub-nivean spaces for hunting small mammals (Hargis and McCullough 1984; Magoun and Vernam 1986). Despite most deadfall lying directly on the ground, Martens used the burn in both winter and summer. How they accessed sub-nivean space to obtain prey (Douglass et al. 1983; Hargis and McCullough 1984; Magoun and Vernam 1986) and avoided possible predation was unknown. Martens using such a born may rely more on surface hunting of prey such as Snowshoe Hares (*Lepus americanus*).

Although Marten use of burned areas was evident, burns may provide suboptimal habitat, similar to conditions found in logged forests where Martens were found at lower density, were less productive, and suffered higher mortality than animals in unlogged forests (Thompson 1994). Quality of burned habitat for Martens probably will vary with burn intensity and pattern, age of burn, and characteristics of regenerating vegetation (i.e., density of overhead canopy in

TABLE 1. Use of burned and unburned habitat by Martens throughout the year and by season, and corresponding Bonferroni intervals. Winter = November-April; summer = May-October.

	Habitat	Actual proportion of use	Expected proportion of use	Bonferroni intervals
Entire year (n=168)	Burn	0.458	0.637	0.359 < p < 0.557
	Spruce forest	0.482	0.312	0.382 < p < 0.521
	Spruce bog	0.012	0.008	0.000 < p < 0.034
	Riparian	0.006	0.015	0.000 < p < 0.030
	Unclassified	0.024	0.025	0.000 < p < 0.056
Winter (n=58)	Burn	0.413	0.578	0.244 < p < 0.575
	Forest	0.552	0.370	0.382 < p < 0.718
Summer (n=110)	Burn	0.482	0.649	0.357 < p < 0.603
	Forest	0.427	0.302	0.308 < p < 0.551

winter). Wildfire may cause dispersal of Martens from the burned area (Raine 1982).

In conclusion, Martens in the Mackenzie Valley study area had large home ranges that incorporated varying amounts of a 21-year-old burn. The majority of Martens could be typified as using the burn extensively but not intensively (i.e., approximately 50% of their home ranges included the burn but they spent less time in the burn than expected on the basis of availability). Only one adult Marten restricted its movements to entirely within the burn. However, live-trapping may not have been far enough from the burn edge to adequately sample Martens whose home ranges were entirely within the burn. Marten activity was regularly noted off the study area in the interior of the burn, but whether these individuals confined their movements to within the burn was unknown. Before broader conclusions about the importance of wildfire to Marten in the taiga can be made, data are required on the home range size, seasonal food habits and prey availability, and habitat selection of Martens in the interior of large burns of different ages.

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Spatio-temporal Distribution of Anadromous (*trachurus*) and Freshwater (*leiurus*) Threespine Sticklebacks, *Gasterosteous aculeatus*

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Competition between similar species or morphotypes that occupy the same habitat may be mitigated by differences in the spatial and/or temporal distribution of individuals. We investigated the spatial and temporal distribution of adult and juvenile, anadromous (*trachurus*) and freshwater (*leiurus*) Threespine Sticklebacks along the Salmon river near Fort Langley, British Columbia. Results indicated that the spatial distribution of juvenile *trachurus* and *leiurus* was a consequence of the distribution of nest sites of breeding adults. It is proposed that the decline in water level during summer caused a depletion of pelagic resource patches in the near shore habitat, and resulted in an increase in competitor density in benthic resource patches. Concurrent with the decline in water level was a significant change in the temporal distribution of *trachurus* juveniles. The larger size and benthic trophic traits of *leiurus* juveniles likely conferred a competitive advantage over *trachurus* fish in shallow water conditions. Although the exact cause for the emigration of *trachurus* juveniles from the near shore habitat could not be determined, it is clear that the decline in the temporal distribution of these fish reduced competition between the two morphotypes.

Key Words: Stickleback, *Gasterosteous aculeatus*, spatio-temporal distribution, competition.

The Threespine Stickleback (*Gasterosteous aculeatus*) has been the subject of many studies in speciation (Hagen 1967, 1973; Bell 1976; Ridgeway and McPhail 1984; Lavin and McPhail 1985, 1987; McPhail 1992) and reproductive behaviour (FitzGerald 1991; FitzGerald and Wootton 1993). Other studies have investigated the longevity, growth, and migration of these fish (Mullem and Vlugt 1964). However, little is known about the spatial and temporal distribution of juvenile sticklebacks, especially in species or morphotypes that occur sympatrically for at least some portion of their life history.

In many coastal rivers and streams, anadromous (*trachurus*) and freshwater (*leiurus*) sticklebacks coexist during spring and much of the summer (Hagen 1967; FitzGerald and Wootton 1993). Adults of these two forms differ in colour, body shape, trophic traits, and life history. Anadromous individuals are silver coloured with lateral plates extending from behind the head on to the caudal peduncle. These individuals also have a streamlined body, and possess numerous long gill rakers indicative of a planktivorous feeding strategy (Hagen 1967). In contrast, the resident freshwater fish are dark with only an anterior row of plates, have a deeper body, and possess trophic characteristics consistent with benthic foraging (Hagen 1967). The anadromous fish live in the sea for most of their life, migrating to fresh water in the spring to breed. The resulting progeny return to the sea during late summer and early autumn (Mullem and Vlugt 1964). Individuals of the freshwater morph remain in streams and pools throughout their life, and also reproduce in the spring (Hagen 1967).

In the Salmon River, breeding anadromous and freshwater males construct nests in shallow water near the shore, and in drainage ditches along the river. Since both forms reproduce in the same habitat, there exists the potential for competition for vital resources, such as food and/or shelter, between juveniles of the two morphotypes. If competition is occurring between these two morphs, one might expect that *trachurus* and *leiurus* juveniles distribute themselves, either spatially and/or temporally, in such a manner as to minimize competition.

The objective of this study was to investigate the hypothesis that juvenile *trachurus* and *leiurus* Threespine Sticklebacks would exhibit differences in their spatio-temporal distribution along the Salmon River. In order to test this hypothesis we collected adult and juvenile sticklebacks from different sampling stations in the near shore habitat along the river during several sampling periods extending from May through August.

Methods

Study area

The Salmon River is a small tributary of the Fraser River located near Fort Langley, British Columbia, Canada (49° 11'N, 122° 35'W). The watershed drains an area approximately 83 km^2. Seven sampling stations were set up along the river, beginning at 500 m from the river mouth to approximately 3 km upstream (Figure 1). This section of the river is slow-flowing and meanders through agricultural fields. The river channel consists largely of mud and sand substrate. Several deciduous tree

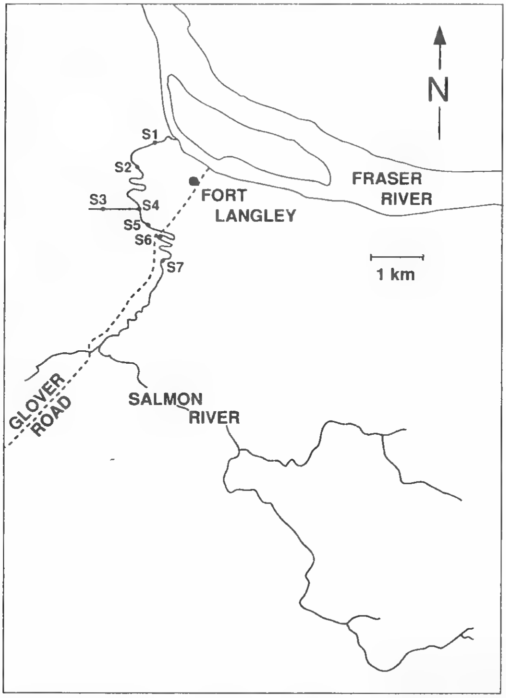

FIGURE 1. Location of sampling stations along the Salmon River, British Columbia. Station 3 was located 500 m up a drainage ditch.

species (*Salix spp.*, *Acer circinatum*, *Alnus rubra*) comprise the riparian vegetation. Station 3 was located approximately 500 m up a small drainage ditch and contained breeding anadromous and freshwater sticklebacks. The last sampling station (S7) is known to be the maximum distance adult anadromous sticklebacks migrate upstream to breed (J. D. McPhail, unpublished data). Near shore habitat consisted of the area immediately alongside the edge of the river amongst and below overhanging grasses. *Elodea* was the dominant submergent macrophyte in this habitat.

Fish collections

Adult anadromous and freshwater sticklebacks were collected from four of the seven sampling stations (stations 2, 3, 5, and 6) with Gee's improved minnow traps (43 cm long by 22 cm diam., with 2.5 cm diameter funnel entrances) at weekly intervals from 5 May through 7 July, 1988. These stations were part of a long term study investigating the speciation and ecology of these two morphs (J. D. McPhail, unpublished data). Fish were identified, counted, and transported to the laboratory.

Juvenile *trachurus* and *leiurus* sticklebacks were collected from all seven sampling stations from 7 July through 26 August, 1988. Stations 4 and 7 were not sampled on 7 July. A 40 cm x 20 cm dip net with 0.10 mm mesh was used to collect juvenile fish. The effort for each station was standardized to fifteen scoops with the bottom of the net just above the river bed. Fish were then placed in labelled jars with 10% formalin.

Body morphometrics

Standard length (SL) was recorded for all juvenile sticklebacks collected from the river. Juvenile *trachurus* and *leiurus* sticklebacks >17 mm were easily identified by their characteristic shape, colour, and number of epidermal plates. The anadromous form also possesses a keel on the caudal peduncle which is absent in the freshwater form. For individuals <17 mm three additional measurements were recorded; body depth (BD), head length (HL), and head depth (HD). All measurements were taken as described in Hubbs and Lagler (1958), and recorded to the nearest 0.05 mm using a dissecting microscope and Helix dial callipers.

Statistical analyses

To aid in the classification of juvenile sticklebacks <17 mm, 99 purebred sticklebacks (41 *trachurus*, 58 *leiurus*) raised in the laboratory were sacrificed, and SL, BD, HL, and HD were recorded following the procedure above. SL in these lab-reared fish ranged from 6.05-30.90 mm which was similar to the range of size for juveniles captured in the Salmon River. A discriminant function analysis was then performed on the lab-reared fish using the variables SL, BD, HL, HD, and the within covariance matrices. The resulting quadratic discriminant function correctly classified 78.1% and 72.4% of the *trachurus* and *leiurus* individuals, respectively. This constituted a total error rate of 25.3% for the two morphs.

Two nonparametric one-way ANOVAs (Kruskal-Wallis test, $\times^2$ approximation) were performed to test if the distribution of adult anadromous and freshwater sticklebacks differed among sampling stations (i.e., to test if there was a significant difference in the spatial distribution of spawning sticklebacks). In addition, four nonparametric one-way ANOVAs were performed to test for a significant effect of sampling period (temporal distribution) and station (spatial distribution) on the number of juvenile *trachurus* and *leiurus* captured. For each sampling station, a two-way ANOVA was performed to test for the effect of sampling period and morph on SL (i.e., size). For all statistical tests a P-value >0.05 was judged to be not significant. All statistical analyses were performed using the SAS statistical package for microcomputers.

Results

Adult spawners

A total of 223 and 243 adult anadromous and freshwater sticklebacks were captured from 5 May

TABLE 1. Number of adult anadromous (AND) and fresh water (FW) sticklebacks captured at different sampling stations and sampling periods from the Salmon River, British Columbia.

Date	Station 2		Station 3		Station 5		Station 6	
	AND	FW	AND	FW	AND	FW	AND	FW
5 May	0	0	2	2	0	0	0	0
11 May	30	0	10	15	20	0	1	0
19 May	7	3	11	35	7	2	1	1
27 May	2	0	31	48	8	20	8	8
2 June	5	1	29	17	5	5	2	2
15 June	5	0	11	35	8	27	10	14
30 June	2	1	0	5	5	6	2	2
7 July	0	0	0	0	0	0	1	4

through 7 July, 1988, respectively. The number of adult anadromous sticklebacks captured at each of the four sampling stations did not differ significantly ($\times^2_3$ = 2.664, P = 0.45), while the distribution of adult freshwater fish changed significantly along the river ($\times^2_3$ = 9.879, P = 0.02). Generally, the number of freshwater adults captured increased as one moved upstream (Table 1). No breeding adult sticklebacks were captured after July 7.

Classification and number of juveniles

A total of 835 (152 *trachurus*, 683 *leiurus*) juvenile sticklebacks were captured from the near shore habitat (Tables 2 and 3). The number of juveniles <17 mm and classified by the quadratic discriminant function was 142. Since the total error rate for misclassification of laboratory-reared fish was 25.3%, approximately 36 wild juveniles were potentially misclassified.

No *trachurus* juveniles were captured from station 7 during any of the sampling periods (Table 2). After combining fish caught in each station across sampling periods, a nonparametric one-way ANOVA revealed that there was no significant difference in the distribution of *trachurus* juveniles caught along the river (i.e., among stations; $\times^2_6$ = 7.21, P = 0.30). Pooling the data across sampling stations indicated that there was a significant decline in the number of

TABLE 2. Mean standard length (mm ± 1SD) of juvenile *trachurus* sticklebacks captured from the near shore habitat at different sampling stations and periods from the Salmon River. n.s. = not sampled.

Date	Sampling station						
	1	2	3	4	5	6	7
7 July	14.7 (3.1) N = 9	16.8 (2.4) N = 11	10.3 (0.4) N = 8	n.s. N = 24	13.6 (3.0) N = 7	15.3 (2.7) N = 7	n.s.
15 July	16.0 (1.5) N = 6	16.9 (2.3) N = 11	12.1 (0.6) N = 9	15.4 (2.5) N = 14	13.8 (2.8) N = 17	18.4 (2.0) N = 5	N = 0
28 July	22.8 (4.4) N = 5	17.7 (2.3) N = 5	11.1 (2.6) N = 2	14.5 (3.1) N = 5	13.2 (4.1) N = 9	14.6 (3.5) N = 5	N = 0
12 August	N = 0	N = 0	N = 0	N = 0	N = 0	N = 0	N = 0
26 August	N = 0	N = 0	n.s.	N = 0	N = 0	N = 0	N = 0

TABLE 3. Mean standard length (mm ± 1 SD) of juvenile *leiurus* sticklebacks captured from the near shore habitat at different sampling stations and periods from the Salmon River. n.s. = not sampled.

Date	Sampling station						
	1	2	3	4	5	6	7
7 July	17.7 (7.6) N = 7	18.2 (8.6) N = 7	17.0 (1.0) N = 21	n.s.	15.2 (4.3) N = 43	21.4 (2.2) N = 4	n.s.
15 July	17.9 (5.1) N = 7	19.8 (6.3) N = 24	17.1 (5.7) N = 47	20.1 (5.8) N = 17	13.5 (2.6) N = 42	19.4 (5.6) N = 24	25.0 N = 1
28 July	25.8 (6.6) N = 12	25.9 (7.6) N = 12	20.3 (4.8) N = 29	19.3 (7.1) N = 21	15.5 (3.8) N = 27	21.0 (5.9) N = 19	18.5 (4.5) N = 22
12 August	28.2 (6.0) N = 10	26.3 (4.9) N = 19	22.7 (5.1) N = 29	19.2 (6.5) N = 29	20.7 (5.9) N = 30	21.6 (6.3) N = 25	23.9 (4.8) N = 13
26 August	30.4 (5.5) N = 7	30.9 (3.7) N = 19	n.s.	22.7 (4.8) N = 32	24.7 (5.6) N = 22	23.9 (5.8) N = 36	28.8 (5.2) N = 26

trachurus juveniles captured during sampling periods ($\times^2_4 = 21.88$, $P < 0.01$). In fact, no *trachurus* juveniles were captured from any sampling station after 28 July (Table 2).

Combining all *leiurus* juveniles for each station across sampling periods indicated that there was a significant difference in the distribution of these fish along the river ($\times^2_6 = 17.52$, $P < 0.01$). The largest number of *leiurus* juveniles were captured between stations 3 and 6, while significantly less fish were removed from stations 1 and 2 (Table 3). Although the number of *leiurus* juveniles captured from station 7 was relatively low, this result may be due partially to the fact that station 7 was not initially sampled. Because of the decline in water level during the summer, station 3 could not be sampled on August 26. Finally, pooling fish captured across sampling stations suggested that there was no significant change in the number of *leiurus* juveniles captured during sampling periods (Table 3; $\times^2_6 = 2.46$, $P = 0.65$).

Size of juveniles

Using capture data from 7 July, 15 July, and 28 July we performed a two-way ANOVA for each sampling station (1-6) to determine the effect of sampling period and morph on the SL (size) of juvenile sticklebacks. For all sampling stations there was no significant interaction between sampling period and morph (for all stations; $F < 1.50$, $P > 0.20$). Results from station 1 indicated that size increased significantly during sampling periods (Tables 2 and 3; $F_{2,40} = 9.94$, $P < 0.01$), but was not significantly different between morphs ($F_{1,40} = 0.04$, $P > 0.90$). For stations 2 through 6, size of juvenile sticklebacks did not vary significantly among the first three sampling periods (for all stations; $F < 2.50$, $P > 0.09$). However, juvenile *trachurus* were significantly smaller than *leiurus* at stations 2,3,4, and 6 (for all stations; $F > 7.20$, $P < 0.01$). Results from station 5 suggested that the average size of juvenile *leiurus* was greater than *trachurus* (Tables 2 and 3), but the effect was weak ($F_{1,156} = 3.50$, $P = 0.06$).

Discussion

Acquisition of suitable resources such as breeding sites, food, and shelter is fundamental to the growth and maintenance of species populations. Competition theory predicts that the existence of two closely related species or morphotypes in the same habitat can occur only if the two populations occupy different ecological niches (Krebs 1985). It follows then, that niche separation, on a spatio-temporal scale, may reduce competition for vital resources between similar morphotypes such as juvenile anadromous and freshwater sticklebacks.

The results of this study indicated that juvenile *leiurus* and *trachurus* sticklebacks occupied the same habitat. In addition, the number of adult and juvenile freshwater fish increased significantly upstream, while the spatial distribution of anadromous adults and juveniles did not change significantly. Thus, it appears that the spatial distribution of juvenile sticklebacks along the river (i.e., among habitat patches) was not the result of competition, but instead a consequence of nest site selection by adult males of both morphotypes.

When discussing spatial distributions of organisms one must be aware of the difficulties associated with scale (Wiens 1989). The spatial scale analyzed in this study was large as it dealt with the distribution of fish at several sampling stations along a river. Although competition did not appear to be a mechanism driving the spatial distribution of juvenile fish at this scale, there are no data to analyze the distribution of fish within habitat patches. A better understanding of the spatial distribution of juvenile sticklebacks should involve sampling among potentially different resource patches within a habitat.

The trophic and body morphology of *trachurus* and *leiurus* juveniles are evolutionary adaptations for efficiently exploiting the micro-habitat (i.e., resource patch) that each morph occupies (Hagen 1967; Taylor and McPhail 1986). Such differences in trophic adaptations between juvenile *trachurus* and *leiurus* sticklebacks likely enable both forms to occupy the same habitat by manipulating different resource patches. For example, Sandlund et al. (1992) found that the coexistence of four morphotypes of Arctic Char (*Salvelinus alpinus*) in a lake was due to the evolution of trophic adaptations specific for different habitats, and resource patches within habitats. Two of the morphs possessed adaptations for feeding in the pelagic zone, while the other two morphs had adaptations suitable for benthic foraging (Sandlund et al. 1992).

The significant decline in the temporal distribution of *trachurus* juveniles from the near shore habitat along the river was associated with a decrease in water level during the summer. Theoretically, a constant decline in water level would result in a reduction of pelagic resource patches for *trachurus* juveniles and force these fish to occupy benthic resource patches. This would increase both intra- and interspecific competitor density. The benthic characteristics of the freshwater morph would be more suitable in shallow water conditions and probably confer a competitive advantage over *trachurus* juveniles. The larger size of freshwater juveniles also may have increased their ability to compete for food and shelter, and has been illustrated in salmonoid species (Chapman 1962; Hartman 1965; Beacham 1993).

Spacing behaviour which results in territoriality is an alternative mechanism for the dispersal of *trachurus* juveniles from the near shore habitat. The establishment of resource patches through territorial behaviour for resident fish is necessary for survival, while energy expenditure on aggressive interactions by migratory individuals may not be adaptive. Although this study did not investigate spacing behaviour, Bakker and Feuth-de Bruijn (1988) found that juvenile freshwater sticklebacks displayed territorial behaviour after eight weeks of hatching. By contrast, *trachurus* juveniles showed no signs of aggression which was probably related to their early migratory behaviour (Bakker and Feuth-de Bruijn 1988). Low aggression among conspecifics serves many benefits, such as anti-predator defence and increased foraging efficiency, during migration (Pitcher 1986).

Whether the emigration of *trachurus* juveniles from the near shore habitat was due to trophic advantage and larger size, or spacing behaviour of the freshwater morph could not be determined in this study. It must be noted that these two potential dispersal mechanisms are not mutually exclusive and may operate either simultaneously or in succession. Nevertheless, it is clear that competition between these two morphs was mitigated through a decrease in the temporal distribution of *trachurus* juveniles. Similar temporal shifts in the distribution of individuals within and among habitat patches also may play a role in the dynamics of complex animal-habitat interactions in single species populations (Pulliam 1988; Pulliam and Danielson 1991; Ostfeld 1992).

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Notes

A Field Technique for Aging Live Beavers, *Castor canadensis*

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New regression models for age estimation of live Beavers, *Castor canadensis*, based on live weight, tail width, and tail length, are more useful for field research than other age estimation techniques.

Key Words: Beaver, *Castor canadensis*, age estimation, Montana.

Researchers and furbearer managers need an easy, reliable method for estimating Beaver, *Castor canadensis*, ages in the field. Beavers can be aged by the degree of basal closure of the cheek teeth and cementum annuli analysis (Van Nostrand and Stephenson 1964); this is recognized as the method of choice and is the standard by which all other methods are judged (Novak 1987). However, this method is impractical for field use because of the difficulty in extracting cheek teeth from live Beavers (Larson and Van Nostrand 1968). Dental X-ray analysis of the lower jaw (Hartman 1992) is a reliable age determination technique for use on live European Beavers (*C. fiber*) that is less laborious than cementum annuli analysis when used on Beaver carcasses. But X-ray analysis has not been tested for North American Beavers and the constraint of bringing a Beaver to the X-ray equipment (or vice versa) prevents this method from being a useful field technique.

Patric and Webb (1960) examined the relationship between Beaver ages and weight, tail dimensions, and zygomatic breadth (N=30). Each criterion was useful for age determination for the first two or three years but declined in usefulness for older age classes. Payne (1979) related Beaver weight (kg) to age (years) with the regression equation

$$\ln(\text{age}) = -4.991 + 2.324 \ln(\text{weight})$$

($r^2 = 0.83$, SE = 0.42, N = 286), providing a useful age determination technique for separating Beavers into the kit, yearling, and adult age classes. Age determination techniques based on single morphological measurements characteristically overlap in the older age classes because of individual variation, colony site variation, variations in parturition date, and differential development (Patric and Webb 1960).

Jackson (1991) predicted membership in five age classes (kits to 4+ year-olds) by combining weight and tail width in a discriminant function. Unfortunately, his model was based on a small sample size (12) and was cumbersome to use. I describe a similar approach using regression models to combine morphological variables.

Methods

In conjunction with a study of Beaver dispersal (Van Deelen 1991), I collected 30 Beavers from western Montana. Weight (kg), total length (cm, from nose to tip of tail), length of the scaly portion of the tail (cm), tail width (cm, at its widest), tail thickness (mm, at the proximal end of the scaly portion), head circumference (cm, at its widest), neck circumference (cm, immediately behind the ears), chest circumference (cm, immediately behind the shoulders), zygomatic breadth (mm, at its widest), right hind footpad length (cm, from the heel to tip of the claw on the longest digit) and right hind foot pad width (cm, at its widest) were recorded for each (Jackson 1991), and each was assigned to an age class (AGE) according to the basal closure of its cheek teeth and cementum annuli analysis (Van Nostrand and Stephenson 1968), and knowledge of the season when it was captured (Patric and Webb 1960). Age assignments were made to the nearest quarter of a year. For example, a Beaver whose cheek teeth indicated that it belonged in the yearling age class was assigned an age of 1.0 years if collected during the summer, 1.25 years if collected during the fall, 1.5 years if collected during the winter, and 1.75 years if collected during the spring. A common 15 June birth date was assumed for all Beavers. M. Jackson provided the morphological measurements and age estimates from 12 additional Beavers

(Jackson 1991), bringing the total sample of Beavers to 42. Sex-related differences in the parameters were not examined since Beavers show no sexual dimorphism in size, pelage color, or other external features (Novak 1987; Nowak 1991).

I chose morphological measurements for inclusion into the model based on two subjective criteria: (1) they needed to be easily and precisely measurable (preferably, without sedating the Beaver), and (2) they had to vary with age. Body weight (WT), tail width (TW), and tail length (TL) satisfied both these requirements. Live Beavers can be weighed in Hancock traps (Hancock Trap Company, Custer, South Dakota) without sedation, and the tail measurements can be safely obtained by maneuvering a Beaver to the back of a trap and pulling its tail through the side.

I used step-wise multiple regression analysis (Wilkinson 1992), rather than discriminant function analysis (which estimates discrete age class categories), because regression analysis gives age estimates on a continuous scale. Age determination should account for the time of year the measurements were made as well as the estimate given by the statistical model (Patric and Webb 1960; Jackson 1991). Aleksiuk and Cowan (1969) found that decreasing photo-period had no effect on the growth of California Beavers, but caused weight loss and inhibited growth in arctic Beavers. Since Montana's latitude is closer to that of California, I assumed a continuous growth model. In addition, the continuous model seemed more appropriate because the sampled Beavers lived in free-flowing, montane streams that rarely froze over; and they were observed to be active throughout the winter.

I examined scatter plots of the three variables and their natural log transformations against both AGE and ln(AGE) to suggest relations suitable for a regression model.

Results and Discussion

Ln(WT), ln(TL), and ln(TW) appeared to have linear relationships with ln(AGE).

The first model fitted was

$$\ln(AGE) = -8.24 + 0.34 \ln(WT) + 2.02 \ln(TL) + 0.70 \ln(TW)$$

($r^2 = 0.77$, SE = 0.36, N = 42, $P < 0.001$). The ln(TW) term explained little of the variability and was dropped. The refitted model was

$$\ln(AGE) = -8.53 + 0.56 \ln(WT) + 2.48 \ln(TL)$$

($r^2 = 0.77$, SE = 0.38, N = 42, $P < 0.001$). Removal of the ln(TL) term produced a model similar to that of Payne (1979),

$$\ln(AGE) = -2.65 + 1.40 \ln(WT)$$

($r^2 = .70$, SE = 0.38, N = 42, $P < 0.001$). Differences between this model and Payne's (1979) may reflect a different weight/age relationship between Beavers from Newfoundland (Payne 1979) and Beavers from Montana.

A model based only on tail dimensions,

$$\ln(AGE) = -9.049 + 1.15 \ln(TW) + 2.19 \ln(TL)$$

($r^2 = 0.77$, SE = 0.36, N = 42, $P < 0.001$), performed as well as or better than the models which used the ln(WT) term. Development of an aging technique based on tail dimensions would be valuable to managers and researchers because TL and TW are easily measured and can be gotten from skinned carcasses. Moreover, TL and TW are more robust than WT to seasonal fluctuations in condition (Patric and Webb 1960).

Age class assignments based on this model agreed with the age class assignments based on cheek teeth development (AGE) in 28 of the 42 cases (66%). The age estimate returned by the model was said to agree with AGE if both rounded off to the same integer. Three (7%) Beavers were placed in the next highest age class and eight (19%) were placed in the next lowest age class. The model underestimated the age of two Beavers (5%) by year two, and one Beaver (2%) by four years. Age class assignment based on Payne's (1979) model agreed with AGE in 19 of the 42 cases (45% Table 1). This subjective comparison of the models does not constitute a valid test because there is no independent data set.

TABLE 1. Prediction performance of the two regression models on a set of 42 Beavers from Western Montana.

	Age Estimation (Years)[1]					
	1	2	3	4	5	N
Sample	13	8	15	2	4	42
Correct predictions						
This study model	13	6	6	2	1	28
Payne (1979) model	11	2	3	0	3	19

[1]Age estimates are based on the condition of the cheek teeth (Van Nostrand and Stephenson 1964), and season of collection. Estimates were rounded to the nearest integer (see text).

TABLE 2. Mean prediction intervals for ages predicted by the regression equation. Prediction intervals were defined as the difference between AGE and the age predicted by the TL and TW regression model.

	Age Estimation (Years)[1]				
	1	2	3	4	5+
Mean	0.21	0.43	0.72	0.08	2.01
S. D.	0.14	0.34	0.29	0.06	1.42
N	13	8	15	2	4

[1]Age estimates are based on the condition of the cheek teeth (Van Nostrand and Stephenson 1964), and season of collection. Estimates were rounded to the nearest integer (see text).

The width of the prediction intervals increased with older age classes (Table 2). This may reflect the fact that the older age classes were not as well represented in the sample, but I suspect that variation in the morphological measurements was increasing as well. As it is, this model appears to be useful for identifying three age classes; kits, yearlings, 2+-year-olds. Refinement with a large sample of actual known-age Beavers (especially older ones) is needed before this model can be used to place Beavers into age classes higher than 2+years-old.

Age determination models based on morphological characteristics are likely to be only regionally applicable due to morphological variability across a species' range. This is certainly true for Beavers because of their vast range in North America (Novak 1987). Beavers may be especially prone to local variation in morphology because arctic and northern populations must endure growth-inhibiting periods of ice cover and declining photo-period that more southern populations do not (Aleksiuk and Cowan 1969).

Like most others (Payne 1979; Jackson 1991; Hartman 1992), these models assume that Beavers aged by cementum annuli analysis and the basal closure of the cheek constitute a known age sample.
This is a tenuous assumption because Van Nostrand and Stephenson (1964), in their seminal paper on this subject, examined only 42 actual known-age Beavers, 35 of which were less than 15 months old. Clearly more work is needed. The data set for this study is available from the author.

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Surf Scoter, *Melanitta perspicillata*, Nesting in Southern Québec

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In late May, 1993, a Surf Scoter, *Melanitta perspicillata,* nest was found at 664 ha Malbaie Lake in the Laurentide Wildlife Reserve 95 km NNE of Québec City. During subsequent brood surveys of the lake several broods were present and a peak count of 139 ducklings was obtained. This is the only published record of a nest in Québec since 1833; the density of breeding pairs in the lake was high relative to other areas, and the lake is well south of the previously described range. The high elevation of Malbaie Lake (820 m) creates ecological conditions similar to those found in the typical high boreal-sub-arctic range of the species.

Key Words: Surf Scoter, *Melanitta perspicillata*, nesting, Malbaie Lake, Québec.

Until recently, the majority of Surf Scoters (*Melanitta perspicillata*) that migrate through, and overwinter in, northeastern North America were thought to come from Alaska and northwestern continental Canada (Bellrose 1980). The only published records of nests in eastern North America were from one on the north shore of the Gulf of St. Lawrence, Québec, (50°20'N, 59°30'W) in 1833 (found by J. J. Audubon) and another on Akpatok Island in Ungava Bay (60°25'N, 68°00'W) in 1903 (Bent 1925:146). During the early 1900s Todd (1963:196) observed a number of broods in north-central Québec and near the James Bay coast. Waterfowl breeding pair surveys in the early 1970s (Gillespie and Wetmore 1974) also indicated that the species was a regular breeder in Labrador and northern Québec. Savard and Lamothe (1991) observed many broods in the Lake Bienville area and other portions of the Great Whale River basin. To date, all published breeding records in Québec come from an area north of latitude 50°N and, with the exception of one nest, pertain to sightings of broods or pairs .

Following up on reported sightings of Surf Scoter broods (R. Ouellet, D. Banville and G. Trencia of the Ministère de l'Environnement et de la Faune du Québec; P. Fragnier, Canadian Wildlife Service, and G. Bouchard, personal communication) on highland lakes in the Laurentide Wildlife Reserve, we visited Malbaie Lake (47°34'N, 71°00'W) on five occasions in 1993. This is a 664 ha lake 820 m above sea level, 95 km NNE of Québec City. During an earlier survey in the Wildlife Reserve (Reed 1964) breeding Surf Scoters were not observed, but Malbaie Lake was not visited.

On 30 May, we surveyed approximately half of the lake by canoe and recorded 61 adult Surf Scoters, mostly in pairs. On one of two wooded islands we found a recently abandoned nest containing six eggs, with a seventh egg destroyed, presumably by a corvid, nearby. The nest was approximately 15 m from shore in a dense stand of Black Spruce, *Picea mariana,* and was partially concealed by a fallen spruce trunk. The six intact eggs averaged 66.5 mm (SD = 1.37 mm) by 45.8 (SD = 0.35). These measurements are similar to those reported by Bent (1925: 147) for this species.

On 1 July, 60 adults (59 females, 1 male) were observed on the lake as well as 49 ducklings, all less than five days old. The ducklings were in five groups (5,7,9,12 and 16 ducklings). Each group was accompanied by a single adult female except the 16 ducklings which were attended by two females. On 20 July, 33 adults (all females) and 128 ducklings in 10 groups (1–36 ducklings), each accompanied by one female, were recorded. On 13 August, only 16 adults (all females) were observed, along with 139 young in 19 groups (1–20 ducklings) 14 of which were accompanied by one female whereas the five others were unaccompanied. During a partial survey on 1 September, approximately four adult females and 18 ducklings were observed; at least two of the ducklings were capable of flight. By backdating from egg and brood data (assuming an approximate laying interval of 1.5 d, an incubation period of about 30 d and fledging age of 50 d), we estimated that egg-laying had begun no later than the third week of May and that hatchings were spread over a period extending from the last week of June through the third week of July.

We were unable to determine the number of Surf Scoter pairs that nested on Malbaie Lake in 1993, but the peak number of ducks recorded during the course of the season helped to establish an order of magnitude. Based on the maximum duckling count of 139, assuming a mean clutch size of seven eggs (Bent 1925: 146) and without accounting for egg or duckling mortality, at least 20 broods used the lake. Based on the peak count of adult females (the peak for males came from a partial survey) and assuming that all were breeders, as many as 59 pairs could have been present. These densities are substantially higher than those reported previously within the described range. A review by Savard and Lamothe (1991) indicated breeding densities of Surf Scoters and Black Scoters, *Melanitta nigra,* combined that ranged from 0.3 to 18 pairs/100km^2 (including land areas) in various regions of Labrador and northern Québec; in most areas, it is unusual to find more than one brood per lake (Todd 1963; A. Reed, R. Benoit and R. Bergeron, unpublished data).

The presence of a significant number of breeding Surf Scoters in this area well to the south of the known range can probably be attributed to its high elevation. The area is a mountainous enclave mostly >800 m above sea level characterized by the presence of high boreal forest plant communities which typically occur farther north (Richard 1975). Malbaie Lake and a few other nearby lakes are probably ecologically similar to those used by Surf Scoters in more northerly areas.

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Long Distance Movement of a Transplanted Beaver, *Castor canadensis*, in Labrador

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Chubbs, Tony E., and Frank R. Phillips. 1994. Long distance movement of a transplanted Beaver, *Castor canadensis*, in Labrador. Canadian Field-Naturalist 108(3): 366.

A yearling Beaver initially marked and transplanted 14 June 1981 was trapped 5 November 1984, 120 km west of the release site.

Key Words: Beaver, *Castor canadensis*, movement, Labrador.

Beavers (*Castor canadensis*) sometimes travel unusually long distances. The longest individual Beaver movement appears to be 390 km for a Beaver marked and recaptured in western Massachusetts (Hodgdon 1978). Beer (1955) found that Beavers dispersed airline distances of up to 50 km and watercourse distances of up to 82 km from the point of original capture. Leege (1968) reported a maximum straight line dispersal distance of 17.6 km and an average movement of 9.0 km for 19 tagged Beavers classified as "travellers". Of 397 Beavers ear-tagged in New Mexico, 27 were subsequently recaptured with the greatest distance travelled by an individual being 51.2 km (Berghofer 1961). Reports indicate that subadult (≤ 24 months) beavers tend to disperse more frequently and over longer distances than do adults (Townsend 1953; Beer 1955). Also, literature values for transplanted Beaver dispersals are much larger than those for natural dispersals (Hibbard 1958; Knudsen 1965).

Here we document a long range movement of a transplanted Beaver which is notable because few have been described in northern latitudes at the edge of the range and none previously in Labrador. On 14 June 1981, a yearling female Beaver was struck by an automobile while crossing Mud Lake Road, 10 km south-east of Goose Bay, Labrador (55°18′, 60°15′). As the animal appeared uninjured, it was eartagged (number 143) and released the same day 15 km away, at Gosling Lake (55°25′, 60°25′). On 5 November 1984, trappers Robert Best and Bruce Hewlett of Happy Valley-Goose Bay, Labrador caught Beaver 143 at Lost Lake (53°09′, 61°59′) approximately 120 km west of the release site. Wildlife personnel were contacted and the ear tag was submitted for identification.

This female beaver was found at an airline distance of 120 km, 41 months after being released. The shortest estimated travel route via water was approximately 240 km upstream from the release site and would have required several overland movements. Such a long movement may have been the result of dispersal of a young, transplanted animal.

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Degree of Association and Use of a Helper by Coastal River Otters, *Lutra canadensis,* in Prince William Sound, Alaska

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Rock, Karen R., Eric S. Rock, R. Terry Bowyer, and James B. Faro. 1994. Degree of association and use of a female helper by coastal River Otters, *Lutra canadensis*, in Prince William Sound, Alaska. Canadian Field-Naturalist 108(3): 367–369.

Nine (6 males and 3 females) River Otters, *Lutra canadensis*, from the Esther Passage area in Prince William Sound, Alaska, were implanted with radio transmitters during the summers of 1990 and 1991. Two females frequently occurred in association with one another (8 of 20 radio locations in 1991; 40 of 72 radio locations in 1990) and had degrees of association of 0.80 and 0.71 for each year, respectively. The average degree of association was only 0.36 for male otters in this same population. In August of both years, these two female otters were observed with pups, and both females fed, carried, and played with the pups, despite one female being a subadult in 1990. Helping with the care of young by subadults is known to exist in only a few species of mammals, but our observations suggest that this behavior exists in marine populations of River Otters.

Key Words: River Otter, *Lutra canadensis*, helping, Prince William Sound, Alaska.

Helping is defined as parent-like behavior toward young that are not offspring of the helper (Lott 1991). Although helping exists in over 200 species of birds, this type of behavior is rare among mammals (Brown 1975). Reproductive altruism among mammals often occurs among carnivores, where hunting efforts are cooperative and food can be brought to the young (Trivers 1985), although such behavior has been reported in other mammalian orders (Emlen 1991). Helpers are hypothesized to increase the number of surviving offspring from parents they help by increasing the rate of prey capture or by defending either food resources or young (Trivers 1985). If related, helpers may benefit from these interactions by increasing their inclusive fitness (Lott 1991). Additionally, subadult helpers may accrue benefits such as the protection afforded by remaining in the established territory of the adults or group being helped, or helpers may learn appropriate parental behavior via their helping experience that may increase their fitness in the long run (Emlen 1991). In some cases, helping may become an obligate behavior because of circumstances such as poor availibility of food, greater adult survivorship, or saturated territories (Trivers 1985).

Study Area

Research was conducted in the Esther Passage area in the northwest corner of Prince William Sound, Alaska (61°30'N, 147°40'W) as part of a larger study on River Otters (Bowyer et al. *in press*[a], *in press*[b]; Duffy et al. 1993, 1994a, 1994b; Testa et al. *in press*). Prince William Sound is a mosaic of islands in the Gulf of Alaska, with abundant freshwater streams and lakes. Terrestrial habitats include old-growth forest and muskeg. The forest overstory is dominated by conifers (*Picea* sp. and *Tsuga* sp.), and the understory contains Salmonberries (*Rubus spectabilis*), blueberries (*Vaccinium* sp.), alders (*Alnus* sp.), Rusty Menziesia (*Menziesia ferruginea*), and various mosses, mushrooms, and fungi.

Coastal populations of Alaskan River Otters inhabit a narrow strip of thick coastal forest and forage primarily in nearshore waters and rocky intertidal habitats, although freshwater streams and lakes are utilized occasionally, particularly during salmon spawning (Bowyer et al. *in press*[a], *in press*[b]; Larsen 1984). The most heavily used onshore areas are latrine sites that are identified by the presence of numerous otter feces, discolored and trampled vegetation, lack of many understory mosses and forbs, numerous burrows, and trail systems (Bowyer et al. *in press*[a], *in press*[b]).

Methods

In summer 1990, we live-trapped River Otters in the Esther Passage area of Prince William Sound, Alaska, using Hancock traps (Hancock Trap Company, Hot Springs, SD) from May to the end of June (Duffy et al. 1993). All captured otters were implanted with radio-transmitters (Telonics, Mesa, Arizona) by a licensed veterinarian and released in the area near their capture sites. All procedures used in this study were approved by an independent

Animal Welfare Committee at the University of Alaska Fairbanks.

Throughout summer 1990, all radio-implanted otters near Esther Island were located almost daily from small skiffs outfitted with H-antennas and scanning radio receivers. Once located, the position of an otter was plotted on a United States Geographical Suvey topographical map (scale 1:63500) and data on time of day, otter activity, and signal quality were recorded. If the otter was located visually, and was not disturbed, we attempted to follow the otter with the skiff and record its behavior and movements.

In 1991, our efforts focused on the behavior of these otters. Groups of otters were located opportunistically as we maneuvered the skiff along the shoreline, scanning for radio-implanted otters. Once a group was located visually, we followed their progress along the coastline in our skiff from a distance >10 m, and recorded behavioral activity by scan sampling (Altmann 1974) every 10 min.

The degree of association was calculated according to Schaller (1972) for each otter we radio located, where

$$a = \frac{2N}{n_1 + n_2},$$

with n_1 representing the number of times otter 1 was observed, n_2 the number of times otter 2 was observed, and N the number of times they were observed together. A degree of association of 1.0 would indicate that a pair of animals had remained together during all observations.

Results

Although most of our captured otters were males (6 of 9 individuals), we captured an adult, lactating female (referred to hereafter as 1640) on the northeast end of Esther Island on 6 June 1990. On 12 June 1990, in the same vicinity, we captured an immature female River Otter (referred to hereafter as 1810). Frequently, the two females occurred together (40 of 72 radio locations in 1990, and 8 of 20 radio locations in 1991) near their capture site. Degrees of association of 0.71 and 0.80 were calculated according to Schaller (1972) for these two female otters in the summers of 1990 and 1991, respectively. This contrasts with an average degree of association of 0.36 for male otters in this same population.

On 2 August 1990, when we first observed these two females together, they were accompanied by three pups, which were presumed to be the offspring of 1640 because she was lactating when captured in June. This group of otters was initially observed in the intertidal area, but as we approached, each female grabbed a pup by the neck in the manner described by Harris (1968) and swam out of view. We considered this transport of a pup by the subadult otter to be a helping behavior. We left this study area on 13 August 1990, and no further observations were made on these female-pup interactions that year.

On 12 August 1991, we once again observed otters 1640 and 1810 with a group of pups. One adult female was at the head of this group and the other adult female at the rear as they swam in a sheltered lagoon. (Due to their proximity, it was not possible to distinguish via radiotelemetry which female was in which position on this day). As one adult ushered the two pups into the forest cover, the second female emerged from a dive, dragging a Pink Salmon (*Oncorhynchus gorbuscha*) carcass to the area to which the other otters had retreated.

On 25 August 1991, we observed this same group of two pups and two females wrestling and pushing one another in a playful manner in a grassy, shallow, intertidal area. A few moments later, the otters tried to climb to a latrine site, where the pups had difficulty traversing the steep, inclining entrance. Otter 1640 ushered the pups to an alternate, more level entrance site. Later in the evening, 1640 led the pups to a nearby stream and caught pink salmon for the pups. She carried each struggling fish up to the stream bed and released her grip on them; the pups killed these salmon. She engaged in this behavior four times, and if the pups lost their grip on the fish, she would "bat" it back in their direction with her forepaw. Our assumption that the pups were the offspring of 1640 is based on these feeding observations. We left the Esther Passage field camp on 26 August 1991, so we are unsure how long these females and pups continued to associate with each other.

Discussion

Degrees of association for the two female River Otters were considerably higher than for males. Our observations of otter 1810 aiding in protecting, feeding, and playing with pups that were presumably those of otter 1640 suggests that helping behaviors exist in this population of River Otters. In the first year of study, this helper was a subadult, but by the second year she would have been an adult, capable of bearing young (Dockor et al. 1987).

These results are in contrast with Melquist and Hornocker (1983), who reported that female River Otters were solitary, raising their pups without help from the male or other females. Liers (1951) also reported that captive female River Otters actively kept male otters away from their young pups, and did not report long-term associations involving other females.

In a coastal population of River Otters on Baranof Island in southeast Alaska, however, Woolington (1984) observed groups (obstensively a family) of River Otters, and noted they typically contained an adult female, other adult-sized otters, and young-of-the-year. Although one of his study groups contained a subadult male, Woolington (1984) was never able to confirm the presence of a second adult or subadult female in family groups. This is in contrast to our observations for Prince William Sound, where subadults were clearly members of social groups.

A similar type of group structure to that of River Otters in marine ecosystems has been reported in coastal populations of Cape Clawless Otters (*Aonyx capensis*), which occur in family groups that exclude adult males (Rowe-Rowe 1978). Giant River Otters (*Pteronura brasiliensis*) are also known to occur in family groups (Duplaix 1980).

We are uncertain what factors may promote helping behavior in River Otters or which sex and age classes are typically involved in helping. Additionally, it is unknown if the female helper we observed was related to the female that she helped, that 1640 was the mother of the pups both years, or that 1810 was the helper both years. Little information exists on dispersal mechanisms in these otters, and we do not know whether female pups typically remain in their natal home ranges following weaning. Nonetheless, this would explain the large groups we observed that contained more than one adult otter. All River Otters in our study area occurred in groups, ranging in size from 2 to 13 individuals, which may predispose them to developing a helper system.

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New Information on the Distribution of Marine Fish Leeches of the Genus *Notostomum* (Hirudinea: Piscicolidae)

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Utevsky, Serge Yu. 1994. New information on the distribution of marine fish leeches of the genus *Notostomum* (Hirudinea: Piscicolidae). Canadian Field-Naturalist 108(3): 370–371.

Examination of five lots of fish leeches from the Canadian Arctic previously identified as, *Notostomum cyclostomum* showed that all belonged to the species *Notostomum laeve*. This indicates that the latter species has a circumpolar distribution while *N. cyclostomum* is restricted to the North Pacific.

Key Words: Fish leeches, *Notostomum laeve*, *N. cyclostomum*, distribution, Canadian Arctic.

The genus *Notostomum* includes two species of marine piscicolid leeches: *N. laeve* Levinsen, 1882 and *N. cyclostomum* Johansson, 1898. *Notostomum laeve* is an arctic species. It has been recorded from the west and east coasts of Greenland and from Spitzbergen, Franz Josef Land, Barents Sea, Kara Sea, Laptev Sea and East Siberian Sea (Wesenberg-Lund 1926; Epshtein 1961, 1967a, 1967b). Fish hosts include *Selache maxima, Somniosus microcephalus, Hippoglossus pingvis* and *Licodes lütkeni* (Levinsen 1882; Wesenberg-Lund 1926). Arthur and Albert (in press, J. R. Arthur, personal communication) have recently found a single specimen of *N. laeve* from the Greenland Halibut, *Reinhardtius hippoglossoides,* originating from Cumberland Sound, Northwest Territories, Canada. *Notostomum cyclostomum* has been reported primarily from the North Pacific Ocean in the Bering Sea, Okhotsk Sea, Sea of Japan, Gulf of Alaska and northern British Columbia, Canada (Moore and Meyer 1951; Epshtein 1962, 1967a, 1967b; Sloan et al. 1984) although there has been one report from the Canadian Arctic (Madill 1988: see below). This species uses crabs *Chionoecetes bairdi, Paralithodes camtschatica* and *Lithodes aequispina* as a substrate for cocoon deposition, but feeds on the blood of skates and flatfishes *Limanda aspera* and *Hippoglossus stenolepis* (Moore and Meyer 1951; Epshtein 1982; Sloan et al. 1984).

Five lots of fish leeches from the Canadian Arctic, previously identified as *N. cyclostomum* (see Madill 1988) were borrowed from the collection of the Canadian Museum of Nature (CMNA) and examined. All individuals were found to possess the very characteristic suckers that are diagnostic of *N. laeve*. The suckers have two halves folded like valves of a shell of clams. The labels accompanying the lots contain no host data.

The new records of *N. laeve* from the Canadian Arctic are:

CMNA1982-0614, Frobisher Bay, Northwest Territories, 63°44′ N, 68°31′ W, 19 July 1981, 1.5 m depth, 1 specimen.

CMNA1984-0743, Starvation Cove, Northwest Territories, 69°10.2′ N, 105°50.6′ W, August 1966, 5 specimens.

CMNA1984-0744, Wellington Bay, Victoria Island, Northwest Territories, 69°10′ N, 106°28′ W, September 1965, 1 specimen.

CMNA1993-0040. Cape Parry, Amundsen Gulf, Northwest Territories, 70°17.9′ N, 123°55′ W, 213 m depth, 5 August 1963, 1 specimen.

CMNA1993-0042, Foxe Basin, Northwest Territories, 69°20.5′ N, 81°43.5′ W, 51 m depth, 11 August 1956, 1 specimen.

These new records indicate that *N. laeve* occurs throughout the Canadian Arctic and is a circumpolar species, whereas *N. cyclostomum* is restricted to the North Pacific and does not occur in the Arctic Ocean.

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I am grateful to J. A. Fournier, Canadian Museum of Nature, Ottawa, Ontario, for arranging the loan of this valuable material, to J. Richard Arthur, Institute Maurice Lamontage, Department of Fisheries and Oceans, Mont Joli, Quebec, for informing me of his paper in press, and to E. Burreson, Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, Virginia, who independently examined the specimens reported by Madill and confirmed identification.

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Black-capped Chickadees, *Parus atricapillus*, Eat Eggs of Other Birds

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Pribil, S., and J. Picman. 1994. Black-capped Chickadees, *Parus atricapillus*, eat eggs of other birds. Canadian Field-Naturalist 108(3): 371–372.

A Black-capped Chickadee (*Parus atricapillus*) was observed visiting an experimental nest containing eggs. The Chickadee pecked a large hole in one egg and consumed a portion of the egg content.

Key Words: Black-capped Chickadee, *Parus atricapillus*, behavior, egg-destruction, predation, competition.

Destruction of eggs by small passerine birds is a relatively rare phenomenon that has been observed mainly in members of two closely related families: wrens (Troglodytidae) and catbirds (Mimidae) (Belles-Isles and Picman 1986a,b; Bent 1948; Bowman and Carter 1971; Sealy 1994; Verner 1975). The relative rarity of the egg-pecking behavior among passerines may be explained by the high costs associated with the behavior, such as the risk of injury or death inflicted upon the attacker by resident birds (Belles-Isles and Picman 1987). Alternatively, it is possible that egg-destroying behavior is more common, and that the lack of evidence is due to difficulties associated with observing the behavior in nature. Egg-destroying behavior in Black-capped Chickadees (*Parus atricapillus*) was first recorded by Picman and Belles-Isles (1988). These authors observed one individual pecking eggs in an artificial nest, and inferred from photographs taken by a hidden camera that chickadees pecked eggs in additional six cases. Because the camera took only a single photograph of each event, the authors could not determine whether the chickadees consumed the content of the broken eggs. In this contribution, we report the second direct observation of egg-pecking by this species, and provide evidence that the chickadee consumed part of the broken egg.

Our observation took place on the Borthwick ridge near Ottawa, Ontario (45°23′N, 75°32′W, altitude 70 m), during an investigation of Gray Catbird (*Dumetella carolinensis*) breeding behavior. On 18 June 1993 at 1026 h Eastern Daylight Time (EDT), we placed an intact catbird nest containing two catbird eggs (from failed nesting attempts) and one fresh Red-winged Blackbird (*Agelaius phoeniceus*) egg in the crotch of a young tree 1.5 m above ground and 4 m from an active catbird nest. We observed the experimental nest from a concealed location 50 m away with a 60 x spotting scope rested on a tripod. At 1033 h EDT, one Black-capped Chickadee arrived at the experimental nest and perched on its edge. The chickadee then swiftly and vigorously pecked an egg inside. After the pecking, the chickadee drank the content of the egg. The drinking movement can be described as follows: the chickadee lowered its head into the nest, beak pointed downwards. It remained in this position for 1–2 seconds, then raised its head to the initial upright position. This motion was repeated 10–12 times. About 40–50 seconds later, the chickadee left and joined several other chickadees foraging in willows (*Salix* sp.) nearby.

We checked the experimental nest after the chickadee's departure and found the catbird eggs intact. There was, however, an irregular 8 x 5 mm oval hole in the blackbird egg. A small amount (about 5%) of the albumen volume was missing from the egg. There was no albumen spilled on the egg surface or in the nest cup. Because the hole was on top of the egg, and because edges of the hole were above the level of the albumen, the missing portion could not had been spilled. Our observation of the drinking behavior, together with the fact that a portion of the albumen was missing, provides compelling evidence that the chickadee drank a portion of the albumen.

We do not know what happened to the egg-shell fragments removed from the hole. During the pecking, the chickadee did not make any movements that would indicate removal of the fragments from the nest. There were no fragments on the egg surface or in the nest cup. When we carefully opened the blackbird egg, we found no fragments inside the egg. It is possible that the chickadee swallowed the shell fragments. Alternatively, it is possible that the fragments stuck to the chickadee's bill and were accidentally thrown away during the vigorous pecking.

It was unlikely that the chickadee was a breeding individual. There were nesting boxes in the area that we had distributed for House Wrens (*Troglodytes aedon*). Several chickadees nested in the boxes in 1994, but the last brood of the season fledged on 4 June from a box 490 m away. Because our observation occurred two weeks after this date, we believe that the chickadee was not a breeding individual. Considering the fact that the chickadee joined a group of conspecifics, it is more likely that the individual was a member of a post-breeding family group.

The function of the egg-destroying behavior is little known. It has been proposed that birds attack clutches of other birds (1) to acquire suitable nesting sites for their own use; (2) to break eggs and consume their contents; (3) to reduce competition for food; (4) to force other birds to breed farther away, hence reducing predation on their own nests; and (5) to free potential mates, thereby increasing their chances of mating (Finch 1990; Hausfater and Hrdy 1984; Labov et al. 1985; Pribil and Picman 1991). Our observation supports the "food-consumption" hypothesis. However, the hypotheses may not be mutually exclusive. It is possible that attacking individuals gain several benefits at the same time, and that the relative importance of various benefits varies with the progress of the season. For example, acquisition of nesting sites and mates may be important early in the season, competition for food and avoidance of predators during breeding, and consumption of eggs during the period of high energy demands. More research is needed to establish the relative importance of these benefits.

Acknowledgments

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Unusual Numbers of Laysan Albatrosses, *Diomedea immutabilis*, off the West Coast of Haida Gwaii, Queen Charlotte Islands, British Columbia

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Gaston, Anthony J. 1994. Unusual numbers of Laysan Albatrosses, *Diomedea immutabilis*, off the west coast of Haida Gwaii, Queen Charlotte Islands, British Columbia. Canadian Field-Naturalist 108(3): 373.

Fourteen Laysan Albatrosses, *Diomedea immutabilis*, and unusually high numbers of Black-footed Albatrosses, *Diomedea nigripes*, were observed off the West coast of Haida Gwaii on two voyages up to 10 km offshore in November 1993.

Key Words: Laysan Albatross, *Diomedea immutabilis*, Haida Gwaii.

The Laysan Albatross, *Diomedea immutabilis*, breeds in the Hawaiian Islands where the population is estimated to be about 2.5 million (Harrison 1990). The species occurs off the west coast of North America, from British Columbia southwards, in small numbers throughout the year, but more in winter than summer (Farrand 1983; Harrison 1986). It is considered very rare in British Columbia waters, where there were 13 live sightings up to 1988, all of single birds (Campbell et al. 1990). A further nine records from the B.C. continental shelf were mapped by Morgan et al. (1991), who considered the species a rare/accidental.

On 8 November 1993, on a voyage from Skidegate Channel south to Englefield Bay, about 5 km off the west coast of Moresby Island in the Haida Gwaii (Queen Charlotte Islands) archipelago, I observed five Laysan Albatrosses in the vicinity of a fishing boat hauling cod traps. There were an estimated 200 Black-footed Albatrosses, *Diomedea nigripes*, 200 Sooty Shearwaters, *Puffinus griseus*, 150 Glaucous-winged and Herring gulls, *Larus glaucescens* and *L. argentatus*, 100 Northern Fulmars, *Fulmarus glacialis*, (of which 80% were dark phase), 20 Black-legged Kittiwakes, *Rissa tridactyla*, and two Short-tailed Shearwaters, *Puffinus tenuirostris*, in the vicinity. Most of these birds were crowding closely around the stern of the fishing boat, or aggregated on patches of discharged offal. However, three of the Laysan Albatrosses did not stay in the vicinity but merely appeared to investigate the concentration of birds and then flew on. The wind was light westerly and sea conditions were choppy with a moderate swell.

On 13 November 1993, I made the same trip in the reverse direction. The wind was approximately 50 km h^{-1} from the south-east with big swells and considerable whitecaps. No fishing boats were encountered on this trip, but nine Laysan Albatrosses were sighted in the course of the voyage, all 4–6 km offshore, in flight and fairly evenly spread out. During the same voyage I recorded approximately 200 Northern Fulmars, 50 Sooty Shearwaters, 50 Black-legged Kittiwakes and 20 Glaucous-winged Gulls. No Black-footed Albatrosses were seen.

The number of Laysan Albatrosses sighted appears exceptional compared with previous records from British Columbia waters. The number of Black-footed Albatrosses seen was also unusual. Campbell et al. (1990) reported only one record of larger numbers of Black-footed Albatrosses; 280 in June off Virgin Rocks, Vancouver Island. The maximum number they reported for autumn was 125 and most previous records from Haida Gwaii waters have occurred in spring and summer. Morgan et al. (1991) also recorded maximum numbers in summer.

Water temperatures off the coast of British Columbia were unusually high during the period from spring 1992 up to and including November 1993. An El Nino/Southern Oscillation event of 1992-1993 had persisted for much longer than usual, leading to an extended period of warm ocean temperatures (Institute of Ocean Sciences, Sidney, B.C., unpublished). The presence of unusual numbers of Laysan and Black-footed albatrosses off Haida Gwaii in November 1993 may have been related to these high ocean temperatures.

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Female Arctic Wolf, *Canis lupus arctos*, mating with Domestic Dogs, *Canis familiaris*, in Northeast Greenland.

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Maagaard, Lars, and Jes Graugaard. 1994. Female Arctic Wolf, *Canis lupus arctos*, mating with Domestics Dogs, *Canis familiaris,* in northeast Greenland. Canadian Field-Naturalist 108(3): 374-375.

A young, wild female Arctic Wolf, *Canis lupus arctos*, performed courtship behaviour and mating with domestic sleddogs, *Canis familiaris*, in northeast Greenland in the presence of humans.

Key Words: Arctic Wolf, *Canis lupus arctos*, courtship behaviour, mating, Domestic Dog, *Canis familiaris*, Northeast Greenland.

Reported encounters between Arctic Wolves, *Canis lupus arctos*, and Domestic Dogs, *Canis familiaris*, in Greenland have often been fatal for one of the parties. In some cases the dogs have been killed by the physically superior wolf in fights, whereas in other cases the wolf has been shot by man in order to protect the dogs (Manniche 1910; Giæver 1930; Freuchen 1963; Maagaard, unpublished). Although Arctic Wolves have been reported to accept human presence in Canada (Mech 1987, 1988), no comments about their behavioural response to humans and dogs has been recorded in Greenland in recent years. This note describes a meeting between wolf and dog and gives a description of subsequent courtship and mating behaviour.

The population of Arctic Wolves disappeared from northeast Greenland about 1939 (Dawes et. al 1986). The extinction of the Greenland wolves was probably a result of intensive hunting on the species conducted by Danish and Norwegian trappers in northeast Greenland in the begining of this century (Giæver 1930; Pedersen 1934, 1963; Jennov 1945). During the last two decades Arctic Wolves have immigrated in to the northern and eastern parts of Greenland again. Most of the wolves probably come from Ellesmere Island, and very few are actually are born in Greenland (Dawes et al. 1986; Maagaard 1988).

The present observations were made in the area around Weatherstation Danmarkshavn (76°46′N, 18°42′W), northeast Greenland, in the period 1988-1991. In 1979, the first wolf was seen in the area (Hansen 1979) and until 1987 wolves were observed only occasionally (Maagaard 1988). In April 1988, however, a pack of four wolves arrived and stayed in the area until October. The pack included an adult male and female and two younger females which probably were from a litter produced by the two adults in 1987. The pack raised two cubs which were born in the middle of June 1988. This is the first reliable observation to verify wolf reproduction in Greenland (Maagaard 1988). The wolves generally accepted human appearence as long as the person stayed 200-300 meters from the pack. However, one of the one-year old females was very curious and came as near as 5 m to humans. Also she contacted the sleddogs which were chained at the weather station and often was seen sniffing and playing with one of the dogs, especially during the night.

All six wolves disappeared from the area in autumn 1988. None of them were observed until July 1990 when one female arrived again. She had a distinct "black cross" mark in the fur over the shoulders and therefore was easily identified as the "curious young female".

During a trekking tour with two young male dogs in the period 1-5 July 1990, the female wolf followed the group and was very eager to contacting the dogs. During all encounters, she squeaked or whined with a low sound, probably to get in contact with the dogs. Once the dogs had accepted the wolf, all three animals ran and played together in a group. Almost instantly the wolf presented her anal region with a lifted tail to the dogs and allowed the dogs to smell this area. The wolf's behaviour was very similar to that of female sleddogs just before copulation with dogs. Therefore, we assume that the female wolf tried to encourage the dogs to copulate. However, the two male dogs did not respond to this strong courtship behaviour, probably because of their young age.

On 4 April 1991, the female wolf appeared again and followed a sledge team of two men and eleven dogs from Danmarkshavn on a one-week tour in Dove Bay. When the men camped 5 April the wolf started to play with the dogs that were tied to a long travel chain. After the wolf had contacted all the male dogs and presented her anal parts to them she selected the strongest and most dominant male dog in the pack and mated with him. Matings with the same dog were performed again two times in the following month (6 April and 6 May) in the same way on other sledge tours. All three times the mating act were performed completely and ended up with a copulatory tie between wolf and dog. The wolf was observed frequently during in the subsequent summer but she did not seem to be pregnant and no pups were ever observed.

In Greenland, mating between wolves and dogs has only been reported from Thule District in northwestern Greenland (Vibe 1981). Here the local hunters have been known to release a female dog in heat when male wolves appeared in the area in order to improve the local dogs gene pool with characteristics of wolves. However, incidents of mating between wild female wolves and tame dogs have not been previously observed in Greenland.

We suggest that this female wolf mated with the male dog because of the low density of wolves, and therefore lack of available conspecific mates, in northeast Greenland. As she had been accustomed to humans and domestic dogs from a young age, the step to mating with a dog when she came in oestrous was very small.

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A New Brunswick Black-legged Kittiwake, *Rissa tridactyla*, Colony

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Kehoe, F. Patrick. 1994. A New Brunswick Black-legged Kittiwake, *Rissa tridactyla*, colony. Canadian Field-Naturalist 108(3): 375–376.

A breeding colony of Black-legged Kittiwakes (*Rissa tridactyla*) was discovered in New Brunswick in 1992. In 1993, this colony included 25 nests and produced 29 young. Kittiwakes have not bred in New Brunswick in the previous 100 years.

Key Words: Black-legged Kittiwake, *Rissa tridactyla*, colony, breeding, nest site.

The Black-legged Kittiwake (*Rissa tridactyla*) is an abundant winter resident in New Brunswick (Squires 1976). However, there have been no recent breeding records of this species south of Cape Breton, Nova Scotia (Lock 1987). On 8 June 1992 during an excursion to the Wolves Archipelago in the Bay of Fundy, New Brunswick (44° 58'N, 66° 55'W) a breeding colony of kittiwakes was discovered.

The colony was on South Wolf Island on a south facing granite cliff. Nest sites were approximately 3–10 m above the high tide mark. During this visit eight pairs were observed on nest sites and approximately 50 other kittiwakes in adult plumage were present. On 20 June 1992 there were 12 breeding pairs present and approximately 50 other individuals. The 12 nest sites were identified by the presence of nesting material (seaweeds and grasses) and the fact that the incubating member of the pair was reluctant to leave the nest. The closest nests were approached within 15 m by boat but were not checked for the presence of eggs.

The colony was visited again on 10 May 1993. Three pairs were observed on the cliffs but no nesting material was present. On 9 July 1993, 25 nest sites were occupied by pairs and approximately 20 other kittiwakes were present. During a subsequent visit on 17 August 1993, 19 successful nest sites were identified by the presence of pre-fledged, fully feathered young. Ten nests each contained two young and nine nests contained one young. At least 29 young were produced from a minimum of 25 nests. Some young may have fledged prior to our August visit and some nests may have been initiated and lost prior to the July visit.

Non-breeding kittiwakes have been observed on the cliff at South Wolf Island during the fall and winter months since 1986 (personal observation). This site has been visited regularly during spring eider banding trips since 1986 but 1992 was the first year that there was breeding evidence at this colony.

Kittiwakes have been expanding their breeding range in both Europe and North America (Lock 1972, 1987). Colonies in Nova Scotia had a mean annual growth rate of almost 16% per annum between 1971 when colonies were first discovered and 1983 (Lock 1987). These colonies have continued to grow, although at a slower rate, to the present (Lock, personal communication).

Kittiwakes have not been reported to breed in New Brunswick recently (Squires 1976, Erskine 1992). However, Audubon (1840) had reported this species from Grand Manan, only 20 km southwest of the present location, and Chamberlain (1887) reported that kittiwakes bred in the Bay of Fundy; however, Squires (1952) stated that there were no acceptable records. Palmer (1949) also disputed the Audubon report; however, given the present information, it seems plausible that the earlier records were accurate. Thus, it is likely that kittiwakes are re-establishing themselves in New Brunswick. It is interesting to note that Common Murres (*Uria aalge*) and Great Cormorants (*Phalacrocorax carbo*) have also recently re-established themselves as breeding birds on at least one site each, in the same general area, after nearly a century's absence (Erskine 1992).

A second potential nesting colony was located at Whitehorse Island 15 km northwest of the present location. This island also has a steep southern facing cliff. Up to 50 kittiwakes have been observed at this site during July and August since 1991. Several pairs of these birds have been observed on ledges heavily stained with white guano but no nesting material was observed. This suggests that the ledges used by these pairs are specific and I speculate that these could become future nest sites.

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News and Comment

A Proposal to Amend Article 17 of the Constitution of The Ottawa Field-Naturalists' Club to be presented at the 117th Annual Business Meeting in January 1996

Whereas the wording of Article 17 of the Constitution which was approved at the 114th Annual Business Meeting and ratified at the 115th Annual Business Meeting has caused some discussion about the actual intent of the article, some clarification would be useful; therefore,

It is moved by Frank Pope, seconded by Bill Gummer, that Article 17 be reworded as follows:

"Article 17. Amendments

(a) The Constitution may be amended by majority vote at an Annual Business Meeting. Each motion must be moved by one member and seconded by another member. Motions for amendments may themselves be amended by a two-thirds majority of the members present. There shall be two procedures for amending the Constitution, as given in sections (b) and (c) of this article.

(b) The normal procedure shall be that each prosposed amendment to the Constitution shall deal with only one article.

(c) An alternative procedure shall be that a proposed amendment to the constitution may deal with more than one article where the changes to those articles are editorial and do not alter the intent of any article.

(d) Notice of proposed amendments must be published in *The Canadian Field-Naturalist* at least one month before they are to be presented at an Annual Business Meeting."

FRANK POPE

President, The Ottawa Field-Naturalists' Club
Received 7 December 1994

Errata: *The Canadian Field-Naturalist* 108 (1) and (2)

In 108(1) and 108(2), on the inside front cover under Associate Editors: 'Warren K. Ballard' should read Warren B. Ballard.

In 108(2) page 247, left text column, line 17: navel should read naval.

For Taulman, James F., and James H. Williamson. 1994. Food preferences of captive wild Raccoons, *Procyon lotor*, from East Texas. Canadian Field-Naturalist 108(2): 170–175 two references were omitted from Literature Cited:

Pyke, G. H., H. R. Pulliam, and **E. L. Charnov.** 1977. Optimal foraging: a selective review of theory and tests. Quarterly Review of Biology 52: 137–154.

Smallwood, P. D., and **W. D. Peters.** 1986. Grey squirrel food preferences: The effects of tannin and fat concentration. Ecology 67: 168–174.

The reference to **Pyare et al.** 1993 should be deleted.

Book Reviews

Zoology

Putting Biodiversity on the Map: Priority Areas for Global Conservation

By C. J. Bibby, N. J. Collar, M. J. Crosby, M. F. Heath, Ch. Imboden, T. H. Johnson, A. J. Long, A. J. Stattersfield, and S. J. Thirgood. 1992. International Council for Bird Preservation, Cambridge, England. vi +90 pp., illus. £12.50; U.S.$23.50.

The International Council for Bird Preservation (ICBP) decided there was a pressing need to map the world's biodiversity to identify where the most immediate action for conservation is required. It created the ICBP Biodiversity Project to investigate and map endemic bird species. While the ultimate objective is to identify the critical areas for all life, the ICBP used birds as they are good indicators of the important areas. Birds are widely dispersed, even to remote islands, their taxonomy and geographic distribution is well known, and they are sensitive to environmental stress. These characteristics are not shared by other animals or plants.

The ICBP used Geographic Information Systems (GIS) and other computer techniques to map the locations of landbirds with a historical breeding range below 50 000 km^2. This resulted in a list of 2609 restricted-range species. Information on these species is collected and loaded into a computerized database. Any area with two or more restricted-range species confined within their boundaries was classified as an Endemic Bird Area or EBA.

With the data in a manipulable form, the ICBP viewed it in a variety of ways to help organise their thinking and, therefore, decision making into a logical framework. Data evaluation can be a dry and exhausting task and the ICBP have made great efforts to present the statistics in a digestible form. The report abounds in full colour charts, graphs, and maps, supported by top-quality photographs. Despite this it is not an easy book to read. The reader must keep track of the assumptions and criteria used as the evaluation proceeds and must absorb a number of acronyms and codes, as well as assessing the meaning of the data.

The data generated raise some valuable insights. For example, although 147 countries are home to restricted-range birds (62% of all countries) well over half occur in only ten countries. Not surprisingly most of the 221 EBAs identified (76%) are in the tropics and a high proportion (34%) are in forested areas. The EBAs contain 2484 restricted-range species or 26% of all birds and occupy only 4.5% of the land surface. Indeed 20% of birds occupy just 2% of the land area. Unfortunately only 8% of the areas covered by EBAs are protected, affording our must vulnerable birds scant protection.

Regional accounts cover the EBAs in six areas, which do not include northern USA and Canada or northern Europe and Russia. Again, careful data manipulation and mapping are used to highlight the EBAs. For Europe, Africa, and Australia, this is simple but it is very complex for Asia and South America. Here, small changes in elevation or short distances can produce profound changes. The authors have compared their designated EBAs with mapped data for other animals. Needless to say there is a strong but not total correlation.

In organising their EBAs in order of priority the authors have avoided awarding highest marks to the biggest areas (which likely will have the most species due to size. A smaller area could be more unique) by using an equation to predict expected species for the EBA size. Areas with more than the expected number of species get the highest mark. They have also used uniqueness as a factor. This is based on the principle that it is more important to save species in unique taxa than those in a family with a large number of members. I have more trouble accepting this factor. While I see the scientific justification I find it impossible to make an ethical choice. The authors use the available data from other animals and plants to complete the ranking and arrive at a summary score. By including the degree of threat and the state of protection the authors achieve their final conclusions.

One can argue that this system has weaknesses. It does not account for migratory areas, so the Bahamas-Michigan territory of the Kirtland's Warbler is missed. Other animals are not treated as rigorously as birds, so the Black-footed Ferret is missed. There is no discussion on sub-species, so the Ipswich Sparrow is missed. As taxonomy is an evolving science this may be an important omission in the future. The authors admit they have left out seabirds as they present special problems. This, however, leaves the question of feeding territory open. Where would the Galapagos be without its marine feeding grounds? Despite these comments, the method does have a defensible rationale that suppresses the abitrary and brings a focus to an unwieldy problem. I am left with one unanswerable question, however. Most of the EBAs are in the poorer, tropical regions with rapidly growing populations. How are we, the wealthier individuals of this world, going to convince these people that "our" long-term view of natural heritage should take precedent over "their" desperate economic problems?

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The Amphibians and Reptiles of Alberta: A Field Guide and Primer of Boreal Herpetology

By Anthony P. Russell and Aaron M. Bauer. 1993. University of Calgary Press, Calgary and University of Alberta Press, Edmonton. x + 264 pp., illus., cloth $29.95; paper $24.95.

Although Alberta is justifiably renowned for its dinosaurs, coverage of its extant herpetofauna has been limited to regional field guides (e.g., Behler and King 1979; Froom 1982; Cook 1984; Stebbins 1985) and popular and technical works. Thus, the publication of *The Amphibians and Reptiles of Alberta; A Field Guide and Primer of Boreal Herpetology* is long overdue, but is has been worth the wait.

Following a short introductory chapter (pages 1-4) which discusses the significance of the Albertan herpetofauna and states the rational for this book, the remainder of the volume is divided into three parts. The first consists of three chapters of relevant background information: "Characterization of Amphibians and Reptiles" (pages 5-27), "The Amphibians and Reptiles of Alberta: A Brief Introduction" (pages 29-34), and "How to Observe Amphibians and Reptiles" (pages 35-38).

Chapter 5, "A Guide to the Amphibians and Reptiles of Alberta" (pages 39-137), is this book's main focus. A checklist of the ten amphibian and eight reptile species that definitely occur in Alberta, plus the four species that may occur in the province, is followed by three taxonomic keys that identify adults of all 22 species, and the late stage larvae and eggs of all 11 amphibian species. The 22 concise species accounts are arranged as follows: common and scientific names; a 10.5 × 6.5 cm pen and ink drawing or a 3.5 × 3.5 cm black-and-white photograph of an adult; "Description"; "Larvae"; "Variation"; "Natural history"; "Reproduction"; "Voice" (anurans only); "Distribution", including a 3.3 × 3.3 cm generalized map of the species' North American range and, if appropriate, a page-sized point locality map of its Albertan distribution; "Remarks"; and "Significant references". Color photographs (11 × 7.5 or 11 × 17 cm), at the chapter's end, depict an adult of each species that definitely occurs in Alberta.

The third portion of this book is devoted to natural history, particularly that of mid- to high-latitude herpetofaunas. Chapter 6, "Zoogeography of the Alberta Herpetofauna" (pages 143-154), describes the five major Albertan biomes and the parameters limiting each species' distribution in the province. The seventh chapter, "Amphibian and Reptile Natural History" (pages 155-167), discusses trophic and population dynamics, plus key aspects of reptile and amphibian life histories, with emphasis on amphibian larval biology and metamorphosis. The next two chapters, "Coping with the Cold" (pages 169-180) and "The Challenge of Aridity" (pages 181-188), describe adaptations and strategies employed by native species for surviving the rigors of the Albertan climate. Chapter 10, "Defence and Venoms" (pages 189-198), describes common defensive mechanisms and strategies of reptiles and amphibians, as well as the prevention and treatment of snake bites. The eleventh and final chapter, "Man and the Herpetofauna" (pages 199-206), concentrates on how human activities have affected the Albertan herpetofauna.

The "Bibliography" (pages 207-248) is extensive, consisting of 50 general and 886 specific articles. A "Glossary" (pages 249-253) of 76 terms used in the text and an "Index" (pages 255-264) of 829 terms complete this book.

The book itself is well-designed and attractive; it is small enough (14.5 × 23.5 cm) to carry in a jacket pocket or knapsack in the field, and the binding and stitching of the hardcover edition is robust. The sixteen color plates are printed on matte paper and are all excellent. The contrast in most of the 13 black-and-white photographs is poor, presumably the result of poor printing by the publisher; the *Chelydra serpentina* account would have benefitted from a photograph that clearly shows the unique body form of this species. The 59 line drawings range from adequate to (particularly those of the snakes) excellent.

The only factual error that I noted in this book was the claim that "Reptiles first appeared in the Permian Period" (page 13). In fact, reptiles were present and reasonably diverse during the Permian and the preceding Pennsylvanian (Carroll 1988), and may have arisen as early as the Mississippian (Smithson 1989). Although cladograms are de rigueur for phylogenetic analyses, given this book's broad audience an evolutionary tree may have been more appropriate than the cladogram (Figure 2.1) used to depict tetrapod relationships. Finally, some readers may find the inconsistent documentation of diagnostic features among similar species confusing (e.g., number and relative sizes of the chinshields are given for *Thamnophis elegans* and *T. sirtalis*, but not for *T. radix*).

In spite of the admittedly minor flaws that I have addressed above, I am very impressed with this book. Russell and Bauer have produced a first rate field guide, with broad appeal, that effectively places the extant Albertan herpetofauna into its proper evolutionary, historical, and ecological context. As such, this volume is not only a reliable field guide, but it is also an adequate introductory herpetological text.

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On Methuselah's Trail

By Peter D. Ward. 1993. W. H. Freeman and Company, New York. 212 pp., illus. U.S.$12.95.

We are all too familiar with extinctions of dinosaurs, mammoths, and sabre tooth cats. These were just some of the noteworthy animals that have existed in the past and have inevitably come to an end. But what about the survivors of the extinction events, the ones that have changed little over vast periods of geological time? The fundamental question asked is why they survived and other did not.

Peter Ward, an invertebrate paleontologist with the University of Washington, examines some of these survivors as witnesses to the past rather than mere novelties. His book *On Methuselah's Trail* is a wonderful work of scientific romanticism combining autobiographical sketches and narratives that emphasize the uniqueness of the survivors. Ward takes advantage of the fact that invertebrates generally have longer evolutionary lineages (like brachiopods or even the horseshoe crabs) than most major (albeit more popular) vertebrate groups, and thus the invertebrate record illustrates the big picture more coherently. He has collected in, and understands, most major parts of the earth fossil record. Ward takes the reader right to the moment the ammonites became extinct 65 million years ago, and lets us endure with him the manmade hazards while collecting at a Spanish locality that has frozen that moment in time.

On Methuselah's Trail is arranged somewhat chronologically, because it discusses the invertebrate record that extends back to the Cambrian Period more than 500 million years ago. But it also intermixes yesterday with today. Fossil collecting alternates with biology: supervising students joyfully chiselling out Ordovician trilobites, bryozoans, corals, and brachiopods in the Ohio Valley and diving in the cool waters in Puget Sound to collect contemporary brachiopods for a university class; collecting ammonites in many European localities; and collecting live Nautilus in the Pacific Ocean.

The question of why a particular group of organisms survived and others did not can be a little less baffling if we examine modern, related forms. For example, why did the ammonites fail to cross the Mesozoic/Cenozoic boundary? A related cephalopod, the Nautilus, survived and may give some clues as to the mechanics of the extinction event that also claimed the dinosaurs. The slow reproductive capabilities of the Nautilus may have helped it outlive the "event" 65 million years ago.

Ward also enters areas that are not in his expertise, the waves of plant invasions on land and the most familiar vertebrate survivor, the Coelacanth. Here he shifts from autobiographical accounts to biographical sketches of the men and women who were the lucky pioneers in their fields.

Ward's book portrays paleontology in a romantic and informative way. Supervising students collecting fossils he says "I hide a smile as I watch this industry, for these college students are not far removed from more childish pursuits, and they appreciate this type of work for the childish fun and wonder of it". Yet this romanticism can get a little thick. In referring to some general geological information about the state of Washington, he states "This obscuring stratum is the gift of the Ice Age Glaciers". For those few of you who have attempted to remove some of this "obscuring stratum" to get at the lower bedrock, the word "gift" does not come to mind. It's a pain in the ass and a strain on the back. This book, however, is no pain or strain but thoroughly enjoyable.

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A Wing in the Door: Adventures with a Red-tailed hawk

By Peri Phillips McQuay, Hounslow Press, Willowdale, Ontario. 205 pp., illus. $17.99.

Occasionally temporary friendships exist between humans and wildlife that provide a rare opportunity for the observation and understanding of a species. In April 1988, the Avian Care Foundation released an immature two-year-old Red-tailed Hawk in a conservation area that was home to Peri Phillips McQuay and her family. So begins the story of a most extraordinary friendship between the McQuays and the hawk they chose to call Merak.

In beautiful prose the author describes the highlights of daily living as the family observes what they quickly discover is a human-imprinted hawk as it gains the knowledge needed to eventually survive in the wild independently. Life in the household revolved around obtaining a steady supply of mice and muskrats to supplement the hawk's diet, keeping peace between their domestic pets and the hawk, and monitoring the movement in the surrounding area of "the bird". Merak, however, over the three years, wins the family's hearts and provides a rewarding and rare understanding of red-tails only afforded those who have been able to observe a bird in such close proximity.

The author excels in her visual descriptions throughout the book and gives readers day-to-day accounts of hunting tactics, nest building, the moulting process, mating rituals, etc. In addition there are provided detailed observations of the hawk's physiology and behaviour.

McQuay is a gifted writer who provides insightful observation. Through her narrative, she proficiently relays to the reader not only her understanding of Merak but also of many other aspects of the natural world around her. One can sense she is at home in the wild and as she smoothly describes the plants, animals and birds she encounters on her walks.

Throughout the book, the author includes elucidating inserts of factual information relating to natural history. Topics such as flight, senses, calls, food, methods of attack, and lifespan are expanded upon, and listed for quick and easy reference. Combining this feature with the notes, bibliography, and index, the book can also be a useful source of reference for Red-tailed Hawks.

This book is very enjoyable and a rewarding read that provides rare insight into the life of a Red-tailed Hawk from the vulnerable human-imprinted stage to that of a mature independent raptor.

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Bears: Monarchs of the Northern Wilderness

By Wayne Lynch. Douglas and McIntyre (Greystone). 242 pp., $45.00

In northern environments, there reside four of the world's eight species of bears, namely the Polar Bear, the Brown Bear, the Asiatic Black Bear, and the American Black Bear. As the aforementioned share many similarities in location, scientific grouping, and hibernating behaviour, Lynch has chosen to focus his book entirely on them, and for a reader's general information, briefly addresses the four species of tropical bears in Appendix A.

Lynch demonstrates his expertise as both a photographer and writer with an impressive text and an exceptional display of photographs. He uses a coffee-table format which lends itself to this subject matter with large, full colour photographs accompanied by lengthy captions. These photographs are both visually delightful and informative. The use of action shots and close-ups further enhances the text.

The book begins with a brief profile of each individual bear including its description, physiology, and distribution. The bulk of the book covers a one-year period, broken into six time-frames, (Jan/Feb/Mar-Apr/May-June-Jul/Aug-Sep-Oct/Nov/Dec). This is unique, effective, and beneficial format that allows the reader a continuous comparison of all the species throughout their annual cycle. The Asiatic Black Bear receives the least amount of coverage due to the unavailability of research material. It is, however, addressed frequently enough throughout the book to demonstrate its differences and similarities with the other three.

Throughout the timed segments, the author explores bear ethology with meticulous detail. The topics of hibernation, birth of young, hunting tactics, mating and reproduction, social hierarchy, and home ranges are discussed at length. Readers will derive a wealth of knowledge on these four species and all facets of their life.

The reader notes that it took the author nine years to finish this book and the extensive research included reviewing of technical papers, attending meetings, travelling, field observation, and his creation of photographs. Addressing four species simultaneously is a challenging task and Lynch's material is well-presented and organized with a flowing writing style.

In addition to being an enlightening and informative read, the bibliograhy, index, and overall depth of coverage makes the book a useful reference source. Combining this fact with the abundance of quality photography it is highly recommended.

A complimentary book on bears that uses a different approach but is equally exciting is *Bears: Majestic Creatures of the Wild* that addresses a multitude of expected and related topics featuring contributions from thirty highly educated professionals on the eight species of bear, with Dr. Ian Stirling as the consulting editor.

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Guide to the Birds of Iceland: A Practical Handbook for Identification

By Thorsteinn Einarsson. 1991. Örn og Örlygur Publishing House, Reykjavik. 239 pp., 190 illus.

This book is a translation of the original Icelandic work published in 1987. Unlike many translations of technical or quasi-technical publications, it reads easily.

The identification of birds in Iceland is simplified by the relatively small size of the avifauna. When seasonal visitors and migrants are tallied up, the list is 110 species long, all of which are treated in this volume. The illustrations of individual species are primarily colour photographs, and the guide suffers from many of the disadvantages associated with photo-guides. The difficulties involved in trying to adequately illustrate all essential key characters in a photograph are recognized by the authors, who have included black-and-white line sketches to assist in identification of some species.

The text is of variable usefulness as a field tool. This is presumably a reflection of the limited chances for confusing species. In some cases the text is largely limited to differentiating a relatively uncommon species from a more widely encountered bird (e.g., Goldeneye from the more common Barrow's Goldeneye). A birder alreayd in possession of a decent guide to European birds would not likely gain much advantage from this book in the field. However, it contains some useful information regarding the distribution of a number of species. I found the map of sea bird colonies, which includes the relative proportions of guillemot species (murres in North America) nesting at the various sites, to be quite handy. An interesting addition is a set of drawings illustrating the partition of coastal nesting habitat among species.

The book is organised unconventionally. Appropriately enough for an island nation, "seabirds" come first followed by waders and gulls. A multilingual list of Icelandic birds, and a short section on protection of birds in Iceland are appended.

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Atlas of the Mammals of Ontario

By J. S. Dobbyn. 1994. Federation of Ontario Naturalists, Don Mills, Ontario. viii + 118 pp., illus. $9.35.

This is a valuable start to providing an accurate database for mammalian distribution in Ontario. One must always start somewhere, and the authors, contributors, and volunteers who have made this possible should certainly be commended. Care has been taken to ensure that the records are accurate and the data are presented in a well-explained and easy-to-understand manner. I hope that this forms a basis for a continuing project that will update and perfect this record in a manner similar to the very successful bird atlas that preceded it (Caiman, Eagles, and Helleiner 1987). This book is certainly a critical reference for any naturalist's library, and well worth the reasonable cost.

The 83 species of natural and three exotics recorded (including some extirpated or questionable records) are documented with one page each, including a short discussion of the historical and present distribution, a provincial map of distribution marked as 100 km × 100 km squares and a half province map with distribution as 10 km × 10 km squares. Actual data are recorded on a 100 m × 100 m basis. The maps are very detailed. I assume (although the methodology section does not provide this detail) that the records are in a GIS database and thus will be easily updated and retrieved. The ability of the Bird Atlas to provide lists for geographic locations is a most valuable tool. The mammal atlas has 14 pages of introduction and 92 pages of species accounts. The data were obtained from 21 institutes and 444 volunteers, and include 164 697 records. The shortage of volunteers and difficulties with observing some of the mammal species did result in some shortfalls as compared to the bird atlas, with its 1351 volunteers and the more easily observed avifauna. Again, the importance is that this is a start and the basis for continued observation and recording.

With the benefits of this atlas in mind, I feel there is a need for soliciting for continued input. I would have suggested a comment sheet or instructions on how to submit supplemental data or revisions. Such a program has been very successful in the U.S. Fish and Wildlife Service's habitat suitability index modelling program. I thought there was some uneven treatment that needs to be resolved in future revisions and was also surprised at the small number of references cited. R. L. Peterson and C. G. van Zyll de Jong were cited for almost everything and also provided a large portion of the text materials. Perhaps they should have been co-authors. J. Eger and N. Wilson are referred to as "contributors", but had, to my thinking, significant "co-authorship". I was surprised at the lack of information from the vast, unpublished files of the Ministry of Natural Resources. Much of this was tabled at the recent timber management environmental assessment. Even if the Federation of Ontario Naturalists opposed the concept, they should not have ignored the information. The atlas indicates the gaps in data resulting from no trapping records for places like Algonquin Park and yet there is no reference to *Wild furbearer management and conservation in North America* edited by M. Novak et al. and produced by the Ministry of Natural Resources (reviewed in *The Canadian Field-Naturalist* 103 (1): 120–121, 1989).

Other examples of uneven areas of treatment included the lack of discussion of how habitat distribution or degradation has effected mammal distribution. For some species, such as the Eastern Mole, Woodland Vole, Northern Bog Lemming, and Badger, there is a good treatment of this highly relevant topic. In most cases it is not even discussed. Other examples just tease us a bit. The Least Shrew, we are told, is not common due to shortages of preferred habitat. This preference is not specified. Three races of Deer Mice have different habitat preferences, but what are they? Three pages were devoted to three colour phases of Grey Squirrel, but the Red Fox and Grey Wolf, equally important species with similar colour phases, only received a page each. I do not think these issues harm the book, but I do think they show some expedition of production and could be revised with future editions. In general, I thought the publication could have benefitted from a longer and more detailed write up for all species.

I highly recommend this as an excellent reference source on mammals in Ontario. I also hope that there is an electronic updating system with plans to revise the publication in the future.

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The Bamboo Bears: The Life and Troubled Times of the Giant Panda

By Clive Roots. 1989. Hyperion Press, Winnipeg, Manitoba. x + 102 pp., illus. $23.95.

The Giant Panda, due to its charming appearance and low numbers in captivity, has become one of the most popular animals in history. Clive Roots, director of the Assiniboine Park Zoo in Winnipeg, has taken this opportunity to outline the story of this endangered species.

The book is divided into 10 chapters that include climate, physiography, vegetation, and additional vertebrates in the panda's geographic range; reproductive biology, growth of young, and factors influencing survival; the panda's discovery by the western world and various expeditions initiated to collect museum specimens; and expeditions made into China to capture live pandas and the 3 phases of China's export of pandas for display in zoos.

The most interesting and well written chapter describes panda evolution and the controversy over whether they are more closely related to Ursidae or Procyonidae. Other chapters include the panda's diet in the wild and in zoos; a discussion of bamboo, the panda's principal food; zoo conservation of the panda, emphasizing captive breeding; panda conservation in the wild, emphasizing deforestation and management strategies being developed to ensure its survival; and the short-term loan of pandas for displays in zoos, outlining the cost-benefits of these loans with respect to possible loss of breeding opportunities and overall species survival.

The author makes several negative and erroneous statements describing this unique carnivore; for instance, "...the panda's daily routine is stereotyped and monotonous...", "...top speed of little more than a clumsy trot...", and "...bumbling habits...". Additionally, Mr. Roots has developed several overgeneralized, unsupported concepts including "If it [the panda] becomes the twenty-first century's dodo it will only prove what has been suspected, and perhaps known, for many years. That there really is not a great deal of hope for any large wild animals on this planet".

The book is generously illustrated with color photographs of varying quality. There are virtually no typographical errors. An index is provided, although I question the usefulness of some entries (e.g., "hospitable climate" in place of "climate"). This coffee table book is of limited value to the scientific community, and provides only a brief list of selected references. One common difficulty I have with books of this nature is that a lack of direct citations precludes cross referencing the author's statements. It is interesting to note that this book was published about the same time that a pair of pandas were on loan at the Assiniboine Park Zoo. I recommend Schaller et al. (1985) for serious students of panda ecology and conservation biology.

Clive Roots attempts to document the plight of the panda, emphasizing the need for conservation of endangered species. Because it provides some useful information of a general nature, I recommend this book with reservation to the casual reader interested in Giant Pandas and species conservation.

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The Birder's Guide to Bed and Breakfasts

By Peggy van Hulsteyn. 1993. John Muir Publications, Santa Fe, New Mexico. xii + 368 pp., illus. U.S. $15.98.

Even before my copy of this book arrived I wondered how I could review a book that attempted to combine two different concepts. Birding brings a sensation of the lonely, rugged wild, while a Bed and Breakfast, or B&B, is a social, often luxurious, experience. On receipt of my volume I knew I would have problems as I was immediately struck by what the book did not contain. I looked for a description of a number of my favourite birding spots, like Brigantine, New Jersey, and was disappointed not to find them. Checking the table of contents I realised that, on average only two birding sites per state are described, meaning much is left out. I then realised that although all 48 mainland states plus Hawaii are included, only four of Canada's provinces are covered.

The descriptions of the birding areas are brief and give only a general, and sometimes muddled, sense of a location's possibilities. Winter birds, like alcids, are sometimes lumped with summer birds, like terns. Some exciting birds, like Mile High canyon's famous owls, are not mentioned. There is often little sense of how difficult it can be to see some of the species, like Long-tailed Jaeger. You get more a sense of a writer who has learned something of birds rather than a birder who has forced herself to write. Missing are the precise directions, seasonal distribution charts, habitat preferences, and daily activity patterns that are so useful and that we have come to expect in a modern site guide. The author may have been wiser to have listed all the key birding areas, with minimal information, and referred the reader to the many excellent site guides that are now available.

The descriptions of the Bed and Breakfasts (B&Bs) are quite different from the birding information. We became B&B fans many years ago in Wales, when there was literally no room at the inn, and were "forced" to stay at a little stone cottage overlooking Red Kite country. This book's descriptions give a good sense of the nature of B&Bs in general as well as the individual character of each guest home. The basic information on the accommodation, food, and surroundings is well presented and there is normally enough detail to get a feel for the character of the host and the charm of the location. Fundamental information on price, credit cards, smoking, seniors discounts, and pets is given in a simple table. The author has also remembered to include the availability of wheelchair access.

It was clearly difficult to select the most appropriate B&Bs for each area. Those chosen run from the simple to the bizarre, from rustic to wilderness opulence. I was intrigued by the "Centre Street" in Logan, Utah, which has King Tut, Purple Dragon, Pirate's Paradise, and eleven other fantasy-style theme rooms. The Alaskan B&Bs are luxurious lodges buried in the wilderness that carry hefty price tags; over Cdn. $600 per night, double occupancy. In contrast, a charming old southern house in Decatur, Alabama, offers two rooms for Cdn. $68 apiece. I sorted a randomly selected sample of 100 B&Bs by price. Fourteen percent were below Cdn. $68, U.S. $50, 24 percent were between $68 and $102, 30 percent were between $102 and $137, and 32 percent were over Cdn. $137, U.S. $100. So over 60 percent charge more than Cdn. $100. My colleagues and I have been charged an average of Cdn. $82 at Canadian hotels this year, and I recently stayed at a B&B for Cdn. $45. I am unable to say if these prices reflect an overall higher cost ofr B&Bs in the U.S. or whether the author has tended to choose the more elegant options.

The book is also somewhat marred by proof reading faults. The front cover photos are given as Klamath Basin, Canada (it is in Oregon) and the Allen House, Maine (it is in Massachusetts). Similar minor errors, such as room price reversals and misspelled words occur in the text. The book is attractively illustrated with black-and-white photos of birds and B&Bs. The bibliography contains references to field guides but does not include a single site guide.

This is a good and useful book, despite some of the comments above. A clearer focus on the intent and then the framework of the book would have made it a classic. But this is not the type of project that really ends. Buy it, use it and let the author have your suggestions, updates, and additions and the second edition should be a classic!

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Wild Wings: An Introduction to Birdwatching

By Tim Fitzharris. 1994. McClelland & Stewart, Toronto 191 pp., illus. $24.99.

Tim Fitzharris is a veteran observer of nature, and the author/photographer of ten books on natural history. In this book, Fitzharris acquaints beginning birders with the basics needed to identify various species using a conversational writing style and an abundance of colour photographs.

Those readers familiar with the author's book *The Audubon Society Guide to Nature Photography* will find this book very similar in style and format. As in the above, this book's introduction familiarizes readers with the equipment needed to get started. The most common ways of identifying birds using size, shape, flying styles, and the more challenging tasks of spotting distinguishing characteristics and identigying species by birds songs are the discussed.

With this basic "how to" information adequately addressed, the author takes readers on an armchair journey to various North American habitats highlighting specific species. Five chapters beautifully present these very different environments by using text and photographs. A number of species are examined by discussing field marks, songs, and characteristic behaviours, as well as providing close-up photographs. Upon completion, readers should have a basic understanding of what type of birds one can expect to encounter in the habitats they are visiting. With this knowledge and a personal field guide, identification will prove much easier.

The author concludes with birding "hotspots" in North America including Bonaventure Island, Quebec; Churchill/Hudson Bay, Manitoba; and Point Pelee, Ontario, where great numbers of birds can be viewed during breeding or migration periods.

Novice birders will find this an enjoyable and informative introduction to birdwatching and an indispensable reference tool. Experienced birders will enjoy Fitzharris' approach to observation and the illuminating photography.

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Seashores: Peterson First Guide

By John C. Kricher. 1992. Houghton Mifflin, Boston. 128 pp., illus. U.S. $4.95

It is an excellent idea to produce a series of "intoductory" field guides which, as editor Roger Tory Peterson says, "offer a selection of animals and plants you are most likely to see during your first forays afield". Unfortunately, I don't feel that this book fully accomplishes that goal. Organizing the book according to environment, such as "Northeastern Rocky Coast" or "Salt Marshes and Estuaries", is logical, but since there is no table of contents you cannot easity find the book section which corresponds to the area you happen to be exploring. Also, the index is incomplete: the entry for sea stars did not include page 16 where two of the four sea stars in the book are shown. An inexperienced naturalist would have no choice but to page randomly through the book, looking for something familiar. A more serious complaint is the fact that a significant number of organisms shown are not common at all, and seem to be out of place in a "First" book: the Atlantic Puffin on page 12 is hardly a common sight along most of the east coast, and among the "Birds of the Dunes" is the Peregrine Falcon, an endangered species. The basket star on page 16 is presumably shown because it is so spectacular. In 10 years of beach walks on Cape Cod I have never seen one and even Rachel Carson in "The Edge of the Sea" said "to see a basket starfish close inshore is one of those rare happenings that lives always in memory". Single-celled Radiolaria pictured on page 76 are strictly open-ocean organisms.

There are some nice features in the illustrations, such as picturing shellfish in place under the sand with the siphons and "feet" extended. Unfortunately, the labels for the softshell and hardshell clam (the shellfish most novices might be aware of due to their value as food) are reversed. Overall I felt the illustrations were unnecessarily small with much empty space on the pages and not as sharp as equivalent pictures in other guides such as the full-fledged Peterson Atlantic Seashore. Also, the colors in the illustrations often did not agree with the text: For example, the "brown" rockweed looks olive green and the "olive" knotted wrack looks brown. The oyster drill is described as a "small white snail" but in the picture it is quite dark.

A number of inaccuracies and unexplained statements are also frustrating, particularly in a book for beginners. When you begin to understand how plants and animals interact, you become an ecologist, not an environmentalist. The common periwinkle is identified by its "pale lip", but we are never told or shown what the lip is. The figures of sea urchin and test are not labelled. Symbiosis does not necessarily mean the relationship is beneficial to both organisms (that is mutualism). Giant kelp cannot survive "in the dark depths" without blades in the upper, better illuminated waters to gather light.

Despite my criticisms, when I field tested this book in several of the local seashore environments I was able to identify most of the obvious organisms. Nevertheless, even for a beginner, I would recommend the regular Peterson Atlantic Seashore by Kenneth Gosner.

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Arena Birds: Sexual Selection and Behavior

By Paul A. Johnsgard. 1994. Smithsonian Institution Press, Washington. 330 + viii pp., U.S. $39.95

No area in ornithology, ethology, or evolutionary biology is more fascinating than the anatomical and behavioural richness that has developed among birds whose courtship involves arenas, courts, and leks. (So great is this fascination that a seminar in which I participated welcomed a visiting researcher in this area with improvised garb and dance in imitation of the species under discussion.) As the subtitle indicates, the emphasis is on the behavioural interactions between and within the sexes that produce mating advantages.

The book begins appropriately with a review of inter- and intra-sexual selection from the seminal introduction of these concepts by Charles Darwin in 1871 to their extensive elaboration in contemporary models. Germane issues include secondary traits, aspects of communicative signals, the possible role of parasitic infestation, and the costs and benefits of choice by females and of aggregation by males. Next considered are appropriate terminology for the variety of mating systems, natural versus sexual selection, species recognition and hybridization (common and of great interest from several angles), and key aspects such as hotshots and hotspots. The remaining ten chapters present findings for the various groups of species which are widespread taxonomically (including ducks, pheasants, sandpipers, lyrebirds, manakins, and birds of paradise) and within each of which there is much diversity. Body sizes range from 3 g for hummingbirds to 20 kg bustards, mating patterns from monogamy to extreme promiscuity, adornments from ocellated feathers to painted bowers, and behavioural elements from dramatic aerial displays to auditory ones such as drummng and learned songs.

Reflecting the long-term interests of the author expressed in the Preface and for which he is well known, the ethological accounts are carefully presented and analyzed. Coverage of the literature is satisfyingly full, extending from the early observations of workers such as Konrad Lorenz and Frank Chapman to the present. In addition to the extensive references there are an index (of authors and birds, but not subjects) and a helpful glossary. As usual from this publisher, the book is well composed, the writing is very clear, and extensive tables and drawings effectively summarize much information and illustrate behavioural displays as well as other features such as sonograms. Sixteen pages of colour plates underline the visual magnificence of the species. Useful interspecific comparisons are drawn and critical interpretation is shown in the consideration of crucial aspects of such topics as lekking in grouse and diversity of behaviour by male ruffs.

While the ethological considerations are extensive, readers interested in discussion of the ecological factors driving the mating system, or their phylogeny as seen in cladograms, and the predictions which can be based on such discussion, may be somewhat dissatisfied. But for everyone interested in birds, behaviour, or evolution this will be a valuable book.

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Whitetail Autumn

By J. J. Ozoga. 1994. Willow Creek Press, Minocque, Wisconsin. 160 pp., illus. U.S. $29.50.

The White-tailed Deer is one of our most successful, most wide-spread, and often most controversial large mammals. Because of each of these issues, it is essential to have a good source of data for management decisions and public information. I believe that this book fills both functions quite well.

When I reviewed Cox and Ozoga's *Whitetail Country* (1988. *The Canadian Field-Naturalist* 102(4): 755), I felt it was one of the most interesting books I had ever read. This is a continuation in the same manner. The pictures alone would make the book well worth purchasing. I had to look at them each several times and read the titles before I went on to read the text itself. I think that anyone would find these interesting as coffee table entertainment. The naturalist will find the text very informative.

I have used the earlier *Whitetail Country* as a reference in my work. Few of the wildlife species that I have worked with have had such excellent and professionally complete references. *Whitetail Autumn* goes beyond this in detail, dealing only with the one season. It is also most up to date, with references as recent as 1994. Even though it is filled with technical detail and relates only to one quarter of the year, this book never loses its interest.

In spite of the three pages of references, it soon becomes obvious that much of the book is written from Ozoga's own personal experiences, over thirty years of research on whitetails. The concentration on the northeastern United States results from his working with the Michigan Department of Natural Resources. Perhaps, if there is any fault, it is the lack of discussion of the effects of autumn in harsher or more mild parts of the whitetail's extensive range. I would highly recommend the book for those with a casual interest in deer, for naturalists, and for wildlife managers. I likewise await his other three seasons.

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ENVIRONMENT

Applied Ecology

By Edward I. Newman. 1993. Blackwell Scientific Publications, Oxford, Cambridge, Massachusetts. 328 pp., illus. U.S. $31.95.

The world's resources are increasingly harvested at what are hoped to be "sustainable" levels. In order to set these "sustainable" limits, an understanding of ecological theory and their implementation is useful. In response to attempts to apply ecological knowledge, a number of new journals and books are being published. This book, in the author's words, "is aimed at people who want to find out about how ecology can contribute to solution of a wide range of problems... primarily undergraduates studying biological science".

The book is not intended to be comprehensive but to be easy to use. Dr. Newman has accomplished ease of access to the information held within by providing one chapter on each of the following themes: climate change, agriculture, fisheries, forestry, pests, pollution, and conservation. Within each chapter, information is readily found with the help of informational boxes and side headings. The chapters are written in standard format which should aid for future referral. If further information is required the reader can find additional readings listed at the end of the chapters. A glossary is provided at the end of the book preceeding the list of references and index.

The author has succeeded in providing an easily understood text. Unfortunately, in an effort to have information easily retrieved, I feel the readability has suffered. The reading is disrupted by the informational boxes and referral to tables and figures in other discussions. I also found some of the discussion dated, specifically within the fisheries theme.

Applied Ecology does provide a introduction to the topics it covers at what I believe should be the undergraduate first or second year level, which is the author's intent. The information provided is easily retrievable, another of the author's intentions. As an introductory text, the book should have a future.

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MISCELLANEOUS

Julian Huxley: Biologist and Statesman of Science

Edited by C. Kenneth Waters and Albert Van Helden. 1992. Rice University Press, Houston, Texas. vii + 380 pp., illus. U.S. $32.50.

Julian Huxley (1887-1975) has been well-known in a variety of circles as a preeminent British zoologist, a popularizer of science, the Secretary of the London Zoological Society and, after World War II, as the first Director-General of UNESCO. It is less well-known that from 1913 to 1916 Huxley worked in the United States, where he founded the Department of Biology at the Rice Institute. The Woodson Research Centre of the Rice University Library acquired most of Julian Huxley's papers and, in 1987, Rice University organized a symposium to celebrate the centennial of Huxley's birth.

Nearly thirty scientists and historians of science from Britain, Canada, and the United States participated in the symposium. Nineteen papers, including a few long ones, and others that were short reponses to the longer presentations, constitute this volume. The book begins with an excellent introductory essay "Revising Our Picture of Julian Huxley," by C. Kenneth Waters. The main body of the text is divided into three parts: "Huxley and His Times," "Huxley the Biologist," and "Huxley the Statesman of Science." In part one, Colin Divall's "From Victorian to a Modern: Julian Huxley and the English Intellectual Climate," focuses on Huxley's philosophical background that influenced his interests and concerns. It is followed by two brief responses by Peter Stansky and Martin J. Wiener, respectively. The concluding essay in this section is Robert Olby's "Huxley's Place in Twentieth-Century Biology."

In part two, eight essays discuss Huxley as a biologist. Six of these are detailed works, among them J. A. Witowski, "Julian Huxley in the Laboratory: Embracing Inquisitiveness and Widespread Curiosity;" F. B. Churchill "*The Elements of Experimental Embryology:* a Synthesis for Animal Development;" Richard W. Burkhardt, Jr. "Huxley and the Rise of Ethology;" John R. Durant, "The Tension at the Heart of Huxley's Evolutionary Ethology;" William B. Provine "Progress in Evolution and the Meaning in Life;" and John Beatty, "Julian Huxley and the Evolutionary Synthesis." The two short pieces are Elof A. Carlson, "Huxley's Interest in Developmental Biology" and Solly Zuckerman, "Comments and Recollections."

Part three contains three essays each on Huxley and eugenics, and Huxley and the popularization of science, respectively. Garland E. Allen's long paper

"Julian Huxley and the Eugenical View of Human Evolution" is followed by two shorter ones: Diane B. Paul's "The Value in Diversity of Huxley's Eugenics," and Elazar Barkan's "The Dynamics of Huxley's View on Race and Eugenics." Daniel J. Kevles's paper, "Huxley and the Popularization of Science," is complemented by D. L. Maheu's "The Ambiguity of Popularization," and Robert L. Patten, "The British Context of Huxley's Popularization." There is also a useful appendix by Nancy L. Boothe on the Huxley papers at Rice University, and a list of Sources (i.e., a bibliography).

I have listed the chapter titles to indicate the richness of the topics explored in the symposium. The general reader may find the second part too detailed, however, and too heavy on the context of the history of biology, to the detriment of Huxley's own contributions to science. Nevertheless, the book is an enjoyable, well-written, informative, and highly useful contribution to the existing literature on both Julian Huxley and the history of 20th century biology.

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NEW TITLES

Zoology

†**The abundance and distribution of estuarine birds in the Strait of Georgia, British Columbia.** 1994. Edited by R. W. Butler and K. Vermeer. Canadian Wildlife Service Occasional Paper No. 83. Environment Canada, Ottawa. 78 pp., illus.

Animal babies: a habitat-by-habitat guide to how wild animals grow. 1994. By S. Parker. Rodale Press, Emmaus, Pennsylvania. 176 pp., illus. U.S. $30.

The animal mind. 1994. By J. L. and C. G. Gould. Scientific American Library, New York. 236 pp., illus. U.S. $32.95.

Animals alive: an ecological guide to animal activities. 1994. By D. Holley. Roberts Rinehart, Niwot, Colorado. 312 pp., illus. U.S. $29.95.

*__Atlas of the mammals of Ontario.__ 1994. By J. Dobbyn. Federation of Ontario Naturalists, Don Mills, Ontario. viii + 120 pp., illus. $9.35.

†**Biology of North American tortoises.** 1994. Edited by R. B. Bury and D. J. Germano. U.S. National Biological Survey, Washington. 204 pp., illus.

*__City peregrines: a ten-year saga of New York City falcons.__ 1994. By S. Frank. Hancock House Publishers, Surrey, British Columbia. 313 pp., illus. $29.95.

†**A field guide to legendary northwoods animals.** 1994. By G. Winter. Willow Creek Press, Minocqua, Wisconsin. 126 pp., illus. U.S. $16.95.

†**Instream flows to assist the recovery of endangered fishes of the upper Colorado River basin.** 1994. By J. A. Stanford. Biological Report 24. U.S. Biological Survey, Washington. 47 pp., illus.

*__Journey to the ants.__ 1994. By B. Holldobler and E. O. Wilson. Harvard University Press, Cambridge. 228 pp., illus. U.S. $24.95.

†**Martens, sables, and fishers: biology and conservation.** 1994. Edited by S. W. Buskirk, A. S. Harestad, M. G. Raphael, and R. A. Powell. Cornell University Press, Ithaca. xvi + 484 pp., illus. U.S. $65.

†**Proceedings of the 16th Northwest Pacific Pink and Chum Salmon Workshop.** 1994. Alaska Sea Grant College Program, Fairbanks. 192 pp., illus. U.S. $10.

*__Whitetail autumn.__ 1994. By J. J. Ozoga. Willow Creek Press, Minocqua, Wisconsin. 160 pp., illus. U.S. $29.50.

Botany

Algae and water pollution. 1994. Edited by S. C. Rai, J. P. Gaur, and C. J. Soeder. Schweizerbart'sche, Stuttgart, Germany. ix + 144 pp., illus. DM 89; U.S. $57.

Ecophysical adaptation strategies of intermedial marine macroalgae. 1993. By R. Einav. J. Cramer, Stuttgart, Germany, 91 pp. DM 60.

Freshwater algae of the southeastern United States, part 6: Chlorophyceae, Zygnematales, Desmidiaceae. 1993. By G. E. Dillard. J. Cramer, Stuttgart, Germany. 166 pp., illus. DM 120.

*__Guide to flowering plant families.__ 1994. By W. B. Zomlefer. University of North Carolina Press, Chapel Hill. 430 pp., illus. Cloth U.S. $49.95; paper U.S. $24.95.

†**The lichens of British Columbia illustrated keys, part 1: foliose and squamulose species.** 1994. By T. Goward, B. McCune, and D. Meidinger. B.C. Ministry of Forests, Victoria. 181 pp., illus.

†**Scientific and common names of 7,000 vascular plants in the United States.** 1994. Edited by L. Brako, A. Y. Rossman, and D. F. Farr. 304 pp. U.S. $29 in U.S.A.; U.S. $36 elsewhere.

Environment

Beyond the numbers: a reader on population, consumption, and the environment. 1994. Edited by L. A. Mazur. Island Press, Washington. xvi + 444 pp. Cloth U.S. $40; paper U.S. $19.95.

Principles of conservation biology. 1994. By G. K. Meffe and C. R. Carroll. Sinauer Associates, Sunderland, Maryland. 575 pp., illus. U.S. $46.95.

Proceedings of the Second International Conference on Reservoir Limnology and Water Quality. 1994. Edited by V. Straskrabova and J. F. Talling.

Schweizerbart'sche, Stuttgart, Germany. viii + 294 pp., illus. DM 178; U.S. $115.

Restoring prairie wetlands: an ecological approach. 1994. By S. M. Galatowitsch and A. van der Valk. Iowa State University Press, Ames. x + 246 pp., illus. U.S. $42.95.

The straitkeeper's handbook: a teacher's guide to discovering the ecology of Georgia Strait. 1993. By the Save Georgia Strait Alliance, Nanaimo, British Columbia. 130 pp. $20.

***Tatshenshini: river wild.** 1993. Edited by K. Budd and R. Careless. Raincoast Books, Vancouver. 128 pp., illus. $29.95.

Thinking like a mountain: Aldo Leopold and the evolution of an ecological attitude toward deer, wolves, and forests. 1994. Reprint of 1974 edition. By S. L. Flader. University of Wisconsin Press, Madison. xxxii + 283 pp., illus. Cloth U.S. $52; paper U.S. $14.95.

World resources 1994 - 95: a guide to the global environment. 1994. By the World Resources Institute. Oxford University Press, New York. xii + 400 pp., illus. U.S. $23.95; Teacher's guide U.S. $6.95; and PC disk U.S. $99.95.

Miscellaneous

†Into Africa. 1994. By C. Parker. University of Chicago Press, Chicago. vii + 277 pp., illus. U.S. $24.95.

†Memorabilia of Helen Irene Battle 1903 - 1994, the University of Western Ontario. 1994. By W. W. Judd. Phelps, London. Order from author, 50 Hunt Club Drive, London, Ontario N6H 3Y3. 68 pp., illus. $8.

One hundred and one botanists. 1994. By D. Isely. Iowa State University Press, Ames. 358 pp., illus. U.S. $32.95.

†Pattern and process in host-parasitoid interactions. 1994. By B.A. Hawkins. Cambridge University Press, New York. x + 190 pp., illus. U.S. $42.95.

Population, the complex reality: a report of the population summit of the world's scientific academics. 1994. By the Population Summit. North American Press, Golden, Colorado. xi + 404 pp. U.S. $35.

Books for Young Naturalists

Amazing animals. 1994. By G. Legg. Watts, New York. 48 pp., illus. U.S. $13.95.

Animals in disguise. 1994. By M. Duprez. Charlesbridge, Watertown, Massachusetts. 44 pp., illus. U.S. $14.95.

The aquarium take-along book. 1994. By S. L. Gerstenfeld. Viking, New York. 104 pp., illus. U.S. $14.99.

The big bug book. 1994. By M. Facklam. Little, Brown, Boston. 32 pp., illus. U.S. $15.95.

Butterfly. 1994. By A. J. L'Hommedieu. Child's Play, New York. 6 pp., illus. U.S. $5.95.

Cunning carnivores. 1994. By S. Parker. Steck-Vaughn, Austin, Texas. 40 pp., illus. U.S. $13.98.

Do bears give bear hugs? First Questions and answers about animals. 1994. By Time-Life Books, Alexandria, Virginia. 48 pp., illus. U.S. $14.95.

Egg, tadpole, frog. 1994. By A. J. L'Hommedieu. Child's Play, New York. 6 pp., illus. U.S. $5.95.

Environmental science: high school science fair experiments. 1994. By H. S. Dashefsky. Tab, Blue Ridge Summit, Pennsylvania. 160 pp., illus. Cloth U.S. $19.95; paper U.S. $12.95.

Fearsome fish. 1994. By S. Parker. Steck-Vaughn, Austin, Texas. 40 pp., illus. U.S. $13.98.

Fishy facts; Furry facts. 1994. By I. Chermayeff. Gulliver Books/HBJ, San Diego. 32 pp., illus. Each. U.S. $10.95 each.

From tadpole to frog. 1994. By W. Pfeffer. Harper Trophy, New York. 32 pp., illus. Cloth U.S. $15; paper U.S. $4.95.

Lobsters: gangsters of the sea. 1994. By M. M. Cerullo. Cobblehill Books, New York. 56 pp., illus. U.S. $15.99.

Plants and animals. 1994. By A. Ward. Watts, New York. 32 pp., illus. U.S. $11.40.

Poisons in our path: plants that harm and heal. 1994. By A. O. Dowden. Harper Collins, New York. 64 pp., illus. U.S. $17.

The polar bear: master of the ice. 1994. By V. Tracqui. Charlesbridge, Watertown, Massachusetts. 37 pp., illus. U.S. $6.95.

Scary spiders. 1994. By S. Parker. Steck-Vaughn, Austin, Texas. 40 pp., illus. U.S. $13.98.

Seashore. 1994. By D. Burnie. Dorling Kindersley, New York. 61 pp., illus. U.S. $9.95.

Vanishing habitats and species. 1994. By J. Walker. Watts, New York. 32 pp., illus. U.S. $12.40.

Wetlands. 1994. By R. Rood. Harper Collins, New York. 48 pp., illus. U.S. $13.

Wetlands, plants, and animals coloring book. 1994. By A. Bernhard. Dover, New York. 48 pp., illus. U.S. $2.95.

What lives in a shell? 1994. By K. W. Zoefeld. Harper Trophy, New York. 32 pp., illus. Cloth U.S. $15; paper U.S. $4.95.

*assigned for review
†available for review

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Second Class Mail Registration No. 0527 – Return Postage Guaranteed. Date of this issue: October-December 1994 (June 1995).

Back Numbers and Index

Most back numbers of this journal and its predecessors, *Transactions of The Ottawa Field-Naturalists' Club,* 1879-1886, and The Ottawa Naturalist, 1887-1919, and *Transactions of The Ottawa Field-Naturalists' Club and The Ottawa Naturalist – Index* compiled by John M. Gillett, may be purchased from the Business Manager.

Cover: A Red Fox, *Vulpes vulpes,* foraging on Balsam Fir, *Abries balsamea*, cones. This individual spent over 15 minutes searching along the tree tops. Six cones were taken, chewed and partially eaten, two of these were later fully consumed. See note by B. Sklepkovych pages 479–481.

The Canadian Field-Naturalist

Volume 108, Number 4 October–December 1994

Rare Vascular Plant Collections from the St. Elias Mountains, Northwestern British Columbia

George W. Douglas[1], Jim Pojar[2], Del Meidinger[3], and Karen McKeown[2]

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[2]Ministry of Forests, Forest Sciences, Bag 5000, 3726 Alfred Avenue, Smithers, British Columbia V0J 2N0
[3]Ministry of Forests, Research Branch, 31 Bastion Square, Victoria, British Columbia V8W 3E7

Douglas, George W., Jim Pojar, Del Meidinger, and Karen McKeown. 1994. Rare vascular plant collections from the St. Elias Mountains, northwestern British Columbia. Canadian Field-Naturalist 108(4): 391–396.

Two taxa new to British Columbia (*Chrysosplenium wrightii* and *Aphragmus eschscholtzianus*) and nine others new to the St. Elias Mountains, British Columbia are reported. In addition, 25 other rare taxa from the region are discussed.

Key Words: Rare vascular plants, new species, St. Elias Mountains, northwestern British Columbia.

Vascular plant collections in extreme northwestern British Columbia have been limited and mainly restricted to areas near the Haines Road. In the St. Elias Mountains, a total of 11 collectors, between 1956 and 1991, made a total of 66 rare vascular plant collections.[1] This paper reports the results of a floristic study conducted in these mountains during July-August 1992, which has more than doubled our rare plant collections in the study area. Of the 25 rare plants presently known in the area, 18 were recollected in 1992. In addition, 11 new species were recorded for the area, including two new records for British Columbia (*Aphragmus eschscholtzianus* and *Chrysosplenium wrightii*). The 1992 survey also revealed that nine other taxa, previously thought to be rare, are now known to be much more frequent and should no longer be classified as rare. These taxa include: *Astragalus nutzotinensis, Boschniakia rossica, Oxytropis varians, O. viscida, Rubus arcticus ssp. stellatus, Salix glauca* var. *acutifolia, S. setchelliana, Spiraea stevenii* and *Swertia perennis.*

Specimens collected by G. Douglas[2] are deposited in the Royal British Columbia Museum herbarium while all other collections are deposited in the Ministry of Forests, Smithers herbarium. Taxonomy and nomenclature follows Douglas et al. (1989, 1990, 1991, 1994). This paper briefly cites collection sites of the 36 rare vascular plants known in the region and documents the 1992 collections.

Species New to British Columbia

Aphragmus eschscholtzianus Andrz. ex DC[3]., Eschscholtz's Little Nightmare[4].

This species was previously known from coastal northwestern Alaska, the Aleutian Islands and southwestern Yukon (Hulten 1968). In the Yukon, where it is also listed as a rare species (Douglas et al. 1981), its southernmost location was at Goatherd Mountain in the St. Elias Mountains (Douglas and Ruyle-Douglas 1978), about 100 km north of the 1992 collection site in British Columbia. The latter collection was made at Sediments Ridge, 59°48′N 137°24′W (*Meidinger 92052*).

Chrysosplenium wrightii Franc. & Sav., Wright's Golden-Saxifrage (or Golden Carpet).

The 1992 collection taken at Squaw Creek,

[1]Data collected by the Conservation Data Centre, Victoria from collections at CAN, DAO, UBC and V.

[2]All G. Douglas collections, with the exception of *Lesquerella arctica* and *Primula cunefolia*, were collected during a helicopter survey funded by the Ministry of Forests and the Ministry of Environment, Lands and Parks. The *Lesquerella arctica* collections were made during a river rafting expedition funded by the Sierra Club of Canada. The collection of *Primula cunefolia* was made during a vehicle survey along the Haines Road.

[3]The collections of *Aphragmus eschscholtzanus*, *Draba corymbosa* and *D. stenopetala* were identified by Gerald A. Mulligan, Ottawa.

[4]Common names follow Douglas et al. 1989, 1990, 1991, 1994.

59°59′N 137°06′W (*J. Pojar & Meidinger 920219*), represents a first record for B.C. Previously, this amphiberingian species was known from just east of Bering Straight, east through Alaska and the Yukon to the western Northwest Territories (Porsild and Cody 1980). In the Yukon, the southernmost locality is at Profile Mountain, St. Elias Mountains, approximately 140 km to the north of the B.C. collection (Douglas et al. 1981).

Species New to the St. Elias Mountains, British Columbia

Artemisia furcata Bieb. var. *heterophylla* (Bess.), Hult. Three-forked Mugwort.

This species was previously known in B.C. only from the Brooks Peninsula, northern Vancouver Island (Douglas and Ruyle-Douglas 1978). A second record now exists from Squaw Creek, 59°59′N 137°06′W (*J. Pojar & Meidinger 920188*).

Carex rupestris Bell. *ex* All. ssp. *rupestris*, Curly (or Rock) Sedge.

One of the four previous B.C. collections was taken at Mansfield Creek (Haines Road) while the others were taken in northcentral B.C. It was collected once in 1992 above the Tkope River, 59°27′N 136°54′W (*McKeown & J. Pojar 92357*).

Diapensia lapponica L., Diapensia.

This species was previously known from only a single site in northcentral B.C. (Straley et al. 1985). During 1992 it was taken from above the confluence of the Tatshenshini/Alsek rivers, 59°29′N 137°48′W (*McKeown 92135*), from above the confluence of the Hay/Melbern glaciers, 59°16′N 137°27′W (*McKeown 92191*) and from Pentice Ridge, 59°22′N 137°25′W (*Goward s.n., Schofield s.n.*).

Draba corymbosa R. Br. *ex* DC., Baffin's Bay Draba (or Whitlow-grass).

This taxon has previously been recorded from three sites in northwestern B.C., all to the south of the present study area. In 1992 it was collected at three sites: Squaw Creek, 59°59′N 137°06′W (*J. Pojar & Meidinger 920214D, 920209*), Tkope River, 59°29′N 136°57′W (*McKeown 92323*), 59°27′N 136°54′W (*92343*), and Sediments Ridge, 59°45′N 137°22′W (*Meidinger 92031, 92032, 92045*).

Draba stenopetala Trautv., Alaska Draba (or Whitlow-grass).

The only previous record for this species in B.C. was taken to the south of the present study area. It was collected in 1992 at Squaw Creek, 59°59′N 137°06′W (*J. Pojar & Meidinger 920214B*).

Lesquerella arctica (Wormsk. ex Hornem.) S. Wats. var. *arctica*, Arctic Bladderpod.

Although this species was previously known from 13 sites in northern B.C., no records were known from the study area. In this study, it was collected at the O'Connor River, 59°37′N 137°11′W (*G. Douglas & Bell 12625*) and Towagh Creek, 59°28′N 137°28′W (*G. Douglas & Bell 12629*).

Sagina nivalis (Lindbl.) Fries., Snow Pearlwort.

Known previously from only northcentral B.C. (Straley et al. 1985). It was collected at the Vern Ritchie Glacier, 59°41′N 137°02′W (*McKeown 92087*) in 1992.

Tofieldia coccinea Richards, Northern False Asphodel.

Four collections of this species, all from east of the study area in northern B.C., were previously known. In 1992 nine collections were made at Tomahnous Creek, 59°33′N 137°17′W (*G. Douglas, Bell & Freese 12604*), Alsek/Tatshenshini rivers, 59°29′N 137°48′W (*McKeown 92133, 92136*), Tweedsmuir Glacier, 59°44′N 137°56′W (*McKeown 92039*), Hay/Melbern glaciers, 59°16′N 137°27′W (*McKeown 92188*), Melbern/Konamoxtg glaciers, 59°35′N 137°33′W (*R. Pojar 920079*, Icefield Ranges north of Tatshenshini/Alsek rivers, 59°29'N 137°47′W (*J. Pojar 920157*), Basement Creek, 59°30′N 137°29′W (*Meidinger 2303-04* and Ninetyeighter Creek, 59°27′N 137°40′W (*Meidinger 92023*) in the study area.

Woodsia glabella R. Br., Smooth Cliff Fern (or Woodsia).

This species has been collected at 16 sites in northern B.C. east of the study area. In the study area in 1992 it was recorded from Range Lake, 59°59′N 137°48′W (*Schofield s.n.*) and north of Sediments Creek, 59°47′N 137°18′W (*McKeown 92209*) during 1992.

Species Recollected from the St. Elias Mountains in 1992

Cardamine umbellata Greene, Siberian (or Umbellate) Bitter-cress.

All 17 of the previous collections of this species were taken to the east of the study area in northern B.C. Collections made in the study area during 1992 came from Tkope River, 59°34′N 137°09′W (*R. Pojar 92035*), the west fork of Tats Creek, 59°38′N 137°47′W (*J. Pojar 920029*) and Tats Lake, 59°37′N 137°44′W (*McKeown 92025*).

Carex bicolor Bell. ex All., Two-coloured Sedge.

Although known from seven collections elsewhere in northern B.C., this sedge was known previously from only one site (Mile 90, Haines Road) in the study area. During 1992 it was collected from the Vern Ritchie Glacier, 59°41′N 138°02′W (*McKeown 92099*), the Tweedsmuir Glacier, 59°44′N 137°56′W (*McKeown 92038*), the Melbern Glacier, 59°12′N 137°10′W (*McKeown 92241*) and Tats Creek, 59°38′N 137°47′W (*J. Pojar 920023*).

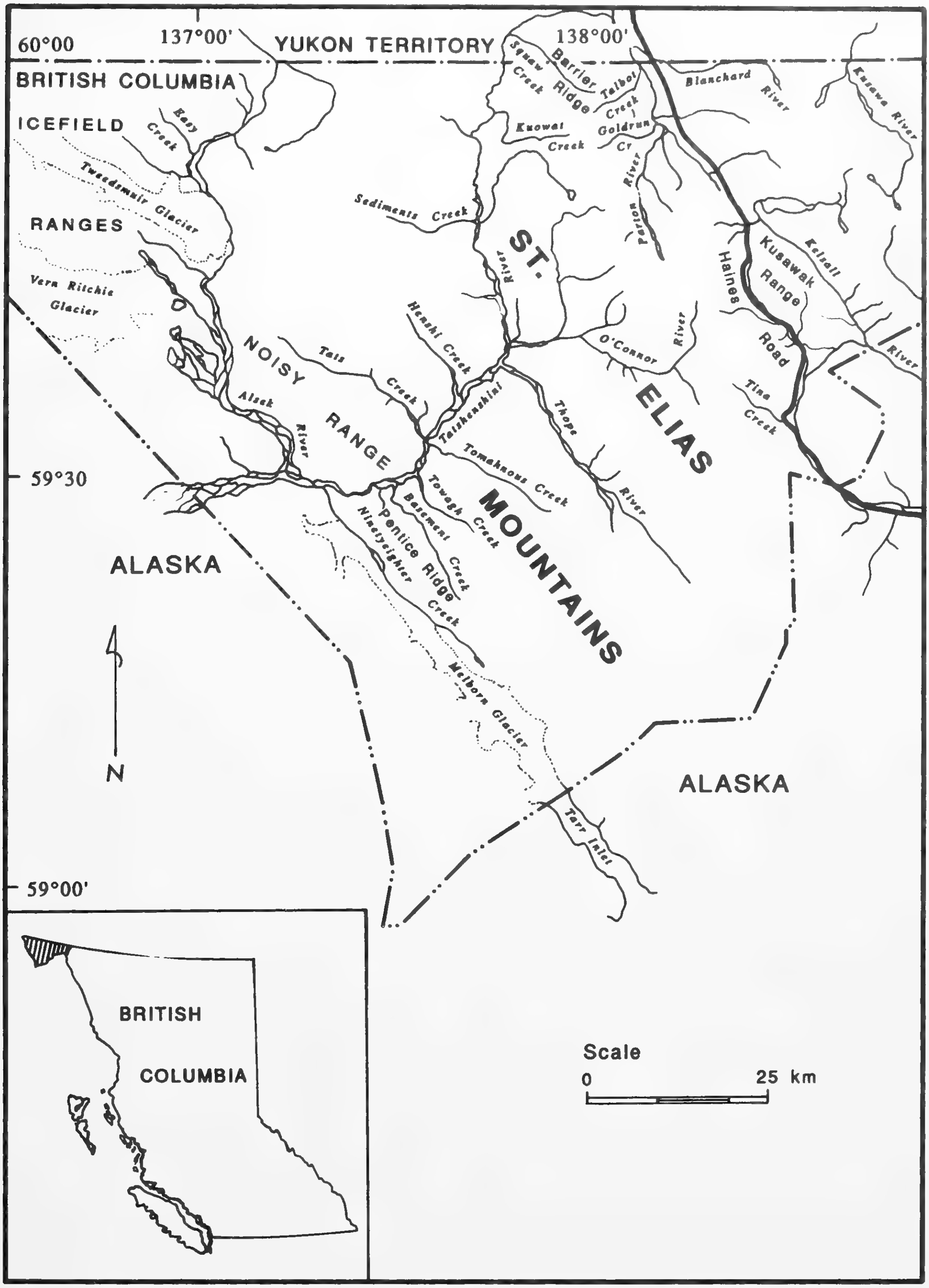

FIGURE 1. Location of St. Elias Mountains study area in northwestern British Columbia.

Carex membranacea Hook. in Parry, Fragile Sedge.
This species was previously known from seven northern B.C. sites. All of these were taken in the study area, including collections at Nadahini Mountain, Alsek River/Easy Creek and Miles 60-98, Haines Road. In 1992 it was again collected at

Mosquito Flats on the Haines Road, 59°43′N 136°43′ W (*G. Douglas & S. Douglas 12685*).

Castilleja hyperborea Pennell, Northern Paintbrush (or Indian-paintbrush).

Previously this species was known only from two sites in B.C., one from the Haines Road (Scoggan 1979) and one from Tats Lake in the study area. Six additional collections were taken during 1992. Collection sites included the Talbot Creek headwaters, 59°57′N 136°58′W (*G. Douglas & S. Douglas 12646*), Blanchard Lake, 59°58′N 136°25′W (*G. Douglas & S. Douglas 12674*), Kudwat Creek headwaters, 59°55′N 137°03′W (*G. Douglas, Bell & Freese 12703*), Tkope River, 59°29′N 136°57′W (*McKeown & J. Pojar 92324*), Tats Creek, 59°38′N 137°43′W (*R. Pojar 92011)* and Squaw Creek, 59°59′N 137°06′W (*J. Pojar 920179*).

Euphrasia arctica Lange ex Rostrup var. *disjuncta* (Fern. & Wieg.) Cronq. in C.L. Hitchcock et al., Arctic Eyebright.

Although this taxon was known previously from 14 sites in northern B.C., only one of these (from the confluence of the Tatshenshini/Alsek rivers) was from the study area. In 1992 it was collected from the Tweedsmuir Glacier, 59°44′N 137°56′W (*G. Douglas & S. Douglas 12668*), the Vern Ritchie Glacier, 59°41′N 138°02′W (*McKeown 92089*) and Basement Creek, 59°59′N 137°06′W (*Meidinger 2303-2*).

Luzula confusa Lindb., Confused Woodrush.

This taxon was previously known from 12 sites in northern B.C., of which two (Mount Mansfield and Three Guardsmen Mountain) are in the study area. It was recollected at Squaw Creek, 59°30′N 137°29′W (*J. Pojar 920182*) in 1992.

Minuartia elegans (Cham. & Schlecht.) Schischk., Northern Sandwort.

Known previously from four sites east of the study area in northern B.C., this species was collected from the Noisy Range, 59°31′N 137°32′W (*R. Pojar 92058*), Squaw Creek, 59°59′N 137°06′W (*J. Pojar & Meidinger 920176A*) and Tats Creek, 59°40′N 137°45′W (*McKeown 92179*) in 1992.

Oxytropis huddelsonii Porsild, Huddelson's Locoweed (or Oxytrope).

Seventeen collections of this taxon were previously known from northern B.C., 11 of these in the study area at Three Guardsmen Mountain, Easy Creek, Alsek River/Easy Creek, Mount Mansfield, Sediments Creek and Miles 58-82, Haines Road. During the present study, it was collected at Kudwat Creek, 59°55′N 137°03′W (*G. Douglas, Bell & Freese 12702*), Tkope River, 59°33′N 137°03′W (*G. Douglas, Bell & Freese 12597*), Tats Lake, 59°39′N 137°41′W (*G. Douglas, Bell, & Freese 12715*), *Meidinger 92003*), Tkope River, 59°29′N 136°57′W (*McKeown & J. Pojar 92292, 92311*), Basement Creek, 59°30′N 137°29′W (*Meidinger 2303-12*), Sediments Ridge, 59°47′N 137°22′W (*Meidinger 92038, 92046, J. Pojar 910010*) and Noisy Range, 59°31′N 136°32′W (*R. Pojar 92061*).

Oxytropis jordalii Porsild ssp. *jordalii*., Jordal's Locoweed.

This species was known previously from three sites in B.C., one of them (Pentice Ridge) in the study area. In 1992 it was collected at Tomahnous Creek, 59°33′N 137°17′W (*G. Douglas, Bell & Freese 12607*), at Henshi Creek, 59°38′N 137°19′W (*G. Douglas, Bell & Freese 12617)*, Tweedsmuir Glacier 59°44′N 137°56′W (*McKeown 92048*), Tkope River, 59°29′N 136°57′W (*McKeown & J. Pojar 92280*), Pentice Ridge, 59°22′N 137°25′W (*J. Pojar 910034*) and Tats Creek, 59°38′N 137°47′W (*J. Pojar 920031*).

Oxytropis maydelliana Trautv., Maydell's Locoweed (or Oxytrope).

The only previous collection of this species in B.C. was taken in the study area at Mount Mansfield. It was collected three times during 1992 at Tkope River, 59°27′N 136°54′W (*McKeown & J. Pojar 92345*), Sediments Ridge, 59°45′N 137°22′W (*Meidinger 92048*) and the Noisy Range, 59°31′N 137°32′W (*J. Pojar 920130*).

Oxytropis scammaniana Hult., Scamman's Locoweed (or Oxytrope).

This taxon has been previously collected three times in B.C., once in the study area in the Blanchard River area. The 1992 collection was taken at Goldrun Creek, 59°54′N 136°59′W (*G. Douglas & S. Douglas 12652*).

Polemonium boreale Adams, Northern Jacob's-ladder.

Eleven collections of this species are known in B.C., three of them from the Tats Glacier and Mount Mansfield in the study area. In 1992 it was collected at Sediments Ridge, 59°48′N 137°24′W (*McKeown 92206, J. Pojar 910019, Meidinger 92028, 92030b*).

Primula cuneifolia Ledeb. ssp. *saxifragifolia* (Lehm.) W. W. Smith & Forrest, Wedge-leaf Primrose.

This species is known from eight previous collections ranging from N Vancouver Island to northern B.C. Five were taken in the study area at Tats Lake, Tats Creek and along the Haines Road at Mile 58 and lower Tina Creek. In 1992 it was collected in the Tina Creek headwaters, 59°37′N 136°30′W (*G. Douglas & S. Douglas 12688)*, Pentice Ridge, 59°22′N 137°25′W (*Goward s.n.*) and again in the Tats Lake/Tats Creek area, 59°38′N 137°46′W (*McKeown 92007, J. Pojar 910031, 920036*).

Saxifraga davurica Willd. ssp. *grandipetala* (Engl. & Irmsch.) Hult. Large-petalled Saxifrage.

Although this taxon was first mapped (near the Haines Road) for B.C. by Hultén (1968), it was omitted from the flora of B.C. by Packer (1991) since no material was available in Canadian herbaria to verify the record. The 1992 collection, taken above Squaw Creek, 59°59′N 137°06′W (*J. Pojar & Meidinger 920216*), now substantiates the occurrence of the species in B.C.

Saxifraga serpyllifolia Pursh., Thyme-leaved Saxifrage.

This species was first reported from Mt. Edziza (Pojar et al. 1976) and subsequently has been found at nine other sites in northern B.C. Two of these, from the Blanchard River and Kusawak Range, were located in the study area. An additional three collections were made in 1992 from Blanchard Lake, 59°58′N 136°25′W (*G. Douglas & S. Douglas 12671*), Talbot Creek (*G. Douglas & S. Douglas 12648*) and Squaw Creek, 59°59′N 137°06′W (*J. Pojar & Meidinger 920197*).

Selaginella sibirica (Milde) Hieron, Northern Selaginella.

This taxon was previously known from four collections in B.C. (Boivin 1967; Pojar et al. 1976; Douglas and Ruyle-Douglas 1978). One of these was from Nadahini Mountain in the study area. During 1992 two more collections were made, one just east of the study area at White Pass, 59°38′N 135°08′W (*G. Douglas & S. Douglas 12639*) and one in the study area northwest of Sediments Creek, 59°51′N 137°32′W (*G. Douglas & S. Douglas 12696*).

Senecio atropurpureus (Ledeb.) Fedtsch., Purple-haired Groundsel.

Six collections of this species were previously known in northern B.C. Five of them were from the study area at the Blanchard River, Nadahini Mountain, Mount Mansfield, Kusawak Range and the Haines Road (Mile 63). Four new sites were located during 1992 including Goldrun Creek, 59°54′N 136°59′W (*G. Douglas & S. Douglas 12654*), Blanchard Lake, 59°58′N 136°31′W (*G. Douglas & S. Douglas 12670*), Blanchard River, 59°58′N 136°40′W (*G. Douglas & S. Douglas 12677*) and Squaw Creek, 59°59′N 137°06′W (*J. Pojar & Meidinger 920213*).

Senecio tundricola Tolm., Northern Groundsel.

This taxon was previously known from three sites in northern B.C. Two of them, from Blanchard River and Mount Mansfield, are located in the study area. In 1992 it was collected at Barrier Ridge, 59°57′N 136°58′W (*G. Douglas & S. Douglas 12650*), Blanchard River, 59°58′N 136°40′W (*G. Douglas & S. Douglas 12676*) and Squaw Creek, 59°59′N 137°06′W (*J. Pojar & Meidinger 920181, 920208*).

Species Previously Known in the Region But Not Recollected in 1992

Artemisia alaskana Rydb., Alaska Sagebrush.

This species was previously known only from the Squaw Creek area, west of the Haines Road. In 1992 Mr. Frank Lomer collected a second B.C. record for the plant along the Atlin Road, approximately 120 km east of the present study area.

Astragalus umbellatus Bunge, Tundra Milk-vetch.

This taxon is known in B.C. from seven collections, six in the study area (at Nadahinii Mountain and Miles 60-98 along the Haines Road), and one in the northern Cassiar Range, northwest of Good Hope Lake (Pojar et al. 1976).

Draba glabella Pursh var. *glabella*, Smooth Draba (or Whitlow-grass).

Known previously from 10 collections in northern B.C., two of them from the Haines Road (Miles 68 and 75).

Erigeron uniflorus L. var. *eriocephalus* (J. Vahl) Boivin, Northern Daisy.

This taxon is known only from three sites in northern B.C., one of which was taken in the Kusawak Range, near the Haines Road.

Montia bostockii (Porsild) Welsh, Bostock's Montia.

This species is known only from the Kusawak Range, near the Haines Road, in B.C. (Douglas and Ruyle-Douglas 1978).

Senecio ogotorukensis Packer, Ogotoruk Creek Butterweed.

This species is known from only two sites on the Alsek River in B.C. (Douglas and Ruyle-Douglas 1978).

Senecio sheldonensis Porsild, Mount Sheldon Butterweed.

Known from 20 collections in northern B.C., three were taken in the study area along the Haines Road (Three Guardsmen Pass and Miles 85 and 98).

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Tree and Shrub Communities of Wooded Draws Near the Matador Research Station in Southern Saskatchewan

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Composition of tree and shrub communities in wooded draws near the Matador Research Station in southern Saskatchewan featured three tree and 11 shrub community types identified by dominant cover: *Acer negundo*, *Populus* x *jackii* (*Populus deltoides* x *Populus balsamifera*), *Populus tremuloides*, *Salix bebbiana*, *Prunus virginiana*, *Crataegus chrysocarpa*, *Symphoricarpos occidentalis*, *Rosa* spp. (*R. woodsii* x *R. acicularis*), *Elaeagnus commutata*, *Juniperus horizontalis*, *Shepherdia argentea*, *Rhus aromatica* var. *trilobata*, *Artemisia cana* and a Mixed Shrub type co-dominated by *Symphoricarpos occidentalis*, *Prunus virginiana*, *Rosa* spp. and *Amelanchier alnifolia*. A total of 133 species of vascular plants were present in the 136 stands sampled; species richness ranged from 27 in the *Rosa* spp. community to 59 in the *Elaeagnus commutata* community. In all communities the number of forb and graminoid species (22 to 49) exceeded that of trees (0 to 3) and shrubs (5 to 11). A diversity index based on total canopy cover revealed that diversity in tree and shrub communities was similar; in all communities the diversity index for the herbaceous stratum was generally greater than the tree or shrub strata. A similarity index based on species frequency ranged from 0.11 to 0.83 whereas a cover-based similarity index ranged from 0.01 to 0.62 indicating the canopy cover and its uniformity was very different among communities. Ordination of frequency data suggests that *Elaeagnus commutata* was a distinct community whereas *Juniperus horizontalis* and *Artemisia cana* were similar as were *Rhus aromatica* var. *trilobata* and *Shepherdia argentea*. The remaining communities formed another cluster of similar communities. Ordination using total canopy cover suggests that *Populus tremuloides*, *Crataegus chrysocarpa*, and *Salix bebbiana* communities were distinct from the others. The communities of *Shepherdia argentea*, *Artemisia cana*, *Rhus aromatica* var. *trilobata* and *Juniperus horizontalis* were clustered, and the remaining tree and shrub communities tended to form another group. Less similarity in canopy coverage among communities probably reflects constraints imposed on plant growth by the environment within communities. Plant communities dominated by woody species are more numerous and diverse than acknowledged in earlier ecological studies.

Key Words: Cover, herbs, ordination, richness, riparian ecosystems, species diversity, Saskatchewan.

Wooded draw or coulee ecosystems stand out on the prairies because of their unique species composition and position in the landscape. Estimates of the extent of plant communities that are dominated by woody species on the Northern Great Plains range from 1% (Bjugstad 1977) to about 3% (Kirby and Ransom-Nelson 1987). Even though wooded draws occupy a small fraction of the landscape, they add structural, functional, genetic and aesthetic diversity to these important areas. They tend to receive high use by humans, wildlife and livestock, and are important habitat for many plant and animal species.

Wooded draws are riparian ecosystems with intermittent streams. Riparian ecosystems, areas fringing water systems (Skovlin 1984), have unique soils and contain plant and animal communities that are restricted beyond the water channel and its corridor by the harsher, drier environment surrounding it (Naiman et al. 1992). The integrity of wooded draws is important in the function of entire landscapes, because they are juxtaposed between upland and aquatic ecosystems (Forman and Godron 1986). Wooded draws function as filters and corridors as well as barriers hindering movement across the landscape (Forman 1983).

Historically, wooded draws have been exploited by humans for water, wood, shelter, gravel, grazing, cultivation, habitation, recreation and as sites for garbage disposal (Smith 1988). In the United States more than 70% have been destroyed since European settlement (Swift 1984) with those in the drier regions most frequently obliterated. Although data are lacking, trends in Canada are likely similar.

In the northern United States considerable effort has been placed recently on completing comprehensive inventories of plant communities in wooded draws (Hansen et al. 1984a, 1984b; Girard et al. 1984; Voorhees and Uresk 1992; Leonard et al. 1992). In Canada, however, vegetation of wooded draws has generally been superficially described. Coupland (1950) described the vegetation of coulees in the Canadian Mixed Prairie as being composed of *Symphoricarpos occidentalis* (Western Snowberry), *Rosa* (Wild Rose) and *Salix* spp. (willow) with vegetation varying with moisture conditions. Areas with favorable moisture support *Artemisia cana* (Silver Sagebrush), *Rosa macounii* (Macoun's Rose), *Symphoricarpos occidentalis* and various species of *Salix* (Clarke et al. 1947). Looman (1987) noted that most deciduous woods in the Northern Mixed Prairie occurred in ravines and river valleys and are dominated by *Fraxinus pensylvanica* (Green Ash), *Quercus macrocarpa* (Bur Oak), *Acer negundo* (Manitoba Maple), or *Populus deltoides* (Plains Cottonwood).

The present study was undertaken to describe the composition of communities dominated by trees and shrubs within a wooded draw ecosystem near the Matador Research Station in southern Saskatchewan in the summers of 1991 and 1992. Inventories and descriptions of this nature are required for the development of comprehensive conservation and management strategies for these unique landscape elements.

The Study Area

Research was conducted at the Matador Research Station (50°42'N, 107°43'W, approximate elevation 675 m), 70 km north of Swift Current and 40 km southeast of Kyle, Saskatchewan in the summers of 1991 and 1992. The area had not been grazed by domestic livestock since the late 1960s when it was set aside for research. There is no record or evidence of the wooded draws being burned. Most of the area surrounding the wooded draws is native grassland, although cultivated land occurs within 2 km.

Geology and Soils

The study area is located within a glacial lake plain with steep draws (Figure 1) (de Jong and Stewart 1973). Drainage channels in the South Saskatchewan River Valley resulted from erosion by meltwater flowing along a stagnant ice front (Cant 1976). Upland soils are weakly developed Chernozems of the Sceptre association. They are uniform deposits of heavy clay developed on glaciolacustrine deposits. Soils on the valley slopes and eroding escarpments are hillwash, a complex of Regosolic soils; weakly developed Chernozems are on dissected slopes (de Jong and Stewart 1973).

Climate

Climate is classified as arid with a cold season (Ripley 1973). The mean annual temperature is 3.3°C; on average the coldest month is January at -14.5°C; July is the warmest, averaging 18.8°C. Annual precipitation totals 327 mm; approximately two-thirds is received as rain during the summer and the remainder as snow.

Vegetation

Taxonomy of plants was based on *Budd's Flora of the Canadian Prairie Provinces* (Looman and Best 1987). Representative specimens of each plant species were collected, identified and placed in the W. P. Fraser Herbarium at the University of Saskatchewan. The *Agropyron-Koeleria* grassland faciation dominates the uplands surrounding the wooded draws (Coupland 1961). This type is dominated by *Agropyron dasystachyum* (Northern Wheatgrass), *Agropyron smithii* (Western Wheatgrass) and *Koeleria cristata* (Prairie Junegrass); *Carex eleocharis* (Low Sedge) dominates the understory. A common associate is *Stipa viridula* (Green Needlegrass) with *Stipa comata* (Needle-and-thread) and *Stipa spartea* (Porcupine Grass) gaining dominance on the valley slopes.

After numerous reconnaissance visits, 14 community types of woody species were identified in the draws based on physiognomy and canopy cover of dominant species: *Acer negundo*, *Populus* x *jackii* (a hybrid of *Populus deltoides* and *Populus balsamifera*) (Cottonwood), *Populus tremuloides* (Trembling Aspen), *Salix bebbiana* (Beaked Willow), *Prunus virginiana* (Chokecherry), *Crataegus chrysocarpa* (Round-leaved Hawthorn), *Symphoricarpos occidentalis*, *Rosa* spp. (*Rosa woodsii* x *Rosa acicularis*), *Elaeagnus commutata* (Wolfwillow), *Juniperus horizontalis* (Creeping Juniper), *Shepherdia argentea* (Buffaloberry), *Rhus aromatica* var. *trilobata* (Skunkbush), *Artemisia cana* and a Mixed Shrub community that is co-dominated by *Symphoricarpos occidentalis*, *Prunus virginiana*, *Rosa* spp. and *Amelanchier alnifolia* (Saskatoon Berry).

Methods

Eight to 12 stands of each community type were sampled. Within each stand, percent canopy cover (Daubenmire 1959), frequency of all species in 0.5 $\times$ 0.5 m quadrats, density (stems m^{-2}) of trees and shrubs were determined, and the landscape position was recorded. Five of these 0.25 m^2 quadrats were placed 2 m apart along four 10 m transects spaced 2 m apart in each stand, for a total of 20 quadrats. Transects were placed along the contour of slopes to minimize variation in soil conditions and contact with ecotones (Daubenmire 1959; Mueggler and Stewart 1980). In each stand the density of shrubs was estimated and then counted in five randomly selected quadrats. Density was estimated in the remaining 15 quadrats and the double sampling procedure (Cook and Stubbendiek 1986) was then used to adjust the estimated densities of shrubs. Density of trees was determined using the nearest neighbor method (Barbour et al. 1980).

Simpson's diversity index, and Sorensen and Morisita's similarity indices were derived from formulas given by Brower and Zar (1977). Diversity and similarity indices range from 0 to 1 with larger values indicating greater diversity within communities or greater similarity between communities. Conversely, values approaching 0 indicate less diversity or community similarity. The similarity indices for frequency and total

FIGURE 1. Oblique aerial view of the wooded draws studied near the Matador Research Station in southern Saskatchewan.

canopy cover were subjected to polar ordination (Barbour et al. 1980).

Results and Discussion

Community Characteristics

Three tree, 16 shrub, 27 graminoid and 87 forb species were present in the stands sampled (Appendix 1). The 133 species present was considerably greater than the 10 to 30 species recorded in several habitat types dominated by woody species in western North Dakota (Hansen et al. 1984a), but lower than the 220 species in gallery forests along the Missouri River (Keammerer et al. 1975).

Symphoricarpos occidentalis, *Rosa* spp. (*Rosa woodsii* x *Rosa acicularis*), *Galium boreale* (Northern Bedstraw) and *Stipa viridula*, were common to all community types. *Carex filifolia* (Thread-leaved Sedge) occurred in the *Artemisia cana* and *Juniperus horizontalis* communities, while other species of *Carex* (sedge) that could not be accurately identified occurred in the remaining community types. Girard et al. (1984) also reported that *Carex* spp. and *Symphoricarpos occidentalis* were predominant understory species in communities dominated by hardwoods in southwestern North Dakota. *Elymus glaucus* (Smooth Wildrye), a provincially rare species in Saskatchewan (V. Harms, W. P. Fraser Herbarium, University of Saskatchewan, personal communication), was present in 11 of the 14 communities.

Acer negundo Community

This community occurred on flat alluvial benches in the bottom of wide draws that provided little protection from the harsher environment characteristic of the uplands, and where there are significant fluxes of water. In North Dakota, *Acer negundo* is also primarily restricted to floodplains (Wikum and Wali 1974). *Symphoricarpos occidentalis* was the most common shrub with *Elymus glaucus* and *Viola rugulosa* (Western Canada Violet) most common in the herbaceous stratum (Table 1). The canopy cover (26%) of shrubs contrasts with nearly 50% contributed by shrubs in the *A. negundo*/*Prunus virginiana* habitat type in Montana (Hansen et al. 1991). However, as in the present study, Wikum and Wali (1974) and Keammerer et al. (1975) noted a lack of shrubs in *A. negundo* communities in North Dakota. *Symphoricarpos occidentalis* had the greatest density (10.6 m^{-2}) among shrubs while *A. negundo* averaged 0.7 stems m^{-2} (Table 2).

Populus x *jackii* Community

Populus x *jackii* communities existed where wooded draws narrowed and steep valley walls pro-

TABLE 1. Canopy cover (%) of plant species with ≥ 5.0% cover in at least one of the 14 communities in the wooded draws near the Matador Research Station in southern Saskatchewan.. The number of stands sampled is in parentheses.

Species	Community													
	Acne[#] (n=8)	Poja (n=9)	Potr (n=9)	Sabe (n=9)	Prvi (n=12)	Crch (n=9)	Mixed (n=9)	Syoc (n=11)	Rosa (n=10)	Elco (n=10)	Juho (n=8)	Shar (n=11)	Rhar (n=10)	Arca (n=11)
Trees														
Acer negundo	78.7													
Populus x *jackii*	7.1	76.5	<0.1											
Populus tremuloides	0.7	6.3	82.4	0.3				0.1						
Total	86.5	82.8	82.4	0.3				0.1						
Shrubs														
Amelanchier alnifolia		14.3	14.0	4.3	4.4	5.3	25.7	1.1		3.2		6.6	11.3	
Artemisia cana								0.6			0.2	6.9	19.5	41.2
Cornus stolonifera	<0.1	1.9	6.8	15.0	0.2	2.2	1.7			0.7		<0.1		
Crataegus chrysocarpa		0.5	0.8		2.9	87.3	13.1			0.2			2.5	
Elaeagnus commutata			0.5							30.9	0.2	0.2	3.6	
Juniperus communis		1.4	8.2	0.8			2.0	1.6		2.9	<0.1	1.7		
Juniperus horizontalis			4.9							10.4	70.7	10.1	12.3	1.7
Prunus virginiana	7.3	9.1	8.7	5.3	84.7	5.4	36.5	0.8	0.5	6.1		12.0	18.7	
Rhus aromatica var. *trilobata*			2.0		0.1						0.4	5.0	60.2	
Ribes oxyacanthoides	1.3	2.1	1.3	9.6	9.6	0.6	3.1	1.9	15.3			4.7		0.1
Rosa spp.	6.2	31.4	24.0	12.2	13.3	11.4	30.5	11.1	95.6	9.4	0.5	33.8	17.2	1.3
Salix bebbiana		<0.1		71.6										
Shepherdia argentea											0.1	46.8		
Symphoricarpos occidentalis	46.2	58.1	34.8	31.0	31.4	15.6	44.1	89.2	51.2	23.8	0.6	30.2	20.9	7.3
Total	61.0	119.9	107.5	149.8	146.8	127.8	156.8	106.5	162.8	87.6	72.7	158.0	166.2	51.6
Graminoids														
Agropyron smithii			1.1			0.1	0.1	9.4	0.6	11.7	3.3	4.8	16.2	13.6
Andropogon scoparius										6.4				
Bouteloua gracilis										5.7	2.5	0.6	20.7	14.7
Calamovilfa longifolia										5.8	2.7		19.2	7.1
Carex filifolia											7.2			1.0
Carex spp.	6.0	1.3	1.6	2.9	0.8	3.6	5.9	8.7	2.6	7.2		3.3	15.4	
Elymus glaucus	31.7	1.8	1.9	4.8	0.7	0.4	0.7	1.7	1.2			<0.1	2.6	
Muhlenbergia cuspidata			0.4							0.3	5.9		4.2	0.8
Muhlenbergia racemosa	1.0	7.4		2.8	0.4		0.2	0.2				1.4		
Stipa comata			0.2							3.0	9.1	2.4	5.6	3.8
Stipa spartea										1.4			5.8	0.8

TABLE 1. *Concluded.*

Species	Acne[#] (n=8)	Poja (n=9)	Potr (n=9)	Sabe (n=9)	Prvi (n=12)	Crch (n=9)	Mixed (n=9)	Syoc (n=11)	Rosa (n=10)	Elco (n=10)	Juho (n=8)	Shar (n=11)	Rhar (n=10)	Arca (n=11)
Stipa viridula		0.2	1.1	0.2	0.1	0.1	0.3	3.7	0.1	26.7	3.2	17.3	61.9	47.7
Total	41.3	12.9	10.2	14.0	3.1	6.3	7.9	25.9	5.0	77.0	41.1	31.4	162.0	93.0
Forbs														
Anemone canadensis	4.4	4.7	3.2	1.5	1.5	0.4	7.1	1.7	0.8	1.4				
Aralia nudicaulis			6.9											
Artemisia frigida			0.1					0.2		7.4	11.5	3.2	2.6	14.7
Artemisia ludoviciana	0.1						0.3	1.4				2.7	22.1	0.5
Comandra umbellata var. *pallida*										12.5	0.5	0.1	1.3	1.0
Galium boreale	2.4	2.9	3.4	2.7	4.7	6.2	7.7	15.2	11.3	6.7	0.3	7.5	8.3	0.2
Monarda fistulosa	0.1	0.5	0.8	1.3	0.3	0.6	4.3	2.0	2.3			0.4	5.8	
Opuntia polyacantha										1.7	4.1	1.0	39.2	3.6
Psoralea argophylla										7.5	0.5		1.7	0.1
Rhus radicans var. *rydbergii*	<0.1	5.0	2.5	2.5	0.1	3.9	<0.1					3.5	5.8	
Smilacina stellata	1.6	1.7	0.2	1.3	2.3	1.9	2.0	0.6	0.3	2.6		0.9	9.4	
Solidago canadensis var. *salebrosa*	3.9	1.2	1.4	6.4	1.5	0.3	0.8	3.3	5.9	0.2		0.6		
Thalictrum venulosum	2.1	2.6	1.2	5.2	1.0	2.9		0.5	0.4			2.7		
Thermopsis rhombifolia			0.4	0.4	<0.1					5.4	2.1	1.7	1.7	2.2
Urtica dioica var. *procera*	9.0	2.5	0.3	7.8	4.0	1.3	<0.1	3.0	5.0			0.1		
Viola rugulosa	13.8	6.8	6.8	5.5	8.5	8.8	5.7	0.7	2.1	0.8		0.9		
Total	46.5	31.8	34.1	41.4	25.3	27.8	29.7	34.0	31.1	68.5	30.8	36.3	126.9	33.6
Grand Total	235	234	247	206	175	162	194	167	199	233	145	226	455	178

[#]Acne-*Acer negundo*, Poja-*Populus* x *jackii*, Potr-*Populus tremuloides*, Sabe-*Salix bebbiana*, Prvi-*Prunus virginiana*, Crch-*Crataegus chrysocarpa*, Mixed-Mixed Shrub, Syoc-*Symphoricarpos occidentalis*, Rosa-*Rosa* sp., Elco-*Elaeagnus commutata*, Juho-*Juniperus horizontalis*, Shar-*Shepherdia argentea*, Rhar-*Rhus aromatica* var. *trilobata* and Arca-*Artemisia cana*.

TABLE 2. Mean density (stems m^{-2}) of trees and shrubs in the 14 communities dominated by woody species near the Matador Research Station in southern Saskatchewan.. The number of stands sampled is in parentheses.

Species	Community													
	Acne* (n=8)	Poja (n=9)	Potr (n=9)	Sabe (n=9)	Prvi (n=12)	Crch (n=9)	Mixed (n=9)	Syoc (n=11)	Rosa (n=10)	Elco (n=10)	Juho (n=8)	Shar (n=11)	Rhar (n=10)	Arca (n=11)
Trees														
Acer negundo	0.7													
Populus x jackii	<0.1	0.3												
Populus tremuloides	<0.1	<0.1	0.6					<0.1						
Shrubs														
Amelanchier alnifolia		2.6	1.4	0.6	0.5	0.5	3.8	0.2		0.2	0.2	0.8	0.8	
Artemisia cana								0.1			0.1	0.6	3.6	4.5
Cornus stolonifera		0.3	0.9	2.7	<0.1	0.4	0.3			0.1		<0.1		
Crataegus chrysocarpa		0.3	0.2		0.2	10.1	1.2			<0.1			0.1	
Elaeagnus commutata			0.1							5.0	0.1		0.3	
Juniperus communis		<0.1	<0.1				0.1	<0.1		0.9	<0.1	0.1		
Juniperus horizontalis			0.1							0.7	5.8	0.4	0.1	0.3
Prunus virginiana	1.1	0.9	0.7		7.9	0.7	5.6	0.2	<0.1	0.9		2.2	0.8	
Rhus aromatica var. *trilobata*			0.2								<0.1	0.2	9.0	
Ribes oxyacanthoides	0.4	2.6	0.5	1.1	0.1	0.2	1.1	0.4	2.2	0.1		0.7		<0.1
Rosa spp.	2.2	6.4	3.6	2.7	2.1	4.8	6.9	1.4	13.9	2.0	0.1	3.2	0.8	0.3
Rubus idaeus var. *strigosus*	<0.1	0.1	0.3	0.1	0.1	0.1	<0.1	<0.1						
Salix bebbiana		<0.1												
Shepherdia argentea											<0.1	3.1		
Symphoricarpos occidentalis	10.6	15.6	8.0	7.8	16.2	3.7	16.1	27.5	9.4	3.2	0.1	5.6	3.4	2.0

*Acne-*Acer negundo*, Poja-*Populus* x *jackii*, Potr-*Populus tremuloides*, Sabe-*Salix bebbiana*, Prvi-*Prunus virginiana*, Crch-*Crataegus chrysocarpa*, Mixed-Mixed Shrub, Syoc-*Symphoricarpos occidentalis*, Rosa-*Rosa* sp., Elco-*Elaeagnus commutata*, Juho-*Juniperus horizontalis*, Shar-*Shepherdia argentea*, Rhar-*Rhus aromatica* var. *trilobata* and Arca-*Artemisia cana*.

vided protection from the harsh environment of the uplands. *Symphoricarpos occidentalis* had the greatest cover among shrubs, whereas *Muhlenbergia racemosa* (Marsh Muhly) and *Viola rugulosa* had the most cover among herbs (Table 1). *Symphoricarpos occidentalis* also dominated the understory of *Populus deltoides* communities along the Little Missouri and Missouri Rivers in North Dakota (Nelson 1961; Everitt 1968; Wilson 1970). *Symphoricarpos occidentalis* had the greatest density among woody species, and on average there were 0.3 *P.* x *jackii* stems m^{-2} (Table 2).

Populus tremuloides Community

Populus tremuloides communities were widespread, occurring on both alluvial deposits in the valley bottoms and on eroded till on slopes. It occupied drier areas above stream channels and potentially high gradient stream areas. Hansen et al. (1991) also described habitat types dominated by *P. tremuloides* that occupied narrow draws along rivers and hillsides with seeps in Montana. *Populus tremuloides* grew only on lower north-facing slopes in North Dakota (Wikum and Wali 1974).

Floristic composition of the *Populus tremuloides* communities in the wooded draws was similar to other areas in the northern Great Plains (Moss 1932, Looman 1987). The shrub understory was dominated by *Symphoricarpos occidentalis*; *Aralia nudicaulis* (Wild Sarsaparilla) and *Viola rugulosa* had the greatest cover among the forbs (Table 1). Graminoids were not common, but *Elymus glaucus* had the most cover. *Symphoricarpos occidentalis* had the highest density among woody species at 8.0 stems m^{-2} (Table 2).

Salix bebbiana Community

Salix bebbiana communities were restricted to narrow, gravel stream channels in the bottoms where draws widened. Hansen et al. (1991) described a *Salix bebbiana* community on alluvial terraces and moist areas near springs and seeps in Montana. *Symphoricarpos occidentalis* had the greatest cover and the highest density among the shrubs; *Urtica dioica* (Stinging Nettle) and *Elymus glaucus* were the most common herbaceous species (Tables 1 and 2).

Prunus virginiana Community

Five of the 12 *Prunus virginiana* stands occupied alluvial benches adjacent to tree communities. The remaining stands occurred in concave slopes with alluvial soils deposited over eroded till. Distribution of this community is similar in North Dakota where it grows in upland draws, in the bottoms of some draws and on hillsides where additional moisture is received (Nelson 1961; Aipperspach 1980). Snow accumulation and runoff are likely sources of this water. *Symphoricarpos occidentalis* had the greatest cover and stem density of shrubs in the understory (Tables 1 and 2). *Viola rugulosa* was the most common forb, and *Carex* spp. and *Elymus glaucus* provided the greatest cover among the graminoids.

The *P. virginiana* community may be an ecotonal or seral community, because it fringes tree communities on unstable valley slopes. Hansen et al. (1991) also considered *P. virginiana* communities seral in Montana, and attributed the absence of other shrubs to a dense overstory. However, they noted that *Symphoricarpos occidentalis*, *Prunus americana* (American Plum), and *Crataegus succulenta* (Long-spined Hawthorn) increase with chronic disturbance.

Crataegus chrysocarpa Community

This community was found on alluvial deposits in three of nine cases; the remaining stands resided on valley walls on eroded till, mass wastings. Although *Symphoricarpos occidentalis* had the greatest cover (Table 1), *Rosa* spp. had the highest stem density (Table 2). *Viola rugulosa* was the most common forb, and *Carex* spp. were the most abundant graminoids.

Mixed Shrub Community

This community was located in shallow, upland draws extending down the valley slopes. Three stands were found on west, east and northeast aspects, and one was located on a southeast aspect. *Symphoricarpos occidentalis* had the greatest cover and density among the shrubs followed by *Prunus virginiana*, *Rosa* spp., and *Amelanchier alnifolia* (Tables 1 and 2). *Galium boreale*, *Anemone canadensis* (Canada Anemone), and *Carex* spp. had the most cover among the forbs and graminoids, respectively.

The Mixed Shrub community is similar to a "Brush" complex in North Dakota (Nelson 1961). A major difference is that *Rhus aromatica* var. *trilobata* co-dominates in North Dakota (Nelson 1961), but it was not a component of the Mixed Shrub community in the present study. Girard et al. (1984) considered this community as ecotonal between woody vegetation and the associated prairie. The Mixed Shrub community in the present study is also interpreted as ecotonal, occurring in tension zones created by variable coulee morphology. Interdigitating peninsulas are formed by grassland vegetation extending into the draws from the upland on convex surfaces, and the Mixed Shrub community extends into the uplands on concave sites with greater moisture (Pennock et al. 1987) and protection from environmental extremes.

Symphoricarpos occidentalis Community

One stand of this community occurred on an alluvial deposit next to a water channel, and the remaining stands were on slopes of the draws. In North Dakota *Symphoricarpos occidentalis* communities occur in coulee bottoms, hillsides, and on *Artemisia cana* flats that are similar to those of the present study (Mastel 1983). *Rosa* spp. was the sub-dominant shrub measured by both canopy cover and stem density (Tables 1 and 2). *Galium boreale* had the greatest cover among the forbs, whereas *Agropyron smithii* and *Carex* spp. were major graminoids. Hansen et al. (1984b) described a similar *S. occidentalis* community in North Dakota with *Rosa woodsii* (Wood's Rose) and *A. smithii* as subdominants. In Minnesota, *S. occidentalis* communities were characterized by a herbaceous understory of *Poa pratensis* (Kentucky Bluegrass) and *Agropyron repens* (Quackgrass) (Pelton 1953).

Rosa spp. Community

One-half of the stands sampled in this community were in the bottom of the draws on benches with alluvial deposits; lower slope positions with alluvium over eroded till supported the other stands. *Symphoricarpos occidentalis* had the second greatest canopy cover among the shrubs; *Galium boreale* and *Carex* spp. had the most cover among forbs and graminoids, respectively (Table 1). Density of *Rosa* spp. averaged nearly 14 stems m^{-2} and the mean for *S. occidentalis* was about 9 stems m^{-2} (Table 2). In Montana, Hansen et al. (1991) noted that *Rosa woodsii* communities occupied sites that would potentially support *Fraxinus pensylvanica/Prunus virginiana* or *Acer negundo/Prunus virginiana* communities.

Elaeagnus commutata Community

Elaeagnus commutata communities occupied upper slopes on all aspects. Eight of the ten stands sampled occurred in convex slopes and two were on concave positions. The understory was dominated by *Stipa viridula* and *Comandra umbellata* var. *pallida* (Bastard Toadflax) (Table 1). Density of *E. commutata* averaged nearly 5 stems m^{-2} (Table 2).

Elaeagnus commutata is associated with *Shepherdia argentea*, *Symphoricarpos occidentalis*, *Rosa* spp. and *Prunus virginiana* in *Populus tremuloides* communities, and in the shrub extension between trees and grassland in Manitoba (Moss 1932). However, in the present study *E. commutata* was observed only in small amounts in the *Populus tremuloides*, *Juniperus horizontalis* and *Rhus aromatica* var. *trilobata* communities.

Juniperus horizontalis Community

Juniperus horizontalis communities occurred on upper convex slopes that are prone to erode. This creeping shrub is common in drier areas of the Canadian Prairies where it forms large mats on dry, eroding banks and hillsides (Coupland 1950; Hulett et al. 1966). The present study confirms these previous reports. *Artemisia frigida* (Pasture Sage) and *Stipa comata* dominated the forb and graminoid strata in this study (Table 1). Stem densities of *J. horizontalis* were greatest among woody species (Table 2).

Shepherdia argentea Community

Eight *Shepherdia argentea* stands occupied alluvial deposits over eroded till and the remaining stands were on upper slopes. The total canopy cover averaged 226% with shrubs contributing most (Table 1). *Rosa* spp. and *Symphoricarpos occidentalis* had the greatest canopy cover in the shrub understory, the density of latter species was twice that of the former (Table 2). Cover of *Galium boreale* and *Stipa viridula* was greatest among the forbs and graminoids. Similar floristic composition was observed in other *S. argentea* communities on the Canadian Prairies and in Montana (Looman 1987; Hansen et al. 1991). *Shepherdia argentea* can dominate or be an associate within *Populus deltoides*, *Salix* spp., *Amelanchier alnifolia*, *Prunus virginiana*, *Rosa* spp., *Symphoricarpos occidentalis*, *Ribes oxyacanthoides* (Northern Gooseberry) and *Crataegus rotundifolia* (Round-leaved-Hawthorn) communities in the Canadian Prairies (Looman 1984), a trend that was not observed in the wooded draws in the present study.

Rhus aromatica var. *trilobata* Community

All *Rhus aromatica* var. *trilobata* stands occurred on warm and dry, south or southeasterly aspects. In southeastern Montana *Rhus trilobata* communities occur on upper slopes with west to southeast exposures (Brown 1971). The 455% canopy cover in this community was about twice that of most of the other communities (Table 1). *Stipa viridula* was the dominant graminoid and *Opuntia polyacantha* (Prickly-pear Cactus) dominated the forbs. *Rhus aromatica* var. *trilobata* had almost 9 stems m^{-2} (Table 2).

Artemisia cana Community

Ten of the 11 *Artemisia cana* stands occurred on slopes of the draws, while the remaining stand was located near the bottom. Seven stands were on southerly aspects, three faced north and one faced east. An *Artemisia cana/Agropyron smithii* association is restricted to moderate slopes on southwesterly to southeasterly exposures in southeastern Montana (Brown 1971), and alluvial flats, terraces and higher valley sites with little soil development in western North Dakota (Hanson and Whitman 1938; Nelson 1961; Hansen et al. 1984b). The shrub canopy of *A. cana* communities was open with graminoids providing 52% of the low (178%) canopy cover. Cover of *Stipa viridula* and *Artemisia frigida* was greatest among the graminoids and forbs (Table 1). *Artemisia cana* had the highest density among shrubs with nearly 5 stems m^{-2}. As in the present study, graminoids also contributed the greatest canopy cover to *A. cana* communities in Montana, with *Agropyron smithii* and *Stipa viridula* most common (Hansen et al. 1991).

Species Richness and Diversity

Species richness ranged from 27 in the *Rosa* spp. community to 59 in that dominated by *Elaeagnus commutata* (Table 3). *Acer negundo* and *Populus* x *jackii* communities had the most (3) tree species. Shrub species were most numerous in

TABLE 3. Species richness and Simpson's diversity index based on canopy cover for the total canopy and each vegetation strata for each community type dominated by woody species near the Matador Research Station in southern Saskatchewan.

Vegetation Strata	Community													
	Acne*	Poja	Potr	Sabe	Prvi	Crch	Mixed	Syoc	Rosa	Elco	Juho	Shar	Rhar	Arca
	Species Richness													
Trees	3	3	1	2	—	—	—	1	—	—	—	—	—	—
Shrubs	5	9	11	8	9	8	9	8	5	10	8	11	9	5
Forbs and Graminoids	35	34	46	34	27	23	30	25	22	49	43	47	34	46
Total	43	46	58	44	36	31	39	34	27	59	51	58	43	51
	Simpson's Diversity Index													
Trees	0.95	0.94	—	0.99	—	—	—	—	—	—	—	—	—	—
Shrubs	0.96	0.96	0.97	0.98	0.96	0.99	0.93	0.72	0.70	0.99	0.76	0.96	0.99	0.99
Forbs and Graminoids	0.99	0.99	0.99	0.97	0.99	0.98	0.99	0.98	0.99	0.90	0.98	0.99	0.90	0.95
Total	0.86	0.83	0.85	0.85	0.72	0.73	0.86	0.70	0.69	0.82	0.74	0.95	0.82	0.85

*Acne-*Acer negundo*, Poja-*Populus* x *jackii*, Potr-*Populus tremuloides*, Sabe-*Salix bebbiana*, Prvi-*Prunus virginiana*, Crch-*Crataegus chrysocarpa*, Mixed-Mixed Shrub, Syoc-*Symphoricarpos occidentalis*, Rosa-*Rosa* sp., Elco-*Elaeagnus commutata*, Juho-*Juniperus horizontalis*, Shar-*Shepherdia argentea*, Rhar-*Rhus aromatica* var. *trilobata* and Arca-*Artemisia cana*.

the *Populus tremuloides* community (11) and least abundant (5) in the *Rosa* spp. and *Artemisia cana* communities. Forbs and graminoids were the most abundant lifeforms ranging from 49 in the *Elaeagnus commutata* to 22 in the *Rosa* spp. communities, respectively.

Simpson's diversity index, derived from total canopy cover, ranged from a low of 0.69 in the *Rosa* spp. Community to 0.95 in the *Shepherdia argentea* Community (Table 3). Among the vegetation strata, the diversity index was generally greatest among the forbs and graminoids. It was greatest in the *Acer negundo*, *Populus* x *jackii*, *Populus tremuloides*, *Prunus virginiana*, Mixed Shrub, *Rosa* spp. and *Shepherdia argentea* communities and lowest in those dominated by *Rhus aromatica* var. *trilobata* and *Elaeagnus commutata*. Diversity of shrubs was greatest in the *Crataegus chrysocarpa*, *Elaeagnus commutata*, *Rhus aromatica* var. *trilobata* and *Artemisia cana* communities and lowest in the *Rosa* spp. and *Symphoricarpos occidentalis* communities.

Community Similarity

Sorensen's similarity index, based on frequency, indicates that the presence or absence of plant species was most similar between *Populus* x *jackii* and *Salix bebbiana* communities, while *Acer negundo* and *Juniperus horizontalis* communities were the least similar (Table 4). Among the tree communities, *Acer negundo* and *P.* x *jackii* were least similar, and *A. negundo* and *Populus tremuloides* were most alike. Shrub communities showed a great range in similarity with *Rosa* spp. and *Crataegus chrysocarpa* most similar and *Juniperus horizontalis* and the Mixed Shrub community least alike.

Ordination of frequency data suggests that *Elaeagnus commutata* was a distinct community whereas *Juniperus horizontalis* and *Artemisia cana* were similar, as were *Rhus aromatica* var. *trilobata* and *Shepherdia argentea* (Figure 2). The remaining communities appeared similar. The unique nature of the *E. commutata*, *J. horizontalis* and *A. cana*, *R. aromatica* var. *trilobata* and *S. argentea* communities may be attributed the understory which was dominated by *Stipa viridula*, *Stipa comata* and *Agropyron smithii*, species that are characteristic of the surrounding grassland. By contrast forbs provided most cover in the understory of the remaining shrub and tree communities.

Morisita's similarity index, derived from canopy cover shows low similarity among communities, indicating that although many species are common, their canopy cover and its uniformity is very different among communities (Table 5). When shrub and tree communities were compared, *Juniperus horizontalis* was least similar to *Acer negundo* and *Populus* x *jackii*. Among the tree communities, *A. negundo* and *P.* x *jackii*, and *A. negundo* and

TABLE 4. Sorensen's community similarity index based on frequency for the 14 communities dominated by woody species near the Matador Research Station in southern Saskatchewan.

	Community													
	Acne*	Poja	Potr	Sabe	Prvi	Crch	Mixed	Syoc	Rosa	Elco	Juho	Shar	Rhar	Arca
Acne		0.65	0.70	0.58	0.62	0.60	0.62	0.53	0.56	0.25	0.11	0.42	0.30	0.15
Poja			0.67	0.83	0.64	0.64	0.61	0.60	0.40	0.33	0.12	0.36	0.30	0.16
Potr				0.64	0.58	0.54	0.70	0.53	0.47	0.40	0.33	0.55	0.45	0.29
Sabe					0.69	0.68	0.62	0.66	0.56	0.36	0.19	0.50	0.34	0.21
Prvi						0.62	0.62	0.64	0.63	0.38	0.18	0.53	0.29	0.18
Crch							0.63	0.63	0.77	0.64	0.18	0.53	0.39	0.24
Mixed								0.48	0.54	0.36	0.15	0.39	0.36	0.18
Syoc									0.74	0.47	0.28	0.61	0.46	0.35
Rosa										0.74	0.35	0.15	0.39	0.23
Elco											0.58	0.64	0.56	0.58
Juho												0.56	0.52	0.70
Shar													0.59	0.61
Rhar														0.67
Arca														

*Acne-*Acer negundo*, Poja-*Populus* x *jackii*, Potr-*Populus tremuloides*, Sabe-*Salix bebbiana*, Prvi-*Prunus virginiana*, Crch-*Crataegus chrysocarpa*, Mixed-Mixed Shrub, Syoc-*Symphoricarpos occidentalis*, Rosa-*Rosa* sp., Elco-*Elaeagnus commutata*, Juho-*Juniperus horizontalis*, Shar-*Shepherdia argentea*, Rhar-*Rhus aromatica* var. *trilobata* and Arca-*Artemisia cana*.

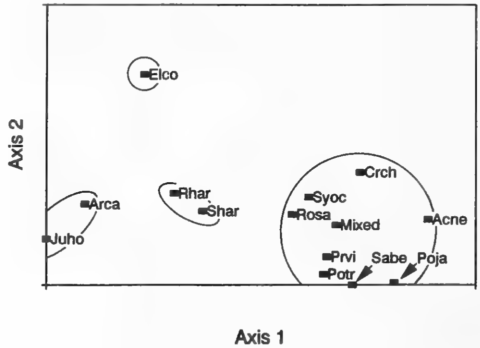

FIGURE 2. Two-dimensional ordination based on similarity of species frequency in plant communities dominated by woody species near the Matador Research Station in southern Saskatchewan. Abbreviations are Acne=*Acer negundo*, Poja=*Populus* x *jackii*, Potr=*Populus tremuloides*, Sabe=*Salix bebbiana*, Prvi=*Prunus virginiana*, Crch=*Crataegus chrysocarpa*, Mixed=Mixed Shrub, Syoc=*Symphoricarpos occidentalis*, Rosa=*Rosa* spp., Elco=*Elaeagnus commutata*, Juho=*Juniperus horizontalis*, Shar=*Shepherdia argentea*, Rhar=*Rhus aromatica* var. *trilobata* and Arca=*Artemisia cana.*

Populus tremuloides were most and least similar, respectively. Canopy cover of *Artemisia cana* and *J. horizontalis* were most similar among the shrub communities. *Crataegus chrysocarpa*, *Rosa* spp., *J. horizontalis*, *Rhus aromatica* var. *trilobata* and *A. cana*, and the Mixed Shrub versus *J. horizontalis* were least similar.

Ordination using total canopy cover suggests that *Populus tremuloides*, *Crataegus chrysocarpa*, and *Salix bebbiana* communities were distinct from the others (Figure 3). The communities of *Shepherdia argentea*, *Artemisia cana*, *Rhus aromatica* var. *trilobata* and *Juniperus horizontalis* were clustered, and

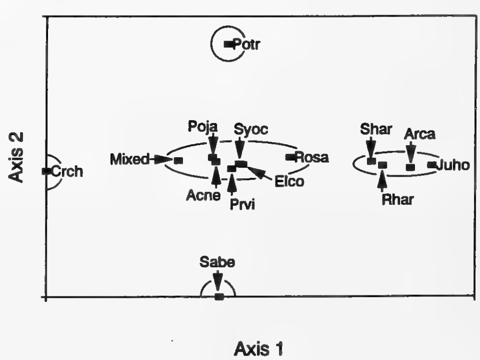

FIGURE 3. Two-dimensional ordination based on similarity of total canopy cover in plant communities dominated by woody species near the Matador Research Station in southern Saskatchewan. Abbreviations are as in Figure 2.

TABLE 5. Morisita's community similarity index based on canopy cover for 14 communities dominated by woody species near the Matador Research Station in southern Saskatchewan.

	Community													
	Acne*	Poja	Potr	Sabe	Prvi	Crch	Mixed	Syoc	Rosa	Elco	Juho	Shar	Rhar	Arca
Acne		0.30	0.16	0.12	0.29	0.07	0.32	0.20	0.24	0.13	0.01	0.19	0.06	0.02
Poja			0.18	0.12	0.37	0.08	0.37	0.22	0.20	0.13	0.01	0.04	0.07	0.03
Potr				0.01	0.14	0.06	0.23	0.20	0.19	0.11	0.03	0.14	0.05	0.03
Sabe					0.13	0.06	0.18	0.17	0.13	0.08	0.01	0.10	0.03	0.02
Prvi						0.09	0.62	0.11	0.10	0.10	0.07	0.14	0.04	0.03
Crch							0.18	0.04	0.01	0.06	0.01	0.07	0.02	0.02
Mixed								0.31	0.31	0.20	0.01	0.26	0.09	0.04
Syoc									0.10	0.08	0.05	0.01	0.46	0.35
Rosa										0.35	0.15	0.11	0.03	0.23
Elco											0.06	0.64	0.56	0.58
Juho												0.56	0.52	0.70
Shar													0.09	0.13
Rhar														0.15
Arca														

*Acne-*Acer negundo*, Poja-*Populus* x *jackii*, Potr-*Populus tremuloides*, Sabe-*Salix bebbiana*, Prvi-*Prunus virginiana*, Crch-*Crataegus chrysocarpa*, Mixed-Mixed Shrub, Syoc-*Symphoricarpos occidentalis*, Rosa-*Rosa* sp., Elco-*Elaeagnus commutata*, Juho-*Juniperus horizontalis*, Shar-*Shepherdia argentea*, Rhar-*Rhus aromatica* var. *trilobata* and Arca-*Artemisia cana*.

the remaining tree and shrub communities tended to form another group.

Among the tree dominated communities, ordination of species frequency indicated that the *Populus tremuloides* community was distinct from *Acer negundo* and *Populus* x *jackii*. By contrast the similarity of species frequency in these communities, suggests that the communities share many species. These differences between communities using canopy cover likely reflect the influence of the different tree species on the understory, or that environmental conditions are sufficiently different among communities to alter the growth and expression of understory species, or both.

Conclusions

Plant communities dominated by woody species in the draws studied in southern Saskatchewan were more numerous, had more taxa, and were structurally more complex than previously acknowledged (e.g. Coupland 1950; Clarke et al. 1947). Tree and shrub communities were equally diverse and species richness was greatest in the forb and graminoid strata. With the exception of *Populus tremuloides* communities, tree-dominated communities were limited to valley bottoms; shrub communities occurred in the bottoms and on the slopes of draws.

In the tree-dominated communities, shrubs provided the largest percentage of the cover, and, except for the *Acer negundo* community, forbs had greater cover than graminoids. *Elymus glaucus* provided more than 75% of the cover among the graminoids in the community dominated by *A. negundo*. Until more is learned of the status of *E. glaucus* in Saskatchewan, the *A. negundo* community probably deserves special recognition and management to favor this grass.

Among the shrub communities, shrubs provided the greatest cover except in the *Artemisia cana* community where grasses provided more than 50% of the canopy cover. It may seem appropriate, therefore, to consider the *Artemisia cana* community a grassland community; however, physiognomically it is characterized by the shrub.

The communities described in the present study occur throughout a large expanse of southern Saskatchewan. However, observations of other wooded draw ecosystems in the southern reaches of the Canadian Prairie Provinces will reveal that plant communities are more numerous than those described here. For example, we have observed communities dominated by *Populus deltoides*, *Populus balsamifera* (Balsam Poplar), *Ulmus americana* (American Elm), *Fraxinus pennsylvanica*, *Cornus stolonifera* (Red-osier Dogwood), *Amelanchier alnifolia*, *Betula* spp. (Birch), *Salix* spp., and *Ribes* spp. (Gooseberry). Elsewhere, different species associations can be expected with the dominant trees and shrubs noted in the present study. In addition, communities that are dominated by forbs or graminoids also exist within wooded draws.

There is a lack of understanding of the role of wooded draw ecosystems, but they are intrinsically important components of the functional integrity of the prairie landscape. Additional studies of the composition, structure and function of wooded draw ecosystems throughout the Prairie Provinces are needed. Without this basic information, sound conservation and management strategies cannot be developed for the remaining native prairie as recommended in the Prairie Conservation Action Plan (Anonymous 1988).

Few wooded draws remain in unaltered condition, and the threats to them are numerous. In the southern regions of the Prairie Provinces the primary threats to these ecosystems stem from human activities, primarily agriculture, but other human uses also have impacts. Cultivation, introduction of exotic plants, alteration of hydrologic regimes, increased sedimentation, nutrient transport and deposition, herbicide and pesticide drift, uncontrolled livestock grazing, recreational use, resource extraction and the fragmentation and isolation of these ecosystems all have potentially serious consequences. Although ecologists recognize these disturbances, the extent and consequences of them on wooded draw ecosystems are not documented. As human activities increase on the prairies, so do the direct and indirect impacts on wooded draws and organisms that occupy them, and the uplands. Wooded draws must be viewed and treated as elements of the prairie landscape, as well as distinct entities.

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APPENDIX 1. Scientific and common names for all plant species collected in the wooded draws near the Matador Research Station in southern Saskatchewan.

Scientific Name	Common Name
Acer negundo L.	Manitoba Maple
Achillea millefolium L.	Yellow Milfoil
Actea rubra (Ait.) Willd.	Red Baneberry
Agoseris glauca (Pursh) Raf.	False Dandelion
Agrohordeum macounii (Vasey) LePage	Macoun's Wildrye
Agropyron dasystachyum (Hook.) Scribn.	Northern Wheatgrass
Agropyron smithii Rydb.	Western Wheatgrass
Agropyron subsecundum (Link) Hitch.	Awned Wheatgrass
Agropyron trachycaulum (Link) Malte var. *trachycaulum*	Slender Wheatgrass
Amelanchier alnifolia Nutt.	Saskatoon Berry
Andropogon scoparius Michx.	Little Bluestem
Anemone canadensis L.	Canada Anemone
Anemone patens L. var. *wolfgangiana* (Bess.) Koch.	Crocus Anemone
Antennaria aprica Greene.	Low Everlasting
Arabis glabra (L.) Bernh. var. *glabra*	Tower Mustard
Arabis holboellii Hornem. var. *pinetorum* (Tidestr.) Rollins	Rock Cress
Arabis retrofracta Graham	Reflexed Rock Cress
Aralia nudicaulis L.	Wild Sarsparilla
Arenaria lateriflora L.	Blunt-leaved Sandwort
Artemisia biennis Willd.	Biennial Wormwood
Artemisia cana Pursh	Silver Sagebrush
Artemisia campestris L.	Plains Wormwood
Artemisia frigida Willd.	Pasture Sage
Artemisia ludoviciana Nutt.	Prairie Sage
Aster falcatus Lindl.	White Prairie Aster
Aster hesperius Gray	Willow Aster
Aster laevis L.	Smooth Aster
Aster laevis L. var. *geyeri* Gray	Smooth Aster
Astragalus agrestis Dougl.	Milk-vetch
Astragalus bisulcatus (Hook.) A. Gray	Two-grooved Milk-vetch
Astragalus missouriensis Nutt.	Missouri Milk-vetch
Astragalus striatus Nutt.	Ascending Purple Milk-vetch
Astragalus tenellus Pursh	Loose-flowered Milk-vetch
Axyris amaranthoides L.	Russian Pigweed
Beckmannia syzigachne (Stend.) Fern.	Slough Grass
Betula occidentalis Hook.	River Birch
Bouteloua gracilis (HBK) Lag.	Blue Grama Grass
Bromus porteri (Coult.) Nash	Nodding Brome
Bromus ciliatus L.	Fringed Brome
Bromus inermis Leyss.	Smooth Brome
Calamagrostis inexpansa A. Gray	Northern Reed Grass
Calamovilfa longifolia (Hook.) Scribn.	Sand Grass
Campanula rotundifolia L.	Harebell
Carex backii Boott.	Back's Sedge
Carex filifolia Nutt.	Thread-leaved Sedge
Carex obtusa Lilj.	Blunt Sedge
Carex praegracilis W. Boott.	Graceful Sedge
Carex rossii Boot.	Ross's Sedge
Carex sprengelli Dewey	Sprengell's Sedge
Chenopodium gigantospermum Aellen	Maple-leaved Goosefoot
Cirsium flodmanii (Rybd.) Arthur	Flodman's Thistle
Clematis ligusticifolia Nutt.	Western Virgins-bower
Collomia linearis Nutt.	Narrow-leaved Collomia
Comandra umbellata (L.) Nutt. var. *pallida* (DC.) Jones	Bastard Toadflax
Cornus stolonifera Michx.	Red-osier Dogwood
Crataegus chrysocarpa Ashe.	Round-leaved Hawthorn
Cymopterus acaulis (Pursh) Raf.	Plains Cymopterus
Cystopteris fragilis (L.) Bernh.	Fragile Fern
Deschampsia caespitosa (L.) Beauv.	Tufted Hairgrass
Descurainia sophia (L.) Webb.	Flixweed

APPENDIX 1. *Continued.*

Scientific Name	Common Name
Disporum trachycarpum (S. Wats.) B. & H.	Fairybells
Elaeagnus commutata Bernh.	Wolfwillow
Eleocharis palustris (L.) R. & S.	Creeping Spike-rush
Elymus glaucus Buckl.	Smooth Wildrye
Epilobium ciliatum Raf.	Northern Willowherb
Erigeron asper Nutt.	Rough Fleabane
Erigeron caespitosus Nutt.	Tufted Fleabane
Erigeron flavum Nutt.	Yellow Umbrellaplant
Erysimum cheiranthoides L.	Wormwood Mustard
Fragaria virginiana Duchesne	Smooth Wild Strawberry
Fraxinus pensylvanicus var. *subintergerrima* (Vahl.) Fern.	Green Ash
Galium boreale L.	Northern Bedstraw
Galium triflorum Michx.	Sweet-scented Bedstraw
Gaura coccinea Pursh. var. *glabra* (Lehm.) Torr. & Gray	Scarlet Gaura
Geum aleppicum Jacq.	Yellow Avens
Geum triflorum Pursh	Three-flowered Avens
Hackelia americana (Gray) Fern.	Nodding Stickweed
Haplopappus spinulosa (Pursh) DC.	Spiny Ironplant
Heracleum lanatum Michx.	Cow-parsnip
Heterotheca villosa (Pursh) Shinners	Hairy Golden-aster
Hieracium umbellatum L.	Canada Hawkweed
Hordeum jubatum L.	Wild Barley
Hymenoxys richardsonii (Hook.) Cockerell	Colorado Rubberweed
Juncus balticus Willd.	Baltic Rush
Juniperus communis L.	Low Juniper
Juniperus horizontalis Moench	Creeping Juniper
Lactuca pulchella (Pursh) DC.	Blue Lettuce
Lathryus ochroleucus Hook.	Cream-coloured Vetchling
Lesquerella arenosa (Richards.) Rydb. var. *arenosa*	Sand Bladderpod
Linum lewsii Pursh	Blue Flax
Linum rigidum Pursh var. *rigidum*	Large-flowered Yellow Flax
Lonicera dioica L. var. *glaucescens* (Rydb.) Butters	Twining Honeysuckle
Lysimachia ciliata L.	Fringed Loosestrife
Mentha arvensis L. var. *villosa* (Benth.) S. R. Stewart	Field Mint
Mertensia paniculata (Ait.) G. Don.	Tall Lungwort
Monarda fistulosa L.	Wild Bergamot
Muhlenbergia cuspidata (Torr.) Rydb.	Prairie Muhly
Muhlenbergia racemosa (Michx.) BSP	Marsh Muhly
Opuntia polyacantha Haw.	Prickly-pear Cactus
Oryzopsis micrantha (Trin. & Rupr.) Thurber.	Little-seeded Ricegrass
Osmorhiza aristata (Thumb.) Make. & Yabe var. *longistylis* (Torr.) Boiv.	Smooth Sweet Cicely
Oxytropis campestris var. *varians* (Rydb.) Barneby	Late Yellow Locoweed
Parietaria pensylvanica Muhl.	American Pellitory
Phlox hoodii Richards	Moss Phlox
Plantago major L.	Common Plaintain
Poa canbyi (Scribn.) Piper	Canby Bluegrass
Poa cusickii Vasey	Early Bluegrass
Poa interior Rydb.	Wood Bluegrass
Poa palustris L.	Fowl Bluegrass
Poa pratensis L.	Kentucky Bluegrass
Poa sandbergii Vasey	Sandberg's Bluegrass
Polypogon convolvulus L.	Beard Grass
Populus angustifolia James	Narrow Leaved Cottonwood
Populus balsamifera L.	Balsam Poplar
Populus tremuloides Michx.	Trembling Aspen
Populus x *bernardii* Boiv.	Cottonwood
Populus x *jackii* Sarg.	Cottonwood
Potentilla arguta Pursh	White Cinquefoil
Potentilla concinna Richards var. *concinna*	Early Cinquefoil
Prunus virginiana L.	Chokecherry

APPENDIX 1. *Concluded.*

Scientific Name	Common Name
Ranunculus abortivus L.	Smooth-leaved Buttercup
Rhus aromatica Ait. var. *trilobata* (Nutt.) Barkley	Skunkbush
Rhus radicans L. var. *rydbergii* (Small) Rehder	Poison Ivy
Ribes americanum Mill.	Wild Black Currant
Ribes oxyacanthoides L.	Northern Gooseberry
Rosa acicularis Lindl. x *Rosa woodsii* Lindl.	Wild Rose
Rosa woodsii Lindl.	Wood's Rose
Rubus idaeus var. *strigosus* Michx.	Wild Red Raspberry
Salix bebbiana Sarg.	Beaked Willow
Salix interior Rowlee	Sandbar Willow
Senecio canus Hook.	Silvery Groundsel
Shepherdia canadensis (L.) Nutt.	Canada Buffaloberry
Sisymbrium altissimum L.	Tumbling Mustard
Sisyrinchium montanum Greene	Blue-eyed Grass
Smilacina stellata (L.) Desf.	Star-flowered Solomon's Seal
Smilax herbacea L. var. *lasioneura* (Hook.) DC.	Carrionflower
Solidago canadensis L. var. *salebrosa* (Piper) M.E. Jones	Graceful Goldenrod
Solidago rigida var. *humilis* Porter	Stiff Goldenrod
Solidago spathulata DC. var. *neomexicana* (Gray) Cronq.	Mountain Goldenrod
Sporobolus cryptandrus (Torr.) A. Gray	Sand Dropseed
Stipa comata Trin. & Rupr.	Needle-and-thread
Stipa spartea Trin.	Porcupine Grass
Stipa viridula Trin.	Green Needlegrass
Symphoricarpos occidentalis Hook.	Western Snowberry
Taraxacum laevigatum (Willd.) DC.	Red-seeded Dandelion
Taraxacum officinale Weber	Dandelion
Thalictrum venulosum Tre.	Veiny Meadow Rue
Thlaspi arvense L.	Stinkweed
Thermopsis rhombifolia (Nutt.) Richards	Golden Bean
Townsendia exscapa (Richards.) Porter	Low Townsendia
Tragopogon pratensis L.	Goats's Beard
Urtica dioica L. var. *procera* (Muhl.) Wedd.	Stinging Nettle
Vicia americana Muhl.	American Vetch
Viola adunca J. E. Smith	Early Blue Violet
Viola nuttallii Pursh	Nuttall's Yellow Violet
Viola rugulosa Greene	Western Canada Violet
Zizia aptera (A. Gray) Fern.	Heart-leaved Alexanders

Charophytes of Crooked Lake, Saskatchewan*

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Six charophyte taxa are reported from Crooked Lake, Saskatchewan and its immediate drainage system. In addition to the ubiquitous *Chara globularis*, two varieties in the *Chara vulgaris* complex not previously distinguished from Saskatchewan, *C. vulgaris* var. *longibracteata* and a *C. contraria* variant are recorded. *Tolypella glomerata* and *T. prolifera* also inhabit the lake and one *Nitella* species was located in the area. Taxonomically important features are described and illustrated for these taxa and general ecological parameters are provided as well as North American distribution ranges. Other species known to inhabit Saskatchewan are listed.

Key Words: Charophytes, Stoneworts, *Chara*, *Nitella*, *Tolypella*, Saskatchewan, distributions.

Even though stoneworts are common in most fresh and moderately saline waters, the charophyte flora of Canada is poorly described and documented. Only two regional surveys have been attempted, one from British Columbia (Allen 1951) and the other from insular Newfoundland (Mann 1989) and both of these are far from comprehensive. The major Canadian collection of Charophytes housed in the Phycological Herbarium of the Canadian Museum of Nature, Ottawa (CANA) indicates that the prairie region centered in Saskatchewan is only sporadically represented. The few prairie specimens are mostly incidental collections, those of John Macoun from the late nineteenth and early twentieth centuries being the most numerous, best known, and most widely distributed in other herbaria. Many species recorded from the area are only represented in the literature by a single collection, at most several, so information on their distribution and frequency is almost totally lacking. Numerous studies carried out on the sloughs, freshwater and saline lakes often totally omit mention of the Charophyte flora or only refer to them at the generic level; very few have identified specimens to the specific level (Rawson and Moore 1944; Hammer and Heseltine 1988). In almost all cases no descriptive information on which identifications were based is included with literature reports.

Wood's (1965) monograph of the Characeae, while being a monumental and extremely valuable work, nevertheless has produced at least one major problem for students of Charophyte taxonomy and phytogeography. His classification based mainly on morphology combines numerous taxa into large "species groups" which encourages the reporting of "groups" rather than recognizably described "species", especially by individuals not thoroughly acquainted with Charophyte taxonomy and its historical development. For example, two groups well represented in Canada include the "*Chara globularis* complex" and the "*Chara vulgaris* complex". Most, if not all, of Wood's eight varieties of *Chara globularis* Thuill. and many of the over two dozen forms are undoubtedly not conspecific (Proctor 1971, 1975; Bhatnagar 1989; John et al 1990). Yet the most commonly used key to the Charophytes of North America (Wood 1967) readily identifies all of these taxa as *C. globularis* Thuill. without further distinction. Therefore, it is not possible to determine from a literature report whether taxonomically correct variety *globularis* form *globularis* (= *C. fragilis* Desv.) is intended or whether the collective sense is being employed when this name is cited. Consequently many existing literature citations are of no use to a phytogeographer unless voucher specimens can be examined and these are not often available. A similar, but more complex and less understood situation occurs in the "*Chara vulgaris* complex" where many more varieties and forms appear to exist. This problem has previously been reiterated in a different context by Proctor (1971, 1975, 1980) but is here stressed so that future reports can be made more meaningful. If Wood's (1965) system is employed, taxa must be identified to variety and form to provide maximum information and preferably the key characters stated on which the determination was based. In much of Canada where Charophyte variations and distributions are poorly known, detailed documentation as provided in this paper is required, locality by locality, region by region, until the broad picture emerges.

This report describes the Charophyte flora of a single southeastern Saskatchewan lake basin and provides some additional general observations of distributions across the Canadian prairies. Possibly

*This paper is dedicated to Professor M.V.S. Raju, University of Regina, upon his retirement.

botanists and naturalists will recognize from the paucity of available data that much challenging opportunity exists for the collection and study of this commonly occurring and interesting group. A good understanding of the group's variations, distributions and northern limits awaits the basic information provided by such local and regional studies.

Study Area

The Qu'Appelle Basin drains an area of approximately 50 000 km^2 of south-central and south-eastern Saskatchewan via the Qu'Appelle River into the Assiniboine River as part of the Hudson Bay drainage system (Anonymous 1972). The Qu'Appelle Valley and its branches pass through gently undulating agricultural lands which are intensively cultivated and grazed. Of the eight major lakes, Crooked Lake, the second last in the chain, is located approximately 30 km northeast of Grenfell, Saskatchewan. The sigmoid shaped lake is 9 km in length and 0.8 - 1.6 km in width covering an area of 14.6 km^2. Maximum depth is 16.5 m with a mean depth of 7.9 m.

The Qu'Appelle lakes are highly eutrophic, supporting much aquatic plant growth and high fish populations (Atton and Johnson 1962) and planktonic blooms of the blue-greens *Aphanizomenon* and *Anabaena* are common in the summer months (Hammer 1970). High loading rates of nutrients such as nitrogen and phosphorous are due to agricultural runoff, shoreline cottage development, and sewage effuents entering the system from two major centers, Regina and Moose Jaw. In general, the waters of the Qu'Appelle system are highly mineralized, very hard, high in alkalines and sulphates and at times very turbid (Anonymous 1971). Turbidity is largely due to a combination of factors including runoff, wind/wave action and planktonic blooms. The climate of the entire drainage area is semi-arid receiving an average of 39 cm of precipitation annually resulting in low flow and flushing rates, further exacerbating the eutrophic nature of the system.

Because of the considerable seasonal variation of factors such as runoff, flow rates, temperature, aquatic growth, agricultural activity and cottage activity, the water chemistry also fluctuates seasonally. Conductivity measured in the Qu'Appelle River at the outflow of Crooked Lake varied from 1400 µmhos/cm in April to 1800 in October 1970 and pH ranged from 8.7 to 8.5 during the same period (Anonymous 1971). Atton and Johnson (1962) record pH values in Crooked Lake itself as 8.0 on the bottom to 8.5 at the surface. One set of surface water measurements were taken in Crooked Lake on 18 July 1993 with a conductivity of 1700 µmhos/cm and a pH of 8.9. The waters of Crooked Lake can therefore be classified as slightly brackish using the scale of Stewart and Kantrud (1971).

Crooked Lake has extensive areas of plant growth including vasculars, charophytes and other benthic and planktonic algae. A several meter zone from the shore affected by wave action is generally free of macrophytes to a depth of 2 m. Often a narrow zone of open growing macrophytes such as *Zannichellia palustris* L. and charophytes mixed with mats of *Cladophora* sp. borders the shoreward side of the dense "weed" beds which extend to depths of about 6 m maximum. The most common constituents of these vascular beds are *Ceratophyllum demersum* L., *Myriophyllum spicatum* L., *Potamogeton pectinatus* L., *P. richardsonii* (Ar. Benn.) Rydb., *Ruppia maritima* L., and *Zannichellia palustris* L., all species tolerant of high salinities. The vascular "weed line" does not extend beyond the 6 m water depth contour probably because of low light penetration and possibly oxygen depletion during the growing season at depths greater than this. Inside the weed line a narrow zone of *Cladophora* and *Tolypella* quickly gives way to the vegetation-less zone with increased depth.

Methods

Collections were made in July and August of 1989 and again in July of 1993. Charophytes were obtained by hand or with a long-handled rake in small and shallow water bodies. A heavy toothed metal two-edged rake bar on a long rope was also thrown into deeper water from shore. Most sampling within Crooked Lake proper was done from a boat using either a very long-handled rake or a heavy toothed drag on a rope. Specimens were preserved in 5% formalin, some also being pressed and dried as herbarium sheets.

Although the charophyte species of Crooked Lake could be found throughout their ecological zones, considerable collection was often necessary to find good vigorously growing and fruiting representative material. Every effort was made to sample broadly and to select the best material possible for liquid preservation. Even though dried charophytes are easier and safer to store, they often present difficulties in morphological interpretation and measurement if not carefully prepared. Care was taken to avoid fragmentary, mixed, senescent or dilapidated material, or that which was ecologically and therefore morphologically unrepresentative of the taxon. As with vascular plants, taxonomy must be based on well chosen and highly representative material and fragmentary collections must be viewed with some reservation.

Measurements of gametangial and oospore features are provided for all taxa as is the common practice when describing charophytes. Sometimes differences are distinct and measurements are useful in delimiting taxa, but often intergradation occurs and they are of only limited value. A variety of complicating factors associated with measurements suggest that literature citations should probably best be interpreted only in the broadest and most general terms unless methodology is precisely explained. Oogonia, antheridia, and oospores continue to enlarge as they mature and there is often no easy way to determine when these are fully mature so selection of material can bias results. Choosing fully ripe oospores is probably the least subjective and therefore also probably one of the most consistent and useful measurements when comparing literature reports of different authors. Also it can often not be determined from some citations how the measurements were actually taken, whether the coronula was included, whether oospore ridges, claws and cages were included, whether fossae widths were taken from intact oospores or from crushed, flattened membranes, and so on. Whether abiotic factors (water depth, nutrients, temperature, etc.) and growth cycle stages can produce significant size variation in the gametangia and spores of a particular genotype is not clear. Counts such as the number of striae (ridges) on the oospore or the number of spiral cell convolutions of the oogonium as seen laterally are also subject to interpretation and certainly individual counts should be interpreted as "plus or minus one" in most cases.

In the present study attempts were made to choose gametangia and spores that appeared fully mature and hence at the upper end of the size range. In all cases at least 12 measurements were made, often 20 - 30. Oogonial length includes the coronula; coronula height is given separately. Width of the oogonia was measured at the greatest distance across when viewed laterally. The number of spiral cell convolutions were also counted from oogonia viewed laterally. Oospore length measurements do not include claws or cage, but width does include the ridges; fossae width was measured on intact spores. All measurements were made with a compound microscope at 100 X using a calibrated eyepiece. Oospore membranes were studied at 400 X.

Drawings were made with a Zeiss Technival stereomicroscope fitted with a drawing tube or by projecting the image of liquid preserved material onto a paper surface with a normal 35 mm slide projector utilizing "micro-observational cells" available from Ward's Natural Science Ltd. and other biological suppliers. The drawings are therefore essentially microscopic tracings of actual selected specimens and as such accurately portray size and proportion. In each of the plates, except that for *Nitella*, the plant "habit" diagram is a photocopy of an actual pressed herbarium specimen, slightly retouched in a few cases so the image would copy clearly. All drawings except the habit photocopy were made from decalcified material preserved in 5% formalin. For specimens of the genus *Chara* it was especially important to examine and illustrate younger internodes before much growth had obscured the fundamental cortication pattern and before spine cells absciss.

Conductivity measurements were taken with a Myron L DS (Model EP-10) conductivity meter while pH readings were obtained with a Cole-Parmer digital meter (pHep$^+$). These values were corroborated with a color indicator solution (La Motte wide range comparator).

Crooked Lake and the entire surrounding area involved in this study is included on the Canadian Topographical Map 62 L/10 "Crooked Lake", Edition 3 published in 1987 by Energy, Mines and Resources Canada. Locations are recorded using the one thousand meter Universal Transverse Mercator (U.T.M) Grid co-ordinates.

Voucher specimens are housed in the Sir Wilfred Grenfell College Herbarium (SWGC) as liquid preserved material and/or dried herbarium sheets. Duplicate sheets of the *Chara* and *Tolypella* species described in this study have been deposited with (CANA), the Phycological Herbarium of the Canadian Museum of Nature, Ottawa (Mann No. 107, No. 108, No. 188, No. 190, No. 191, No. 192B). Herbarium abbreviations are listed in Holmgren et al. (1990) except for the Sir Wilfred Grenfell College Herbarium (SWGC) which is not yet listed.

Species Accounts

1. *Chara vulgaris* L. var. *longibracteata* (Kütz.) J. Groves and Bullock-Webster [= *C. vulgaris* var. *vulgaris* f. *longibracteata* (Kütz.) H. and J. Groves]. [Figure 1]

The thallus of this vigorous species measures up to 45 cm in length with axes up to 936 µm in diameter. Cortication is diplostichous and distinctly aulacanthous, spine cells being small, attached singly and often lying appressed to the stem in the furrows created by the narrower primary cortical cells (Figure 1b). Stipulode cells are short, round tipped and equal in both tiers. Branchlets are usually of 7 segments, the lower 3 - 4 being corticated and the end of 3 - 4 ecorticated cells often quite elongate. Gametangia occur at the lowest 3 - 4 corticated nodes. The length of the bracteoles and anterior bract cells is characteristic, these being very long, often in excess of 6000 µm and up to 14 times the length of a mature oogonium. In this collection the two bracteoles are always shorter than the anterior bract cells, both becoming progressively longer at the fertile nodes closer to the branchlet tip. Considerable variation occurs within this material, Figure 1c illustrating bract and bracteole lengths almost falling within ranges of those normally reported for the species (var. *vulgaris*) to the frequently extreme lengths characteristic of var. *longibracteata* (Figure 1d).

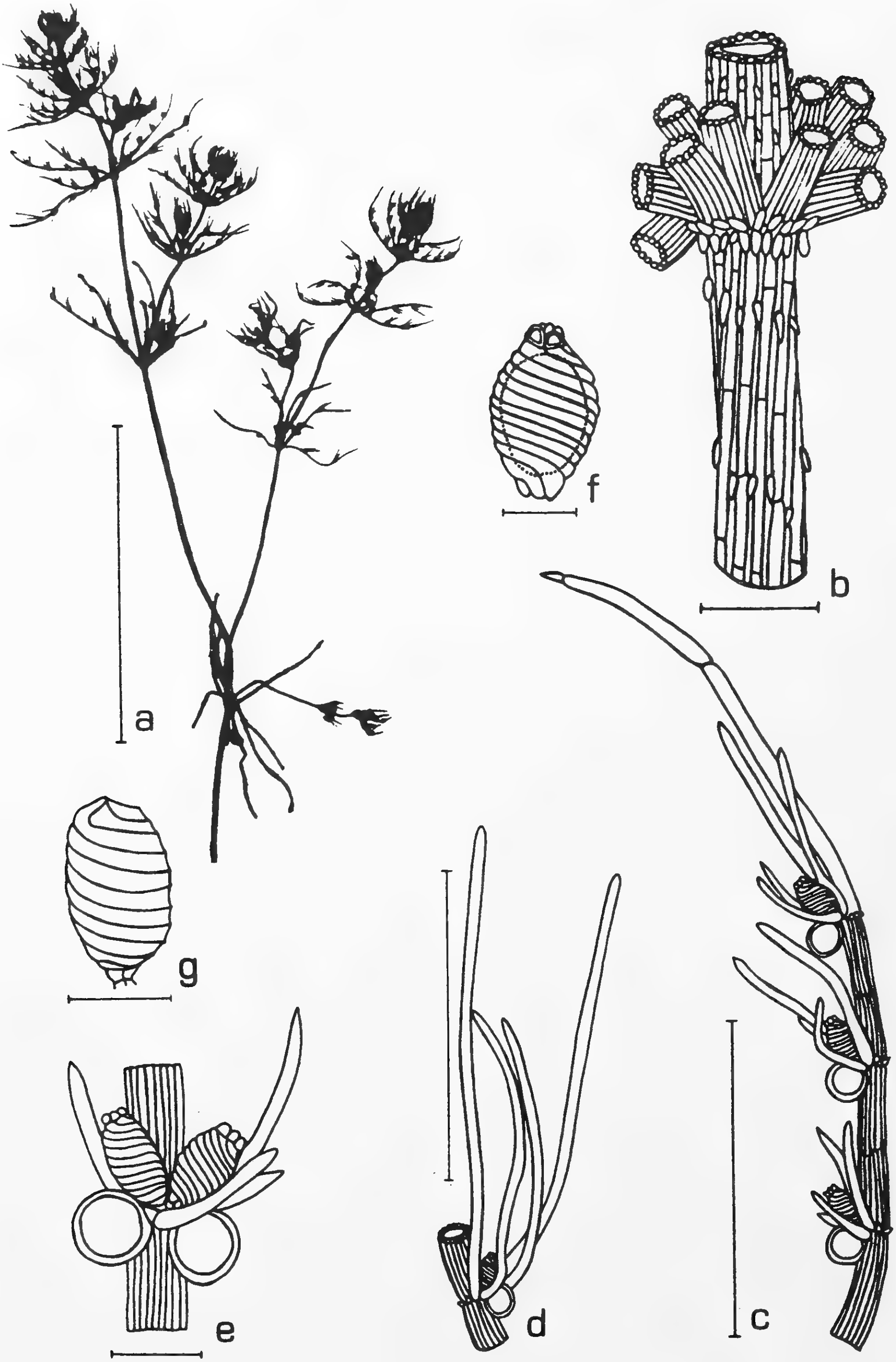

FIGURE 1. *Chara vulgaris* var. *longibracteata*. a: plant habit, photocopied herbarium specimen, scale bar = 5 cm; b: enlarged portion of axis and node, scale bar = 1000 µm; c: a branchlet, scale bar = 3000 µm; d: a branchlet node showing very long bracteoles and bract cells, scale bar = 5000 µm; e: a branchlet node with geminate antheridia and archegonia, scale bar = 500 µm; f: oogonium, scale bar = 300 µm; g: oospore, scale bar = 300 µm.

Table 1 provides gametangial and oospore measurements. The geminate condition of both antheridia and oogonia occurs (Figure 1e) but not with great frequency. Coronula cells are connivent with rounded tips (Figure 1f). Oospores are bronze to brown and appear translucent under reflected light. Prominent claws with a basal cage are present (Figure 1g). At 400 X the oospore membrane appears pale orange-brown with a moderately coarse, but loosely granulate ornamentation.

The species group *Chara vulgaris* is here being separated from the species group *C. contraria* in the traditional sense, *C. vulgaris* being aulacanthous, cells of the two stipulode tiers being equal in size, bracteoles and anterior bract cells often being several times as long as mature oogonia, and mature oospores being brown in color. *Chara contraria*, on the other hand, is tylacanthous, the upper tier of stipulode cells are often somewhat larger than the lower and more tapering and pointed than in *vulgaris*, bracteoles and anterior bract cells are usually shorter than those of *vulgaris*, and mature oospores are black. The initial basic distinction is the aulacanthous/tylacanthous feature. This seems to be the most practical approach at the moment since evidence exists that the two taxa groups are almost certainly not conspecific (Grant and Proctor 1972; John et al. 1990). Until future thorough studies of the "*C. vulgaris* complex" produce additional evidence, it seems fruitless to debate this issue especially when experienced workers have little difficulty in distinguishing these two groups when good representative material is available. Both *C. vulgaris* and *C. contraria* have numerous reported varieties and forms.

Chara vulgaris is a common, widespread and cosmopolitan species found throughout most of North America. Although not separating aulacanthous *vulgaris* from tylacanthous *contraria*, Wood's (1967) map is probably reasonably accurate for both taxa if one considers the northern boundary to be approximate. However, both taxa are common in Newfoundland (Mann 1989) which is omitted on the map. Wood (1965) records f. *longibracteata* only from Europe citing no North American records. Allen (1950) observes that of the four common varieties, var. *longibracteata* is the most frequently encountered in Britain. Halsted (1879) mentions it from New Mexico, Iowa, and New York, but his descriptions are vague and appear to fall within the normal var. *vulgaris* range. Allen (1951) records a specimen from the Bow Lakes, Banff, Alberta. I saw only one aulacanthous specimen from Saskatchewan at the Canadian Museum of Nature collection (CANA 28831) from a stagnant pool 19.2 km south of Indian Head (Jones and Ledingham No. 770, 1968). It appears to be similar to the Ekapo Creek material, having well-developed anterior bracts and bracteoles.

The *Chara vulgaris* var. *longibracteata* material here described was collected from Ekapo Creek which empties into the Qu'Appelle River through a broad coulee at the eastern end of Crooked Lake. The creek carries meltwater in spring, but normally ceases to flow during the dry summers of most years, only the deeper pools retain water for the entire year. This collection was from such a small stagnant pool (Cowessess Golf Course, Green No. 5) with a muddy substrate and water of 1 m in depth. Vascular aquatics included *Ceratophyllum* sp., *Sagittaria* sp., *Myriophyllum* sp., *Utricularia* sp., and *Lemna minor* L. A thick mat of *Chara* occurred in the open water at the center of the pool where competing vasculars were scarce or absent. Unfortunately water parameters such as pH and conductivity are not available for this site, however, recorded data from the mouth of Ekapo Creek (Anonymous 1971) report conductivity at 700 μmhos/cm in April/May to 1100 in June/July 1970, considerably less than the Qu'Appelle River at 1400 and 1650 μmhos/cm during the same period.

TABLE 1. Gametangial and oospore features of *Chara* species. Measurements are presented as means (μm) with range values in parentheses.

	C. vulgaris	*C. contraria*	*C. globularis*
Oogonium			
length	691(639-721)	906(845-1009)	785(752-834)
width	426(412-443)	573(525-628)	451(422-484)
coronula height	80	116	155
convolutions	(12-14)	(11-12)	(12-14)
Oospore			
length	500(484-536)	614(587-649)	559(515-618)
width	306(268-330)	423(391-453)	381(340-412)
No. of ridges	(9-11)	(9-11)	(9-11)
fossae width	57	74	62
Antheridium			
diameter	387(350-412)	385(361-453)	341(309-361)

Hydrogen ion values ranged from pH 7.8 - 8.1 as compared to river values of pH 8.6 - 8.7.

2. *Chara contraria* A. Braun ex Kütz. [= *C. vulgaris* var. *vulgaris* f. *contraria* (A. Braun ex Kütz.) Wood]. [Figure 2]

This Crooked Lake *Chara* has a thallus length from 30 - 50 cm and axes of up to 832 μm in diameter. The olive to golden-brown axes are moderately to heavily encrusted, diplostichous and strongly tylacanthous (Figure 2b). In older axes the cortication may become irregular by overlapping growth of ends of the narrower secondary cells, sometimes developing an almost triplostichous arrangement. Tiny, almost globular spine cells are produced singly at the primary cortex nodes. Two tiers of small stipulode cells are present, the cells of the upper tier often slightly larger than those of the lower tier.

Branchlets are very long, up to 50 mm, most of the length due to three ecorticate end segments (Figure 2c). The tip cell is small, conical and pointed, the penultimate cell is of intermediate length and the ecorticate basal cell is much elongated. Three or four, occasionally two or five, short basal branchlet internodes are regularly corticated, gametangia being borne at all corticated nodes. Bracteoles and anterior bract cells are very short, less than mature oogonial length, while posterior bract cells are tiny, often obscure.

Male and female gametangia are conjoined at the nodes, the geminate condition of both antheridia and oogonia being very common. Antheridia are orange in color, mature oogonia being either orange like the antheridia or of a greenish color. Coronula cells have connivent rounded tips (Figure 2d), occasionally slightly spreading. Oospores are dark brown to black with short basal claws and thin finger-like processes at the coronula end (Figure 2e). Crushed oospore membranes appear finely granular at 400 X and are brown in color. Table 1 lists gametangial and oospore measurements.

This variant of *Chara contraria* differs from the typical in several ways; it has very long whip-like ecorticate branchlet ends, the bracteoles and anterior bract cells are very short, the geminate condition is common, and the oospore usually features elongated finger-like processes at the coronula end. Migula (1897) mentions a rare form (f. *capillacea*) with elongated branchlet ends, but in habit and other structural features it is not like the present variety. Likewise, Wood's (1965) var. *nitelloides* from South America shows some similarities, but differences as well. Corillion (1957) mentions the geminate condition occurs sometimes in *C. contraria* as well as *C. vulgaris*. Although individually most of the characteristic features of the Crooked Lake material have been reported before in *C. contraria*, their occurrence together in such robust plants apparently has not been previously noted. I have not encountered reference to the peculiar prominent apical projections on the oospore. Even so, at present this taxon will simply be regarded as an extreme variant of *C. contraria* without according it any special taxonomic status.

Chara contraria is a cosmopolitan taxon occurring throughout most of North America. Four collections of tylacanthous material from southern and central Saskatchewan were seen in the Canadian Museum of Nature (CANA) but these have not been critically assessed and require further study. None appear to show the combination of characters of the Crooked Lake material.

This taxon is ubiquitous throughout Crooked Lake preferring the shallower water between the wave affected margins and the dense vascular "weed" zone. Here it grows at a depth of 1.5 - 3.0 m intermixed with the common coarse filamentous alga *Cladophora* and open growing vasculars such as *Zannichellia*. It extends into the edge of the vascular beds, but has not been found growing within the beds or beyond the beds in deeper water. In one area where extensive Beaver (*Castor canadensis*) activity had cleared a large area which would have normally contained dense vascular growth, this *Chara* produced thick mats of especially luxuriant growth on the muddy substrate among the Beaver runs in 1 - 3 m of water. Both Olsen (1944) and Langangen (1974) characterize *C. contraria* as a species of alkaline freshwaters of high calcium content, *C. vulgaris* having very similar preferences.

3. *Chara globularis* Thuill. (= *C. fragilis* Desv., = *C. globularis* Thuill. var. *globularis* form *globularis* Wood). [Figure 3]

Chara globularis produces stout axes 30 - 50 cm in length and up to 730 μm in diameter. The main axis (Figure 3b) exhibits triplostichous cortication and cells of the primary and secondary rows are about the same diameter (isostichous). Spine cells are rudimentary and globular as are the two tiers of stipulodes. All parts of the thallus are moderately encrusted. Branchlets usually have eight corticated segments plus two short ecorticate end segments (Figure 3c). The lowest three, sometimes four, nodes from the base exhibit conjoined gametangia. Bracteoles and anterior bract cells are shorter than the mature oogonia while posterior bract cells are rudimentary. Coronula cells are connivent with the tips separated, sometimes slightly spreading (Figure 3d). Mature oogonia including the coronula cells are pale green to pale orange and antheridia are deep bright orange in living material. Intact oospores exhibit prominent basal claws and appear dark brown to black with reflected light (Figure 3e). Table 1 lists gametangial and oospore measurements which fall within the traditionally reported values (Corillion 1957; Wood 1965; Moore 1986).

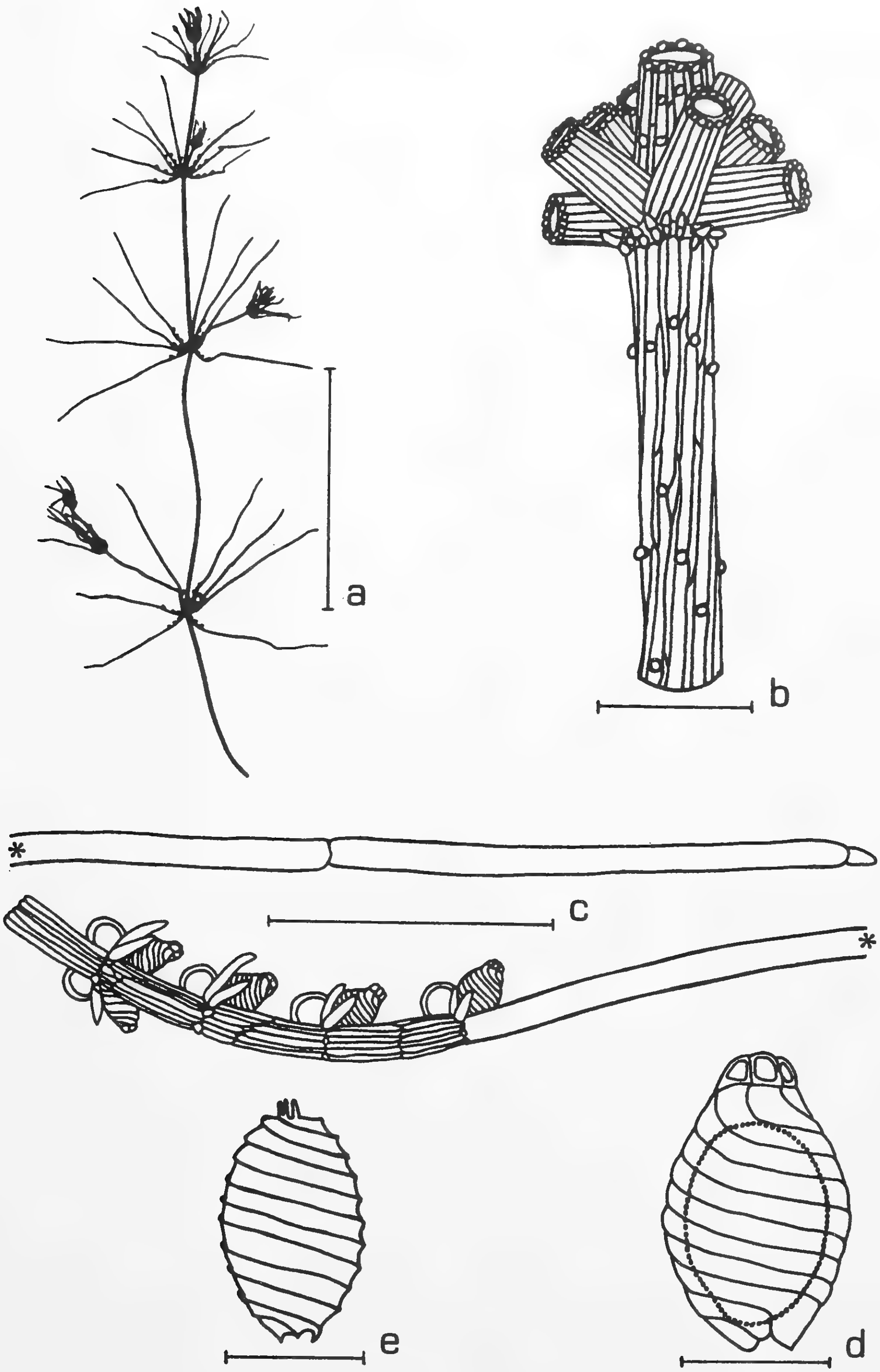

FIGURE 2. *Chara contraria*. a: plant habit, photocopied herbarium specimen, scale bar = 5 cm; b: enlarged portion of axis and node, scale bar = 1000 μm; c: branchlet, scale bar = 3000 μm; d: oogonium, scale bar = 500 μm; e: oospore, scale bar = 400 μm.

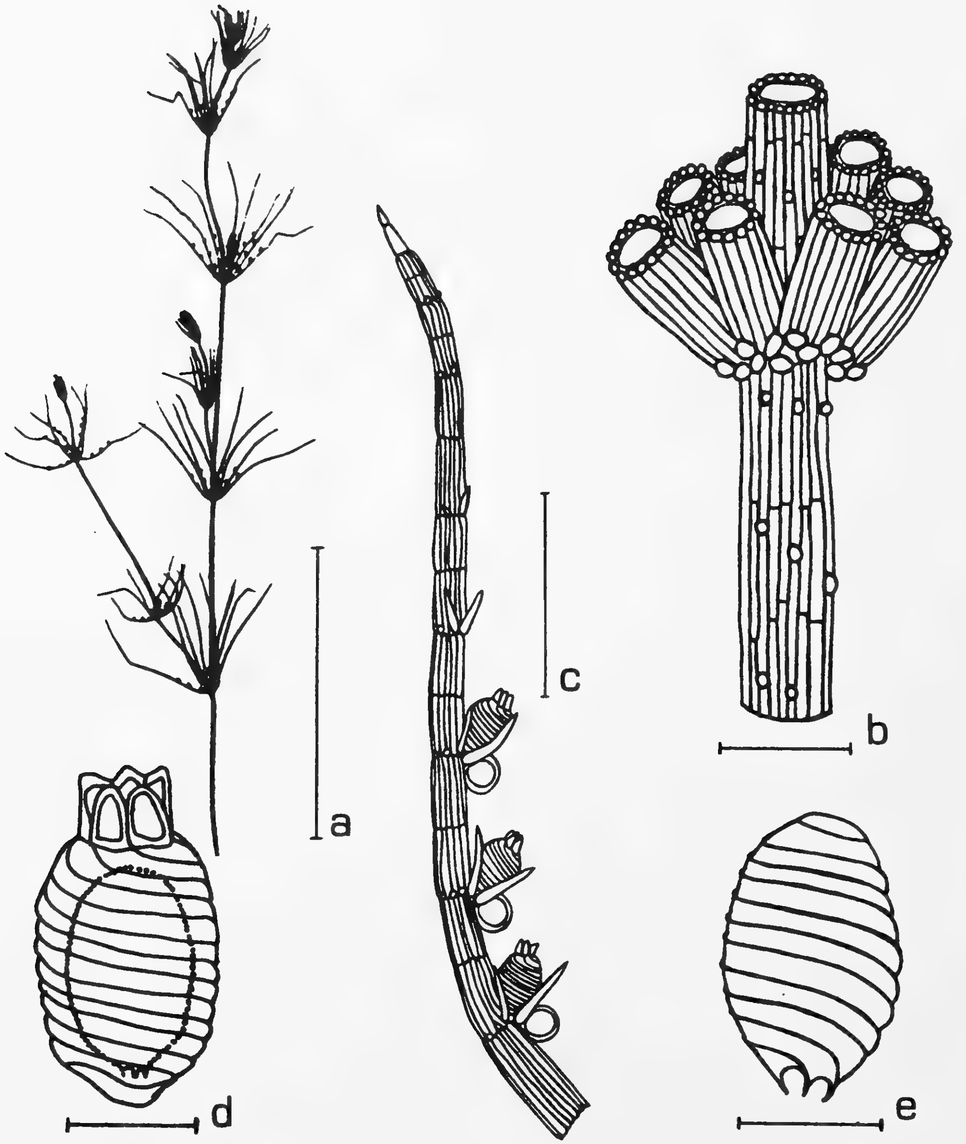

FIGURE 3. *Chara globularis*. a: habit, photocopied herbarium specimen, scale bar = 5 cm; b: enlarged main axis and node, scale bar = 1000 µm; c: branchlet, scale bar = 2000 µm; d: oogonium, scale bar = 300 µm; e: oospore, scale bar = 300 µm.

This species was located in an oxbow of the Qu'Appelle River approximately 6 km upstream from the west end of Crooked Lake (U.T.M. Grid 508115). The oxbow was created in earlier years from a section of the meandering river that had been mechanically straightened for flood control purposes. *Chara globularis* covered the entire bottom in a thick carpet rooted in a fine muddy clay in 1 - 1.5 m of clear stagnant water. Conductivity measured 2500 µmhos/cm and pH was 9.1, values somewhat higher than those of Crooked Lake. The oxbow was largely bordered by willows with *Typha* encroaching into the open water along part of the shore. Although this species has not yet specifically been located in Crooked Lake, its presence in the upstream drainage system and its general ubiquitous distribution suggest it may also be found in the lake. I also located it in a roadside borrow pit in agricultural country 9 km south of the Qu'Appelle Valley rim on provincial highway number 47 (U.T.M. Grid 007473). It is recorded as a species with a great range of ecological tolerance, from mildly acid to very alkaline and from fresh oligotrophic waters to those distinctly eutrophic, brackish, or saline (Olsen 1944; Langangen 1974).

Wood (1965) does not mention any Canadian specimens, only stating that this taxon is widespread in North America and elsewhere. His distribution map (Wood 1967) combines all his varieties so it is not possible to distinguish this taxon from it. However, sufficient Canadian collections exist (CANA) from Newfoundland, across southern Canada to British Columbia, the Yukon, and Northwest Territories to indicate it is one of our most widespread and common species. I have seen two regional specimens at the Canadian Museum of Nature (CANA) from Saskatchewan and one from Manitoba. These include CANA 15924 from Bear Lake, mile 63 of the Hansen Lake Road, Saskatchewan (B. de Vries 1962) which contains a mixture of *C. globularis* and *C. contraria*, CANA 5930 from Henzel, Saskatchewan (J. Macoun and W. Herriot 1906) and CANA 29333 from Fort Whyte, Manitoba (C. Garton). Rawson and Moore (1944) cite *C. fragilis* from Stoney Lake, Saskatchewan, and Hammer and Heseltine (1988) report *C. globularis* Thuill. from saline Wakaw Lake, Saskatchewan, but as discussed earlier, whether this taxon or another in the *C. globularis* complex is intended is not clear.

4. *Tolypella glomerata* (Desv. in Lois.) Leonh. [= *Tolypella nidifica* var. *glomerata* (Desv. in Lois.) Wood]. [Figure 4]

Tolypella glomerata produces a branching moderately encrusted thallus up to 35 cm in length, the axes being slender and up to 800 μm in diameter (Figure 4a). Branchlets at non-fertile nodes are simple and undivided. Fertile branchlets are compacted into dense heads usually less than 1 cm in diameter near the tips of the branches (Figure 4b). Branchlets of the fertile whorls are mostly once divided in a monopodial fashion, the 3 - 4 laterals only produced at the first node from the base are smaller in length and diameter than the main axis of the branchlet (Figure 4c). Characteristic of the species are the large allantoid end cells with rounded tips on both the main branchlet axis and on the laterals which place it in the Section *Obtusifolia* (Section *Tolypella* of Wood, 1965). Often a single antheridium flanked by two oogonia occur at the base of the laterals, however, up to five oogonia in a cluster have been observed here and also at the base of the branchlet where it joins the main axis.

Table 2 lists reproductive structure measurements. The Crooked Lake material exhibits most of the characteristic features of the species as documented in the standard references (Groves and Bullock-Webster 1920; Corillion 1957; Wood 1965; Moore 1986) with several variations. Antheridial diameter is the largest recorded for this taxon, approaching that of *Tolypella nidifica* of Europe. Oospore size also appears to be somewhat greater than that normally recorded for the species. The coarse linear membrane decoration pattern, which has long been recognized as a major feature of the taxon, is present but the lines often separate leaving smooth patches, sometimes extensively so, across the fossae (Figure 4f). This differs from Newfoundland material and European reports which seem to indicate that the coarse linear pattern occurs more or less uniformly across the fossae. Frame (1977) reiterates that the membrane decoration of *T. glomerata* and closely related *T. nidifica* of Europe differ significantly with the scanning electron microscope and that differences exist even between North America and European members of the morphological species *T. glomerata* as well as differences within North American populations. Ripe oospores of Crooked Lake specimens are orange-brown with reflected light.

Earlier North American workers (Allen 1883; Allen 1954) recognized two taxa closely related to, and in addition to *Tolypella glomerata*, *T. longicoma* Br. and *T. comosa* Allen. These were merged with *T. glomerata* as a variety of *T. nidifica* (*T. nidifica* var. *glomerata*) by Wood (1965). Considering the variation associated with this group it appears that a thorough reappraisal of the *T. glomerata/nidifica* complex may be warranted.

This species grows at the greatest depth recorded for the Crooked Lake charophytes. Although vascular plants normally grow no deeper than 6 m, *Tolypella glomerata* can be collected in deeper water near the weed line intermixed with the ubiquitous lake *Cladophora*. It was also collected in "holes" in the weed beds where the thick vascular vegetation cover was broken, again associated with mats of *Cladophora*, but never amongst the dense vasculars.

Wood's (1967) map which does not separate related taxa, shows that the *Tolypella nidifica* complex extends in a broad belt across the United States entering Canada only in the Canadian prairies. The only Canadian citation by Wood (1965) is of J. Macoun's (1879) collection var. *glomerata* from a "pond west of Saskatchewan". Whether "Saskatchewan" here should read "Saskatoon" or whether this is actually an Alberta report is not clear. The Canadian Museum of Nature contains a single specimen of *T. glomerata* from the region (CANA 5910) from a "shallow prairie pond 16 km east of Canmore, Alberta, on Banff-Calgary Highway" (A. E. Porsild 18151A, 11 July 1951). I have recently reported (Mann, in press) a collection of *T. glomerata* from the tip of the Great Northern Peninsula in Newfoundland and this together with the prairie reports constitute the most northerly records in North

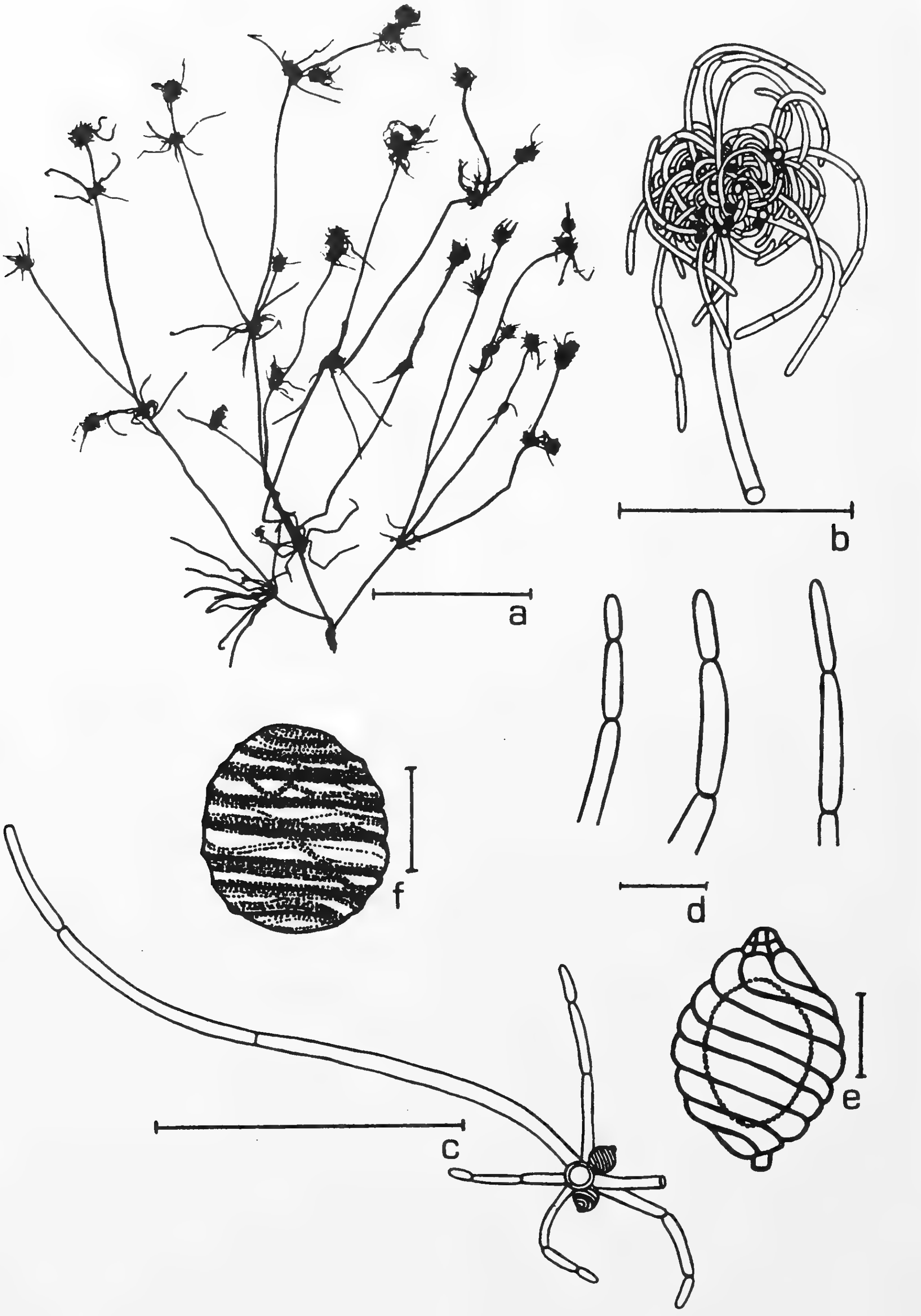

FIGURE 4. *Tolypella glomerata*. a: habit, photocopied herbarium specimen, scale bar = 5 cm; b: enlarged terminal "head", scale bar = 1 cm; c: branchlet with four laterals, scale bar = 5000 µm; d: variations in terminal cells, scale bar = 1000 µm; e: oogonium, scale bar = 200 µm; f: oospore showing linear ornamentation, scale bar = 200 µm.

TABLE 2. Gametangial and oospore features of *Tolypella* species. Measurements are presented as means (μm) with range values in parentheses.

	T. glomerata	*T. prolifera*
Oogonium		
length	557(474-618)	573(515-618)
width	444(391-474)	424(381-453)
coronula height	50	50
convolutions	(9-11)	(11-12)
Oospore		
length	409(371-433)	409(370-433)
width	334(319-350)	336(319-350)
No. of ridges	(7-8)	(8-10)
fossae width	62	57
Antheridium		
diameter	469(402-515)	267(216-288)

America. The Newfoundland and Crooked Lake specimens show some differences in growth habit, gametangial size and oospore membrane decoration, but how significant these are is not understood at present.

5. *Tolypella prolifera* (Ziz. ex A. Braun) Leonh. [= *Tolypella intricata* var. *intricata* form *prolifera* (Ziz. ex A. Braun) Wood]. [Figure 5]

Crooked Lake *Tolypella prolifera* is a stouter plant than *T. glomerata* with axes up to 1050 μm in diameter, with longer simple sterile branchlets and fewer but larger fertile heads (Figure 5a). Actively growing axes are lightly to moderately encrusted and have a brighter grass green color compared to the olive green of older more encrusted axes and those of *T. glomerata*. Branchlets of the dense fertile "birds-nest" heads usually bear laterals at two nodes above the base in a monopodial fashion, the laterals often again branching (Figure 5b). Very characteristic of the section to which it belongs, Section *Acutifolia* (Section *Rothia* of Wood 1965), are the tapering branchlet and lateral axes, with each cell closer to the tip becoming progressively smaller, the end cell producing a small sharp conical tip (Figure 5c). In almost all morphological respects it exhibits the features normally used to distinguish this taxon (Groves and Bullock-Webster 1920; Corillion 1957; Wood 1965).

Gametangial and oospore measurements are given in Table 2. Coronulas remain attached as oospores mature, the upper tier of five coronula cells are approximately twice the height of the lower tier (Figure 5d). Intact mature oospores are dull brown in color with reflected light as are the crushed spore membranes with transmitted light. Oospore membranes are more or less smooth or at least only very indistinctly and irregularly ornamented at 400 X except for a narrow band of irregular coarse granules on either side of the ridges. I can find no reference to these narrow granular strips in any of the traditional light microscope literature or in more recent scanning electron studies.

Unlike *Tolypella glomerata*, *T. prolifera* tends to grow among the vascular macrophytes where their growth is not excessively dense. Crum (1975) noted that *Ceratophyllum demersum* L. because of its dense stands, was a negative indicator of *T. prolifera* and *T. intricata*, but that more open growing species like *Potamogeton* and *Myriophyllum* were positive indicators of presence. Observations in Crooked Lake also support this relationship. In Britain, *T. prolifera* is listed in the Red Data Books as a potentially endangered species, its habitat specified as "... exclusively a plant of small alkaline water bodies such as ditches, rivers, canals or peat pits. It prefers slow-moving water and tends to grow in deeper water than other members of the genus" (Stewart and Church 1992).

Although Wood (1965) considers this taxon a form of *Tolypella intricata*, earlier workers and a number of modern authorities treat it at the species level (Corillion 1957; Sawa 1973; Blazencic et al. 1990). This taxon appears to be distributed across most of the United States and southern Canada excluding the maritimes and Newfoundland. Wood (1965) only lists two Canadian records, one from Quebec and one from Saskatchewan. Allen (1954) notes records from British Columbia, Saskatchewan, Lake Huron and Lake Ontario. Also, a collection at the Canadian Museum of Nature (CANA) occurs from Bolton Creek, near Bennett Lake, Ontario. Curiously enough, even though Wood (1965) lists its occurrence in Saskatchewan, his distribution map (Wood 1967) totally excludes this taxon from the entire Canadian prairies and north-central United States. *Tolypella prolifera* is relatively well represented in the national collection (CANA) from southern Saskatchewan and Alberta with a total of

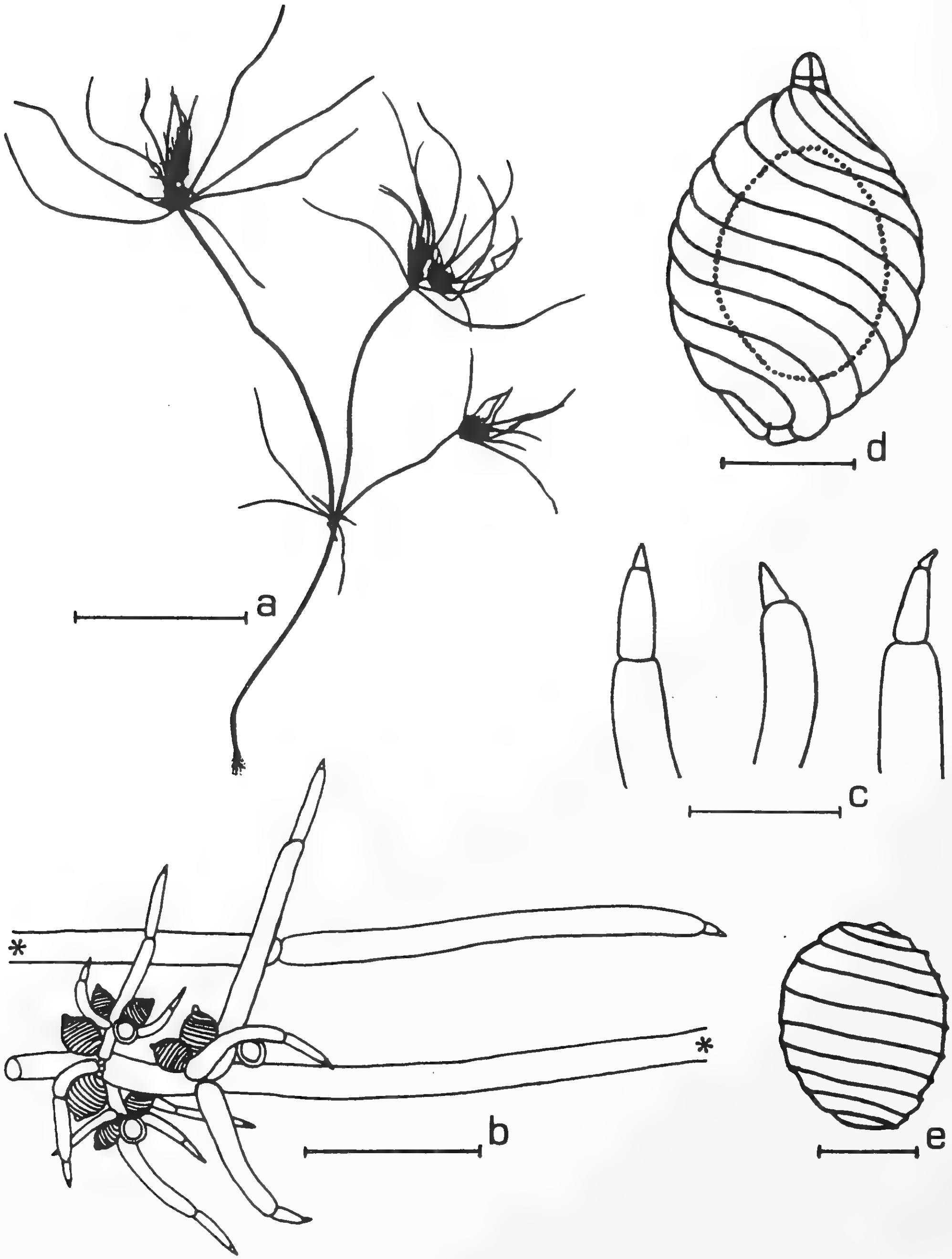

FIGURE 5. *Tolypella prolifera*. a: habit, photocopied herbarium specimen, scale bar = 5 cm; b: branchlet, scale bar = 2000 µm; c: variation in branchlet end cells, scale bar = 500 µm; d: oogonium, scale bar = 200 µm; e: oospore, scale bar = 200 µm.

seven specimens. Saskatchewan collections are listed from pools and lakes in the Moose Jaw, Regina, and Yorkton areas and the Alberta collection from Pot Hole Creek.

6. *Nitella* sp. [Figure 6]

When examining the *Chara vulgaris* material from Ekapo Creek, a single stem of *Nitella* was found, its anchoring rhizoidal mass still intertwined with those

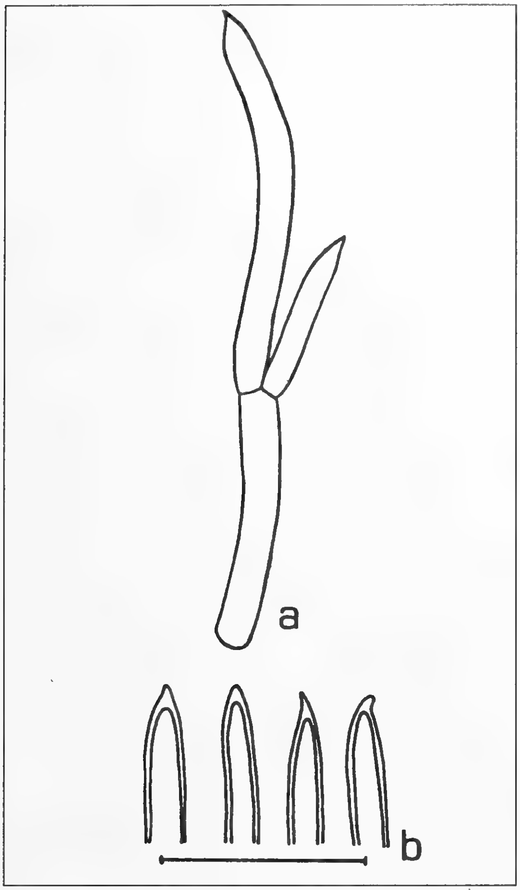

FIGURE 6. *Nitella* sp. a: typical branchlet; b: variation in branchlet apices, scale bar = 1000 μm.

of some *Chara* axes. A thorough search of all collections made from this site turned up no further *Nitella* specimens. The plant was entirely sterile, no gametangia were present. The thallus axis is very slender, only 215 μm in diameter and 20 cm in length with six branchlets per node. Dactyl apices are mostly acute or acute-apiculate as described and illustrated in Wood (1965) and Wood and Imahori (1964) (Figure 6b). From its once furcate branchlets, single-celled dactyls and acute dactyl apices, it most likely is *Nitella flexilis* or a closely related form. Dactyls are of unequal size as illustrated in Figure 6a.

Both monoecious *Nitella flexilis* and dioecious *N. opaca* are cosmopolitan species and among the most commonly collected Nitellas. Because members of the *N. flexilis* complex can flourish over an extremely broad range of environmental parameters (Olsen 1944; Langangen 1974), they should be frequently encountered throughout the area, especially so in the more oligotrophic northern lakes. Even though Wood (1965, 1967) treats these two as a single taxon, this approach may no longer be tenable and monoecious and dioecious taxa should be distinguished whenever possible (Sawa 1965; Proctor 1975, 1980). If the opportunity arises, this site should again be thoroughly sampled in an attempt to obtain additional material on which to base a more sound taxonomic judgement.

Other Charophytes Recorded From Saskatchewan

The following records of Saskatchewan charophytes are those for which specimens are known to exist or which are otherwise considered to be well documented. The information may be of use to others involved in charophyte studies or in more general aquatic studies where charophytes are only one of the components being investigated. If taxonomic identity of these or other collections not thoroughly described in the literature is critical, then it would be prudent for investigators to check the actual specimens, if possible, to verify original determinations.

Specimens housed in the Phycological Herbarium of the Canadian Museum of Nature, Ottawa are listed as CANA followed by accession number, collector, date of collection in brackets and approximate location. Scattered unreported specimens possibly also occur in prairie herbaria or larger collections such as (NY), (US) and others, especially specimens obtained since the early nineteen-sixties.

Chara canescens Desv. & Lois. in Lois. (= *C. evoluta* T.F. Allen. All CANA specimens are monoecious)
— CANA 5943, 5944 J. Macoun (1879) "Saskatchewan"
— CANA 5873, 5933 J. Macoun (1896) Park Beg, Saskatchewan
— CANA 29327 J. Hudson (1955) Mortlach, Saskatchewan
— citation in Hammer and Heseltine (1988) Wakaw Lake, Saskatchewan

Chara globularis var. *virgata* (Kütz.) R. D. Wood (= *C. delicatula* Agardh)
— citation in Wood (1965), J. Macoun (1879) "Ponds west of Saskatchewan"

Chara aspera Deth. ex Willd. [*C. globularis* var. *aspera* (Deth. ex Willd.) Wood]
— CANA 5951 J. Macoun (1879) "Saskatchewan"
— CANA 5926, 5929 J. Macoun and W. Herriot (1906) Henzel, W. of Yorkton, Saskatchewan
— CANA 5927, 5928 J. Macoun and W. Herriot (1906) French, W. of Saskatoon, Saskatchewan
— CANA 28830 G. Ledingham (1987) Hudson Bay, Saskatchewan

Chara aspera var. *macounii* Allen [*C. macounii* (Allen) Robinson, *C. globularis* var. *virgata* f. *macounii* (Allen) Wood]
— citation in Robinson (1906) and Wood (1965), J. Macoun (1879) Long Lake, Saskatchewan

Chara braunii Gm. (*C. coronata* Ziz. ex Bischoff)
— CANA 28837 G. Ledingham and B. Rever (1960) W. of Regina, Saskatchewan
— CANA 5937, 5938, 5952 J. Macoun (?) "Canada". No specific location given.

Chara buckellii G.O. Allen
— cited in Hammer and Heseltine (1988) Waldsea Lake, Saskatchewan

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The Flora of the Yukon Territory: Additions, Range Extensions and Comments

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Two taxa are reported as new to the Canadian flora, 56 native taxa and 42 introduced taxa are reported as new to the flora of the Yukon Territory, 5 taxa are deleted from the flora, 197 significant range extensions of native taxa within the Territory, and 23 significant range extensions of introduced taxa within the Territory are reported. Comments are presented on 5 taxa which might be found in the Territory in the future and comments are presented on 17 other native taxa.

Key Words: Vascular plants, Canada, Yukon Territory, flora, new records, range extensions, deletions.

In 1968 Eric Hultén published his excellent *Flora of Alaska and Neighboring Territories*, a followup of his earlier *Flora of Alaska and Yukon* (1941-1950). This volume contained keys and descriptions together with distribution maps for all the species known to him in the area covered, together with a second map depicting worldwide distribution.

Since 1968, a number of botanists have published papers in which new distributional records have been reported for various parts of the Yukon Territory. Porsild (1966), Murray (1971) and Douglas and Ruyle-Douglas (1978) presented new information for what is now Kluane National Park and adjacent regions; Scotter and Cody (1979) and Rosie (1991) presented range extensions in the southeast; Porsild (1975) produced an extensive publication on the flora of the Ogilvie Mountains adjacent to the Dempster Highway and in the vicinity of Mayo, based mainly on the collections of his brother Robert; and in the north papers on the flora have been published by Welsh and Rigby (1971), Wein et al. (1974), Nagy et al. (1979) and Cwynar (1983). Of these four northern publications, that of Welsh and Rigby was the most extensive. Welsh (1974) also published *Anderson's Flora of Alaska and adjacent parts of Canada*, but although this volume did include distributional information, there were no distribution maps for the individual species.

A flora uniquely of the Yukon Territory which contains keys and descriptions, illustrations of all species together with distribution maps of all species by the present author is now in press (Agriculture Canada Publication). In many instances the distribution maps in the above flora are vastly different from those of Hultén (1968) as the result of more recent collecting by the author, employees of the Yukon Department of Renewable Resources (particularly Catherine Kennedy and Valerie Loewen), Loney Dickson (Canadian Wildlife Service, Environment Canada), Susan Aiken (Canadian Museum of Nature) and such avid amateurs as Rhonda Rosie and Greg Brenner who have provided specimens, often from remote regions, for my study. The present work is designed to give the basis for the range extensions and new records found on the maps in the *Flora of the Yukon Territory*. Common names follow (Cody *in press)* where available but for other species none have been outlined.

In order to readily access the taxa treated in the body of this paper the following lists by status and by family are presented, the latter annotated. In a few instances taxa recorded as new have previously been reported as occuring in the Territory by such authors as Boivin (1966-67) and Welsh (1974) but without reference to any supporting specimens.

Synoptic list by Yukon Status

Taxa new to Canada: (2)

Oxytropis mertensiana
Poa pseudoabbreviata

Native taxa new to the Yukon Territory: (56)

Arabis columbiana
drepanoloba
eschscholtziana
exilis
holboellii var. *secunda*
lignifera
media
nuttallii
pinetorum
Artemisia globularia
richardsoniana
Aster laevis ssp. *geyeri*
Athyrium alpestre ssp. *americanum*
Betula pumila var. *glandulifera*
Botrychium ascendens
spathulatum
Calamagrostis deschampsioides
purpurascens var. *laricina*
Carex flava
marina
pachystachya

prairea
Ceratophyllum demersum
Cynoglossum boreale
Danthonia spicata
Elatine triandra
Eriogonum flavum var. *aquilinum*
Eriophorum gracile
Gentiana glauca f. *chlorantha*
Geum triflorum
Hippuris montana
Hordeum brachyantherum
Juncus nodosus
Lathyrus nootkatensis
Lonicera involucrata
Lysimachia thyrsiflora
Myosotis alpestris ssp. *asiatica*
Orthocarpus luteus
Parrya arctica
Platanthera stricta
Poa abbreviata
abbreviata ssp. *pattersonii*
arctica ssp. *caespitans*
cusickii
Potamogeton zosteriformis
Potentilla bipinnatifida
egedii
ovina
Puccinellia andersonii
phryganodes
Ruppia spiralis
Scirpus microcarpus
Scolochloa festucacea
Sium suave
Smelowskia borealis ssp. *jordalii*
Stipa nelsonii ssp. *dorei*

Introduced taxa new to the Yukon Territory: (42)
Agropyron sibiricum
Agrostis capillaris
Arabis glabra
Atriplex patula
Brassica rapa
Chrysanthemum ircutianum
leucanthemum
Clematis tangutica
Dianthus plumarius
Dracocephalum thymiflorum
Elymus repens
Euphorbia esula
Festuca trachyphylla
Gaillardia aristata
Galeopsis tetrahit
Gypsophila elegans
Lactuca biennis
Lepidium ramosissimum
Linaria vulgaris
Medicago falcata
sativa
Neslia paniculata
Onobrychis viciifolia
Pastinaca sativa
Phalaris canariensis
Polygonum buxiforme
Potentilla biennis
Secale cereale
Silene vulgaris
Sonchus arvensis ssp. *uliginosus*
asper
Spinacea oleracea
Stachys pilosa
Taraxacum erythrospermum
Thalictrum dasycarpum
venulosum
Urtica urens
Vaccaria hispanica
Veronica longifolia
Vicia angustifolia
cracca
villosa

Range extensions of native taxa within the Yukon Territory: (197)
Adoxa moschatellina
Agrostis exarata
Angelica lucida
Antennaria pulcherrima
Arabis kamtschatica
Arenaria capillaris
Armeria maritima ssp. *arctica*
Artemisia alaskana
campestris
Asplenium trichomanes-ramosum
Astragalus bodinii
eucosmus ssp. *eucosmus*
eucosmus ssp. *sealei*
nutzotinensis
Atriplex subspicata
Boschniakia rossica
Botrychium lunaria
Boykinia richardsonii
Calamagrostis stricta ssp. *inexpansa*
Caltha natans
Campanula rotundifolia
Cardamine purpurea
Carex arcta
atrofusca
aurea
bicolor
bonanzensis
buxbaumii
canescens
capitata
crawfordii
deflexa
diandra
eleusinoides
filifolia
foenea
franklinii
glacialis
glareosa
gynocrates
interior
lapponica
lasiocarpa ssp. *americana*
livida
loliacea
media
microglochin
microptera

peckii
rossii
rostrata
rotundata
sabulosa ssp. *leiophylla*
subspathacea
sychnocephala
ursina
williamsii
Castilleja miniata
raupii
Chenopodium capitatum
Cirsium foliosum
Claytonia ogilviensis
tuberosa
Coeloglossum viride ssp. *bracteatum*
Cornus unalaschkensis
Cryptogramma crispa var. *acrostichoides*
Cypripedium calceolus ssp. *parviflorum*
Delphinium brachycentrum
Dodecatheon pulchellum
Douglasia arctica
ochotensis
Draba cana
corymbosa
incerta
lactea
macounii
nivalis
porsildii
stenoloba
stenopetala
Dryas drummondii
hookeriana
Eleocharis acicularis
quinqueflora
Elymus alaskanus ssp. *alaskanus*
alaskanus ssp. *borealis*
alaskanus ssp. *hyperarcticus*
spicatus
Epilobium arcticum
Equisetum hyemale ssp. *affine*
pratense
Erigeron hyperboreus
hyssopifolius
peregrinus ssp. *callianthemus*
philadelphicus
purpuratus
uniflorus ssp. *eriocephalus*
yukonensis
Eriophorum viridi-carinatum
Galium boreale
triflorum
Gentiana algida
glauca
prostrata
Geum glaciale
Glyceria borealis
Goodyera repens
Halimolobus mollis
Helictotrichon hookeri
Hierochoe pauciflora
Honckenya peploides var. *diffusa*
Juncus castaneus ssp. *leucochlamys*
triglumis ssp. *albescens*
Koeleria asiatica
Lathyrus japonicus
Lepidium bourgeauanum
Lesquerella arctica ssp. *calderi*
Limosella aquatica
Linum lewisii
Listera borealis
cordata
Lomatogonium rotatum ssp. *tenuifolium*
Lycopodium alpinum
clavatum var. *monostachyon*
Mertensia maritima
paniculata var. *alaskana*
Minuartia rossii ssp. *rossii*
stricta
Montia bostockii
scammaniana
Myrica gale
Oxycoccus microcarpus
Oxytropis campestris ssp. *roaldii*
huddelsonii
scammaniana
Papaver mcconellii
Pedicularis lapponica
macrodonta
Petasites frigidus ssp. *arcticus*
Poa porsildii
Phalaris arundinacea
Phippsia algida
Plantago canescens
Podistera macounii
yukonensis
Polygonum caurianum
Potamogeton friesii
Potentilla bimundorum
gracilis
norvegica
pensylvanica
pulchella
Puccinellia arctica
deschampsioides
grandis
Pyrola asarifolia
Ranunculus aquatilis var. *eradicatus*
cymbalaria
sulphureus
turneri
Rorippa barbareifolia
Rumex acetosa ssp. *alpestris*
salicifolius ssp. *triangulivalvis*
Sagina nivalis
Salix arctophila
chamissonis
maccalliana
ovalifolia ssp. *ovalifolia*
ovalifolia var. *arctolitoralis*
rotundifolia ssp. *rotundifolia*
rotundifolia ssp. *dodgeana*
Saxifraga aizoides
bronchialis ssp. *codyana*
oppositifolia ssp. *smalliana*
razshivinii
rufopilosa
serpyllifolia
Scirpus caespitosus ssp. *austriacus*

rollandii
validus
Selaginella sibirica
Senecio kjellmanii
ogotorukensis
pauperculus
Sisyrinchium montanum
Smelowskia borealis ssp. *borealis*
Solidago canadensis var. *salebrosa*
Sparganium minimum
mullipedunculatum
Stellaria dicranoides
longifolia
umbellata
Synthris borealis
Tofieldia coccinea
Utricularia intermedia
Vahlodea atropurpurea ssp. *latifolia*
Veratrum viride ssp. *eschscholtzii*

Range extensions of introduced taxa within the Yukon Territory: (23)
Agrostis gigantea
Alopecurus pratensis
Avena sativa
Bromus inermis
Cerastium arvense
Chenopodium album
pratericola
rubrum
Crepis tectorum
Deschampsia elongata
Gnaphalium uliginosum
Hieracium umbellatum
Lolium perenne ssp. *multiflorum*
Matricaria matricarioides
perforata
Phleum pratense
Polygonum convolvulus
lapathifolium
Ranunculus repens
Rumex longifolius
Spergularia rubra
Taraxacum officinale
Thlaspi arvense

Taxa deleted from the Yukon Territory flora because of misidentifications or questionable locality data: (5)
Carex lenticularis var. *lipocarpa*
lyngbyei
Epilobium leptophyllum
Juncus tenuis
Tsuga heterophylla

Comments on additional native taxa in the Yukon Territory: (17)
Cardamine microphylla
Carex chordorrhiza
circinata
spectabilis
Cassiope mertensiana
Chrysosplenium wrightii
Comandra umbellata ssp. *pallida*
Hipopitys monotropa
Maianthemum canadense ssp. *interius*
dilatatum
Menziesia ferruginea
Nymphaea tetragona ssp. *leibergii*
Oxytropis viscida
Poa arctica "proliferate form"
Ranunculus sabinei
Salix fuscescens
Zizea aptera

Annotated List by Family

LYCOPODIACEAE

Lycopodium alpinum L., Alpine Clubmoss — YUKON: Richardson Mts., turfy bank on N side of Dempster Hwy. Km 465, 67°02'N 136°13'W, *Cody & Ginns 30096*, 4 July 1982 (DAO)[1]; Richardson Mts., in turf on rocky slope, 64°44.5'N 137°28'W, *Cody & Ginns 32094*, 15 July 1982 (DAO).

These collections which are the first for the Richardson Mountains extend the known range some 275 km to the northeast from a site in the Ogilvie Mountains.

Lycopodium clavatum L. var. *monostachyon* Hook. & Grev. (*L. lagopus* (Laestadius ex C. Hartman) G. Zinserling ex Kuzeneva-Prochorva), Common Clubmoss — YUKON: steep hummocky slope below ridge top, Richardson Mts., 65°55'N 135°46'W, *Cody & Ginns 30184*, 5 July 1982 (DAO); along shore of lake, [Barn Mts.], Hanging Lake, 68°23'N 138°23'W, *L.C. Cwynar 1399*, 21 July 1977 (DAO).

These collections extend the known range northward into northern Yukon some 450 km from sites along the southern Dempster Highway.

SELAGINELLACEAE

Selaginella sibirica (Milde) Hieron., Spikemoss — YUKON: rocky slope, Richardson Mts., 66°26.5'N 135°48'W, *Cody & Ginns 30778*, 8 July 1982 (DAO); lower turfy rocky slopes, Richardson Mts., 66°25'N 135°58'W, *Cody & Ginns 30566*, 7 July 1982 (DAO); flat tableland of shattered stone, 66°16'N 135°48'W, *Cody & Ginns 30374*, 6 July 1982 (DAO); tundra turf on ridge, Richardson Mts., 66°07.5'N 136°07'W, *Cody & Ginns 30027*, 4 July 1982 (DAO); west-facing limestone outcrop in alpine tundra, Southern Richardson Mts., 66°04'N 135°50'W, *L.C. Cwynar 1174*, 6 July 1977 (DAO); dry site on lower mid-slope of mountain, Bonnet Plume River, 64°56'N 133°50'W, *C.E. Kennedy 92B-70*, 16 August 1992 (DAO).

Hultén (1968) knew this species from western and northern Yukon Territory. Porsild (1975) extended the known range in the central part to the vicinity of the Dempster Highway and Mount Haldane. The collections cited here extend the known range into

[1]Herbarium acronym (Holmgren et al. 1990)

the southern Richardson Mountains and the northern Wernecke Mountains.

EQUISETACEAE
Equisetum hymale L. ssp. *affine* (Engelm.) Stone, Scouring-rush — YUKON: Lunch stop bar, Bell River, 67°18.7'N 137°07'W, *J.V. Matthews*, 28 July 1980 (DAO).

Previously known in the Yukon Territory only as far north as the Yukon River northwest of Dawson, some 350 km southwest of the Bell River site.

Equisetum pratense L., Meadow Horsetail — YUKON: Richardson Mts., 67°16'N 136°30'W, *Cody & Ginns 31102*, 9 July 1982 (DAO); foothill slopes associated with white spruce-willow - *Calamagrostis*, Bell River, 67°27'N 137°14'W, *Wein et al. 229a*, 21 June 1972 (DAO); in deep moss in white spruce woods on flood plain of river, Bell River, 67°53'N 136°53'W, *Cody & Ginns 32157*, 15 July 1982 (DAO); river terrace associated with white spruce-alder, Richardson Mts., 67°20'N 136°45'W, *Wein et al. 248f*, 8 July 1972 (DAO); Old Crow River near mouth of Johnson Creek, *Youngman & Tessier 635*, 12 July 1964 (CAN); white spruce stand, Dog Creek, 68°23'N 138°46'W, *L.C. Cwynar 1467*, 25 July 1977 (DAO).

These collections help complete the known distribution in northern Yukon Territory and are disjunct from collections along the Yukon River and southern Dempster Highway. This species however is known in northeastern Alaska from north of the Brooks Range (Hultén 1968).

OPHIOGLOSSACEAE
Botrychium ascendens W.H. Wagner — YUKON: Dawson, *Porsild 2040* (CAN).

This collection, which was growing with *B. lunaria* and is the only one known for this species in the Yukon Territory, was cited as a paratype by Wagner and Wagner (1986). It should be added to the list of rare species for the Territory (Douglas et al. 1981).

Botrychium lunaria (L.) Sw., Moonwort — YUKON: Blue Bluff, 67°38.1'N 138°41.6'W, *J.V. Matthews*, 2 August 1981 (DAO); willow dominated gravel bar, Babbage River, 68°47'N 138°38'W, *S.G. Aiken 90-077*, 14 July 1990 (CAN).

Hultén (1968) knew this taxon in the northern Yukon Territory from a single collection in the central Richardson Mountains. The specimens cited here extend the known range into Ivavvik National Park a distance of some 125 km.

Botrychium spathulatum W.H. Wagner — YUKON: Mile 95, Canol Road, Upper Rose River Valley, *Porsild & Breitung 10428* (CAN).

This specimen which is the only one known for this species in the Yukon Territory, was cited as a paratype by Wagner and Wagner (1990). It should be added to the list of rare species for the Territory (Douglas et al. 1981).

PTERIDACEAE
Cryptogramma crispa (L.) R.Br. var. *acrostichoides* (R.Br.) C.B. Clarke, American Parsley Fern — YUKON: Alaska Hwy. 88 miles east of Teslin, 60°10'N 130°30'W, *C.H.D. Clark 361*, 19 August1943 (CAN); on rocky talus slope, Itsi Range near Yukon-Mackenzie border, 62°57'N 130°09'W, *Calder & Kukkonen 27685A*, 31 July-2 August 1960 (DAO); along alpine stream bank, ca 2 km W of Bates Lake (southwest end), 60°10'N 137°42'W, *G.W. & G.G. Douglas 9273*, 20 August 1975 (DAO); in *Arctostaphylos uva-ursi* stand, ca. 2 km W of Bates Lake (south end) 60°12'N 137°43'W, *H.L. & I.J. Weaver 753*, 20 August 1975 (DAO).

Previously known in the Yukon Territory from the south and east slopes of Mount Sheldon adjacent to the Canol Road (Porsild 1951).

ASPIDIACEAE
Athyrium alpestre (Hoppe) Rylands ssp. *americanum* (Butters) Lellinger (*A. distentifolium* Tausch. ssp. *americanum* (Butters) Hultén) — YUKON: occasional on open rocky slopes above lake from 5000 ft. upwards, unnamed lake in Itsi Range near Yukon-Mackenzie border, 62°57'N 130°09'W, *Calder & Kukkonen 27681*, 31 July - 2 August 1960 (DAO).

This collection represents a northeastern extension of the known range from the northern part of the Alaskan Panhandle. This species is new to the flora of the Yukon Territory and should be added to the list of rare vascular plants for that territory (Douglas et al. 1981). The collection reported here was mapped without comment by Cody and Britton (1989).

ASPLENIACEAE
Asplenium trichomanes-rámosum L. (*A. viride* Hudson), Green Spleenwort —YUKON: Ogilvie Mts., tundra turf on mountain top and slopes, SW of Mt. Gibben, 64°39'N 139°23'W, alt. 4750 ft., *Cody & Ginns 33638B*, 6 July 1984.

The only other known collection from the Yukon Territory was also gathered in the Ogilvie Mountains 10 miles from the Alaska border by *E. & J. Lohbrunner* on 16 July 1936 (Porsild 1951; Douglas et al. 1981).

PINACEAE
Tsuga heterophylla (Raf.) Sarg., Western Hemlock — YUKON: White Horse Rapids, *A.L. Bolton*, 1898 (US).

This specimen was cited and mapped by Hultén (1941) in *Flora of Alaska and Yukon* but was omitted without comment in *Flora of Alaska and Neighboring Territories* (Hultén 1968), and there is no mention in Anderson's *Flora of Alaska and Adjacent Parts of Canada* (Welsh 1974) of its occurrence in southern Yukon Territory. Hultén (1940) stated that Bolton visited White Pass, Summit and Middle lakes, Dominion Creek, and Fifty Mile River in 1899, but it is questionable that a suitable habitat for *T. heterophila* could be found in that area, and it is possible that the specimen was actually picked up en route through the Alaska Panhandle either before or after his sojurn in the Yukon.

SPARGANIACEAE

Sparganium minimum (Hartzm.) Fries — YUKON: dry sedge zone of fen, Big Salmon River, 61°53'N 134°55'W, *C.A. McEwen 5502*, 2 July 1982 (DAO); shallow basin marsh, Yukon River basin, 62°08'N 133°00'W, *C.A. McEwen 5063*, 4 August 1982 (DAO).

Previously known in the Yukon Territory from two collections from the Dawson area reported by Hultén (1941) and considered rare by Douglas et al. (1981).

Sparganium multipedunculatum (Morong) Rydb., Bur-reed — YUKON: lake edge, Porcupine River at 140°35'W, east of Rampart House, *J.E.H. Martin 102*, 26 July 1951 (DAO).

This collection represents an extension of the known range of some 300 km northward from a site on the Dempster Highway (Porsild 1975).

POTAMOGETONACEAE

Potamogeton friesii Rupr., Pondweed — YUKON: Shaeffer Lake, 66°44'N 138°02'W, *C. Kennedy Sc-1*, 22 July 1975 (DAO).

Hultén (1968) knew this species in the Yukon Territory from only two localities in the extreme south. Porsild (1975) extended the known range north to the Stewart Plateau and the southern Dempster Highway. The specimen cited here extends the known range northward another 225 km to a site adjacent to the Arctic Circle. Additional specimens from sites between those recorded by Hultén (1968) and Porsild (1975) are preserved at CAN and DAO.

Potamogeton zosteriformis Fern. — YUKON: open water of wetland, 60°39'N 136°40'W, *J. Majiski*, Northern biomes #5011, 15 August 1984 (DAO); ponds south of McQuesten Lake, 64°04'N 135°23'W, *V. Loewen 24*, 5 August 1988 (DAO).

The map in Hultén (1968) *sub P. zosterifolius* Schum. ssp. *zosteriformis* (Fern.) Hultén shows a locality at about 63°N latitude in Alaska adjacent to the Alaska-Yukon border, and Welsh (1974) suggested that the species should be sought in southern Yukon. New to the flora of the Yukon Territory.

Ruppia spiralis L. (*R. maritima* L. ssp. *spiralis* (L.) Aschers.), Ditch-grass — YUKON: Neddlerock Creek, 62°45'N 135°45'W, *C. Kennedy 05*, 10 July 1985 (DAO).

The specimen cited above is immature and is placed under *spiralis* only tentatively. This is the only modern record of a *Ruppia* species in the Yukon Territory. John Matthews, Geological Survey of Canada (personal communication) has collected fossil seeds of a *Ruppia* species in the Old Crow Basin, Porsild and Cody (1980) have reported *R. spiralis* from Nahanni National Park in southwestern District of Mackenzie and Heglund (*in press*) has found it in the Yukon Flats region of east-central Alaska.

GRAMINEAE

Agropyron sibiricum (Willd.) P.B. — YUKON: very dry level clay ground, south end of runway at RCAF station, Whitehorse, *Gillett & Mitchell 3920*, 21 July 1949 (DAO); waste area, Carmacks, 62°05'N 136°17.5'W, *W.J. Cody 26466*, 28 June 1980 (DAO).

Bowden (1965) reported the presence of this species in the Yukon on the basis of the Whitehorse collection, but the reference has been overlooked by later authors. The species is native in southcentral former USSR and has been introduced in scattered localities in Canada and the western United States.

Agrostis capillaris L. (*A. tenuis* Sibth.), Colonial Bent Grass — YUKON: path to tower, Nisutlin Delta, 60°15'N 132°30'W, *C. Kennedy N-7* (DAO).

This grass, introduced from Europe, is found in North America mainly in the moister areas of the Maritime Provinces and British Columbia. New to the Yukon Territory. It should be looked for elsewhere in moist situations along roadsides and in waste areas.

Agrostis exarata Trin., Spike Redtop — YUKON: Hotsprings meadow, McArthur/Ethel Lake area, 63°04'N 135°42'W, *C. Kennedy 698, 705, 753*, 8 August 1987 (DAO).

These collections represent an extension of the known range in the Yukon Territory of some 500 km northwest of mineral spring sites east of Watson Lake and some 250 km north of sites near the Alaskan coast.

Agrostis gigantea Roth, Creeping Bent Grass — YUKON: gravel of dock area, Carmacks, 62°05'N 136°17.5'W, *W.J. Cody 26301*, 26 June 1980 (DAO).

Previously known in the Yukon Territory only from Dawson where it was collected by *M.O. Malte s.n.* on 12 August 1916 (DAO); a European introduction.

Alopecurus pratensis L., Meadow Foxtail — YUKON: north of junction of Anvil Road and Aex Road, Faro, *V. Hodgson 887*, 1 July 1983 (DAO); disturbed gravel at beach, Kathleen Lake, 60°35'N 137°15'W, *Cody & Ginns 28368*, 26 July 1980 (DAO).

An introduced species previously known in the Yukon Territory only from Dawson.

Avena sativa L., Oats — YUKON: along roadside, about 1 mile north of Mayo, 63°36'N 135°53'W, *Calder & Gillett 4089*, 1 August 1949 (DAO).

A cultivated escape previously known in the Yukon Territory from Sheldon Lake on the Canol Road (Porsild 1951).

Bromus inermis Leyss., Smooth Brome — YUKON: disturbed sites in the Eagle Plains [66°16'N 137°00'W], *T.D.W. James 10*, 1979 (DAO).

An introduced species previously known only as far north as Mayo and Dawson (Hultén 1968).

Calamagrostis deschampsioides Trin. — YUKON: saturated flats with standing water with dominants *Dupontia fisheri*, *Salix* & *Castilleja*, SW shore of outer delta, Phillips Bay, Beaufort Sea, 69°13'N 138°27'W, *Dickson & Allen 5355A, 5367*, 28 July 1982 (DAO); on tidal flats, Phillips Bay 69°13'N 138°21'W, *H.L. Dickson 6067*, 16 August 1983 (DAO); on moist 80% vegetated tidal flats, Kay Point, NE Phillips Bay, 69°18'N 138°22'W, *H.L. Dickson 6081*, 16 August 1983 (DAO); saturated wet sedge meadow, East Phillips Bay, 69°15'N 138°23'W, *H.L. Dickson 6073*, 16 August 1983 (DAO); on tidal mud flats, Kay Point area, E. side of Phillips Bay, 69°16'N 138°24'W, *H.L. Dickson 6040*, 16 August 1983 (DAO).

New to the Yukon Territory but known along the Arctic Coast to the east in the District of Mackenzie and to the west in Alaska; the species should be added to the list of rare plants of the Yukon Territory (Douglas et al. 1981).

Calamagrostis purpurascens R.Br. var. *laricina* Louis-Marie, Purple Reedgrass — YUKON: on gravelly blowout area, 8 mi. WSW of Haines Junction, Kluane National Park, *G.W. & G.G. Douglas 6704*, 1 August 1973 (DAO); on open dryish sandy soil in meadow, Dezadeash River Valley, St. Elias Mountains, *A.M. Pearson 67-258*, 12 July 1967 (CAN).

This variety occurs sporadically throughout much of the range of *C. purpurascens* var. *purpurascens*; it has not been recorded previously from the Yukon Territory although Greene (1980) included it in his unpublished thesis.

Calamagrostis stricta (Timm) Koeler ssp. *inexpansa* (Gray) C.W. Greene (*C. inexpansa* Gray), Northern Reedgrass — YUKON: 4 miles W of Lapierre House, *Youngman & Tessier 514*, 6 August 1964 (CAN).

This taxon is not otherwise known in the Yukon Territory from north of about latitude 64°30'N, it does however occur north of Lapierre House in both Alaska and the District of Mackenzie (Hultén 1968).

Danthonia spicata (L.) Beauv., Poverty Oat Grass — YUKON: Hot springs near the Beaver River, 60°23'N 125°34'W, *G.W. Scotter 24770*, 22 July 1977.

New to the Yukon Territory. Previously reported by Scotter and Cody (1979) as *D. intermedia*, a species which is of scattered occurence north to about latitude 63°N in the Yukon Territory. It should be added to the list of rare plants of the Yukon Territory.

Deschampsia elongata (Hook.) Munro, Slender Hairgrass — YUKON: marshy ground, Dawson, *F. Congdon*, 1904 (DAO).

Hultén (1968) mapped only one site near Whitehorse. The species has not been collected in recent years; native in western North America but introduced in the Yukon Territory.

Elymus alaskanus (Scribn. & Merr.) Á. Löve ssp. *alaskanus* (*Agropyron boreale* (Turcz.) Drobov ssp. *alaskanum* (Scribn. & Merr.) Melderis) — YUKON: ground squirrel burrow, Richardson Mts., 68°12'N 136°35'W, *Cody & Ginns 31361*, 11 July 1982 (DAO); rocky shore, Rampart House on Edmund's Island, *C.C. Loan 615*, 17 July 1951 (DAO).

Not previously recorded from northern Yukon Territory.

Elymus alaskanus (Scribn. & Merr.) Á. Löve ssp. *borealis* (Turcz.) Á. & D. Löve (*Agropyron boreale* (Turcz.) Drobov ssp. *boreale*) — YUKON: riverbank, McNeish Site, 69°21'N 139°30'W, *L.C. Cwynar 376*, 21 July 1975 (DAO); in sand among washed stones of braided stream bed, tributary of Firth R., British Mts., *W.J. Cody 27159*, 7 July 1980 (DAO).

Not previously recorded from northern Yukon Territory.

Elymus alaskanus (Scribn. & Merr.) Á. Löve ssp. *hyperarcticus* (Polunin) Á. & D. Löve — YUKON: in fine silt of gravel bar, Malcolm River, 69°31'N 138°50'W, *S.G. Aiken 88-290*, 13 July 1988 (CAN).

Not previously recorded from northern Yukon Territory.

Elymus repens (L.) Gould (*Elytrigia repens* (L.) Nevski, *Agropyron repens* (L.) Beauv.), Quack Grass — YUKON: roadside Mayo, 63°36'N 135°53'W, *Gillett & Calder 4245*, 2 August 1949 (DAO); Dawson, *J.A. Calder 4340*, 11 August 1949 (DAO). Cabin clearing in *Populus* ssp. - *Picea glauca* woodland, Ditch Road E off Dempster Hwy. Km 8, 64°02'N 138°36'W, *W.J. Cody 28011*, 18 July 1980 (DAO).

Introduced, not previously recorded from the Yukon Territory; a cosmopolitan weed.

Elymus spicatus (Pursh) Gould (*Agropyron spicatum* (Pursh) Scribn. & Smith) —YUKON: isolated clump on dry south-facing slope beside Sheep Creek, British Mountains, 69°10'N 140°05'W, *Aiken & Consaul 90-038*, 8 July 1990 (CAN).

This collection represents an extension of the known range in the Yukon Territory of some 600 km north from the vicinity of Dawson.

Festuca trachyphylla (Hackel) Krajina, Hard Fescue — YUKON: common along roadsides, Dawson, *Calder & Billard 3547*, 7 July 1949 (DAO).

This specimen was mapped by Aiken and Darbyshire (1990) but the basis for this single occurrence in the Yukon was not cited; introduced from Europe.

Glyceria borealis (Nash) Batchelder, Northern Manna Grass — YUKON: Nisutlin River Delta, Teslin Lake, 60°15'N 132°35'W, *Ereaux & Lortie 21-1*, 1 September 1983 (DAO); vegetated sand bar of river, 61°21'N 133°17'W, *C.A. McEwen 2511*, 24 July 1982 (DAO); emergent, Big Salmon River, 61°41'N 134°31'W, *C.A. McEwen 2505*, 4 July 1982 (DAO); shallow basin marsh, 62°08'N 133°W, *C.A. McEwen 2016*, 4 August 1982 (DAO).

This species was considered rare in the Yukon Territory by Douglas et al. (1981) but has doubtless been overlooked because of its wet habitat requirements; it was previously known only from Dawson, Keno Hill and the Little Atlin Lake area.

Helictotrichon hookeri (Scribn.) Henrard (*Avena hookeri* Scribn.; *Avenochloa hookeri* (Scribn.) Holub) — YUKON: Daughney Lakes, Pine Lake Airstrip, 68°08'N 131°02'W, *R. Johansen 81*, 1989, (DAO); SW-facing grassy slope, Aishihik Lake, *M.A. Sauchyn 349*, 28 July 1981 (DAO, WAT); adjacent to wet meadow, 7 miles SW of Whitehorse on Fish Lake road, 60°42'N 135°14'W, *J. Nathan 31*, 16 July 1988 (DAO); dry sandy gravelly grass covered bench, Hutchi Lake, 61°10'N 136°35'W, *R. Florkiewicz 136*, 4 August 1987 (DAO); top of grassy hillside, South Lake, 61°05'N 136°35'W, *R. Florkiewicz 105*, 15 July 1987 (DAO); flat meadow-dry sand and gravel bench, along old Dalton trail, Hutchi Lake, 61°13'N 136°25'W, *R. Florkiewicz 135*, 12 August 1987 (DAO); *Artemisia* area, Minto, 62°36'N 136°49'W, *J.V. Matthews*, 20 August 1974 (DAO); common on open grassy flats in prairie opening in dry spruce forest, Mile 147 from Alaska Highway on road to Dawson, 62°35'N 136°49'W, near Minto, *Calder & Kukkonen 28077*, 10 August 1960 (DAO); occasional on steep, open, west-facing slope at 2400 ft., Tantalus Butte at Carmacks, 62°07'N 136°16'W, *Calder & Kukkonen 27987*, 9 August 1960 (DAO).

Previously known from a single locality in the Yukon Territory from gravel flats near the mouth of Duke River, 61°24'N 139°07'W (CAN, photo DAO, Douglas et al. 1981); same locality, *Anderson & Brown 10068* (S, photo DAO); same locality, *Raup et al. 13893*, (CAN, photo DAO).

Hierochloe pauciflora R.Br., Arctic Holy Grass — YUKON: near lake on higher dry ridges with *Festuca brachyphylla*, East of Stokes Point Lagoon, 69°20'N 138°44'W, *H.L. Dickson 5885*, 10 August 1983 (DAO).

Previously known from the Yukon Territory only from Clarence Lagoon (Douglas et al. 1981).

Hordeum brachyantherum Nevski (*H. jubatum* L. ssp. *breviaristatum* Bowden) —YUKON: beach, Carcross, 60°10'N 134°44'W, *J.M. Gillett 3800*, 14 July 1949 (DAO).

Hultén (1942) cited and mapped this species from two localities in the Yukon Territory, Dawson (where he considered it introduced) and Bennett. He did not map the latter collection in 1968, possibly because the town of Bennett is in northern British Columbia at the south end of Bennett Lake. Carcross is undoubtedly at the northern limit of the natural range and the species should be added to the list of rare species of the Yukon Territory (Douglas et al. 1981).

Koeleria asiatica Domin — YUKON: Richardson Mts., windswept turfy tundra 66°55'N 136°08'W, *Cody & Ginns 30988*, 8 July 1982 (DAO); Richardson Mts., alpine tundra on saddle, 67°42'N 136°50'W, *Cody & Ginns 29937*, 3 July 1982 (DAO); Richardson Mts., on ground squirrel burrow, 68°12'N 136°35'N, 11 July 1982, *Cody & Ginns 31356* (DAO); moist turfy alpine slope, same locality and date, *Cody & Ginns 31374* (DAO); *Dryas*, dwarf shrub/forb slope, Richardson Mts., 68°12'45"N 137°29'30"W, *Lowen & Staniforth 92-073*, 7 July 1992 (DAO); *Dryas*, dwarf shrub/forb ridge, Richardson Mts., 68°16'53"N 137°02'15"W, *Lowen & Staniforth 92-095B*, 7 July 1992 (DAO); *Dryas*, dwarf shrub tundra, Richardson Mts., 68°21'47"N 137°21'43"W, *Lowen & Staniforth 92-091*, 10 July 1992.

Douglas et al. (1981) knew this species in the Yukon Territory only from the Aishihik Lake and Minto areas. Cody and Porsild (1968) extended the known Arctic range eastwards from northern Alaska to the Richardson Mountains in northwestern District of Mackenzie. The specimens cited above now establish the presence of *K. asiatica* in northern Yukon Territory.

Lolium perenne L. ssp. *multiflorum* (Lam.) Husnot, Italian Rye Grass — YUKON: gravel creek bank, Irons Creek, Alaska Hwy. km 955.2, 60°00'N 127°52'W, *W.J. Cody 32258*, 5 July 1983 (DAO); south facing slope, Pelly River Ranch, 62°50'N 137°12'40"W, *M. Willoughby 45*, 1989 (DAO).

Hultén (1942) sub. *L. multiflorum* reported that this weed was collected at West Dawson on 18 August 1902 by Macoun. It has not since been found in the Dawson area. The Iron's Creek specimen cited above represents a recent introduction perhaps related to erosion control along the highway right-of-way.

Phalaris arundinacea L., Reed Canary Grass — YUKON: damp sunny area, North of Little Braeburn

Lake, Km 285 Klondike Hwy., 61°32'N 135°49'W, *V. Hodgson 1069*, 26 June 1984 (DAO); disturbed sites in the Eagle Plains [66°16'N 137°00'W], *T.D.W. James 9*, 1979 (DAO).

This species was considered rare in the Yukon Territory by Douglas et al. (1981) who knew it from the vicinity of Whitehorse, Albert Creek west of Watson Lake and the Coal River Springs. The Braeburn Lake site is about 100 km northwest of Whitehorse where it may be native, but it is undoubtedly introduced at the Eagle Plains site.

Phalaris canariensis L., Canary Grass — YUKON: Pelly Farm, Ft. Selkirk, *H. Bostock 288*, 1949 (CAN, photo DAO).

Reported by Boivin (1966-67) as occurring in the Yukon Territory but no locality was given. It was not mapped by Hultén (1968).

Phippsia algida (Sol.) R.Br. — YUKON: grassy slope, Buckland Hills, 69°19'N 139°35'W, *S.G. Aiken 88-252*, 13 July 1988 (CAN); moist clay of gravel bar, Shingle Point, 68°58'N 137°16'W, *S.G. Aiken 88-211*, 12 July 1988 (CAN); tundra on south-facing slope, Herschel Island, 69°37'N 139°05'W, *S.G. Aiken 88-096*, 6 July 1988 (CAN).

Considered rare in the Yukon Territory by Douglas et al. (1981) on the basis of collections from Kluane National Park and Mile 58 Dempster Highway; not previously recorded from northern Yukon.

Phleum pratense L., Timothy — YUKON: disturbed sites in Eagle Plains [66°16'N 137°00'W], *T.W.D. James 7*, 1979 (DAO).

An introduced species previously known only as far north as Dawson (Hultén 1968).

Poa abbreviata R.Br. ssp. *abbreviata* — YUKON: shattered limestone on mountain top, Ogilvie Mountains, 12 miles NNW of Mt. Harper, 64°44'N 140°14'W, *Cody & Ginns 34389*, 13 July 1984 (DAO); common on open, sparsely vegetated limestone slopes below summit, Mt. Sedgewick, British Mts., 68°53'N 139°06'W, *J.A. Calder 34462*, 19 July 1962 (DAO); Richardson Mts., Summit Lake area, 67°59'N 136°18'W, *Loewen & Gould 91-238a*, 13 July 1991 (DAO); Richardson Mts., Summit Lake area 67°59'N 136°29'W, *Loewen & Gould 91-223*, 14 July 1991 (DAO).

Welsh (1974) in his flora reported this species from northern Yukon Territory but not in his earlier work on that region (Welsh and Rigby 1971); it should be added to the list of rare plants (Douglas et al. 1981).

Poa abbreviata R.Br. ssp. *pattersonii* (Vasey) Á. Löve, D. Löve & Kapoor (*P. jordalii* Porsild) — YUKON: Kluane National Park: alpine communities, Mt. Maxwell, 60°45'N 138°34'W, *G.W. Scotter 21277*, 4 August 1972 (DAO); Sheep Mtn., southwest plateau, above Kluane Lake, 61°00'N 138°34'W, *Krajina & Hoefs s.n.*, 18 July 1970 (DAO); E-facing alpine slope, above Alsek R. at Marble Cr., 60°27.5'N 137°54'W, *Cody & Ginns 28559*, 28 July 1980 (DAO); alpine slope, Kluane Range, Mt. Desolei E of Kimberly Cr., 60°50'N 137°57'W, *Cody & Ginns 28736*, 30 July 1980 (DAO); E-facing alpine slope, Kluane National Park above Alsek R. at Marble Cr., 60°27.5'N 137°54'W, *Cody & Ginns 28559*, 28 July 1980 (DAO).

Soreng (1991) reported this taxon as new to the Yukon Territory on the basis of a collection from Kluane National Park; it should be added to the list of rare plants of the Yukon Territory (Douglas et al. 1981).

Poa arctica R.Br. "proliferate form" — YUKON: broken stone of stream bed, Bell River, Richardson Mts. 68°07'N 137°06'W, *Cody & Ginns 31965*, 14 July 1982 (DAO); alpine tundra turf on saddle and adjacent slope below, Ogilvie and Wernecke Mts., Cloudy Range, 64°35'N 138°27'W, *Cody & Ginns 33044*, 2 July 1984 (DAO); shore grass, Herschel Island, 69°35'N 138°55'W, *C. Kennedy 896*, 10 August 1985 (DAO); old creek runoff channel on disturbed slope, Stokes Point, 69°20'N 138°44'W, *H.L. Dickson 5979*, 14 August 1983 (DAO); Richardson Mts., Summit Lake area, 67°46'N 136°31'W, *Loewen & Gould 91-105*, 11 August 1991 (DAO).

Hultén (1968) stated "Plants with viviparous spikelets occur" but Porsild in Porsild and Cody (1980) stated that "var. *vivipara* Hook. is strictly eastern Arctic". The specimens cited here have most spikelets with very obvious proliferation.

Poa arctica R.Br. ssp. *caespitans* (Simmons) Nannf., Arctic Blue Grass —YUKON: turf and braided cobble of river bed, British Mountains, Malcolm River valley, 69°18'N 140°18'W, *W.J. Cody 27522A*, 10 July 1980 (DAO); turfy broken rocky dome, British Mountains, 10 km E of Firth River, 68°49'N 140°14'W, *W.J. Cody 27358*, 9 July 1980 (DAO); dry open exposed gravel ridge overlooking delta, Lower Blow River Delta, 69°55'N 137°10'W, *Dickson & Allen 5325* (DAO); Hanging Lake, 68°23'N 138°23'W, *L.C. Cwynar 1338, 1355A, 1423*, July 1977 (DAO); pocket on steep stony mountain slope, Richardson Mts., S end of Skull Range, 68°28'N 137°27'W, *Cody & Ginns 31634*, 12 July 1982 (DAO); steep striped stony slope, Richardson Mts., N side of Dempster Hwy. Km 465, 67°02'N 136°13'W, *Cody & Ginns 30144*, 4 July 1982 (DAO); turfy rocky slope Richardson Mts., 66°02.5'N 135°32'W, *Cody & Ginns 30447*, 6 July 1982 (DAO); on broken stone, scrub alpine zone, Dempster Hwy., Km 75.5, N of Tombstone Mtn., 64°32'N 138°14'W, *W.J. Cody 26549*, 1 July 1980 (DAO); tundra turf on saddle and adjacent broken rocky and turfy slope, Mt. Gladman, 64°43'N 140°49'W, *Cody & Ginns 35194*, 19 July 1984 (DAO); alpine, Kluane Range, Mt. Desolei E of Kimberley Cr., 60°50'N 137°57'W, *Cody & Ginns 28738*, 30 July 1980 (DAO).

This is a circumpolar subspecies with many gaps which has not previously been recorded from the Yukon Territory.

Poa cusickii Vasey — YUKON: dry sandy gravelly hillside, Stony Creek/37 Mile Lake Road, 60°54'N 135°41'W, *R. Florkiewicz 22*, 22 May 1987 (DAO); sheltered south slope, Stony Creek, 60°50'N 135°50'W, *R. Florkiewicz 10*, 25 June 1988 (DAO); open dry south slope, Stony Creek, 60°50'N 135°50'W, *R. Florkiewicz 71*, 1 June 1988 (DAO).

Douglas et al. (1981) considered this taxon to be an introduction on the basis of a collection from adjacent to the Alaska Highway near Bear Creek. The specimens cited above support the possibility that it is native in this region of the Yukon Territory and disjunct from Lake Athabasca in northwestern Alberta (Packer 1983).

Poa porsildii Gjaerevoll — YUKON: moist tundra slopes, mountain above Fish Creek, 64°18'N 138°00', *Cody & Ginns 33147, 33157*, 4 July 1984 (DAO); tundra turf, E of Hamilton Creek, 64°19'N 137°34'W, *Cody & Ginns 34625*, 14 July 1984 (DAO); turfy rocky tundra slope, Cloudy Range east of the Canadian River, 64°27'N 138°54'W, *Cody & Ginns 33477*, 6 July 1984 (DAO); hummocky tundra, Dempster Hwy. Km 85, 64°36'N 138°18'W, *W.J. Cody 26610*, 1 July 1980 (DAO); tundra turf and gravel on saddle and adjacent slopes, 10 miles SW of Mt. Gibben, 64°37'N 139°28'W, *Cody & Ginns 33664*, 6 July 1984 (DAO); turfy tundra on mountain top and slopes, 16 mi. SW of Chapman Lake, 64°40'N 138°28'W, *Cody & Ginns 33369, 33385*, 5 July 1984 (DAO); dry patchy tundra turf and rocky slope, 16 miles SW of Two Beaver Lake, 64°33'N 137°42'W, *Cody & Ginns 33216*, 4 July 1984 (DAO); alpine tundra turf on saddle and adjacent slopes, SE flank of Mt. Gibben, 64°41'N 139°11'W, *Cody & Ginns 33613*, 6 July 1984 (DAO); moist tundra turf in saddle between mountains, 1 mile N of Seela Pass, 64°43'N 138°54'W, *Cody & Ginns 33345*, 5 July 1984 (DAO); wet turf on mountain saddle, 10 miles E of Blackstone Lake, 65°10'N 137°28'W, *Cody & Ginns 34398*, 14 July 1984 (DAO); turfy tundra, 8 miles W of Two Beaver Lake, *Cody & Ginns 33270a, 33275*, 4 July 1984 (DAO); tundra turf and adjacent limestone rocky slopes on mountain top, 20 mi. W of Chapman Lake, 64°53'N 138°58'W, *Cody & Ginns 34015*, 8 July 1984 (DAO); seepage channel down turfy tundra slope, Mt. Patterson, 64°04'N 134°38'W, *Cody & Ginns 33061*, 3 July 1984 (DAO); alpine seepage slope, McArthur/Ethel Lake area, 63°08'N 135°40'W, *C. Kennedy 350*, 29 July 1987 (DAO); alpine meadow seepage slope, McArthur/Ethel Lake area, 63°13'N 135°45'W, *K. Asquith 783*, 9 August 1987 (DAO).

This dioecious species which is endemic to Central Alaska, Central Yukon and the Mackenzie Mountains of the District of Mackenzie was considered to be rare in the Yukon Territory by Douglas et al. (1981), who at the time of publication knew it from only four sites. It is however quite frequent, at least in the Central Ogilvie Mountains.

Poa pseudoabbreviata Roshev. — YUKON: altered basic volcanics at 5000 ft., Upper Malcolm River, 69°11'N 140°55'W, *O. Hughes*, 2 August 1962 (DAO).

This species was reported as new to the Yukon flora by Cody et al. (1990) on the basis of two collections by C. E. Kennedy gathered in 1988 and 1989, one of which was also from the Malcolm River nearby at 69°20'N 140°12'W. The specimen cited above was discovered among some unidentified collections.

Puccinellia andersonii Swallen — YUKON: sand spit, Clarence Lagoon 69°37'N 140°47'W, *Aiken & Consaul 90-053*, 9 July 1990 (CAN) (det. J.I. Davis).

This high-arctic species which was known across the Canadian Arctic Archipelago to Banks Island, and disjunct to Richardson Island in the Mackenzie Delta and Pt. Lay in northwestern Alaska (Porsild and Cody 1980) is now reported for the first time from coastal Yukon Territory. It should be added to the list of rare species in the Territory (Douglas et al. 1981).

Puccinellia arctica (Hook.) Fern & Weath. — YUKON: sand spit, Clarence Lagoon, 69°37'N 140°47'W, *Aiken & Consaul 90-052* (CAN) (det. J.I. Davis).

Previously known in the Yukon Territory only from Herschel Island where considered rare by Douglas et al. (1981).

Puccinellia deschampsioides Soerensen — YUKON: small pond in Von Wilczek Lake system, 62°44'N 136°39'W, *V. Loewen 1*, 15 August 1988 (DAO).

Previously known in the Yukon Territory only from the south end of Kluane Lake (Douglas et al. 1981).

Puccinellia grandis Swallen — YUKON: saline meadow, north end of Atlin Lake, 60°02'N 133°50'W, *R. Johansen*, 10 August 1990 (DAO); saline grass meadow, east of Km. 221 Klondike Hwy.; 61°02.75'N 135°11.33'W, *D.W. Murray*, 11 July 1990 (DAO). Swallen (1944) reported this taxon from Whitehorse (*Hitchcock 4289* (US)).

The Hitchcock specimen was collected in July 1909 and is the basis for the inclusion of *P. grandis* in *The Rare Vascular Plants of the Yukon* (Douglas et al. 1981), although the authors did not see it or find any other collections in Canadian herbaria.

Puccinellia phryganodes (Trin.) Scribn. & Merr. — YUKON: dry delta mud flats, dominant, SE Phillips Bay, Babbage River Delta, 69°15'N 138°23'W, *H.L. Dickson 6070*, 16 August 1983 (DAO); Herschel Island, 69°34'N 138°54'W, *A. Dutilly*, 18 July 1940 (CAN); sand spit, Clarence Lagoon, *Aiken & Consaul 90-051*, 9 July 1990 (CAN).

This is a circumpolar arctic, obligate littoral species which has long been known from coastal District of Mackenzie and Alaska but is here reported for the Yukon Territory for the first time. It should be considered for addition to the list of rare plants for the region (Douglas et al. 1981) but it is easily overlooked and may be more frequent than these collections show.

Scolochloa festucacea (Willd.) Link, Sprangletop — YUKON: palustrine system characterized by bulrush, sedge, willow, foxtail, barley, small pond in Von Wilczek Lake system, 62°44'N 136°39'W, *V. Loewen*, 15 August 1988 (DAO).

This is a wide-ranging species from western Europe to western Siberia with large gaps in western North America; Cody (1956) reported it for the first time in southern District of Mackenzie from whence it has since been collected several times; from the Great Slave Lake area it was then disjunct to the vicinity of Beaver on the Yukon River in the Yukon Flats area east central Alaska (Hultén 1968; Heglund *in press*). The location cited above is intermediate between the Alaskan and Mackenzie sites and the species is new to the flora of the Yukon Territory. It should be added to the list of rare species for the Territory (Douglas et al. 1981).

Secale cereale L., Rye — YUKON: gravel areas near warehouses, scarce, Watson Lake, 60°07'N 128°48'W, *J.M. Gillett 3582*, 5 July 1949 (DAO).

Introduced; not previously recorded for the Yukon Territory.

Stipa nelsonii Scribn. ssp. *dorei* Barkworth & Maze (*S. columbiana sensu* A.S. Chase & Hitchc.; *S. occidentalis* Thurb. ex Wats. var. *minor* (Vasey) C.L. Hitchc.) — YUKON: common on dry, west-facing, prairie slope above lake at 2000', Marsh Lake at Mile 886 Alaska Hwy., 60°33'N 134°25'W, *Calder & Kukkonen 27965*, 7 August 1960 (DAO); on lacustrine deposits on Recent Lake Alsek near junction of Kaskawulsh and Dezadeash R. in mesic meadow, *G.W. & G.G. Douglas 6649*, 1 August 1973 (DAO); open south facing sandy slope, Stoney Creek, 60°50'N 135°50'W, *R. Florkiewicz 19*, 19 June 1988 (DAO); sheltered, rocky-sandy, southfacing, same locality, *R. Florkiewicz 44*, 8 July 1988 (DAO); open slope of point into lake, Unnamed Lake, 60°07.5'N 127°21.5'W, *W.J. Cody 32396*, 7 July 1983 (DAO).

Hultén (1968) indicated two localities on his map and said "probably introduced". This taxon is certainly not introduced at all the above sites, but is disjunct from the main distribution in western North America.

Vahlodea atropurpurea (Wahl.) Fr. ssp. *latifolia* (Fries) Porsild (*Deschampsia atropurpurea* (Wahl.) Scheele var. *latifolia* (Fries) Scribn.) — YUKON: common on lush, open, grassy slopes below cliffs above lake at about 5200', unnamed lake in Itsi Range near Yukon-Mackenzie border, 62°57'N 130°09'W, *Calder & Kukkonen 27692*, 31 July-2 August 1960 (DAO); hotsprings meadow, McArthur/Ethel Lake area, 63°04'N 135°42'W, *C. Kennedy 742*, 8 August 1987 (DAO); meadow near treeline, McArthur/Ethel Lake area, 62°57'N 135°01'W, *K. Asquith 837*, 27 August 1987 (DAO).

Considered rare in the Yukon Territory by Douglas et al. (1981) who knew it only from Mile 218 and Mile 268 Canol Road from whence it was reported by Porsild (1951), and Bennet Lake.

CYPERACEAE

Carex arcta Boott — YUKON: Nisutlin River Delta, Teslin Lake, 60°15'N 132°35'W, *Ereaux & Lortie 24-1*, 1 September 1983 (DAO).

Rosie (1991) recently reported a new station at Frances Lake for this rare species. It is otherwise only known in the Yukon Territory from Johnson's Crossing, Mount Sheldon and MacMillan Pass (Douglas et al. 1981).

Carex atrofusca Schk. — YUKON: Almost Lake, 60°28'N 131°05'W, *C. Kennedy A-24*, 28 July-2 August 1984 (DAO).

This collection represents an eastward extension of the known range of some 350 km.

Carex aurea Nutt. — YUKON: on gravelly-sandy abandoned channel of Anderson Creek, north of Frances Lake, 61°33'N 129°28'W, *R. Rosie 1465*, 25 June 1982 (DAO); in moist soil along roadside, Tom Creek Tower Hill, *R. Rosie 937*, 31 July 1980 (DAO); along shrubby and grassy bank, Tom Creek, 60°16'30"N 129°01'30"W, *R. Rosie 1421*, 15 July 1981 (DAO); wet moss over tufa, Coal River Spring, 60°09'N 127°26'W, *W.J. Cody 32287*, 6 July 1983 (DAO).

These are the first collections to be reported from southeastern Yukon Territory east of the Canol Road.

Carex bicolor All., Sedge — YUKON: sedge *Sphagnum* tundra, Richardson Mts., 68°11'41"N 137°25'30"W, *Loewen & Staniforth 93-248*, 17 July 1993 (DAO); sedge *Sphagnum* meadow, Richardson Mts., 68°19'39"N 136°33'55"W, *Loewen & Staniforth 93-217*, 15 July 1993 (DAO); wet sedge tundra, Richardson Mts., 68°19'29"N 136°39'18"W, *Loewen & Staniforth 93-288*, 22 July 1993 (DAO);

moist hummocky dwarf shrub tundra, Richardson Mts., 68°28'33"N 136°28'33"W, *Loewen & Staniforth 93-159*, 10 July 1993 (DAO).

This is a circumpolar species which was known to Hultén (1968) only from widely scattered localities in southern Yukon Territory and a site on the Alaska/Yukon boundary in the far north. It was, however, not included in the list of rare plants (Douglas et al. 1981). It has not previously been recorded from the Richardson Mountains.

Carex bonanzensis Britton — YUKON: slumping winter road, Klo Kut, 7 km upstream of Old Crow, Porcupine River, 67°34'N 139°41'W, *L.C. Cwynar 60*, 4 July 1975 (DAO).

This collection is from an area about 400 km north of the Dawson area from which the type was collected. The species was considered rare in the Yukon Territory by Douglas et al. (1981), but is more widespread in central Yukon than was known at that time.

Carex buxbaumii Wahlenb. — YUKON: moist lake shore, small island in the middle of an unnamed lake, 60°07.5'N 127°21.5'W, *W.J. Cody 32384*, 7 July 1983 (DAO).

This species which is uncommon in southern Yukon Territory south of latitude 62°N has not previously been reported from east of the Canol Road in the Territory.

Carex canescens L. — YUKON: stony braided stream and adjacent willow-spruce of river valley, headwaters of Waters River, Richardson Mts., *Cody & Ginns 32046*, 15 July 1982 (DAO).

This collection extends the known distribution in the Yukon Territory northward from about latitude 65°N adjacent to the Dempster Highway.

Carex capitata L. — YUKON: British Mountains, 69°26'N 140°45'W, *A.M. Martell 80-25*, 30 June 1979 (DAO); *Dryas* meadow, same locality, *Martell & McEwen 659*, 2 July 1980 (DAO).

Porsild (1975) extended the known range northward adjacent to the Dempster Highway and Cwynar (1983) further north to the Porcupine River valley. The collections cited here represent a further northward extension of some 225 km to the north slope of the British Mountains.

Carex chordorrhiza Ehrh. ex L.f.

Hultén (1968) mapped only one locality for this species on the Arctic Coast of the Yukon Territory. Douglas et al. (1981) considered it a rare species in the Territory, based on collections along the Dempster Highway through the Ogilvie Mountains (Porsild 1975), in the British Mountains and at Shingle Point on the Arctic Coast. Since that time it has been collected in the Nisling River area (5 sheets), adjacent to the Pelly River (1 sheet), in the Porcupine River and southern British Mountains (11 sheets) and along the Arctic Coast including Herschel Island, (4 sheets), and northern Richardson Mountains (all DAO). It is therefore not a rare species in the Yukon Territory, but rather is one that is widespread but requires a boggy habitat which is frequently overlooked because it is often difficult to access.

Carex circinata C.A. Meyer.

This taxon has been reported as occurring in the Yukon Territory (Porsild 1966; Hultén 1968; Welsh 1974) on the basis of a specimen collected at Slims River elevation 4800 ft. (*L.A. Spetzman 81*, 26 June 1962 CAN). The two plants on the sheet which has been revised to *C. nardina* Fries, have quite narrow spikes and the few female florets left have 3 stigmas and are thus what some authors have segregated as *C. hepburnii* Boott. Hultén (1968) also plotted another site adjacent to the British Columbia border for which no voucher specimen could be traced. The species is therefore only doubtfully included in the flora of the Yukon Territory.

Carex crawfordii Fern. — YUKON: small wetland, Coal River Springs, 60°10'N 127°07'W, *C. Kennedy 143*, July 1983 (DAO); muck among stones along creek, Irons Creek bridge, Alaska Hwy. Km 955.2, 60°00'N 127°52'W, *W.J. Cody 32627*, 11 July 1983 (DAO); Needlerock Creek, 62°45'N 135°45'W, *C. Kennedy 49*, 11 July 1985 (DAO); palustrine system, pond west of Horseshoe Slough, 63°26'N 135°07'W, *V. Loewen 3, 29*, 14 August 1988 (DAO).

This species was considered rare by Douglas et al. (1981) but the collections cited above show that is much more widespread.

Carex deflexa Hornem. — YUKON: borrow pit area, Km 307 Dempster Hwy., 66°04'N 137°18'W, *W.J. Cody 27879*, 16 July 1980 (DAO).

This is an extension of the known range of 225 km northward from sites on the Klondike Loop Highway just south of latitude 64°N.

Carex diandra Schrank — YUKON: slumping winter road, Klo Kut, 7 km upstream of Old Crow, 67°34'N 139°41'W, *L.C. Cwynar 347*, 18 July 1975 (DAO); in shallow water, Tack Lake, Bluefish Basin, 67°30'N 139°35'W, *L.C. Cwynar 569*, 1 July 1976 (DAO).

These sites lie some 400 km north of the previously known northern limit at about 64°N latitude.

Carex eleusinoides Turcz. — YUKON: flood bank of stream, Clear Cr. at Stewart R., Km 598 Klondike Hwy., 63°37'N 137°36'W, *Cody & Ginns 29242*, 10 August 1980 (DAO); wet gravel by creek, Dempster Hwy. Km 78.5, 64°33'N 138°12'W, *W.J. Cody 26573, 26574*, 1 July 1980 (DAO); gravel and turf on valley floor by stream, Richardson Mts., 66°25'N 135°58'W, *Cody & Ginns 30557*, 7 July

1982 (DAO); stony braided stream and adjacent willow-spruce of river valley, headwaters of Waters River, Richardson Mts., 67°38'N 137°17'W, *Cody & Ginns 32039a*, 15 July 1982 (DAO); Richardson Mts., Summit Lake area, 67°43'N 136°42'W, *Loewen & Gould 91-161*, 1991 (DAO).

Douglas et al. (1981) considered this species to be rare in the Yukon Territory even though they knew it from Kluane Lake, Keno Hill, MacMillan River and the Richardson Mountains (Wein et al. 1974). The specimens cited above depict an even wider distribution.

Carex filifolia Nutt. — YUKON: rock outcrop on east bank of river, Bonnet Plume River, 64°22'N 132°45'W, *C.E. Kennedy 92B-26*, 16 August 1992 (DAO).

This collection represents an extension of the known range from the Yukon River drainage northward some 300 km.

Carex flava L. — YUKON: moist lake shore, small island in the middle of an unnamed lake, 60°07.5'N 127°21.5'W, *W.J. Cody 32386*, 7 July 1983 (DAO).

Carex flava is a circumpolar species with widely separated populations. In eastern Canada it is found from Newfoundland to the Great Lakes region of Ontario, disjunct to the James Bay area and disjunct to western Alberta and British Columbia. The collection from the extreme southeast of the Yukon Territory cited above is the first for the Yukon Territory. Also, the maps in Hultén (1968) and Crins and Ball (1989) indicate a site in northern British Columbia near the Yukon border; it should therefore be looked for in the vicinity of Bennet Lake. The species should be added to the list of rare species for the Territory (Douglas et al. 1981).

Carex foenea Willd. (*C. siccata* Dew.) — YUKON: fluvial bench above river, Old Pelly River Rd. near Km 428 Klondike Hwy., 62°36.25'N 136°55'W, *D.W. Murray*, 1990 (DAO).

Considered rare in the Yukon Territory by Douglas et al. (1981) on the basis of two known collections, one of which was near Midway on the Klondike Hwy. at 62°35'N 136°49'N.

Carex franklinii Boott — YUKON: in moist mossy tundra, Frances Lake, 61°24'N 129°28'W, *R. Rosie 1491*, July 1976 (DAO); tundra turf on saddle and adjacent broken rocky and turfy slope, Mt. Gladman, 64°43'N 140°49'W, *Cody & Ginns 35193, 35195*, 19 July 1984 (DAO); tundra turf with broken limestone rocks on mountain ridge, W of Hart River, 64°59'N 137°06'W, *Cody & Ginns 34467*, 14 July 1984 (DAO); pockets of soil on steep broken rocky slope, Km 154.5 Dempster Hwy., 65°05'N 138°13'W, *W.J. Cody 27935*, 17 July 1980 (DAO); scree slope, Dempster Hwy. Km 224, 65°34'N 138°10'W, *W.J. Cody 26676*, 2 July 1980 (DAO); steep slide rock and turfy valley wall, Richardson Mts., 66°48'N 136°13'W, *Cody & Ginns 30757*, 7 July 1982 (DAO); river bank, British Mts., Firth R., 68°48'N 140°39'W, *W.J. Cody 27112*, 7 July 1980 (DAO); turfy broken rocky dome, British Mts., 10 km E of Firth R., 68°49'N 140°14'W, *W.J. Cody 27357*, 9 July 1980 (DAO); turfy tundra on bench, British Mts., Firth R., 69°13'N 139°49'W, *W.J. Cody 27266*, 8 July 1960 (DAO); British Mts., Sheep Creek, 69°10'N 140°09'W, *C. Kennedy 417*, 8 August 1988 (DAO).

The map in Hultén (1968) indicates only three locations for this species in the Yukon Territory. Cwynar (1983) gives an additional locality at Hope Lake in the southern Richardson Mountains. The specimens cited above show that *C. franklinii* is widespread in the Territory, although not common.

Carex glacialis Mack. — YUKON: south-facing calcareous alpine forest-tundra, Southern Richardson Mountains, 66°04'N 135°50'W, *L.C. Cwynar 1219*, 8 July 1977 (DAO); damp west-facing limestone ridge, Useful Lake, 67°11'N 140°26'W, *L.C. Cwynar 270*, 12 July 1975 (DAO); Tack Lake Ridge, 67°32.3'N 139°35'W, *J.V. Matthews*, 10 July 1981 (DAO); orange "Fellfield" S of Hanging Lake, 68°23'N 138°23'W, *L.C. Cwynar 1328*, 16 July 1977 (DAO); dry calcareous ridgetop, junction of Joe Creek and Firth River, *L.C. Cwynar 372*, 21 July 1975 (DAO); Sheep Mountain, 69°11'N 140°12'W, *C. Kennedy 420*, 12 August 1988 (DAO); Buckland Hills E of headwaters of Okpioyuak Creek, *C. Kennedy 359b*, 8 August 1988 (DAO).

Previously known in the Yukon Territory north of latitude 66°N only from 2 miles NW of Sam Lake, 68°28'N 138°40'W (Nagy et al. 1979).

Carex glareosa Wahlenb. — YUKON: brackish wetland in shelter of Pauline Cove, Herschel Island, 69°34'N 138°55'W, *C. Kennedy 2027*, 23-30 July 1986 (DAO); on margins of low centre polygons, ca 5 km SW of centre spit of Stokes Point Lagoon, 69°20'N 138°53'W, *H.L. Dickson 6016b*, 16 August 1983 (DAO); in wet-saturated pond bottom, E of Stokes Point Lagoon, 69°20'N 138°44'W, *H.L. Dickson 5884*, 10 August 1983 (DAO); wet mesic-saturated flats, Phillips Bay, 69°14'N 138°29'W, *Dickson & Allen 5360*, 28 July 1982 (DAO); dry lowlands, lower Blow River Delta, 69°56'N 137°09'W, *Dickson & Allen 5303*, 24 July 1982 (DAO).

Previously known in the Yukon Territory only from Shingle Point (Douglas et al. 1981).

Carex gynocrates Wormskj. (*C. dioica* L. ssp. *gynocrates* (Wormsk.) Hultén) —YUKON: second caribou lookout [Porcupine River], 67°35'N 139°31'W, *L.C. Cwynar 1545* (DAO).

This collection which extends the known range northward some 350 km north from sites mapped by Hultén (1968) in the Yukon Territory is still within the limits postulated by Hultén. In the District of Mackenzie, to the east, the species is known still farther north in the Mackenzie River Delta.

Carex interior Bailey — YUKON: Coal River Springs, 60°16'N 127°07'W, *C. Kennedy 91*, 10 July 1983 (DAO).

This is the third record for the Yukon Territory. Porsild (1951) when he reported this species from Liard Hot Springs in northern British Columbia inferred that it should be found in the Yukon Territory. Porsild and Cody (1980) and Douglas et al. (1981) have since mapped it from near Watson Lake on the basis of a specimen at CAN and Rosie (1991) has reported it from Frances Lake.

Carex lapponica O.F. Lang (*C. canescens* L. var. *subloliacea* Laested) — YUKON: *Sphagnum* bog, 60 Mile River Valley, 64°02'N 140°39'W, *G. Brunner 112*, 18 July 1991 (DAO).

Douglas et al. (1981) reported this species as rare in the Yukon Territory on the basis of collections from the Canol Road some 500 km SSE of the specimen cited here.

Carex lasiocarpa Ehrh. ssp. *americana* (Fern.) Hultén — YUKON: Eagle L., ca. 52 km W of Burwash Landing, 61°23'30"N 139°41'30"W, *R.D. Wickstrom 388*, 20 August 1974 (DAO).

Porsild (1975) reported this plant as new to the flora of the Yukon Territory on the basis of a specimen collected on the lower slopes of Mount Haldane (*R.T. Porsild 1161* CAN). Porsild (1951) had previously reported an occurrence along the Alaska Highway at Mile 1226 and Mile 1391 west of the Yukon border in Alaska and suggested the possibility of introduction because the plant was not otherwise known northwest of Lake Athabaska at that time. Subsequent collections in Alaska (Hultén 1968) would throw doubt on this interpretation as would the collection from Mount Haldane and the specimen cited above. The dot on the map for western Yukon (Hultén 1968) was probably a misinterpretation of the Mile 1226 collected by Porsild (1951). The collection cited above is thus only the second known from the Yukon Territory. *Carex lasiocarpa* ssp. *americana* is considered rare in the Yukon Territory by Douglas et al. (1981). The map in Taylor (1983) depicts a collection from the valley of the Liard River just south of the Yukon border; the plant was otherwise not known to Taylor from north of latitude 55°N in British Columbia.

Carex lenticularis Michx. var. *lipocarpa* (Holm) Standley (*C. kelloggii* Boott).

The map in Hultén (1968) indicates collection sites in the Yukon Territory just north of the British Columbia border, but no substantiating specimens could be found. The presence of this plant in the Yukon is therefore in doubt but it should be searched for in the southern parts of the Territory because Standley (1985) cited specimens from north of 60°N latitude to the east in the District of Mackenzie.

Carex livida (Wahl.) Willd. s.lat. — YUKON: Nisling River, Camp 1, 61°55'N 137°51'W, *Reynolds et al. 71, 72, 121, 124*, 22-25 July 1980 (DAO); Nisling East, Camp 2, SW of lake, 61°56'N 137°19'W, *Reynolds & Glabolt 96, 97*, 28 July 1980 (DAO).

This species which was treated as rare in the Yukon Territory by Douglas et al. (1981) was known to them only from along the Dempster Highway between latitudes 64°N and 66°N, and in the southeast at Rancheria and near Watson Lake.

Carex loliacea L. — YUKON: boggy muskeg, Rampart House, *C.C. Loan 654*, 26 July 1951 (DAO); slumping winter road, Klo Kut, 67°34'N 139°41'W, *L.C. Cwynar 351*, 18 July 1975 (DAO); edge of bog, 9 km E of Old Crow on Porcupine River, 67°35'N 139°37'W, *L.C Cwynar 224*, 10 July 1975 (DAO); edge of quaking mat, lake south of Porcupine River opposite to Rat Indian Creek, 67°25'N 138°17'W, *L.C. Cwynar 911*, 19 July 1976 (DAO).

Not previously recorded in the Yukon Territory from north of 64°N latitude (Hultén 1968).

Carex lyngbyei Hornem. Porsild (1966) reported *C. lyngbyei* ssp. *cryptocarpa* (C. A. Mey.) Hultén as new to the flora of the Yukon Territory on the basis of collections from the vicinity of Carcross (*A.E. & R.T. Porsild 18434-5* and *Spetzman 1962-88*).

Cayouette (1987) in his study of *Carex lyngbyei* revised the two Porsild collections to *C. macrochaeta* C. A. Mey. but could not trace the Spetzman collection which therefore must previously have been revised to some other taxon. *Carex lyngbyei* is therefore deleted from the flora of the Yukon Territory.

Carex marina Dewey (*C. amblyorhyncha* Krecz.) — YUKON: Herschel Island; 69°37'N 139°06'W, *C. Kennedy 641*, 27 July 1985 (DAO); 69°35'N 138°55'W, *C. Kennedy 945, 950*, 11 August 1985 (DAO); dry gravel of sandspit, Blow River Delta, 69°56'N 137°11'W, *Dickson & Allen 5287*, 24 July 1982 (DAO); inactive delta, Malcolm River, 69°34'N 139°55'W, *C. Kennedy 238*, 29 July 1988 (DAO).

The map in Hultén (1968) for this circumpolar species depicts collections from both arctic Alaska and coastal northwestern District of Mackenzie. The species is new to the flora of the Yukon Territory and should be added to the list of rare plants for that region (Douglas et al. 1981).

Carex media R.Br. — YUKON: common in boggy muskeg, Rampart House, 67°25'N 141°00'W, *C.C. Loan 653*, 26 July 1951 (DAO); gravel and turf on valley floor by stream, Richardson Mts., 66°25'N

135°58'W, *Cody & Ginns 30553*, 7 July 1982 (DAO).

In the Yukon Territory the main range of *C. media* is south of latitude 64°35'N; it has not previously been reported in the northern part, but was to be expected.

Carex microglochin Wahl. — YUKON: Traverse Mountain E of Sheep Cr., *C. Kennedy 388*, 8 August 1988 (DAO).

The map in Hultén (1968) indicates a collection on the Alaska-Yukon border nearby, but this is the first collection clearly from northern Yukon Territory.

Carex microptera Mack. — YUKON: on sand and gravel bar of Tom Creek, 60°16'N 129°01'W, *R. Rosie 1425A*, 15 July 1981 (DAO); stony shore of stream, Irons Creek, 60°00'N 127°52'W, *W.J. Cody 32273*, 5 July 1983 (DAO); disturbed gravel beach of small lake, Mackenzie Mts., 63°03'N 130°55'W, *W.J. Cody 29598*, 7 July 1981 (DAO); moist gravel by roadside ditch, Km 480 Canol Road, Mackenzie Mts., *W.J. Cody 29515*, 4 July 1981 (DAO).

Hultén (1968) knew this species in the Yukon Territory only from the vicinity of Whitehorse.

Carex pachystachya Cham.

In a recent study, Whitkus and Packer (1984) have demonstrated that most of the specimens mapped by Hultén (1968) as *C. macloviana* d'Urv. ssp. *pachystachya* (Cham.) Hultén are indeed ssp. *macloviana*. The map in Whitkus and Packer (l.c.) indicates only two collections of *C. pachystachya* in extreme southern Yukon. This taxon should be added to the list of rare plants of the Yukon Territory.

Carex peckii E.C. Howe — YUKON: disturbed gravel, Sidney Creek, Canol Rd. km 46, 60°47'N 133°05'W, *W.J. Cody 26137* (DAO); moist sandy gravel, valley of Rose River, Canol Rd. km 106, 61°17'N 133°00'W, *W.J. Cody 26174* (DAO).

This rare species in the Yukon flora was previously only known from the vicinity of Dawson (Douglas et al. 1981).

Carex prairea Dewey in Wood — YUKON: muskeg, vicinity of Liard R. about 6 mi SE of Watson L., 60°02'N 128°35'W, *Raup & Correll 11029*, 3 August 1943 (MICH, CAN, photos DAO).

According to the map in Packer (1983), this is an extension of the known range northward from central Alberta. It may be distinguished from the related *C. diandra* by the leaf sheaths being strongly tinged with copper colour toward the summits ventrally rather than being pale or whitish, the more or less moniliform inflorescence, and the perigynia being appressed at maturity and nearly or completely concealed by the large scales rather than tending to spread at maturity and therefore not concealed by the scales. New to the flora of the Yukon Territory.

Carex rossii Boott — YUKON: disturbed sandy soil of borrow pit by airstrip (road), Km 321 Dempster Hwy. 66°08'N 137°08'W, *W.J. Cody 27872*, 16 July 1980 (DAO).

This is a northward extension of the known range of some 275 km, but may possibly be an introduction here.

Carex rostrata Stokes — YUKON: forms fringe behind *Menyanthes* and *Potentilla palustris* and *Carex limosa* mat, lake south of Porcupine River, opposite Rat Indian Creek, 67°25'N 138°17'W, *L.C. Cwynar 910*, 19 July 1976 (DAO); dried up border of small lake, Klondike Hwy. Km 634, 63°51'N 138°02'W, *W.J. Cody 28102*, 19 July 1980 (DAO).

The first specimen was cited by Cwynar (1983) as a range extension northward from sites reported by Porsild (1975) adjacent to the Dempster Highway in the Ogilvie Mountains. However, all other material formerly placed under *C. rostrata* has recently been revised to *C. utriculata* by Reznicek (*in preparation*). The second collection is somewhat atypical and sterile and according to Reznicek (personal communication) is a possible hybrid with *C. utriculata*. *Carex rostrata* should now be considered for inclusion in the list of rare species of the Yukon Territory (Douglas et al. 1981).

Carex rotundata Wahl. — YUKON: polygon channel, 7 km WSW of Stokes Point, 69°20'N 138°55'W, *C. Kennedy 288*, 1 August 1988 (DAO); wet sedge habitat, 4 km S of SE end of Stokes Point Lagoon, 69°19'N 138°46'W, *H.L. Dickson 5910c*, 11 August 1983 (DAO); 3 km W of Komakuk Beach, 69°35'N 140°17'W, *C. Kennedy 372*, 8 August 1988 (DAO); coastal plain, 10 km NW of Roland Bay, 69°25'N 139°03'W, *C.E. Kennedy 89-50*, 30 July 1989 (DAO); Northern Yukon National Park, S of Herschel Island, 69°24'49"N 139°00'55"W, *C.E. Kennedy 89-93*, 1 August 1989 (DAO); 1.5 km S of King Point Lagoon, 69°05'N 137°59'W, *H. L. Dickson 6045*, 16 August 1983 (DAO); creek bank, Jarvis Cr. at Alaska Hwy., 60°55'N 137°53'W, *Cody & Ginns 28639*, 29 July 1980 (DAO).

This species was considered rare by Douglas et al. (1981) but this status should be reconsidered.

Carex sabulosa Turcz. ssp. *leiophylla* (Mack.) A.E. Porsild (*C. leiophylla* Mack.) — YUKON: west side of Kusawa Lake, 60°21'N 136°22'W, *C. Kennedy K25*, 2 July 1986 (DAO).

The type of *Carex leiophylla* was collected on sand dunes at Carcross by Alice Eastwood in 1914 from whence it has since been collected by several botanists. Porsild (1966) reported its presence on the shores of Lake Bennett nearby and made the transfer *C. sabulosa* ssp. *leiophylla*. Douglas and Ruyle-Douglas (1978) reported a collection from near the junction of the Kaskawulsh and Dezadeash rivers in Kluane National Park about 16 km WSW of Haines Junction. The site from which the collection cited above was gathered is intermediate between the two previously known localities. Subspecies *leiophylla* is rare in the Yukon Territory (Douglas et al. 1981) but should be looked for in similar sand dune situations in the southwestern part of the Territory. It is interesting to note that a very distinctive smut, *Planetella lironis* Savile is common to both *C. maritima* Gunn. (a distigmatic taxon historically included in the section Foetidae Tuckerm.) and *C. sabulosa* ssp. *leiophylla* (a tristigmatic taxon historically included in the section Atratae Kunth), two widely separated sections in the genus *Carex* (Savile 1951; Savile and Calder 1953). Savile and Calder (1953) have suggested that because of their similarity of habitat and the smut that is common only to the two, among other characters, that they are closely related and should both be included in section Foetidae. They considered *C. leiophylla* (*C. sabulosa* ssp. *leiophylla*) a nearly direct ancestor of *C. maritima*. Reznicek (1990) discussed this possibility in his paper on the evolution of sedges.

Carex spectabilis Dewey

A specimen collected in the Peel River Lowlands 66°33'N 134°33'W (*Bird & Benson 29671* (UAC)) has been revised to *C. limosa*. This specimen was the basis for a disjunct record in northern Yukon Territory (Bird 1974; Douglas et al. 1981). The species is known in the Yukon Territory only from southern Kluane National Park.

Carex subspathacea Wormsk. (*C. salina* Wahl. var. *subspathacea* (Wormsk.) Tuck.) — YUKON: wet saturated mud-sedge delta flats, Lower Blow River Delta, 69°56'N 137°09'W, *Dickson & Allen 5301, 5306*, 24 July 1982 (DAO); wet mesic-saturated flats, Phillips Bay, SW shore of outer delta, *Dickson & Allen 5357* (DAO).

This species which was reported as rare in the Yukon Territory by Douglas et al. (1981), was known only from Herschel Island and Komakuk Beach at that time.

Carex sychnocephala Carey — YUKON: palustrine system, pond west of Horsehoe Slough, 63°26'N 135°07'W, *V. Loewen*, 14 August 1988 (DAO); saline pond shore, 60°42'N 135°36'W [about 30 km W of Whitehorse], *J. Natham 36*, 19 July 1988.

Previously known in the Yukon Territory only from the Ross River area where considered rare by Douglas et al. (1981).

Carex ursina Dewey — YUKON: wetlands, Phillips Bay, SW shore of outer delta, 69°15'N 138°31'W, *Dickson & Allen 5387*, 29 July 1982 (DAO); Firth River Delta, 69°30'20"N 139°24'50"W, *C.E. Kennedy 89-177*, 1989 (DAO).

Previously known on the Arctic Coast only from Demarcation Point, Herschel Island and Shingle point and considered rare by Douglas et al. (1981).

Carex williamsii Britt. — YUKON: Nisling River, Camp 1, 61°55'N 137°51'W, *Reynolds & Glabolt 144*, 24 July 1980 (DAO); Nisling East, Camp 2, 61°56'N 137°19'W, *Reynolds & Glabolt 99*, 28 July 1980 (DAO); alpine seepage slope, McArthur/Ethel Lake area, 63°08'N 135°40'W, *C. Kennedy 355*, 29 July 1987 (DAO); Phillips Bay, 69°14'50"N 138°32'25"W, *C.E. Kennedy 89-174*, 7 August 1979 (DAO); 19 km SSE of Kay Point, 69°07'N 138°20'22"W, *C.E. Kennedy 89-200*, 1989 (DAO).

Considered as rare by Douglas et al. (1981) who knew it from north of Old Crow and between Miles 53-58 Dempster Highway. The type was collected at Dawson in 1899 by R. S. Williams (NY, photo DAO).

Eleocharis acicularis (L.) R. & S., Least Spike-rush — YUKON: 5 km SE of King Point, 69°04'59"N 137°54'00"W, *C.E. Kennedy 89-187a*, 8 August 1989 (DAO).

The map in Hultén (1968) depicts the occurrence of this species as far north as Dawson. Porsild (1975) extended the known northern limit in the Territory to about latitude 65°N at Mile 84 Dempster Highway. This extension of the known range to the Arctic Coast is however not surprising because both Hultén (1968) and Porsild and Cody (1980) show it as occurring on the Arctic Coast of the District of Mackenzie east of the Mackenzie River Delta.

Eleocharis quinqueflora (F. Hartm.) Schwartz (*E. pauciflora* (Lightf.) Link var. *fernaldii* Svens.), Spike-rush — YUKON: wet silty riverbank with *Equisetum* and *Carex aquatilis*, junction of Rat Indian Creek and Porcupine River, 67°32'N 138°20'W, *L.C. Cwynar 895*, 18 July 1976 (DAO).

This is a northward extension of the known range of some 350 km from a site adjacent to the Dempster Highway. The specimen cited here was reported by Cwynar (1983) as *E. uniglumis* (Link) Schult.

Eriophorum gracile Koch, Cotton-grass — YUKON: Coal River Springs proposed park, Site 20, 60°05'N, 127°30'W, *C. Kennedy 89a*, 10 July 1983 (DAO).

This is a circumpolar non-arctic species which in the District of Mackenzie to the east is known from a few sites in the southern Precambrian Shield and also in Nahanni National Park and then was considered to be disjunct to Central and Coastal Alaska (Porsild and Cody 1980). The collection cited above helps fill in the area between these previously known distributions and is the first for the Yukon Territory. The species should be added to the list of rare vascular plants of the Yukon Territory (Douglas et al. 1981).

Eriphorum viridi-carinatum (Engelm.) Fern. — YUKON: Coal River Springs, *C. Kennedy 159*, July

1983 (DAO); *Salix-Carex* community bordering bog, Big Salmon River, 61°23'N 133°26'W, *C.A. McEwen 1509*, 29 June 1982 (DAO).

Douglas et al. (1981) knew this species in the Yukon Territory only from the vicinity of Watson Lake. The Coal River Springs locality is about 70 km to the east of Watson Lake, while the Big Salmon River site is about 190 km NW of Watson Lake. This species is also known from near Morley Lake at Mile 769 Alaska Highway, 59°58'N 132°07'W in northern British Columbia (*Calder 28313* (DAO)).

Scirpus caespitosus L. ssp. *austriacus* (Pallas) Asch. & Graeb. (*Trichophorum caespitosum* (L.) Hartm.), Bulrush — YUKON: river bank, British Mountains, Firth R., 68°48'N 140°39'W, *W.J. Cody 27128*, 7 July 1980 (DAO).

Welsh and Rigby (1971) reported the first record for northern Yukon from Old Crow Flats at 68°16'N 139°22'W. The collections cited here extend the known northern distribution north into the British Mountains.

Scirpus microcarpus Presl — YUKON: gravel and silt bar on island, Yukon River just downstream from mouth of Stewart River, 63°20'N 139°28'W, *Cody & Ginns 34752*, 16 July 1984 (DAO).

This is the first substantiated record for the species in the Yukon Territory. Packer (1983) included the Yukon in his distributional information but no substantiating specimens could be found. *Scirpus microcarpus* should be added to the list of rare plants of the Yukon Territory (Douglas et al. 1981).

Scirpus rollandii Fern. — YUKON: growing with *Carex gynocrates*, broad valley of Watson R., 60°15'N 134°47'W, *W.J. Cody 25787b*, 16 June 1980 (DAO); marly lake shore, Twin Lakes, 61°42'N 135°56'W, *R.T. Porsild 1878*, 21 June 1969 (CAN).

Douglas et al. (1981) knew this species only from the Kluane Lake to the Champagne area. Although still known only from the southwest, the collections cited here demonstrate that it is more widespread.

Scirpus validus Vahl, (*S. tabernaemontanii sensu* Douglas et al. (1981)) —YUKON: north of Blind Creek Road, Faro, *V. Hodgson 839*, 8 July 1982 (DAO); 61°32'N 133°55'W, *C.A. McEwen 6501*, 22 July 1982 (DAO); 60°10'N 135°00'W, *G.H. Lortie 9-67*, July 1967 (DAO); North Von Wilczek Lake NE of Minto, 62°43'N 136°42'W, *Calder & Kukkonen 28059*, 10 August 1960 (DAO).

Douglas et al. (1981) sub. *S. tabernaemontanii* included this species among the rare plants of the Yukon Territory. The specimens cited above would indicate that the species although not common is much more widespread in the Territory than considered by them and bears out the veracity of the map in Hultén (1968). On this basis, the species should probably be removed from the list of rare plants of the Yukon Territory.

JUNCACEAE

Juncus castaneus Sm. ssp. *leucochlamys* (Zinz.) Hultén, Bog-rush — YUKON: pond in dredge tailing edge, Hunker P.O. [63°58'N 138°58'W], *J. Campbell 40*, 8 July 1950 (DAO); wet ditch by roadside, Hunker Creek Road, *J.D. Campbell 67*, 31 July 1951 (DAO); Mayo Landing, *C. Broadfoot*, 1943 (DAO); rare along margin of lake in mucky-gravelly area, 7 miles north of Carcross, 60°16'N 134°44'W, *Calder & Kukkonen 28294*, 15 August 1960 (DAO); gravel river flats of creek, Albert creek, 60°03'N 128°56'W, *Calder & Gillett 26554*, 5 July 1960 (DAO); in wet mucky soil along Campbell Highway near Tom Creek, *R. Rosie 961*, 24 August 1980 (DAO); stony shore of stream, Irons Creek, Alaska Hwy. km 955.2, 60°00'N 127°52'W, *W.J. Cody 32271*, 5 July 1983 (DAO); on stones by small stream, Dempster Hwy., Km 8, 64°02'N 138°36'W, *Cody & Ginns 28932*, 6 August 1980 (DAO); river flood channel, N Tatonduk Valley (Sheep Mtn.), 65°11'N 140°30'W, *D.M. Dickinson 29*, 25 July 1983 (DAO).

Hultén (1968) knew this subspecies in the Yukon Territory from a single site at about longitude 140°W adjacent to the Alaska Highway. As demonstrated by the specimens cited above it is widespread across southern Yukon Territory.

Juncus nodosus L. — YUKON: moist bank, small island in middle of an unnamed lake, 60°07.5'N 127°21.5'W, *W.J. Cody 32356*, 7 July 1983 (DAO); wet open field near spruce forest, Rancheria Ring Rd. access 2, 60°12'N 129°10'W, *R. Florkiewicz 91-088*, 25 June 1991 (DAO); productive waterfowl area, Needlerock Creek, 62°35'N 135°30'W, *Kennedy & Ereaux NR10*, 1985 (DAO).

The distribution maps in Hultén (1968) and Porsild and Cody (1980) indicate collections from northeastern British Columbia, central Alaska and western District of Mackenzie. The nearest known sites in the District of Mackenzie are in Nahanni National Park at 61°25'N 126°36'W (Scotter and Cody 1974) and in northeastern British Columbia at Liard Hotsprings 59°10'N 126°00'W (Porsild and Crum 1961). *Juncus nodosus* is new to the known flora of the Yukon Territory and should be added to the list of rare vascular plants of the Yukon (Douglas et al. 1981).

Juncus tenuis Willd.

This taxon was included in The Rare Vascular Plants of the Yukon (Douglas et al. 1981) on the basis of a specimen collected in the Ross River valley near the north end of Sheldon Lake (*Porsild & Breitung 11535* (CAN)) and was plotted as *J. tenuis* by Hultén (1968). Porsild (1951) had earlier reported *Juncus dudleyi* Wieg. as new to the Yukon Territory on the basis of his identification of this specimen. The specimens mounted on the herbarium sheet are all quite young, but are definitely rhizomatous, have apiculate leaf sheaths, lack a coriacous auricle, have 3 stamens with anthers ca. 0.45 mm long with the filaments 3 times the length of the anther, and are therefore better referred to *Juncus balticus* s.lat.

Juncus triglumis L. ssp. *albescens* (Lange) Hultén (*J. albescens* (Lange) Fern.) — YUKON: flat hummocky subalpine, Firth River, 68°48'N 140°39'N, *W.J. Cody 27104*, 7 July 1980 (DAO); Upper Muskeg Creek, 68°44'N 140°08'W, *C. Kennedy 51*, 24 July 1988 (DAO); turf and braided cobble of river bed, Malcolm R., *W.J. Cody 27494*, 10 July 1980 (DAO); wet tundra, McNeish Site, 60 km W of Stokes Point, 69°21'N 139°30'W, *L.C. Cwynar 384*, 21 July 1975 (DAO).

Previously known in the Yukon Territory north only to about latitude 66°N.

LILIACEAE

Maianthemum canadense Desf. ssp. *interius* (Fern.) Á. Löve & D. Löve, Wild Lily-of-the-valley.

The presence of this taxon in the Yukon Territory has not yet been documented. It should however be searched for in the extreme southeastern part. To the east it is know to occur about 12 km from the Yukon border (District of Mackenzie, in moss among shubbery in open *Picea glauca* woods, east side of Liard River 15 miles southwest of Fort Liard, 60°05'N 123°47'W, *Cody & Spicer 11583*, 23 July 1961 (DAO)), and to the south in British Columbia it is known along the Alaska Highway (British Columbia: common in dense spruce woods, east of Coal River at Mile 524 Alaska Highway, 59°36'N 126°43'W, *Calder & Gillett 26514*, 5 July 1960 (DAO).

Maianthemum dilatatum (Wood) Nels. & Macb., Deerberry.

A collection from south of the Yukon border suggests that this taxon should be searched for in the extreme southwestern part of the Yukon Territory (British Columbia, damp clay soil, Haines Road Mile 45, approx. 59°30'N 136°30'W, *Taylor et al. 1552*, 18 July 1956 (DAO,V).

Tofieldia coccinea Richards., False Asphodel — YUKON: limestone ridge, crest and sides of ridge adjacent, 60°05'N 127°25'W, *W.J. Cody 32574*, 10 July 1983 (DAO).

The main range of this nearly circumpolar species in the Yukon Territory lies north of latitude 64°N. Elsewhere in the southern part it is rare in the southwest, some 700 km to the west of the site reported here.

Veratrum viride Ait. ssp. *eschscholtzii* (A. Gray) A. Löve & D. Löve, White Hellebore — YUKON: tundra turf in mountain valley, east flank of Steamboat Mountain, 64°15'N 135°33'W, *Cody & Ginns 33095* (DAO); meadow, Mayo Lake area, 63°45' to 64°00'N 134°30' to 135°00'W, *L.H. Green 70*, 5 August 1952 (DAO); a few stands in ravine near summit, Keno Hill, 63°57'N 135°10'W, *Gillett & Calder 4369*, 6 August 1949 (DAO).

These collections are the northernmost yet reported from the Yukon Territory. The nearest known sites are adjacent to the Canol Road some 225 km to the southeast.

IRIDACEAE

Sisyrinchium montanum Greene, Blue-eyed Grass — YUKON: common in a few places on open flats, side road to Lake Laberge, 60°56'N 135°07'W, *Calder & Gillett 25785*, 22 June 1960 (DAO); rare in sedge mats at lakeshore, Twin Lakes campsite on Dawson-Whitehorse Road, 61°42'N 135°50'W, *Calder & Gillett 25813*, 22 June 1960 (DAO); large *Fescue* meadow, Old Pelly Road, 62°38'10"N 136°53'4"W, *R. Johansen 58*, 1989 (DAO).

Douglas et al. (1981) knew this taxon only from eastern Kluane National Park and the Haines Junction area; although still known only from the southwestern part of the Yukon Territory, its rarity should be reconsidered.

ORCHIDACEAE

Coeloglossum viride (L.) Hartm. ssp. *bracteatum* (Muhl.) Hultén (*C. viride* (L.) Hartm. var. *virescens* (Willd.) Luer, *Habenaria viridis* (L.) R.Br. var. *bracteata* (Muhl.) Gray), Bracted Green Orchid — YUKON: poorly drained river terrace to west of river mainstream, confluence of Bonnet Plume River and Rapitan Creek, 65°10'N 134°20'W, *C.E. Kennedy 92B-91*, 18 August 1992 (DAO).

This collection represents a northward extension of the known range in the Yukon Territory of some 550 km from a site in the vicinity of Little Atlin Lake, the only other known locality in the Territory; the species is considered rare by Douglas et al. (1981).

Cypripedium calceolus L. ssp. *parviflorum* (Salisb.) Hultén (*C. parviflorum* Salisb.), Small Lady's-slipper — YUKON: Faro area, 62°12'N 133°10'W, *C.E. Kennedy 90-36*, 18 July 1990 (DAO); alluvial site adjacent to river, Bonnet Plume River, 64°22'N 132°25'W, *C.E. Kennedy 92B-18*, 15 August 1992 (DAO); alluvial terrace, Bonnet Plume River, 64°56'N 133°50'W, *C.E. Kennedy 92B-87*, 17 August 1992 (DAO).

This is a rare species in the Yukon Territory. Douglas et al. (1981) knew it only from the Alaska border at 66°N latitude, but Hultén (1968) also plotted a record from adjacent to the Nahanni Range road which could not be traced.

Goodyera repens (L.) R.Br., Dwarf Rattlesnake-plaintain — YUKON: poorly drained river terrace, confluence of Bonnet Plume River and Rapitan Creek, 65°10'N 134°20'W, *C.E. Kennedy 92B-90*, 18 August 1992 (DAO); Dempster Highway, Mile 148, *R.T. Porsild 2011*, 4 August 1972 (CAN).

These collections are the northernmost yet reported from the Yukon Territory. Porsild (1975) knew it only from Kluane Lake, White River and the Canol Road.

Listera borealis Morong, Northern Twayblade — YUKON: in rich white spruce woods at base of NE slope, Hope Lake, 66°04'N 135°50'W, *L.C. Cwynar 1292*, 14 July 1977 (DAO); Porcupine caribou herd winter range along Dempster Highway from Eagle Plains Lodge (Km 371) north to the District of Mackenzie border (Km 458), *C. Kennedy PCH-19*, 7 July 1980 (DAO).

The only other record for this species north of latitude 64°N in the Yukon Territory is from Rampart House on the Alaska border some 300 km northwest of the Hope Lake site reported here.

Listera cordata (L.) R.Br., Heart-leaf Twayblade — YUKON: rare in mossy area in spruce woods by lake, Mile 648 Alaska Hwy., 60°02'N 129°02'W, *Calder & Kukkonen 27915*, 6 August 1960 (DAO); moist sunny slope, alpine, Km 21 Upper Sheep Creek Rd., Km 154 Canol Rd., *V. Hodgson 1303*, 22 July 1984 (DAO); hotsprings meadow, McArthur/Ethel Lake area, 63°04'N 135°42'W, *C. Kennedy 735*, 8 August 1987 (DAO).

Douglas (1981) reported this species as rare in the Yukon Territory on the basis of a Porsild collection from Mount Sheldon (Porsild 1951); Rosie (1991) reported a second collection from Tom Creek, northwest of Watson Lake; the collections cited here show that the species is more widespread, although still rare.

Platanthera stricta Lindl. (*P. saccata* (Greene) Hultén, *Habenaria saccata* Greene), Slender Bog Orchid — YUKON: Whitehorse, Porter Creek, 60°45'N 135°07'W, border of small alkaline lake, *Cody & Ginns 28757*, 31 July 1980 (DAO).

According to the map in Hultén (1968) this species is found only in the coastal region in the northern part of its range, but southward it does cross the mountains to southwestern Alberta, Nevada and New Mexico (Packer 1983). This is an extension of range northeastward across the divide into southwestern Yukon from the Alaska Panhandle of some 200 km. *P. stricta* is new to the flora of the Yukon Territory and should be added to the list of rare vascular plants for that territory (Douglas et al. 1981).

SALICACEAE

Salix arctophila Cock. ex Heller — YUKON: limestone outcrop, South Cache Creek Hills, 68°04'N 136°35'W, *Welsh & Rigby 11159*, 15 July 1971 (CAN); tundra, west fork of Cache Creek, 68°07'N 136°37'W, *Welsh & Rigby 11549*, 23 July 1971 (CAN); Jurassic Kingak Shale at 3000 ft., 68°28'N 136°28'W, *J.K. Rigby*, 12 June 1973 (CAN); sandy soil of stream bank, 3 miles S of Shingle Point Dew Line Site, *G. Ironside*, 30 June 1971 (CAN); low wet areas with *Carex aquatilis* 4 km S of Stokes Point, 69°19'N 138°46'W, *Dickson & Allen 5915*, 11 August 1983 (CAN); in low centre polygon 3 km S of Stokes Point, 69°22'N 138°54'W, *Dickson & Allen 6018*, 16 August 1983 (CAN); gravel bar of river, Clarence Lagoon, 69°35'N 140°44'W, *Consaul & Aiken 971*, 9 July 1990 (CAN).

Argus (1973) knew this willow in the Yukon Territory from only three localities: Firth River at the Alaska border, King Point and Canol Road M 284 and it was considered rare by Douglas et al. (1981).

Salix chamissonis Anderss. — YUKON: Richardson Mts.: Hope Lake, 66°04'N 135°30'W, *L.C. Cwynar 1271*, 11 July 1977 (DAO); 66°16'N 135°48'W, *Cody & Ginns 30393, 30394*, (DAO); 66°25'N 135°58'W, *Cody & Ginns 30612, 30561* (DAO); 66°26.5'N 135°48'W, *Cody & Ginns 30804, 30805, 30808, 30815* (DAO); 66°32'N 136°25'W, *Cody 26726* (DAO); 67°02'N 136°13'W, *Cody & Ginns 30092* (DAO); 66°44'N 135°52'W, *Cody & Ginns 30898* (DAO); 67°19'N 136°15'W, *Cody & Ginns 31079* (DAO); 67°19'N 136°15'W, *Cody & Ginns 31046, 31092, 31096* (DAO); 67°33'N 136°25'W, *Cody & Ginns 31202* (DAO); 67°42.5'N 136°37'W, *Cody & Ginns 29932* (DAO); 67°44'N 136°29'W, *Cody & Ginns 29883* (DAO); 68°18'N 136°30''W, *Cody & Ginns 31291b* (DAO); 68°31'N 137°03'W, *Cody & Ginns 31638, 31639* (DAO); British Mts.: 66°30'N 140°47'W, *A.M. Martell 80-36, 80-37a*, (DAO); 69°26' 140°45'W, *A.M. Martell 80-38* (DAO).

When Douglas et al. (1981) considered *S. chamissonis* as rare in the Yukon Territory it was known to them from a few collections in the Richardson Mountains north to Shingle Point and at Trout Lake on the east side of the British Mountains. The collections cited above show that it is much more frequent and over a larger area and that its rare status should be reconsidered. The species barely enters District of Mackenzie Fin the Richardson Mountains.

Salix fuscescens Anderss.

Douglas et al. (1981) considered this species to be rare in the Yukon Territory. Recent collections in the Richardson and British Mountains and in the Old Crow region show that it is much more widespread in the northern part of the Territory and its status should be reassessed.

Salix maccalliana Powlee — YUKON: Coal River Springs, *C. Kennedy 32*, July 1983 (DAO).

This site is about 80 km east of Watson Lake from whence Douglas et al. (1981) reported the species as rare in the Yukon Territory.

Salix ovalifolia Trautv. var. *ovalifolia* — YUKON: dunes, 5 km E of Firth River delta, 69°30'N 139°13'W, *L.C. Cwynar 421*, 21 July 1975 (DAO, CAN); dominant on tidal flats, Kay Point area, 69°13'N 138°21'W, *Dickson & Allen 6064*, 16 August 1983 (CAN); saline marshland, Stokes Point, 69°20'N 138°44'W, *Consaul & Aiken 1010*, 11 July 1990 (CAN); costal dunes along wet shore of Babbage River Estuary, 69°13'N 138°28'W, *Dickson & Allen 5387*, 28 July 1982 (CAN).

Hultén (1968) suggested on his map and Douglas et al. (1981) reported its occurence at the mouth of the Firth River but did not cite any specimens.

Salix ovalifolia Trautv. var. *arctolitoralis* (Hultén) Argus (*S. arctolitoralis* Hultén) — YUKON: wet mesic-saturated monocot-*Salix* flats, Phillips Bay, west side of Babbage River Estuary, *Dickson & Allen 5362*, 28 July 1982 (CAN); moist 50% vegetated tidal flats, Kay Point, NE of Phillips Bay, 69°18'N 138°22'W, *Dickson & Allen 6078*, 16 August 1983 (CAN); mud flats, Lower Blow River Delta, 68°56'N 137°08'W, *Dickson & Allen 5304*, 25 July 1982 (CAN); Clarence Lagoon, 69°37'N 140°46'W, *P.F. Cooper 746* and *754*, 8 July 1974 (CAN).

Argus (1973) knew this rare species only from Shingle Point (*A.E. Porsild 7094* (CAN)).

Salix rotundifolia Trautv. ssp. *rotundifolia* — YUKON: Clarence Lagoon, 69°37'N 140°46'W, *P.F. Cooper 774*, 8 July 1979 (CAN); on unnamed ridge beside Malcolm River, 69°21'N 140°22'W, *Consaul & Aiken 998*, 10 July 1990 (CAN); British Mts., 69°09'N 139°19'W, *P.F. Cooper 866* and *877*, 11 July 1979 (CAN).

Hultén (1968) knew this taxon in the Yukon Territory in the extreme southwest. The specimens cited above extend its known range into northwestern Yukon from adjacent Alaska.

Salix rotundifolia Trautv. ssp. *dodgeana* (Rydb.) Argus (*S. dodgeana* Rydb.) —YUKON: steep sparsely vegetated, limestone slopes, Mt. Sedgewick, 68°53'N 139°06'W, *Calder 34466*, 19 July 1962 (DAO); tundra turf, 25 km S of Clarence Lagoon, 69°18'N 140°48'W, *W.J. Cody 27036*, 6 July 1980 (DAO); broken rocky hump on mountain side, E of Firth R., 69°12'N 139°32'W, *W.J. Cody 27784*, 12 July 1980 (DAO); wet tundra, Clarence Lagoon, 69°37'N 140°49'W, *W.J. Cody 26812*, 5 July 1980 (DAO); same locality, *P.F. Cooper 747*, 11 July 1979 (CAN); stony slope S of Malcolm R., 69°15'N 140°52'W, *W.J. Cody 27552*, 10 July 1980 (DAO); old snow patch, 10 km E of Firth R., 68°49'N 140°14'W, *W.J. Cody 27386*, 9 July 1980 (DAO); tundra turf on mountain top, 11 miles W of Blackstone Lake, 65°11'N 137°27'W, *Cody & Ginns 34411*, 14 July 1984 (DAO); shattered stone and turf on mountain top, 65°10'N 138°45'W, *Cody & Ginns 34238*, 13 July 1984 (DAO); broken limestone and turf on mountain saddle, 12 miles SE of Blackstone Lake, 65°06'N 137°27'W, *Cody & Ginns 34424*, 14 July 1984 (DAO); reddish limestone mountain top, 12 miles NNE of Blackstone River, 65°00'N 138°13'W, *Cody & Ginns 33852*, 8 July 1984 (DAO); broken rocky saddle, 15 miles NNW of Mt. Gibben, 64°55'N 139°19'W, *Cody & Ginns 34205*, 12 July 1984 (DAO); tundra turf and adjacent limestone rocky slopes on mountain top, 20 mi W of Chapman Lake, 64°53'N 138°58'W, *Cody & Ginns 34007*, 8 July 1984 (DAO); shattered limestone on mountain top, 12 miles NNW of Mt. Harper, *Cody & Ginns 34391*, 13 July 1984 (DAO); tundra turf on mountain top and slopes, SW of Mt. Gibben, 64°39'N 139°23'W, *Cody & Ginns 33649*, 6 July 1984 (DAO); alpine tundra turf on saddle and adjacent slope below, Cloudy Range, 64°35'N 138°27'W, *Cody & Ginns 33043*, 2 July 1984 (DAO).

Hultén (1968) knew this taxon only from the central Mackenzie Mountains of western District of Mackenzie. Argus (1973) cited a Calder specimen from the Richardson Mountains and several specimens from Kluane National Park in the Yukon Territory as well as 10 from various sites across Alaska and one from eastern Siberia. The specimens cited above demonstrate that this taxon is quite frequent in both the Ogilvie and British mountains in the Yukon Territory. In addition Bird (1974) cited specimens (sub. *S. rotundifolia*) from the northern Wernecke Mountains and Knorr Range of the northern Mackenzie Mountains.

MYRICACEAE

Myrica gale L., Sweet Gale — YUKON: wet sedge meadow, small island in middle of an unnamed lake, 60°07.5'N 127°21.5'W, *W.J. Cody 32366*, 7 July 1983 (DAO); Nisutlin River Delta, Teslin Lake, 60°15'N 132°35'W, *Ereaux & Lortie 49-4*, 1 September 1983 (DAO); in a bog, Dempster Highway near Mile 130, Ogilvie Mts., *R.T. Porsild 2023*, 4 August 1982 (CAN).

Porsild (1975) reported this species as little collected and appearing to be restricted to the Dawson-Mayo districts. Rosie (1991) reported a site in the Frances Lake area to the southeast. The sites reported here indicate that it is still more widespread and the known range is extended northward adjacent to the Dempster Highway some 175 km from the Dawson area.

BETULACEAE

Betula pumila L. var. *glandulifera* Regel (*B. glandulifera* (Regel) Butler) —YUKON: terrace of hot spring, Larsen Creek Hot Springs, 60°12'N 125°32'W, *G.W. Scotter 24679*, 20-21 July 1977 (DAO); mature spruce-fir forest near hot springs, same locality, *G.W. Scotter 24688*, 20-21 July 1977 (DAO); *Picea mariana* bog, small unnamed lake, 60°06'N 127°31'W, *W.J. Cody 32520*, 10 July 1983 (DAO); thicket along lake eastern end of Watson Lake, 60°05'N 128°43'W, *H.M. Raup 12989A*, 3 September 1944 (CAN).

Dugle (1966) plotted a single site in the Yukon Territory in the vicinity of Dawson for this taxon but did not cite the specimen; other localities plotted were in extreme southwestern District of Mackenzie and northeastern British Columbia adjacent to the Yukon border. It should be considered for addition to the rare plants of the Yukon Territory (Douglas et al. 1981).

URTICACEAE

Urtica urens L., Dog Nettle — YUKON: Dawson, *Elgin Schoff*, August 1904 (TRT, photo DAO).

This species which is rare in western Canada was presumably introduced to the Dawson area about the time of the Gold Rush. It has not been collected in the Yukon since it was found by Schoff. The specimen cited here was plotted by Bassett et al. (1974) but has been overlooked by other authors. No information about the collector has been located.

SANTALACEAE

Comandra umbellata (L.) Nutt. ssp. *pallida* (A.DC.) Piehl, *C. pallida* A.DC., Pale Comandra.

The only specimen known to Hultén (1944) was one collected by Frithiof Andersson on 18 June 1898 (S), which bears the locality data "Alaska: Yukon District". Hultén (1944) surmized that this was collected while the expedition's boat was being transported through the Five Finger Rapids (62°16'N 136°21'W) on the Yukon River. I have seen a photocopy of this specimen which bears the annotation by Bernard Boivin "Locality too vague, never confirmed and far out of range. Perhaps erroneous as to locality". The species has, however, since been collected at the south end of Kluane Lake (Douglas et al. 1981), but the circle on the map in the *The Rare Vascular Plants of the Yukon* publication was incorrectly placed in the vicinity of Dawson rather than at Five Finger Rapids.

POLYGONACEAE

Erigonum flavum Nutt. var. *aquilinum* Reveal — YUKON: S-facing slope, sandy matrix with gravels and boulders, Aishihik Lake area, *M.A. Sauchyn 323*, 26 July 1981 (DAO, WAT).

This variety is otherwise only known from the type locality in Alaska (Eagle Bluff, 64°48'N 141°12'W) about 425 km to the northwest of Aishihik Lake. Hultén (1967) reported that the Alaskan discovery was nearly 1300 miles (2090 km) north of what had been considered the northernmost limits of *C. flavum s.lat.* This taxon should be added to the list of rare plants in the Yukon Territory (Douglas et al. 1981).

Polygonum buxiforme Small, Knotweed — YUKON: disturbed ground by highway construction buildings, Dempster Hwy., Km 283, 65°55'N 137°32'W, *W.J. Cody 27885*, 16 July 1980; roadside, Dempster Hwy., Km 337, 66°13'N 136°57'W, *W.J. Cody 26697*, 2 July 1980.

This is a native weedy species which is frequent in disturbed situations in the Prairie Provinces (Wolf and McNeill 1986) and has now extended it range in similar situations through the Yukon Territory north to the Dempster Highway.

Polygonum caurianum Robinson — YUKON: open disturbed area, Km 286 Canol Road, *V. Hodgson 145*, 22 July 1980 (DAO); sandy riverbank, McRae's Landing on Stewart River, *Gillett & Mitchell 4176*, 29 July 1949 (DAO); Hunker Camp [Dawson area], *J. Campbell*, 6 September 1950 (DAO); sandy-earthy bank by roadside, south slope of Moosehide Mountain, Dawson, *Calder & Billard 3787*, 19 July 1949 (DAO); open mud flat, Jensen Flats on "loop" southeast of Dawson, 63°42'N 138°33'W, *Calder & Billard 3891*, 24 July 1949 (DAO); cobble riverbank, junction of Rat Indian Creek and Porcupine River, 67°34'N 138°20'W, *L.C. Cwynar 962*, 22 July 1976 (DAO).

Considered rare by Douglas et al. (1981) who knew it from only three localities in the Yukon Territory: Haines Junction, Mayo and Mount Sheldon.

Polygonum convolvulus L., Black Bindweed — YUKON: in old horse corral, southeast of Frances Lake, only a few seen and apparently not maintaining themselves as not seen in 1981 or 1982, *R. Rosie 264*, 24 September 1975 (DAO); south bank of Yukon River near bridge, Carmacks, 62°05'N 136°17'W, *C.E. Kennedy 93A-1*, 10 August 1993 (DAO).

Hultén (1968) knew this introduced species only from Dawson, where it has been collected as recently as 1992, and Whitehorse. The specimens cited above show that the introductions have been more widespread.

Polygonum lapathifolium L., Willow Weed — YUKON: drying up flat by small lake, Old Dawson Road W of Carmacks, 62°07'N 136°22'W, *W.J. Cody 28168a*, 20 July 1980; same locality *W.J. Cody 26392*, 27 June 1980.

Previously known in the Yukon Territory only from Mayo (Douglas et al. 1981).

Rumex acetosa L. ssp. *alpestris* (Scop.) A. Löve — YUKON: moist to dry tundra hillsides, Richardson Mts., 68°31'N 137°03'W, *Cody & Ginns 31655*, 12 July 1982 (DAO); *Festuca*/*Carex* meadow, 4 km S of Upper Liard, 60°07'55"N 128°59'10"W, *D. Murray 11*, 1989 (DAO).

Otherwise in the Territory, this taxon is known only from the Upper Quill creek valley north of Kluane

Lake (Löve and Freedman 1956; Porsild 1966; Douglas et al. 1981). In central Alaska it occurs as far east as about 148°W. It is interesting however that a collection was reported from the adjacent Richardson Mountains in the District of Mackenzie by Erling Porsild (1943 - sub *R. acetosa*). This latter collection is the only one known from the Continental Northwest Territories (Porsild and Cody 1980).

Rumex longifolius DC. — YUKON: Tombstone Mountain Campground, Dempster Highway Km 74, 64°30'N 138°14'W, *Cody & Ginns 29078*, 7 August 1980 (DAO).

New to the flora of the Yukon Territory. Adventive from Europe; previously known in northwestern North America from coastal and inland sites in Alaska.

Rumex salicifolius Weinm. ssp. *triangulivalvis* Danser (*R. triangulivalvis* (Danser) Rech. f., *R. sibiricus* Hultén) — YUKON: disturbed gravel, Ogilvie River crossing, Km 198, Dempster Hwy., *W.J. Cody 27919*, 16 July 1980 (DAO); cobble riverbank, junction of Rat Indian Creek and Porcupine River, 67°32'N 138°20'W, *L.C. Cwynar 901*, 18 July 1976 (DAO); Bone Bar, junction of Schaeffer Lake and Old Crow River, 67°50'N 139°51'W, *L.C. Cwynar 91*, 5 July 1975 (DAO); *Artemsia* bluff at junction of Old Crow and Porcupine rivers, 67°34'N 139°42'W, *L.C. Cwynar 1499*, 26 July 1977 (DAO); Blue Bluff, 67°38.1'N 138°41.6'W, *J.V. Matthews*, 2 August 1981 (DAO); Black Fox bar, 68°2.73'N 139°35.78'W, *J.V. Matthews*, 30 July 1981 (DAO); Black Fox site, 68°04'N 139°34'W, *J.V. Matthews*, 30 August 1981 (DAO).

Hultén (1968) and Porsild and Cody (1980) mapped this species as far north as Dawson. The specimens cited above extend the known distribution in the Yukon Territory north to the Porcupine River drainage.

CHENOPODIACEAE

Atriplex patula L., Spear Orach — YUKON: common around clay margins of dried up alkaline pond, Mile 985 Alaska Hwy., 60°48'N 136°45'W, *Calder & Kukkonen 28252*, 14 August 1960 (DAO); common around clayey margin of alkaline lake between Minto and Pelly Crossing, 62°46'N 136°36'W, *Calder & Kukkonen 28095*, 10 August 1960 (DAO); occasional in wet alkaline margin of a brackish slough, Mile 984.5 Alaska Hwy. west of Whitehorse, *R.L. Taylor 4094*, 14 July 1959 (DAO).

Introduced, new to the flora of the Yukon Territory.

Atriplex subspicata (Nutt.) Rydb. — YUKON: saline pond shore, 15 miles W of Whitehorse on Alaska Highway, 60°51'N 135°36 - 135°45'W, *J. Nathan 141* (DAO).

A native species new to the Yukon Territory where it is at its known northwestern limit. In the District of Mackenzie it is known only from the Salt Plain west of Fort Smith; elsewhere in Canada it is known from Newfoundland to British Columbia (Porsild and Cody 1980).

Chenopodium album L., Lamb's-quarters — YUKON: hot springs near the Beaver River, 60°23'N 125°34'W, *G.W. Scotter 24773*, 22 July 1977 (DAO); open clearing, Stewart Landing, *Gillett & Mitchell 4112*, 27 July 1949 (DAO); along river where garbage is thrown, Ericson's Wood Camp, 16 miles below Big Salmon on the Lewes River, *Gillett & Mitchell 3990*, 25 July 1949 (DAO); waste gravel areas, Whitehorse, *Gillett & Mitchell 3861*, 18 July 1949 (DAO); clearing along river bank, Thistle Creek at Yukon River, 63°04'N 139°29'W, *Gillett & Mitchell 4060*, 26 July 1949 (DAO); disturbed roadside, Klondike Hwy., Km 536, *Cody & Ginns 29251*, 10 August 1980 (DAO); disturbed open area, Km 286, Canol Road, *V. Hodgson 144*, 22 July 1980 (DAO); roadsides, ditches and waste places, Dawson, *Calder & Billard 4558C*, 18 August 1949 (DAO); north fork of Klondike River, *W.E. Cockfield*, 13 July 1919 (CAN); Dawson, *M.O. Malte 283*, 12 August 1916 (CAN); sand dunes along Lake Bennett, *A.E. Porsild 18493*, 25-26 August 1951 (CAN); roadside weed, vicinity of Mackintosh, Mile 1022, Alaska Highway, *Schofield & Crum 7646*, 8 July 1957 (CAN); house clearing, Dublin Gulch, Mayo, *J.D. Campbell 406A*, 12 July 1948 (CAN).

This is a widespread introduced species in North America; Hultén (1968), on his map, has a sweeping line across the southwestern travelled part of the Yukon Territory but did not plot any sites. The specimens cited above confirm its presence in the Territory.

Chenopodium capitatum (L.) Aschers, Strawberry-blite — YUKON: disturbed sandy soil of borrow pit, Km 321, Dempster Hwy., 66°08'N 137°08'W, *W.J. Cody 27869*, 16 July 1980 (DAO).

This is an extension of the known range northward from sites in the Dawson area.

Chenopodium pratericola Rydb. — YUKON: garden area, Haines Junction, 60°46'N 137°35'W, *Cody & Ginns 28392*, 26 July 1980 (DAO); drying up flat by small lake, 2 miles W of Carmacks on old Dawson Rd., 62°07'N 136°22'W, *W.J. Cody 28172*, 20 July 1980 (DAO); dry, sunny south-facing slope, Sunnydale, a few miles south of West Dawson, *Calder & Billard 3691*, 14 July 1949 (DAO); open grassy slope, south slope of Moosehide Mountain, Dawson, *Calder & Billard 4552*, 18 August 1949 (DAO).

This species which occurs from British Columbia to extreme western Ontario and southward into the United States was reported by Packer (1983) as also occurring in the Yukon Territory. Supporting specimens are cited above but in this area they may possibly be introduced.

Chenopodium rubrum L., Red Goosefoot — YUKON: 68°2.73'N 139°35.78'W, *J.V. Matthews*, 30 July 1981 (DAO).

A northward extension of the known range of some 600 km from a site near the Pelly River.

Spinacea oleracea L., Garden Spinach — YUKON: garden area, Haines Junction, Mile 1,019 Alaska Highway, 60°46'N 137°35'W, *Cody & Ginns 28389*, 26 July 1980 (DAO).

New to the flora of the Yukon Territory - probably ephemeral.

PORTULACACEAE

Claytonia ogilviensis McNeill — YUKON: scree slope, 15 miles NNW of Mt. Gibben, 64°55'N 139°19'W, *Cody & Ginns 34165*, 12 July 1984 (DAO); calcareous scree shale, Ogilvie Mountains, Windy Pass, 65°04'N 138°15'W, *C. Parker 1022*, 23 June 1984 (ALA).

These specimens are from the second and third known localities of this rare Yukon endemic that was first discovered by L. H. Green in 1958 in the Ogilvie Mountains at 65°04'N 140°56'W (DAO) near the Alaska border and described by John McNeill in 1972.

Claytonia tuberosa Pall. — YUKON: in deep moist moss by small stream in alpine meadow, Mackenzie Mts., Macmillan Pass area, 63°10'N 130°09'W, *W.J. Cody 29777*, 12 July 1981 (DAO); wet seepage area, Richardson Mts., Dempster Hwy. Km 465, *Cody & Ginns 30080*, 4 July 1982 (DAO); wet alpine tundra meadow, Richardson Mts., 68°08'N 136°46'W, *J.D. Lambert*, 31 July 1966 (DAO).

Hultén (1968) knew this species from the Ogilvie Mts. and the Kluane National Park areas. The specimens cited above represent northward and eastward extensions of the known range of some 400 and 200 km respectively. This amphi-beringian species is also known to the east in the Mackenzie Mts. of western District of Mackenzie (Porsild and Cody 1980).

Montia bostockii (Porsild) Welsh (*Claytonia bostockii* Porsild) — YUKON: tundra turf and seepage area in mountain valley, W of Blackstone River, Alt. 4000 ft., Ogilvie Mts., 65°39'N 137°34'W, *Cody & Ginns 34936*, 17 July 1984 (DAO).

The type of this species was collected by H. S. Bostock in the Dawson range about 62°N 138°W; the main range is however in the Kluane National Park area southwest of the type locality although Hultén (1968) mapped a collection from about 63°30'N latitude in the White Mountains of adjacent Alaska. The specimen cited here is the northernmost yet found, being some 350 km north of the type locality.

Montia scammaniana (Hultén) Welsh (*Claytonia scammaniana* Hultén, *C. arctica sensu* Porsild (1975), *C. porsildii* Jurtsev, *C. sarmentosa sensu* Cwynar (1983)) — YUKON: British Mountains, alpine meadow S of Malcolm R., 69°15'N 140°52'W, *W.J. Cody 27525*, 10 July 1980 (DAO); British Mountains, broken rock and turf and seepage area, 3 km E of Firth R., 69°03'N 140°24'W, *W.J. Cody 27422*, 9 July 1980 (DAO); Barn Mountains, alpine meadow, 68°25'N 138°15'W, *L.C. Cwynar 1367*, 20 July 1977 (DAO); Richardson Mountains: White Mountains, depression in tussock tundra by 'Dall Ridge', 67°59'N 136°32'W, *V. Behan-Pelletier s.n.*, 1 August 1987 (DAO); Richardson Mountains, wet meadow, 66°22'N 135°49'W, *Cody & Ginns 30529, 30540*, 6 July 1982 (DAO); Ogilvie Mountains, 64°38'N 138°32'W, in damp nearly level scree (snowbed site), *R. Frisch s.n.*, 31 July 1976 (DAO).

The map in Hultén (1968) indicated a single locality for this species in the Yukon Territory — presumably based on specimens collected in the McArthur Mountains - Mayo area by Hugh Bostock in 1940 and 1941 (CAN). The species was considered rare in the Yukon Territory by Douglas et al. (1981). The species, as borne out by the specimens cited above is much more widepread than previously thought, but nowhere can it be considered common. Porsild (1975) reported *Claytonia arctica* as new to the Yukon Territory on the basis of a specimen collected by his brother Robert in the Ogilvie Mountains adjacent to the Dempster Highway (*R.T. Porsild 477*) and Jurtsev (1981) pointed out that this latter specimen was quite different from the Siberian plant named *C. arctica* by Adams. Jurtsev named this specimen the type of his new species *C. porsildii* which is here considered a synonym of *M. scammaniana*.

CARYOPHYLLACEAE

Arenaria capillaris Poir. (*A. capillaris* var. *nardifolia sensu* Porsild and Cody (1980)) — YUKON: Richardson Mts., steep striped stony slope, on N side of Dempster Hwy., Km 465, 67°02'N 136°13'W, *Cody & Ginns 30129*, 4 July 1982 (DAO).

The map in Hultén (1968) suggests that this species should be found in northern Yukon Territory. The collection cited here is some 450 km north of the nearest site in the Territory, but it is known from nearer sites in northern Alaska and northwestern District of Mackenzie.

Cerastium arvense L., Field Chickweed — YUKON: Klondike Valley, 63°57'N 138°44'W, *C.E. Kennedy 90-168*, 20 August 1990 (DAO).

This is an extension of the known range of some 150 km northwest from a site on the Pelly River.

Dianthus plumarius L., Garden Pink — YUKON: Haines Junction, Mile 1019 Alaska Highway, 60°46'N 137°35'W, garden area, *Cody & Ginns 28396*, 26 July 1980 (DAO).

Apparently persisting after cultivaton. New to the flora of the Yukon Territory.

Gypsophila elegans Bieb., Baby's Breath — YUKON: by building, Ross River Forestry Station, 61°59'N 132°26'W, *Cody & Ginns 28841*, 3 August 1980 (DAO).

Garden escape; new to the flora of the Yukon Territory.

Honckenya peploides (L.) Ehrh. var. *diffusa* (Hornem.) Mattf., Seabeach-sandwort — YUKON: shores of harbour, 69°08'N 137°56'W, *O. Hughes*, 31 July 1962 (DAO); in open on sandy gravel beach ridge along spit, SE end of Stokes Point Lagoon, 69°21'N 138°44'W, *H.L. Dickson 5900*, 10 August 1983 (DAO); sand spit, Northern Yukon National Park, S of Herschel Island, 69°25'49"N 139°00'15"W, *C.E. Kennedy 89-86*, 1 August 1989 (DAO); Nunaluk Spit, offshore Malcolm River Delta, 69°30'N 139°34'W, *C. Kennedy 240a*, 29 July 1988 (DAO).

Considered rare in the Yukon Territory by Douglas et al. (1981) who knew it only from Herschel Island.

Minuartia rossii (R.Br.) Graebn. ssp. *rossii* — YUKON: alpine slope, Kluane Range, Mt. Desolei E of Kimberley Creek, 4000-5000 ft., 60°50'N 137°57'W, *Cody & Ginns 28700*, 30 July 1980 (DAO); esker ridges near Klutlan Glacier, St. Elias Range, 61°37'N 140°40'W, *G.W. Scotter 20961*, 2 August 1972 (DAO); alpine communities, Kluane National Park, 60°56'N 138°28'W, *G.W. Scotter 21071*, 4 August 1972 (DAO).

In the Yukon Territory this species is otherwise known only from Herschel Island and Shingle Point on the Arctic Coast (Wolf et al. 1979; Douglas et al. 1981).

Minuartia stricta (Sw.) Hiern — YUKON: tundra turf on saddle and adjacent rocky and turfy slope, Mt. Gladman, 64°43'N 140°49'W, *Cody & Ginns 35213*, 19 July 1984 (DAO).

This is a northward extension of the known range of some 400 km from the Kluane region.

Sagina nivalis (Lindbl.) Fries (*S. intermedia* Fenzl) — YUKON: wet depression by creek, Dempster Hwy. Km 47, *Cody & Ginns 29060*, 7 August 1980 (DAO); disturbed gravel of and by old airstrip, Stokes Point, 69°20'N 138°43'W, *W.J. Cody 26937*, 5 July 1980 (DAO); saline marshland, Stokes Point, 69°20'N 138°44'W, *Consaul & Aiken 1007B*, 11 July 1990 (CAN).

These collections represent new localities for a rare Yukon Territory species (Douglas et al. 1981).

Silene vulgaris (Moench) Garcke (*S. cucubalus* Wibel), Bladder Campion —YUKON: waste clearing along road through *Picea glauca-Populus balsamifera* woodland by Klondike River, 15 mi. E of Dawson, 64°04'N 139°05'W, *Cody & Ginns 32877*, 1 July 1984 (DAO); fairly common in hayfield and near buildings, Rock Creek area 12-15 miles east of Dawson, *G. Brunner*, 6 July 1990 (DAO).

Adventive from Europe; in Canada found from Newfoundland and Nova Scotia west to British Columbia (Fernald 1950) and localized in the Yukon Territory from whence it has not previously been recorded.

Spergularia rubra (L.) J. & C. Presl, Purple Sandspurry — YUKON: Km 283 Dempster Highway, 65°55'N 137°32'W, disturbed ground by highway construction buildings, *W.J. Cody 27892*, 16 July 1980 (DAO); Km 84 Canol Road, 61°03'N 133°00'W, roadbed, *Cody & Ginns 28799*, 2 August 1980 (DAO); Km 598, Klondike Highway, borrow pit, 63°37'N 137°36'W, *Cody & Ginns 29231*, 10 August 1980 (DAO); Km 305 Canol Road, 62°20'N 131°37'W, gravel roadside, *W.J. Cody 29745*, 11 July 1981 (DAO); Km 420 Canol Road, Jeff Lake, 63°03'N 130°23'W, disturbed ground *W.J. Cody 29448*, 3 July 1981 (DAO); Km 480 Canol Road, 62°49'N, 130°58'W, *W.J. Cody 29509*, 4 July 1981 (DAO); Km 334 Canol Road, *V. Hodgson 423*, 28 July 1981 (DAO); Km 75 Canol Road, *V. Hodgson 383*, 28 June 1981 (DAO); Sheldon Lake, 62°42'N 131°03'W, *R. Dale 88*, 8 August 1977 (DAO); found with *Matricaria matricarioides* on Cat Road into California Creek, 64°01'N 140°21'W, *G. Brunner 118*, 29 July 1991 (DAO).

Previously reported from the Mayo area by Porsild (1975) and Tom Creek (Rosie 1991). The widely separated roadside locations of these collections would seem to indicate that this plant is being spread by road grading equipment. It will undoubtedly be found to be much more widespread in coming years.

Stellaria dicranoides Fenzl — YUKON: Ogilvie Mountains, shattered stone and turf on mountain top, 65°10'N 138°45'W, alt. 5100 ft., *Cody & Ginns 34224*, 13 July 1984 (DAO); Ogilvie Mountains, Nahoni Range, 65°32'N 139°30'W, 1500 m, common in high elevation, barren ground areas of most mountains in northern Ogilvies visited (about 20 sites) in association with *Papaver walpolei*, which is also common in these same areas — apparently restricted to the "White Dolomite rocks" in this area, *J.D. Lafontaine s.n.*, 8 July 1985 (DAO).

Douglas et al. (1981) reported this species as one of the rare Yukon plants on the basis of a single plant collected by D. M. Wood and J. D. Lafontaine (DAO) on a rocky scree slope on top of a mountain (elev. 1525 m) at km 155 Dempster Highway. This species, which is Amphi-Beringian in distribution, but with large gaps, was known to Hultén (1968) from only four widely separated areas in Alaska. In the Yukon Territory it is certainly more common than originally surmised, as shown by Lafontaine's observations (above), but still very restricted in its range.

Stelleria longifolia Muhl. — YUKON: lake edge, 35 km NE of Old Crow, 67°42'N 139°08'W, *L.C. Cwynar 722*, 9 July 1976 (DAO); grassy clearing, junction of Schaeffer Creek and Old Crow River, 67°50'N 139°51'W, *L.C. Cwynar 290*, 16 July 1975 (DAO).

These collections represent an extension of the known range of this species of some 450 km northward from the vicinity of Dawson.

Stellaria umbellata Turcz. — YUKON: wet depression by creek, Dempster Highway, Km 47, Scout Car Creek, 64°19'N 138°27'W, *Cody & Ginns 29055*, 7 August 1980 (DAO).

This is only the third collection of this rare species in the Yukon Territory. Murray (1971) reported it from the St. Elias Mountains and also mentioned a second collection (*Calder 34333* (DAO)) from Trout Lake in the British Mountains. This latter collection was not seen nor mentioned by Douglas et al. (1981) in their work related to the rare plants of the Yukon. The collection cited above from the Ogilvie Mountains is intermediate between the St. Elias and British Mountain sites.

Vaccaria hispanica (Miller) Rauschert (*V. pyramidata* Medic., *Saponaria vaccaria* L.), Cow Herb — YUKON: West Dawson, *E. Schoff*, July 1904 (TRT, photo DAO); West Dawson, *Macoun*, 23 August 1902 (CAN).

This introduced species was reported by Boivin (1966-67) as occurring in the Yukon Territory but it has been overlooked by recent authors. It has not been observed in the Dawson area in recent years.

CERATOPHYLLACEAE

Ceratophyllum demersum L., Hornwort — YUKON: dredged from middle of lake, Square Lake, 67°51.4'N 139°40.5'W, *J.V. Matthews*, 27 July 1981 (DAO); pond west of Horseshoe Slough, 63°26'N 135°07'W, *V. Loewen 10*, 14 August 1988 (DAO); same locality, *V. Loewen 9*, 11 August 1988 (DAO).

This circumpolar non-arctic species is rare in Alaska and District of Mackenzie (Hultén 1968; Porsild and Cody 1980). Welsh (1974) stated that it occurred in northern Yukon Territory, but did not cite any collections, nor was it reported in his Reconnaissance of Northern Yukon (Welsh and Rigby 1971). Cwynar (1983) was not aware of the earlier report of Holmquist (1971) of an occurence at 68°12'N 139°23'W when he reported a site in Old Crow Flats not far from the Matthews collection cited above. Douglas et al. (1981) were also unaware of this report. The Horseshoe Slough collections cited here are from a site about 550 km southeast of the Old Crow Flats sites.

NYMPHAEACEAE

Nymphaea tetragona Georgi ssp. *leibergii* (Morong) Porsild, Dwarf Water-lily.

In his paper on *Nymphaea tetragona* in Canada, Porsild (1939) cited specimens of ssp. *leibergii* from Quebec to western Great Slave Lake in the District of Mackenzie. Hultén (1949: page 1740) cited a specimen collected by Anderson along the Alaska Highway near the Canadian border. The map in Hultén (1968) depicts a number of localities in the Tanana River valley adjacent to the Alaska Highway, including one on the Yukon side of the Alaska-Yukon border. This latter dot is presumably a misplacement for the *Anderson 9160* collection. A collection by C. H. D. Clarke at Mile 85 Haines Road (CAN) which was initially thought to have been made in the Yukon Territory was later proven to be from northern British Columbia a few miles south of the Yukon border. This species should be looked for in the Yukon Territory.

RANUNCULACEAE

Caltha natans Pall. — YUKON: Netro Lake, 67°50.76'N 139°7.10'W, *J.V. Matthews*, 23 July 1981 (DAO).

This site, which is some 300 km north of sites reported by Porsild (1975) from the Ogilvie Mountains adjacent to the Dempster Highway, is the northernmost yet reported in the Yukon Territory.

Clematis tangutica (Max.) Korsh., Golden Clematis — YUKON: gravel roadbank, McIntyre Creek Road, near Alaska Hwy., Whitehorse, 60°44'N 135°09'W, *Cody et al. 35402*, 24 July 1984 (DAO).

Introduced. New to the flora of the Yukon Territory. Brunton (1979) mapped the known distribution of this species in Alberta. The northernmost site known to him at that time was Edmonton.

Delphinium brachycentrum Ledeb., Larkspur — YUKON: oriented lakes west of Clarence Lagoon, 69°37'N 140°58'W, *C. Kennedy 343*, 8 August 1988 (DAO).

Douglas et al. (1981) recorded only two Yukon Territory localities for this rare Canadian species. This third collection which is cited here is from close to the Alaskan border in Ivavvik (Northern Yukon) National Park.

Ranunculus aquatilis L. var. *eradicatus* Laest. (*R. confervoides* (E. Fries) E. Fries), White Water-buttercup — YUKON: shallow stream, Dog Creek Site, 8 km SW of Sam Lake, 68°23'N 138°46'W, *L.C. Cwynar 1066*, 28 July 1976 (DAO); shallow water, winter road E of Klo Kut and W of Porcupine River, 67°34'N 139°36'W, *L.C. Cwynar 1092*, 4 August 1976 (DAO).

These collections represent a northward extension of the known range in the Yukon Territory of some 400 km, but it is known from the Mackenzie River Delta to the east, and northern Alaska to the west.

Ranunculus cymbalaria Pursh, Northern Seaside Buttercup — YUKON: growing at drying edge of *Arctophila fulva* dominated wet zone, Stokes Point, 69°20'N 138°44'W, *Aiken & Consaul 90-058*, 11 July 1990 (CAN); disturbed gravel, Ogilvie River crossing, Km 198, Dempster Hwy., 65°22'N 138°18'W, *W.J. Cody 27918*, 16 July 1980 (DAO).

This is a circumpolar species which has large gaps in its distribution in northwestern North America and Europe. The collections cited here extend its known range into Ivavvik National Park. It is however known from extreme northwestern District of Mackenzie (Porsild and Cody 1980).

Ranunculus repens L., Creeping Buttercup — YUKON: along edge of small pond in *Carex-Equisetum* community, M1186.5, Alaska Hwy., 62°12'N 140°41'W, *Douglas & Tait 10474*, 28 July 1977 (DAO).

Hultén (1968) plotted seven localities on his distribution map for this species. No specimens from these localities could be located at DAO or CAN. It is possible that records for *R. reptans* L. (*R. flammula* L.) were confused with those for *R. repens* in this work.

Ranunculus sabinei R.Br. (*R. pygmaeus* Wahlenb. ssp. *sabinei* (R.Br.) Hultén.

The map in Porsild (1957) indicates a collection from the vicinity of Herschel Island on the Arctic Coast of Yukon Territory. This report has been repeated in Hultén (1968), Welsh (1974), Porsild and Cody (1980), and Douglas et al. (1981) but in no case was a specimen cited. A search of the herbaria of the Canadian Museum of Nature (CAN) and Agriculture Canada (DAO) at Ottawa failed to uncover a specimen, nor could one be found at Stockholm or Provo.

Ranunculus sulphureus Soland., Sulpher Buttercup — YUKON: S Wernecke Mts., Hart's Pass, 64°40'N 135°07'W, *R. Frisch 18*, 15 July 1979 (DAO); Hart Lake, 64°36'N 135°10'W, *P. Vernon*, July 1961 (DAO); wet turf on mountain saddle, 10 miles E of Blackstone Lake, 65°10'N 137°28'W, *Cody & Ginns 34400*, 14 July 1984 (DAO); tundra turf on mountain top, 20 miles W of Chapman Lake, 64°53'N 138°58'W, *Cody & Ginns 33983*, 8 July 1984 (DAO); alpine tundra turf, SE flank of Mt. Gibben, 64°41'N 139°11'W, *Cody & Ginns 33594*, 6 July 1984 (DAO); wet hummocky *Sphagnum* meadow, Richardson Mts., 67°19'N 136°15'W, *Cody & Ginns 31042*, 9 July 1982 (DAO); windswept turfy tundra and moist meadow valley, Richardson Mts., 66°55'N 136°08'W, *Cody & Ginns 31011*, 8 July 1982 (DAO); wet seepage area, Richardson Mts., N side of Dempster Hwy. Km 465, *Cody & Ginns 30078*, 4 July 1982 (DAO).

Hultén (1968) knew this species in the Yukon Territory from the Kluane and British mountains, but it is here reported for the first time from the Ogilvie, Wernecke and Richardson mountains.

Ranunculus turneri Greene — YUKON: damp mossy sites, old beaches of river, near Dempster Hwy. Km 200, *R. Frisch 15*, 11 June 1979 (DAO).

This collection is from about 225 km south of the Porcupine River in northern Yukon Territory, the southernmost area known to Douglas et al. (1981). The species is also more frequent in the region shown on the map in Douglas et al. and its status as a rare plant should be reassessed.

Thalictrum dasycarpum Fisch. Mey. & Avé-Lall., Purple Meadow Rue — YUKON: hay meadows, 15 miles east of Dawson at Henderson Corner, *G. Brunner 25*, 26 June 1991 and *114*, 22 July 1991 (DAO).

At this locality 40 to 50 plants were observed, all of which had perfect flowers producing pollen and later in the year, mature achenes. Introduced; in its native range, northwestern Ontario to southeastern British Columbia *T. dasycarpum* is largely dioecious, but polygamodioecious plants do occur.

Thalictrum venulosum Trel. (*T. turneri* Boivin) — YUKON: edge of field by old farm, Sunnydale, a few miles south of West Dawson, *Calder & Billard 3703*, 14 July 1949 (DAO); dry ground amongst roses, North Fork, Km 9, Dempster Highway, *S. Frisch*, 9 June 1989 (DAO).

Boivin (1966-67) reported *T. turneri* as occurring in the Yukon Territory, presumably on the basis of the Calder & Billard collection, but the presence of this species in the Territory has been overlooked by recent authors.

PAPAVERACEAE

Papaver mcconellii Hultén — YUKON: broken stone and turf on mountain slope, British Mts., 2 km S of Malcolm R., 69°17'N 140°24'W, *W.J. Cody 27430*, 9 July 1980 (DAO); broken rocky hump on mountain side, British Mts., E of Firth R., 69°12'N 139°32'W, *W.J. Cody 27774*, 12 July 1980 (DAO); braided cobble of river bed, British Mts., Malcolm R. valley, 69°17'N 140°52'W, *W.J. Cody 27513*, 10 July 1980 (DAO); alpine tundra turf on saddle and adjacent slope below, Ogilvie Mts., Cloudy Range, 64°35'N 138°27'W, *Cody & Ginns 33045*, 2 July 1984 (DAO).

Hultén (1968) shows only two localities in the Richardson Mountains on his map. The species is now known from the British Mountains, Ogilvie Mountains, in the Mayo area and Kluane region in addition to other sites in the Richardson Mountains between latitudes 66°N and 68°30'N.

BRASSICACEAE (CRUCIFERAE)

Arabis columbiana Macoun (*A. sparsiflora* Nutt. var. *subvillosa* (Wats.) Rollins) — YUKON: well to rapidly drained undulating mid-slope, Klondike

Highway right-of-way, 11 km S of Carmacks, 62°01'N 136°15'W, *Kennedy & Mossop 2d*, 2 June 1991 (DAO); Rampart House on the Alaska-Yukon border, *J.E.H. Martin 47*, 16 June 1951 (DAO).

This species occurs from southern British Columbia south to Washington, Oregon, Idaho, Nevada, Utah and California and is disjunct to the sites reported above in the Yukon Territory. It should be added to the list of rare species of the Territory (Douglas et al. 1981).

Arabis drepanoloba Greene — YUKON: occasional in alpine meadows near mountain stream, Mt. Caribou, 5 miles N of Carcross, 60°14'N 134°42'W, *Gillett & Mitchell 4546*, 17 August 1949 (DAO); alpine communities, Profile Mts., Kluane National Park, *G.W. Scotter 21285, 21287*, 5 August 1972 (DAO); Kaskawulsh nunatack, St. Elias Mts., jct. N and central arms Kaskawulsh Glacier, *D.F. & B.M. Murray 1075*, 25 July 1967 (CAN, photo DAO).

This species which occurs in southwestern Alberta, southeastern British Columbia and adjacent United States is disjunct to southwestern Yukon Territory. It should be added to the list of rare species of the Territory (Douglas et al. 1981).

Arabis eschscholtziana Andrz. (*A. hirsuta* (L.) Scop. ssp. *eschscholtziana* (Andrz.) Hultén) — YUKON: in lush meadow dominated by *Veratrum eschscholtzii*, on glacial moraine, Fisher Glacier, ca. 6 km SE and ca. 5 km N of British Columbia border, Kluane National Park, 60°03'N 137°53'W, *H.L. & I.J. Weaver 437*, 29 July 1975 (DAO); in *Festuca altaica* community, 1.5 m W of Bates Lake, Kluane National Park, 60°11'N 137°39'W, *H.L. & I.J. Weaver 35*, 4 July 1975 (DAO); prairie, vicinity of Pine Creek near Mi. 1019 [Alaska Highway], 60°47'N 137°35'W, *H.M. & L.G. Raup 11753*, 16 June 1944 (ALA, photo DAO); common in grassy area on slightly alkalie flats, Mile 10 on road to Dawson from Alaska Highway, 60°56'N 135°07'W, *Calder & Gillett 25781*, 22 June 1960 (DAO).

This species which is found in coastal Alaska south through western British Columbia to Washington, Oregon and Idaho is found only in the southwest of the Yukon Territory. It should be added to the list of rare species of the Territory (Douglas et al. 1981).

Arabis exilis A. Nels. — YUKON: occasional and scattered on open, south-facing grassy slope, SW of Squanga Lake at M 858, Alaska Hwy., 60°23'N 133°45'W, *Calder & Gillett 25730*, 20 June 1960 (DAO); west-facing rocky slopes, north end of Marsh L. at M 887, Alaska Hwy., 60°33'N 134°25'W, *Calder & Gillett 24940*, 2 June 1960 (DAO); steep, dry, south-facing bluff at Marsh L., Km 1414, Alaska Hwy., *J.R. Grant 89-00389*, 20 May 1989 (ALA, photo DAO); common on open south-facing grassy-rocky slope, M 952, Alaska Hwy., 60°50'N 135°55'W, *Calder & Gillett 24387*, 12 May 1960 (DAO); same locality, *Calder & Gillett 25107*, 7 June 1960 (DAO); clearing in forest on lower slopes, Mt. McIntyre, south of Whitehorse, *Gillett & Mitchell 3458*, 21 June 1949 (DAO); dry slope, McDougal Lease 7 miles SW of Whitehorse on Fish Lake road, 60°42'N 135°14'W, *J. Nathan 150*, 12 July 1988 (DAO); steep open gravelly slope, Whitehorse, *Gillett & Calder 3104*, 31 May 1949 (DAO); steep, dry, open slope, near McIntyre Creek, Whitehorse, *Gillett & Mitchell 3899*, 20 July 1949 (DAO); open, gravelly areas on west-facing slope below Mt. White, M 3 from Alaska Hwy. on road to Atlin, 60°18'N 133°57'W, *Calder & Gillett 25171*, 9 June 1960 (DAO); common on open, south-facing grassy slopes in a few places, M 13 from Alaska Hwy. on road to Dawson, *Calder & Gillett 24859*, 1 June 1960 (DAO); common on steep, south-facing, grassy slopes above lake, 7 miles north of Carcross, 60°16'N 134°44'W, *Calder & Gillett 24900*, 2 June 1960 (DAO); on dry gravelly esker, Braeburn Lake, 61°27'N 135°48'W, *R.T. Porsild 1918*, 15 July 1969 (CAN, photo DAO).

This species occurs in the northwestern United States, southwestern Alberta and British Columbia north into southwestern Yukon Territory. Specimens have not previously been cited from the Territory.

Arabis glabra (L.) Bernh., Tower Mustard — YUKON: Johnson's Crossing, *M.P. & R.T. Porsild 752*, 16 August 1947 (CAN).

Known only from this locality in the Yukon Territory; probably introduced.

Arabis holboellii Hornem. var. *secunda* (Howell) Jepson — YUKON: in *Populus balsamifera* stand, ca. ½ mi. W of Mile 1022, Alaska Hwy., on Bear Creek Road, *G.W. & G.G. Douglas 5424B*, 27 July 1973 (DAO); common on steep, open west-facing, grassy slope, Conglomerate Mtn., between M 63 & 67 on road from Alaska Hwy. to Dawson, 61°38'N 135°52'W, *Calder & Gillett 24945*, 3 June 1960 (DAO); borrow pit, Clear Cr. at Stewart R., Klondike Hwy. Km 598, *Cody & Ginns 29234*, 10 August 1980 (DAO); rocky bank of Yukon R., Dawson, *Calder & Billard 3001*, 12 June 1949 (DAO); south slope of Moosehide Mtn., Dawson, *Calder & Billard 3215*, 20 June 1949 (DAO).

This variety is widespread across Canada and northwestern United States. It is thus far known from only four localities in the Yukon Territory and should be added to the list of rare plants of the Territory (Douglas et al. 1981).

Arabis kamtschatica (Frisch.) Ledeb. (*A. lyrata* L. ssp. *kamchatica* (Fisch.) Hultén) — YUKON: braided stony streambed and adjacent white spruce and willow scrub, Richardson Mts., 67°27'N 136°38'W, *Cody & Ginns 31191*, 10 July 1982 (DAO); stony braided stream and adjacent willow-spruce of river valley, Richardson Mts., headwaters of Waters River, 68°38'N 137°17'W, *Cody & Ginns 32024*, 15 July 1982 (DAO); 67°27'N 136°22'W, *R.W. Wein 246*, 5 July 1972 (DAO).

Not previously recorded from northern Yukon Territory.

Arabis lignifera A. Nels. — YUKON: scattered on open stony ground on hilltop, app. 4 km SE of Tagish, 60°16'N 134°12'W, *R. Rosie 730*, 18 June 1979 (CAN, photo DAO).

This species is found is southern British Columbia and Alberta south to California and Wyoming, and is disjunct to southwestern Yukon Territory. It should be added to the list of rare species of the Territory (Douglas et al. 1981).

Arabis media N. Busch (*A. arenicola* var. *pubescens sensu* Hultén 1968) —YUKON: disturbed gravel of and by old airstrip, Stokes Pt., 69°20'N 138°43'W, *W.J. Cody 26924*, 5 July 1980 (DAO); disturbed gravel and tundra, Stokes Pt., 69°20'N 138°43'W, *W.J. Cody 27062*, 7 July 1980 (DAO); dunes, west side of Clarence Lagoon, 69°37'N 140°54'W, *L.C. Cwynar 433*, 21 July 1975 (DAO); active delta, Firth River Delta, 69°30'N 139°30'W, *C.E. Kennedy 156*, 26 July 1988 (DAO); headwaters of Bear Creek NW of Trail Creek, 68°51'N 159°52'W, 1160 m, *C.E. Kennedy 88*, 24 July 1988 (DAO); 15 km SSE of Kay Point, 69°08'50"N 138°20'35"W, *C.E. Kennedy 89-172*, 7 August 1989 (DAO).

Hultén (1973) pointed out that he had misapplied the name *Arabis arenicola* var. *pubescens* to the Alaskan plant. *Arabis arenicola* is an endemic of the subarctic and arctic westward to longitude 110°W in Eastern North America from East Greenland. *Arabis media* differs from it in having a more open inflorescence, uniseriate, narrower siliques and slightly more lobed, not fleshy leaves. The map in Hultén (1968) shows that the plant is in the northwestern sector of Alaska west of longitude 150°W and essentially near the coast. It is new to the flora of the Yukon Territory. Our Yukon specimens have petals slightly longer (to 5.5 mm) than specimens in Herb. DAO from the Soviet Union. The species should be added to the list of rare plants of the Yukon Territory (Douglas et al. 1981).

Arabis nuttallii Robins. — YUKON: open sunny slope, Km 47, Tagish Road (about 2 km north of road), *V. Hodgson 288*, 14 June 1981 (DAO); river bank within town limits, Lewes R., Whitehorse, *Porsild & Breitung 9175*, 7 June 1944 (CAN).

This species occurs from southern British Columbia and Alberta south to Washington, Utah and Wyoming, and is disjunct to southern Yukon Territory. It should be added to the list of rare species of the Territory (Douglas et al. 1981).

Arabis pinetorum Tidestrom (*A. holboellii* Hornem. var. *pinetorum* (Tidestrom) Rollins — YUKON: dry prairie on high moraine, vicinity of Champagne, app. 60°47'N 136°28'W, *Raup et al. 13162*, 23 June 1948 (ALA, photo DAO); common in Aspen woods on south-facing prairie slope, M 13 from Alaska Hwy. on road to Dawson, 60°59'N 135°10'W, *Calder & Gillett 24870A*, 1 June 1960 (DAO); common on open, west-facing, rocky-grassy slope, a few miles SE of Minto at M 145 from Alaska Hwy. on road to Dawson, 62°33'N 136°47'W, *Calder & Gillett 24983A*, 3 June 1960 (DAO); along southeast-facing slope in sandy soil, Sunnydale area about 3 miles south of West Dawson, *Calder & Billard 3402A*, 30 June 1949 (DAO); dry, sunny meadow, Rampart House on the Alaska-Yukon border, *C.C. Loan 441*, 15 June 1951 (DAO).

This species occurs from Manitoba to British Columbia south into northwestern United States and north into southwestern District of Mackenzie, Yukon Territory and Alaska. It should be considered for possible addition to the list of rare plants of the Territory (Douglas et al. 1981).

Brassica rapa L. (*B. campestris* L.), Bird Rape — YUKON: garden, Ditch road E of Dempster Hwy. Km 8, 64°02'N 138°36'W, *W.J. Cody 28051*, 18 July 1980 (DAO); Haines Road near Dezadeash Lake, 60°28'N 136°59'W (approx.), *W. Bilawich*, 1990 (DAO).

This introduced species has not previously reported from the Yukon Territory but there is a specimen collected by Elgin Schoff in 1904 labelled only Yukon Territory at TRT.

Cardamine microphylla Adams (*C. minuta* Willd.).

The map for this species in Hultén (1968) depicts an Amphi-Beringian plant that extends as far eastward in northern Alaska at about longitude 144°W. Cody and Porsild (1968) extended the known range eastward to the Richardson Mountains of northwestern District of Mackenzie on the basis of specimens collected by J. A. Calder near the Yukon border. Welsh and Rigby (1971) reported it as new to the flora of the Yukon Territory on the basis of specimens from NE Mount Page and the Malcolm River in the western British Mountains. Douglas et al. (1981) did not include it in their rare plant study because they considered it to be too widespread. There are currently some 34 specimens preserved in DAO which were collected in the British and Richardson mountains south nearly to latitude 66°N.

Cardamine purpurea Cham. & Schlecht. — YUKON: Wernecke Mts., 64°40'N 135°21'W, *R. Frisch 84*, 14 July 1979 (DAO).

The collection cited here is from about 150 km east of sites in the Ogilvie Mountains where the species has been collected numerous times.

Draba cana Rydb. (*D. lanceolata sensu* Am. auth. non Royle) — YUKON: limestone outcrop, Useful Lake, 50 km SSW of Old Crow, 67°11'N 140°26'W, *L.C. Cwynar 260*, 12 July 1975 (DAO); tundra turf on bench, British Mts., Firth R., 69°13'N 139°49'W, *W.J. Cody 27275*, 8 July 1980 (DAO).

Mulligan (1971) mapped this to about 66°N latitude in the Yukon Territory. He did, however, plot a collection from the mountains of northern Alaska near the Yukon border.

Draba corymbosa R.Br. ex DC. (*D. macrocarpa* Adams) — YUKON: wet talus slope, Goatherd Mtn. ca. 37 mi. SSE of Haines Junction, *G.W. Douglas 6957*, 11 August 1973 (DAO); high ridge, St. Elias Mts., 60°55'N 138°43'W, *D.F. & B.M. Murray 927*, 9 July 1967 (DAO); high ridges below "Fox" Glacier, St. Elias Mts., *D.F. & B.M. Murray 1818*, 17 July 1968 (DAO); wet alpine scree slope, Hoodoo Mtn., 60°43'N 138°14'W, *G.W. Douglas 10832*, 11 July 1978 (DAO); moist alpine scree slope, Chalcedony Mtn., ca. 23 mi. WSW of Haines Junction, *G.W. & G.G. Douglas 6782*, 3 August 1973 (DAO); alpine communities, Mt. Maxwell, 60°45'N 138°34'W, *G.W. Scotter 21144*, 4 August 1972 (DAO); high alpine boulder field, Ruby Range, *J. Bastido 11*, 10 August 1981 (DAO); shattered limestone on mountain top, 12 miles NNW of Mt. Harper, 64°44'N 140°14'W, *Cody & Ginns 34387*, 13 July 1984 (DAO); broken rocky saddle and adjacent rocky slopes, 15 miles NNW of Mt. Gibben, 64°55'N 139°19'W, *Cody & Ginns 34208*, 12 July 1984 (DAO); reddish limestone mountain top, 12 mi. NNE of Chapman Lake, 65°00'N 138°13'W, *Cody & Ginns 33858*, 8 July 1984 (DAO); rock knoll, McNeish Site, 60 km W of Stokes Point, 69°21'N 139°30'W, *L.C. Cwynar 388*, 21 July 1975, (DAO); alpine fell fields, west side of White Mountain, 67°59'N 137°47'W, *Welsh & Rigby 12182*, 27 June 1973 (photo DAO).

Hultén (1968) sub. *D. macrocarpa* plotted only two specimens from sites in the Yukon Territory, one in Kluane National Park and one on the Arctic Coast neither of which have been examined. From the above however, it can be seen that this species is distributed widely in the mountainous regions of the Territory.

Draba incerta Payson — YUKON: scree slope, Dempster Hwy., Km 224, 65°34'N 138°10'W, *W.J. Cody 26679*, 2 July 1980 (DAO); west-facing limestone outcrop in alpine tundra, Southern Richardson Mts., 66°04'N 135°50'W, *L.C. Cwynar 1175*, 6 July 1977 (DAO); turfy limestone alpine tundra, same locality, *L.C. Cwynar 1166*, 5 July 1977 (DAO).

Nagy et al. (1979) extended the known range north to 68°N latitude from Kluane National Park and the Carcross area. The specimens cited above now record the presence of this species in the northern Ogilvie Mountains and the southern Richardson Mountains.

Draba lactea Adams — YUKON: alpine tundra turf on saddle and adjacent slope below, Cloudy Range, 64°35'N 138°27'W, *Cody & Ginns 33034*, 2 July 1984 (DAO); shattered limestone on mountain top, 12 miles NNW of Mt. Harper, 64°44'N 140°14'N, *Cody & Ginns 34388*, 13 July 1984 (DAO); limestone rubble and patchy turf on saddle, 4 miles S of Ogilvie River, *Cody & Ginns 33903*, 8 July 1984 (DAO); Clarence Lagoon, Northern Yukon National Park, 69°37'N 140°44'W, *C. Kennedy 265*, 30 July 1988 (DAO); Clarence Lagoon, 69°37'N 140°46'W, *P.F. Cooper 784*, 8 July 1979 (CAN).

Hultén (1968) knew this species in the Yukon Territory only from adjacent to the Canol Road and in the extreme southwest. Welsh and Rigby (1971) reported six collections from the northern part of the Territory but these have been revised to either *D. fladnizensis* Wulf. or *D. palanderiana* Kjellm. by G.A. Mulligan. The specimens cited here are thus the first reports for the Ogilvie and British mountains.

Draba macounii Schulz — YUKON: shattered stone and turf on mountain top, Ogilvie Mts., 65°10'N 138°45'W, *Cody & Ginns 34232*, 13 July 1984 (DAO); dry river bottom in turf on outwash areas, Richardson Mts., 68°00.5'N 136°38'W, *Cody & Ginns 31852*, 13 July 1982 (DAO); fine broken stones and turf in saddle and adjacent slopes, Richardson Mts., 68°06'N 136°37'W, *Cody & Ginns 31800*, 13 July 1982 (DAO); rare on rock ledges at base of cliff above timberline, mountain 4 miles west of Upper Hyland Lake, 62°03'N 128°59'W, *Calder & Kukkonen 27905*, 3 August 1960 (DAO).

Porsild (1975) reported this species as new to the Yukon Territory on the basis of specimens collected by R.T. Porsild adjacent to the Dempster Highway. Specimens cited above extend the known range northward to the Ogilvie Mountains. Mulligan (1976) reported it from the southern part of the Territory on the basis of collections from Kluane National Park. The Calder and Kukkonen collection from near the Mackenzie border is intermediate between Kluane Park and sites reported by Cody and Porsild (1968) in the southern Mackenzie Mountains.

Draba nivalis Liljebl. — YUKON: loose scree in slopes of ridge rising SW of lake, vicinity of Summit Lake, Richardson Mts., 67°42'N 136°28'W, *J.G. Packer 1282*, 28 July 1981 (DAO); Pennsylvanian limestone ridgetop in *Dryas-Saxifraga oppositifolia* heath, Fish Creek, 68°N 136°32'W, *S.L. Welsh 11982*, 19 June 1973 (CAN).

The collections cited here which are the first reports for the Richardson Mountains are an extension of the known range of some 400 km north from sites in the Ogilvie Mountains adjacent to the Dempster Hwy. (Porsild 1975).

Draba porsildii G.A. Mulligan — YUKON: alpine tundra, Dempster Highway, 64°41'30"N 138°24'23"W, 1165 m. a.s.l., *C.E. Kennedy 92A-61*, 19 July 1992 (DAO).

This is an extension of the known range of some 425 km northward from Kluane National Park and a site on the Canol Road to the Ogilvie Mountains.

Draba stenoloba Ledeb. — YUKON: wet sedge, British Mountains, 69°26'N 140°45'W, *A.M. Martell 79-38a*, 13 July 1979 (DAO).

This collection is disjunct some 550 km to the northwest from a site in the White Mountains of central Alaska plotted by Hultén (1968); elsewhere in the Yukon Territory it is known in the south only north to about latitude 63°N along the Canol Road.

Draba stenopetala Trautv. — YUKON: stony alpine tundra turf summit and upper steep slopes, Ogilvie Mountains, alt. 6100 ft., 64°39'N 138°10'W, *Cody & Ginns 33009*, 2 July 1984 (DAO); shattered rock with patches of turf, Ogilvie Mountains, alt. 6600 ft., 64°34'N 137°35'W, *Cody & Ginns 34100*, 12 July 1984 (DAO).

Douglas et al. (1981) included this species in their list of the rare plants of the Yukon Territory. At that time *D. stenopetala* was known only from the St. Elias Mountains. The specimens cited here are an extension of the known range northward some 400 km to the mountains of central Yukon Territory where it occurs at similar altitudes.

Halimolobus mollis (Hook.) Rollins — YUKON: rocky knoll, 60 km W of Stokes Point, 69°21'N 139°30'W, *L.C. Cwynar 400*, 21 July 1975 (DAO); *Artemisia* bluff at junction of Old Crow and Porcupine rivers, 67°34'N 139°42'W, *L.C. Cwynar 1496*, 26 July 1977 (DAO); dry south-facing silty bluff, 13 km upstream of junction of Old Crow and Porcupine rivers, 67°35'N 139°30'W, *L.C. Cwynar 706*, 7 July 1976 (DAO); south-facing silt bluff, E of Old Crow Ski Lodge, 67°34'N 139°49'W, *L.C. Cwynar 439*, 4 June 1976 (DAO); 2nd Caribou Lookout, 67°35'N 139°32.5'W, *J.V. Matthews*, 30 July 1981, (DAO).

The specimens cited above represent new records for northern Yukon Territory as indicated on the distribution maps for this species given in Hultén (1968) and Porsild and Cody (1980).

Lepidium bourgeauanum Thell. — YUKON: shallow soil over broken rock by radio tower, N of junction of Forty Mile Road and Klondike Loop Hwy., 64°14'N 140°25'W, *Cody & Ginns 28980*, 6 August 1980 (DAO); gravel beach of Ogilvie R., Km 243 Dempster Hwy., 65°43'N 138°00'W, *W.J. Cody 27912*, 16 July 1980 (DAO); disturbed ground by highway construction bldgs., Km 283 Dempster Hwy., 65°55'N 137°32'W, *W.J. Cody 27886*, 16 July 1980 (DAO).

Mulligan (1961) knew this mainly western species from only four localities in the Yukon Territory: Pine Creek [Haines Junction], Carcross, Dawson and West Dawson, presumably all the results of introductions. In addition to the above collections which extend the known range northward there are an additional 12 specimens in DAO from across the southern parts of the Yukon Territory.

Lepidium ramosissimum A. Nels. — YUKON: gravel and silt road allowance, Klondike Loop Highway near Braeburn Lake, 61°27'N 135°45'W, *Cody & Ginns 32821a*, 29 June 1984 (DAO); gravel road allowance Klondike Loop Highway, Km 571, 63°32'N 137°05'W, *Cody & Ginns 32853*, 30 June 1984 (DAO); along gravelly roadside, Tower Hill, Tagish, *R. Rosie 738*, 20 July 1979 (DAO).

Introduced; new to the flora of the Yukon Territory; a map depicting the Canadian distribution is given in Mulligan's (1961) treatment of the genus *Lepidium*.

Lesquerella arctica (Wormskj.) S. Wats. ssp. *calderi* (Mulligan & Porsild) Hultén (*L. calderi* Mulligan & Porsild) — YUKON: Hope Lake, 66°04'N 135°50'W, *L.C. Cwynar 1315*, 14 July 1977 (DAO); flat broken limestone, turfy tableland, headwaters of Doll Creek, 66°08'N 135°44'W, *Cody & Ginns 30466*, 6 July 1982 (DAO); turfy tundra, rocky outcrops and soil boils in saddle, 66°08'N 135°51'W, *Cody & Ginns 30248*, 5 July 1982 (DAO); alpine summit, east side of Mt. Raymond, 66°23'N 136°10'W, *Cody & Ginns 30672*, 7 July 1982 (DAO); steep slide rock and turfy valley wall, 66°48'N 136°13'W, *Cody & Ginns 30763*, 7 July 1982 (DAO); stony dry river bed, 68°02'N 136°47W, *Cody & Ginns 31473*, 11 July 1982 (DAO); ALASKA: east facing limestone cliff and rubble slopes, Keele Mts., 3.9 km SE of VABM White, 66°37'N 141°07'W, *R. Lipkin 91-4*, 8 June 1991 (DAO).

Mulligan and Porsild (1969a) reported this taxon from near Horne Lake, 67°49'N 135°59'W in the Richardson Mountains, in northwestern District of Mackenzie. The specimens cited above are however the first reports from the Richardson Mountains, in northeastern Yukon Territory and the first for the State of Alaska. Sites in the Wernecke Mountains were reported by Bird (1974).

Neslia paniculata (L.) Desf., Ball Mustard — YUKON: Dawson, *E. Schoff*, 1904 (TRT, photo DAO); Dawson Creek, *Macoun*, 6 August 1902 (CAN).

Boivin (1966-67) reported this introduced species for the first time from the Yukon Territory, but did not cite any collections or localities. It has not been observed in the Territory since 1904.

Parrya arctica R.Br. — YUKON: top of cliffs just E of Boot Eating Creek, Herschel Island, *P.F. Cooper 433*, 9 May 1979 (DAO).

This species which is endemic to the Canadian Arctic Archipelago is new to Yukon Territory. It should be added to the list of rare plants (Douglas et al. 1981).

Rorippa barbareifolia (DC.) Kitagawa — YUKON: sparse along muddy lake margin, 35 km NE of Old Crow, 67°42'N 139°08'W, *L.C. Cwynar 720*, 9 July 1976 (DAO); riverbank, junction of Porcupine and Rat Indian creeks, 67°34'N 138°20'W, *L.C. Cwynar 932*, 20 July 1976 (DAO); stony braided stream and adjacent willow-spruce of river valley, Richardson Mts., headwaters of Waters River, 67°38'N 137°17'W, *Cody & Ginns 32040*, 15 July 1982 (DAO).

Previously known in northern Yukon Territory only from a sandy cliffside at Rampart House on the Yukon-Alaska border (Douglas et al. 1981). The collections cited here extend the known range eastwards towards the only site known in the District of Mackenzie at Fort McPherson (Hultén 1968; Cody 1979).

Smelowskia borealis (Greene) Drury & Rollins ssp. *borealis* — YUKON: Richardson Mts., alpine saddle and scree slopes, 66°44'N 135°53'W, alt. 3200 ft., *Cody & Ginns 30966*, 8 July 1982 (DAO); limestone scree, southern Richardson Mts., 66°04'N 135°50'W, *L.C. Cwynar 1180*, 6 July 1977 (DAO).

These collections are the first reported from the Richardson Mountains. To the southeast this taxon is known from the Knorr Range of the Mackenzie Mountains (Bird 1974).

Smelowskia borealis (Greene) Drury & Rollins ssp. *jordalii* (Drury & Rollins) Cody — YUKON: altered basic volcanics at 5000', Upper Malcolm River, 69°11'N 140°55'W, *O. Hughes*, 2 August 1962 (DAO); Mount Sedgwick [68°53'N 139°08'W) *C. Kennedy 121*, 25 July 1988 (DAO).

Not previously reported from the Yukon Territory.

Thlaspi arvense L., Penny Cress — YUKON: Columbia Gas Plant, 60°06'27"N 124°07'16"W, *D.W. Smith*, 26 August 1980 (DAO); open disturbed area, Km 286, Canol Road, *V. Hodgson 143*, 22 July 1980 (DAO); roadside gravel, Canol Rd., 62°48.5'N 131°01'W, *W.J. Cody 29487*, 4 July 1981; by building, Ross River Forestry Station, 61°59'N 132°26'W, *Cody & Ginns 28844*, 3 August 1980 (DAO); clearing along river shore, Minto, 62°36'N 136°52'W, *Gillett & Mitchell 4036*, 26 July 1949 (DAO); along roadside embankment, about 2 miles east of Dawson, *Calder & Billard 3513*, 4 July 1949 (DAO); cabin clearing, Ditch Road E off Dempster, Km 8, 64°02'N 138°36'W, *W.J. Cody 28006*, 18 July 1980 (DAO).

Hultén (1968) knew this species from two localities in south central Yukon Territory. Rosie (1991) added another site at Frances Lake [61°25'N 129°30'W] and suggested that this weedy species would probably be found at other sites beyond those known by Hultén (1968).

SAXIFRAGACEAE

Boykinia richardsonii (Hook.) Gray - YUKON: only noted in one spot along alpine rivulet at about 4000 ft. in small valley below saddle, Ogilvie Mts., 65°37'N 138°56'W, *Calder & Gillett 25924*, 26 June 1960 (DAO); steep rocky seepage slope 10 miles NW of Chapman Lake, 64°58'N 138°08'W, *Cody & Ginns 34164*, 12 July 1984 (DAO); damp alpine meadows, 5000 ft., Ogilvie Mts., E of Dempster Hwy. Km 205, *R. Frisch 159*, 8 August 1980 (DAO); colonizing steep south (N-facing) bank of creek, Gillespie Creek (tributary of Bonnet-Plume R.), 64°43'N 133°38'W, *R. Frisch 160*, 22 September 1979 (DAO).

Only one Ogilvie Mountain locality was plotted by Hultén (1968); this presumably was based on the specimen collected by Calder & Gillett cited above. The central Yukon Territory range is extended south-eastwards across the Ogilvies by some 300 km by the additional collections cited above. The species is apparently rare in this area but much more frequent in the Alaskan mountains to the west and in the British Mountains to the north.

Chrysosplenium wrightii Fr. & Sav.

This species was considered to be rare in the Yukon Territory by Douglas et al. (1981). It is now represented in DAO and CAN by 10 specimens from the Ogilvie Mountains, 2 from the British Mountains, 3 from the Richardson Mountains at the Yukon-Mackenzie border, 8 from the St. Elias Range, and one from the vicinity of Carcross. Its status should be reviewed.

Saxifraga aizoides L., Yellow Mountain Saxifrage — YUKON: seepage slope, west side of Sheep Creek Valley at junction of Firth River, 69°10'N 140°20'W, Northern Yukon National Park, *C.E. Kennedy 89-4*, 19 July 1989 (DAO).

Saxifraga aizoides is considered rare in the Yukon Territory by Douglas et al. (1981), who reported it from the Canol Road, Selwyn Mountains and Ogilvie Mountains. The collection cited above is an extension of the known range of some 440 km northward from the Ogilvie Mountain sites. The known range of this species has also recently been extended into northern Alaska (Schick 1992).

Saxifraga bronchialis L. ssp. *codyana* (Zhmylev) Cody (*S. codyana* Zhmylev 1992).

This taxon is endemic to the British Mountains and northern Richardson Mountains of the Yukon

Territory and Philip Smith Mountains of the Brooks Range in northern Alaska. Additional collections from the British Mountains not seen by Zhmylev have since been found: headwaters of Bear Creek NW of Trail Creek, 68°51'N 139°52'W, *C. Kennedy 90b*, 1988 (DAO); south-facing slope of upper outcrop, Craig Creek, 69°28'N 140°59'W, *Consaul & Aiken 850*, 4 July 1990 (CAN); 69°27'N 139°42'W, *P.F. Cooper 917*, 12 July 1979 (CAN); 69°10'N 139°14'W, *P.F. Cooper*, 11 July 1979 (CAN).

Saxifraga oppositifolia L. ssp. *smalliana* (Engler & Irmsch.) Hultén, Purple Saxifrage — YUKON: steep sparsely vegetated limestone slopes, Mt. Sedgewick, 68°53'N 139°06'W, *J.A. Calder 34393*, 19 July 1962 (DAO); alpine tundra, Cottonwood Creek (headwaters), 68°42'N 139°36'W, *Nagy & Larsen 74-8*, 25 May 1974 (DAO); turfy broken rocky dome, 10 km E of Firth R., 68°49'N 140°14'W, *W.J. Cody 27351*, 9 July 1980 (DAO); turf and braided cobble of river bed, Malcolm R. valley, 69°19'N 140°18'W, *W.J. Cody 27477*, 10 July 1980 (DAO); stony slope S of Malcolm R., 69°15'N 140°52'W, *W.J. Cody 27541*, 10 July 1980 (DAO).

The specimens cited above extend the known range of this subspecies eastwards from the Brooks Range in northern Alaska into the British Mountains of northern Yukon. In the Yukon Territory ssp. *smalliana* is also known in the Ogilvie Mountains (Hultén 1968).

Saxifraga razshivinii Zhmylev (*S. davurica sensu* N. Am. auth.) — YUKON: alpine saddle in turf, 66°02.5'N 135°32'W, *Cody & Ginns 30436*, 6 July 1982 (DAO); wet meadow, 66°22'N 135°49'W, *Cody & Ginns 30532*, 6 July 1982 (DAO); wet draw in mud, 66°16'N 135°48'W, *Cody & Ginns 30413*, 6 July 1982 (DAO); moist alpine turf, 67°33'N 136°25'W, *Cody & Ginns 31231*, 10 July 1982 (DAO); moist turf on stony slope by small stream, Bell River, 68°07'N 137°06'W, *Cody & Ginns 31998*, 14 July 1982 (DAO); exposed slope, 68°08'N 136°46'W, *J.D. Lambert*, 31 July 1966 (DAO); alpine tundra, 68°18'N 136°30'W, *Cody & Ginns 31286*, 11 July 1982 (DAO); patchy turf and broken stone in saddle, Spear Mt., 68°18'N 136°59'W, *Cody & Ginns 31941*, 14 July 1982 (DAO); open south-facing slopes, Boulder Ck., *Nagy & Goski 74-151a*, 22 June 1974.

This species was known in the Yukon Territory from the British, Ogilvie and Kluane mountain areas (Hultén 1968) but has not previously been recorded from the Richardson Mountains in the northeast.

Saxifraga rufopilosa (Hultén) A.E. Porsild (*S. nivalis* L. var. *rufopilosa* Hultén — YUKON: upper middle slope of mountain-stony, S side of Empire Mtn., 69°07'N 140°53'W, *W.J. Cody 27588*, 10 July 1980 (DAO); dry slope, upper Fish Creek, 69°24'N 140°27'W, *W.J. Cody 27636A*, 11 July 1980 (DAO); shale slope, 12 km S of Clarence Lagoon, 69°30'N 140°47'W, *W.J. Cody 27000*, 6 July 1980 (DAO).

These collections, all from the British Mountains represent an extension of the range in the Yukon Territory known to Porsild (1975) of some 350 km northward from sites in the Ogilvie Mountains.

Saxifraga serpyllifolia Pursh — YUKON: wet alpine meadow, 68°08'N 136°46'W, *J.D. Lambert*, 31 July 1966 (DAO); fine broken stones and turf in saddle, 68°06'N 136°37'W, *Cody & Ginns 31817*, 13 July 1982 (DAO).

This species has not previously been reported from the Richardson Mountains in northeastern Yukon Territory. Elsewhere in the Territory it is known from the British, Ogilvie and Kluane mountain regions.

ROSACEAE

Dryas drummondii Richards., Yellow Dryas — YUKON: gravel wash, Dempster Hwy., Km 157, 65°04'N 138°20'W, *Cody & Ginns 29102*, 8 August 1980 (DAO); gravel beach of Ogilvie R., Km 243, Dempster Hwy., 65°43'N 138°00'W, *W.J. Cody 27915*, 16 July 1980 (DAO); Bonnet Plume R., 65°01'N 134°05'W, *P. Vernon*, 6 July 1961 (DAO); gravel creek bed, Canyon Creek, Richardson Mts., 66°11'N 136°05'W, *Cody & Ginns 30340*, 5 July 1982 (DAO); Bluefish Sect. Bar., 67°23.1'N 140°21.6'W, *J.V. Matthews*, 17 July 1981 (DAO).

The known range of this species in the Yukon Territory which was previously only slightly north of latitude 64° is now extended some 400 km northward.

Dryas hookeriana Juz. — YUKON: moorland ridges between the valleys, southern spur of Mt. Sheldon, [62°44'N 131°05'W] *R. Dale 60*, 29 July 1977 (DAO); on alpine tundra, 1530 m, Nipple Mtn., East Arm, Frances Lake, *R. Rosie BCPM109*, 18 July 1973 (DAO); alluvial terrace on the river floodplain, Bonnet Plume River, 64°56'N 133°50'W, *C.E. Kennedy 92B-81*, 17 August 1992 (DAO).

In the Yukon Territory, previously known only from Kluane National Park (Porsild and Cody 1980).

Geum glaciale Adams — YUKON: windswept turfy tundra and moist meadow valley, Richardson Mts., 66°55'N 136°08'W, *Cody & Ginns 31007*, 8 July 1982 (DAO); very wet drainage channel through alpine meadow, Richardson Mts., 66°22'N 135°49'W, *Cody & Ginns 30543*, 6 July 1982 (DAO); common on open NE-facing alpine slopes, Ogilvie Mts., approx. 65°37'N 138°56'W, *Calder & Gillett 25921*, 26 June 1960 (DAO); rock glacier at 5000 ft., to east above Bond Creek, 64°44'N 134°45'W, *P. Vernon*, 11 July 1961 (DAO); Selywyn Mts.: 'Shortcut Creek' (Bonnet-Plume R), 4000 ft., 64°43'N 133°38'W, *R. Frisch 102b*, 22 September 1979 (DAO); alpine site above Bonnet Plume River, 64°56'N 133°50'W, *M. Williams 92B-*

58, 16 August 1992 (DAO); Mackenzie Mts.: Reptile Creek, 5000 ft., 64°40'N 132°00'W, *F. Frisch 102a*, 11 September 1979 (DAO).

The map in Hultén (1968) shows this species as occuring in the Yukon Territory only on Herschel Island, extreme northern Richardson Mountains and on the Alaskan border south of the Arctic Circle. It is, however, frequent in the British Mountains and northern Richardson Mountains and is now known, as indicated above, to be widely distributed southward.

Geum triflorum Pursh, Prairie Smoke — YUKON: common on open grassy flats in opening in dry spruce forest, near Minto, Mile 147 from Alaska Highway on road to Dawson, 62°35'N 136°49'W, *Calder & Kukkonen 28071*, 10 August 1960 (DAO); open dry roadside, rangeland occupied by both elk and horses which straddles the Alaska Highway at the Takhini River burn (1958), Stony Creek, 60°50'N 135°50'W, *R. Florkiewicz 53*, 13 June 1988 (DAO).

This is an extension of the known range of this prairie species from the Peace River Region to the south and from dry prairies south of Great Slave Lake in southwestern District of Mackenzie (Porsild and Cody 1980). New to the flora of the Yukon. The species should be added to the list of rare vascular plants of the Yukon (Douglas et al. 1981).

Potentilla biennis Greene — YUKON: summit of hill, Dawson, *Macoun*, 8 August 1902 (CAN); on the hill, by the Klondike River near Dawson, *Macoun*, 11 July 1902 (CAN).

This is a native species of southern interior British Columbia and western United States presumably introduced in the Dawson area at the time of the Gold Rush.

Potentilla bimundorum Sojak (*P. multifida* auth.) — YUKON: old gravel beach, Burwash, 61°22'N 138°59'W, *Raup et al. 13953*, 2 August 1948 (CAN); gravel outwash fan, Mile 1054 Alaska Highway, *G.W. & G.G. Douglas 5530*, 1 July 1973 (CAN); silt-gravel river flats, White River along Alaska Highway, 61°59'N 140°33'W, *Calder & Gillett 26383*, 2 July 1960 (DAO); disturbed gravel by building, Arctic Institute Establishment, Kluane Lake, 61°02'N 138°25'W, *W.J. Cody 25887*, 18 June 1980 (DAO).

Porsild (1966) reported the first collection of this species for the Yukon Territory from Silver City at the south end of Kluane Lake. Hultén (1968) knew the species only from the vicinity of Dawson.

Potentilla bipinnatifida Dougl. ex Hook. — YUKON: open meadow, Rampart House on the Alaska-Yukon border [67°25'N 140°59'W], *C.C. Loan 694*, 9 August 1951 (DAO); dry gravelly area, vicinity of Mackintosh, *Schofield & Crum 7330*, 29 June 1957 (CAN); common in prairie, vicinity of Mackintosh, *Schofield & Crum 8008*, 26 July 1957 (CAN); open site in black moist soil, St. Elias Mts., Kaskawalsh River Valley, *A.M. Pearson 67-280*, 16 July 1967 (CAN).

These are the only records for the Yukon Territory of a native species which occurs across Canada from Newfoundland to British Columbia. It is new to the Yukon Territory and should be added to the list of rare plants (Douglas et al. 1981).

Potentilla egedii Wormskj. — YUKON: Herschel Island, 69°31'N 139°06'W, *C. Kennedy 917*, 10 August 1985 (DAO); on built up organic debris at mouth of river, coastline between Running River and Shingle Point 68°58'N 137°16'W, *S.G. Aiken 88-219*, 12 July 1988 (CAN).

This is a circumpolar halophyte, with a rather broken distribution, which is new to the known flora of the Yukon Territory. To the east it is known near the mouth of the Mackenzie River and to the west, along the west coast of Alaska. The species should be added to the list of rare plants of the Yukon Territory (Douglas et al. 1981).

Potentilla gracilis Dougl. — YUKON: sunny, dry, gravel area, Km 312 Canol Road, *V. Hodgson 440*, 29 July 1981 (DAO).

Previously known in the Yukon Territory only from the vicinity of Dawson and the Whitehorse-Haines Junction-Kluane Lake area.

Potentilla norvegica L. — YUKON: Big Lake site (Netro Lake), 67°52.4'N 139°10.6'W, *J.V. Matthews*, 23 July 1981 (DAO); Husky Lake, 68°19.19'N 140°8.15'W, *J.V. Matthews*, 26 July 1981 (DAO).

These collections represent a northward extension of the known range of some 300 km from a site adjacent to the Dempster Highway.

Potentilla ovina J.M. Macoun — YUKON: Mount St. Elias Quad., Outpost Mt. at south end of Kluane Lake, 60°56'N 138°22'W, ca 2140 m.s.m., *D.F. Murray 3429*, 17 July 1971 (CAN); Kaskawulsh nunatak, jct. N and central arms Kaskawulsh Glacier, W of Kluane Lake, 6000 ft., *D.F. & B.M. Murray*, 1 July-1 August 1965 (CAN).

These collections represent a northwestward extension of the known range from the mountains of southwestern Alberta at about 53°N latitude, a distance of some 1300 kilometers. Elsewhere in Canada this species is only known along the east slope of the Cordilleran in western Alberta (Packer 1983) and extreme southeast British Columbia (Straley et al. 1985); southward it extends to California, Utah and New Mexico. *Draba kananaskis* is similarly disjunct (Mulligan 1970) as is *D. albertina* (Mulligan 1975) although the latter is more widespread both in southern British Columbia and the Yukon Territory.

Potentilla pensylvanica L. — YUKON: Rocky outcrop, Firth River, 69°12'N 140°07'W, *A.M. Martell 80-13*, July 1979 (DAO).

Cwynar (1983) reported a considerable northward extension of the known range from about latitude 64°N to Old Chief at 67°35'N in the Porcupine River valley. The collection reported here is a further northward extension of nearly 200 kilometers to the British Mountains.

Potentilla pulchella R.Br. — YUKON: Herschel Island, 69°34.5'N 138°54.2'W, *J.V. Matthews*, 31 July 1983 (DAO); Ptarmigan Bay spit (opposite Herschel I.), 69°29;'N 139°05'30"W, *C.E. Kennedy 89-112*, 4 August 1989 (DAO).

Douglas et al. (1981) map a site on the north slope of the Richardson Mountains, cite Welsh (BRY, 1971, 1974), and give the habitat "shale slopes in the arctic". No specimens of this species are cited by Welsh and Rigby (1971) or by Welsh (1974) who stated that the species does occur in northern Yukon. This latter statement may have been based on the distribution map in Hultén (1968).

FABACEAE (LEGUMINOSAE)

Astragalus bodinii Sheld. — YUKON: disturbed ground, Albert Creek, Cassiar Hwy. S of Alaska Hwy., 60°02'N 129°03'W, *W.J. Cody 25549*, 10 June 1980; Hess River, 63°22'N 131°54'W, *W.J. Cody 29735*, 10 July 1981 (DAO); on sand bar along Rock Creek, 66°58'N 136°56'W, *Welsh & Rigby 12236*, 28 June 1973 (CAN).

The collections cited above are widely separated east and north of the main range in the Yukon Territory where at least in some localities it appears to be invading disturbed situations.

Astragalus eucosmus Robins. ssp. *eucosmus* — YUKON: gravel flats of creek, "Peavine Camp" on tributary of Porcupine, 65°48'N 138°35'W, *Calder & Gillett 26233*, 28 June 1960 (DAO); wooded levee, Canyon Creek, Richardson Mts., *Cody & Ginns 30311a*, 5 July 1982 (DAO); in sand among washed stones of braided stream bed, tributary of Firth R., 69°07'N 140°15'W, *W.J. Cody 27158*, 7 July 1980 (DAO).

The collections cited here represent extensions of the known range in the Yukon Territory north from about latitude 64°N.

Astragalus eucosmus Robins. ssp. *sealei* (Lepage) Hultén - YUKON: bog tussocks, ca 4 miles up Dezadeash River Valley from Mackintosh, *Schofield & Crum 7382*, 30 June 1957 (CAN); on dry gravel behind river, Dempster Rd., Mile 57, *R.T. Porsild 225* (CAN); 14 km SSE of Kay Point, 69°11'56"N 138°22'12"W, *C.E. Kennedy 89-155*, 6 August 1989 (DAO); strongly mounded valley floor, Richardson Mts., Summit Lake Area, 67°47'N 136°10'W, *Loewen & Gould 91-197*, 1991 (DAO).

Hultén (1968) knew this taxon only from Herschel Island. It is thus new to the British and Richardson mountains and also central and southwestern Yukon Territory.

Astragalus nutzotinensis Rousseau — YUKON: British Mts., braided cobble of river bed, Malcolm R. valley, 69°17'N 140°52'W, *W.J. Cody 27506*, 10 July 1980 (DAO); stony slope, S of Malcolm R., 69°15'N 140°52'W, *W.J. Cody 27538*, 10 July 1980 (DAO); turf and braided cobble of river bed, Malcolm R. valley, 69°17'N 140°18'W, *W.J. Cody 27466*, 10 July 1980 (DAO); in fine silt of gravel bar, Malcolm River, 69°31'N 139°50'W, *S.G. Aiken 88-288*, 13 July 1988 (CAN); in vicinity of talus slope and unglaciated rock outcrop northwest of confluence of Sheep Creek with Firth River, 69°28'N 140°59'W, *Consaul & Aiken 932*, 8 July 1990 (CAN); Richardson Mts., rock scree, Canyon Creek, 66°11'N 136°05'W, *Cody & Ginns 30320*, 5 July 1982 (DAO).

The range of this endemic species of unglaciated Alaska and Yukon is here extended from the Brooks Range in northern Alaska eastwards into the British Mountains and southern Richardson Mountains of northern Yukon Territory; elsewhere in the Yukon, it is known from the mountains of the Kluane region.

Lathyrus japonicus Willd. s.lat., Beach Pea — YUKON: Keno, Mayo District, *George Black*, 20-28 June 1927 (CAN).

Most specimens of this species have been gathered along seashores but the species is known inland from around the Great Lakes and in Manitoba. Elsewhere in the Yukon Territory it is only known in the vicinity of Shingle Point on the Arctic Coast (Douglas et al. 1981).

Lupinus nootkatensis Donn — YUKON: alpine area on west side of Alsek R. north of Lowell Glacier, approx. 60°17'N 138°W, *A.M. Pearson*, 28 July 1970 (DAO); subalpine meadow, Onion Lake, ca. 46 mi. S of Haines Junction, *G.W. & G.G. Douglas 7108*, 12 August 1973 (DAO).

Welsh (1974) and Douglas et al. (1989) both include the Yukon Territory in the distribution of this species, presumably on the basis of the Onion Lake specimen cited above (which was originally determined *L. arcticus*). Both collections are from southern Kluane National Park. The species should be added to the list of rare plants of the Yukon Territory (Douglas et al. 1981).

Medicago falcata L., Yellow Alfalfa — YUKON: waste ground, Carmacks, 62°05'N 136°17'W, *W.J. Cody 28182*, 20 July 1980 (DAO); highway ditch, Whitehorse, 60°43'N 135°03'W, *Cody & Ginns 28198*, 21 July 1980 (DAO); garden area, Haines Junction, Mile 1019 Alaska Highway, 60°46'N 137°35'W, *Cody & Ginns 28394*, 26 July 1980 (DAO).

Introduced. New to the flora of the Yukon Territory.

Medicago sativa L., Alfalfa — YUKON: highway ditch, Whitehorse, 60°43'N 135°03'W, *Cody &*

Ginns 28197, 21 July 1980 (DAO); roadside, large patches, locally abundant, just east of Whitehorse, *B.W. Smith et al. cc3488*, 18 July 1987 (CAN).

Introduced. New to the flora of the Yukon Territory.

Onobrychis viciifolia Scop., Sainfoin — YUKON: highway ditch, Whitehorse, 60°43'N 135°03'W, *Cody & Ginns 28199*, 21 July 1980 (DAO).

Introduced. New to the flora of the Yukon Territory.

Oxytropis campestris (L.) DC. ssp. *roaldii* (Ostenf.) Cody (*O. roaldii* Ostenf.) — YUKON: tundra turf and broken rock on mountain ridge, 5 miles N of Mt. King, 65°17.5'N 140°18'W, *Cody & Ginns 34310*, 13 July 1984 (DAO); tundra turf on mountain slope, Richardson Mts., 68°02'N 136°47'W, *Cody & Ginns 31456*, 11 July 1982 (DAO); tundra turf in saddle, Richardson Mts., 68°07'N 136°30'W, *Cody & Ginns 31511*, 11 July 1982 (DAO); open dry rocky ridge, 2 miles west of Sam Lake [68°30'N 138°35'W], *Nagy & Pearson 74-305*, 13 July 1974 (DAO); tundra, Firth River on Arctic Coastal Plain about 23 miles from coast, *E. Cashman 24*, 11 July 1956 (DAO).

Specimens cited by Welsh and Rigby (1971) as *O. arctica* from Sam Lake the Buckland Hills may possibly be referred to ssp. *roaldii*, but in addition to the British Mountains, Herschel Island collections in the extreme north this taxon is now known from the northern Richardson Mountains and the Ogilvie Mountains.

Oxytropis huddelsonii A.E. Porsild — YUKON: sparsely vegetated rocky summit, about 57 miles along 60 Mile Road from West Dawson to Alaskan border, 64°05'N 140°53'W, *Calder & Billard 3595*, 9-10 July 1949 (DAO); broken rock and turf on mountain top, Mt. Hart, 63°55'N 140°25'W, *Cody & Ginns 33826*, 7 July 1984 (DAO); alpine ridge above Cirque Lake, 63°07'N 135°41'W, *K. Asquith 401*, 31 July 1987 (DAO); tundra turf, mountain above Fish Creek, 64°18'N 138°00'W, *Cody & Ginns 33134*, 4 July 1984 (DAO); tundra turf on mountain ridge, E of Hamilton Creek, 64°19'N 137°34'W, *Cody & Ginns 34620b*, 14 July 1984 (DAO); rocky turf on saddle and adjacent rocky slopes, N and E of Hart River, 64°51'N 136°45'W, *Cody & Ginns 34507b*, 14 July 1984 (DAO).

Hultén (1968) knew this species only from central eastern Alaska and southwestern Yukon Territory. The specimens cited above are from about the same latitude as the Alaskan sites known to him but extend the known range in the Territory some 400 km northward.

Oxytropis mertensiana Turcz. — YUKON: Richardson Mts., very wet drainage channel through alpine meadow, 66°22'N 135°49'W, *Cody & Ginns 30542*, 6 July 1982 (DAO); wet draw in mud, 66°16'N 135°48'W, *Cody & Ginns 30415*, 6 July 1982 (DAO).

These collections represent an extension of the known range of *O. mertensiana* some 450 km southeast to the southern Richardson Mountains from sites in the Brooks Range in northern Alaska. New to Canada and the Yukon Territory. The species should also be looked for in the Ogilvie Mountains because it is also known to the west of these mountains in Alaska. It should be added to the lists of rare plants of the Yukon Territory (Douglas et al. 1981) and Canada (Argus and Pryer 1990).

Oxytropis scammaniana Hultén — YUKON: slope of cirque, alpine, McArthur/ Ethel Lake area, 63°08'N 135°32'W, *C. Kennedy 422*, 1 August 1987 (DAO); Willow/*Betula*/fir Krummholz, McArthur/ Ethel Lake area, 63°14'N 135°45'W, *C. Kennedy 791a*, 10 August 1987 (DAO); sandy soil on exposed south face at 5000 ft., north of Mayo, 64°10'N 135°25'W, *J.E. Thomlinson 6*, 20 June 1957 (DAO); vegetated talus, Sorrel Pass, S Wernecke Mts., *R. Frisch 126*, 14 July 1979 (DAO); rocky turf on saddle and adjacent rocky slopes, N and E of Hart R., 64°51'N 136°45'W, *Cody & Ginns 34507a*, 14 July 1984 (DAO).

These are the first sites reported in the Yukon Territory east of the Klondike and Dempster Highways. To the east it is localized in the Backbone Ranges of the Mackenzie Mountains at approximately 63°40'N 127°50'W in western District of Mackenzie.

Oxytropis viscida Nutt. s.lat.

In his monograph of the North American species of *Oxytropis* Barneby (1952) included *Astragalus leucanthus* Pall. (*O. leucantha* (Pall.) Pers.) in the synonomy of *O. viscida* Nutt. var. *subsucculenta* (Hook.) Barneby. Because the specific name *leucanthus* was published in 1800, 38 years before the *viscida* name, Boivin (1967) made the following series of transfers and new names under *O. leucantha*:

var. *gaspensis* (Fern. & Kelso) Boivin
var. *ixodes* (Butt. & Abbe) Boivin
var. *hudsonica* (Greene) Boivin
var. *hudsonica* f. *galactantha* Boivin
var. *leuchippiana* Boivin
var. *depressa* (Rydb.) Boivin
var. *viscida* (Nutt.) Boivin

Welsh (1972) has since demonstrated that the type specimen of *Oxytropis leucantha* is eglandular and belongs to a Siberian phase of *O. campestris* (L.) DC. and therefore should be excluded from priority considerations in the names of vicid phases of North American species of *Oxytropis*. The names listed above are therefore either superfluous or need to be transferred elsewhere. Var. *leuchippiana*, the type of which was collected at Whitehorse, is of particular interest here. In view, however, of the great variability found in *Oxytropis viscida* (Barneby 1952;

Hultén 1967; Welsh 1967), it seems best for the present at least, to treat all the glandular plants found in the Yukon under the all-inclusive name *O. viscida* Nutt. s.lat.

Vicia angustifolia (L.) Reichard, Common Vetch — YUKON: Power Station, Dawson City, *S. Landhäusser*, 29 July 1992 (DAO).

Introduced; not previously recorded from the Yukon Territory.

Vicia cracca L., Tufted Vetch — YUKON: Dawson, roadside ditch near the hospital, rare, *Calder & Billard 3807*, 20 July 1949 (DAO); roadside among scrub, Dawson, 64°04'N 139°27'W, *W.J. Cody 26472*, 29 June 1980 (DAO).

Porsild (1951) reported *Vicia cracca* from Dawson on the basis of a specimen collected by M. O. Malte; this Malte specimen has been revised to *V. villosa* (see below). It is not certain whether Hultén's map record (Hultén 1968) for Dawson was based on the Malte or the Calder collection.

Vicia villosa Roth, Hairy Vetch — YUKON: Dawson, *M.O. Malte*, 9 August 1916 (CAN).

This collection was cited by Porsild (1951) as *V. cracca*. Although the species may no longer be present at Dawson, *V. villosa* has not previously been recorded from the Yukon Territory.

LINACEAE

Linum lewisii Pursh, Wild Blue Flax — YUKON: rock outcrop on east bank of river, Bonnet Plume River, 64°22'N 132°45'W, *C.E. Kennedy 92B-25*, 16 August 1992 (DAO); Wind River in the Peel River Basin, *C. Camsell*, 8 July 1905 (CAN).

Hultén (1968) knew this species from the vicinity of Rampart House on the Porcupine River area adjacent to the Alaska boundary but the two localities above are the only other known stations in the Yukon Territory north of 63°N.

EUPHORBIACEAE

Euphorbia esula L., Leafy Spurge — YUKON: in hayfield associated with *Thalictrum venulosum*, Henderson Corner, 15 miles E of Dawson, *G. Brunner*, 25 August 1992 (DAO).

An introduced weed not previously known from the Yukon Territory.

ELATINACEAE

Elatine triandra Schk. — YUKON: in tundra pond in 1 ft. of water on wet saturated-moist lowland dominated by *Carex* and *Salix* with *Potamogeton filiformis* and *Poa arctica*, Lower Blow River Delta, 69°08'N 137°48'W, *Dickson & Allen 5311*, 25 July 1982 (DAO and Herb Dickson).

This is an extension of the known range of some 1200 km northwest from the single known station in the District of Mackenzie northwest of Yellowknife (Porsild and Cody 1980). The species is new to the flora of the Yukon Territory and should be added to the list of rare plants of the Territory (Douglas et al. 1981).

ONAGRACEAE

Epilobium arcticum Samuelss. — YUKON: south-facing slope, 68°56'N, 138°58'W, *Nagy et al. 74-471*, 18 July 1974 (DAO); *Equisetum-Dryas*-sedge high slope, 69°11'N 140°11'W, *C.E. Kennedy 89-18*, 19 July 1989 (DAO); upper middle slope of mountain — stony, S side of Empire Mtn., 69°07'N 140°53'W, *W.J. Cody 27590*, 10 July 1980 (DAO).

Porsild (1975) reported this amphi-Atlantic species as new to the Yukon Territory on the basis of a collection in the Ogilvie Mountains adjacent to Mile 54, Dempster Highway. The collections cited above are intermediate between sites in the northern Richardson Mountains in northwestern District of Mackenzie and the Brooks Range in northern Alaska plotted in Porsild and Cody (1980) and the species is new to northern Yukon Territory.

Epilobium leptophyllum Raf.

This taxon was reported as new to the Yukon Territory by Porsild (1966) on the basis of two specimens collected by Schofield and Crum in the vicinity of Mackintosh. This was the basis of Hultén's (1968) only record for the Yukon. These specimens which have since been revised to *E. palustre* were not located by Douglas et al. (1981) at the time they were preparing the rare plant manuscript.

HIPPURIDACEAE

Hippuris montana Ledeb. — YUKON: sand and gravel river bar, Nisling River Valley, 61°54.5'N 137°52'W, *Cody & Ginns 28282*, 23 July 1980 (DAO).

This site is about equidistant from a site in south Central Alaska, a site near the southern Alaska coast, and a site in the northern Alaska Panhandle. The species is new to the flora of the Yukon Territory and should be added to the list of rare plants (Douglas et al. 1981).

UMBELLIFERAE

Angelica lucida L. — YUKON: hotsprings meadow, McArthur/Ethel Lake area, 63°04'N 135°42'W, *C. Kennedy 701*, 8 August 1987 (DAO).

Previously known in the Yukon Territory only from southeastern Kluane National Park and Macmillan Pass (Douglas et al. 1981).

Pastinaca sativa L., Wild Parsnip — YUKON: wet area, Ainsley Creek, 10 miles below Indian River, a short distance south of Dawson, common, *S. Lowe s.n.*, 16 August 1949 (DAO); meadow close to road, Henderson Corner 15 miles east of Dawson, *G. Brunner 113*, 22 July 1991 (DAO); same plant, *G. Brunner 122*, 25 August 1991 (DAO).

Introduced from Europe. New to the flora of the Yukon Territory.

Podistera macounii (Coult. & Rose) Mathias & Const. (*Ligusticum mutellinoides* (Crantz) Willar ssp. *alpinum* (Ledeb.) Thell.) — YUKON: sparse alpine heath, Richardson Mts., 66°37'N 136°15'W, *R. Frisch*, 18 June 1978 (DAO); on W side of westernmost range, windswept turfy tundra and moist meadow valley, Richardson Mts., 66°55'N 136°08'W, *Cody & Ginns 31009*, 8 July 1982 (DAO); turfy scree slope, Richardson Mts., 65°59'N 135°22'W, *Cody & Ginns 30245*, 5 July 1982 (DAO).

Hultén (1968) depicted this endemic species as occurring eastward in Alaska to about longitude 143°W. Welsh (1974) stated that it occurred in northern Yukon and adjacent Mackenzie and Douglas et al. (1981) stated "Dempster Highway north of the Arctic Circle to the north slope of the Richardson Mountains", but neither cited any specimens. Seven specimens from the northern Richardson Mts., of Yukon are preserved in the Vascular Plant Herbarium (DAO); the specimens cited above extend the known range to the southern part of the Richardson Mountains.

Podistera yukonensis Mathias & Constance — YUKON: talus slope on bedrock knob of Chert Mtn., Ogilvie Mts., Tombstone Range, alt. 7500 ft., 64°24'N 138°53'N, *C.E. Kennedy 93A-239*, August 1993 (DAO).

This rare endemic described by Mathias and Constance (1950) had previously only been collected three times, once in Alaska near Eagle, and twice in the Yukon Territory at Little Klondike River (type locality) and Mile 58 on 60 Mile Road near the Alaska-Yukon boundary (*Calder & Gillett 26337* (DAO); Hultén 1967). The collection cited above was obtained about 50 km north of the type locality. In addition to herbarium material, Calder and Gillett also collected living material at Mile 58 that was taken to Ottawa. A chromosome count of $2n=22$ was determined by R. J. Moore on this material, but was apparently never reported in the literature (Figure 1).

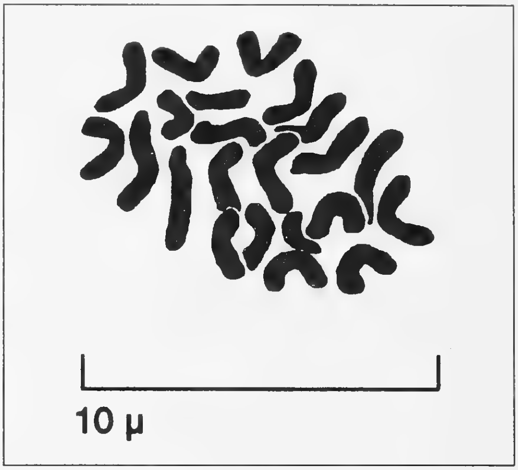

FIGURE 1. *Podistera yukonensis* chromosomes. Drawn (from xerox copy) by M. Jomphe 18 May 1994.

Sium suave Walt. — YUKON: Nisutlin River Delta, Teslin Lake, 60°15'N 132°35'W, *Ereaux & Lortie 4-2*, 31 August 1983 (DAO); Slough, East shore of Teslin Lake, 60°13'N 132°52'W, *Raup & Correll 11102*, 9 August 1943 (CAN); Klondike Valley, 63°59'N 138°45'W, *C.E. Kennedy 90-156*, 20 August 1990 (DAO).

New to the flora of the Yukon Territory and should be added to the list of rare plants (Douglas et al. 1981).

Zizea aptera (Gray) Fern. — YUKON: Haines Junction, *L. Fournier s.n.*, 25 juillet 1958 (QFA, photo DAO).

Boivin (1966-67) reported the occurrence of this species in southern Yukon Territory presumably on the basis of this collection. The report, however, was not picked up by either Hultén (1968) or Welsh (1974), but Douglas et al. (1981) did include *Zizea aptera* in their treatment of rare plants on the basis of this specimen.

CORNACEAE

Cornus unalaschkensis Ledeb. (*C.* x *intermedia* (Farr.) Calder & Taylor, *C. canadensis* x *C. suecica sensu* Hultén (1968)) — YUKON: disturbed ground along roadside, Km 30 W of Dawson on Klondike Loop Hwy., 64°08'N 139°42'W, *Cody & Ginns 34063*, 11 July 1984 (DAO); Mile 47 on 60 Mile Road west of Dawson, 64°08'N 140°40'W, *J. Terasmae*, 25 July 1961 (DAO); open shrub tundra, Mallard, Ogilvie Mts., *D.M. Dickinson 4*, 15 July 1983 (DAO); open meadowland near riverbank, Sheldon Lake, *R. Dale 26*, 23 July 1977 (DAO).

Calder and Taylor (1965) knew this entity in the Yukon Territory from a single locality near Dawson; Hultén did not map this locality but plotted a site on the Canol Road near the Mackenzie border.

PYROLACEAE

Hypopitys monotropa Crantz (*Monotropa hypopitys* L.), Pinesap — BRITISH COLUMBIA: Dawson Peaks west of the southern part of Teslin Lake, 59°57'N 132°30'W, *A. Dutilly 28386*, 30 August 1940 (QFA, photo DAO).

This specimen, like others collected by Dutilly on that date were labelled Teslin Lake, Yukon, but as explained under *Cassiope mertensiana* it was collected south of the border in northern British Columbia. Douglas et al. (1990) gave the distribution of *H. monotropa* as frequent in southern British Columbia, infrequent northward to 57°N; circumboreal, north to southeast Alaska, east to Newfoundland and south to California, Mexico and

Florida. The collection cited here from 59°57'N is thus an extension of the known range northward of about three degrees latitude and the species should be looked for in moist coniferous forests in the extreme southern part of the Yukon Territory.

Pyrola asarifolia Michx., Pink-flowered Wintergreen — YUKON: upland tundra not far from coast, Firth River, 69°30'N 139°20'W, *E.H. McEwen 119*, 9 June 1953 (CAN).

This is an extension of the known range into northern Yukon Territory of some 450 km from the central Ogilvie Mts. (Porsild and Cody 1980).

ERICACEAE

Cassiope mertensiana (Bong.) D. Don, White Mountain Heather — BRITISH COLUMBIA: Dawson Peaks, 59°57'N 132°30'W, *A. Dutilly 28390A*, 30 August 1940 (DAO, QFA).

This specimen, which was distributed as *C. tetragona*, was labelled as having been collected at Teslin Lake, Yukon, but according to Dutilly's note book and diary was actually collected at Dawson Peaks in northern British Columbia while he was on a two day excursion from Teslin Lake. The species is at its known northern limit of distribution at Dawson Peaks but should be looked for in protected alpine situations in southern Yukon Territory.

Menziesia ferruginea J.E. Smith, False Azalea — BRITISH COLUMBIA: Dawson Peaks, 59°57'N 132°30'W, *A. Dutilly 28388*, 30 August 1940 (DAO).

This specimen, like the above, was labelled as having been collected at Teslin Lake, Yukon, but was actually collected at Dawson Peaks in Northern British Columbia where it is at its known northern limit of distribution, but it should be looked for in protected alpine situations in southern Yukon Territory.

Oxycoccus microcarpus Turcz. — YUKON: wet area of tundra, 3 miles S of Shingle Point, *G. Ironside s.n.*, 18 July 1971 (CAN).

This collection extends the known range northward to near the Arctic Coast from the Porcupine River valley.

PRIMULACEAE

Dodecatheon pulchellum (Raf.) Merr. (*D. pauciflorum* (Durand) Greene) — YUKON: alpine, Cirque Lake at foot of Grey Hunter Peak, 63°08'N 135°42'W, *B. Gallagher 257*, 28 July 1987 (DAO).

This species was included among the rare plants of the Yukon Territory by Douglas et al. (1981) who knew it from the Dawson and Porcupine River areas. The collection cited here is from some 200 km southeast of Dawson.

Douglasia arctica Hook. — YUKON: hummocky alpine tundra, Richardson Mts., 66°42'N 137°03'W, *Cody & Ginns 29989*, 3 July 1982 (DAO); open broken stone slope, Dempster Hwy. Km 406, 66°33'N 136°22'W, *W.J. Cody 26731*, 3 July 1980 (DAO); moist hummocky turf and dry and turfy rocky saddle, Richardson Mts., 66°22'N 135°49'W, *Cody & Ginns 30496*, 6 July 1982 (DAO); flat tableland of shattered stone, Richardson Mts., 66°16'N 135°48'W, *Cody & Ginns 30369*, 6 July 1982 (DAO); shale fellfield, Southern Richardson Mts., 66°04'N 135°50'W, *L.C. Cwynar 1203*, 6 July 1977 (DAO); tufry rocky slope, Richardson Mts., 66°02.5'N 135°32'W, *Cody & Ginns 30451*, 6 July 1982 (DAO); open rocky-gravelly areas near summit, Cathedral Rocks, Ogilvie Mts., 66°02'N 138°44'W, *Calder & Gillett 26128*, 27 June 1960 (DAO); gravel road bank, Dempster Hwy. Km 256, 65°47'N 137°45.5'W, *W.J. Cody 26687*, 2 July 1980 (DAO); head of Kandik River, 65°41'N 140°28'W, *O. Hughes*, 18 August 1962 (DAO); dry, rocky areas on uppermost parts of sandstone ridge, Ogilvie Mts., 65°47'N 138°17'W, *Calder & Gillett 2590*, 25 June 1960 (DAO).

Hultén (1968) knew this taxon only in the extreme north of the Yukon Territory. Wein et al. (1974) extended the known range southward in the Richardson Mountains. The specimens cited above now extend the known range further south in the Richardson Mountains and into the northern Ogilvie Mountains.

Douglasia ochotensis (Willd.) Hultén — YUKON: late-snow area on north-facing slope, Ogilvie Mts., 65°47'N 138°17'W, *Calder & Gillett 25901-2*, 25 June 1960 (DAO).

Hultén (1968) did not know this taxon from the Yukon Territory although he did plot a collection from the Richardson Mts. in northwestern District of Mackenzie. This latter collection has not been found although Hultén (in lit.) stated "The *Douglasia* was collected at Trout Lake by Krajina, I saw it in his herbarium in Vancouver". Welsh and Rigby (1971) cited collections from three localities in the British Mountains and additional collections from that area are now preserved at DAO. In addition Wein et al. (1974) cited two localities north of Old Crow, extending the known range about 100 km southward. The collection cited above is a further extension of the known range southward some 225 km to the northern Ogilvie Mountains where it was in flower at the time of collection. Specimens of *D. arctica* in fruit where collected nearby on the same date (*Calder & Gillett 25901-1* DAO).

Lysimachia thyrsiflora L., Yellow Loosestrife — YUKON: Boggy lake margin, unnamed lake, 60°03'N 127°36'W, *W.J. Cody 32444*, 8 July 1983, (DAO); wet shoreline of stream, unnamed lake, 60°07.5'N 127°21.5'W, *W.J. Cody 32416*, 7 July 1983 (DAO).

Douglas et al. (1981) placed this species in their

Excluded Species Appendix because of a "locality error". The specimens cited here are thus the first authentic records for the Yukon Territory and the species should be added to the list of rare species.

PLUMBAGINACEAE

Armeria maritima (Mill.) Willd. ssp. *arctica* (Cham.) Hultén — YUKON: sand dune area, arctic coastal plain near Firth River, 69°10'N 139°'W, *A. Rencz 285*, 17 July 1972 (ALTA); coastal dunes, 5 km E of Firth River Delta, 69°30'N 139°13'W, *L.C. Cwynar 411*, 21 July 1975 (DAO); Herschel Island, 69°37'N 138°58'W, *C. Kennedy 147*, 13 July 1985 (DAO).

Cwynar (1983) when he reported this taxon new to the flora of the Yukon Territory inadvertently reported his collection No. 411 from his Site 1 at 69°30'N 140°40'W rather than his site 2 at 69°37'N 138°58'W as shown on the label. Two additional sites are reported here.

GENTIANACEAE

Gentiana algida Pallas — YUKON: gentle W-facing slope, *Dryas* mat, sedges, Ogilvie Mts., Eagle Pass, 64°46'N 140°07'W, *D.M. Dickinson 41*, 26 July 1983 (DAO); very steep NE-facing slope, Ogilvie Mts., Blackfly, 65°51'N 140°23'W, *D.M. Dickinson 59*, 5 August 1983 (DAO); alpine meadow, Wernecke Mts., 64°32'N 136°12'W, *R. Frisch 204*, 31 July 1979 (DAO).

Porsild (1975) reported the northernmost collection known to him at Mile 82, Dempster Hwy. The Dickinson collections cited here extend the known distribution northward some 150 km to the northwest and the Frisch collection is the first site known in the Wrenecke Mountains.

Gentiana glauca Pallas — YUKON: wet meadow, 66°22'N 135°49'W, *Cody & Ginns 30536*, 6 July 1982 (DAO); wet seepage area, N side of Dempster Hwy. Km 465, 67°02'N 136°13'W, *Cody & Ginns 30083*, 4 July 1982 (DAO); steep upper slopes of mountain, saddle between two peaks of Mt. Sittichinli, 67°10.5'N 136°17'W, *Cody & Ginns 31024*, 9 July 1982 (DAO); alpine meadow, Richardson Mts., *Cody & Ginns 32076*, 67°44.5'N 137°28'W, 15 July 1982 (DAO); moist turfy slope, Mt. McGuire, 67°55.5'N 137°22'W, *Cody & Ginns 32119*, 15 July 1982 (DAO); turf by mountain stream, 68°11'N 136°28'W, *Cody & Ginns 31744*, 13 July 1982 (DAO); turf among rocks, 68°18'N 136°30'W, *Cody & Ginns 31318*, 11 July 1982 (DAO); Creek, 68°22'N 136°29'W, *J.D. Lambert*, 31 July 1966 (DAO).

These collections, all from the Richardson Mountains, extend the known range in northern Yukon Territory northward from south of latitude 66°N about 300 km.

Gentiana glauca Pallas f. *chlorantha* Jordal — YUKON: in reindeer lichen, Mackenzie Mts., 10 km NE of Niddery L., *W.J. Cody 29386*, 1 July 1981 (DAO); moist graminoid meadow, Richardson Mts., 68°09'51"N 137°12'05"W, *Loewen & Staniforth 93-135B*, 8 July 1993 (DAO).

This form with yellowish flowers is not otherwise known in the Yukon Territory.

Gentiana prostrata Haenke, Moss Gentian — YUKON: British Mountains, 69°13'N 139°03'W, *P.F. Cooper 988*, 13 July 1979 (CAN); damp sandy excavation site, McNeish Stie, 60 km W of Stokes Point, 69°21'N 139°30'W, *L.C. Cwynar 383*, 21 July 1975 (DAO); British Mountains (Loney Creek), 69°20'N 139°47'W, *P.F. Cooper 1066*, 14 July 1979 (CAN); British Mountains, 68°57'N 139°54'W, *P.F. Cooper 1178*, 16 July 1980 (CAN); British Mountains, 69°26'N 140°55'W, *P.F. Cooper 1020*, 18 July 1980 (CAN); gravel bed on south side of Sheep Creek, 69°28'N 140°59'W, *Consaul & Aiken 992*, 10 July 1990 (CAN).

Hultén (1968) knew this species in the Yukon Territory north of the Ogilvie Mountains from a single site approximately south of Shingle Point. It is reported here from the British Mountains and Ivavvik National Park for the first time.

Lomatogonium rotatum (L.) Fries ssp. *tenuifolium* (Griseb.) A.E. Porsild —YUKON: sandy alluvial, Upper Babbage River Delta, 68°13'N 138°20'W, *C. Kennedy 89-202*, 8 August 1989 (DAO); Margaret Lake, 68°50'N 140°35'W, *C. Kennedy 186*, 27 July 1988 (DAO).

These collections from Ivavvik National Park represent a northward extension of the known range of ssp. *tenuifolium* of some 450 km from sites along the Dempster Highway; ssp. *rotatum* is known in northern Yukon from Herschel Island and Shingle Point (CAN).

BORAGINACEAE

Cynoglossum boreale Fern., Northern Wild Comfrey — YUKON: open slope of point into lake, unnamed lake, 60°07.5'N 127°21.5'W, *W.J. Cody 32395*, 7 July 1983 (DAO).

New to the flora of the Yukon Territory. Douglas et al. (1989) record this species as infrequent in mesic, open sites in the lower montaine zone in central and northern British Columbia; in Alberta it is known only from the vicinity of Edmonton (Packer 1983). A map of the distribution in Canada is provided (Figure 2). It should be added to the list of rare plants of the Yukon Territory (Douglas et al. 1981).

Mertensia maritima (L.) S.F. Gray, Sea Lungwort — YUKON: sandy gravel beach ridge along spit, SE end of Stokes Point Lagoon, 69°21'N 138°44'W, *H.L. Dickson 5901*, 10 August 1983 (DAO); sand spit, S of Herschel Island, 69°25'49"N 139°00'15"W, *C.E. Kennedy 89-84*, 1 August 1989 (DAO); sand spit, Clarence Lagoon, *Consaul & Aiken 964*, 9 July 1990 (CAN).

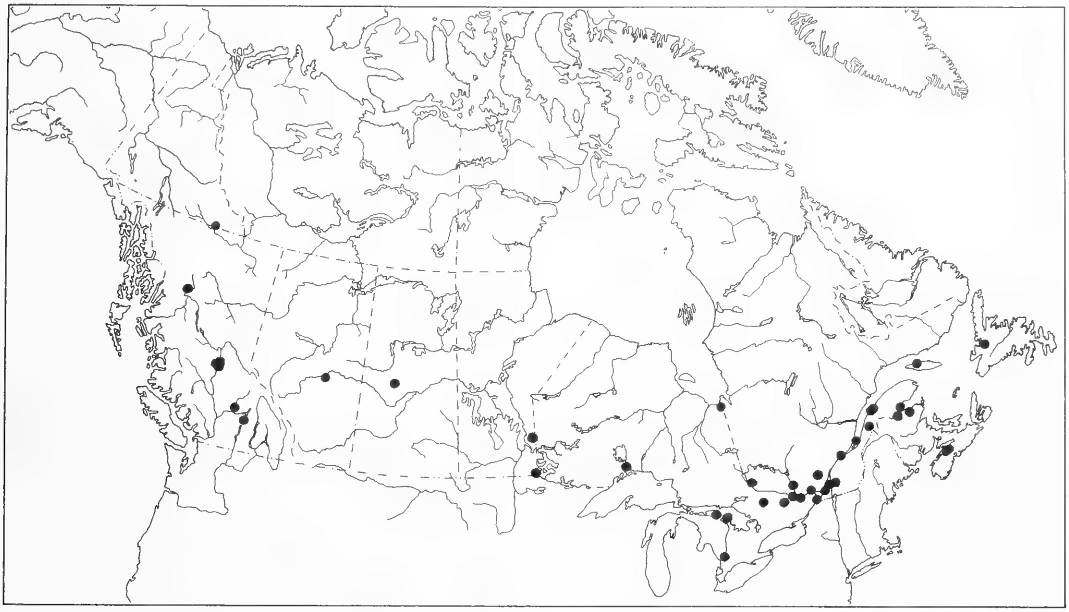

FIGURE 2. Canadian distribution of *Cynoglossum boreale*.

Previously known in the Yukon Territory only from Herschel Island (Douglas et al. 1981).

Mertensia paniculata (Ait.) G. Don var. *alaskana* (Britt.) L.O. Williams, Bluebell — YUKON: in deep moss in white spruce woods on flood plain of river, Bell River, 67°33'N 136°53'W, *Cody & Ginns 32152*, 15 July 1982 (DAO); alpine tundra of saddle and talus slope, NW of Mt. Dennis, 67°42.5'N 136°37'W, *Cody & Ginns 29908*, 3 July 1982 (DAO).

The specimens cited here are the first reported from the Richardson Mountains of northern Yukon Territory.

Myosotis alpestris Schm. ssp. *asiatica* Vestergr. ex Hultén f. *eyerdamii* (Boivin) Cody (*M. sylvatica* Hoffm. var. *alpestris* (Schm.) Koch f. *eyerdamii* Boivin) — YUKON: stream valley, NW coast Herschel Island, 69°37'N 139°09'N, *P.F. Cooper 902*, 12 July 1979 (CAN, photo DAO).

New to the Yukon Territory; Boivin (1966-67) knew this white-flowered form only from southern Alaska and southwestern Alberta.

LABIATAE

Dracocephalum thymiflorum L. (*Moldavica thymiflora* (L.) Rydb.), Thyme-flowered Dragonhead — YUKON: In gravel by deserted house 2 miles E of Dawson on road to Bear Creek, only time noted in Dawson area, *Calder & Billard 3269*, 24 June 1949 (DAO); waste clearing along road through *Picea glauca - Populus balsamifera* woodland by Klondike River 15 mi. E of Dawson, 64°04'N 139°05'W, *Cody & Ginns 32875*, 1 July 1984 (DAO); North Fork, Km 9 Dempster Highway, *G. Brunner*, 15 July 1989 (DAO).

An introduced plant not previously recorded from the Yukon Territory. The 1949 collection by Calder & Billard on 24 June was fresh and green whereas the 1984 collection by Cody & Ginns on 1 July and the 1989 collection by Brunner of 15 July were brown and overmature.

Galeopsis tetrahit L. ssp. *bifida* (Boenn.) Fries — YUKON: open disturbed area, old army camp, Km 286 Canol Road, *V. Hodgson 141*, 22 July 1980 (DAO).

This taxon which is introduced from Europe was previously known in Canada from Newfoundland to British Columbia and north to Fort Simpson in the District of Mackenzie. It is new to the flora of the Yukon Territory.

Stachys pilosa Nutt. (*Stachys palustris* L. var. *pilosa* (Nutt.) Fern.) —YUKON: Hayfield, Lousetown on south bank of Klondike River opposite Dawson, *Calder & Billard 3944*, 26 July 1949 (DAO).

Douglas et al. (1981) because they could not find a confirming specimen for the dot on the map in Hultén's Flora of Alaska and Neighboring Territories (1968) omitted this species in their publication on rare plants. The habitat in which the plant was found however suggests that it was introduced in that area.

SCROPHULARIACEAE

Castilleja miniata Dougl. — YUKON: Coal River Springs proposed park, site 8, just west of Coal River, *C. Kennedy 41*, July 1983 (DAO).

Scotter and Cody (1979) reported the occurrence this species in southeastern Yukon Territory at Larsen Creek Hot Springs, 60°12'N 125°32'W. The map in Douglas et al. (1981) depicts a site to the west (east of Atlin Lake). The specimen cited above is intermediate between these two sites and represents the third known locality for this rare species in the Yukon Territory.

Castilleja raupii Pennell — YUKON: tundra turf of mountain meadow above and west of Hart River, 65°27'N 137°08'W, *Cody & Ginns 34813*, 17 July 1983 (DAO); tundra turf and seepage area in mountain valley, W of Blackstone River, 65°39'N 137°34'W, *Cody & Ginns 34914*, 17 July 1983 (DAO); west-facing slope above tree-line, Cathedral Rocks, 66°02'N 138°44'W, *Calder & Gillett 26124*, 29 June 1960 (DAO); dry calcareous wooded slope, Dempster Hwy., Km 230, *R. Frisch 319*, 10 July 1980 (DAO); moist alpine meadow, Km 465, Dempster Hwy. [67°02'N 136°13'W] *D.M. Wood*, 22 July 1982 (DAO); floodplain with *Equisetum*, Porcupine R., 67°09'N 137°32'W, *S.C. Zoltai*, 30 July 1972 (DAO); alpine meadow by stream in valley bottom, 66°26.5'N 135°48'W, *Cody & Ginns 30793*, 8 July 1982 (DAO).

Welsh and Rigby (1971) reported this species from northern Yukon for the first time on the basis of a collection from SW of Sam Lake and it has since been collected nearby from the Old Crow R. area: *L.C. Cwynar* (DAO). The sites reported here extend the known range into the Richardson and northern Ogilvie mountains demonstrating that it is widespread in the region.

Limosella aquatica L. — YUKON: Nisutlin River Delta, Teslin Lake, 60°15'N 132°35'W, *B. Ereaux 144*, 28-31 August 1984 (DAO).

Previously known in the Yukon Territory only from Sheldon Lake on the North Canol Road where it was very rare on the muddy west shore just above the water's edge (Porsild 1951).

Linaria vulgaris Miller, Butter-and-eggs — YUKON: roadside clearing in *Picea glauca* wooded area, Mile 780 Alaska Hwy., 3 mi. NW of Morley River crossing, 60°10'N 132°15'W, *V.L. Harms 17253*, 24 August 1970 (DAO, CAN); gravel roadbank, McIntyre Creek Road, near Alaska Hwy., Whitehorse, *Cody et al. 35403*, 24 July 1984 (DAO); hayfields 15 miles east of Dawson, *G. Brunner*, 17 July 1990 (DAO).

Introduced from Eurasia; not previously reported from the Yukon Territory.

Orthocarpus luteus Nutt., Owl's-clover — saline grass meadow, east of Km 221 Klondike Hwy., 61°01'45"N 135°11'W, *D.W. Murray 1085-8*, 11 July 1990 (DAO); steep open rocky slope, near Faro, 3000 m, 62°12'N 133°10'W, *C.E. Kennedy 90-63*, 20 July 1990 (DAO).

This species was formerly known in Canada across the prairie region from Thunder Bay District Ontario to British Columbia and north into the Slave River valley just north of 60° in the District of Mackenzie; the specimens cited above are new records for the Yukon Territory and are disjunct from the nearest known record near Hudson Hope in the Peace River District of Northern British Columbia. It should be added to the list of rare Yukon Territory plants (Douglas et al. 1981).

Pedicularis lapponica L., Lapland Lousewort — YUKON: turf in narrow valley, Richardson Mts., N slope of Skull Range, 68°35'N 137°20'W, *Cody & Ginns 31528*, 12 July 1982 (DAO); flat hummocky turf of creek valley, Richardson Mts., 66°27'N 135°35'W, *Cody & Ginns 30833*, 8 July 1982 (DAO); moist low shrub-dwarf shrub tundra, Richardson Mts., 68°16'23"N 136°40'10"W, *Loewen & Staniforth 93-089*, 5 July 1993 (DAO).

Previously known from the British Mountains, Sam Lake and Ogilvie Mountains adjacent to the Dempster Highway. (Douglas et al. 1981) but not previously reported from the Richardson Mountains.

Pedicularis macrodonta Richards. (*P. parviflora sensu* Porsild & Cody 1980)) —YUKON: bog around small unnamed lake, 60°06'N 127°31'W, *W.J. Cody 32530*, 10 July 1983 (DAO).

Previously known in the Yukon Territory from a single collection at Nares Lake, 60°10'N 134°40'W, (*Lt. F. Schmatka* (?) 22 June 1943 (GH)). Considered rare in the Yukon Territory by Douglas et al. (1981).

Synthris borealis Pennell — YUKON: rare and local in depression in lush meadow, Cathedral Rocks, Ogilvie Mts., 66°02'N 138°44'W, *Calder & Gillett 26125*, 29 June 1960 (DAO); alpine tundra on saddle, Richardson Mts., *Cody & Ginns 29961*, 3 July 1982 (DAO); windswept turfy tundra and moist meadow valley, Richardson Mts., 66°55'N 136°08'W, *Cody & Ginns 31008*, 8 July 1982 (DAO); polygonal ground, 67°22'N 136°32'W, *R.W. Wein 254*, 10 July 1972 (DAO); occasional on steep SW-facing shale slope, Richardson Mts., 67°33'N 136°12'W, *J.A. Calder 34097*, 9 July 1962 (DAO); steep, heathy, east-facing slopes above creek, Fish Creek area, Richardson Mts., 67°57'N 136°27'W, *J.A. Calder 34141*, 14 July 1962 (DAO).

The above collections extend the known range into northern Yukon Territory north of 66°N latitude. Of particular interst is the annotation on the *Calder 34014* specimen by T. Mosquin giving the chromosome number of $2n$=24 from plants grown from seed of this collection. Mulligan and Porsild (1969b) have also reported the chromosome number $2n$=24 based on a collection from the Ogilvie Mountains. This species is endemic to

Alaska, Yukon and extreme northwestern District of Mackenzie.

Veronica longifolia L. — YUKON: Mile 1019 Alaska Highway, 60°46'N 137°35'W, waste ground along highway at old Experimental Farm, *Cody & Ginns 28385*, 26 July 1980 (DAO).

A garden escape; first report as growing outside cultivation in the Yukon Territory.

OROBANCHACEAE

Boschniakia rossica (C. & S.) Fedtsch., Ground-cone — YUKON: alder-moss slope, Northern Yukon [Ivavvik] National Park, Firth River, 69°09'N 140°09'W, *C.E. Kennedy 89-6*, 19 July 1989 (DAO); confluence of Sheep Creek and Firth River, 69°10'N 140°10'W, *C.E. Kennedy 426*, 8 August 1988 (DAO).

These collections represent a northward extension of the known range of some 150 km from sites in the Porcupine River drainage.

LENTIBULARIACEAE

Utricularia intermedia Hayne, Flat-leaved Bladderwort — YUKON: creeping in mud, Old Crow Flats 5 km NW of Junction of Johnson and Little Flat Creeks, *L.C. Cwynar 801*, 12 July 1976 (DAO).

Not previously reported from northern Yukon Territory and considered rare by Douglas et al. (1981) but known from northwestern District of Mackenzie and northern Alaska (Porsild and Cody 1980).

PLANTAGINACEAE

Plantago canescens Adams — YUKON: a few plants on heathy gravel flats along margin of river near Trout Lake and Babbage River, 68°48'N 138°43'W, *J.A. Calder 34507*, 21 July 1962 (DAO).

Previously known in northern Yukon from Rampart House (Hultén 1968) and (Bassett 1973) and Old Crow (Welsh and Rigby 1971). The collection cited here is from about 175 km north of Old Crow.

RUBIACEAE

Galium boreale L., Northern Bedstraw — YUKON: common on dry mountain ridge, Rampart House, *C.C. Loan 565*, 11 July 1951 (DAO); common in dry, open field, Rampart House, *C.C. Loan 623*, 21 July 1951 (DAO); meadow, 7 km upstream of Old Crow, Porcupine River, 67°34'N 139°41'W, *L.C. Cwynar 82*, 4 July 1975 (DAO); silty riverbank, junction of Rat Indian Creek and Porcupine River, 67°34'N 138°20'W, *L.C. Cwynar 883*, 18 July 1976 (DAO); slope, rock bluff 8 km downstream of junction of Driftwood and Porcupine rivers, 67°35'N 138°19'W, *L.C. Cwynar 1004*, 23 July 1976 (DAO).

These collections from the Porcupine River drainage are an extension of the known range in northern Yukon Territory of some 225 km from a site in the Peel River drainage (Bird 1974); however, the species was known to Hultén (1968) in northern Alaska adjacent to the Yukon border.

Galium triflorum Michx. — YUKON: hotsprings meadow, McArthur/Ethel Lake area, 63°04'N 135°42'W, *C. Kennedy 721*, 8 August 1987 (DAO).

This species, which is considered rare by Douglas et al. (1981) was previously known in the Territory only from about latitude 61°N.

CAPRIFOLIACEAE

Lonicera involucrata (Richards.) Banks ex Spreng., Black Twinberry — YUKON: Haines Junction, *L. Fournier s.n.*, juillet 1958 (QFA, photo DAO).

Boivin (1966-67, 1968) reported this species as occurring in the Yukon Territory, but in neither publication did he give the basis for his inclusion of the region. It should now be added to the list of rare species for the Yukon Territory (Douglas et al. 1981).

ADOXACEAE

Adoxa moschatellina L., Moschatel — YUKON: moist shady ravine, Rampart House, *C.C. Loan 471*, 21 June 1951 (DAO); on hillside in moist shady woods, Rampart House, *J.E.H. Martin 20*, 3 June 1951 (DAO).

This is a range extension of some 350 km northward in the Yukon Territory from sites in the southern Ogilvie Mountains (Porsild 1975).

CAMPANULACEAE

Campanula rotundifolia L., Harebell — YUKON: sunny, dry, gravel area, km 312 Canol Road, *V. Hodgson 441*, 29 July 1981 (DAO).

This species was considered rare in the Yukon Territory by Douglas et al. (1981). The specimen cited above from approximately 62°30'N is about two degrees north of Johnson's Crossing, at the southern end of the Canol Road, from whence the nearest collection was gathered by M. P. Porsild. A. E. Porsild (1951) considered the Johnson's Crossing stand as possibly introduced.

ASTERACEAE (COMPOSITAE)

Antennaria pulcherrima (Hook.) Greene — YUKON: bedrock knoll on north shore of river, Bonnet Plume River, 64°20'N 132°45'W, *C.E. Kennedy 92B-98*, 14 August 1992 (DAO).

This site is about 300 km north of the nearest previously known locations along the Canol Road.

Artemisia alaskana Rydb. — YUKON: British Mts.: scree slope, 69°26'N 140°45'W, *A.M. Martell 79-2*, 16 July 1979 (DAO); near Firth River Canyon, 69°17'N 139°43'W, *C. Kennedy 318*, 2 August 1988 (DAO); in sand among washed stones of braided stream bed, tributary of Firth R., 69°07'N 140°15'W, *W.J. Cody 27170*, 7 July 1980 (DAO); Richardson Mts.: sedge slope, 67°43'N 136°32'W, *R.W. Wein 17D*, 13 July 1972 (DAO); moraine, base of Dennis Mtn., McDougall Pass, *L.C. Cwynar 339*, 18 July 1975 (DAO).

Porsild (1975) extended the known northern range in the Yukon Territory north to Miles 57-58, Dempster Hwy. Welsh & Rigby (1971) had however already recorded its presence on a gravel bar of the Babbage River at 68°58'N 138°25'W in the extreme north of the Territory. The collections cited here extend its known distribution east and west into the Richardson and British mountains.

Artemisia campestris L. s.lat. (*A. canadensis* Michx., *A. borealis* Pall.) —YUKON: dry site on lower mid-slope of mountain, Bonnet Plume R., 64°56'N 133°50'W., *C.E. Kennedy 92B-73*, 16 August 1992 (DAO); gravel creek bed, Canyon Creek, Richardson Mts., 66°11'N 136°05'W, *Cody & Ginns 30347*, 5 July 1982 (DAO).

The collections cited here extend the known northern limits northward into the Wernecke and southern Richardson mountains from the Mayo and Dawson-Yukon River areas.

Artemisia globularia Cham. ex Bess. — YUKON: BRITISH MOUNTAINS: broken rocky hump on mountain side, E of Firth R., 69°12'N 139°32'W, *W.J. Cody 27792*, 12 July 1980 (DAO); *Dryas*, Lupine meadow, 69°13'N 139°35'W, *R.W. Wein 264*, 21 July 1972 (DAO); tundra turf on bench, Firth R., 69°13'N 139°49'W, *W.J. Cody 27258*, 8 July 1980 (DAO); dry rocky rubble, Malcolm River, 69°20'N 140°12'W, *C.E. Kennedy 89-39*, 23 July 1989 (DAO); broken stone and turf on mountain slope, 2 km S of Malcolm R., 69°16'N 140°24'W, *W.J. Cody 27459*, 9 July 1980 (DAO); alpine meadow and drainage slope, tributary of Malcolm R., 69°19'N 140°33'W, *W.J. Cody 27662*, 11 July 1980 (DAO); S side of Empire Mts., 69°07'N 140°53'W, *W.J. Cody 27594*, 10 July 1980 (DAO); stony heath in mountains, upper Clarence R. at Alaska border, *R. Frisch 234*, 15 June 1980 (DAO).

Artemisia globularia is new to the flora of the Yukon Territory and should be added to the list of rare species for that region (Douglas et al. 1981). The specimens cited here extend the known range eastward about 550 km from a site in the Brooks Range plotted by Hultén (1968).

Artemisia richardsoniana Bess. — YUKON: turf and braided cobble of river bed, Malcolm River valley, 69°18'N 140°18'W, *W.J. Cody 27465, 27470*, 10 July 1980 (DAO); coastal dunes, 5 km E of Firth River delta, 69°30'N 139°13'W, *L.C. Cwynar 403*, 21 July 1975 (DAO); beach, Firth River, 69°12'N 140°07'W, *A.M. Martell 80-12*, 11 July 1980 (DAO); in shallow sand built up of gravel bar, Malcolm River, 69°31'N 139°50'W, *S.G. Aiken 88-299*, 13 July 1988 (CAN); gravel bar, Firth River, 69°20'N 139°30'W, *S.G. Aiken 88-066*, 6 July 1988 (CAN); calcareous gravel, Sheep Creek, 69°10'N 140°15'W, *Consaul & Aiken 935*, 8 July 1990 (CAN).

Artemisia richardsoniana is new to the flora of the Yukon Territory and should be added to the list of rare species for that region (Douglas et al. 1981). A map of the previously known distribution is northern Alaska and northwestern Northwest Territories may be found in Porsild and Cody (1980).

Aster laevis L. ssp. *geyeri* (A. Gray) Piper (*A. laevis* L. var. *geyeri* A. Gray), Smooth Aster — YUKON: Marsh Lake, 60°31'N 134°20'W, *S. Harris s.n.* (UAC, photo DAO).

First record for the Yukon Territory but previously known from just south of the British Columbia border (Hultén 1968). It should be added to the list of rare plants of the Yukon Territory (Douglas et al. 1981).

Chrysanthemum ircutianum Turcz. (*C. leucanthemum sensu* Hultén 1968) — YUKON: along fence row and in grassy area about abandoned house; only noted in this one locality; Dawson-town area, *Calder & Billard 3557*, 7 July 1949 (DAO).

The specimen cited here was the basis for Hultén's (1968) only map record for *C. leucanthemum* in the Yukon Territory. This is the first record for *C. ircutianum* occurring in the Territory and it has not been observed since 1949; introduced from Eurasia.

Chrysanthemum leucanthemum L., Ox-eye Daisy — YUKON: grassy scrub clearing by buildings, Alder Cr. off Km 201, Haines Hwy., 60°21'N 137°10'W, *Cody & Ginns 28453*, 27 July 1980 (DAO).

The specimen from Dawson plotted by Hultén (1968) as *C. leucanthemum* has been referred to *C. ircutianum* (DC.) Turcz., thus making the specimen cited here the first record for *C. leucanthemum* in the Yukon Territory; introduced from Eurasia.

Cirsium foliosum (Hook.) DC. — YUKON: dry knoll, small island in middle of an unnamed lake, 60°07.5'N 127°21.5'W, *W.J. Cody*, 7 July 1983 (DAO).

Rosie (1991) extended the range of this rare species in the Yukon Territory eastward from sites adjacent to the Canol Road. The site reported here is a further extension southeast of Francis Lake of some 175 km.

Crepis tectorum L., Annual Hawk's-beard — YUKON: waste clearing along road through *Picea glauca* —*Populus balsamifera* woodland by Klondike River 15 mi E of Dawson, 64°04'N 139°05'W, *Cody & Ginns 32878*, 1 July 1984 (DAO).

Hultén (1968) plotted a single site near Haines Junction. Rosie (1991) reported a second site at Watson Lake. The site reported above is the northernmost yet reported but the species is widespread in southern Yukon Territory and specimens have been collected at the following cites: Whitehorse, Mile 33 Campbell Highway, Mile 1176, Alaska Highway, Kilometre 955.2, Alaska Highway, Kilometre 949.5, Alaska Highway, Tay Creek on Canol Road, Kilometre 334 Canol Road, Haines Junction, Faro, Braeburn Lake, Ross River and Carmacks (all DAO), thus indicating a fast expansion of the range of this weedy species.

Erigeron hyperboreus Greene — YUKON: scree slopes, tundra turf and seepage areas, British Mts., Roland Creek, 69°12'N 139°16'W, *W.J. Cody 27227*, 8 July 1980 (DAO); tundra turf on bench, British Mts., Firth R., 69°13'N 139°49'W, *W.J. Cody 27279*, 8 July 1980 (DAO); broken stone and turf on mountain slope, British Mts., 2 km S of Malcolm R., 69°16'N 140°24'W, *W.J. Cody 27453*, 9 July 1980 (DAO); lush, late-snow area on south-facing slope underlain by limestone, British Mts., Mt. Sedgewick area, 68°53'N 139°06'W, *J.A. Calder 34420*, 19 July 1962 (DAO); heathy slope underlain by limestone near summit, British Mts., Mt. Sedgewick, 68°53'N 139°06'W, *J.A. Calder 34469*, 19 July 1962 (DAO); dry south-facing slopes, 68°56'N 138°58'W, *Nagy et al. Sam 74-445*, 18 July 1974 (DAO); rock knob, McNeish Site, 60 km W of Stokes Point, 69°21'N 139°30'W, *L.C. Cwynar 424*, 21 July 1975 (DAO); lower Firth River, *J. McNeish*, 1955 (CAN); Mesozoic deposits, Mount Conybeare, *S.G. Aiken 88-276*, 13 July 1988 (CAN); in vicinity of talus slopes and unglaciated rock outcrop northwest of confluence of Sheep Creek with Firth River *Consaul & Aiken 934 & 944*, 8 July 1990 (CAN).

Porsild (1975) knew this species in the Yukon Territory only from the lower Firth River (June McNeish in 1955 (CAN)) and at 65°18'N 141°00'W (*D.D. Cairnes*, 26 July 1912 (CAN)). The map in Hultén (1968) depicts two sites on the Alaska-Yukon border, the Cairnes collection and Rampart House (*C.C. Loan 568A* (DAO)), and a site at the mouth of the Mackenzie River in the District of Mackenzie. No voucher specimen for this latter site has been found and it may represent a mistaken placement of the Firth River site of J. McNeish. The specimens cited above indicate that *E. hyperboreus*, although restricted to northwestern Yukon Territory, is much more common than indicated by Douglas et al. (1981).

Erigeron hyssopifolius Michx. — YUKON: vegetated silt bars, Upper Hart R., 64°36'N 135°48'W, *R. Frisch 221*, 26 July 1980 (DAO); small rock outcrop adjacent to river, Bonnet Plume River, 64°44'50"N 133°40'50", *C.E. Kennedy 92B-2*, 12 August 1992 (DAO); boreal white spruce with understory of willow-shrub, birch/lichen, Bonnet Plume River, 64°22'N 132°23'W, *C.E. Kennedy 92B-16*, 14 August 1992 (DAO).

Hultén (1967) reported the first Yukon Territory collection of this species from Margaret Lake, Upper Bonnet Plume River [65°21'N 134°30'W] which he had made on 10 August 1964. The collections cited above extend the known range in this region.

Erigeron peregrinus (Pursh) Greene ssp. *callianthemus* (Greene) Cronquist —YUKON: Cassiar Mountains, 20-30 miles east of Teslin Lake and 10-15 miles north of Alaska Highway, *W.H. Poole s.n.*, 1952 (DAO); Cassiar Mountains, 60°08'N 130°25'W, *W.H. Poole 136*, 18 July 1955 (DAO).

Douglas et al. (1981) stated on page 55 that the occurence of ssp. *callianthemus* in the Yukon Territory was unconfirmed. In the text on page 27 the range of *E. peregrinus* in the Yukon Territory was given as Cassiar Mountains and southeastern Kluane National Park. However an examination of specimens at DAO from these two regions shows that the Cassiar Mountain material with involucral bracts glandular on the back are clearly referable to ssp. *callianthemus* and the Kluane material (collected by G. Douglas) which has involucral bracts villous on the back but lack stipitate glands, are clearly referable to ssp. *peregrinus*. This is also true for the specimen cited by Porsild (1975) as ssp. *callianthemus* (Tincup Lake, 61°46'N 139°14'W, *R.T. Porsild* 1986). The specimen plotted by Hultén (1968) from this area as ssp. *callianthemus* could not be located, but is presumably also ssp. *peregrinus*.

Erigeron philadelphicus L.

Specimens collected by R. Wein (Wein et al. 1974) and O. Murie (Hultén 1967, 1968) from along the Porcupine River in northern Yukon Territory have been revised to *Erigeron glabellus* ssp. *pubescens*. *Erigeron philadelphicus* is thus only known from extreme southern parts of the Territory where it is considered rare by Douglas et al. (1981).

Erigeron purpuratus Greene — YUKON: in open rocky areas, about 3 miles east of Dawson on road to Bear Creek, *Calder & Billard 3261*, 23 June 1949 (DAO); gravel bed, Dawson, *J.A. Calder YT47*, 23 June 1949 (DAO); dry rocky-gravel area, Bear Creek area 7-8 miles east of Dawson, *Calder & Billard 3019*, 12 June 1949 (DAO); gravel outwash of river, Km 7 Dempster Hwy., 64°01'N 138°35'W, *Cody & Ginns 32883*, 1 July 1984 (DAO); gravel by "ditch", Ditch Road E of Km 8 Dempster Hwy., *W.J. Cody 28045*, 18 July 1980 (DAO); disturbed slope, Dempster Hwy., Km 24 nr. Glacier Cr., 64°08'N 138°33'W, *Cody & Ginns 29032*, 7 August 1980 (DAO); gravel road bank, Dempster Hwy., Km 37, 64°14 138°32'W, *Cody & Ginns 29044*, 7 August 1980 (DAO); disturbed gravel, Dempster Hwy. Km 111, 64°46'N 138°21'W, *Cody & Ginns 29087*, 7 August 1980 (DAO); in sand among washed stones of braided stream bed, British Mts., tributary of Firth R., 69°07'N 140°15'W, *W.J. Cody 27132*, 7 July 1980 (DAO); sandy soil near river, Walking River [68°55'N 137°19'W], *G. Ironside*, 4 July 1971 (CAN).

Becker (1976) described a new species of *Erigeron* closely related to *E. purpuratus*, *E. mexiae*. *Erigeron mexiae* has since been placed in synonymy of *E. pallens* Cronq. These share the distinction of being the only two species of *Erigeron* in the Yukon Territory which have a purple-tinged pappus and because of this feature, specimens of *E. pallens* were at one time identified as *E. purpureus*. *Erigeron pallens* is an alpine species of tundra, scree and rocky slopes whereas *E. purpuratus* is essentially a lowland species found in gravelly situations. A character which was thought to be distinctive in *E. pallens* was that occasional early leaves were shallowly 3-lobed. Some specimens in the collections cited above also possess early 3-lobed leaves, but these leaves are decidedly longer and narrower than those of *E. pallens*, and the lobes are also longer and narrower. This character has not previously been noted (Figure 3). Specimens from the British Mountains (*P.F. Cooper 962 & 991* (CAN)) which were originally determined *E. purpuratus* and *E. mexiae* respectively, have both been revised to *E. hyperboreus*. The latter was the basis for the report in Douglas et al. (1981) of *E. mexiae* from the British Mountains. The main range of *E. purpuratus* in the Yukon Territory is in the southwestern part north to 64°45'N and it is then disjunct to the arctic slope.

Erigeron uniflorus L. ssp. *eriocephalus* (Vahl ex Hornem.) Cronq. (*E. eriocephalus* Vahl ex Hornem.) — YUKON—MACKENZIE border: occasional on steep rocky banks and cliffs above creek, Fish Creek, Richardson Mts., 67°57'N 136°27'W, *J.A. Calder 34140*, 14 July 1962 (DAO).

This circumpolar taxon was previously known in northern Yukon Territory from the Arctic Circle near the Alaska border but was to be expected in the Richardson Mountains because it also occurs in northwestern District of Mackenzie.

Erigeron yukonensis Rydb. — YUKON: British Mountains, Babbage River drainage, Trout Lake area, east side of river on tundra, *J.D. Lambert s.n.*, 19 July 1965 (DAO).

The type specimen for this species was collected by Williams at Dawson in 1899 and it has since been collected several times in that area. Other more recent collections have been reported from Whitehorse and the Dempster Highway in the Yukon Territory and along the arctic coast of the District of Mackenzie east to Coronation Gulf and also in the southern Mackenzie Mountains (Cronquist 1947; Porsild 1975; Porsild and Cody 1980). The British Mountains site represents a range extension of some 450 km north from the sites on the Dempster Highway.

Gaillardia aristata Pursh, Gaillardia — YUKON: Along roadside, Mile 1016 Alaska Highway, Kluane National Park Headquarters, *G.W. & G.G. Douglas 6224*, 21 July 1973 (DAO); waste ground along highway at old Experimental Farm, Mile 1019 Alaska Highway near Haines Junction, 60°46'N 137°35'W, *Cody & Ginns 28386*, 26 July 1980 (DAO).

FIGURE 3. Lobed leaves of *Erigeron pallens* (left) and *Erigeron purpuratus* (right). Drawing by M. Jomphe.

This species which occurs from British Columbia to Manitoba and south into the United States has not previously been reported from the Yukon Territory where it is presumably an escape from cultivation. It was also reported as an introduction on farmland near Fort Simpson in the District of Mackenzie (Cody 1961).

Gnaphalium uliginosum L., Everlasting — YUKON: abundant in black mucky soil in disturbed area, Mayo, *R. Rosie 447*, 28 August 1977 (DAO); drying up flat by small lake 2 miles west of Carmacks on old Dawson Road, 62°07'N 136°22'W, *W.J. Cody 28173*, 20 July 1980 (DAO).

Hultén (1950) cited a single specimen (*Anderson 9740* preserved in his personal herbarium) collected at Mayo; this introduced species has thus perservered in the Mayo area and the collection from west of Carmacks is a second locality for the Yukon Territory.

Hieracium umbellatum L. (*H. scabriusculum* Schwein.), Narrow-leaved Hawkweed —YUKON: roadside gravel, Contact Creek Esso Station, Alaska Hwy. Km 949.5, 60°01'N 127°44.5'W, *W.J. Cody 32506*, 9 July 1983 (DAO); sandy soil along roadside, between Hunker Summit and Dominion Creek gold camp on "loop" southeast of Dawson, *J.A. Calder 4544*, 16 August 1949 (DAO).

Douglas et al. (1981) included *H. umbellatum* in The Rare Plants of the Yukon on the basis of two collections from hot springs at Watson Lake and Beaver River in the extreme southeast. The specimen from near Dawson which was plotted by Hultén

(1968) was apparently not seen by Douglas et al. (1981), but this and the collection from Contact Creek cited above probably represent introductions.

Lactuca biennis (Moench.) Fern., Tall Blue Lettuce — YUKON: 2nd hot springs on Larsen Creek, 60°12'30"N 125°32'W, *G.W. Scotter 24724*, 22 July 1977 (DAO).

The map in Hultén (1968) indicates a collection from adjacent to the southeastern Yukon-British Columbia border, but no substantiating specimen for this has been found. The specimen cited here thus confirms the presence of this introduced species in the Yukon Territory.

Matricaria matricarioides (Less.) Porter, Pineapple-weed — YUKON: cabin clearing in *Populus* ssp. — *Picea glauca* woodland, Ditch Road E off Dempster Hwy. Km 8, 64°02'N 138°36'W, *W.J. Cody 28004*, 18 July 1980 (DAO); disturbed ground by highway construction bldgs., Km 283 Dempster Hwy., 65°55'N 137°32'W, *W.J. Cody 27891*, 16 July 1980 (DAO); disturbed sandy soil of borrow pit, Km 321 Dempster Hwy., 66°08'N 137°08'W, *W.J. Cody 27870*, 16 July 1980 (DAO).

The map in Hultén (1968) depicts sites north to Dawson, but the range is here extended some 225 km northward. This introduced species is also much more widely spread in the south than it was known to Hultén.

Matricaria perforata Mérat (*Tripleurospermum inodorum* (L.) Schultz-Bip. —YUKON: by building, Ross River Forestry Station, 61°59'N 132°26'W, *Cody & Ginns 28840*, 3 August 1980 (DAO).

Rosie (1991) reported this introduced species as new to the flora of the Yukon Territory based on a specimen collected at Francis Lake in 1970. It will undoubtedly be found in settled areas elsewhere in the Territory in the future.

Petasites frigidus (L.) Fries ssp. *arcticus* (Porsild) Cody (*P. arcticus* Porsild) — YUKON: fine broken stones and turf in saddle and adjacent slopes, Richardson Mts., 68°06'N 136°37'W, *Cody & Ginns 31826*, 13 July 1982 (DAO); wet turf in stream valley, Richardson Mts., Bell River, 68°07'N 137°06'W, *Cody & Ginns 32004*, 14 July 1982 (DAO); moist alpine turfy slope, Richardson Mts., 68°12'N 136°35'W, *Cody & Ginns 31345*, 11 July 1982 (DAO); alpine meadow, creek bed and adjacent turfy slopes, Richardson Mts., 66°44'N 135°52'W, *Cody & Ginns 30938*, 8 July 1982 (DAO); valley with mature white spruce and willow, Richardson Mts., 66°27'N 135°35'W, *Cody & Ginns 30886*, 8 July 1982 (DAO); rich spruce woods on side of moraine, Southern Richardson mountains, 66°04'N 135°50'W, *L.C. Cwynar 1225*, 8 July 1977 (DAO); riverbank, N side of Porcupine Creek, 1 km upstream of Rat Indian Creek, *L.C. Cwynar 921*, 19 July 1976 (DAO); scree slope, Dempster Hwy. Km 251, 65°46'N 137°52'W, *W.J. Cody 26686*, 2 July 1980 (DAO).

The type locality for this taxon was the Reindeer Station on the East Branch of the Mackenzie River Delta. At the time of publication Porsild (1943) knew of only one locality in Yukon Territory (between King and Kay Points on the Arctic Coast). Porsild abd Cody (1980) mapped the then known range southward through the Richardson and Mackenzie mountains to Nahanni National Park. The known range is now extended into the Richardson Mountains in northeastern Yukon Territory south to the northern limits of the Ogilvie Mountains.

Senecio kjellmanii A.E. Porsild (*S. atropurpureus* (Ledeb.) Fedtsch. ssp. *tomentosus* (Kjellm.) Hultén) — YUKON: upper middle slope of mountain, S side of Empire Mtn., 69°07'N 140°53'W, *W.J. Cody 27583*, 10 July 1980 (DAO); alpine meadow, tributary of Malcolm R., 69°19'N 140°33'W, *W.J. Cody 27673*, 11 July 1980 (DAO); broken rock and turf, 3 km E of Firth R., 69°03'N 140°24'W, *W.J. Cody 27404*, 9 July 1980 (DAO); E of Canyon Creek headquarters, 69°04'N 139°43'W, *C. Kennedy 390*, 8 August 1988 (DAO); moist turf on stony slope by small stream, Bell R., 68°07'N 137°06'W, *Cody & Ginns 31990*, 14 July 1982 (DAO); wet meadow, 66°22'N 135°49'W, *Cody & Ginns 30537*, 6 July 1982 (DAO).

Nagy et al. (1979) reported the first known occurrence of this species in northern Yukon Territory. The localities cited above extend the known distribution in the north east and west to the Richardson and British mountains.

Senecio ogotorukensis Packer (*S. conterminus sensu* Hultén (1968) pro parte) —YUKON: scattered on dry mountain ridge, Rampart House on the Yukon-Alaska border, *C.C. Loan 566*, 11 July 1951 (DAO); dry limestone bluff, Klo Kut, 67°34'N 139°41'W, *L.C. Cwynar 35*, 4 July 1975 (DAO); fellfield summit, Schaeffer Mountain, 67°46'N 139°44'W, *L.C. Cwynar 98*, 5 July 1975 (DAO); open dry rocky ridge, 2 miles west of Sam Lake [68°30'N 138°35'W], *Nagy & Pearson 74-301*, 13 July 1974; shale slope, Babbage River drainage south of Trout Lake, 68°48'N 138°43'W, *J.D. Lambert*, 12 August 1965 (DAO).

Packer (1972) knew this species from Alaska, except the north slope, and west central and southwest Yukon Territory. The specimens cited here extend the known range into northern Yukon.

Senecio pauperculus Michx. — YUKON: finer sediment on surface of gravel bar, on east bank of Bonnet Plume River about 2 miles above its junction with Noisy Creek, 65°52'N 134°55'W, *C.R. Harrington CR-72-78-8*, 10 July 1975 (DAO).

This is an extension of the known range northward from latitude 64°N of about 250 km.

Solidago canadensis L. var. *salebrosa* (Piper) M.E. Jones, Goldenrod — YUKON: Needlerock Creek, 62°45'N 135°45'W, *C. Kennedy 54*, 12 July 1985 (DAO); wetland area of small lakes near Needlerock Creek, 62°35'N 135°30'W, *B. Ereaux 86-7*, 5 August 1986; open willow-birch shrub, Sheldon Lake, 62°42'N 131°03'W, *R. Dale 85*, 8 August 1977 (DAO); mouth of Thistle Creek on Yukon River, 63°06'N 139°29'W, *Cody & Ginns 35362*, 20 July 1984 (DAO); Yukon River ½ mile upstream from Chandindu River, 64°15'N 139°40'W, *Cody & Ginns 34786* (DAO); Island in Yukon River at mouth of Rosebute Creek, 63°31'N 139°43'W, *Cody & Ginns 35372*, 20 July 1984 (DAO); Yukon River at mouth of Indian River, 63°47'N 139°44'W, *Cody & Ginns 34728*, 16 July 1984 (DAO); Yukon River 2 miles upstream from Forty Mile, 64°23'N 140°32'W, *Cody & Ginns 35006*, 18 July 1984 (DAO); Yukon River 4 miles NNW of mouth of Coal Creek, 64°31'N 140°33'W, *Cody & Ginns 35086*, 19 July 1984 (DAO).

Douglas et al. (1981) reported this plant as rare in the Yukon Territory on the basis of collections from Larsen Creek (Scotter and Cody 1979) (DAO) and Alaska Highway Mile 674 (CAN). Collections from Dawson (*Calder 4342* (DAO)) and Rawson's wood camp, (17 miles below Selkirk on the Yukon River (*Gillett & Mitchell 4048*) (DAO)) which were plotted by Hultén (1968) were unfortunately not examined by Douglas et al. (1981). The collections cited above show that this species is much more widely spread in the Yukon Territory than previously thought.

Sonchus arvensis L. ssp. *uliginosus* (Bieb.) Nyman (*S. arvensis* L. var. *glabrescens* Guenth., Grab. & Wimm.), Perennial Sow-thistle — YUKON: along roadside, Alaska Highway Mile 1018, 60°46'N 137°33'W, *G.W. & G.G. Douglas 9129* (DAO); open roadside Km 11, Blind Creek Road, Faro, *V. Hodgson 594*, 7 August 1983 (DAO); waste ground, Carmacks, 62°05'N 136°17'W, *W.J. Cody 28183*, 20 July 1980 (DAO); Slims River flats at Kluane Lake, 61°01'N 138°31'W, *Cody & Ginns 28622*, 29 July 1980 (DAO).

This introduced weedy species is apparently becoming widely spread in southern Yukon Territory. It has not been reported previously but was to be expected.

Sonchus asper (L.) Hill, Spiny Sow-thistle — YUKON: Dawson, *E. Schoff*, August 1904 (TRT).

This introduced weedy species has not previously been recorded from the Yukon Territory nor has it been found again since 1904. It is, however, known from along the Yukon River in Alaska (Hultén 1968).

Taraxacum erythrospermum Andrz. ex Bess. (*T. laevigatum* (Willd.) DC.), Red-seeded Dandelion — YUKON: common near courthouse, Dawson, *Calder & Billard 2894B*, 8 June 1949 (DAO); gravel of river flood plain, Little Rancheria R., Mile 670, Alaska Hwy., *W.J. Cody 25553*, 10 June 1980 (DAO).

Welsh (1974) included Yukon in the range of this introduced species but there is no indication given for its inclusion.

Taraxacum officinale Weber ex Wiggers, Common Dandelion — YUKON: cabin clearing in *Populus* spp. — *Picea glauca* woodland, Ditch Road E off Dempster Hwy. Km 8, 64°02'N 138°36'W, *W.J. Cody 28032*, 18 July 1980 (DAO).

Hultén (1968) knew this species only in the southern parts of the Territory. It is, however, now much more widely spread.

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Notes

Swarming of Yolk-Sac Herring, *Clupea harengus* L., Larvae at the Sea Surface

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Bradford, Rodney G. 1994. Swarming of yolk-sac herring, *Clupea harengus* L., larvae at the sea surface. Canadian Field-Naturalist 108(4): 477–479.

Larval collections over a known and surveyed demersal herring egg bed in the Gulf of St. Lawrence showed the existence of surface concentrations exceeding 10^6 larvae $\cdot m^{-3}$ over a bottom depth of 18 m. Observation of individual larvae revealed co-ordinated orientation toward the survey vessel. Active migration is shown to be as plausible an explanation for their arrival at the surface as is passive transport. These observations together with other published accounts of natural behaviour of yolk-sac larvae aggregations suggest that herring hatch with the ability to co-ordinate behaviour and may respond to their environment by exercising depth selection.

Key Words: Herring, *Clupea harengus*, larvae, swimming, behaviour.

A large (1.19 km^2) demersal Herring egg bed at a depth of ≈18.0 m was spawned on the night of 8 September 1988 on Fishermans Bank, Prince Edward Island, Canada (46°02′ N; 62°15′ W). Spawn dredged from the bed and plankton tows above the bed on 16 September at 13:15 AST revealed no sign of hatching, but on 17 September 1988 at 09:15 AST yolk-sac herring larvae were sighted from the survey vessel at the surface and directly over the egg bed. Viewing conditions were exceptionally good with no cloud cover, gentle unbreaking seas (wave height <0.5 m), and light winds (< 10 $km \cdot h^{-1}$). Larvae arrived at the surface in dense clouds (area ≈1-10 m^2), or 'swarms', which were clearly visible from a distance of about 5 m as a "shimmering" upon the sea surface. Closer inspection indicated that this was the result of reflection/refraction of sunlight off the eye pigments of the larvae. A 4-minute tow of a 1 m ring net with a 435 µm mesh at a speed of 0.5 knots captured a quantity of larvae which overflowed a 1-*l* volume cod-end, in spite of a 30 cm tear along the mid-section of the net.

Quantitative estimates of the concentration of larvae at the surface were obtained after returning the boat to the point of the original sighting, and filling a 4-*l* pail at random with surface (0-0.25 m) water about every 10 minutes while drifting over the next hour. The drift path was estimated to be about 0.5 km. Larvae were retrieved by straining the contents of the pail through the detached cod-end (250 µm mesh) of the plankton net and preserved in a 3% formalin - seawater (≈30 ppt salinity) solution. Mean concentration (± 1 standard deviation; n = 6) was 6420 ± 4820 larvae$\cdot m^{-3}$ with minimum and maximum concentrations of 1500$\cdot m^{-3}$ and 13250$\cdot m^{-3}$ respectively. One sample taken from a swarm as it came into view at the surface yielded an estimate of $1.25 \cdot 10^6$ larvae$\cdot m^{-3}$. Mean preserved length (± 1 SD) was 6.15 ± 0.54 mm (n = 253; minimum = 4.79 mm; maximum = 7.62 mm).

Larvae were sighted at 35 of 37 stations spaced grid-like every 200 m over the egg bed, and were still present when the boat left Fishermans Bank to return to port (total observation time = 8 h). Tidal phases were sequentially the flood, slack and ebb. Larvae oriented toward the boat as they passed into view from under the boat and thereby suggesting a group response to a common stimulus.

Examination of dredged spawn revealed that only the upper three of approximately 10 deposited egg layers ultimately developed into free-swimming larvae, even though most eggs had been fertilized. High egg mortalities are not unusual for this spawning site (Messieh 1988; Messieh and Rosenthal 1989). Therefore, with a typical egg diameter of 1 mm the potential number of viable larvae per square meter of spawn is of the order $3 \cdot 10^6$, which is roughly twice the observed number of larvae (m^{-3}) upon their arrival at the sea surface. The time required for the diffusion of the observed surface concentration of larvae from the egg bed was estimated to be 25 hours from:

$$\frac{\partial c}{\partial t} = \frac{\partial}{\partial t} \left[k_v \frac{\partial c}{\partial z} \right] \qquad (1)$$

for the initial conditions of 0 larvae•m^{-3} at the sea surface and 3•10^{6} larvae•m^{-3} at the sea bottom, and assuming (a) instantaneous emergence, (b) neutrally buoyant larvae, and (c) negligible natural mortality and/or advective losses, and where C is larvae•m^{-3}, t is time (s), Z is the vertical distance (18m), and k_v is the vertical eddy diffusivity (0.0012 m^2•s^{-1}).

The magnitude of the vertical eddy diffusivity (k_v) was estimated as:

$$k_v = \frac{C_D \cdot Q^2}{200\, f} \qquad (2)$$

where C_D is the drag coefficient (0.0025), Q is the root mean square tidal current speed typical for this region of the Gulf of St. Lawrence (0.1m•s^{-1}; from Pingree and Griffiths 1980) for periods of 0.5 to 1 day (Petrie and Drinkwater 1978), and f is the Coriolis parameter (1.05 • 10^{-4}). The estimate of 25 h for the larvae to diffuse to the sea surface is comparable to the maximum elapsed time of 20 h between the sightings at the surface and the previous day's dredge samples/plankton tows.

Discussion

The larvae could have easily swum the 18m to the surface, a distance three orders of magnitude greater than their body length. Rates of ascent via swimming calculated between the time of the initial observations and either the maximum possible time (20 h) or the availability of a phototactic clue (sunrise at 1035 GMT; Bracken 1984) are 0.28 mm•s^{-1} and 2.35 mm•s^{-1} respectively. Both estimates are less than either known sustained (5.8 mm•s^{-1}; Bishai 1960) or burst (30 mm•s^{-1}; Rosenthal and Hempel 1970) swimming speeds for yolk-sac herring larvae. Yolk-sac larvae observed directly, via SCUBA, over egg beds in a Norwegian fjord migrated vertically towards the surface shortly after they hatched (Johannesen 1986).

Passive transport of the yolk-sac larvae to the surface, and their presence there for at least seven hours, although plausible rests on acceptance of the maximum possible time between hatching and their arrival at the surface as the appropriate time scale. In addition, both the known negative buoyancy of yolk-sac larvae (Blaxter and Ehrlich 1974; Henri et al. 1985), and the likelihood of horizontal diffusion must be ignored. Furthermore, natural egg densities in spawning beds are typically less than half the theoretical maximum which was used in the calculations above (Messieh et al. 1987; D. Cairns, personal communication). Collectively, these factors suggest that the calculated time for diffusion of herring larvae to the surface of 25 h is an underestimate.

The boat, while drifting parallel to the surface swell, may have had a localized shearing effect on the surface current, thereby affording a reference point to which the larvae responded. Herring larvae can both detect and react to water velocity shear either at hatch or soon afterwards (Bishai 1960). Yolk-sac larvae could, therefore, conceivably influence their rate of dispersal by migrating upwards through velocity shears which are detectable on length scales equivalent to their body size and thereby reduce the influence of bottom friction.

The arrival of larvae at the surface in patchy, high concentrations (order 10^{6} larvae•m^{-3}), under calm conditions, suggests cohesiveness through an intraspecific response. Iles and Caddy (1972) observed from a submarine the simultaneous lift-off of larvae from an egg bed on Georges Bank. Yolk-sac herring larvae have chemoreceptive abilities, including an innate response to the presence of other larvae (Dempsey 1978).

Direct observations on yolk-sac larvae under naturally occurring conditions (e.g., Iles and Caddy 1972; Johannesen 1986; this study) support laboratory studies that show herring larvae can both sense and respond to their immediate environment at hatch (Bishai 1960; Dempsey 1978). Thus, concentrations of yolk-sac larvae which remain near the bottom for several days (e.g., Saville 1971; Henri et al. 1985) could represent an "activity" rather than a demonstration of limited faculties. Johannessen (1986) noted that even though herring larvae could swim vertically upon hatching, subsequent sampling detected no migratory patterns indicative of endogenous rhythms until after the absorption of the yolk-sac. Therefore, the dispersal of herring larvae from spawning grounds is not necessarily either obligative "passive" (Fortier and Leggett 1983) or analogous to the dispersal of particles with negative buoyancy until ontogenetic changes allow for regular vertical migrations (e.g., Henri et al. 1985). Facultative responses by herring larvae from the onset of the pelagic stage appear to exist, and could represent the behavioural component of an effective dispersal mechanism.

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Arboreal Foraging by Red Foxes, *Vulpes vulpes*, during Winter Food Shortage

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Red Foxes (*Vulpes vulpes*) are not known to exhibit arboreal habits. I describe several observations of arboreal foraging behaviour by Red Foxes on Baccalieu Island, Newfoundland. Lack of winter food was believed to have contributed to the semi-arboreal behaviour exhibited by the Red Foxes on Baccalieu Island.

Key Words: Red Fox, *Vulpes vulpes*, arboreal, foraging, Newfoundland.

A variety of carnivores have adapted arboreal habits, however, many species are constrained to certain locomotor activities by morphology (Taylor 1989). Among the Canidae, arboreal behaviour is unusual and only the Gray Fox (*Urocyon cinereoargenteus),* which is closely associated with the deciduous forests of North America (Hall 1981), is known to exhibit arboreal tendencies. Trees may be used when seeking food, as temporary resting places, as lookout sites and in avoiding predators (*see* Trapp and Hallberg 1975; Fritzell and Haroldson 1982). Comparatively, Red Foxes are not known to exhibit arboreal behaviour. However, they are an opportunistic and highly skilled predator, and where seabirds constitute an important component of the diet, they may climb steep, narrow cliff-ledges and prey on seabird eggs, chicks and adults (Murie 1959; Macarone and Montevecchi 1981; Sklepkovych 1986). This note describes arboreal foraging behaviour by Red Foxes in relation to winter food shortage.

From 1983–1986, I studied the predatory behaviour of Red Foxes in relation to the breeding seabird colonies on Baccalieu Island, Newfoundland

(48°07′N, 54°12′W). Red Foxes are believed to have colonized the island by crossing over pack ice (Maccarone and Montevecchi 1981) which in some years fills the Baccalieu Tickle, a waterway between the island and the mainland (~3.2 km; Sklepkovych 1986). The population of foxes on Baccalieu Island during the study period was estimated at 11 adults, of which seven were readily distinguishible based on pelage markings, colour characteristics and size. No other mammals live on Baccalieu Island, limiting the diet of Red Foxes primarily to seabirds, which nest in large numbers along the central and southeastern portions from April to October (Montevecchi and Tuck 1986; Sklepkovych and Montevecchi 1989). Steep cliffs form much of the shoreline of Baccalieu Island, limiting the foxes' ability to scavenge marine food. During winter months when seabirds no longer nest, alternate prey are scarce (Sklepkovych 1986). Passerines, seaducks and gulls are found on or near the island, but they appear difficult for Red Foxes to capture. Scat analysis suggested that scavenged and hoarded prey composed the largest portion of Red Fox diet during winter (Sklepkovych 1986).

The following observations were made during February-March 1985. The thickness of snow cover on Baccalieu Island varied between different locations from 2 cm to 2 m depending on wind conditions and resulting drifts. Home range use by Red Foxes was more homogeneous during winter than during other periods of the year. A greater incidence of fox activity was noticeable (based on sighting and tracks) during this period along the western portion of Baccalieu Island, where little activity takes place during the seabird breeding season (Sklepkovych 1986). Foxes were also observed scavenging along the limited beaches and on both stable and flowing pack-ice. Large flocks of seaducks (e.g., Common Eiders, *Somateria mollissima*) occur along the island's edge and Red Foxes may occasionally find injured or trapped birds along, or in ice leads (R. Hyde, personal communication; Tuck 1960). Indirect evidence from tracking signs suggested that Red Foxes may hunt and capture passerines and ducks although direct observations indicated that they were rarely successful (Sklepkovych 1986). Scat analyses verified that seabirds, particularly Leach's Storm-Petrels (*Oceanodroma leucorhoa*), captured and hoarded prior to winter composed the largest proportion of fox winter diets (Sklepkovych 1986).

Three separate instances of arboreal foraging were noted among two individual Red Foxes. The first took place on 23 February 1985, when a fox was observed standing upright on its hind legs looking up and over a stand of short (~3 m) Balsam Fir (*Abies balsamea*) trees. After checking four trees in this manner, the fox jumped up onto a fir by grabbing the tree branches with its forepaws and climbing up using its hind legs. Once on top, the fox walked among the neighboring trees while searching among the few full treetops. After 2 min of searching, the fox tore off and began chewing a Balsam Fir cone, the remnants of which were discarded after ~30 s. A second cone was taken in the same manner, however, the fox jumped from the tree and ate it while resting on the ground. The cone was intermittently chewed, but eventually swallowed whole after ~3 min. Similar behaviour was noted for this fox three days later. During 1 h of observation, this individual spent over 15 min actively foraging in the Balsam Fir treetops. The fox tore off and chewed six fir cones. Four of the six cones were chewed for >1 min. and >50% of each cone was swallowed (see front cover). Two of the six Balsam Fir cones that had dropped to the ground were later collected by the fox, casually chewed and eaten whole.

The most pronounced example of Red Fox arboreal behaviour involved a second individual on 7 March 1985. I was walking in a wooded area when I spotted a Common Raven (*Corvus corax*) fly from a nearby tree. I then observed movement in a White Birch (*Betula papyrifera*) about 6 m from where the Raven had flown and spotted a Red Fox at a height of ~8 m standing on a branch (< 4 cm in diam.). The fox, unaware of my presence, began walking and searching along a branch occasionally stopping to look up and down at neighboring branches and trees. When the fox reached the outer portion of the branch, where its weight might no longer be supported, it backed up ~2 m and jumped lightly down 1 m to a lower branch. This branch was also searched, after which the fox jumped to a neighboring birch tree searching the branches and trunk in a similar manner. The fox jumped with little effort among the branches occasionally pausing between jumps. After searching in the second birch tree for 3 min, the fox jumped to the ground from a height of 3 m and continued foraging along the ground in the woods occasionally looking up into the trees. Ten minutes later the fox climbed to the lower branches of an American Mountain Ash (*Sorbus americanus)* by jumping onto and scurrying with its hind legs up the tree trunk. In the latter part of a 2 hour observation period, this fox was also seen foraging along the tops of Balsam Fir trees and eating fir cones (N = 1 eaten / 3 chewed).

During this study period, nine fox observations (n = 7 individuals) lasting ~20 hours were made. The two Red Foxes exhibiting arboreal behaviour climbed trees in a manner similar to Gray Foxes (Fritzell and Haroldson 1982) by scurrying up the trunk or trunk branches and then walking or jumping between branches or trees. "Tuckamore", an atypical growth form of "fir trees" in windswept areas of Newfoundland, with branches that are stiff, short and interlocking, occasionally has the power of supporting animals on its surface. However, in both cases of arboreal foraging in conifers, foxes were observed climbing on or along "typical" growth forms. Arboreal tendencies were further substantiated in the climbing of deciduous trees.

Arboreal behaviour was observed among two different individuals on separate occasions suggesting that this method of foraging may be more common than previously suspected. Red Foxes are adept climbers and trees with large branches low to the ground may readily be accessible to foxes (for photo see Macdonald 1987). Red Foxes being opportunistic may try to gain access to tree limbs bearing fruits or when artificially provisioned with foods such as suet at bird feeders (e.g., see Larsson 1986). Perhaps when faced with severe food stress, such as on Baccalieu Island, Red Foxes may be more likely to forage in trees. It is not known whether foxes are capable of stalking and capturing birds or other animals in trees. Because Red Foxes are secretive, examples of arboreal behaviour in the wild are rare. To the best of my knowledge, the utilization of fir cones for nutrition or as temporary relief from hunger has not been reported. Murie (1959) noted that during periods of prey scarcity foxes may eat food items that appear to have little value (see also Lloyd 1980). Although coniferous cones may provide some nutrients (A. E. Diamond, personal communication, University of New Brunswick), it is doubtful that they serve any important nutritive value, and are probably ingested to help satiate hunger. The arboreal "foraging" behaviour exhibited by Red Foxes on Baccalieu Island appears to be unusual and further demonstrates the opportunistic nature of Red Foxes.

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Artificial Nest Parasitized by a Brown-headed Cowbird, *Molothrus ater*

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A Brown-headed Cowbird egg was found in one of 1532 artificial passerine nests set up in eight marshes and upland habitats in the Ottawa-Hull region in the course of an experimental study on nest predation conducted in 1989–1990. This is the first reported case of parasitic laying by a Brown-headed Cowbird in an artificial open-cup nest that lacked activity of the adults around the nest and signs of normal passerine egg-laying pattern. We suggest that this was an "accidental" host choice by the cowbird.

Key Words: Brown-headed Cowbird, *Molothrus ater*, nest parasitism, host choice.

The Brown-headed Cowbird (*Molothrus ater*) is a brood parasite known to have laid its eggs in nests of over 220 host species (Friedmann et al. 1977; Friedmann and Kiff 1985). Although this species parasites open-cup nests, occasional parasitism of nests of hole-nesting species has been reported (Friedmann et al. 1977; Picman 1986; Petit 1991). The reproductive success of cowbirds depends on the cowbirds' ability to find suitable host nests in which to lay (Clark and Robertson 1981) and on the host rejection frequency of cowbird eggs which can reach 100% (Rothstein 1975, 1982). To locate a host nest, the female cowbird usually perches on elevated posts and observes the behavior of nearby breeding birds before restricting her active search to a limited area (Thompson and Gottfried 1976). However, nests can be located and parasitized in the absence of the breeding adults (Thompson and Gottfried 1981; Freeman et al. 1990).

To study the mechanisms by which cowbirds find and select host nests, some authors have placed out artificial nests (Thompson and Gottfried 1976, 1981; Lowther 1979). In studies where "clutches" of eggs were introduced at one time in artificial nests and left with no further manipulations, no laying by female cowbirds was recorded (Thompson and Gottfried 1976, 1981). In contrast, in cases where eggs were deposited in nests one per day to simulate normal passerine egg-laying pattern, nest parasitism by cowbirds was recorded infrequently (1 out of 25 nests) (Thompson and Gottfried 1981) or not (Yahner and DeLong 1992). These findings suggest that female Brown-headed Cowbirds need certain information on host activities to locate nests to parasitize. This note describes a case of parasitic laying by a female Brown-headed Cowbird in an artificial open-cup nest that lacked host activity around the nest and signs of normal passerine egg-laying pattern.

This event took place in the course of a study on nest predation of marsh-nesting birds using artificial nests in the Ottawa-Hull region, Canada (Jobin 1991). During the two-year study, 1532 artificial passerine nests were set up in eight different marshes and adjacent uplands to examine patterns of nest predation in three different habitats with varying degrees of human-related disturbance: urban areas , agricultural areas and natural forests. Urban areas received 194 and 158 nests in upland and marsh habitats, respectively; agricultural upland and marsh habitats 329 and 291 nests, and natural upland and marsh habitats 360 and 200 nests, respectively. Artificial nests (10-12 cm wide, 4-6 cm deep) were built from dry grass using transparent and odorless glue simulating the Red-winged Blackbird (*Agelaius phoeniceus*) nest (Picman et al. 1988). One single, fresh Blue-breasted Quail (*Coturnix chinensis*) egg was deposited in each nest at the time the nests were placed out. Nests were set up 20 m apart along transects running perpendicular from the center (deep end) of the marsh through the shallow marsh area and adjacent upland habitat. Nest height varied from 0 to 200 cm.

Nests and eggs were left unattended for three 15-day periods each year. In 1989 and 1990, artificial nests were set up from 9 May to 24 May, 19 June to 6 July and 17 July to 3 August. In 1989, after the nests were set up, we inspected them the following day and then at three-day intervals. In 1990, we visited the nests only twice, after seven and 13 days of exposure, because results from the first year showed that the change in predation frequencies occurring over a three-day period was negligible, and that frequent nest visits caused damage to the surrounding vegetation.

The parasitism event occurred in 1990. The nest was set in place on 21 May. On 28 May, the nest and quail egg were undisturbed, but on 3 June a Brown-headed Cowbird egg was found in the artificial nest.

The quail egg had been punctured and was found in the grass 20 cm away, presumably punctured and displaced by the cowbird.

The parasitized artificial nest was placed on the ground 10 m away from the marsh edge in the upland habitat in an agricultural area along the Ottawa River (45°30′N, 75° 30′W). The external diameter of the nest was 10.5 cm and the nest was 4.4 cm deep at the center. The quail egg was 25.2 mm long and 20.5 mm wide. The cowbird egg found in the nest was 20.0 mm long and 16.4 mm wide. Mean height of live and dead vegetation surrounding the nest was about 120 cm and 80 cm, respectively. Reed-canary Grass (*Phalaris arundinacea*) and sedges (*Carex* spp.) were the dominant herbaceous species around the nest while shrubs consisted of willows (*Salix petiolaris*) and Meadowsweet (*Spiraea alba*). Nest concealment when seen from above was lower than 50%. The proximate habitat consisted of hay fields adjacent to an extensive cattail marsh. There was a 50-m wide strip of scrubland of willows and meadow-sweet between the marsh edge and the hay field. Two hedgerows consisting of ash (*Fraxinus americana*) and elm (*Ulmus rubra*) trees were in the vicinity.

Several open-nesting passerine species nested in the area. The most abundant were the Yellow Warbler (*Dendroica petechia*), Red-winged Blackbird, Swamp Sparrow (*Melospiza georgiana*), Song Sparrow (*Melospiza melodia*), Common Yellowthroat (*Geothlypis trichas*), Savannah Sparrow (*Passerculus sandwichensis*), and Bobolink (*Dolichonyx oryzivorus*). Actual cowbird density in the area was not determined. Cowbirds were however observed during each visit and cowbird eggs were found in three Yellow Warbler and two Song Sparrow nests in the study area. Nest predation was high in that area during that experiment. Ninety percent and 95% of the nests were depredated after 7 and 13 days, respectively. The main predators were Raccoons (*Procyon lotor*), Striped Skunks (*Mephitis mephitis*) and American Crows (*Corvus brachyrhynchos*).

Brown-headed Cowbirds sometimes parasitize nests lacking host activity (Freeman et al. 1990; this study). The presence of nest owners is thus not always necessary for finding and parasitizing nests as was suggested by Thompson and Gottfried (1976, 1981) and Lowther (1979). However, only one out of 1532 (0.07 %) was parasitized in this study, which suggests that the experimental nests presented only a weak stimulus for female cowbirds.

The size of eggs could influence female cowbirds choice of a host's nest. King (1973) found that nests containing large eggs were avoided by captive Brown-headed Cowbirds and Lowther (1979) argued that the use of *Coturnix* eggs could be a possible reason of Thompson and Gottfried's (1976) unsuccessful attemps to induce Brown-headed Cowbird parasitism of artificial nests. This argument could be misleading because in our study, we used *Coturnix chinensis* eggs, which are smaller than eggs of other *Coturnix* species and one nest was parasitized. Size of *Coturnix chinensis* eggs falls within the range of cowbird hosts' egg size such as the Red-winged Blackbird egg (25 x 18 mm). Therefore, egg size should not have reduced the frequency of parasitic laying by the cowbirds. Mills (1987) found that the size of host eggs was not an important factor for a nest to be parasitized. Several cases of "accidental" host choice have been reported where Brown-headed Cowbird eggs were found in nests of small passerine species; e.g., of Golden-crowned Kinglet (*Regulus satrapa*) (Friedmann et al. 1977) and Blue-gray Gnatcatcher (*Polioptila caerulea*) (Friedmann 1971) as well as in large passerine and non-passerine species nests such as American Crow (Hatch 1967) and Virginia Rail (*Rallus limicola*) (Friedmann et al. 1977). These observations suggest that the size of host eggs can vary considerably and therefore need not be a major factor in host choice in Brown-headed Cowbird laying activity.

Cowbird hosts frequently experience very high frequencies of nest parasitism (Rothstein 1975). Artificial nests are very rarely parasitized, presumably because the absence of host activities (1) reduces the value of a stimulus, and (2) reduces the chances of finding the experimental nests. Although there were many suitable hosts in our study area, parasitic laying in our experimental nest by a female cowbird could have been the result of her physiological state that could have forced her to lay her egg in any available nest. The choice of our experimental nest by a female cowbird would thus be a case of "accidental" host choice.

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Surplus Killing of White-tailed Deer, *Odocoileus virginianus*, by Coyotes, *Canis latrans*, in Nova Scotia

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I documented an apparent case of surplus killing of White-tailed Deer, *Odocoileus virginianus*, by Eastern Coyotes, *Canis latrans*, in Kejimkujik National Park, Nova Scotia. A group of three to four coyotes killed a group of five female deer on the night of 16 March 1993. With the exception of one fawn, the deer appeared to be in excellent physical condition. Deep snow conditions probably contributed to this event.

Key Words: Eastern Coyotes, *Canis latrans,* White-tailed Deer, *Odocoileus virginianus*, depredation, surplus killing.

The food habits of the Coyote, *Canis latrans*, in eastern Canada have been widely documented (La Pierre 1985; Messier et al. 1986; Moore and Millar 1986; Parker 1986; Sabean 1991). While most food habit studies suggest the relative importance of various food items to the predator, they usually provide little information on the potential impacts of predation upon specific prey populations (Lavigne 1992). Early studies of the Eastern Coyote (Ozaga and Harger 1966; Hamilton 1974; Richens and Hugie 1974) concluded that the bulk of the White-tailed Deer, *Odocoileus virginianus*, component of their diet was obtained from scavenging. More recent studies (Hilton 1978; Parker and Maxwell 1989; Dibello et al. 1990; Lavigne 1992) have confirmed that Coyotes can and do kill deer. However, the potential effects of Coyote predation on deer populations remain poorly understood.

Surplus killing of a prey species by a predator may indicate the potential for overexploitation, which is not evolutionarily favourable. Andelt et al. (1980) documented surplus killing of domestic turkeys by Coyotes in Nebraska, while several researchers (Brawley 1977; Munoz 1977; Nass 1977) have documented surplus killing of domestic sheep by Coyotes. Kruuk (1972) reported that surplus killing of wild prey by carnivores was rare. In Alaska, Eide and Ballard (1982) discussed surplus killing of Caribou, *Rangifer tarandus*, by Gray Wolves, *Canis lupus*. Mech et al. (1971) described surplus killing of White-tailed Deer in Minnesota by Gray Wolves. There are no documented cases of surplus killing of any free ranging prey species by Coyotes. This paper is an account of apparent surplus killing of White-tailed Deer by eastern Coyotes in southwestern Nova Scotia.

At 12:00 pm, 16 March 1993 I began to follow backwards (backtrack) the trail of a group of three to four Coyotes as part of an ecological study of the eastern Coyote in Kejimkujik National Park, Nova Scotia, 44°N, 65°E. The group included a radio-tagged adult male captured and collared on 16 November 1992; his mate, and one to two unidentified individuals. At this time the Coyotes were undisturbed and moving in a north-easterly direction. The temperature had reached -27°C the previous night with a westerly wind gusting up to 35 km/hr. Snow cover was approximately 65 cm thick.

After approximatly 1 km of trail I found an adult female deer which had been killed by the Coyotes and, although the ambient temperature was -12°C, it was not completely frozen. Continued tracking revealed that the doe had been one of a group of five deer killed by the Coyotes the previous night. The freshness of the kills and the condition of the snow allowed me to recount the events of the previous night.

The deer in question appeared to have spent considerable time in a mature mixed wood stand. Deer mobility in this area was restricted due to a recent 33 cm snowfall. At the time the Coyotes first became aware of the deer, three of the deer appear to have been bedded along the edge of a small clearing, while the other two were feeding.

The Coyotes were travelling in single file in a relatively straight south-westerly direction when they crossed a small ridge within 75 m of the deer. The Coyotes split up and ran towards the deer, scattering the deer such that one ran in a northerly direction, one in a westerly direction, and the other three in an easterly direction. While running, the deer sank up to 45 cm in the snow (their briskets were dragging) while the Coyotes sank only 2-3 cm.

An adult female deer (2 3/4 yrs. old, 80.4% femur marrow fat) ran west up a small ridge for 200 m before turning to face the single Coyote which was chasing it. The deer was killed on the spot, apparently by suffocation, as evidenced by the puncture wounds observed high on the throat. Only the one Coyote fed on this deer, consuming approximately 2.5 kg (a large portion of the liver and only minimal flesh were consumed).

A female fawn (74.1% femur marrow fat) ran approximately 250 m in a northerly direction into an alder swale where it was brought down and killed by a single Coyote. Tracks indicated that the Coyote likely trotted behind the fawn until it was exhausted before killing it; again apparently by suffocation. Ravens, *Corvus corax*, were already feeding on this carcass, with approximately 10 kg of flesh and viscera having been removed. Two Coyotes may have fed on this carcass. Ravens had not fed on any of the other carcasses. The other three deer ran together in an easterly direction. Tracks indicated that two Coyotes apparently trotted behind these deer, rarely breaking into a run. After 150 m a female fawn (32.8% femur marrow fat) was pulled down and killed. Only the liver and a minimal amount of flesh (< 5 kg total) was consumed. Only one Coyote fed on this deer, the other continued pursuing the remaining deer.

After another 240 m a single Coyote pulled down and killed an adult doe (6¾ yrs. old, 83.3% femur marrow fat). The only marks on this deer were the puncture wounds evident on the throat and a small tear on the right flank. The same Coyote appears to have then continued pursuing the fifth deer (female, 2¾ yrs. old, 85.8% femur marrow fat). The Coyote caught up with this deer after 300 m and continued the pursuit another 170 m before pulling the deer down. The deer regained its footing but was pulled down again within 30 m, with considerable blood and hair being strewn on the snow. The deer again broke away and traveled a further 40 m before being killed. The other Coyotes appear to have arrived at this site sometime thereafter. Numerous tracks and beds in the snow suggest that the group spent considerably more time feeding and resting in this area than at any of the other kill sites. Approximately 12-13 kg of flesh had been removed from this deer when I arrived. After leaving this site, the Coyotes backtracked approximately 300 m to a mature hardwood knoll where they bedded down. The Coyotes probably left this site < 1 hour before I began to backtrack their trail.

On the evening of 18 March or during the early hours of 19 March, the group killed a sixth deer, an adult doe (8¾ yrs. old, 88.1% marrow fat) approximately 3 km north of the previous kill sites. The Coyote group made at least three unsuccessful chases of deer on March 20. By then mild temperatures (the daily high was 7°C on March 20) had compacted the snow and deer were less vulnerable to predation by Coyotes. The Coyotes did not return to any of the kills, and by April 1, Ravens had completely consumed the edible portions of the carcasses.

I removed the left femur and jaw bone from each carcass. Deer were aged based on tooth development and wear using the method outlined by Severinghaus (1949). The percent femur marrow fat was assessed using the methods of Neiland (1970). Four of the five deer had reasonable fat stores around the heart, kidneys, viscera, and on the rump. One of the fawns had considerably lower fat deposits. At least three of the deer were infected with bot fly larvae, *Cephenemyia* spp. Larvae almost completely blocked the junction of the nasal passage and the trachea of the fifth deer killed by the Coyotes, which travelled at least 440 m further than any of the other deer before being killed. The

Coyotes did not return to the deer carcasses, perhaps due to the human disturbance.

Little is known about the potential impacts of Coyote predation on deer population dynamics in eastern Canada. Parker and Maxwell (1989) documented an apparent shift in prey selection from hares, *Lepus americanus,* to White-tailed Deer from January to March 1984 in northern New Brunswick. Dibello et al. (1990) noted a similar trend in Maine. Both suggested that the switch may have been due to increased Coyote mobility due to breeding activity (Parker and Maxwell (1989) recorded that the greatest minimum daily cruising distances by Coyotes occurred during the latter part of the breeding season in February and March and suggested that this increased travel would lead to an increase in chance encounters between deer and Coyotes) and decreased deer mobility due to deep dense snow conditions. Nelson and Mech (1986) reported that snow cover thickness accounted for 51% of the variation in annual wolf predation rates on White-tailed Deer in Minnesota. Huggard (1993) reported that wolves increased their predation rates on ungulates and decreased their scavenging activities with increasing snow thickness.

Winter tracking data from Kejimkujik National Park (Patterson 1995) suggests that during the winters of 1992–1993 and 1993–1994 Coyotes in southwestern Nova Scotia were capable of killing deer throughout the winter and under varying snow conditions. In 1992–1993 snow cover > 30 cm deep did not occur until early February and by 20 March melting snows prevented any significant amount of snow tracking to be carried out. The distribution of confirmed deer kills by month in 1992–1993 was 2, 2, and 6 from January through March respectively. Although snow cover > 50 cm was present in early January of 1994, snow cover was minimal during the entire month of March. Confirmed deer kills in 1993–1994 were 3, 2, and 0 in January, February, and March, respectively. Although the percent frequency occurrence of deer hair in Coyote scats was highest in January, the total Coyote scat volume made up of deer hair increased from December through March (Patterson 1995), consistent with other studies (Messier et al. 1986; Parker and Maxwell 1989; Dibello et al. 1990).

Parker and Maxwell (1989) and Lavigne (1992) both reported Coyotes killing deer in good physical condition based on the presence of > 80% femur marrow fat (FMF). Although Bischoff (1954) and Mech and Delguidice (1985) caution that high FMF does not always indicate that an ungulate was in good physical condition, Lavigne (1992: 155) concluded that "FMF levels approximating 80% or higher are closely associated with substantial reserves (e.g., ≥ 5 percent TBF (*total body fat*)) of other body fat depots that are characteristic of 'good' physical condition." In Maine (Lavigne 1992) and New Brunswick (Kohler 1987) the physical condition and age distribution of Coyote killed deer closely matched that estimated for the population. Parker and Maxwell (1989) found a disproportionate number of fawns in Coyote-killed deer examined in northern New Brunswick. In Kejimkujik National Park, I examined the remains of 30 deer fed upon by Coyotes between October 1992 and February 1994. Of the 21 which could be aged and/ or sexed, 8 were adult does, 4 of which had > 80% FMF. The other four had FMF levels between 60-80%, indicating marginal condition according to the guidelines suggested by Lavigne (1992). Of the 17 deer for which FMF could be assessed, none had levels < 30%, the threshold below which Lavigne (1992:155) suggested "deer would be considered severely malnourished with nearly exhausted fat depots and considerable ongoing catabolism of protein." Given the relatively low density of deer in Kejimkujik at the time of this occurrence (Patterson 1995), predation on deer which would otherwise probably have survived the winter may represent additive mortality.

In southern Quebec, Messier and Barrette (1985) reported reduced Coyote predation on deer using winter yards as opposed to those outside yards. They attributed this reduction to increased deer mobilitity due to a well established network of trails within deer yards, and to the fact that concentrations of deer facilitate earlier detection of predators. Winters in southwestern Nova Scotia are generally not severe enough to elicit significant yarding behaviour in deer. As such, deer in south-western Nova Scotia may be particularly vulnerable to predation when thick snow conditions do occur. Despite intensive snow tracking of Coyotes for at least 15 years in many areas of the northeast, this report remains unique. As such, I speculate that surplus killing of free ranging prey by eastern Coyotes is rare and probably dependent upon severe winter weather conditions.

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Extralimital Occurrences of Beluga, *Delphinapterus leucas*, and Walrus, *Odobenus rosmarus*, in Bathurst Inlet, Northwest Territories

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Stewart, Barbara E., and Page M. Burt. 1994. Extralimital occurrences of Beluga, *Delphinapterus leucas*, and Walrus, *Odobenus rosmarus*, in Bathurst Inlet, Northwest Territories. Canadian Field-Naturalist 108(4): 488–490.

Beluga and Walrus have discontinuous distributions in the Canadian Arctic, apparently resulting from a major geographical barrier or gap in the central Canadian Arctic separating western and eastern populations of both species. Here we present information about one extralimital sighting of Beluga and three extralimital occurrences of Walrus in Bathurst Inlet, Northwest Territories, situated in the area of discontinuity. We discuss these observations and other extralimital records with respect to ice cover in the area.

Key Words: Beluga, *Delphinapterus leucas*, Walrus, *Odobenus rosmarus*, extralimital, distribution, Arctic mammals, marine mammals, Bathurst Inlet.

Beluga (*Delphinapterus leucas*) and Walrus (*Odobenus rosmarus*) have discontinuous distributions in the Canadian Arctic. Local knowledge from Inuit, who depend upon Beluga and Walrus for subsistence, and scientific information both indicate that neither species typically occurs in the central Canadian Arctic. Beluga do not usually penetrate the area between Dolphin and Union Strait, and Victoria Strait (Harington 1966; Kingsley 1979; Read and Stephansson 1976; Riewe 1992; Sergeant and Brodie 1975; Stewart and Stewart 1989). They are rarely taken at Coppermine (67°49′N, 115°05′W) (Sergeant and Brodie 1975) on Coronation Gulf: only one Beluga was harvested between 1962 and 1971 (Smith and Taylor 1977), and none was taken between 1988 and 1993 (Department of Fisheries and Oceans 1991, 1992a, 1992b, 1993, 1994). Similarly, east of Bathurst Inlet, only one Beluga was harvested at Spence Bay (69°32′ N, 93°31′ W) between 1962 and 1971 (Smith and Taylor 1977) and none was caught between 1988 and 1993 (Department of Fisheries and Oceans 1991, 1992a, 1992b, 1993, 1994). One Beluga was sighted at Cambridge Bay (69°03′ N, 105°10′ W) in the summer of 1977 (Riewe 1992).

Walrus are not found usually between the eastern Chukchi Sea and the central Canadian Arctic (Davis et al. 1980; Fay 1985; Harington 1966; Mansfield 1967; Richard and Campbell 1988; Riewe 1992); the Pacific Walrus, *O. r. divergens*, is found to the west and the Atlantic Walrus, *O. r. rosmarus*, is found to the east of this gap in distribution. In the Beaufort Sea region, twenty-seven extralimital Walrus sightings occurred between 1911 and 1960 (Harington 1966); one Walrus was harvested at Coppermine between 1962 and 1971 (Smith and Taylor 1977); one Walrus overwintered off Banks Island in 1972 (Stirling 1974); and four Walrus have been taken in the western Canadian Arctic since 1988 (Department of Fisheries and Oceans 1991, 1992b). To the east of Bathurst Inlet, historical records and current local knowledge suggest that Walrus are observed and hunted rarely west of the Boothia Peninsula (Harington 1966; Mansfield 1967; Riewe 1992). Only one Walrus was harvested in Spence Bay between 1962 and 1971 (Smith and Taylor 1977). Recent Inuit reports indicate that Walrus are hunted occasionally on the east side of the Boothia Peninsula, in the mouth of Lord Mayor Bay, and that two Walrus have been taken (date unknown) in the Pelly Bay area (Riewe 1992). No harvests of Walrus have been recorded for Cambridge Bay, Gjoa Haven, Spence Bay, or Pelly Bay between 1988 and 1993 (Department of Fisheries and Oceans 1991, 1992a, 1992b, 1993, 1994). There are no known accounts of Walrus in Victoria Strait or Queen Maud Gulf but an absence of permanent settlements in this area limits opportunities for observations.

This note documents one extralimital sighting of Beluga and three extralimital occurrences of Walrus in Bathurst Inlet, Northwest Territories, which is located on the mainland coast in the central Canadian Arctic (Figure 1), in the area of discontinuity. The two main Inuit communities located on the inlet are Umingmaktok (formerly Bay Chimo; 67° 41′ N, 107°55′ W) and Bathurst Inlet (66⁰ 50′ N, 108°08′ W) where a seasonally operated ecotourism lodge is also located.

Two Beluga were sighted in Gordon Bay (66°53′ N, 107°10′ W) in the southeast area of Bathurst Inlet, in late July 1989, by Mr. Boyd Warner from a Cessna Super Cub flying at an altitude < 1 000 ft (< 304 m). No information is available about the route or ice cover encountered by the two observed whales.

No previous records of Beluga sightings in Bathurst Inlet exist. Generally, it is thought that permanent pack ice separates the Beaufort Sea Beluga from those occurring further east of the central Canadian Arctic (Sergeant and Brodie 1975).

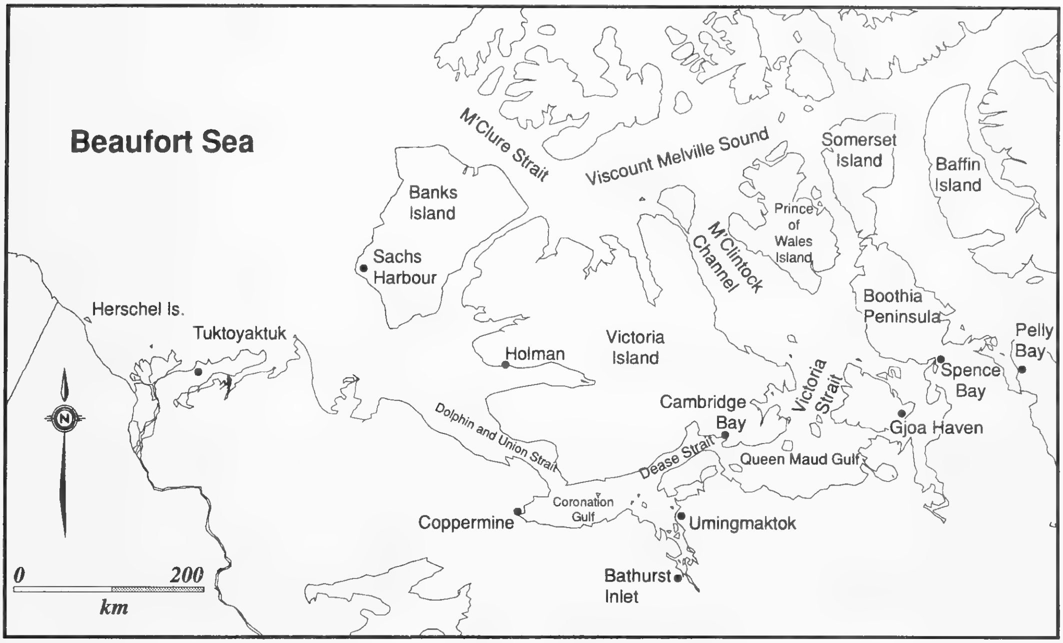

FIGURE 1. Map of the central Canadian Arctic, illustrating place names mentioned in the text.

However, recent movements of a satellite-tagged Beluga from Tuktoyaktuk through M'Clure Strait to eastern Viscount Melville Sound (see Norris 1994) demonstrates that for some Beluga at least, areas with heavy ice coverage and areas previously unknown as migration corridors, can be penetrated.

Three observations of Walrus have been detailed in the Bathurst Inlet Lodge records. In the Bathurst Inlet Wildlife Observation Book (II), the late H. Albert Hochbaum (former Head, Delta Field Station, Portage la Prairie, Manitoba) reported, in August 1978, that William Koaha, a respected elder who hunted and resided in Umingmaktok (Bay Chimo), caught a Walrus there in 1951 and saw another near the south lip of the Quadyuk Islands (66°52′ N, 107^0 56′ W) in the summer of 1953. No archival material from the Walrus taken by Koaha is known by us to exist. Mr. Boyd Warner also saw a Walrus on 13 July 1984 near the tip of Young Island (66°53′ N, 108°00′ W).

There is at least one previous record of Walrus being taken or sighted near Bathurst Inlet, probably in the early 1940s (Harington 1966), but incomplete oral accounts and unattributed written records make interpretation of the information difficult (Harington 1966; Kingsley 1979). W. F. Joss heard of a Walrus being taken near Bathurst Inlet in the early 1940's (Quinn, personal communication *in* Harington 1966) and Loughrey (1959) cites L. A. Learmonth's 1952 account of a Walrus being taken, some years earlier, on one of the islands at the mouth of Bathurst Inlet. Bird and Bird (1961) also state "Two Walruses were taken many years ago in Arctic Sound (67°30′ N, 108°50′ W)". It is unclear if these accounts are fully independent of each other.

Of the three instances of extralimital Walrus distribution identified in this paper, none provides morphometric data, repeat observations suggesting migratory routes, or other descriptive information (e.g., tusk size and shape) to confirm the identity of the animals as Pacific or Atlantic Walrus. Harington (1966) asserts that the core of the geographical barrier limiting marine mammal distribution in the central Arctic is the year-round ice coverage in Queen Maud Gulf, Victoria Strait, M'Clintock Channel, Viscount Melville Sound, and M'Clure Strait, all to the east and north of Bathurst Inlet. Following Harington's reasoning that this ice barrier zone separates clusters of extralimital sightings of southwestern Pacific Walrus from those of northeastern Atlantic Walrus, we suggest that the Walrus observed in Bathurst Inlet were likely the Pacific subspecies, *O. r. divergens*.

These extralimital occurrences of Beluga and Walrus in the main body of Bathurst Inlet are considered rare. We document, for the first time, southern penetration to Gordon Bay and the Quadyuk Islands for Beluga and Walrus respectively.

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Mr. and Mrs. G. Warner, Bathurst Inlet Lodge, for access to the Bathurst Inlet Lodge Wildlife Observation Books. A. Blouw, Freshwater Institute, generously provided graphic support. Reviews of this manuscript provided by H. Cleator, J. Garlich-Miller, S. Innes, P. Richard, R. E. A. Stewart, and I. Stirling are appreciated. We thank the Arctic Marine Mammal Ecology and Assessment Research Section, Department of Fisheries and Oceans, Winnipeg, for support during the preparation of this manuscript.

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White-belted Coloration in a Masked Shrew, *Sorex cinereus*, from Massachusetts

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Brooks, Robert T., and Katherine L. Doyle. 1994. White-belted coloration in a Masked Shrew, *Sorex cinereus*, from Massachusetts. Canadian Field-Naturalist 108(4): 491–492.

A Masked Shrew (*Sorex cinereus*) with white-belted coloration pattern was captured in a mixed deciduous-coniferous forest in central Massachusetts. Only one other published record of this pelage condition in *S. cinereus* was found in an intensive search of the literature and no similarily colored specimens were found in collections of several national or regional museums.

Key Words: Masked Shrew, *Sorex cinereus*, belted coloration, Massachusetts.

A specimen of the Masked Shrew (*Sorex cinereus*) with white-belted coloration was captured by the authors in a pitfall trap on 8 July 1994 in the town of New Salem, Franklin County, in central Massachusetts (42°26′50.2″ N; 72°22′14.4″ W). The study site was forested (53% pine/hemlock, 47% maple/oak) and located adjacent to a temporary pond.

Prior to the capture of this specimen, 81 (in 1992), 35 (1993) and 132 (1994) *S. cinereus* with normal coloration had been captured at this study site. The belted specimen was a sexually immature female with a total length of 99 mm and a mass of 3.8 g. Age was estimated to be 18-24 wks based on tooth wear and cranial characteristics as described by Rudd (1955).

The belted coloration of this specimen occurred as a transverse white band that completely encircled the animal (Figure 1). The belt began anterior to the middle of the body and included the ventral side of the forelimbs. The width of the belt, measured on the prepared skin, ranged from 10 mm to 13 mm dorsally and was 20 mm wide ventrally. The variation in the ventral-posterior margin of the belt seen in Figure 1 is an artifact of preparation. The posterior 31 mm of the tail was also white.

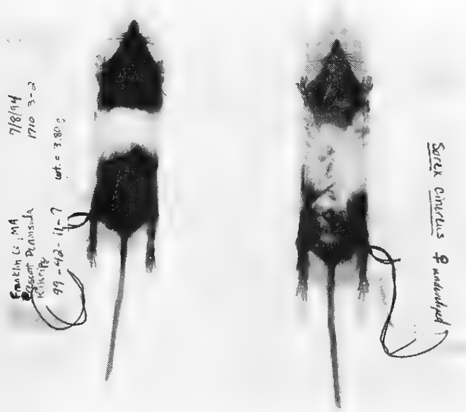

FIGURE 1. Dorsal (left) and ventral (right) views of *Sorex cinereus* with belted pelage coloration from Franklin County, Massachusetts.

Belted coloration is described as a fairly regular type of white-spotting in rodents and ungulates (Searle 1968). In our review of the literature, we found one record of belted coloration in *S. cinereus* (Pearce 1934). The occurrence of belted coloration is not mentioned in reviews of shrew pelage coloration (Jackson 1928; Elder 1960; Fons et al. 1983; Churchfield 1990).

No specimens of *S. cinereus* with belted coloration are housed in the mammal collections of the University of Massachusetts Museum of Zoology; Vertebrate Museum, Shippensburg University; Museum of Comparative Zoology, Harvard University; Carnegie Museum of Natural History; Museum of Natural History, University of Kansas; American Museum of Natural History; National Museum of Natural History; Royal Ontario Museum; or the Canadian Museum of Nature. This specimen (UMMZ 4163) will be retained in the mammal collection of the University of Massachusetts.

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A Striped Skunk, *Mephitis mephitis*, Repels Two Coyotes, *Canis latrans*, without Scenting

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Walton, Lyle R., and Serge Larivière. 1994. A Striped Skunk, *Mephitis mephitis*, repels two Coyotes, *Canis latrans*, without scenting. Canadian Field-Naturalist 108(4): 492–493.

An encounter between a female Striped Skunk (*Mephitis mephitis*) and two Coyotes (*Canis latrans*) is reported. Display behavior by the Skunk was sufficient to resolve the encounter without any physical contact or scenting.

Key Words: Striped Skunk, *Mephitis mephitis*, Coyote, *Canis latrans*, predation, behavior.

Striped Skunks (*Mephitis mephitis*) are occasionally preyed upon by Great Horned Owls (*Bubo virginianus*) (Wilkinson 1913), Badgers, *Taxidea taxus* (Sargeant et al. 1982), Coyotes (*Canis latrans*; Young and Jackson 1951), and Domestic Dogs (*Canis familiaris*; Verts 1967). However, the chemical defense of the Striped Skunk is believed to repel most potential predators. Scenting can only occur a limited number of times (Verts 1967), and therefore is believed to be used only as a last resort (Verts 1967). Displays of defensive postures by Striped Skunks, combined with conspicuous coloration facilitates recognition by predators (Verts 1967; Endler 1991), hence decreasing the need to spray during encounters.

We report an instance during which a Striped Skunk successfully repelled two Coyotes without any physical contacts or scenting. The subsequent movements of both Coyotes and Striped Skunk were observed using night-vision goggles (AN-PVS 5, Bill's Electronics Ltd., Mildmay, Ontario). Observations were further enhanced by a full moon and a clear sky.

On the night of 25 May 1994, while radio-tracking a female Striped Skunk along a prairie creek drainage in central Saskatchewan (52°N, 107°W), LRW noticed two Coyotes on the opposite side of the creek, 30 m away (23:32h). At this time, the skunk was foraging in tall (>1 m) vegetation, 30 m from the observer, and approximately 65 m from the Coyotes.

The pair of Coyotes followed the creek for 150 m, moving away from the observer. The canids then crossed the 2-m wide creek and changed direction, coming back towards both skunk and observer. At this time, L.R.W. sat down, motionless, in 50-cm tall vegetation, and 35 m behind the skunk. The skunk was in 20-cm tall vegetation.

The Coyotes came trotting abreast 5 m apart, and their movements in the adjacent wheat stubble were noisy and audible ≤65 m. Following a straight course, the Coyotes entered the creek drainage where the skunk was located.

The skunk stopped foraging and raised its tail when the Coyotes were <25 m (23:40h). The Coyotes kept coming closer, and the closest Coyote started to circle 15-20 m from the skunk, while the second stopped 20 m away. When the circling Coyote approached the skunk to within 10 m, the skunk charged towards the Coyote, with its tail raised. The skunk stopped 5 m from the canid, which then retreated and stopped 15 m from the skunk. At this time, the second Coyote started circling the skunk. As the Coyote approached to within 8 m, the skunk charged 5 m towards this second Coyote, now 3 m away. The second Coyote retreated, joined the first Coyote, and both canids began moving away (23:42h).

Following the departure of the Coyotes, the skunk remained stationary with its tailed raised until 23:44h, at which time it resumed foraging. Although taller (1.5 m tall) cover consisting of willows (*Salix* sp.), rosebushes (*Rosa* sp.), Buckbrush (*Symphoricarpos occidentalis*), Wolf Willows (*Elaeagnus commutata*), and Buffalo Berry (*Shepherdia argentea*) was in proximity (12 m away), the skunk made no attempt to flee for cover during, or following the encounter. Instead, the skunk continued foraging along the creek drainage for the rest of the night, in vegetation ca. 30 cm high. Throughout the observation, there was no indication that either the Coyotes or the skunk noticed the observer.

Although numerous species are listed as natural predators of Striped Skunks (Godin 1982), accounts of actual or attempted predation are rare, and only available for Great Horned Owl (Wilkinson 1913), Red Fox (*Vulpes vulpes*; Houseknecht and Huempfner 1970), and the Badger (Gilbert and Hill 1960). The presence of remains of Striped Skunks in predator feces (Red Fox: Korschgen 1959; Coyote: Messier et al. 1986), or at predator den sites (Red Fox: Fleskes and Klaas 1993) does not permit differentiation between skunks killed and those consumed as carrion. Furthermore, studies on the mortality of adult free-ranging Striped Skunks usually rank diseases and roadkills as the primary causes (Verts 1967), while predation accounts for less than 5% (1/22 investigated adult mortalities: Sargeant et al. 1982). The observation reported here suggests that encounters between Striped Skunks and potential predators can be terminated without any physical contact or scenting. Furthermore, it attests to the efficiency of behavioral warnings displayed by Striped Skunks. Although it is not possible to determine whether the two Coyotes had previous encounters with skunks during which spraying occurred, the outcome of this interaction had the same ecological consequences for the Striped Skunk.

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Golden Eagles, *Aquila chrysaetos*, Preying on a Coyote, *Canis latrans*

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Woelfl, Manfred, and Sybille Woelfl. 1994. Golden Eagles, *Aquila chrysaetos,* preying on a Coyote, *Canis latrans*. Canadian Field-Naturalist 108(4): 494–495.

Four Golden Eagles, *Aquila chrysaetos*, were found feeding on a freshly-killed Coyote, *Canis latrans*, pup in southeastern Alberta.

Key Words: Golden Eagle, *Aquila chrysaetos*, Coyote, *Canis latrans*, predation, Alberta.

During a biophysical inventory in the Canadian Forces Base Suffield north of Medicine Hat, Alberta, we observed Golden Eagles (*Aquila chrysaetos*) feeding on a Coyote (*Canis latrans*) pup. On 3 August 1994 at 2030 h, as we drove a dirt road along the South Saskatchewan River, we flushed four Golden Eagles (two adults and two immatures) from Sagebrush-Needle Grass (*Artemisia cana-Stipa comata*) 50 m from the road. Upon examination, we found a freshly-killed male Coyote pup within the immediate area of the initial observation. By this time of year, the pup was approximately 3-4 months old (Harrison et al. 1991; Andelt et al. 1979). The carcass was opened from the throat to the chest and the wound was still wet with blood. Otherwise, the body appeared to be intact. Within the immediate surroundings, we found no traces of a chase or a struggle.

Three days later, on 6 August at 1830 h we reexamined the site and found both the complete skeleton and hide. The spine was broken between the seventh and eighth vertebrae, and the hide was punctured in the vicinity of the broken vertebrae. The puncture wounds measured 5 mm in diameter. No wounds were found on the skull. We surmised that the Coyote pup had been surprised in the open and killed by one or more eagles by breaking the spine.

Observations of Golden Eagle - Coyote interactions exist. However, no actual killing of a Coyote by an eagle has been reported. Ford and Alcorn (1964) described three instances in which Golden Eagles attacked adult Coyotes as though they were prey. Wells and Bekoff (1978) and Bowen (1980) observed incidents suggesting food competition between these two species. Dekker (1985) saw Golden Eagles interact with Coyotes on several occasions; once, an adult eagle swooped at an adult Coyote, but the Coyote escaped. Hatch (1968) reported that two eagles killed a Red Fox, *Vulpes vulpes*.

Eagles also are known to prey on larger mammals; e.g., Bighorn Sheep (*Ovis canadensis*) lambs, Lawson and Johnson 1982; Caribou (*Rangifer tarandus*) calves, Dave Mossop, personal communication; Mountain Goat (*Oreamnus americanus*) kids, Wigal and Coggins 1982; Chamois (*Rupicapra rupicapra*) kids, personal observation.

Apart from human persecution, malnutrition (Windberg et al. 1985), disease (Nellis and Keith 1976), cannibalism (Camenzind 1978) and predation (e.g., Andelt 1985; Koehler and Hornocker 1991) have been reported as Coyote mortality factors. Coyote pups begin to forage on their own at about two months of age (Harrison et al. 1991, Harrison and Gilbert 1985), reassociating with their parents at rendezvous-sites only occasionally. During this period, they are quite vulnerable to predation because they lack experience and are not protected by their parents. Golden Eagle predation on Coyotes may be an important factor in pup mortality, especially in the open, coverless prairie. In this instance, the nearest cover, a coulee with some willow (*Salix* sp.) shrubs, was approximately 300 m away from the kill site.

Acknowledgments

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Evidence of Bobcats, *Lynx rufus*, in Southeastern Alberta

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Woelfl, Manfred, and Sybille Woelfl. 1994. Evidence of Bobcats, *Lynx rufus*, in southeastern Alberta. Canadian Field-Naturalist 108(4): 495–496.

During a scent-station and tracking survey in the Canadian Forces Base Suffield in summer 1994, we found evidence of Bobcat presence north of its described distribution in southeastern Alberta.

Key Words: Bobcat, *Lynx rufus*, distribution, Alberta.

The Bobcat's secretive behaviour often results in a lack of evidence for its presence. Smith (1993) described the Bobcat's distribution within Alberta as limited to the area south of Cypress Hills, west along the Milk River drainage, and north into the Rocky Mountains up to Banff National Park. Hall (1981) and Williams (1946) recorded sightings south of a line approximately between Lethbridge and Cypress Hills. Parker et al. (1983) suggested that Bobcats do not occur farther north due to thick winter snow.

During a biophysical survey of the National Wildlife Area on Canadian Forces Base Suffield (50°32′N, 110°32′E), we found evidence of Bobcat sign (Figure 1). On 1 August 1994, we searched the shoreline of the South Saskatchewan River. On a fresh, sandy Beaver (*Castor canadensis*) slide we found a set of tracks, measuring 5.5* 5.5 cm (front) and 5.5 * 4.7 cm (hind). No claw marks were visible and the pad's anterior border was distinctively two-lobed which is characteristic of Bobcat prints (Murie 1954).

Local residents also reported the presence of Bobcats in the area (Figure 1). Two sightings of animals during summer 1993 along coulees not associated with the South Saskatchewan River, and occasional sightings along the river in recent years, indicate regular Bobcat presence in the area. Locals confirmed that the Bobcat is confined to the South Saskatchewan River Valley north of Medicine Hat (B. Page, personal communication) and to the Red Deer River Valley as far west as Dinosaur Provincial Park (J. Campbell, personal communication).

Banfield (1974) included the eastern portion of the Red Deer River valley as part of Bobcat distribution in Alberta. Soper (1964) stated that the northern limit of Bobcat distribution was uncertain, but that it probably extended north to the lower reaches of the Red Deer River. A local resident of Buffalo had told him in 1945 that locals had observed Bobcats along the Red Deer River east and west of the village and two had been shot by hunters. Our observation suggest that Bobcats occur at least along the South Saskatchewan River.

Our study area was composed of mixed prairie which slopes down to the South Saskatchewan River and consisted of terraces, steep ravines and intervening, eroded slopes. The area is one of the driest in

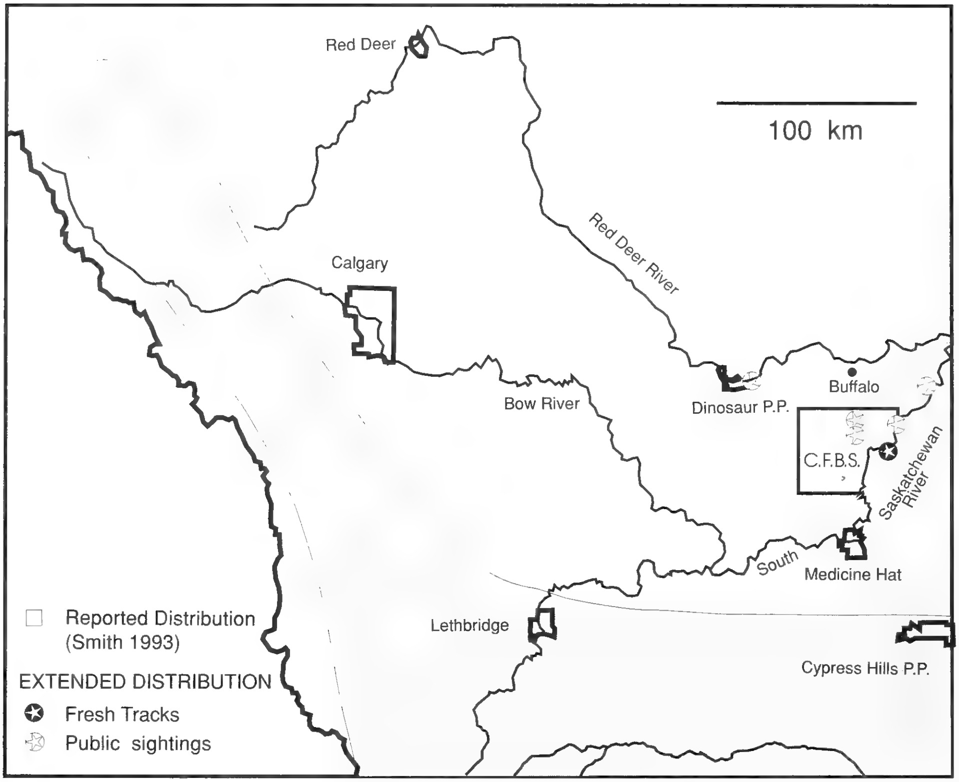

FIGURE 1. Distribution of the Bobcat in southeastern Alberta (C.F.B.S. = Canadian Forces Base Suffield).

Alberta, with warm summers (30-40°C) and low precipitation (summer average 40 mm). Winter temperatures average –7.2°C, with shallow snow and only a few days of continous snow cover. If deep snow limits Bobcat distribution as suggested by Parker et al. (1983), the Suffield area would appear suitable as Bobcat habitat. Additional sightings are necessary to further elaborate the Bobcats' distribution in Alberta.

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Cougar(s), *Felis concolor*, with a Kill for 27 Days

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Thompson, Michael J., and William C. Stewart. 1994. Cougar(s), *Felis concolor*, with a kill for 27 days. Canadian Field-Naturalist 108(4): 497–498.

We observed a Cougar (*Felis concolor*) beside a freshly killed adult female Elk (*Cervus elaphus*) near Missoula, Montana, on 13 March 1994. We returned on 12 of the next 26 mornings, including 8 April, and always observed one Cougar with the kill, but on 31 March we observed two Cougars. On 9 April we did not observe a Cougar, but a Golden Eagle (*Aquila chrysaetos*) was present on the kill. This is evidence for the longest reported association of a Cougar with a kill.

Key Words: Cougar, *Felis concolor*, Elk, *Cervus elaphus*, predation, Montana.

In the northwestern United States, Cougars, *Felis concolor*, primarily prey upon Deer, *Odocoileus* spp., and Elk, *Cervus elaphus* (Hornocker 1970; Seidensticker et al. 1973; Murphy 1983; Murphy et al. 1992; Williams 1992). Intervals between kills vary due to factors including Deer and Elk abundance, alternate prey abundance and vulnerability, carcass decomposition rate, disturbance from other predators or scavengers, and individual variability (Hornocker 1970). Cougars normally remain near a kill until they consume it, and Cougars seldom return to a kill once they have left it (Seidensticker et al. 1973). Seidensticker et al. (1973) documented a maximum length of association with ungulate kills of 19 days in central Idaho. Cougar research in Yellowstone National Park indicates any association over 11 days would be noteworthy (K. M. Murphy, personal communication). Such associations are rarely documented because Cougars are secretive and occupy remote habitats; therefore, it is difficult to confirm a kill and reobserve a Cougar frequently without introducing disturbance and affecting behavior.

We made 13 observations of a Cougar with an Elk kill in Missoula County, Montana (46°46′36″N; 113°36′28″W), incidental to annual Elk surveys. Observations were from a Citabria airplane for 1–2 minutes each between 0–3 hours after sunrise, at a height of about 60 m.

The kill site was a gently sloping ridgeline at 1763 m above sea level, 422 m above the West Fork Cramer Creek. The ridgeline was grass covered and nonforested, beside an open Douglas-fir (*Pseudotsuga menziesii*) forest on a northwest exposure. The site was about 30 m from an old logging road, which was closed to motorized traffic by a gate about 1.5 km away. The closest human habitation was a rural residence at the gate.

On Day 1 (13 March 1994), we observed an adult female Elk carcass on its side with neck and legs fully extended, and a Cougar lying beside, head-up at our approach. The Elk was on snow, and fresh-appearing blood pooled at the throat. We observed no other blood, nor any signs of feeding on the Elk. When we made a second aerial pass over the kill, the Cougar arose and began covering the Elk by pawing snow. We returned about 1 h later and observed the Elk abdomen covered with snow, and a Cougar bedded in the open a few meters away. When we circled in the plane, the Cougar again covered its kill, possibly reacting as it would to an avian scavenger. From these observations, we presumed the Cougar killed the Elk that day.

We flew on Days 2–4, and observed a Cougar near the kill each morning. On Day 2, the blood at the throat of the Elk was not visible, and scattered patches of hair had been removed from the side of the carcass; the Cougar again covered the carcass when we circled the plane. Sometime during Days 2-4, the Cougar apparently dragged the carcass about 10 m to a small logging-slash pile. On Day 4, a Cougar was lying squarely on its back beside the carcass, and remained in this position as the plane circled. Weather prevented us from visiting the site on Days 5-13.

We observed similar Cougar behavior at the kill site on Days 14-17. On Day 18, we did not observe a Cougar beside the carcass, but we observed one walking away about 200 m distant. The Cougar appeared to react to the airplane by increasing its pace. On Day 19, we observed a Cougar in open forested cover for the first time, about 10 m from the kill. We lost visual contact with the Cougar for a few seconds when we circled the airplane. When we resumed visual contact we observed two Cougars of similar size running from the kill site, and we could not find a Cougar where we observed one seconds earlier. One Cougar was following, or possibly chasing, the other for about 300 m before we lost visual contact. On Days 20-21, we again observed one Cougar beside the carcass. Weather prevented us from visiting the site on Days 22-26.

On Day 27 (8 April 1994), we observed one Cougar feeding on the carcass. Red tissue was visible on a rib of the carcass and along the Cougar's mouth. On Day 28, we aerially searched the area and did not find a Cougar. We observed a Golden Eagle (*Aquila chrysaetos*) perched on the carcass; this was the first time we noted any scavenger at the site. We presumed the Cougar had abandoned the kill.

We hiked to the kill site on the afternoon of Day 28, 6-30 hours after the Cougar apparently left. We located the Elk head, spinal column and rib-cage cleaned and intact. The bones and hoof of one leg, a pile of hair, rumen contents and some viscera, were also located beside the slash pile. We concluded that one or more Cougars had consumed all edible parts of the kill, as has been reported elsewhere (Hornocker 1970).

We estimated the Elk was 6.5 years old (Quimby and Gaab 1957). The neck was broken between the axis and first vertebra, which corresponded with the location of the blood observed on Day 1. Examination of the femur marrow (Riney 1955) suggested the Elk had been healthy. Assuming an average live weight of 236 kg for a mature female Elk (Murie 1951), and assuming the unconsumed remains of the Elk constituted about 30% of its live weight (Hornocker 1970), the Cougar(s) consumed about 165 kg in 27 days, or an average of 6.1 kg per day.

Without the aid of individually recognizable animals, we could not verify that the Cougar which killed the Elk also attended the kill for 27 days. Seidensticker et al. (1973) reported that females with kittens were most sensitive to another Cougar's approach, and were sometimes supplanted at kills by resident males. However, we did not observe kittens, and Murphy (personal communication) suggested the habitat characteristics at the kill site did not match the normal security requirements for young kittens. Cougars do not usually approach the kills of others (Seidensticker et al. 1973).

Murphy (personal communication) indicated it was unusual for a Cougar to consume a kill so slowly, and suggested our observation of two Cougars was important for interpretation. Although we observed two Cougars on only one occasion, Murphy suggested both Cougars may have been present more often, one undetected if it used cover more than the other. On the rare occasions when one Cougar associated with another in central Idaho, the cats were usually a consort pair or young adult siblings (Seidensticker et al. 1973). If the Cougars were a consort pair, mating may have distracted them from efficient consumption of the kill. Because the Cougars appeared similar in size, they may have been young adult siblings. Newly independent adults may be less successful killers of large prey, and may be more reluctant to leave an Elk kill than more experienced adults (J. S. Williams, personal communication). Further, our observations of a Cougar with a kill for 27 days suggests a relatively low density of potential competitors for Cougar kills in the West Fork Cramer Creek (Murphy, personal communication).

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Une addition à la flore du Québec: *Monarda punctata* var. *villicaulis* (Lamiaceae)

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Boudreault, Catherine, et Jacques Brisson. 1994. Une addition à la flore du Québec: *Monarda punctata* var. *villicaulis* (Lamiaceae). Canadian Field-Naturalist 108(4): 499–500.

Une population de Monarde ponctuée (*Monarda punctata* var. *villicaulis*) fut trouvée pour la première fois au Québec, dans la région du Haut-Saint-Laurent. Cette population, qui comprend plus d'une centaine d'individus, déplace légèrement la limite nord de l'aire de répartition connue de l'espèce par 20 km.

A population of Dotted Monarda (*Monarda punctata* var. *villicaulis*) was found for the first time in Quebec, in the Haut-Saint-Laurent region. This population, which has more than 100 individuals, extends the known distribution of the species northward by 20 km.

Mots-clés: Monarde Ponctuée, *Monarda punctata*, Lamiaceae, plantes rares, Québec.

Key Words: Dotted Monarda, *Monarda punctata*, Lamiaceae, rare plants, Quebec.

Au cours de l'été 1994, une population de Monarde ponctuée (*Monarda punctata* var. *villicaulis*) (Lamiaceae) fut trouvée dans le sud du Québec, près de la frontière américaine, dans le cadre de travaux de végétation réalisés dans la MRC du Haut-Saint-Laurent (Bouchard et al. 1985). Cette population, la première connue pour le Québec, déplace légèrement la limite nord de l'aire de répartition connue de l'espèce.

La population, qui comprend plus d'une centaine d'individus, fut découverte près de Cazaville (45°03′N, 74°22′O), approximativement 5,5 km au nord de la frontière américaine. Le territoire fait partie de la région écoclimatique du Tempéré froid moyen humide (MCTh) (Groupe de travail sur les écorégions 1989). La région de Cazaville est caractérisée par de vastes zones de sable d'origine littorale datant de la dernière période post-glaciaire (Bariteau 1988). La population occupe une butte sableuse, ouverte, adjacente à un chemin forestier. En périphérie, une forêt secondaire feuillue, dominée principalement par le Peuplier à grandes dents (*Populus grandidentata*) ou l'Érable rouge (*Acer rubrum*), occupe le milieu. Outre une récente plantation expérimentale de pins à proximité, il n'y a pas de terres en culture ou de bâtiments à moins de 500 m de la population. Le site correspond aux caractéristiques de l'habitat de l'espèce à travers son aire de distribution: *M. punctata* préfère les milieux ouverts, sablonneux (Morton 1987; Gill 1981). Les autres espèces abondantes parmi la population sont *Solidago nemoralis, Rubus alleghaniensis* et *Rhus typhina*. Fait à noter, la plaine sableuse de Cazaville recèle une autre plante rare de la famille des Lamiaceae: *Hedeoma hispidum* (Bouchard et al. 1983; Lavoie 1992).

M. punctata se trouve dans l'est des États-Unis, du Nouveau-Mexique à la Floride au sud, et du Minnesota au Vermont au nord. Bien que plusieurs variétés de cette espèce aient été décrites, seule la variété *villicaulis* se retrouve au Canada et dans les états américains qui lui sont limitrophes (Scora 1967). Au Canada, *M. punctata* var. *villicaulis* fut trouvé en quelques endroits dans le sud de l'Ontario (Gill 1981; Morton 1987). Dans l'état de New York, qui borde le Québec au sud du territoire étudié, la plante est commune autour de la ville d'Albany, mais rare ailleurs. Dans le tiers nord de l'état, des populations existent à Pitcairn (comté de St-Lawrence), à Watertown (comté de Jefferson) et à Upper Jay (comté d'Essex), respectivement à quelques 120, 170 et 100 km de la population québécoise. Plus à l'est, au Vermont, des spécimens de *M. punctata* ont été récoltés dans les comtés de Chittenden et de Franklin, la récolte la plus nordique ayant été faite en 1920 près de Highgate (Comté de Franklin), à une douzaine de km de la frontière du Québec, et à 120 km de la population québécoise.

L'occurence de *M. punctata* dans les plaines sableuses ouvertes, souvent perturbées, rend difficile la détermination de son statut de plante introduite ou indigène à la périphérie de son aire de distribution. Cependant, même lorsque son origine est incertaine, l'espèce est souvent considérée comme indigène, principalement pour des considérations de conservation. Par exemple, *M. punctata* est sur la liste des plantes rares du Vermont, malgré la possibilité qu'un bon nombre sinon toutes les mentions connues soient des introductions (E. J. Marshall, communication personnelle). En Ontario, trois des quatre populations répertoriées pour la province ont été trouvées le long de voies ferrées et sont donc considérées comme introduites, et seulement une population récemment trouvée dans le comté de Haldimand-Norfolk serait d'apparence indigène (Morton 1987). Sur la base de cette population, l'espèce fut inscrite sur la liste des plantes rares de l'Ontario (Argus et al. 1982–1987) et du Canada (Argus et Pryer 1990). *M. punctata* est aussi considéré comme rare en Pennsylvanie, et menacé en Ohio et au Kentucky (Morton 1987). Il se peut qu'il soit impossible de déterminer avec certitude l'origine de la population de Cazaville et, en vertu de cette incertitude, un statut de plante rare pour le Québec devrait lui être accordé. *M. punctata* serait ainsi classé parmi les plantes rares de "colonies à distribution restreinte" (Bouchard et al. 1983). Par conséquent, l'espèce devrait être ajoutée à la liste des plantes vasculaires susceptibles d'être désigneés menacées ou vulnérables au Québec (Lavoie 1992).

Des spécimens de *M. punctata* ont été déposés à l'herbier Marie-Victorin (MT: Brisson & Boudreault No. 94-035). Le traitement taxonomique des monardes peut être trouvé dans McClintock et Epling (1942), Scora (1967) et Gill (1981).

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Litterature Citée

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News and Comment

Formation of The Bat Society of Manitoba

I have been a bat enthusiast of several years, am familiar with most of the species in Manitoba, have given presentations to school and scouting groups, and am a founding member of The Bat Society of Manitoba. This society has an executive and formal constitution and was formed to compile possible locations, breeding habits, migration patterns, food intake, and general observations on bats in Manitoba. Although Bat Conservation International of Austin, Texas, already provides a wealth of information of North American bats, specific information on Canada's bats is limited, and this lack may most effectively be corrected by a society with a Canadian emphasis.

The Bat Society of Manitoba will strive to further awareness, respect, and appreciation for Canadian bats through education and information, to liaise with Bat Conservation International and other bat societies worldwide, and to develop understanding of Canadian bats' populations and their patterns. Its membership is diverse, including teachers, cavers, and government and university bat researchers from Ontario, Manitoba and Saskatchewan.

Members will receive a quarterly newsletter compiled from submissions by members or other sources, bat box plans, and news of banding and lectures available. Submission of reports, studies, or articles is encouraged. Membership fees are $10/year, payable to The Bat Society of Manitoba. Additional information will be supplied on request.

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Book Reviews

ZOOLOGY

Rhythms in Fishes

Edited by M. A. Ali. 1992. Plenum, New York. viii + 348 pp., illus. U.S. $95.

Rhythmic phenomena are major elements among the most general and important patterns of biological dynamics. This book examines these among the largest group of vertebrates. As volume 236 in the life sciences series, it records a NATO Advanced Science Institute held in Lennoxville in August 1991. Among the opening chapters Ali, well known for his earlier association with this series, explains the emphasis on fishes and provides a useful and chatty historical review. There is a valuable overview of the statistical analysis of periodic phenomena by Legendre and Dutilleul within the context of time series, with appropriate attention to dealing with short samples and to available computer software. The consideration by Gerkema on mechanisms and adaptive values of rhythms is all the more important since these are only lightly touched on elsewhere. This discussion of causation and function is good but brief, and accompanied by an intriguing allometric scaling of period length against body mass whose axes cover an impressive six and 13 orders of magnitude. The presentation on behaviour and rhythms by Noakes is a pleasant scan of ethology but, despite the title, deals little with rhythms.

Six chapters focus on behavioural observations. For ultradian rhythms Peters and Veeneklaas focus on physiology and locomotion while for tidal rhythms Gibson examines activity, reproduction, and controlling factors. Leatherland et al. provide an excellent overview on lunar rhythms, including the effects of high tides on migration and reproduction, thermoregulation, and patterns and mechanisms of growth. Meier carefully investigates environmental and physiological aspects of circadian neuroendocrinal regulation in the Gulf Killfish. This chapter includes a multioscillator model and the volume's most colourful sentence in the lament that "vague generalizations…seem to have narcotized the intellect into an inactive stupor". Sleep and inactivity, including interactions with other behavioural categories such as care of a brood, are reviewed by Reebs while Spieler considers the nature, physiological correlates, and possible mechanisms of feeding-entrained circadian rhythms.

Eight closely allied chapters attend to the anatomy, biochemistry, and physiology underlying rhythmic phenomena, with emphasis on the suprachiasmatic (SC) nuclei, the pineal, and melatonin. Zachmann, Falcón, et al. survey the role of melatonin and the complex regulation of its secretion by pineal photoreceptors. Gern et al. cover similar terrain, with attention to the pineal in rainbow trout not as a clock but as an endocrinal photometer. They also collate discussions among the authors. Tabata presents extensive results on interactions among various photoreceptors, including extraretinal and nonpineal ones, important for rhythmic activity in a catfish. In trout Meissl and Brandstätter interpret the physiology of pineal photoreception for rhythms. Anatomical and biochemical aspects of rhythmic retinal adaptation are examined by Wagner et al., including tantalizing mention of possible links with pheromones. Interested in a master-clock homologous to those in other vertebrates, Holmqvist et al. marshall the neuro-anatomical and -chemical evidence implicating retinohypothalamic projections and the SC nuclei, and consequences for smoltification in Atlantic salmon, and indicate the need for physiological studies.

The book ends inconclusively with some unpolished remarks on heterogeneous issues such as the pineal, the extent of endogeneity, links between physiology and ethology, and applications. Fortunately, many of the chapters, while varying in format from reviews to research reports, are enhanced by outlining potential future work. The emphasis on fishes is in fact inevitably compromised by comparisons with other species, especially mammal, and this enhances the breadth of appeal of the book. Many phenomena remain poorly understood, and the best chapters, such as those by Leatherland et al. and Spieler, evaluate alternative possible explanations. As would indeed be expected given the price, the volume is well (although not flawlessly) composed, illustrated, and indexed. There is a useful glossary of technical terms from *acrophase* to *Zeitgeber*. True to its series, this book is highly specialized, but for fish physiologists and ethologists, as well as chronobiologists generally, it contains valuable material.

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Animal Behavior

Edited by Tim Halliday. 1994. University of Oklahoma Press, Norman. 144 pp., illus. $25.95.

Here is an excellent addition to the genre of academically solid yet appealing books serving to introduce a subject to a broad audience. The text is supplied by well-known, and mostly British, contributors, and is brightly augmented by superb photographs and illustrations in a very effective large-format layout which includes boxes highlighting selected examples. The emphasis is on the diversity of behaviour and its functional aspects, especially in vertebrates, and the tone is cheerfully conversational.

The four main sections are From Birth to Maturity (courtship, mating (including alternative strategies), births, and parenting, including helpers), Food and Shelter (hunting (including co-operative aspects, misconceptions about some species, and domestication by humans), foraging and storing, and animal architecture (under which termite mounds scale taller than our skyscrapers)), The Social Animal (panoply of communications, aggression, hierarchy, and symbiosis), and Instinct and Intelligence (survival skills handling temperature and water balance, migration (including the key role of stored fat), and adaptations, particularly through learning, to a world increasingly dominated by humans). While the coverage is broad and up-to-date, there is no discussion of what is *not* known for each topic. Similarly, there is an index but unfortunately no list for further reading. There are a few minor infelicities, such as an all-black "white-winged chough" on page 31, and a photograph of a hummingbird illustrating a discussion of migration in Arctic terns on page 124.

Of the most similar recent books, David Attenborough's 1990 *The Trials of Life* is a companion to the television series while Peter Slater's (Editor) 1987 *The Encyclopedia of Animal Behavior* is very similar indeed, in scope and layout (also 144 pages of text measuring 28 x 21 cm with a big-eyed bird on the cover, and Halliday among the contributors), except that it laudably pays more attention to mechanisms of behaviour such as genetic inheritance which are unfortunately unconsidered in Halliday's volume. Nonetheless, this book is an attractive and competent introduction for general readers.

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Herpetology in Australia: A Diverse Discipline

Edited by Daniel Lunney and Danielle Ayers. 1993. Transactions of the Royal Zoological Society of New South Wales. Surrey Beatty & Sons, Chipping Norton, NSW, Australia. viii + 414 pp. A$80.

This paper-back "perfect bound" volume is a compilation of 67 articles and notes plus 12 book reviews. It was intended to be an overview of the past and present status of herpetology in Australia. On one hand, as an overview, it achieves some of the intended goals but on the other hand, the quality suffers severely. The papers vary widely in significance and scope; some are very interesting and others belong in a society newsletter at best. Contributions range in size from less than one page notes and comments to research articles of greater than ten pages. Short notes predominate. In general, the compilation is definitely not aimed at the academician but rather the amateur herpetologist and interested novelist; overall, there is little meat to the reading. This diversity of quality comes as a surprise as each paper was sent to at least two reviewers. The volume comes nowhere near the exceptionally high standard set by its predecessor, *The Biology of Australasian Frogs and Reptiles*. [Grigg et al. (Editors) 1985. Surrey Beatty and Sons].

The volume consists of many subjects with no theme of organization except to randomly associate topics. About 11 papers can be roughly categorized as historical and species status reports. Some, such as the one dealing with the Northern Territory, are outstanding. About 20 contributions deal with species legislation and/or conservation issues; although some are very interesting, all are destined to be outdated as new laws are passed. There are eight "viewpoints", including a rage by an animal rights activist. Most of the 15 research papers consist of "preliminary" or "initial" reports and few follow rigorous methods. Other papers consist of distribution notes, zoo management, ecological notes, and speculations on amphibian decline. One paper reviews the utility of molecular data in uncovering "cryptic species", recommends this approach as a national priority, but provides neither new insights nor a thorough review of the literature.

Overall, the volume is very disappointing. Perhaps Australia has the most noteworthy herpetofauna of any place on earth. It certainly holds me captive having had the pleasure of two visits. Unfortunately, this volume does little to promote an appreciation and inspire research and conservation interests in this herpetofauna of herpetofaunas.

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The Lives of Birds: Birds of the World and Their Behavior

By Lester L. Short 1993. Henry Holt, New York. xiv + 256 pp. illus. + plates.

A deceptively simple title for an excellent book which is much more than a history of birds from egg to adult. Lester Short is Lamont Curator of Birds at the American Museum of Natural History, author of *Woodpeckers of the World* and many scientific papers. He has travelled the world observing birds in the field and is one of the select few who has seen the Ivory billed woodpecker in Cuba. (Marty Stouffer, of Wild America, was a member of the same expedition.)

The text is well written and each subject clearly defined. The basic life cycle of a bird and representative behaviour are described followed by exceptions to the norm. It is the additional information which makes this book worth reading for knowledgeable ornithologues. Chapters such as The Quest for Territory, The Social Life of a Bird, Bird Communication, and the Interrelationship Between Man and Birds set it apart from, and superior to, similar books. Some of the most recent scientific findings about subjects such as migration, nest building, bird dialects, and how birds learn are incorporated (without attribution) but there is little resort to complex language and highly technical terms, even though the subject matter is complex. That does not make the book any less valid or interesting.

This is recommended reading for all those interested in ornithology, and a valuable addition to a natural history library.

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Crows and Jays: A Guide to the Crows, Jays and Magpies of the World

By Steve Madge and Hilary Burn. Houghton Mifflin Company, Boston. 191 pp., illus. U.S. $40.00.

Some years ago I volunteered to write any unassigned portions of a breeding bird atlas. One of the species accounts I was asked to author was the section on the American Crow. This prompted some derisive comments from a few of the ardent birders for having drawn such a lowly assignment. I, however, was happy for I believe crows have character, real character. True they are not as colourful, elegant and great songsters as some of the other bird families but crows have some amazing behavioral patterns. Steve Madge is another crow enthusiast and he has translated his interest into a fine new book.

Patterned after their earlier book on waterfowl (1988. *Waterfowl*. Houghton Mifflin, Boston) the text covers identification, description, sex and age, measurements, geographical variations, voice, habits, breeding, habitat distribution, status, and references. The information given in each species account has been well presented in a crisp, readable style. The content is well researched and there is a good balance between the amount of information given for obscure and well known species. The book covers jays, magpies, "aberrant" tropical corvids, green magpies, treepies, choughs and jackdaws, ground jays, crows, and ravens. It fully documents 120 species, including 20 considered endangered. Any potential for the future split of a species, as with Florida Scrub Jay, is included and explained. While the main purpose of the text is to inform, the style used makes it also pleasant to read.

Hilary Burn's illustrations are the best I have seen from her to date. I spent some time comparing the black corvids to see if she had captured the subtleties of the differences between similar species. The artwork must have been a painstaking labour of love for she has indeed portrayed the somewhat duller or shinier, more iridescent, longer-legged, fatter-billed and more or less compact characteristics of the black corvids with great care. In addition, I find her work captures the essence and charm that these birds exhibit. I think a large version of one of the grey treepies would look splendid as a work of art in my house. And while most peoples, first concept of the crow family is normally black, the artist's plates quickly remind us that it contains some of the most colourful birds in the world. Our own, often despised, Blue Jay is a case in point and would rival most of the tropical jays and magpies. The top prize probably belongs however to the brilliant-as-a-bee-eater Green Magpies of Asia — an almost gaudily vibrant group.

The artist has added some black-and-white line drawings of non-corvid species to the test. These are of birds that look somewhat similar and could be confused for with a member of the crow family. A few other drawings of bill comparisons and tables of sizes or colour changes are given to assist in the separation of difficult species.

I was slightly disappointed that there is little anecdotal information on behaviour. I recently watched a circle of American Crows taking turns to fly just off the ground with a bag of chips and shake it. The food that was spilled was rapidly eaten and the next crow would have a turn at the bag. I have seen such examples of cooperation on other occasions. However, I realize that if the author had included this type of account the book would have been much longer and would have swamped its more valuable function, as a handbook. This book then is an excellent addition to the birder's bookcase. It is fun to have and use as a book and will be of help when out in the field. It supplements the information given in the field guides and provides a global perspective which will be of great assistance to the travelling birder. Every serious birder should have one, then the appreciation for this interesting family of birds will increase. Now if an errant Carrion Crow arrives in Nova Scotia will I be able to separate it from an American Crow?

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Finches and Sparrows: An Identification Guide

By Peter Clement, Alan Harris and John Davis. 1993. Princetown University Press, Princetown, New Jersey. 500 pp., illus.

This well written book covers 290 species in the families Fringillidae, Estrilidae, and Passeridae, or, in the author's words, the "true" finches and sparrows. It does not include the New World's Grosbeaks, Buntings, and Sparrows outside those families, nor their European allies, the Buntings. Most entries are one to one and a half pages covering identification, description, geographical variation, voice, status, distribution, movements and measurements. No information is given on breeding or courtship behaviour.

The front section of the book contains the plates and a brief repetition of the key identification information opposite each species. The plates depict males, females, and juveniles for most species. Subspecies are not shown unless the plumage difference is significant. A small map shows the current known distribution, on a world or continent scale. Small islands, with populations of the species in question, are highlighted with an arrow, so that they will not be missed. (Except Hawaii, which is just at the map margin.) I found a minor inconsistency in these maps; some introduced species ranges are included, some are not. For example, the Greenfinch is shown as introduced to New Zealand but the southern Australian population is not depicted. Similarly the Spotted Munia is missed from its territory in northern Australia, yet House and Tree sparrows are shown. The text descriptions of range are accurate, however, and the reader should consult the distribution section for the popular cage birds, particularly in tropical regions, to see where they have been introduced or escaped.

The introduction explains the format of the book and how to use each section. The author also describes some of the decisions he has made on such questions as the sequence of species, choice of common name, and the problem of escapees. It is important to read this section as it will help the reader find and interpret information more readily.

While I am enthusiastic about this book, it does have artistic faults. The book is illustrated by two artists, Harris and Davis. Davis's birds are well drawn and composed. He has captured the shapes and postures of each species well. But the plates in my copy are far too highly coloured. The Chaffinches, Bramblings, crossbills, and siskins are more brilliant than I have seen in the wild. Only the colour of the goldfinches approaches reality. The colour for the Harris plates are much closer to the truth. This is especially evident with groups like the redpolls, where the difference in colour between the lightest Common Redpoll and the Hoary Redpoll is a key feature. However this time I think that many of the shapes are incorrect. All of Harris's birds tend toward a similar basic shape. While this works fairly well for the tropical finches like the waxbills, cordenblues, mannikins, firetails, and the like, it distorts the northern species. For example, the body shapes of Evening Grosbeak and Pine Grosbeak are virtually identical. (I traced over them to verify this). My impression of the Evening Grosbeak is that it is a much chunkier bird than the Pine and this does not come across in Harris's plate.

While this book is designed primarily as a reference, it does have many sections that make interesting reading. I enjoyed looking up the status and distribution of a number of birds, both familiar and unknown. I find Pine Grosbeaks appealing because of their acrobatic and amusing antics, and they went up even more in my estimation when I found out that their major food in summer is mosquitoes. I was stunned to learn that Bramblings, a bird I struggled hard to find for the first time many years ago and eventually discovered but a single bird, was seen in a flock of 72 million. Even my later discoveries of flocks of a few hundred paled by comparison. In contrast, the Sao Tome Grosbeak has been seen by only four or five knowledgeable individuals in the 20th century and there is only one known specimen in the world. Similarly, the poorly known Warsangli Linnet lives in Somalia and given the current conditions, will likely remain an obscure species for years to come.

Overall another excellent book for the travelling birder and the answer to many a relatives, gift buying problems. Perhaps we can now persuade the author to produce a companion book on the buntings and New World grosbeaks and cardinals; perhaps entitled the "untrue" finches and sparrows!

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Birds of Texas: A Field Guide

By John H. Rappole and Gene W. Blacklock. 1994. Texas A&M University Press, College Station, Texas. 280 pp., illus. U.S. $40.00.

I opened this book with enthusiasm but as I began to read I became first confused, then frustrated, followed by irritation, and until finally I became sympathetic. My sympathy arose because the authors have done a great deal of work in collecting useful data, but it remains to be turned into useable data. Let me begin by saying what this book is not. It is not a Peterson-style guide (Peterson 1963) that will help you identify birds in the field. It is not a site guide that will take you to an exact spot in the way the Lane guides (Holt 1992/94) do. It is best described as a distributional guide with identifying information and bird photographs.

Each species has a brief account of its plumage, its voice and range in Texas and elsewhere. This is accompanied by a 3 by 3 cm square map of Texas which shows all the county boundaries. Given the large number of counties, the maps are small and congested. A useful introduction explains the terms used and gives a short description of the major habitats.

My troubles began on the first page of the species accounts. The first species, Red-throated Loon, is listed as casual and the map shows a grey zone — identified as representing rare to casual status — along the entire Texas coast. This makes sense. The next species, Arctic Loon is listed as hypothetical; a undefined term that later in the book appears to be synonymous with accidental, although that does not seem to apply here. The map shows the same casual to rare distribution as Red-throated Loon. Turning the page I find the section on Common Loon which lists it as a common to rare transient and an uncommon winter resident on the coast. My visual impression from the map was that it was more common and widespread, but the definitions and the map symbols are consistent this time. My problem stemmed from the broadly-defined map colours. Light dark stretches from common to uncommon and light grey goes from casual to rare.

Yellow-billed Loon comes next and is listed as accidental. A single record shown on the map by a square dot in Lubbock county — perfectly consistent with the text. I decided to check if the dot was located in the correct county using the master map of counties in the introduction. The printing on this map is so small I had to use a magnifying glass to read the print, but the record location is correctly located. Moving on, I find Yellow-nosed Albatross is quoted as accidental in Willacy and Cameron counties, but there is only one dot on the map. Using the master county map I find Willacy and Cameron are side by side. By the time I reach Manx Shearwater the dot symbol (in Nueces county) is being used to indicate casual status. The authors then begin flipping between the grey shading and the dot system to indicate casual status for the remaining tubenoses. For Red-legged Cormorant the term hypothetical emerged again but this time it seemed to mean accidental, as a single record is shown.

By now I had become confused. The inconsistencies in the use of the terms and the map codes continued throughout the book. The two shades of grey plus white used to indicate the broad ranges were not adequate to indicate the winter and summer transients and permanent residents without reference to the text. So I shifted emphasis from how well the book was produced to what use it would be in the field. The standard field guides would be of greater use in identifying any species encountered. More specific directions are needed to find the localised Texas specialties. There are over a dozen publications giving locality information, several excellent national field guides, and Peterson's original guide to Texas (1963). The best I can say is that the *Birds of Texas* is current and contains up-to-date information on rarities, which is not the case in the older books.

The major virtue of this book is the collection of photographs. I prefer artists' illustrations for all the usual reasons; they can show different poses and plumages, highlight important features, and are always in focus. The photographs used in this book have all the usual problems inherent in using photographs; however they are much better than most of the other photograph-using field guides. Overall, the quality is better and they have included a large number of photographs of rarities that are absent from other guides.

For a visit to Texas, you will still need a good field guide and a site guide or two for the birding localities of the places you intent to visit. If you plan to stay for a few months or are a permanent resident, then this book will help you build a bigger list, once you have learned to work with the inconsistencies.

References

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Cormorants, Darters and Pelicans of the World

By Paul A. Johnsgard. 1993. Smithsonian Institution Press, Washington. xiv + 445 pp., illus. U.S. $49.00.

Those of us who find the preparation of books and major papers very time consumptive are generally astounded at the rate at which Paul Johnsgard manages to publish significant tomes on World-wide and North American-wide treatments of various bird families. In this work, he covers three of the six currently recognized families of Pelecaniformes. After a preface and acknowledgements, the book is divided into two main parts: "comparative biology" and species accounts. Three apprendices, a 19-page list of literature (most, but not all cited in the text) and an index close the book. Maps, drawings, and tables supplement the text throughout, and numerous colour plates (not cross-referenced with the text) grace the centre of the volume.

The section on comparative biology consists of seven chapters. The first on phylogeny, taxonomy, and zoogeography includes fossil history in addition to a review of classification of the order as a whole and of each of the three families covered in the book. The second chapter covers anatomy and morphology. Four chapters review behaviour, both "egocentric" and social, including ecological aspects and food habits. The seventh chapter treats population dynamics and conservation biology, the latter aspect rather superficially.

Part two occupies the bulk of the book with one to 11-page accounts of 34 species of cormorants and shags, two species of Anhinga and Darter, and seven species of pelicans. With the exception of the extinct Pallas' Cormorant, each species account is accompanied by a distribution map opposite the first page of text. The text for each covers other vernacular names, distribution, description and identification, various aspects of behaviour, ecology and general biology, population status, and evolutionary relationships. Drawings of various postures accompany several accounts.

Johnsgard has assembled a vast amount of information into handy reference form. Although sometimes heavy reading, naturalists should have no trouble following the text. On the whole, information on North American species appears accurate and is reasonably thorough. Canadians will be especially pleased to see several citations from *Canadian Field-Naturalist* and more local Canadian journals, such as *Blue Jay* and *Ontario Field Biologist*. There are some notable omissions, however. For example, information on the Stum Lake, British Columbia colony of American White Pelican is based on a 1984 government report, whereas readers would have easier access to the pelican chapter in a 1980 book on endangered and threatened species in British Columbia and the Yukon (see review in *Canadian Field-Naturalist* 96: 502–503, 1982) and to a paper in *Colonial Waterbirds* 4: 2–11, 1981. There are also some factual omissions. Habitat used by American White Pelicans is said to include slow-moving rivers, but does not mention the fast-flowing Slave River occupied by our northern-most pelican colony, and the hydroelectric developments that threaten that colony are not included among conservation problems. The phenomenal increase of Double-crested Cormorants is noted, but the corresponding increase in pressure by fishermen and fish farmers to "control" them and the increase in vandalism of cormorant colonies is not discussed, although the 1992 symposium of the Colonial Waterbird Society on this subject is noted. Johnsgard deviates from the American Ornithologists' Union in labelling Pelagic and Red-faced Cormorants as Pelagic and Red-faced Shags and Common Raven as Northern Raven. English species names are in lower case throughout. Outside North America, Johnsgard's coverage of several species is apparently much less accurate, as outlined in a review by P. C. Rasmussen (*Condor* 96: 567–569, 1994).

A book of this length is bound to have a few "typographical" errors, but the number herein suggests either rushed or cursory proof-reading, especially in checking text citations against the literature list. At least seven citations are missing from the list, including one cited 11 times and another cited five times.

Phalacrocorax penicillatus is consistently misspelled *pencillatus*, J. P. Myers is misspelled Myres, and C. Léger is misspelled Luger. *Inland* missing from *Inland Bird Banding News* will hamper readers attempting to locate a paper by Strait and Sloan.

In short, Johnsgard has amassed considerable detail into one volume. The book serves as a useful overview of the three families covered and his literature list provides a good start to any literature search on the group. However, specific details should be checked in the original sources cited and other literature before being assumed as accurate or complete.

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Shorebirds of the Pacific Northwest

By Dennis Paulson. 1993. University of British Columbia Press, Vancouver. 442 pp., illus. $49.95.

Shorebirds receive more than their fair share of avian identification attention. Numerous comprehensive identification guides and papers are devoted to this group of birds. Since the publication of Hayman, Marchant, and Prater's *Shorebirds: An Identification Guide*, little new information has been added to shorebird identification knowledge other than dowitcher and Golden Plover, identification. With these points in mind, one might wonder why most birders would ever wish another shorebird book, particularly one whose title seems to suggest limited scope. *Shorebirds of the Pacific Northwest* is a superior work that all North American birders need.

This is a fine book and is highly recommendable to all birding enthusiasts. The single substantial drawback is the fact that only North American species are covered. For a slightly higher price one can have The Hayman et al. *Shorebirds: An Identification Guide*, which covers every species in the world. Those that have Hayman's book should not hesitate to purchase this book.

The Paulson book covers the 42 species that are annually occurring in the Northwest. Additionally all other species that have occurred in the region are discussed, as are species which Paulson considers potential vagrants to the area. The 78 species covered are all species that have occurred in North America, other than seven of the rarest species. The only "species" not mentioned in any context are Cox's and Cooper's sandpipers, if they are true species.

The introductory chapters are superb. These chapters, particularly the two entitled "What are Shorebirds?" and "Shorebird Identification", are excellent and well worth reading, repeatedly. The chapters contain information that will clarify identification methods. Paulson has managed to produce an excellent text that provides information in manners that I have never seen before. Typical topics such as structure, feather patterns, and feather placement are fully discussed. In the section "Birds in Flight", birds are grouped in various manners. Charts, tables, and illustrations show flight identification by shape, colour, and pattern, grouping by tail and wing pattern, and shorebirds overhead. These are excellent tools to learn shorebird identification by. Never before have these methods been so well documented. My hat is off to Paulson for helping to demystify shorebird identification. Further introductory chapters cover shorebird status and generalized identification methods and tips.

The bulk of the book is species accounts; each consists of an introductory paragraph, abundance bar graphs for the coast and interior, distribution, Northwest status, habitat and behaviour, structure, plumage, identification, in flight, voice, photos, further questions, notes, and references. The sections on notes and photos often correct mistakes in other guides, and pose important questions for which birders can provide answers. Accounts may be only a few paragraphs or several pages in length and supplemented with photographs and illustrations. Each family has an introduction while difficult groups such as *Tringas*, Stints and Peeps, and dowitchers receive a number of pages devoted to identification of the group.

There are several short-comings in this book. The major one is the lack of thorough discussion of some rare and potential species. Most birders are very interested in finding rarities and therefore need more thorough information on the rarest or potential species. In several cases species are limited to a few paragraphs and no photographs. Improvement should not be a problem as many species have been covered in other references and many excellent photographers have contributed work. Clearly it would be beneficial to have these potential species fully covered.

One beef I have with many speciality identification guides is that they do not provide photos or illustrations of all plumages. As many shorebirds are seen in juvenile through definitive plumages, it is disappointing that more information is not presented by including photographs of all identifiable plumages (i.e., juvenile, pre-definitive basic and alternate, and definitive basic and alternate plumages). Finally, several species could have more discussion of subspecies variation that would have allowed for more use by those outside the pacific northwest.

This is a fine book and deserves a place on every birder's book shelf. The introductory chapters are useful for every birder to read and the species accounts are fact filled. Do not think that the title implies a book of limited scope, this is a very useful book.

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The New Atlas of Breeding Birds in Britain and Ireland: 1988-1991

By David Wingfield Gibbons, James B. Reid and Robert A. Chapman. 1994. British Trust For Ornithology, England, 520 pp., illus.

For lo, the winter is past,
The rain is over and gone,
The flowers appear on the earth,
The time of singing has come,
And the voice of the **Turtle Dove** is heard in
our land.

These tranquil, poetic words from the Song of Solomon capture, for me, the essence of early English summer. Sadly, the data collected by this latest British atlas project show the Turtle Dove's range has contracted and its numbers have fallen. Its voice is much more difficult to hear in the valleys where I was born. This reduction in numbers and range is true for a large number of Britain's birds.

For me there are two ways of having a memorable day birding. The first is to find or see a rarity. The second is to see a large variety of species. This is easier to do in Britain than Canada because there is a greater proportion of resident birds to transient migrants. Summer and winter alike, a mix of thrushes, buntings, finches, tits, and gulls can be found with ease. This list is augmented in winter by shorebirds, ducks, and other waterfowl and in summer by swallows, warblers, and other summer nesters. This great diversity is being eroded as the atlas results reveal many declines, some serious. In fact one rare bird of my youth, Red-backed Shrike, is now considered extirpated as a breeding species. But many of the common birds also show declines, generally around 20 percent. Only a few species, mostly recent colonisers, have shown increases.

When I received this book I was somewhat shocked to realise it has been 20 years since the first British Breeding Bird Atlas; I still consider the original volume as one of my new books. The British, who compiled the original bird atlas, did so with the intention of repeating the process periodically and providing a measure of the changes found. This is precisely what this new volume achieves. The pattern is similar to the old in that the main text is a series of species accounts which summarise the field data. The first section of the book describes the methods used for the field work and data evaluation, and also explains how this differs from the original atlas methods and why. The rationale for the leader's final choices of methodology is included in this discussion. The main text is the species accounts, written by many authors and illustrated by numerous artists. Each account has a black-and-white vignette of the bird discussed, which varies from the rapid, action-capturing style of John Busby to the detailed work of Robert Gillmor.

Added this time is the comparison with the original work and an estimate of abundance. New techniques for collecting and processing data have been incorporated and make this a much more scientific work than the first version. It appears that the success of atlases has attracted the attention of the scientific community and the field workers themselves have become more sophisticated in the intervening years. The result is a more useful, more scientifically defensible work than before. It also shows that the work to conserve British breeding birds has barely begun if that island wishes to retain its species diversity. This is despite the growing efforts of groups like the Royal Society for the Protection of Birds (whose annual budget exceeded $65 000 000 this year), the Wildfowl Trust and the Nature Conservancy. If the atlas does no more than destroy complacency it has served its purpose.

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Bird of Jove

By David Bruce. 1994. Texas A&M University Press, College Station. 285 pp., illus. U.S. $13.95.

This book is a reprinting of a 1971 edition by G. P. Putman's Sons. Back in print for the first time in more than a decade, the book tells the true story of the efforts of a falconer, named Sam Barnes, to save a dying female Berkut Golden Eagle from Kirghizstan in eastern Russia and to bring it back to his home in Wales to be trained for falconry. The largest subspecies of the Golden Eagle, Berkut eagles have been used for hundreds of years by the Tarters, decendents of the Mongols, and czars to hunt animals as large as wolves, antelopes, foxes, and bears. According to legend two of them were used with dogs to hunt prey as large and ferocious as leopards and tigers. The book's title refers to a Roman myth that the powerful god Jove had an eagle that killed prey with thunderbolts dropped from its talons.

The story is an enjoyable adventure tale in itself but the numerous descriptions of unusual events involving the training of the Berkut named Atalanta, confrontations with townspeople, and interactions between Atalanta and her canine hunting companion Shep make heart-warming reading. The book contains a great deal of information on the sport of falconry and the techniques used in training a short-winged hawk to hunt. Information ranging from the treatment of diseases such as frounce to the imping of feathers can be found throughout.

Naturalists will find the book to contain interesting information on a very unusual subspecies of Golden Eagle. Those who enjoy reading and learning more about falconry and its history will find this book to be a valuable addition to their libraries.

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The Beak of the Finch

By Jonathan Weiner. 1994. Alfred A. Knopf, New York. 332 pp., illus. U.S. $25.

The author of this book is a writer not a scientist. He has researched the work, results, and lives of a small group of scientists examining evolution and translated the scientist's jargon into more readable prose. This is a worthy effort. Too often science is inaccessible to the non-scientist and anyone who tries to explain, in an unbiased manner, the results of the latest research is to be encourage.

The book primarily describes the work of Peter and Rosemary Grant to measure and evaluate the evolutionary changes in Darwin's finches in the Galapagos. For over 20 years the Grants and a number of other researchers have laboured in the hot sand of these famous islands, catching and measuring finches, collecting and counting seeds, and observing the finch's behaviour. The data show that small but measurable differences in these very closely related birds are sufficient to separate them into species. These differences enable them to take advantage of, or restrict them to, a specific group of seeds, their main food. The Grants can show that, starting from a single windblown species, these finches have developed into separate populations that take maximum advantage of the island's resources. In short, they provide support to Darwin's great theory that species evolved in response to environmental pressures.

The clearest indicator of this adaptation process is the size of a bird's bill. Variations of a millimetre or less in bill length or width can be critical to obtaining or opening a specific seed and, hence, to survival. The Grants' exhaustingly collected data shows how the characteristics are modified by environmental change at a rate that would have astounded Darwin. This pioneering work has encouraged others to look at similar small but measurable changes. The work has blossomed to include bacteria, fruit flies, bugs, sticklebacks, and even elephants!

When Weiner is describing each project and its results the text is clear and enjoyable. Unfortunately he also repeats the conclusions, in a style that is reminiscent of the preachers that denounce evolution. This became irritating and repetitive to the point that I almost gave up just over half way through the book. My interest was resurrected when the author moved on to the sticklebacks and other subjects and returned to his narrative style. I do not react well to the preaching style. Also this book does not "prove" evolution takes place. Rather the work described provides substantial evidence that reinforces my personal belief in Darwin's theory.

The book also provides a warning. Human impact is altering the nature of the changes which are taking place in other living organisms. Bacteria, for example, are responding to our attack by bacterial agents by producing resistant forms. (That is they are evolving under environmental pressure). Our attacks on them are forcing the rate and direction of their evolution to develop those resistant strains. Overfishing produces smaller-sized fish in lesser amounts.

Elephant poaching has resulted in tuskless elephants. So, not only must we accept responsibility for the direct destruction of species and their habitat but also for pushing them onto unnatural evolutionary paths.

The book is illustrated with black and white drawings from Darwin's work and by some charming artwork from the Grants' daughter. If you are prepared to wade through the repetitive sections then this book is an interesting one to read. The story of the research into evolution is fascinating and important and should be available to a wide audience.

ROY JOHN

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A Field Guide to the Whales, Porpoises, and Seals from Cape Cod to Newfoundland

By Steven K. Katona, Valerie Rough and David T. Richardson. 1993. Smithsonian Institution Press, Washington. 316 pp., illus.

This excellent book is almost a mandatory purchase for any east coast naturalist who spends time by the sea. Well organised, well presented, well researched, up-to-date, and full of useful information, this book is both readable and a good reference. It contains chapters on whales and their kin, seals, and other large sea creatures. Appendices cover the important prey species for whales and seals and a guide to the availability of excursions.

Within the chapters each species has its own section that describes the biology, identification, distribution, and other relevant features. The species accounts are absorbing, being filled with anecdotes and supporting information that gives a good sense of the nature of each animal. I was particularly pleased with the up-to-date status of the information and the balanced nature of the abundance and probability-of-occurrence data. Naturalists who have a better understanding of what is possible in their own area and how to correctly identify sightings would improve our knowledge of the lesser-known species. This book is the best way I have found of improving that understanding. I like the addition of the chapter on prey species. It adds to your appreciation of the whales and seals and introduces a new aspect of the sea's ecology. The illustrations consist of numerous small black-and-white photographs supplemented by line drawings. Many of the photographs show the animals at sea and are therefore useful as identification guides.

The book covers the sea area from the southern coast of Massachusetts, around the coast of the Maritimes, down the mouth of the St. Lawrence, and out beyond Newfoundland to the shores of southern Labrador. This means the bulk of the area covered is in Canadian waters. And here lies my one, real complaint. There is a strong U.S. slant to most of the coverage. It is clear that while the authors have good connections with some Canadian operators, these liaisons are incomplete. For example, they list three charter operators for Nova Scotia, including one who has gone bankrupt. Earlier this spring I surveyed the 15 most active operators. I ignored a number of smaller, part-time operators. The most significant omission is Bill Crawford's operation in Cheticamp, Cape Breton; Nova Scotia's oldest and one of its most successful whale watching enterprises. The authors also missed noting the congregation of Pilot Whales of Cape Breton. (They also ignored tuna in their accounts of other large species. We have seen more tuna off Halifax Harbour, this summer, than dolphins, and they constitute an identification problem to the novice). Maps are included to show the locations where whales can be seen from land. This is an excellent idea but only one location is shown for Nova Scotia; Meat Cove, Cape Breton. All the other notable places, such as Briar Island, Chebucto Head, and Pleasant Bay, where whales are observed regularly from land, are missed. Although Newfoundland seems to get better coverage, it is not complete and Prince Edward Island does not even get mentioned. If the authors are going to claim wide coverage I feel that they should do more research to justify the claim.

These negative comments cover only a small portion of the book. The bulk is taken up by the excellent species material and makes this a great purchase for all those interested in whales.

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Studies of White Whales (*Delphinapterus leucas*) and Narwhals (*Monodon monoceros*) in Greenland and Adjacent Waters

Compiled and edited by E. W. Born, R. Dietz, and R. R. Reeves. 1994. Meddelelser om Grønland, Bioscience 39. 259 pp. U.S. $55.00.

This special issue of *Meddelelser om Grønland, Bioscience* is a selection of papers solicited to provide a benchmark in the knowledge of two arctic cetaceans: the Narwhal (*Monodon monoceros*) and the White Whale or Beluga (*Delphinapterus leucas*) in waters adjacent to Greenland. Stocks of both species migrate along the eastern and western coasts of Greenland and may move seasonally into international waters, or in some instances, into the territorial waters of other nations, particularly Canada and Norway (Svalbard).

Whale hunting has long contributed to the subsistence lifestyle of Inuit and the importance of these two species to the socio-economic fabric of the traditional Greenland culture and economy provides a central theme for the organization of the papers, which include information on stock distribution and abundance, exploitation and status, habitat use, behaviour, life history, stock identity, and toxicology. The book provides information, much of it for the first time, of relevance to management and underscores the immediate need for improved knowledge on stock relations, diving behaviour, and mortality. This is information sorely required for adequate stock assessments.

Of particular interest are the three papers on exploitation and status, specifically the overview of recent hunting and population status in West Greenland, which suggests that populations may be dwindling due to overexploitation. This section also introduces the problem of current hunting and product use into a marketing (national and international) context and the influence of treaties and trade agreements on hunting. This is an area of some relevance given worldwide concern over the purported effects of "commercial" exploitation on cetacean stocks. It should facilitate further evaluation of how commercial incentives may affect hunting pressure and how external regulatory influences may effect local economic and cultural development, not only for those stocks utilizing Greenland waters, but also those in the Canadian Arctic (Narwhal and Beluga) and Alaska (Beluga). The section does lack adequate coverage of the Inuit perspective, but hopefully this will be addressed in a future volume.

This book is certainly a must for any scientist or manager immediately involved in the conservation and management of these species and should be compulsory reading for anyone involved in national and international regulatory processes dealing with trade agreements in wildlife resources. I would recommend the book for the serious naturalist to provide an introduction to the problems involved in the conservation and management of such species, the commercial versus traditional aspects of resource exploitation by the Inuit, and the influence of international treaties and agreements on such activity. The volume is well laid out and the information presented in such a fashion that is would be readable by the informed layman. Hopefully, the coverage will stimulate the provision of background for further comparative studies.

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Long Spikes

By Jim Arnosky; Clarion Books, New York. 90 pp., illus. U.S. $12.95.

Jim Arnosky is an author/illustrator of twenty-three nature-oriented children's books, and the recipient of the American Nature Study Society's, Eva L. Gordon Award. *Long Spikes*, his second novel, captures the attention and hearts of all children in a tale that follows the early years in the life of a young buck, Long Spikes.

Throughout the book the reader joins the author in being a keen observer of Long Spikes as he discovers, learns, and matures on his own in the wild. The first chapter is very moving, as one is immediately drawn into a well-written and emotional account of the death of Long Spike's mother who is chased and killed by coyotes. Orphaned and forced to fend for themselves Long Spikes and his twin sister discover that the wilderness can be a frightening place, at other times their only refuge.

The reader will be impressed by the amount of information about deer physiology and behaviour presented. Seasonal changes, predators, doe herds, rutting season and mating rituals, and the role of dominant bucks are just a sample of the many topics incorporated into the novel. Throughout the book readers will appreciate the author's delicate pencil drawings which beautifully complement and enhance the text. It is evident throughout the book that the author has spent a great deal of time observing nature. The writing conveys an appreciation of the natural world while encouraging the joy of discovery through quiet observation.

Long Spikes is a wonderful addition to children's literature, and an asset to any young reader's nature library.

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BOTANY

A Naturalist's Guide to the Arctic

By E. C. Pielou. 1994. University of Chicago Press, Chicago. xv + 327 pp., illus. Cloth U.S. $57.00, Paper U.S. $19.95.

The number of naturalists who have the opportunity to visit the northern parts of Canada and Alaska has been on the increase. Northern travel however does not allow for the great weight of numerous books that might be required to gain an understanding of the various aspects of natural history that might be encountered. Now for that area lying north of continuous permafrost in Alaska, the Yukon Territory, the Northwest Territories and somewhat further south in northern Quebec there is a single volume that can easily be carried for ready consultation.

Information is provided on such topics as the midnight sun, the use of a compass near the magnetic pole, the aurora borealis, climates and atmosphere, the terrain from ice caps and glaciers to tundra, pingos and other land formations and various aspects of plant communities. This is followed by a field guide to arctic plants with line drawings of the species which are most likely to be observed, a field guide to arctic birds, and sections on the terrestrial mammals, walruses, seals, whales, fish, and insects, all similarly illustrated.

This book is full of interesting comments and makes most easy reading. For someone travelling for the first time in our far north and interested in the world about them, it is a must.

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Intermountain Flora, Vascular Plants of the Intermountain West, U.S.A., Volume 5: Asterales

By A. Cronquist. 1994. The New York Botanical Garden, Bronx. 496 pp., illus. U.S. $75.

This is the fifth volume of six that were proposed for the Intermountain Flora, but now it would appear that there are still two to come. Those previously published are Volume 1, *Ferns and Fern Allies* (with introductory materials) (1972), Volume 6, *Monocotyledonae* (1977), Volume 4, *Subclass Asteridae* (except Asteraceae) (1984), and Volume 3B, *Fabales* (1989). All have been reviewed in previous issues of *The Canadian Field-Naturalist.*

The only family in the Order Asterales is Asteraceae (Compositae) which in the manuscript prepared by Arthur Cronquist for this volume of Intermountain Flora contained 130 genera. Like the earlier volumes, the family, genera and species are all described in detail and additional information on the number of species in the genus, the areas in which they predominate, biological distinctions, problems involved in the groups, hybridization, and pertinent references where the author considered them of value to the user. Pertinent synonomy together with place of publication, and information on the type specimen when available are also provided. And indeed comments such as "I am still not satisfied with my treatment of the genus *Cirsium*, but it is the best I can do in the time available for the preparation of the flora", show his deep long-time interest in this group of plants. Arthur Cronquist did a tremendous job in the preparation of the manuscript for this important volume. It is most unfortunate that he did not live to see the end result of the effort.

An addendum of nine pages has fortunately been provided by Noel Holmgren. This includes several Intermountain Asteraceae that have recently been described as new taxa or were inadvertently overlooked in Cronquist's inventory of taxa found in the region. These are treated in the same fashion as the main text together with expansion of Cronquist's keys. One new combination by Holmgren, *Hymenoclea sandersonii* (S.L. Welsh) N.H. Holmgren is included here. It should also be noted that at the end of Cronquist's text there is a list of 35 nomenclatural innovations together with page numbers where they may be found in the text.

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A Utah Flora

Edited by Stanley L. Welsh, N. Duane Atwood, Sherel Goodrich, and Larry C. Higgins. 1993. Second Edition, Revised. Brigham Young University, Provo, Utah. viii + 986 pp. U.S. $65.00 + $6.00 shipping and handling.

In 1987 Welsh, Atwood, Goodrich and Higgins published the first edition of *A Utah Flora*. This was reviewed in *The Canadian Field-Naturalist* 102(2): 406-407, 1988. This treatment included 142 families, 765 genera, 3152 species (including 580 introductions), and 355 infraspecific taxa. It numbered 894 pages.

In the present volume 3284 species (including 682 introductions) and 393 infraspecific taxa are treated. This is a tremendous step forward in only six years. The keys have been altered to include the additional taxa and many taxon descriptions have been enlarged. Information on the presence of type specimens in the Brigham Young Herbarium (BRY) has been added. It is of particular interest that 10 new species and 13 new varieties are included as well as 12 nomenclatural combinations. These have all been published separately (*Rhodora* 95: 392–421, 1993) rather than being published in the flora, itself, as were similar entities in the 1987 edition. Separate publication is a much better practice; particularly for new taxa.

Students and botanists in Utah and adjacent states will welcome this new treatment even though it is thicker and heavier. It is amazing too that the price for such a volume has been kept so low.

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The Cruciferae of Continental North America

By Reed C. Rollins 1993. Stanford University Press, Stanford, California. xvi + 911 pp., illus. U.S. $125.

This is a comprehensive taxonomic treatment of the mustard family, Cruciferae (Brassicaceae), for North and Central America, not including Greenland, the Caribbean Islands, and other islands east of the Continent. It contains original keys, descriptions, cytological and habitat data, and pertinent synonymy for all species and varieties found growing in this area. It also has keys to all genera and photographs and line drawings of plants and plant parts. The author details the criteria that he has used to classify members of this important family. This book represents the culmination of Rollins' 50 plus years of exhaustive and innovative research on the systematics and ecology of the family Cruciferae (Brassicaceae) in the Americas.

Coverage of members of the family occurring in Canada is generally much weaker than south of our border. This has resulted from the fact that Rollins has only examined a small fraction of the material of Cruciferae that is available in Canadian herbaria. In addition, he has excluded many Cruciferae that are cultivated within his study area and has given less attention to naturalized, often weedy, taxa.

This very readable book represents an excellent synthesis of a lifetime of research on Cruciferae by America's foremost expert on the family. It would be a very useful addition to any plant systematic library and is a must-purchase for those interested in the large number of native, naturalized and weedy mustards found in Canada. Although it is an excellent value at the price of U.S. $125, its specialized and fairly technical nature probably makes it a poor-buy for most naturalists.

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ENVIRONMENT

Calculated Risks: Understanding the Toxicity and Human Health Risks of Chemicals in our Environment

By Joseph V. Rodricks. 1992 (paperback 1994). Cambridge University Press, Cambridge. 256 pp., illus.

Increasingly the general public receives news of a source of potential risk to their well being. Unfortunately, the general public tends to lack the skills to understand how the numbers are obtained, or the limitations of such information. In his book *Calculated Risks*, J. V. Rodricks has attempted to provide some appreciation for the scientific basis for the concerns, strengths and weaknesses of such information, and how U.S. policies may result.

The aforementioned is accomplished through a well-organized and readable text. The chapters followed a logical progression of development from basic chemistry to toxicology to risk assessment. A number of case studies are used to explain and clarify how the information is utilized. Technical terms are defined with easily understood terms. The reader is provided an index and a chapter by chapter list of sources and recommended readings. Unfortunately the reader is not supplied with a glossary or a list of acronyms which I felt would have helped for later reference.

The author dealt with American law and federal agencies. For a Canadian reader this may limit the book's value but I believe, although the laws and departments are different, the process is similar. Also a number of Canadian laws and departments do provide the same protection and service.

In short, Joseph V. Rodericks has provided a book which does provide a good general background of the scientific basis utilized for risk assessment. He also has provided some understanding as to the complex issue of how policies are set. The book should be recommended reading for those interested in obtaining an understanding of risk assessment.

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The Visitor's Guide to the Birds of the Rocky Mountain National Parks: United States and Canada

By Roland H. Wauer. 1993. John Muir Publications, Santa Fe, New Mexico. x + 420 pp., illus. U.S. $15.95.

The Rocky Mountains form one of the most familiar and predominant landforms in North America. This mountain system extends from central New Mexico in the south to northern Alaska, a distance of almost 3000 miles (4800 km). This handy, organized, and well-arranged guide covers the most common and obvious birds that can be found in 40 Rocky Mountain National Parks from Alberta to Texas. The book is not meant to replace or to be used as a bird field guide but rather to be used as a companion volume to these more specialized guides. The author wants the reader to become interested in and appreciate birds within the park setting. Three geographic regions are covered: the Northern & Central Rocky Mountains, the Southeastern Rockies and the Southwestern Rockies.

The two introductory chapters provide a good basis to understanding bird biology and the equipment you need in the field. For example, there is a good section on the factors to consider when choosing your binoculars and field guide. The section on birding ethics is commendable. The second chapter discusses parks as islands and the conservation and value of parks for wildlife and people.

The description of each park is treated as a separate chapter. The text is largely anecdotal and opens with a description of a typical experience in the park. The hunting behaviour of an Osprey over a still lake in Grand Teton National Park or a Common Raven flying amongst the steam of Old Faithful in Yellowstone provide some atmospheric examples. Also, the reader is provided with an overview of visitor centre and camping facilities, and addresses where additional park information can be obtained. Each chapter concludes with a list of the most important bird species for the park.

The excellent line drawings by Mimi Hoppe Wolfe scattered throughout the guide enliven the text as do the colour photographs. The photos, found as a group at the middle of the book, are particularly clear and a nice addition to entice you to these wild areas. Other supplementary materials include a checklist of birds (in AOU order) and a list of common and scientific plants. Be aware these lists are not complete. A bibliography to recent publications is extensive and comprehensive. Unfortunately, the only maps of the region are not listed in the table of contents or index but can be found buried in the second chapter. Clearly, this guide could be made much more useful if the maps had been put in a more accessible location such as the inside cover. Overall, the guide is highly readable and a good companion text to the standard bird guides.

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Global Warming and Biological Diversity

Edited by Robert L. Peters and Thomas E. Lovejoy. 1992. Yale University Press, New Haven. xxi + 386 pp., illus. U.S. $17.

This collection of 26 chapters contains an astonishing amount of information, clearly and interestingly presented. Each chapter is a review paper on a different topic by an authority (or small group of authorities) in the field concerned. The book forms part of the scientific literature, being written in typical journal style by active participants in the work described, with full documentation. At the same time, it is written for, and intelligible to, any naturalist concerned about the deteriorating global environment; this means, surely, all naturalists. The book has a full index, which is good to see in a multi-authored work.

Many factors besides global warming are harming the world's biodiversity: deforestation, habitat fragmentation and destruction, increasing UV radiation, river diversions, oil spills at sea, pollution of all kinds, and many others. At the same time, global warming is affecting many characteristics of the natural world that deserve investigation in their own right, not merely for their impact on biodiversity: biotic productivity, the physical and biotic properties of soils, sea level, phenology, and the like. Causative factors and biological responses could have been paired off in many ways. To choose the link between global warming as cause and biodiversity changes as effect is somewhat arbitrary but it does provide a good jumping off point for some very wide-ranging discussions on the biosphere's state of health in the early 1990s.

The predictions about the future offered by some contributors should be taken with a grain of salt. No doubt they will be. Such predictions always start, or should start, with the phrase "other things being equal...", a proviso that destroys their credibility before another word is written. The reason that I recommend the book is that it will broaden the interests, raise the awareness, and increase the store of information of any reader.

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Ecopopulism: Toxic Waste and the Movement for Environmental Justice

By Andrew Szaz. 1994. University of Minnesota Press, Minneapolis. 232 pp. Cloth U.S. $39.95; paper U.S. $16.95.

Increasingly the world is becoming aware of toxic waste problems. Most recently the former Soviet Block governments' lack of "safe guards" for disposal of waste and safety of the general public has drawn world attention. *"Ecopopulism"* is the sociological study of the environmental justice movement's growth, in the United States, as a response to waste disposal issues.

Andrew Szaz's intent is to address the following questions: "How did the awareness come about?"; "How did a nonissue so quickly become a passionate issue?"; "The nation's most important environmental problem?"; "How, why, under what conditions did perceptions so easily become radical action?"; "How did action informed by rather narrow and even apolitical self-interest (NIMBYism) generate one of the most radical environmental ideologies we have today?"; "What impacts has the new environmentalism had on policy and, more broadly, progressive politics?"; "What can we learn from the history of hazardous waste as we search for a way out of this crisis and toward the necessary reconciliation of nature and human activity?"

The book addresses all the above questions in an easy to read manner. The author provides detailed notes and reference lists. The information does not provide a growing trust of government or industry, in fact one wonders how different would we be from the former Soviet Block countries if the environmental justice movement had not started.

Andrew Szaz has provided us a detailed insight of a movement which may very well continue to have greater impact on politics of the world. Although American in content the book is relevant to our Canadian situation. The book should of interest to individuals within the environmental movement and the political world.

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MISCELLANEOUS

A Naturalist in Indian Territory: The Journals of S. W. Woodhouse, 1849-50

Edited by J. S. Tomer and J. J. Brodhead. 1992. University of Oklahoma Press, Norman. 394 pp., illus. U.S. $29.95.

It is generally assumed that detailed natural history work did not get underway in the trans-Mississippi West until almost half a century after the Louisiana purchase. Although several government-sponsored surveys were sent into the region in the early nineteenth century, it was not until scores of Pacific Railroad parties fanned out across the western interior in the 1850s that the natural life of the area was systematically catalogued and described. John Tomer and Michael Brodhead have effectively questioned this view through their critical examination of the field work of Samuel Washington Woodhouse and his Indian Territory journals.

In 1849, Woodhouse, a twenty-seven-year-old doctor practicing in Philadelphia, was appointed surgeon-naturalist to the Creek Boundary expedition survey in Indian Territory (present-day Oklahoma). The assignment was the first of its kind for the local ornithologist, and Woodhouse proved a worthy choice. During two field seasons, while topographical crews marked first the northern and then western boundary, Woodhouse made notes on the natural life of the region, as well as collected any new or interesting specimens. He was also a keen observer of Indian life and visited Native settlements whenever possible. Upon his return to Philadelphia, Woodhouse turned over his specimens to the Academy of Natural Sciences and prepared various reports and articles on his findings. He took part in two other, lesser known expeditions in the early 1850s, but then decided to devote his life to medicine – a fact that probably accounts for the relative obscurity of his work today.

A Naturalist in Indian Territory reproduces Woodhouse's three field journals for 1849-1850. The publication of these notebooks is valuable in itself, but what enhances the monograph are the extensive explanatory footnotes that accompany Woodhouse's daily entries. In fact, Tomer and Brodhead are to be commended for their exhaustive, painstaking research. The book is as much a testament to their scholarship as it is to Woodhouse and his pioneering field work. The editors also provide a brief introductory history of the government naturalist in the trans-Mississippi West, a biographical sketch of Woodhouse, and an appendix of the specimens new to science that were collected during the boundary survey. They round out the journal with a number of photographs and illustrations.

A Naturalist in Indian Territory makes a strong case for the contention that the 1849-50 Creek Boundary survey, in particular the field work of S. W. Woodhouse, was a precursor to the detailed natural history surveys of the 1850s.

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A Naturalist's Mexico

By Roland H. Wauer. 1992. Texas A&M University Press, College Station. 304 pp., illus. Cloth U.S. $38.50; paper U.S. $14.95.

If you ever plan a trip to Mexico and enjoy natural history, get yourself a good map (preferably topographical as the maps included in the book are fairly primitive, and don't do justice to descriptions in the text) and read this book. If you don't plan a trip to Mexico, read this book anyway…you may change your mind! Wauer obviously loves and respects the Mexican landscape and its wildlife. With four regions subdivided into smaller areas which correspond to trips he has taken, and a series of both black-and-white and color photographs depicting many of the environments he describes, Wauer does a good job of impressing upon the reader the great diversity of Mexico's landscape and natural environment. Since he has visited Mexico to bird almost every year since 1966, he also has a good historical perspective on changes in land use and wildlife.

The preface gives a good summary of logistical things to be aware of when travelling in Mexico including safety, money, roads, accommodations, and food. Wauer is definitely a well-rounded naturalist, but his first love and the emphasis of the book is birding. He describes the vegetation well and mentions other animals such as mammals, insects, and reptiles; but generally only when they occur during his birding trips, which is fairly rare. This is not a criticism of the book, since it is probably a very realistic account of what one might expect to see during a natural history trip to Mexico, but perhaps a more descriptive title would have been "A Birder's Mexico". A useful feature of this book is what seems to be a fairly thorough coverage of other references (often original descriptions) to Mexican vegetation and wildlife for the naturalist who wants more details.

While many of Wauer's trips were rigorous expeditions involving extensive travel over rough country, many others were simple half-day walks from his hotel or archaeological sites on the tourist circuit, so this book inspired me to include specific birding plans in any trip I take in the future. The book is not a field guide, but rather a volume to whet your appetite and help plan a trip (or two, or three) to Mexico.

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NEW TITLES

Zoology

Ancient invertebrates and their living relatives. 1995. By H. L. Levin. Cambridge University Press, New York. c350 pp., illus. Cloth cU.S. $59.95; paper cU.S. $24.95.

The animal behavior desk reference. 1994. By E. M. Barrows. CRC Press, Boca Raton, Florida. c608 pp. cU.S.$195 in U.S.A.; cU.S.$234 elsewhere.

The amateur zoologist: explorations and investigations. 1994. By M. Dykstra. Watts, New York. 142 pp., illus. U.S. $12.90.

Bird life of woodland and forest. 1995. By R. J. Fuller. Cambridge University Press, New York. c250 pp., illus. cU.S. $64.95.

Bird song: biological themes and variations. 1995. By C. K. Catchpole and P. J. B. Slater. Cambridge University Press, New York. c250 pp., illus..U.S. $34.95.

*__Ecology and conservation of butterflies.__ 1994. By A. S. Pullin. Chapman and Hall, New York. U.S. $69.95.

Insects of the Los Angeles Basin. 1994. By C. L. Hogue. 2nd edition. University of Washington Press, Seattle. 448 pp., illus. U.S. $45.

*__Lady Grayl: owl with a mission.__ 1994. By R. W. Nero. Natural Heritage/ Natural History, Toronto. 176 pp., illus. $19.95.

*__Lake, river, and sea-run fishes of Canada.__ 1995. By F. H. Wooding. Harbour Publishing, Madeira Park, British Columbia. 300 pp., illus. $32.95.

*__Lizard ecology: historical and experimental perspectives.__ 1994. Edited by L. J. Vitt and E. R. Pianka. Princeton University Press, Princeton. xii + 403 pp., illus. U.S. $39.50.

Mechanisms and physiology of animals swimming. 1995. Edited by L. Maddock, Q. Bone, and J. M. V. Rayner. Cambridge University Press, New York. 260 pp., illus. U.S. $54.95.

†**Ornithology in Ontario.** 1994. Edited by M. K. McNicholl and J. L. Cranmer-Byng. Special Publication No. 1. Ontario Field Ornithologists, % S. Haddington, R.R.# 3, Brighton, Ontario K0K 1H0. xiv + 400 pp., illus. $24.95 + $3.50 postage.

Population production and regulation in the sea: a fisheries perspective. 1995. By D. Cushing. Cambridge University Press, New York. c320 pp., illus. cU.S. $69.95.

Rocky Mountain safari: a wildlife discovery guide. 1994. By C. Illg and G. Illg. Roberts Rinehart, Niwot, Colorado. 88 pp., illus. U.S. $9.95.

*__Sexual selection.__ 1994. By M. Anderson. Princeton University Press, Princeton. xviii + 599 pp., illus. U.S. $24.95.

Zoogeomorphology: animals as geomorphic agents. 1995. By D. R. Butler. Cambridge University Press, New York. c225 pp., illus. cU.S. $49.95.

Botany

Centres of plant biodiversity: a guide and strategy for their conservation, volume 1. 1995. By World Wide for Nature. International Union for Conservation of Nature (IUCN), Cambridge, United Kingdom. £30 + shipping.

*__Exploitation of environmental heterogeneity by plants: ecophysiological processes above- and below-ground.__ 1994. Edited by M. M. Caldwell and R. W. Pearcy. Academic Press, San Diego. xvii + 429 pp., illus.

A field guide to the trees and shrubs of the southern Appalachians. 1994. By R. E. Swanson. Johns Hopkins University Press, Baltimore. x + 399 pp., illus. Cloth U.S. $55; paper U.S. $18.95.

Forest resources in Europe. 1995. By K. Kuusela. Cambridge University Press, New York. 168 pp., illus. U.S. $44.95.

Historical perspectives in plant science. 1995. Edited by K. J. Fray. Iowa State University Press, Ames. 216 pp., illus. U.S. $44.95.

Remarkable agaves and cacti. 1994. By P. S. Nobel. Oxford University Press, New York. x + 166 pp., illus. Cloth U.S. $39.95; paper U.S. $19.95.

*__Scientific and common names of 7,000 vascular plants in the United States.__ 1995. By L. Brako, A. Y. Rossman, and D. F. Farr. APS Press, St. Paul, Minnesota. 294 pp. U.S. $29 in U.S.A.; U.S. $36 elsewhere.

†**Sonoran desert plants: an ecological atlas.** 1995. By R. M. Turner, J. Bowers, and T. L. Burgess. University of Arizona Press, Tucson. 504 pp., illus. U.S. $70.

Terrestrial orchids: from seed to mycotrophic plant. 1995. By H. N. Rasmussen. Cambridge University Press, New York. c332 pp., illus. cU.S. $54.95.

Environment

†**Biodiversity in Canada: a science assessment for Environment Canada.** 1994. By the Biodiversity Science Assessment Team. Environment Canada, Ottawa. 212 pp., illus. + 21 pp. summary volume. Free.

*__Biodiversity in British Columbia: our changing environment.__ 1994. Edited by L. E. Harding and E. McCullum. University of British Columbia Press, Vancouver. 425 pp., illus. $29.95 in Canada; U.S. $29.95 elsewhere + shipping.

Biological control: benefits and risks. 1995. Edited by H. M. T. Hokkanen and J. M. Lynch. Cambridge University Press, New York. c480 pp., illus. cU.S. $99.75.

Data analysis in community and landscape ecology. 1995. Edited by R. H. G. Jongman, C. J. F. terBraak, and P. O. F. R. vanTongeren. Cambridge University Press, New York. c300 pp., illus. U.S. $24.95.

*__Diatoms to dinosaurs: the size and scale of living things.__ 1994. By C. McGowan. Island Press, Washington. xiii + 288 pp., illus. U.S. $24.95; Cdn $29.95.

The ecology of fire. 1995. By R. J. Whelan. Cambridge University Press, New York. c336 pp., illus. Cloth cU.S. $59.95; paper cU.S. $24.95.

†**Environmental ecology: the ecological effects of pollution, disturbance, and other stresses.** 1995. By B. Freedman. 2nd edition. Academic Press, San Diego. xiii + 606 pp., illus.

†**The environmental promise of democratic deliberation.** 1995. By A. G. Gunderson. University of Wisconsin Press, Madison. 288 pp., illus. Cloth U.S. $45.50; paper U.S. $19.95.

†**Environment as a focus for public policy.** 1995. By L. K. Caldwell. Edited by R. V. Bartlett and J. N. Gladden. Texas A&M University Press, College Station. 310 pp. U.S. $39.50.

The environment comes home: Arizona public service's environmental showcase home. 1995. By K. D. Pijawka and A. K. Shetter. University of Arizona Press, Tucson. 120 pp., illus. U.S. $12.95.

*__The Everglades handbook: understanding the ecosystem.__ 1994. By T. E. Lodge. St. Lucie Press, Delray Beach, Florida. xix + 228 pp., illus.

*__Everglades: the ecosystem and its restoration.__ 1994. Edited by S. M. Davis and J. C. Ogden. St. Lucie Press, Delray Beach, Florida. xv + 826 pp., illus. + map.

*__From coastal wilderness to fruited plain: a history of environmental change in the temperate North America from 1500 to the present.__ 1994. By G. G. Whitney. Cambridge University Press, New York. xxxiv + 451 pp., illus. U.S. $54.95.

Global wetlands: old world and new. 1994. Edited by W. J. Mitsch. Elsevier Science, New York. U.S. $285.

†**The greening of ethics.** 1995. By R. Sylvan and D. Bennett. University of Arizona Press, Tucson. 269 pp. Cloth U.S. $45; paper U.S. $22.95.

High frontier: exploring the rain forest canopy. 1994. By M. Moffet. Harvard University Press, Cambridge Massachusetts. Cloth U.S. $39.95; paper U.S. $24.95.

Human impacts on weather and climate. 1995. By W.R. Cotton and R. A. Pielke. Cambridge University Press, New York. c288 pp., illus. Cloth cU.S. $59.95; paper cU.S. $24.95.

Journey to the heart of nature: a guided exploration. 1994. By J. Cornell and M. Deranja. Dawn, Nevada City, California. 123 pp., illus. U.S. $9.95.

Life. 1994. By D. Burnie. Dorling, Kindersley, New York. 64 pp., illus. U.S. $15.95.

Managing habitats for conservation. 1995. Edited by W. J. Sutherland and D. A. Hill. Cambridge University Press, New York. c320 pp., illus. Cloth cU.S. $69.95; paper cU.S. $24.95.

*__Masterworks of man and nature.__ 1994. By anonymous. Facts on File, New York. 400 pp., illus. + maps. U.S. $35.

Mountains and plains: the ecology of Wyoming landscapes. 1994. By D. H. Knight. Yale University Press, New Haven. xi + 338 pp., illus. U.S. $40.

*__The natural heritage of southern Ontario's settled landscapes: a review of conservation and restoration ecology for land-use and landscape planning.__ 1994. By J. L. Riley and P. Mohr. Ontario Ministry of Natural Resources, Toronto. 78 pp., illus. Free.

*__Naturalist.__ 1994. By E. O. Wilson. Island Press, Covelo, California. xii + 380 pp., illus. U.S. $24.95.

*__A naturalist in Florida: a celebration of Eden.__ 1994. By A. Carr. Edited by H. Carr. Yale University Press, New Haven. xxiii + 264 pp., illus. U.S. $28.50.

Natural woodlands. 1995. By G. Peterken. Cambridge University Press, New York. c446 pp., illus. Cloth cU.S. $67.95; paper cU.S. $29.95.

Pisces guide to Caribbean reef ecology. 1994. By W. S. Alevizon. Pisces Books, Houston. ix + 115 pp., illus. U.S. $15.95.

*__A practical guide to environmental impact assessment.__ 1994. By P. A. Erikson. Academic Press, San Diego. xii + 266 pp., illus.

†**Proceedings- ecology and management of annual rangelands.** 1994. Edited by S. B. Monsen and S. G. Kitchen. U.S. Forestry Service Report INT-GTR-313. Intermountain Research Station, Ogden, Utah. 416 pp., illus.

†**Proceedings Thirteenth North American Prairie Conference.** 1994. Edited by R. G. Wickett, P. D. Lewis, A. Woodliffe, and P. Pratt. Conference, Windsor, 6-9

August 1992. Department of Parks and Recreation, Windsor, Ontario. x + 262 pp., illus.

*Quantitative biology: spatial and temporal scaling. 1994. By D. C. Schneider. Academic Press, San Diego. xv + 395 pp., illus.

*Shield country: life and times of the oldest piece of the planet. 1994. Komatik Series Number 4. Arctic Institute of North America, Calgary. 271 pp.

*Size and integrity of standards for natural heritage areas in Ontario. 1993. Edited by S. F. Poser, W. J. Crins, and T. J. Beechey. Proceedings of a seminar. Ontario Ministry of Natural Resources, Huntsville. vii + 138 pp., illus. Free.

Two eagles: the natural world of the United States - Mexico borderlands. 1994. By T. A. Blake and P. Steinhart. University of California Press, Berkeley. xviii + 204 pp., illus. U.S. $55.

Vital signs 1994: the trends that are shaping our future. 1994. By L. R. Brown, H. Kane, and D. M. Roadman. Norton, New York. 160 pp., illus. U.S. $10.95.

†**Where the sky began: land of the tallgrass prairie.** 1995. By J. Madison. Revised edition. Iowa State University Press, Ames. 340 pp., illus. U.S. $24.95.

World resources 1994 - 95 supplements: Teacher's guide to world resources; Teacher's guide basic units; Introduction to our global environment; and Global trends color slides. 1994. By World Resources Institute, Washington. vii + 170 pp., illus. U.S. $6.95; vii + 184 pp., illus. U.S. $6.95; 10 minute video U.S. $12.95; and 50 slides U.S. $14.95.

Miscellaneous

*Arctic artist: the journal and paintings of George Back, midshipman with Franklin, 1819 - 1822. 1994. Edited by C. S. Houston. Commentary by I. S. MacLaren. McGill - Queen's University Press, Downsview, Ontario. 392 pp., illus. $45.

†**The co-operative fish and wildlife research unit program: 60th year celebration.** 1994. By W. R. Goforth. National Biological Survey, Washington. 113 pp., illus. Free.

†**Drinking water: refreshing answers to all your questions.** 1995. By J. Symons. Texas A&M University Press, College Station. 160 pp., illus. Cloth U.S. $24.50; paper U.S. $10.95.

The environmental imagination: Thoreau, natural writing, and the formation of American culture. 1995. By L. Buell. Harvard University Press, Cambridge, Massachusetts. 608 pp., illus. U.S. $35.

*Evolutionary archaeology: methodology issues. 1995. Edited by P. A. Taylor. University of Arizona Press, Tucson. 216 pp., illus. Cloth U.S. $45; paper U.S. $21.95.

The mass-extinction debates: how science works in a crisis. 1994. Edited by W. Glen. Stanford University Press, Stanford. xiv + 370 pp. U.S. $17.95.

†**Minutes of meetings 1928 - 1931 of the McIlwraith Ornithological Club, London, Ontario, Canada.** 1995. By W. W. Judd. Phelps Publishing, London, Ontario. 103 pp. $10.

The sex imperative: an evolutionary tale of sexual survival. 1994. By K. Maxwell. Plenum Press, New York. 324 pp., illus. U.S. $24.95.

Statistical methods in biology. 1995. By N. T. J. Bailey. 3rd edition. Cambridge University Press, New York. c272 pp., illus. Cloth U.S. $49.95; paper U.S. $16.95.

Books for Young Naturalists

Alligators; Lizards; Snakes; Turtles. 1994. By J. E. Gerholdt. Abdo and Daughters, Edina, Minnesota. Each 24 pp., illus. U.S. $13.99.

Ant; Bee; Spider. 1994. By D. Hawcock and L. Montgomery. Random House, New York. Each 10 pp., illus. U.S. $5.99.

Aye-ayes, bears, and condors: an ABC of endangered animals and their babies. 1994. By N. Twinem. Scientific American Books for Young Readers, New York. 32 pp., illus. U.S. $15.95.

Bats: mysterious flyers of the night. 1994. By D. Stuart. Carolrhoda, Minneapolis.

Bats: swift shadows in the twilight. 1994. By A. C. Cooper. Roberts Rinehart, Niwot, Colorado. 64 pp., illus. U.S. $7.95.

Big bugs: getting to know little creatures close up. 1994. By J. Booth. Harcourt Brace, San Diego. 48 pp., illus. U.S. $14.95.

Catching a meal; Changing shape; Making a nest. 1994. By P. Bennett. Thomson Learning, New York. Each 32 pp., illus. U.S. $14.95.

The desert alphabet book. 1994. By J. Pallotta. Charlesbridge, Watertown, Maryland. 32 pp., illus. Cloth U.S. $14.95; paper U.S. $6.95.

Down in the sea: the crab; Down in the sea: the sea slug. 1994. By P. Kite. Whitman, Morton Grove, Illinois. each 22 pp., illus. U.S. $13.95.

Elephant families. 1994. By A. Dorros. Harper Collins, New York. 32 pp., illus. Cloth U.S. $15; paper U.S. $4.95.

Exploring ocean ecosystems. 1994. By Wildlife Education Limited, San Diego. vii + 122 pp., illus. U.S. $94. (Includes 2 teacher's guides and 32 zoobooks).

Frogs and toads. 1994. By S. Parker. Sierra Club Books, San Francisco. 57 pp., illus. U.S. $16.95.

Insects. 1994. By W. Baker and A. Haslam. Thomson Learning, New York. 48 pp., illus. U.S. $15.95.

Janice vanCleave's 201 awesome, magical, bizarre, and incredible experiments. 1994. By J. vanCleave. Wiley, New York. 118 pp., illus. U.S. $12.95.

Mangrove wilderness: nature's nursery. 1994. By B. Lavies. Dutton, New York. 32 pp., illus. U.S. $15.99.

Nature's green umbrella: tropical rain forests. 1994. By G. Gibbons. Morrow Junior, New York. 28 pp., illus. U.S. $15.

Night flier. 1994. By E. Ring. Millbrook Press, Brookfield, Connecticut. 32 pp., illus. U.S. $15.40.

Night prowlers: everyday creatures under every night sky. 1994. By J. Emory. Harcourt Brace, San Diego. 48 pp., illus. U.S. $14.95.

One small square: African savanna; One small square: cave. 1994. By D. M. Silver. Scientific American Books for Young Readers, New York. each 48 pp., illus. U.S. $14.95.

Opossums; Otters; Rabbits and hares; Reindeer. 1994. By E. U. Lepthien. Childrens Press, Chicago. Each 48 pp., illus. U.S. $12.45.

Ornithology. 1994. By E. Doris. Thames and Hudson, New York. 64 pp., illus. U.S. $15.95.

Owls: on silent wings. 1994. By A. C. Cooper. Roberts Rinehart, Niwot, Colorado. 64 pp., illus. U.S. $7.95.

Pollinating a flower. 1994. By P. Benett. Thomson Learning, New York. 32 pp., illus. U.S. $14.95.

Prehistoric life. 1994. By W. Lindsay. Knopf, New York. 64 pp., illus. U.S. $16.99.

Science crafts for kids: 50 fantastic things to invent and create. 1994. By G. Diehn and T. Krautwurst. Sterling, New York. 144 pp., illus. U.S. $19.95.

The snow leopard. 1994. By T. Radcliffe. Viking, New York. 24 pp., illus. U.S. $13.99.

A swim through the sea. 1994. By K. J. Pratt. Dawn, Nevada City, California. 44 pp., illus. Cloth U.S. $14.95; paper U.S. $6.95.

A time for playing; A time for singing. 1994. By R. Hirschi. Cobblehill Books, New York. Each 32 pp., illus. U.S. $13.99.

Watching desert wildlife. 1994. By C. Arnold. Carolrhoda, Minneapolis. 48 pp., illus. U.S. $14.96.

Woods, ponds, and fields. 1994. By E. Doris. Thames and Hudson, New York. 64 pp., illus. U.S. $15.95.

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