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Copy Editors: Wanda J. Cook, Glen Keenleyside and Louis L'Arrivée
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Cover: A fungus fairy ring — Marasmius Ring 1, June 1968. For further description see Figure 2 in Toohey pp. 9–15.

The Canadian Field-Naturalist

Volume 97, Number 1 January-March 1983

Nesting Biology of Solitary Wasps and Bees in the Eastern Townships Region, Quebec

STEPHEN GODFREY[1] and DONALD F. J. HILTON[2,3]

[1]Redpath Museum, McGill University, Montreal, Quebec H3A 2T5
[2]Department of Biological Sciences, Bishop's University, Lennoxville, Quebec J1M 1Z7
[3]Author for correspondence.

Godfrey, Stephen, and Donald F. J. Hilton. 1983. Nesting biology of solitary wasps and bees in the Eastern Townships region, Quebec. Canadian Field-Naturalist 97(1): 1–8.

Trap nests were placed at 23 sites within two locations in the Eastern Townships region, Quebec. Out of 48 trap nests occupied, 34 contained *Ancistrocerus* spp. (*A. antilope* or *A. catskill*), 8 contained *Symmorphus* spp. (*S. albomarginatus* or *S. cristatus*) (Vespidae: Eumeninae), 3 contained *Auplopus caerulescens* or *Dipogon sayi* (Pompilidae) and 3 contained *Megachile inermis* or *M. mendica* (Megachilidae). Information on nest architecture, cell size, sex ratios, prey, parasites and associates is provided for most species.

Key Words: Solitary wasps, solitary bees, *Ancistrocerus, Auplopus, Dipogon, Megachile, Symmorphus,* trap nests.

Many solitary wasps and bees construct brood cells in pre-existing natural cavities such as tunnels made in dead trees by wood-boring insects, or the hollow stems of pithy plants like elderberry (*Sambucus* spp.). Nest structure, nesting behavior, larval food, parasites and predators of these cavity-nesting hymenopterans can be investigated by placing artificial nest cavities at appropriate sites in suitable habitats. Krombein (1967) summarized work done up to that time and reported on his own extensive studies conducted over a 12-year period. In the U.S.A trap-nesting investigations were carried out in Arizona, Florida, Missouri, New York, North Carolina, Tennessee, Wisconsin, and Washington, D.C. For Canada, Fye (1965a, b; 1972) described the biology of wasps and bees obtained in trap nests set out in northwestern Ontario, while Longair (1981) discussed sex ration variations in aculeate Hymenoptera similarly collected at Lake Opinicon, Ontario.

To our knowledge, no trap-nesting studies have ever been done in Quebec and this work was undertaken to provide information on the nesting biology of those species of wasps and bees that use trap nests in this part of Canada.

Materials and Methods

Trap nests were constructed from 20 × 20 or 25 × 25 mm pine or spruce boards cut to 75 or 165 mm lengths. Each piece was cut in half lengthways, the two halves clamped together and a hole drilled longitudinally down the midline. Holes were drilled using a standard wood bit rather than the twist drills employed by Krombein (1967). Following drilling, the clamp was removed and the two halves were taped together with water-resistant masking tape. This method of trap construction allowed future nest contents to be periodically examined by removing the tape and gently separating the two halves.

Five sizes of trap-nests were used: 20 × 20 × 75 mm, hole depth 70 mm, hole diameter 3.2 mm (1/8"); 20 × 20 × 165 mm , hole depth 150 mm, hole diameters either 4.8 mm (3/16") or 6.4 mm (1/4"); and 25 × 25 × 165 mm, hole depth 150 mm, hole diameter either 12.7 mm (1/2") or 16 mm (5/8"). Beginning 1 June 1980 bundles of five (one of each hole diameter) or three (hole diameters of 4.8, 6.4 and 12.6 mm) trap nests were placed at 11 sites adjacent to Bishop's University (Figure 1) and 10 sites near Johnville (Figure 2). In addition, bundles were deposited 3.2 km N of Bishop's University (site number 21) and 2.5 km NNW of Johnville (site number 23). The characteristics of each trap-nest site are given in Table 1.

Trap nests were usually examined weekly until 1 October 1980 and any that had been filled were brought back to the laboratory and replaced by an empty trap nest of the same hole diameter.

Vegetation in this part of Quebec is mixed deciduous forest of the Eastern Townships portion of the

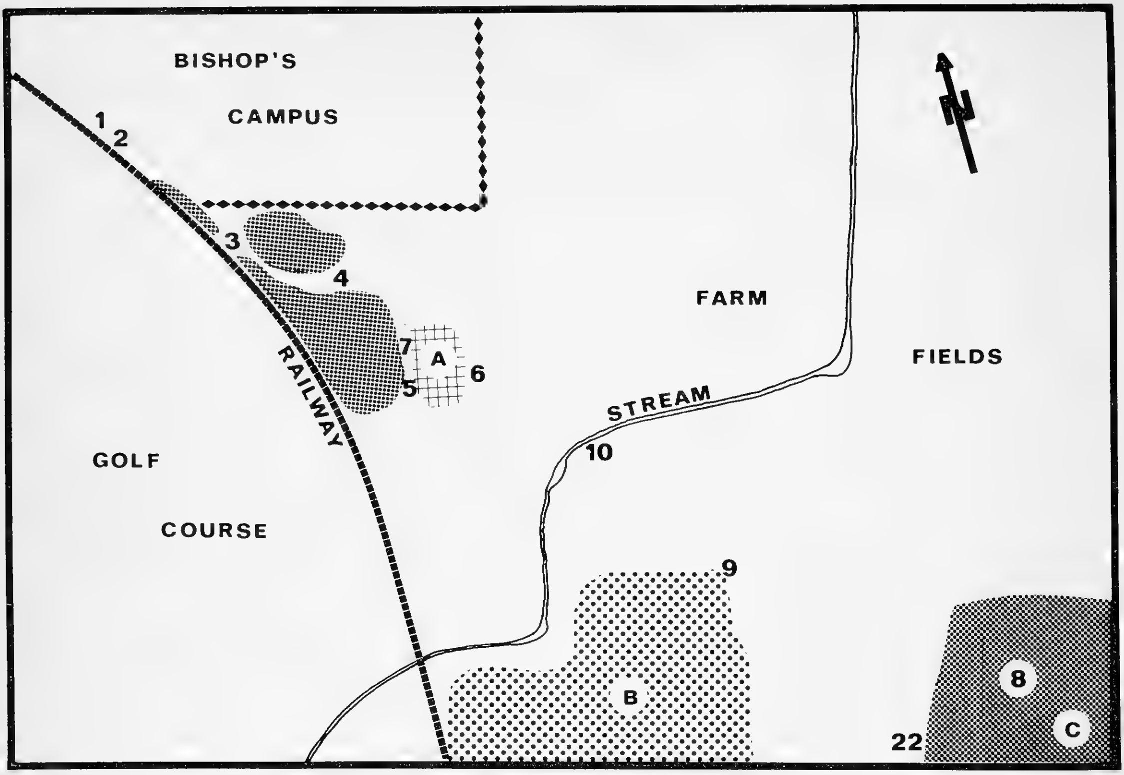

FIGURE 1. Trap-nest sites (numbers) near Bishop's University (45°22′N, 71°51′W). A: refuse dump; B: Red Pine stand; C: mixed deciduous woods. Not to scale.

Great Lakes – St. Lawrence Forest Region (Rowe 1972). Habitats similar to the boreal forest occur locally within the otherwise deciduous hardwood forests, particularly where impeded drainage has contributed towards the formation of Black Spruce-sphagnum (*Picea mariana-Sphagnum* spp.) bogs. The Johnville site (Figure 2) is one such location and its physiography and vegetation are described by Bowers (1966) and Palmer (1970). The vegetation of both localities has been much altered by agriculture, lumbering, buildings, highways, and railways.

Results and Discussion

Cells were not constructed in trap nests with hole diameters of 3.2 or 16 mm. Diameters of 6.4 mm were most preferred as nesting cavities, followed by 4.8 and 12.7 mm (Table 2). These preferences probably reflect the insect's size, type of cell constructed and kinds of materials employed.

A. Eumeninae (Vespidae)

1. *Ancistrocerus a. antilope*

Fourteen of 48 trap nests were occupied by this species (Table 3). Male cells were slightly (not significantly) smaller than female cells (Table 5) and considerably more female than male cells were constructed in each trap nest (4.8 mm, 10F:2M; 6.4 mm, 19F-12M; 12.7 mm, 10F:2M).

Observations on egg laying, cell construction, larval feeding and adult emergence agree with the detailed life-history information provided by Cooper (1953) and Krombein (1967).

Prey consisted of larval Olethreutidae and Pyralidae (Lepidoptera). It is possible larvae from other families were used but we could not determine this since it was impracticable to remove all larvae and send them for identification. Furthermore, by the time some cells were opened the prey had been consumed and any remains were unrecognizable. Generally, prey larvae in each cell were similar (species? genus?) and mixtures of families were rare. Female cells contained seven-eight prey larvae while male cells had only four-five. This reflects the greater nutritional requirements of developing females and must mean the adult female recognizes, and differentially provisions, cells in which she had laid either female or male eggs.

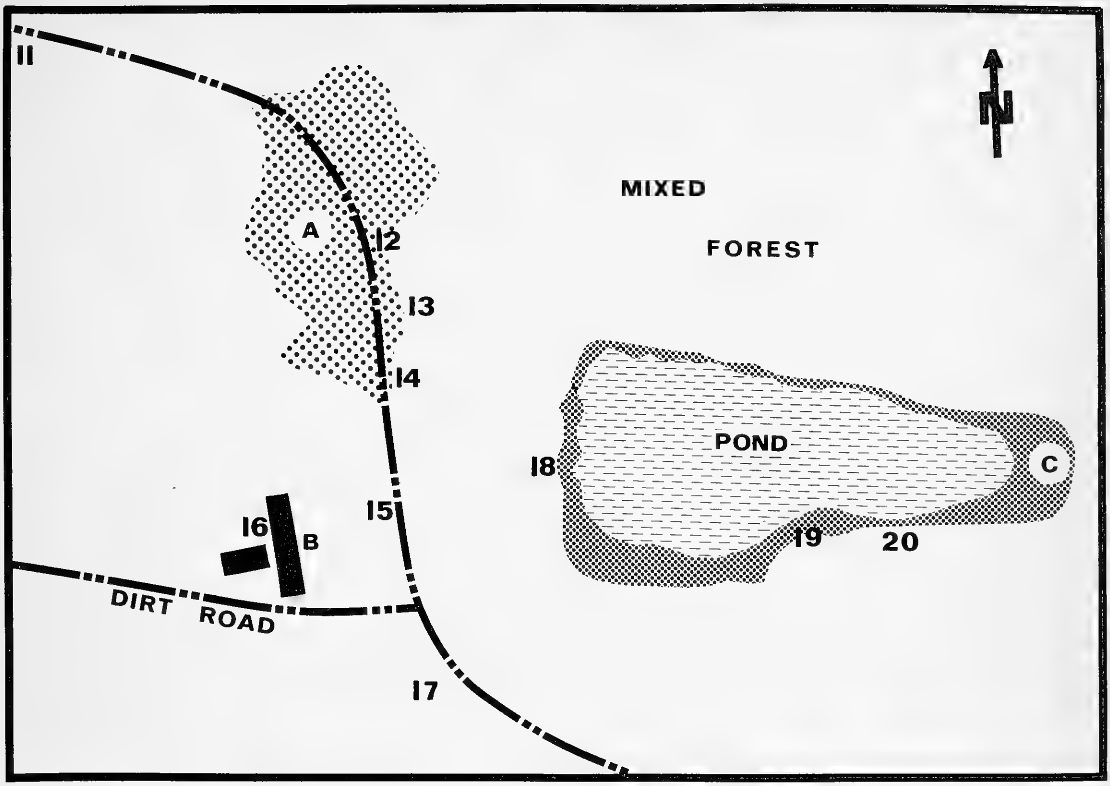

FIGURE 2. Trap-nest sites (numbers) at a bog habitat near Johnville (45°20′N, 71°45′W). A: gravel and sand pit; B: water sheds in forest clearing: G: sphagnum moss and ericaceous shrubs. Not to scale.

The ectoparasitic mite *Kennethiella trisetosa* (Saproglyphidae) occurred on wasps from 2/14 trap nests (site numbers 18 and 19). This mite's life history is intimately connected with its host's life cycle, and includes venereal transmission from male to female wasps (Cooper 1955).

One trap nest (site number 18) also contained an *Exeristes comstockii* larva (Ichneumonidae) in the second cell of a three-celled nest. This wasp killed the larval *A. a. antilope*, consumed the provisions and, after reaching adulthood, chewed its way through the mud partitions to emerge. *Macrocentrus nigridorsis, Meteorus* sp. and *Microtypus* sp. (Braconidae) were each reared from single trap nests. These wasps are solitary endoparasitoids of Lepidoptera larvae and presumably were already present as eggs or young larvae in the prey used as cell provisions. Upon reaching adulthood, these braconids were unable to chew their way through the cell partitions and thus perished since *A. a antilope* was not ready to emerge.

Two trap nests (site numbers 18 and 22) each contained one *Eumea (= Aplomya) caesar* (Tachinidae). Following emergence from their puparia, both these individuals died imprisoned in the host cell. One was in the innermost of three cells and the other was in the middle of three cells. *E. caesar* is transcontinental in distribution and has been reared from the larvae and pupae of various species of Arctiidae, Gracillariidae, Lymantriidae, Noctuidae, Olethreutidae, Pyralidae and Tortricidae (Arnaud 1978). It seems likely that *E. caesar* is a solitary endoparasitoid of certain Lepidoptera larvae used as provisions by *Ancistrocerus a. antilope*.

2. *Ancistrocerus c. catskill*

Twenty of 48 trap nests were occupied by this species (Table 4). Cell structure and egg placement appear to be similar to that described for *A. a. antilope* (Cooper 1953; Krombein 1967). However, female cells were significantly larger than male cells (Table 5) and twice as many female cells as male cells (29F:14M) were constructed in trap nests with a boring diameter of 4.8 mm whereas the reverse occurred in trap nests with a 6.4 mm diameter (17F:32M). Male and female

TABLE 1. Characteristics of trap-nest sites, number of trap nests occupied, and number of provisioned cells constructed at each site.

				Insects utilizing trap nests							
				Ancistrocerus				*Megachile*		*Symmorphus*	
Site No.	Location	Height (cm)	Aspect	*antilope*	*catskill*	*Auplopus*	*Dipogon*	*inermis*	*mendica*	*albomarginatus*	*cristatus*
1	fence	89	open	0	0	0	0	0	0	0	0
2	building	203	open	0	1(10)	0	0	0	0	0	1(4)
3	fence	81	open	0	0	0	0	0	0	0	0
4	stump	38	open	0	1(6)	0	0	0	0	0	0
5	fence	109	open	0	2(7)	0	0	0	0	0	0
6	log	58	open	1(7)[b]	5(18)	0	0	0	0	1(6)	0
7	tree	51+150[a]	shade	0	0	0	0	0	0	0	0
8	stump	102	shade	0	0	0	0	0	0	0	0
9	tree	132+406	open	0	1(6)	0	2(15)	0	0	0	0
10	shrub	51	open	0	0	0	0	0	0	0	0
11	tree	216	shade	0	0	0	0	0	0	0	2(9)
12	log	5	open	0	2(4)	0	0	0	0	0	0
13	tree	153+330	open	0	0	0	0	0	0	0	0
14	log	5	open	1(4)	1(2)	0	0	2(7)	0	1(4)	0
15	tree	114	shade	0	1(11)	1(9)	0	0	0	0	0
16	building	140	shade	0	3(23)	0	0	0	1(6)	0	2(9)
17	tree	170	shade	0	0	0	0	0	0	0	0
18	tree	140	open	6(20)	0	0	0	0	0	0	0
19	tree	107	open	3(14)	3(16)	0	0	0	0	0	0
20	tree	198	shade	0	0	0	0	0	0	0	0
21	building	153	open	0	0	0	0	0	0	0	1(3)
22	tree	119	shade	3(12)	0	0	0	0	0	0	0
23	fence	61	open	0	0	0	0	0	0	0	0
Total				14(57)	20(103)	1(9)	2(15)	2(7)	1(6)	2(10)	6(25)
Mean no. cells/trap nest				4.1	5.1	9	7.5	3.5	6	5	4.2

[a] Two sets of trap nests.

[b] Number of trap nests occupied (total number of provisioned cells).

TABLE 2. Preferences for trap-nest hole diameters.

	Ancistrocerus				*Megachile*		*Symmorphus*	
Diameter (mm)	*antilope*	*catskill*	*Auplopus*	*Dipogon*	*inermis*	*mendica*	*albomarginatus*	*cristatus*
4.8	3/14[a] (21.4%)	9/20 (45%)	0	1/2 (50%)	0	0	0	1/6 (16.7%)
6.4	7/14 (50.0%)	11/20 (55%)	0	1/2 (50%)	0	0	1/2 (50%)	5/6 (83.3%)
12.7	4/14 (28.6%)	0	1/1 (100%)	0	2/2 (100%)	1/1 (100%)	1/2 (50%)	0

[a] Number of trap nests of this hole diameter occupied/total number trap nests occupied by this species.

TABLE 3. Nest characteristics[a] of *Ancistrocerus a. antilope*. Measurements in mm.

Trap number	49	38	21	23	27	47	26	48	1	8	9	32	17	18
Site number	6	14	18	18	18	18	18	18	19	19	19	22	22	22
Diameter	6.4	6.4	4.8	6.4	6.4	6.4	12.7	12.7	4.8	4.8	6.4	6.4	12.7	12.7
Empty space length	—[c]	40	32	—	—	12	—	—	—	11	—	—	—	—
Preliminary plug	—	+[d]	+	+	—	—	?	—	—	—	+	—	—	—
Number provisioned cells	7	4	3	4	4	3	4	2	5	4	5	4	3	5
Provisioned cell lengths[b]	12	16	14	26	22	19	?	12	15	20	21	18	10	15
	10	14	15	23	15	16	11	11	15	17	21	15	10	14
	11	19	15	19	22	13	13		15	17	20	13	9	13
	13	19		15	19		14		13	17	14	24		15
	9								12		17			14
	12													
	8													
Provisioned cell partition thickness	1	2	1.5	2	1	1.5	1.5	1	1.5	2	2	2	1.5	1.5
Intercalary cell length	—	—	—	—	—	—	—	11	—	—	—	—	—	—
Vestibular cell length	31	—	41	38	35	52	50	60	60	41	26	47	86	34
Closing plug thickness	9	—	3	4	?	6	3	—	2	4	5	4	2.5	6

[a] Terminology used in Tables 3, 4 and 6 according to Krombein (1967).

[b] Measurements start from the innermost cell.

[c] Absent.

[d] Present.

cells of *A. c. catskill* were significantly smaller than those of *A. a. antilope* (Table 5).

Prey provisions in all nests belonged to the Gelechiidae, Olethreutidae and Tortricidae (Lepidoptera). One of the tortricids was identified as *Clepsis clemensiana.*

The only parasite obtained was *Chrysis coerulans* (Chrysididae) from site number 5. Chrysidids are solitary ectoparasites of larval wasps and bees, first eating the host's egg or larva and then the provisions. Krombein (1967) reared *C. coerulans* from *A. c. catskill* in New York as well as from other cavity-nesting eumenine vespids in Florida, Maryland and New York.

Apanteles sp., *Dolichogenidea* sp. and *Meteorus* sp. (Braconidae) were each reared from single trap nests of *A. c. catskill.* Some of the *Apanteles* sp. cocoons were hyperparasitized by *Lysibia mandibularis* (Ichneumonidae). All died imprisoned in the *Ancistrocerus c. catskill* cells.

One trap nest from site number 22 had the contents of 2/4 cells destroyed by larval *Megaselia* sp. (Phoridae), 7 females, and *Oscinella* sp. (Chloropidae), 1 specimen. The individuals of *Megaselia* sp. belong to the *aletiae, iroquiana* and *sphinx* group, "all of which are reported from dead grasshoppers, fungi, nests of yellowjackets and sphecid wasps" (B.V. Peterson [1980] personal communication). Krombein (1967) reared *M. aletiae* from *Podium rupifes, Trypargilum collinum rubrocinctum* and *T. striatum* (Sphecidae) from North Carolina, Maryland and New York, respectively and *Pachyodynerus erynnis* (Vespidae) from Florida. Liston (1979) found nearly 40 cocoons of *Megaselia* sp. in 1/16 *Cimbex femoratus* cocoons collected near East Lothian, U.K. Liston considers the presence of *Megaselia* to be fortuitous and probably the result of a female *Megaselia* mistaking a *C. femoratus* pre-pupa for a moribund larva and therefore ovipositing in it. Further, he doesn't think adult *Megaselia* mouthparts are adequate for chewing their way out of the *C. femoratus* cocoon. In opposition, however, he cites R. H. L. Disney's opinion (in a personal communication) that the phorids were obligate parasitoids of the sawfly and would have emerged successfully. *Oscinella* spp. are often plant pests (Cole 1969) but without knowing the species name for this specimen it is not possible to infer what role it was playing in a cell of *Ancistrocerus c. catskill.*

3. *Symmorphus* spp.

Two and six trap nests were occupied by *S. albomarginatus* and *S. c. cristatus*, respectively (Table 6). These two wasps were similar to *Ancistrocerus* spp. in their biology and nest construction (Krombein 1967). However, in this part of Canada *Symmorphus* spp. appear late in the summer and are univoltine whereas *Ancistrocerus* spp. appear earlier and are bivoltine. This was the case in Fye's (1965a) study. In addition, *Symmorphus* spp. are much more likely to construct

TABLE 4. Nest characteristics of *Ancistrocerus c. catskill*. Measurements in mm.

Trap number	3	11	15	42	16	12	29	30	31	7	40	41	45	2	5	4	10	6	24	25
Site number	2	4	5	5	6	6	6	6	6	9	12	12	14	15	16	16	16	19	19	19
Diameter	6.4	4.8	4.8	4.8	4.8	6.4	6.4	6.4	6.4	6.4	4.8	4.8	4.8	4.8	4.8	6.4	6.4	6.4	6.4	6.4
Empty space length	16	15	27	5	20	—	—	42	—	?	74	40	—	—	—	—	—	—	—	—
Preliminary plug	+[c]	—[b]	—	—	+	+	—	—	—	?	—	—	—	—	+	+	—	—	+	+
No. provisioned cells	9	6	4	3	4	5	2	3	4	6	1	3	2	11	10	8	5	7	3	6
Provisioned cell lengths[a]	10	17	10	15	12	11	14	12	8	?	12	18	?	13	10	10	11	7	16	13
	11	15	12	6	11	15	15	10	8	?		16	12	13	10	10	11	10	19	15
	10	13	12	7	11	11		11	11	?		14		12	10	10	11	8	20	14
	11	17	9		10	11			13	?				10	10	10	10	8		10
	7	10				13				?				11	10	10	11	6		10
	7	12								?				11	9	7		13		12
	7													10	8	10		7		
	7													10	8	10				
	7													10	10					
														9	10					
														10						
Provisioned cell partition thickness	1	1	1	1	2.5	1	1	1.5	0.5	?	3	1.5	1	1	1	1	1.5	1	1.5	1.5
Intercalary cell length	—	—	—	—	—	—	—	—	—	?	—	10	—	—	—	—	—	—	—	—
Vestibular cell length	27	23	22	90	15	62	13	41	84	?	31	23	93	9	23	31	52	62	73	43
Closing plug thickness	7	7	4	—	3	2.5	2	5	1.5	?	7	2.5	3	3	3	4	4	2	2	3

[a] Measurements start from the innermost cell.
[b] Absent.
[c] Present.

TABLE 5. Size differences (in mm) between male (M) and female (F) cells of *Ancistrocerus* spp.

	Ancistrocerus					
	antilope		*catskill*			
	M	F	M	F	*antilope* F : *catskill* F	*antilope* M : *catskill* M
Number of cells	12	33	38	48	—	—
Mean length	15.6	16.0	10.1	11.6	—	—
Range	8-22	10-26	6-16	6-19	—	—
S.D.	4.3	4.1	2.2	2.8	—	—
Student's t	0.3218		2.909		5.387	6.214
Significance level	ns		<0.01		<0.001	<0.001

intercalary cells (Table 6) than are *Ancistrocerus* spp. (Tables 3, 4). Krombein (1967) also noted this phenomenon.

As is typical for *Symmorphus*, both species provisioned their cells with larvae of leaf beetles, *Chrysomela* sp. (Chrysomelidae). These are smaller than the lepidopteran larvae utilized by *Ancistrocerus* spp. and larger numbers are used to provision each cell (for *S. c. cristatus*; mean 19; range 18-26).

One trap nest (site number 16) containing three cells of *S. c. cristatus* had one cell parasitized by *Actia interrupta* (Tachinidae) and another by *Melittobia chalybii* (Eulophidae). As was the case for *Eumea caesar* in the cells of *Ancistrocerus a. antilope*, this individual of *Actia interrupta*, following emergence from its puparium, died trapped in the *Symmorphus c. cristatus* cell. *Actia interrupta* is widespread in North America and has been reared from the larvae and pupae of a wide variety of Geometridae, Notodontidae, Olethreutidae and Tortricidae (Arnaud 1978). It apparently bears the same relationship to *Symmorphus c. cristatus* as *Eumea caesar* does to *Ancistrocerus a. antilope (vide supra). Melittobia chalybii* parasitizes the larvae of social and solitary wasps. Large numbers of individuals of both of the types produced by this dimorphic species were found and we captured 70 from the cell when it was opened but many more escaped. Details of its life cycle are provided by Clausen (1962), Evans and Eberhard (1970) and Spradbery (1973). Krombein (1967) considered it to be "a very serious pest" of the various wasps he was investigating in his trap-nesting studies.

B. Pompilidae

1. *Auplopus caerulescens subcorticalis*

Only one trap nest (diameter 12.7 mm) at site number 15 contained nine cells of this species. Cells are barrel-shaped structures (4-5 × 7 mm) made from fine-grained mud and lie loose within the boring hole in an end-to-top fashion. Cells were not opened for prey analysis but Krombein (1967) states that the ones he examined contained *Clubiona* spp. spiders (Clubionidae). In addition, Evans and Yoshimoto (1962) record the spiders *Anyphaena pectora* (Anyphaenidae), *Phidippus audax* (Salticidae) and *Trachelas tranquillus* (Clubionidae) as prey being carried by the adult wasp. However, they were never able to find any provisioned cells of *Auplopus caerulescens subcorticalis*.

2. *Dipogon s. sayi*

Two trap nests, both from site number 9, contained seven and five cells of this species (Table 6). Nest and cell construction were similar to that reported by Evans and Yoshimoto (1962), Fye (1965a) and Krombein (1967). These trap nests were tied to the trunk of a Red Pine (*Pinus resinosa*) on the edge of a *P. resinosa* stand. Female *D. s. sayi* apparently foraged for nest materials in the immediate vicinity since the cell partitions were made up of hundreds of tiny pieces of wood and bark of *P. resinosa*, seeds (unidentified) and bits of lichens (*Cladonia* sp. and *Parmelia sulcata*).

Cells were provisioned with crab spiders (Thomisidae). This agrees with Evans and Yoshimoto (1962), Fye (1965a) and Krombein (1967) who say that Tho-

TABLE 6. Nest characteristics of *Dipogon s. sayi, Symmorphus albomarginatus* and *S. c. cristatus*.

	Dipogon s. sayi		*Symmorphus albomarginatus*		*Symmorphus c. cristatus*					
Trap number	33	52	50	46	36	54	53	37	56	19
Site number	9	9	6	14	2	11	11	16	16	21
Diameter	4.8	6.4	6.4	12.7	6.4	4.8	6.4	6.4	6.4	6.4
Empty space length	—[b]	—	—	—	—	14	—	—	—	—
Preliminary plug	—	—	—	+[c]	—	—	+	+	+	—
No. provisioned cells	7	5	6	4	4	5	4	6	3	3
Provisioned cell lengths[a]	9	6	11	11	12	8	10	10	13	9
	13	13	12	10	9	10	11	10	20	9
	13	5	10	11	11	11	22	12	15	10
	9	8	11	15	12	11	27	10		
	7	3	12			15		9		
	4		11					7.5		
	6									
Provisioned cell partition thickness	7.5	5	?	1	1.5	1	1	1.5	1.5	1
Intercalary cell length	—	—	—	—	3	—	7.5	1	20	4
Vestibular cell length	—	4	50	65	46	52	33	36	34	—
Closing plug thickness	23	15	—	9	18	6	6	5	3	—

[a] Measurements start from the innermost cell.

[b] Absent.

[c] Present.

misidae, especially *Xysticus*, are the typical prey utilized.

C. Megachilidae

1. *Megachile* spp.

M. inermis and *M. mendica* occupied two and one trap nests, respectively (diameters of 12.7 mm), at sites number 14 and 16 (Table 1). Nest architecture of these leaf-cutter bees is similar to that described by Fye (1965b) and Krombein (1967). Seven cells of *M. inermis* had a mean length of 11 mm (range 10-12 mm) and each was constructed from about 25 pieces of what were probably the leaves of Broadleaf Spirea (*Spirea latifolia*). Circular pieces (diameter approximately 10 mm) were used for the ends and oblong pieces (approximately 11 × 20 mm) for the walls. Leaf fragments composing the cells of *M. mendica* were packed in such a way as to make it extremely difficult to separate them for measurement and species determination.

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Fungus Fairy Rings in Soil: Etiology and Chemical Ecology

JOHN I. TOOHEY[1]

Queen's University Biological Station, Elgin, Ontario
[1]Present address: Department of Medicine, University of California at Los Angeles, Los Angeles, California 90024

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Thirty species of fungal sporophores were identified in association with fungus fairy rings on abandoned farm land in a 100 square km study area in the Rideau Lakes Region of Ontario. The rings were characterized with respect to their effects on herbacious vegetation and their rates of expansion. The vegetation was killed, stimulated, or unaffected by the various fungi. Stimulated vegetation appeared to be associated only with fungi which were growing saprophytically whereas killed or unaffected vegetation was associated with either saprophytic or mycorrhizal fungi. The rings reveal two interesting features of soil ecology. Firstly, they demonstrate the dramatic effects that soil fungi can have on herbacious vegetation. Secondly, they indicate that basidiomycete spores give rise to new mycelial colonies in soil at an extremely low rate. Possible mechanisms by which certain fungi affect plant growth are discussed.

Key Words: Fairy rings, fungus rings, soil ecology.

Ring-shaped patterns of altered vegetation in meadows and lawns have been recorded since antiquity. Early references to the phenomenon attributed it to supernatural causes, giving rise to terms such as "fairy rings", "hexenringe", or "cercles magique". Withering (1796) was the first to associate these rings with soil fungi and *Marasmius oreades* was the first fungus so associated. In 1917, Shantz and Piemeisel published a comprehensive treatise on the phenomenon, in which they reviewed the mythology associated with rings, the species reported to cause rings, and their own observations on rings in Colorado. They recognized three types of rings based on the effects produced on the herbacious vegetation: Type I, vegetation killed; Type II, vegetation stimulated; and Type III, no effect on vegetation. They compiled a list of 56 species of fungi reported to cause rings up to that time. More recent reports bring to 127 the number of fungus species reported in association with rings. (A complete list of species, compiled in June, 1981, is available from the Depository of Unpublished Data, CISTI, National Research Council of Canada, Ottawa, Canada, K1A 0S2). In this report, observations on fungus rings in Eastern Ontario are reported. These observations are a sequel to an earlier study on the chemistry of Type I rings, then called "barren rings" (Toohey, et al. 1965a, 1965b).

Methods

The study was carried out in an area of about 100 square km in the vicinity of Queen's University Biological Station at Chaffey's Lock, Ontario. The topography of the region is one of glaciated granite and limestone outcroppings interspersed with relatively flat areas of lacustrine-deposited clay soil. The latter areas with sufficient natural drainage were cleared for farming about 160 years ago and most were abandoned 30 to 60 years ago. Some fields have been unused and have regenerated a young forest; other fields have been used for grazing cattle and have remained as open fields. The herbacious plants in the fields were predominantly grasses, *Phleum pratense, Danthonia spicata, Poa compressa,* or *Poa pratensis;* or the sedge, *Carex pennsylvanica.* Other commonly occurring plants were *Trifolium pratense, T. agrarium, Chrysanthemum leucanthemum, Hieracium florentinum, Ranunculus acris, Echium vulgare, Potentilla recta*, and *Taraxacum offinale*.

Each field was examined for rings by walking through it at different seasons. Rings were identified by altered vegetation and/or by the presence of fungus sporophores. Wooden stakes were placed at the outer edge of the affected band of each ring. Each subsequent year in September or October, new stakes were placed at the advancing edge of the band and measurements of yearly expansion were made at that time. The width of the affected band and the annual increase in radius are reported as averages for all rings of a given species over all the years of observation. The study was begun in 1961 but the rings have been under study for variable periods of time, since many rings have disappeared and new rings were found each year. Sporophores were collected when they first occurred, tentatively identified, preserved by drying, and forwarded to the Mycology Section, Biosystematics Research Institute, Department of Agriculture, Ottawa, for confirmation of identity. The specimens are in the permanent collection of the National Mycological Herbarium (DAOM).

In addition to the systematic study described above, casual observations were made on an exceptional aggregation of rings located on Centre Island of the Toronto Island Parks, Toronto, Ontario. The lawn on which these rings occurred was created in 1960 by dredging sand from Lake Ontario to fill a marsh, followed by seeding with lawn grass seed.

The classification system of Shantz and Piemeisel, based on effect on vegetation, was used with some modification. Each type was dichotomized on the basis of whether or not sporophores were observed on the rings, indicated in the terminology by placing a plus sign (+) or a minus sign (–) after the numeral. Most of the rings of Types I and II were first recognized by the altered vegetation alone, subtype (–), and they were reclassified in subtype (+) in later years when they produced sporophores. A new type, Type 0, was created to accommodate rings in locations where herbacious vegetation was sparse or absent, making it impossible to determine the effect of the fungus on vegetation.

The following definitions apply to terms used in this report to describe patterns of fungus growth in soil. *Band:* a curvilinear area of affected soil or vegetation narrow in one horizontal dimension and long in the other horizontal dimension. *Ring:* a regular curved band forming a complete turn of 360° and, therefore, enclosing an area of unaffected soil or vegetation. The term "ring" is frequently used in a generic sense to refer to any growth pattern of this type even though it is not geometrically complete. *Arc:* a segment of a ring.

Results and Discussion

Description of Fungus Rings

159 rings were studied and 30 species of sporophores were identified in association with the rings. Table 1 lists the species according to ring type and describes the characteristics of the rings produced by each species. The production of sporophores was very much dependent on weather conditions and in most years none were produced. On rings of Types I and II, the sporophores were produced at the outer edge of the altered vegetation. Sporophores of ring species were never observed in random distribution in the study area although sporophores of other species did occur randomly in the area.

Type I Rings. On rings of Type I, the vegetation was suppressed. The degree of suppression was not the same for all species and this Type might be subdivided into two subtypes. In subtype *a*, the vegetation was completely killed producing a band 1 to 2 m wide devoid of plants. This effect was produced on rings of Type I+ by *Clavaria vermicularis* and *Helvella connivens* and was seen on many rings of Type I– (Figure 1). The appearance of these rings was not appreciably affected by weather conditions. In subtype *b*, the vegetation was distinctly suppressed in density and vigour but not killed completely. The affected band was 30 to 60 cm wide and all plant species were equally affected. The degree of suppression was dependent on weather conditions, being most conspicuous in dry seasons and less marked in wet seasons. Rings of subtype *b* were produced by *Amanita flavorubescens, Clavaria cinerea, Inocybe lacera, Russula decolorans, R. densifolia,* and *R. aerugina*.

Most of the rings of Type I were located at the edges of fields within 30 m of the trees bordering the fields or, if they occurred in the centre of fields, there was at least one tree within 30 m. This was true for all of the rings of *Amanita flavorubescens, Inocybe lacera, Russula aeruginea, R. decolorans,* and *R. densifolia,* which is consistent with the reported mycrorrhizal nature of these species (Trappe 1962). However, the relationship of the rings to the trees was not clearly defined. Some rings of the *Russula* species occurred as arcs with the open portion of the arcs facing the line of trees, suggesting that they were related to the tree roots. In contrast, other arcs and some complete rings, although near trees, did not show any geometrical relationship to the trees. A similar undefined relationship was reported by Hawksworth (1962) in rings of *Polyporus confluens* occurring under trees of the species *Pinus contorta* and *Picea engelmanii.*

Type II Rings. On the bands of Type II rings, the vegetation was taller, denser, and a darker green than the adjacent vegetation (Figure 2). This effect was dependent on weather conditions: the stimulation was most pronounced in seasons of heavy rainfall and barely perceptible during periods of drought. In this study, six species of fungi were associated with Type II rings (Table 1). In addition to the rings described in the table, a large group of Type II rings was observed on a lawn on Centre Island, Toronto. These included 80 rings of *Marasmius oreades,* 25 rings of *Lycoperdon curtisii,* and 22 rings of *Melanoleuca humile.* They were all of diameters less than 4 m and were less than 21 years old since the lawn was created in 1960.

Rings of Type II occurred in open fields, frequently several hundred m from the nearest tree, and there was no evidence that any of them were related to trees. Six of the eight species observed on stimulated rings are apparently non-mycorrhizal (*Agaricus campestris, Calvatia fragilis, Clitocybe dealbata, C. subconnexa, Lycoperdon curtisii,* and *Melanoleuca humile*). *Marasmius oreades* is said to be mycorrhizal on *Pinus ponderosa* but this tree does not occur in eastern Canada. *Lycoperdon perlatum* is mycorrhizal but many rings observed in this study were clearly unrelated to trees.

The observations of Shantz and Piemeisel on Type

TABLE 1. Description and classification of fungus rings

Type	Effect on vegetation	Sporophores	Species	Number of rings	Location	Predominant ground cover	Current diameter (m)	Average width of band[6] (cm)	Average annual increase in radius (cm/yr)[6]
I+	killed	present	*Amanita flavorubescens*[1] (M)[2]	8	edges of fields, near *Quercus*[4]	*Phleum*	7-10	45	40
			Clavaria cinerea[1]	4	open fields	*Carex*	2-3	25	7
			Clavaria vermicularis[1]	2	open fields	*Danthonia*	6,7	120	25
			Helvella connivens[1]	1	under *Rhus typhina*	*Poa*	15	100	30
			Inocybe lacera[1]	1	edge of field, near *Betula*	*Danthonia*	13	45	30
			Russula aeruginea[1] (M)	4	edges of fields, near *Populus*	*Danthonia*	2-3	25	20
			Russula decolorans[1,3] *(M)*	2	edges of fields, near *Ostrya*	*Phleum*	15,20	23	32
			Russula densifolia[1] (M)	24	edges of fields, near *Populus*	*Phleum*	2-20	60	20
II+	stimulated	present	*Agaricus campestris*	4	open fields	*Phleum*	3-7	30	20
			Calvatia fragilis	9	open fields	*Phleum*	5-8	32	45
			Clitocybe dealbata	4	open fields	*Phleum*	2-3	13	20
			Clitocybe subconnexa[1]	3	open fields	*Carex, Poa*	5-15	90	75
			Lycoperdon perlatum (M)	3	open fields	*Phleum*	5-8	45	60
			Marasmius oreades (M)	21	open fields	*Phleum*	2-10	20	35
III+	no effect	present	*Cortinarius sp.*	2	edge of field, near *Betula*	*Danthonia*	4,6		22
			Hygrophorus niveus	6	open fields	*Phleum*	2-3		15
			Lyophyllum immundum[1] (M)	3	open fields	*Phleum*	5-6		20
			Paxillus involutus (M)	2	edges of fields, near *Populus*	*Phleum*	12,15		10
			Tricholoma terreum (M)	1	edge of field, near *Thuja*	*Danthonia*	5		25
O	undetermined	present	*Agaricus xanthodermus*[1]	1	under *Ulmus americana*[5]	leaf litter	4		60
			Amanita muscaria (M)	4	under *Quercus rubra*	leaf litter	7-9		24
			Cantharellus cibarius (M)	1	under *Acer saccharum*	leaf litter	8		10
			Cortinarius sp.	1	under *Pinus resinosa*	leaf litter	15		19
			Helvella crispa[1] (M)	1	under *Pinus resinosa*	leaf litter	1		n.d.[7]
			Hygrophorus russula[1] (M)	8	under *Quercus rubra*	leaf litter	8-12		32
			Lactarius resimus[1] (M)	1	under *Tsuga canadensis*	leaf litter	5		n.d.
			Leucopaxillus giganteus[1]	1	under *Acer saccharum*	leaf litter	40		n.d.
			Russula aurantiolutea[1]	1	under *Pinus resinosa*	leaf litter	2		n.d.
			Suillus granulatus[1] (M)	2	under *Pinus strobus*	leaf litter	5,10		30
			Tricholoma irinum (M)	11	under *Quercus rubra*	leaf litter	2-9		60
I–	killed	absent	unknown	20	open fields, edges of fields	*Phleum*	2-23	20-120	20-30
II–	stimulated	absent	unknown	2	open fields	*Phleum*	10,12	30	22

[1] Species not previously reported in association with rings.

[2] (M) after a species name indicates that the species has been reported to be mycorrhizal (Trappe 1962).

[3] Fruiting bodies on both rings were heavily parasitized by the basidiomycete, *Asterophora lycoperdoides*.

[4] "Edge of field" indicates that the centres of the rings were within 30 m of the trees bordering the field. Since the trees were of several genera, only the nearest or the predominant genus is named.

[5] The forests under which Type 0 rings occurred were of mixed tree species, only the nearest or predominant species is named.

[6] The variation was less than 15% above or below the average.

[7] Not determined.

FIGURE 1. A segment of a ring of Type Ia–, photographed June 1, 1964. The diameter of the ring was 9.1 m and the band of killed vegetation was 1.5 m wide. The grass in the normal area on the left was *Phleum pratense*. The upright stakes marked the inner and outer edges of the previous year's growth. The soil in this zone was littered with dead stems of the grass.

II rings were quite similar to those described above. They observed the following fungus species on Type II rings: *Agaricus campestris, A. tabularis, Calvatia cyathiformis, C. fragilis, C. polygonia, Catastoma subterraneum, Lycoperdon curtisii, L. perlatum, Marasmius oreades,* and *Melanoleuca melaleuca.* The first seven of these are non-mycorrhizal and the last three are mycorrhizal. However, their study was carried out in agricultural land in Eastern Colorado and, although not specifically mentioned in their report, it is unlikely that any trees were present. Therefore, it appears that stimulated rings are associated only with fungi which are growing saprophytically.

Type III and Type 0 Rings. Rings of Type III showed no effect on herbacious vegetation and were recognized only by the ring of sporophores (Figure 3). Five fungus species were associated with rings of Type III (Table 1). Eleven species produced rings of sporophores under a canopy of trees where herbacious vegetation was sparse or absent and the ground cover consisted of leaf litter (Table 1). Since it was impossible to determine the effect of these fungi on vegetation, they are grouped separately in Type 0. With the exception of *Hygrophorus niveus,* all of the rings of Type III and Type 0 occurred under trees or near trees and most of the associated fungi have been reported to be mycorrhizal.

Origin of Fungus Rings

Fungus rings occur classically in man-made meadows such as lawns, pastures, parks, or golf courses. The abandoned fields in this study are similar to these classical sites. In all of the sites where rings occur, the soil has been cultivated and then left undisturbed for many years. The cultivation, with its attendant disruption, aeration, and drying, apparently alters the endogenous microbial flora in such a way that newly-established colonies of certain fungi grow symmetrically, much like colonies grow on sterile artificial medium. In this study, three rings of Type I were followed from an early stage. They first appeared as small complete circles of killed vegetation. As they expanded past a 2 m diameter, the centres regenerated

FIGURE 2. A ring of Type II with sporophores of *Marasmius oreades*, photographed in June, 1968. The diameter of the ring was 2.2 m. The flowers were *Chrysanthemum leucanthemum* and *Ranunculus acris*. The band of vegetation inside the ring of mushrooms was dark green.

new vegetation and the affected areas became bands. One of these rings eventually produced sporophores of *Russula densifolia* and two have remained as Type I–.

A great variety of fungi are capable of producing this phenomenon. Although most of them are basidiomycetes, the ascomycetes are represented by the genera *Helvella, Morchella,* and *Tuber.* Many types of basidiomycetes have been reported on rings including agarics, puffballs, boletes, hydnums, and coral fungi. Rings are produced by both saprophytic and mycorrhizal species. The diversity of types suggests that any fungus species could produce the ring phenomenon if given the right conditions. In fact, it is possible that some of the rings on which sporophores have never been observed are caused by imperfect fungi or other protists which do not form visible sporophores. Moreover, it is likely that rings of Type III- exist (no effect on vegetation, no sporophores). Rings of this type would not be detectable by macroscopic methods.

An interesting feature of fungus rings is the failure of spores produced on the rings to colonize adjacent soil. In suitable years many rings produce over 100 sporophores, each of which releases very large numbers of spores. If these spores were successful in giving rise to new mycelium in adjacent soil, even at a very low frequency, the species would become diffusely distributed. In fact, the distribution remains rigidly confined to the ring-shaped pattern for periods as long as several hundred years (see next section). In this study, satellite rings were not observed around established rings and rings of a given species did not regularly occur in clusters. The failure of the spores to establish new mycelium in adjacent soil may be attributable to a characteristic which Garrett (1963) described as the "low inoculum potential of fungi". According to this concept, a critical quantity of metabolically-active fungal protoplasm must be present for a fungus to invade and colonize new substrate. The ring phenomenon provides evidence that fungal spores achieve the critical energy threshold with extremely low frequency.

Growth and Death of Rings

The average annual increase in radius for rings of

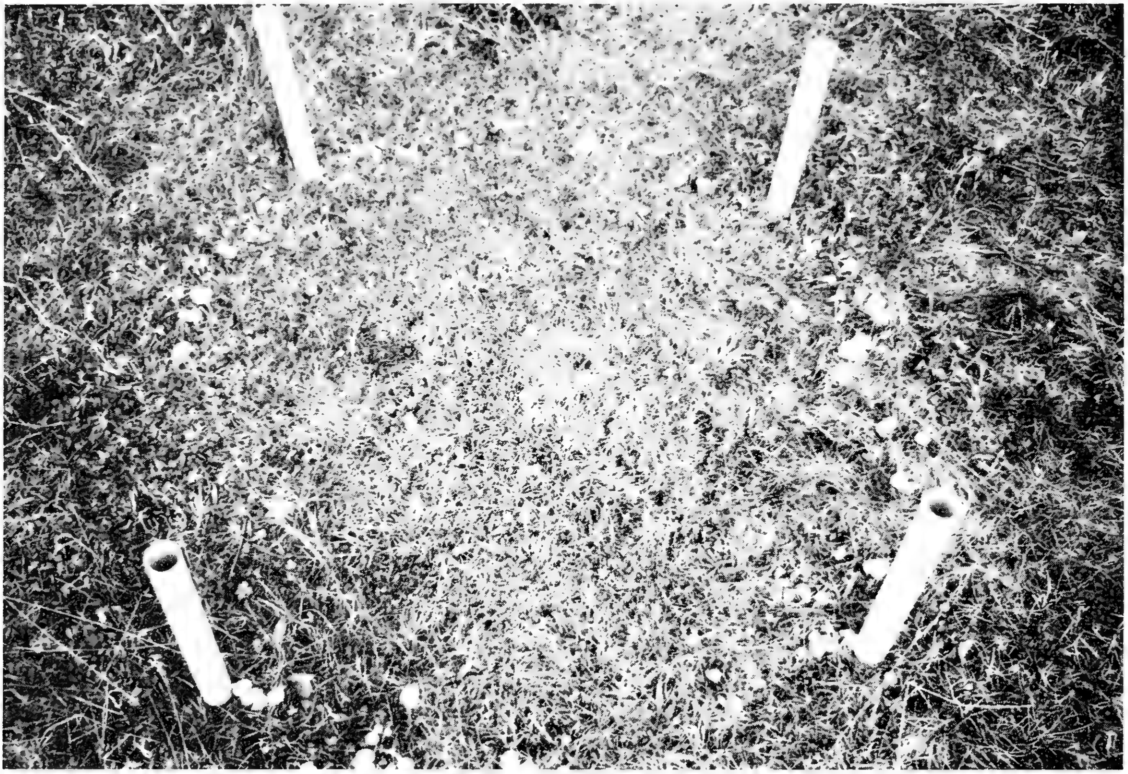

FIGURE 3. A ring of Type III with sporophores of *Hygrophorus niveus*, photographed in October, 1970. The ring was 1.8 m in diameter. Although the lighting appears non-uniform, there was no alteration of the vegetation.

each species is given in Table 1. The expansion rate varied from 7 cm per year for *Clavaria cinerea* to 75 cm per year for *Clitocybe subconnexa*. The expansion rate was characteristic for each species. A variability of ± 15% appeared to be related to the annual rainfall but exact correlations were not made. Based on the diameter of a ring and the expansion rate, the approximate age of the ring can be estimated. Calculated in this way, the oldest ring in this study was a ring of Type I–, which was 75 years old when it disappeared. This calculation has been applied to rings in Colorado, where rings of *Agaricus tabularis* were determined to be 250 years old (Shantz and Piemeisel 1917) and to rings in England where a ring of *Clitocybe geotropa* was determined to be nearly 700 years old (Smith 1957).

In this study, few rings survived past an age of 50 years, and during the study 75 rings disappeared for various reasons. Many rings were killed by grass fires; no ring has ever been observed to revive after being burned over. Other rings disappeared when fields were ploughed. Many rings occurred in fields where forests were regenerating and they disappeared as the ground cover changed from grasses to forest litter. In contrast, some species continued to flourish under a forest cover, most notably *Tricholoma irinum and Hygrophorus russula* (Table 1, Type 0). Many rings were disrupted when they encountered obstacles such as rocks, roadways, or trees, and frequently there was no obvious cause for the disruption. Segments of many rings disappeared without apparent cause, leaving residual arcs: 15 rings disappeared completely in this way.

An interesting feature of fungus rings is the unidirectional outward growth. Reverse (inward) growth does not occur and sporophores are usually produced only on the outer edge of the band. In the absence of specific data, it is possible only to speculate on the reason for the unidirectional growth of the mycelium. The two most obvious explanations are that the mycelium depletes essential nutrients in the soil or that autotoxic chemicals are released.

In rings with altered vegetation, there is a return to normal vegetation on the trailing edge of the band as the ring expands. In rings with suppressed vegetation, the return to normal involves a specialized plant succession which varies somewhat from site to site. A description of the succession which occurred in one location has been published (Toohey *et al.* 1965a). In rings with stimulated vegetation, the return to normal is simply a decrease in the green coloration and vigour of the plants.

Chemical Ecology of Fungus Rings

The fungus ring phenomenon demonstrates the dramatic effects that soil fungi can have on herbaceous vegetation. The chemical mechanisms of these effects are not completely understood at present. The mechanism by which plants are killed on rings of Type I has been partially elucidated. From the soil of these rings a phenazine carboxylic acid-producing strain of *Pseudomonas aureofaciens* has been isolated, while in the adjacent non-ring soil the same bacterium occurred as a non-phenzine-producing variant (Toohey *et al.* 1965a). The phenazine carboxylic acids have herbicidal properties (Toohey *et al.* 1965c). When the phenazine carboxylic acid-producing strain of the bacterium was maintained *in vitro,* it slowly reverted to the non-producing type (Toohey *et al.* 1965a). These findings suggest that the bacterium, which is ubiquitous in soil, is induced to synthesize the herbicidal compounds when it is growing in association with the fungal mycelium in the soil of Type I rings. The testing of this hypothesis *in vitro* has been impeded by the inability to obtain pure cultures of the appropriate fungi. Numerous attempts to obtain cultures from the spores or from sporophore tissue have been unsuccessful.

The plants on Type II rings have the features of increased nitrogen availability. The concentration of ammonia and nitrate in the soil of these rings has been reported to be higher than that in adjacent soil (Bayliss-Elliot 1926; Smith 1957; Shantz and Piemeisel 1917) and it has been speculated that the fungus mycelium accelerates the decomposition of organic matter in the soil, making the nitrogen available (loc. cit.). This hypothesis is supported by the finding discussed above that Type II rings are associated with saprophytic fungi. However, an alternative hypothesis involving enhanced nitrogen fixation must be considered. Although no fungus has been found to have the ability to fix atmospheric nitrogen, the mycelium of several species of fungi has been shown to enhance N_2 fixation by nitrogen-fixing bacteria when the two were grown in mixed culture (reviewed by Jensen and Holm 1975). This phenomenon has been well documented in pure cultures under laboratory conditions, but its significance under natural conditions has not been tested. It is possible that the association of specific fungi with nitrogen-fixing bacteria or blue-green algae in the soil of Type II rings results in enhanced nitrogen fixation. This hypothesis might be tested in vitro if pure cultures of Type II ring fungi were available. Attempts to obtain such cultures have been unsuccessful.

Fungus fairy rings provide circumscribed examples of the pronounced effects which soil fungi can have on herbacious vegetation. It is likely that similar effects occur under less well-defined conditions resulting in generalized suppression or stimulation of plant growth over large areas. An understanding of the mechanisms by which specific fungi affect plant growth could have relevance to practical agronomy. Thus, the fungal flora of soils might be intentionally altered to increase or suppress the growth of herbacious plants.

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Island Biogeography of Seed Plants in Lake Nipigon, Ontario

KEVIN P. TIMONEY

Department of Botany, University of Wisconsin, Madison, WI. 53706
Present Address: Department of Botany, University of Alberta, Edmonton, Alberta T6G 2E9

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Islands supporting boreal forest in Lake Nipigon, Ontario, were sampled for presence of angiosperms and gymnosperms by a timed random walk of constant duration. Sample islands were manifestly different only in size (1.5-13.5 ha) and distance to mainland (1.0-10.5 km). Island species richness was correlated positively with area and negatively with distance. A new isolation index is proposed and shown to be a reliable predictor of island species number. It is suggested that propagules of many plant species on Lake Nipigon decrease in density as 1/distance^2 from a source, and that the total number of propagules produced by a source is directly proportional to the source area. The observed species-distance relation suggests that small distances may have a significant effect on island species number. Near islands are populated by equal numbers of animal and wind-water dispersed plant species. Distant islands are characterized by a predominance of wind-water dispersed plants.

Key Words: Angiosperms, dispersal, distance, gymnosperms, island biogeography, isolation, Lake Nipigon, Ontario, species-area relation.

At what distance does an island's isolation begin to affect higher plant species richness, and how does area *per se* affect species richness? Do islands that differ in area or isolation also differ in their types of propagule dispersal?

Much research has been done on oceanic and habitat islands, and most of that work has centered on the fauna. Continental lake islands have received little attention (c.f. McNeill and Cody 1978). Recent work indicates that higher plant species richness may be affected by isolation no greater than 1.5-10 km (Nip-van der Voort et al. 1979; Crowe 1979; Linhart 1980).

The islands in Lake Nipigon, probably 8,500 to 9,500 years old (Bryson et al. 1969), are most likely near species equilibrium. The lake's islands, of varying size and isolation, provide a test of the effects of short distances, and area, on seed plant species richness. Islands were selected stringently for habitat homogeneity, and recent disturbance by fire, humans, or windstorms resulted in rejection of an island. By sampling islands equal amounts of time, the likelihood of encountering more habitats on larger islands was minimized. The more thorough sampling of small islands provided a rigorous test of the effects of island area on species richness.

The purpose of this study was to find out if distance and area are significantly related to the species richness of seed plants on boreal forest islands.

Description of the Study Area Lake

Lake Nipigon lies about 60 km north of Lake Superior in the Thunder Bay District of NW Ontario. The lake's approximate geographic center is 88° 30′W, 49° 52′N. Nipigon is nearly elliptic in outline, measuring 100 km long by 55 km wide, or about 4300 km^2 (Figure 1). Average lake level is 263 m ASL (Ontario Dept. of Lands and Forests 1965).

The lake lies within the Precambrian Shield (Zoltai 1965). Most of the islands and mainland are underlain by Late to Middle Precambrian diabase and related

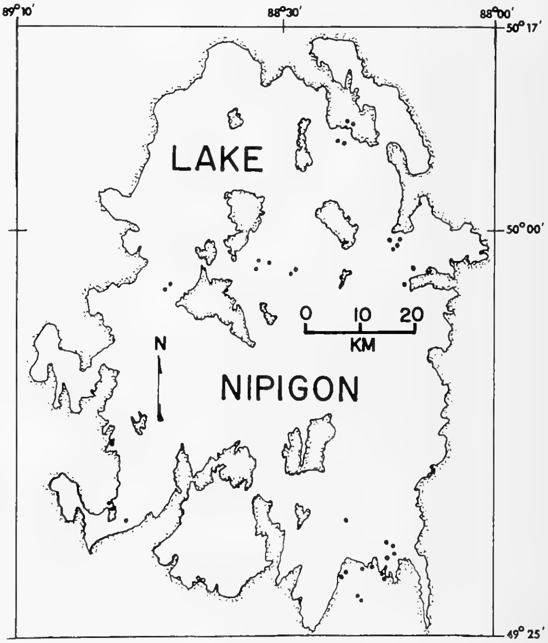

FIGURE 1. Lake Nipigon, NW Ontario, Canada. Sample sites appear as dots.

TABLE 1. Forest vegetation dominants of the sample sites.

	Dominants	Sub-dominants
Trees	*Abies balsamea* *Betula papyrifera*	*Picea mariana* *Picea glauca* *Thuja occidentalis* *Populus tremuloides* *Populus balsamifera*
Shrubs and Small Trees	Saplings of *A. balsamea* and *B. payrifera* *Rubus idaeus* *Alnus crispa* *Sambucus racemosa* *Ribes glandulosum*	*Sorbus decora* *Cornus stolonifera* *Taxus canadensis* *Alnus rugosa* *Salix humilis* *Salix phylicifolia*
Ground Layer	Seedlings of *A balsamea and B. papyrifera* *Linnaea borealis* *Trientalis borealis* *Cornus canadensis* *Moneses uniflora*	*Aralia nudicaulis* *Mitella nuda* *Pyrola secunda* *Rubus pubescens* *Fragaria vesca*

mafic igneous rocks (Ontario Geological Survey 1980). Numerous other bedrock types occur, but no sample sites were located outside the mafic igneous zone. Island and mainland sites (Figure 1) were chosen using the following criteria: homogeneous dominant tree vegetation of *Abies balsamea* (Balsam Fir) and *Betula papyrifera* (White Birch) with *Picea glauca* (White Spruce) and *Picea mariana* (Black Spruce) (Table 1; also see Cooper 1913); island size between 1.5 and 15 ha; absence of swamps, meadows, heaths, jack pine forest, and disturbance due to fires, humans, and windstorms; average slope not exceeding 25%; maximum elevation not exceeding 30 m. Bedrock outcrops, depressions, and steep areas were avoided. Differences in topography on the sample islands were so small that microclimatic differences were imperceptible. Sample islands thus differed manifestly only in area and isolation.

Silty to sandy till overlies the bedrock on the majority of mainland and island sites. Stratified and nonstratified lacustrine deposits of clay, silt, and sand are associated with the till (Ontario Dept. of Lands and Forests 1965). Till depth varies from zero on exposed bedrock to an average of 2.5 m (Zoltai 1965). The present Lake Nipigon shoreline and lower elevations, once covered by the waters of Glacial Lake Kelvin, are dominated by lacustrine deposits (D. A. Fawcett, pers. comm.). The soils of the area are broadly classed as humoferric podzols, with rockland, eutric brunisols, and gray luvisols in the rocky and stony phase (Agriculture Canada 1977). Thin soils over bedrock are common. Timber use capability, an index of plant growth potential, ranges from good to fair for the sample sites (Ontario Ministry of Natural Resources 1976).

The Lake Nipigon basin is enclosed on the north, east, and west sides by the higher land of the Central Plateau (Rowe 1972). The slope of the land is gradual in the south, with some exceptions (e.g., Nipigon River, Pijitawabik Bay, Tchiatang Bluffs, South Bay, Cook Point). In general, the topography is rolling and the relief slight, rarely exceeding 40 m above lake level. Numerous rivers and creeks drain into the lake from the north, east, and west. At Pipestone Bay in the extreme SE the lake is drained by the Nipigon River which flows into Lake Superior near the town of Nipigon.

Hundreds of islands dot the lake, the vegetated ones ranging in size from a few m^2 to about 10,000 ha (e.g., Kelvin Island). Islands are well distributed throughout the lake, though sparse near the eastern shore. The greatest distance between islands does not exceed 10 km. Typical islands appear in Figure 2.

The larger Glacial Lake Kelvin came to occupy the present Lake Nipigon basin with the retreat of the Laurentide Ice Sheet about 9,000 years B.P. (Zoltai 1965; Bryson 1969). Afterwards, water levels fluctuated due to periodic readvances of glacial ice, vertical crustal uplifts, and erosion of lake outlets (Zoltai 1965). All sample islands are similar in elevation, however, and therefore emerged from the receding lake waters at nearly the same time. Thus, all sample islands are of similar age.

Field Methods

Mainland exposures and islands ranging in size from 1.5 to 13.5 ha were sampled for presence of angiosperms and gymnosperms. Presence was determined during a timed random walk. Islands were divided into four quadrants which delimited NE, NW, SE, and SW exposures. Mainland sites were divided into two exposures and were sampled chiefly to determine the species present for island colonization. Fifteen minutes search time was allotted to each island quadrant and mainland aspect. Total search time on any island was one hour. Islands smaller than 1.5 ha were too small to allow one hour of random search time without sampling ground already covered. I set an upper limit of 15 ha; above 15 ha, much nonsearch time was spent travelling between quadrants.

I wrote a description of each island and mainland site immediately after sampling. The description treated the following: slope, width and nature of shoreline, moisture conditions, dominant species in the overstory, shrub and ground layers, presence of blowdowns, clearings, or depressions, and nature of the forest floor (e.g., whether moss or leaf-covered, prominence of rocks and downed trees). Descriptions

FIGURE 2. Typical islands in Lake Nipigon, June 1979.

were later used in deciding whether a site conformed to the experimental habitat type. The actual time spent on any island was at least 4-5 hours.

During random walks, I often stopped search timing to allow travel time in difficult walking on strand, downed trees, or tangles, and to allow time to record species and notes and to identify and collect plants. When 15 minutes of sampling time expired, sampling ceased until I entered a new quadrant. The walking route was random. Sampling time in deep forest, forest edge, and strand was about proportional to the area of the habitat type in each quadrant. The use of quadrants ensured stratified coverage and provided data on possible exposure effects. Species tallies by quadrant were repetitive for any island indicating that most species present were discovered (e.g., 57% of an island's species number was present in a single quadrant; the ratio of species per quadrant: total island species was unrelated to area; the average number of new species between the third and fourth quadrants equaled 3.6). The sampling method was not meant to be an exhaustive search for all higher plants in a study area; some species undoubtedly were not tallied.

At least 28 species were excluded from the study for one of three reasons. Some species, e.g., most *Carex spp.,* were impossible to identify in vegetative condition. A number of voucher specimens of rare species was misplaced by an unnamed agency; unidentified species in the lost batch were excluded. Ephemeral species, which either faded before or became visible after July 20, were excluded (e.g., *Calypso bulbosa*). I recognized one hundred species, 91 of which occurred in the samples. The limited number of species recorded for the sites can be attributed to: choice of only homogeneous *Abies-Picea-Betula* forest, inexhaustive search method, and exclusion of vegetative graminoids, lost voucher specimens, and ephemerals.

Analytical Methods

Numbers of species per island quadrant, island, mainland exposure, and mainland site were determined from field data. Frequency occurrence of each species for islands, mainland sites, and overall, and dispersal mechanisms are given in Appendix 1.

The area of each island was determined by planimeter from Canada Map Office maps (scale = 1:50000, published 1959, '66, '67, '69). Distance to the mainland was measured from an island's nearest shore to the nearest mainland shore. Islands 10 km^2 or larger were observed to support species numbers essentially identical to the mainland, and thus treated as mainland.

Thornton (1967) pointed out that simple distance to nearest neighbour ignores the contribution of other islands. He proposed that the sum or the average of distances of each island to every other island in an archipelago would provide a better index of isolation (c.f. Power 1972). Power (1972) tested two isolation indices, the latter type taking into account that near islands are more likely to contribute propagules to a recipient than are distant islands. For specified maximum distances he estimated isolation as $I = 1 - \sum_{i=1}^{k} \frac{1}{m}$ where m is in miles, and i's are islands or mainland points. Power follows Darlington (1938) in assuming that propagule density varies inversely as the distance from the source, not inversely as the square of the distance as in this study. His isolation index, moreover, does not take into account the area of each stepping stone.

The effective isolation of an island can be viewed as its distance to the mainland minus the contribution of any stepping stones (i.e., islands closer than the mainland which may contribute propagules), the latter islands effectively shortening the distance to the mainland. The stepping stone factor, S_j, was devised to approximate the effective isolation.

Calculation of S_j involved two variables: the distance in km from the recipient to each stepping stone island (Di), and the area in km² of each stepping stone (A_i) estimated by planimeter. $S_j = \sum_{i=1}^{n} \left(\frac{A_i}{D_i^2}\right)$. The effective isolation in km thus = $I = W(1-K)$, where W is the distance from recipient island to mainland in km, and $K = \left(\frac{1}{S_{max}}\right)(S_j)$, where S_{max} is the maximum observed S_j. K (the correction factor for the effect of stepping stones) ranges between 0 and 1, the least isolated having a K value of 1 and therefore an effective isolation of zero, i.e., located on the mainland.

Four assumptions underlie the stepping stone factor. The first and most questionable assumption is that propagule density decreases inversely as the square of the distance from the source (c.f. Johnson and Raven 1970). Such exponential dispersal may hold for water and air-borne propagules, but uniform dispersal may hold for animal borne propagules (MacArthur and Wilson 1967). Secondly, the number of potential propagules was assumed proportional to the stepping stone area. Thirdly, the maximum distance for inclusion of stepping stones equaled the distance to the mainland, with islands 10 km² and larger considered as mainland. Finally, dispersal was assumed equiprobable in all directions.

Regressions of island species number and independent variables were carried out. An alternate isolation factor using $\frac{1}{D}$ (thus $S_j = \sum_{i=1}^{n} \left(\frac{A_i}{D_i^2}\right)$ in place of $\frac{1}{D^2}$ (Darlington 1938) was regressed upon island species number. The effect of exposure (slope aspect) upon species number was tested by ANOVA. Site summaries appear in Table 2, and regression results in Table 3.

Results

Island species richness was correlated positively with area ($p < 0.01$), $\log_e$ area ($p < 0.05$), and average species richness/quadrant ($p < 0.01$), and negatively correlated with distance ($p < 0.05$) and isolation ($p < 0.05$). The $\log_e$ of island species richness was correlated positively with area ($p < 0.05$) and species richness/quadrant ($p < 0.01$), and negatively correlated with distance ($p < 0.05$) and isolation ($p < 0.05$). Species richness/quadrant was correlated positively with island area ($p < 0.05$).

Isolation, distance, and the $\frac{1}{\text{distance}}$ isolation index were all strongly correlated with each other ($p < 0.01$), and all were unrelated to island area.

Mainland and island exposures had no effect on species richness (ANOVA: mainland F = 1.78, df1 = 2, df2 = 7; island F = 1.25, df1 = 3, df2 = 80).

Species with animal borne propagules were numerous on near islands, whereas wind-water dispersed species outnumbered animal dispersed species on distant islands (distance $p < 0.01$, isolation $p < 0.01$, $\frac{1}{\text{distance}}$ index $p < 0.05$). Dispersal type was unrelated to island area. (Table 3).

Of the 91 plant species which occurred in the samples, 31 were dispersed by wind and/or water, 39 by birds and/or mammals; 18 species used both wind-water and bird-mammal dispersal. The dispersal mechanism of three species could not be determined with certainty. Twenty-one of the 91 plant species found at the sample sites were restricted to islands; 14 species were restricted to the mainland, and nine of these 14 species depended on bird-mammal dispersal.

Discussion

The species richness of seed plants in Lake Nipigon is positively correlated with island area. Area *per se* as expressed through higher immigration rates and lower extinction rates of large islands may help account for the increase in species diversity with area. Immigration rate is not independent of area since large islands provide a larger catchment surface for propagules than small islands (the "sampling effect"; Power 1972). The number of wind-borne propagules landing per unit area should be the same on large and small islands. This constant immigration per unit area implies that more propagules will immigrate to larger islands. Water borne immigration should be more a function of island perimeter than area. Areas being equal, a long thin island with low shoreline would receive more propagules than a circular island with a steep margin. Larger islands also might offer more of any given resource to animals bearing propagules.

Enhancement of immigration to large islands may occur for propagules dispersed by the Woodland Caribou (*Rangifer caribou sylvestris* Richardson) during open water migration on Lake Nipigon. Caribou swim rapidly and well for distances of 5-6 km (Jackson 1961), and local fishermen have observed

TABLE 2. Name, area, $\log_e$ area, total species, $\log_e$ species, species/quadrant, ratio of species/quadrant tog total species, distance, isolation, isolation assuming 1/Distance dispersal, and ratio of wind and water dispersed to bird and mammal dispersed plant species of island and mainland sites. Map coordinates are available upon request.

Island	Area	$\log_e$ area	Total species	$\log_e$ sp.	Sp/quadrant	Sp/quad: total sp.	Distance	Isolation	Isolation, using 1/D	Dispersal eatio
McKee	13.2	2.58	44	3.78	27	0.61	3.1	3.0	2.5	1.06
Gypsy	1.5	0.41	33	3.50	21	0.64	3.4	3.2	2.1	1.00
Pipestone	9.7	2.27	39	3.66	20	0.51	1.5	1.4	0.4	1.54
June	1.5	0.41	34	3.53	19	0.56	1.7	1.2	0.2	1.25
Big Tchiatang	3.3	1.19	24	3.18	12	0.50	1.3	1.3	1.3	0.91
Storm	5.9	1.77	25	3.22	15	0.60	3.7	3.5	0.0	0.67
Lightning	2.8	1.03	31	3.43	17	0.55	3.1	3.0	3.0	1.40
Lone	4.4	1.48	23	3.14	11	0.48	7.2	7.1	2.4	1.38
Little Russell	5.0	1.61	38	3.64	18	0.47	1.0	0.7	0.2	1.14
Middle Tichnor	7.1	1.96	38	3.64	17	0.45	2.0	1.7	1.3	1.31
South McIvor	1.5	0.41	32	3.47	20	0.63	2.0	1.9	1.5	1.00
Middle McIvor	11.7	2.46	52	3.95	29	0.56	1.4	0.0	0.2	1.16
W.S. McIvor	1.5	0.41	24	3.18	13	0.54	1.7	1.4	1.1	1.86
Windy McIvor	5.4	1.69	29	3.37	16	0.55	1.7	1.1	1.0	1.67
Cress	1.6	0.47	31	3.43	21	0.68	2.9	2.9	2.7	1.18
Cove	2.7	0.99	36	3.58	22	0.61	2.2	2.2	1.7	1.64
East August	13.5	2.60	35	3.56	23	0.66	6.5	6.4	5.3	2.00
East Remote	3.8	1.34	28	3.33	17	0.61	9.3	9.2	5.3	1.75
West Remote	6.0	1.79	22	3.09	12	0.55	10.5	10.3	3.3	2.40
West August	12.4	2.52	35	3.56	17	0.49	4.2	4.2	3.8	1.33
South August	4.1	1.41	33	3.50	21	0.64	4.6	4.6	4.0	2.00
Mean	5.6	1.72	33	3.50	19	0.57	3.6	3.3	2.1	1.41
Cook-Col. NE			44		36					
NW					34					
Frenchman's Head NE		MAINLAND	38		33					
NE					30					
Queen Anne Point SE			40		37					
NW					14					
Tchiatang SE			45		36					
NW					29					
Cloud SE			43		29					
Point SE					35					
Mean			42		31					

TABLE 3. Correlation(r) values for dependent and independent variables; regression equations listed for significant correlations, Y = a + bx, 19 d.f. error; r @ p = 0.05 = 0.433, r @ p = 0.01 = 0.549; * significant @ p = 0.05; ** significant @ p = 0.01.

	Area	Log$_e$ area	Total spp.	Log$_e$ spp.	Spp./quad.	Distance	Spp./quad. to total spp.	Isolation	Isolation, using 1/D.	Dispersal Ratio
Area	—	—	0.56** 27.0 + 1.0X	0.52* 3.3 + 0.0X	0.43* 15.7 + 0.5X	-0.13	0.11	0.08	0.19	0.08
Log$_e$ Area		—	0.45* 26.4 + 4.3X	0.40	0.27	-0.27	0.18	0.16	0.16	0.13
Total Species			—	—	0.88** 0.2 + 0.6X	0.03	-0.44* 37.0 – 1.2X	-0.48* 36.9 + 1.3X	-0.19	-0.23
Log$_e$ Species				—	0.88** -46.4 + 18.7X	0.06	-0.46* 3.6 – 0.0X	-0.49* 3.6–0.0X	-0.16	-0.23
Species/Quadrant					—	0.50* 0.4 + 0.0X	-0.29	-0.32	0.02	-0.16
Species/Quadrant Total Species						—	0.19	0.20	0.39	0.07
Distance							—	0.99** -0.3 + 1.0X	0.74** 0.5 + 0.5X	0.56** 1.1 + 0.1X
Isolation								—	0.76** 0.6 + 0.4X	0.55** 1.1 + 0.1X
Isolation, using 1/D.									—	0.54* 1.1 + 0.1X
Dispersal Ratio										—

them swimming between the large Kelvin and Shakespeare Islands, an open water crossing of about 10 km. Caribou require plentiful amounts of lichens and browse for survival; thus, their crossings must be more frequent between large islands.

The results, however, do not indicate a general enhancement of animal borne plant immigration to the larger islands. Island area on Lake Nipigon bears no relation to the type of dispersal used by the plant species. Rather, distance appears to govern dispersal type, with bird- or mammal-dispersed species comprising a smaller percentage of the flora on distant islands than on near islands. The prevailing dispersal type of species on distant islands is wind-water. This is understandable in that animal (i.e., dispersal agent) species richness has been shown to decrease with isolation, whereas wind and water can provide transport subject only to the adaptations of the plant propagule and the decrease in propagule density from the source.

Extinction rates are accepted as inverse to island size, but MacArthur and Wilson (1967) hypothesized that small islands may possess exceptionally high area-independent extinction rates. Whether Lake Nipigon's small islands exhibit the special case of area-independent extinction can only be shown experimentally. Area-independent rates or not, small populations may suffer high extinction rates (Pickett and Thompson 1978). Island populations of many species on Lake Nipigon often comprised only one to a few individuals, e.g., *Calypso bulbosa, Clintonia borealis, Cornus canadensis, Pyrola secunda, P. virens,* and *Viola nephrophylla.*

The significant decrease in plant species richness in Lake Nipigon with increasing isolation and distance may result from lower immigration rates to the distant islands. For many species on Lake Nipigon, the small isolation distances must present little barrier to dispersal. Seeds of Orchidaceae and Pyrolaceae are easily blown hundreds of km (van der Pijl 1969). Yet many species with dust-like seeds are saprophytes (e.g., *Corallorhiza trifida, Monotropa uniflora*), mycophytes, or parasites, and the special substrates they require often limit their distribution. Other windborne seeds are less easily dispersed but also less exacting of habitat. Löve (1963) lists average dispersal limits in km for a variety of species, some genera of which are present on Lake Nipigon: *Fraxinus* (0.03), *Abies* (0.09), *Picea* (0.3), *Betula* (1.6), *Taraxacum* (10) and *Lycopodium* (330). Some widespread species on Lake Nipigon can be dispersed by water in addition to their normal wind dispersal, e.g., *Betula papyrifera, Salix* spp., *Populus tremuloides* and *P. balsamifera* (USDA 1974). During the study I observed thousands of seeds several km from land, such as those of Paper Birch and Balsam Poplar afloat in water, and the comose seeds of Fireweed aloft in air.

Dispersal over ice from December through April must also contribute to immigration rates. For plants with winter-persistent fruits, such as birch and spruce, ice could provide a ready avenue for wind dispersal.

Isolation distances for bird-dispersed propagules, such as *Clintonia borealis* berries dispersed by Ruffed Grouse (Ridley 1930), appear trivial on first inspection. Mere flight of a bird between source and recipient islands, however, need not connote successful dispersal. The bird must first eat the fruit (or the fruit or seed become attached to the bird), the seeds must be viable, remain with the bird during the flight, and later be excreted on the recipient island in the proper habitat. Some herbivores, such as White-throated Sparrows, were very active overwater fliers, but others, such as Ruffed Grouse, appeared sedentary. Successful bird dispersal, as with any dispersal, is only one factor determining a plant's distribution; the propagule must establish itself and persist until other successful introductions.

The above discussion emphasizes the roles of area *per se* and the sampling effect in determining island species number. Other explanations exist, such as habitat diversity. Though sample time was held constant over all island sizes, a greater variety of microhabitats may have been encountered on large islands simply because large islands can contain more habitats than small islands. Although no between-island habitat differences were evident, the importance of habitat must not be overlooked. Koopman (1958) has shown that the critical factor in determining the bat species number of southern Caribbean islands is not area or isolation but vegetation. Rate of establishment is a function of the number of sites suitable for germination (Harper 1965) and the rate of immigration. On many islands in Lake Nipigon, mesic herbs are restricted to forest edge. Establishment and persistence in the moss, acidic humus, and nutrient-poor soil may be enhanced in the brighter light of the forest edge.

Competition from mosses may play a role in determining seed plant species richness on islands in Lake Nipigon. Data and observations on the frequency of forest herbs, shrubs, and seedlings in the cushion moss mats (dominated by *Dicranum fuscescens* Turn., *D. rugosum* (Hoffm.) Brid., *Hylocomium splendens* (Hedw.) BSG, and *Pleurozium schreberi* (Brid.) Mitt.) of Nipigon's islands indicate that common higher plants are able to grow in the moss mats. Whether occasional and rare species on Lake Nipigon owe their scarcity in part to moss competition can only be answered by more detailed study. Moss-seed plant competition on Lake Nipigon would not be surprising in that mosses and lichens inhibit establishment of pine, spruce, shrubs and herbs elsewhere in the boreal forest (Braun-Blanquet 1932; Wilde and Krause 1960; Savile 1963; Walter 1973).

Exposure did not affect species richness on either islands or mainlands, due perhaps to the low elevations and gentle slopes of the sample sites.

Conclusions

The results indicate that seed plant species richness of Lake Nipigon islands is affected both by area and by isolation distances less than 10 km. The larger catchment surface of large islands may permit higher immigration rates than those of small islands.

Lower species richness on distant islands may result from lower immigration rates than those of near islands.

Island area in Lake Nipigon bears no relation to plant dispersal type. Wind-water dispersal is the primary means by which plants disperse to distant islands. Near islands are populated by equal numbers of animal and wind-water dispersed plant species.

Acknowledgments

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APPENDIX 1. Recognized species found at the sample sites, their site frequencies, and probable dispersal mechanisms. Nomenclature follows Scoggan 1978.

Species	Islands	Mainlands	Overall	Probable Dispersal[1]
Abies balsamea	1.00	1.00	1.00	wind[3,5] Red Squirrel[2] birds?, water[2]
Acer spicatum	0.33	0.71	0.43	wind, birds?
Achillea millefolium	0.38	0.00	0.29	wind, water, birds
Actaea rubra	0.05	0.57	0.18	birds?
Agrostis perennans	0.57	0.00	0.43	birds?, wind?, water?
Alnus crispa	0.76	0.86	0.79	wind, water[2]
Alnus rugosa	0.43	0.71	0.50	wind, water?
Amelanchier sanguinea	0.29	0.43	0.32	birds
Anaphalis margaritacea	0.05	0.00	0.04	wind?
Aralia nudicaulis	0.43	1.00	0.57	birds (e.g., Pine Grosbeak, Red-bellied woodpecker)
Arctostaphylos uva-ursi	0.05	0.00	0.04	birds (e.g., Blue Grouse), mammals
Aster macrophyllus	0.00	0.71	0.18	wind?, birds?
Betula papyrifera	1.00	1.00	1.00	wind, water[2,3,4], birds
Bromus ciliatus	0.05	0.00	0.04	birds (e.g., Crow)
Calamagrostis canadensis	0.86	1.00	0.89	birds?, wind?, water?
Cardamine pensylvanica	0.24	0.00	0.18	water?, birds?
Carex disperma	0.43	0.57	0.46	birds?, water?, mammals?
Clintonia borealis	0.05	1.00	0.29	Ruffed Grouse
Coptis trifolia	0.14	0.57	0.25	gravity?
Corallorhiza trifida	0.00	0.43	0.11	wind[3]
Cornus canadensis	0.57	1.00	0.68	birds (e.g., Pine Grosbeak, Crow)[4]
Cornus stolonifera	0.95	0.71	0.89	birds (e.g., Crow[4], American Redstart)
Deschampsia caespitosa and *D. flexuosa*	0.19	0.00	0.14	wind[7]
Diervilla lonicera	0.00	0.57	0.14	?
Eleocharis compressa	0.00	0.14	0.04	birds (e.g., ducks and Killdeer[6])
Epilobium angustifolium	0.95	0.57	0.86	wind[2]
Fragaria vesca	0.43	0.29	0.39	birds (e.g., Crow, Starling, Eastern Kingbird)
Fragaria virginiana	0.00	0.29	0.07	birds (e.g., Crow)
Galium triflorum	0.14	1.00	0.36	birds, mammals
Gaultheria hispidula	0.05	0.43	0.14	birds?
Goodyera repens	0.10	0.14	0.11	wind
Hierachloe odorata	0.05	0.00	0.04	wind?, water?
Hydrocotyle americana	0.00	0.14	0.04	birds?
Ledum groenlandicum	0.14	0.00	0.11	birds (e.g., Rock Ptarmigan), reindeer
Linnaea borealis	0.38	1.00	0.54	mammals (e.g., humans[2], deer, hare), birds
Lonicera canadensis	0.00	0.71	0.18	birds?
Lonicera hirsuta	0.00	0.29	0.07	birds (e.g., Grey Vireo, Red-eyed Vireo)
Maianthemum canadense	0.24	1.00	0.43	birds (e.g., Magpie)
Mentha arvensis	0.48	0.14	0.39	water
Mertensia paniculata	0.05	0.86	0.25	gravity?
Mitella nuda	0.29	1.00	0.46	gravity?
Moneses uniflora	0.62	0.43	0.57	wind
Monotropa uniflora	0.24	0.43	0.29	wind?
Oryzopsis asperifolia	0.00	0.14	0.04	birds?
Phalaris arundinacea	0.19	0.00	0.14	birds (e.g., Killdeer, Mallards[6], Reed Bunting), water, wind
Physocarpus opulifolius	0.14	0.00	0.11	wind?[3]
Picea glauca	0.95	0.86	0.93	wind[3,5], rodents?, birds?, water[2]
Picea mariana	0.71	1.00	0.79	wind[3,5], rodents?, birds?, water[2]
Pinus strobus	0.00	0.14	0.04	wind[3,5], birds?, water?
Poa glauca	0.62	0.43	0.57	wind?, water?
Poa palustris	0.52	0.00	0.39	birds?, wind?, water?
Polygonum sp.	0.43	0.14	0.36	birds (e.g., Killdeer and ducks[6])
Populus balsamifera	0.86	0.71	0.82	wind, water[4]

Continued

APPENDIX 1. Concluded.

Species	Islands	Mainlands	Overall	Probable Dispersal[1]
Populus tremuloides	0.81	0.86	0.82	wind, water[4]
Potentilla anserina	0.29	0.14	0.25	water, mammals, birds (e.g., domestic goose)
Potentilla norvegica	0.86	0.29	0.71	birds (e.g., domestic chicken), water?
Potentilla palustris	0.10	0.00	0.07	water?, birds?
Primula mistassinica	0.48	0.00	0.36	wind?
Prunus pensylvanica	0.14	0.43	0.21	birds (e.g., Crow, Robin[4]), mammals
Pyrola secunda	0.67	0.71	0.68	wind
Pyrola virens	0.43	0.29	0.39	wind
Ranunculus pensylvanicus	0.29	0.86	0.43	birds?, water?
Rhamnus alnifolia	0.00	0.14	0.04	birds?
Ribes glandulosum	0.95	0.86	0.86	birds
Ribes hudsonianum	0.19	0.00	0.14	birds
Ribes lacustre	0.00	0.57	0.14	birds
Ribes oxyacanthoides	0.43	0.29	0.39	birds (e.g., Catbird, towhee, Blue Jay, Cedar Waxwing, Robin, etc.)[8]
Ribes triste	0.00	0.14	0.04	birds, reindeer
Rosa acicularis	0.38	1.00	0.54	birds (e.g., Prairie Chicken), mammals
Rubus idaeus	0.90	0.43	0.79	birds (e.g., Crow, Magpie)
Rubus pubescens	0.33	0.86	0.46	birds
Salix humilis	0.90	0.57	0.82	wind, water[4]
Salix phylicifolia	0.67	0.86	0.71	wind, water[4]
Sambucus racemosa	0.52	0.14	0.43	birds (e.g, Crow, Robin, Red-headed Woodpecker)
Schizachne purpurascens	0.05	0.00	0.04	birds?, wind?, water?
Sium suave	0.05	0.00	0.04	water
Solidago graminifolia	0.67	0.00	0.50	wind?, water?
Sorbus decora	0.95	1.00	0.96	birds, mammals
Streptopus roseus	0.00	0.86	0.21	birds?
Taraxacum sp.	0.19	0.00	0.14	wind, birds, water
Taxus canadensis	0.90	0.43	0.79	birds
Thuja occidentalis	1.00	0.86	0.96	wind?, birds?
Trientalis borealis	0.81	1.00	0.86	mammals?
Typha latifolia	0.10	0.14	0.11	wind[7], water
Urtica dioica	0.10	0.00	0.07	wind, birds (e.g., Magpie), mammals
Vaccinium angustifolium	0.14	0.29	0.18	birds, humans[2]
Vaccinium myrtilloides	0.10	0.43	0.18	birds, humans[2]
Viburnum edule	0.29	1.00	0.46	birds
Viola macloskeyi	0.19	0.14	0.18	birds?, ants?
Viola nephrophylla	0.10	0.00	0.07	birds?, ants?, water?
Viola renifolia	0.14	0.86	0.32	birds?, ants?

[1] Source is Ridely (1930) unless otherwise noted
[2] Personal observation
[3] van der Pijl (1969)
[4] USDA Forest Service (1974)
[5] Löve (1963)
[6] de Vlaming and Proctor (1968)
[7] Praeger (1911)
[8] Cooper (1922)
Some dispersal agents listed are not present at Lake Nipigon, but related species are, e.g., domestic goose — Canada Goose.
"?" denotes that dispersal agent is documented for a plant species related to that at Lake Nipigon.

Distribution sur les conifères des lichens appartenant aux Genres *Bryoria, Alectoria, Usnea* et *Ramalina* sur la Côte Nord et la Côte Sud du Golfe Saint-Laurent

M. LAFLAMME-LEVESQUE[1], J. M. PERRON[1] et L. JOBIN[2]

[1]Département de biologie, Faculté des sciences et de génie, Université Laval, Québec G1K 7P4
[2]Laboratoire de recherches forestières des Laurentides, Environnement Canada, Ste-Foy, Québec G1V 4C7

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Seventeen species of corticolous fruticose lichens have been identified in various conifer stands on the St-Lawrence north shore, some of the Mingan Islands, on Bonaventure Island, and in the Gaspé Peninsula. The genus *Bryoria* is represented by 9 species, the genus *Alectoria* by 1, the genus *Usnea* by 4, and the genus *Ramalina* by 4 species. The data on the distribution of the lichens in relation to the substratum are compared with similar information obtained previously on Anticosti Island.

Key Words: Québec, lichens, *Bryoria, Alectoria, Usnea, Ramalina.*

Dix sept espèces de lichens fruticuleux corticoles ont été dénombrées dans différents peuplements conifériens de la Côte Nord du Saint-Laurent, de quelques îles en Minganie, de l'île Bonaventure et de la Gaspésie. Le genre *Bryoria* est représenté par 9 espèces, le genre *Alectoria* par 1, le genre *Usnea* par 4, et le genre *Ramalina* par 4 espèces. Les données recueillies quant à la distribution des lichens sur le substrat sont comparées avec les informations obtenues précédemment à l'île d'Anticosti.

Mots Clés: Québec, lichens, *Bryoria, Alectoria, Usnea, Ramalina.*

Les connaissances sur la composition lichénique des régions insulaires de l'est du Québec se limitent aux travaux de Lepage (1972), Grondin et Melançon (1978) aux îles de Mingan, de Reilly (1972) aux îles de la Madeleine et de Laflamme-Levesque et al. (1979) à l'île d'Anticosti. De part et d'autre de ces îles, les régions côtières bordant le fleuve Saint-Laurent n'ont été soumises à aucune étude quant à la végétation lichénique corticole. D'après ces auteurs, parmi les lichens fruticuleux qui colonisent l'écorce des conifères de ces îles, les genres *Alectoria, Bryoria, Evernia, Ramalina* et *Usnea* sont représentés. Selon Jobin (1973), certains d'entre eux constitueraient un site de ponte pour *Lambdina fiscellaria fiscellaria* (Guén.). Les observations qu'il a effectuées au cours des années 1971-1972 à l'île d'Anticosti indiquent que les oeufs sont déposés, dans 90% des cas, dans les lichens 'pendants' des vieux conifères. Une étude a démontré que ces lichens se composent principalement de 9 espèces du genre *Bryoria* et d'une espèce du genre *Alectoria*. Les données recueillies ont démontré qu'il existe une relation entre l'intensité de recouvrement lichénique du substrat, l'âge des arbres et la densité forestière (Laflamme-Levesque et al. 1979).

Sachant que les relevés épidémiologiques de *Lambdina fiscellaria fiscellaria* sont concentrés dans des régions insulaires et maritimes (Carroll 1956; de Gryse et Schedl 1934), une meilleure connaissance de la composition lichénique corticole et de sa densité, sur la Côte Nord du Saint-Laurent et en Gaspésie, nous permettra de comparer ces 2 milieux en regard du rôle qu'ils pourraient jouer lors de la ponte de l'insecte.

Materiel et Méthodes

Le territoire couvert par cette étude (Figure 1) comprend, sur la Côte Nord du Saint-Laurent, la région située entre Baie-Comeau et Havre-Saint-Pierre. Parallèlement sur la rive sud du fleuve, le territoire étudié en Gaspésie s'étend de Sainte-Anne-des-Monts à Percé. De plus, quelques îles de la Minganie, la Grande Ile, l'île Niapisca, l'île Eskimo, et l'île Bonaventure en Gaspésie ont fait l'objet de notre recherche.

Les données ont été recueillies au cours de l'été 1978, dans 45 places-échantillons sur la Côte Nord et 40 en Gaspésie. Les anciens sites de pullulations de *Lambdina fiscellaria fiscellaria*, la présence de sapinière à maturité et la proximité de grandes rivières constituaient nos principaux critères dans le choix d'une place-échantillon. Un relevé de la composition forestière, de sa densité, de l'âge des arbres, un échantillonnage des lichens fruticuleux corticoles ainsi qu'une évaluation du recouvrement des conifères par ces lichens, constituaient les données accumulées à chaque place-échantillon. Les techniques utilisées pour recueillir ces informations et déterminer la densité lichénique ont été les mêmes que celles utilisées à l'île d'Anticosti, lors d'une recherche antérieure (Laflamme-Levesque et al. 1979).

L'identification des lichens a été faite d'après l'ouvrage de Brodo et Hawksworth (1977), pour les es-

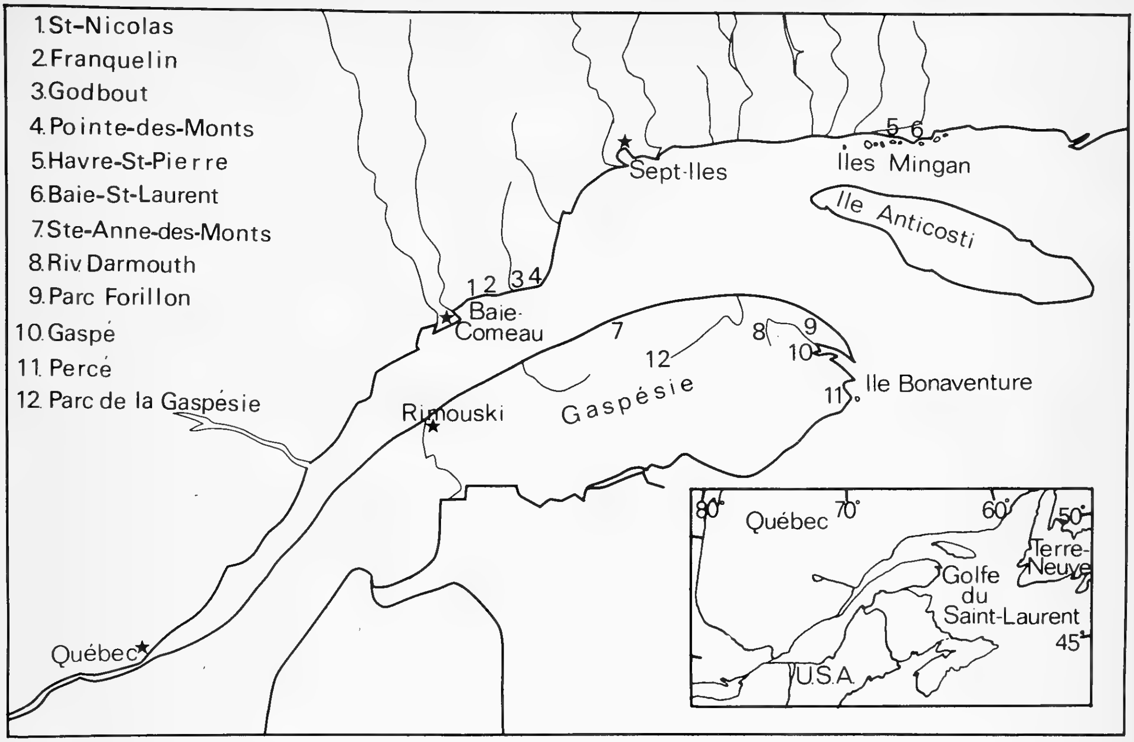

FIGURE 1. Localisation des régions étudiées sur la Côte Nord du Saint-Laurent et en Gaspésie.

pèces appartenant aux genres *Alectoria* et *Bryoria*. L'étude des Usnéacées a nécessité l'utilisation du travail de Dahl et Krog (1973). Enfin, pour les espèces du genre *Ramalina*, notre principale référence a été celle de Hale (1969). Les espèces décelant des problèmes d'identification ont été vérifiées par I.M. Brodo. Les spécimens sont déposés à l'herbier Louis-Marie de l'Université Laval (QFA).

Résultats et Discussion

Composition et Distribution Lichénique

Du point de vue composition lichénique, les conifères de la Côte Nord du Saint-Laurent et de la Gaspésie sont colonisés par les lichens fruticuleux appartenant principalement aux genres *Bryoria, Alectoria, Usnea* et *Ramalina.*

Genre *Bryoria*

Le genre *Bryoria*, subdivisé en sections selon les caractères morphologiques, anatomiques et chimiques des espèces (Brodo et Hawksworth 1977), est représenté par 9 espèces sur le territoire étudié. Il s'agit, pour la section *Bryoria*, de *Bryoria trichodes* (Michx.) Brodo et D. Hawksw., *Bryoria fuscescens* (Gyeln.) Brodo et D. Hawksw., et *Bryoria lanestris* (Ach.) Brodo et D. Hawksw.; pour la section Divaricatae, de *Bryoria simplicior* (Vain.) Brodo et D. Hawksw., *Bryoria furcellata* (Fr.) Brodo et D. Hawksw. et *Bryoria tenuis* (Dahl) Brodo et D. Hawksw.; et pour la section Implexae, de *Bryoria nadvornikiana* (Gyeln.) Brodo et D. Hawksw., *Bryoria capillaris* (Ach.) Brodo et D. Hawksw. et *Bryoria salazinica* Brodo et D. Hawksw.

Dans la section *Bryoria*, les espèces les plus fréquemment rencontrès sont *B. trichodes* et *B. fuscescens; B. lanestris* se retrouve plus rarement. *B. trichodes* est représenté sur tout le territoire étudié par 2 sous-espèces, *B. trichodes* ssp. *trichodes* et ssp. *americana* (Mot.) Brodo et D. Hawksw. (Figure 2, A et B); cette dernière est la plus courante. *B. trichodes* occupe invariablement les 3 niveaux du substrat étudié, soit le sommet, la région médiane et la base des conifères. Il colonise indifféremment *Abies balsamea* (L.) Mill., *Picea glauca* (Moench) Voss et *Picea mariana* (Mill.) B.S.P. Les peuplements conifériens de la Côte Nord du Saint-Laurent et de la Gaspésie recèlent l'abondance de *B. fuscescens* (Figure 2 C) de haut en bas du substrat. Enfin, *B. lanestris*, quoique faiblement représenté, colonise les 2 rives du fleuve (Figure 2 D). Cette espèce se fixe sur le tiers supérieur des

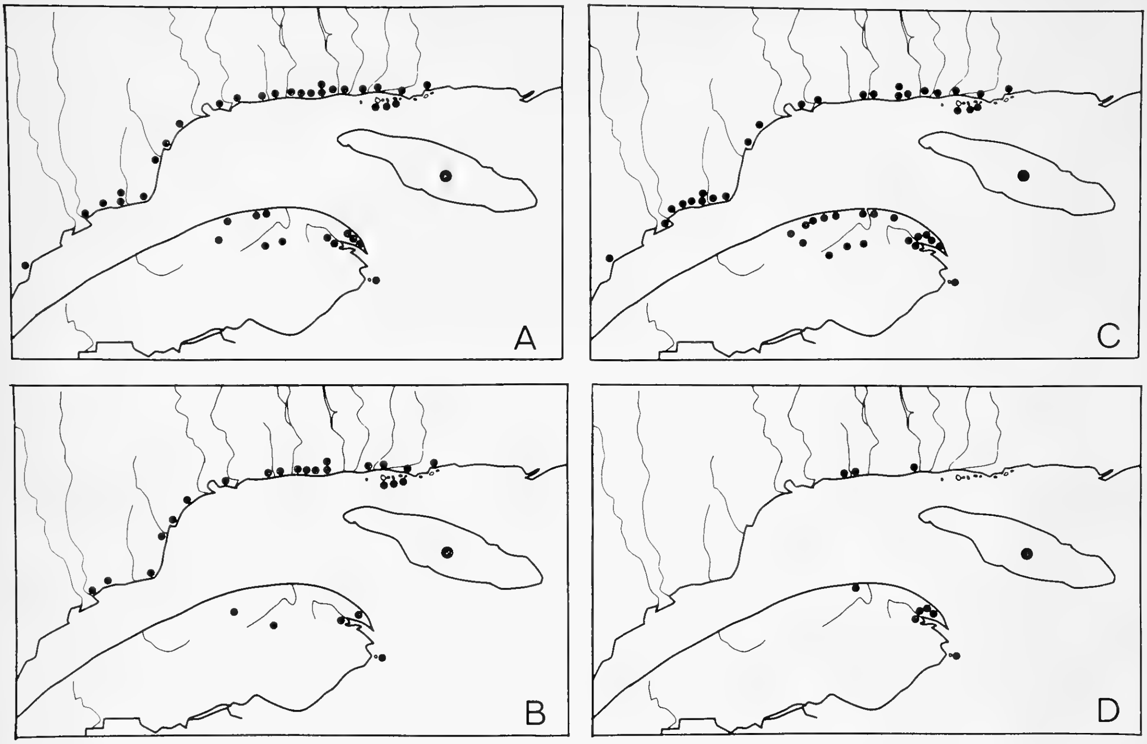

FIGURE 2. Distribution des espèces de la section *Bryoria* du genre *Bryoria* sur la Côte Nord du Saint-Laurent et en Gaspésie: (A) *Bryoria trichodes* ssp. *trichodes*; (B) *Bryoria trichodes* ssp. *americana*; (C) *Bryoria fuscescens*; (D) *Bryoria lanestris*.

arbres 2.5 fois plus souvent que sur le tiers inférieur. Cette observation concorde aussi avec le fait qu'il croît, sur 90% des arbres étudiés, en association avec *B. simplicior*, espèce qui semble aussi avoir un grand besoin de lumière (Brodo et Hawksworth 1977).

Les lichens appartenant à la section des Divaricatae sont représentés par *B. simplicior, B. furcellata* et *B. tenuis*. Certaines conditions d'éclairement pourraient expliquer la présence conjointe de *B. simplicior* et *B. furcellata*, dans 85% des échantillons recueillis. Ces 2 espèces montrent une préférence pour de bonnes conditions de lumière, colonisant ainsi le tiers supérieur des arbres, dans des proportions de 3:1 et 4:3 par rapport au tiers inférieur. Le matériel récolté à l'île d'Anticosti (Laflamme-Levesque et al. 1979) démontrait aussi cette particularité pour *B. furcellata*, mais de façon plus évidente avec un rapport de 9:1. Leur présence est notée sur tout le territoire, à l'exception des îles de Mingan (Figure 3, A et B). Rarissime, *B. tenuis* n'a été identifié que sur le sapin à Havre-Saint-Pierre (Côte Nord) et au Parc Forillon (Gaspésie) (Figure 3 B).

B. nadvornikiana, B. capillaris et *B. salazinica* illustrent la section Implexae. Rare à l'île d'Anticosti (Laflamme-Levesque et al. 1979), tous les peuplements forestiers étudiés sur la Côte Nord du Saint-Laurent et en Gaspésie sont marqués par la présence de *B. nadvornikiana* (Figure 3 C). Sur le territoire étudié, il n'y a pas d'exigences particulières de cette espèce face aux conditions d'éclairement. Sur la Côte Nord et en Gaspésie, la distribution de *B. capillaris* (Figure 3 D) sur les conifères confirme les résultats obtenus à l'île d'Anticosti (Laflamme-Levesque et al. 1979) selon lesquels, il existe une préférence pour les régions les mieux éclairées du substrat. Seulement 2 relevés lichéniques effectués à l'île d'Anticosti permettent de signaler la présence de *B. salazinica*. Absente en Gaspésie, cette espèce n'est notée sur la Côte Nord du Saint-Laurent qu'à Godbout (Figure 3 C), sur la même essence forestière, le sapin.

Genre *Alectoria*

Une seule espèce représente le genre *Alectoria*, *Alectoria sarmentosa* (Ach.) Ach. ssp. *sarmentosa*. Fréquente sur la Côte Nord du Saint-Laurent, elle est plus rarement trouvée en Gaspésie (Figure 4). Con-

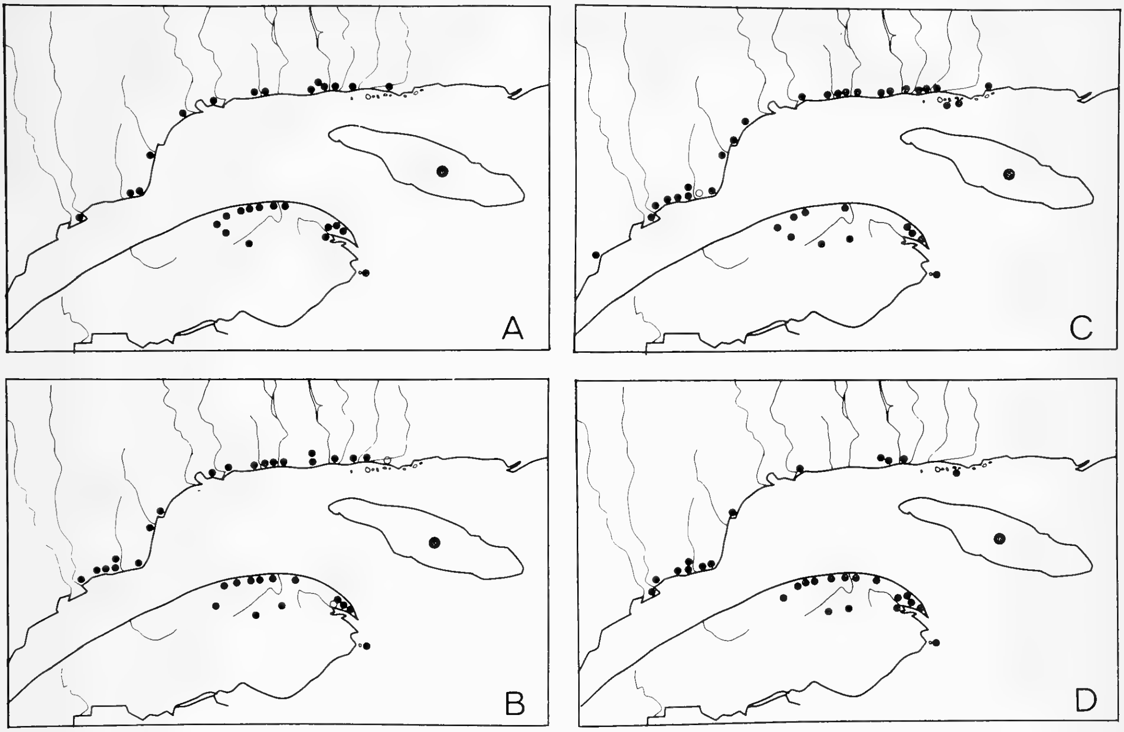

FIGURE 3. Distribution des espèces des sections Divaricatae et Implexae du genre *Bryoria* sur la Côte Nord du Saint-Laurent et en Gaspésie: (A) *Bryoria simplicior*; (B) (●) *Bryoria furcellata*; (0) *Bryoria tenuis*; (C) (●) *Bryoria nadvornikiana*; (0) *Bryoria salazinica*; (D) *Bryoria capillaris*.

trairement aux données recueillies à l'île d'Anticosti (Laflamme-Levesque et al. 1979), le mode de répartition de cette espèce sur le substrat montre une préférence pour la partie ombragée des arbres, se fixant ainsi sur le tiers inférieur des conifères, dans des proportions de 2:1 par rapport au tiers supérieur.

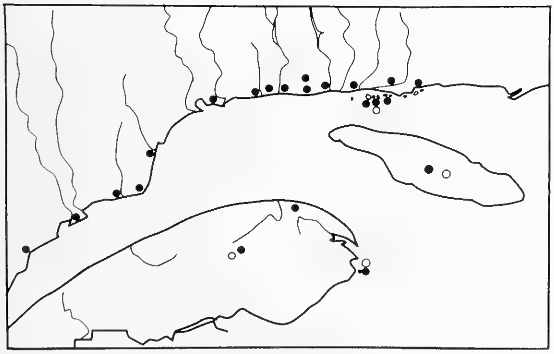

FIGURE 4. Distribution du genre *Alectoria* sur la Côte Nord du Saint-Laurent et en Gaspésie: (●) *Alectoria sarmentosa* ssp. *sarmentosa*, race KC+; (o) *Alectoria sarmentosa* ssp. *sarmentosa, race* KC^{-}

Seules les îles de la Minganie, l'île Bonaventure et le Parc de la Gaspésie possèdent en plus la race chimique KC- (Figure 4).

Genre *Usnea*

Les lichens fructiculeux corticoles appartenant au genre Usnea sont représentés sur le territoire étudié par 4 espèces: *Usnea filipendula* Stirt., *Usnea longissima* Ach., *Usnea sorediifera* (Arn.) Lynge s. lat. et *Usnea trichodea* Ach.

Les peuplements conifériens de la Côte Nord du Saint-Laurent et de la Gaspésie sont tous colonisés par *U. filipendula* (Figure 5A). Sur l'écorce de quelques sapins seulement se sont fixés *U. longissima* et *U. sorediifera* (Figure 5B). Ces espèces ne montrent aucune exigence particulière quant aux conditions d'éclairement, colonisant dans les mêmes proportions, le sommet, la région médiane et la base des arbres. Absente à l'île d'Anticosti et en Gaspésie, *U. trichodea* n'a été identifié sur la Côte Nord qu'à St-Nicolas (Figure 5B), sur un sapin. Contrairement à l'île d'Anticosti où quelques spécimens de *U. subfloridana* Stirt. avaient été récoltés, cette espèce est manquante sur tout le territoire étudié.

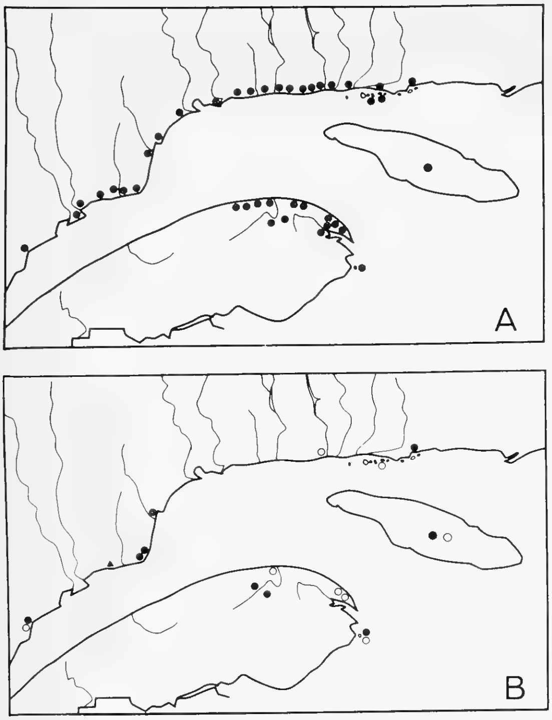

FIGURE 5. Distribution du genre *Usnea* sur la Côte Nord du Saint-Laurent et en Gaspésie: (A) *Usnea filipendula*; (B) (●) *Usnea longissima*; (○) *Usnea sorediifera*; (▲) *Usnea trichodea*.

Genre *Ramalina*

Dans les peuplements conifériens de la Côte Nord du Saint-Laurent et de la Gaspésie, 4 espèces corticoles représentent le genre *Ramalina: Ramalina dilacerata* (Hoffm.) Hoffm. (Syn. *R. minuscula* (Nyl.) Nyl.), *Ramalina roesleri* (Hochst.) Nyl., *Ramalina thrausta* (Ach.) Nyl. et *Ramalina farinacea* (L.) Ach.

L'abondance des espèces *R. dilacerata* et *R. roesleri* se vérifie sur tout le territoire (Figure 6, A et B). Les 2 espèces colonisent le sommet et la base des 3 essences forestières étudiées, le sapin, l'épinette noire et l'épinette blanche.

Concordant avec les données recueillies à l'île d'Anticosti (Laflamme *et al.*, 1979), *R. thrausta* illustre une préférence marquée pour les milieux ombragés, se fixant sur le tiers inférieur des conifères, dans des proportions de 2:1 par rapport au tiers supérieur. Rare sur la Côte Nord du Saint-Laurent, cette espèce se retrouve fréquemment sur le sapin à l'extrémité de la péninsule gaspésienne (Figure 6C).

Absente sur la Côte Nord, les informations recueillies sur *R. farinacea* en Gaspésie confirment les résultats obtenus à l'île d'Anticosti (Laflamme-Levesque et al. 1979) sur la préférence de cette espèce pour les milieux sombres (Figure 6D). En effet, le tiers inférieur des conifères est colonisé par *R. farinacea* 1.7 fois plus souvent que le tiers supérieur.

Description du territoire

La Côte Nord du Saint-Laurent et la Gaspésie constituent 2 territoires fortement différents quant à leur composition forestière. Sur la Côte Nord, les peuplements forestiers qui recouvrent la région côtière située entre Baie-Comeau à l'ouest et Havre-Saint-Pierre à l'est, sont surtout composés de conifères. Les pessières noires occupent une grande partie de la forêt mais, à l'occasion, il y a présence de sapinières qui sont alors situées dans la partie inférieure des bassins de rivière. Elles sont généralement très anciennes, mais des perturbations causées par l'exploitation forestière, le feu ou les pullulations d'insectes en ont diminué l'importance et elles sont souvent réduites à quelques arbres seulement.

La région gaspésienne s'étendant de Ste-Anne-des-Monts à Percé est caractérisée, au point de vue forestier, par son manque d'homogénéité. En effet, les nombreuses perturbations du milieu occasionnées à la suite des périodes successives d'exploitation forestière, des pullulations d'insectes et de feux, ont transformé la forêt en une véritable mosaique où dominent tantôt les feuillus, tantôt les conifères. Les peuplements inventoriés en Gaspésie diffèrent nettement de ceux de la Côte Nord du Saint-Laurent par leur très grande hétérogénéité et par le morcellement créé par les nombreuses perturbations.

Ces régions côtières, quoique fort différentes actuellement de l'île d'Anticosti au point de vue forestier (Laflamme-Levesque et al. 1979) possèdent une végétation lichénique corticole semblable. En effet, les mêmes espèces du genre *Bryoria* se retrouvent sur les conifères des 3 régions étudiées à l'exception de *B. salazinica*, absente en Gaspésie. *B. simplicior* rare à l'île d'Anticosti (Laflamme-Levesque et al., 1979) se retrouve très fréquemment dans les milieux côtiers inventoriés. La présence de la seule espèce illustrant le genre *Alectoria, Alectoria sarmentosa* ssp. *sarmentosa* est notée abondamment sur la Côte Nord du Saint-Laurent et à l'île d'Anticosti (Laflamme-Levesque et al. 1979); elle devient très rare en Gaspésie. La race chimique KC-, notée pour la première fois à l'île d'Anticosti se retrouve également sur les îles de Mingan, l'île Bonaventure et dans le Parc de la Gaspésie. Enfin, à l'exception de *R. farinacea* absente sur la Côte Nord, le genre *Ramalina* est représenté par les mêmes espèces à l'île d'Anticosti (Laflamme-Levesque et al. 1979), sur la Côte Nord et en Gaspésie.

Sur la Côte Nord du Saint-Laurent et en Gaspésie, le petit nombre de sapinières nous empêche d'établir une corrélation, comme ce fut le cas à l'île d'Anticosti, entre la densité de recouvrement lichénique des

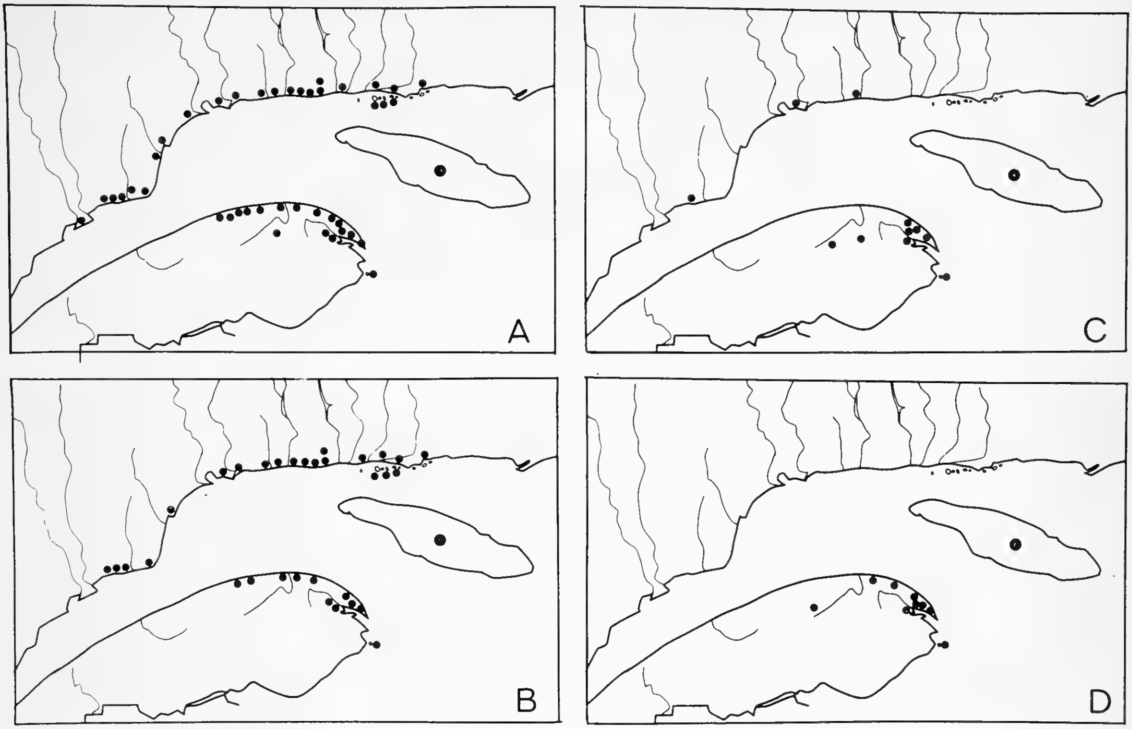

Figure 6. Distribution du genre *Ramalina* sur la Côte Nord du Saint-Laurent et en Gaspésie: (A) *Ramalina dilacerata*; (B) *Ramalina roesleri*; (C) *Ramalina thrausta*; (D) *Ramalina farinacea*.

arbres, leur âge et la densité forestière. Toutefois, il est intéressant de noter que les arbres sur lesquels la densité lichénique dépasse 50% de recouvrement sont âgés d'au moins 50 ans. Les sites dans lesquels les lichens recouvrent si intensément le substrat sont d'une part, des endroits où une pullulation de *L. fiscellaria fiscellaria* a déjà été signalée (Frankelin, Godbout, Riv. Darmouth, Pointe-des-Monts, Riv. Mingan, Baie St-Laurent, île Eskimo, île Niapisca), et d'autre part de vieilles sapinières n'ayant pas subi de perturbations importantes (Havre-Saint-Pierre, Parc Forillon, Parc de la Gaspésie).

Remerciements

Nous sommes reconnaissants envers le Dr. I. M. Brodo du Musée des Sciences naturelles, Ottawa, pour son aide dans l'identification des lichens. L'assistance technique de M. Charles Coulombe fut grandement appréciée lors du travail sur le terrain. Cette recherche a pu être réalisée grâce aux octrois du Conseil national de recherches du Canada, subvention A-5764.

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Amphibians of the Province of Newfoundland

JOHN E. MAUNDER

Newfoundland Museum, Duckworth Street, St. John's, Newfoundland A1C 1G9

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Eight species of amphibians have been confirmed for Newfoundland. The Striped Chorus Frog (*Pseudacris triseriata*) and the Green Frog (*Rana clamitans*) are found on the island only. The Blue-spotted Salamander (*Ambystoma laterale*), the Two-lined Salamander (*Eurycea bislineata*) and the Mink Frog (*Rana septentrionalis*) are found in Labrador only. The American Toad (*Bufo americanus*), the Wood Frog (*Rana sylvatica*) and the Northern Leopard Frog (*Rana pipiens*) are found in both sections of the province. All six species confirmed for Labrador are native there. All five species found on the island have been introduced, but have spread, naturally and with human assistance, from their original sites of introduction. Two additional species, the Eastern Redback Salamander (*Plethodon cinereus*) and the Spring Peeper (*Hyla crucifer*), have been reported from Labrador, but their status remains hypothetical.

Key Words: frogs, toads, salamanders, Newfoundland, Labrador, introductions, distributions, range extensions, range limits, interspecific competition.

This paper is a synthesis of what is known about the amphibians of the province, and covers past and present distributions, introductions, dispersal, and some breeding biology.

Amphibians have been investigated only superficially in the province of Newfoundland. Much of what is known can be found in reports dealing with broader geographic areas (Bleakney 1954, 1958; Harper 1956), or in the form of notes by transient field-workers and "travellers in the country" (Packard 1866, 1891; Maret 1867; Kindle 1924; Austin 1932; Ayre 1938; Cook and Folinsbee 1975; Cook and Preston 1979; de Graaf, Boles and Lovisek 1981). More specific papers have been written by Johansen (1926), Backus (1954), Cameron and Tomlinson (1962) and Buckle (1971).

Sources of information, other than the literature, include personal interviews with field-workers, field work by the author to confirm some distribution records, and a unique school-participation project known locally in Newfoundland as "Project Frog".

Most of the new data concerning four amphibian species introduced to the island of Newfoundland between 1960 and 1966 (Buckle 1971) was gleaned from the excellent, continuing field observations of Mr. James Buckle, or obtained while on field excursions in his company.

"Project Frog" was a cooperative effort involving the Natural History Section of the Newfoundland Museum at St. John's and students from forty participating junior high schools located throughout the island of Newfoundland and the mainland of Labrador. Following guidelines set out by the museum in a project handbook, and under the supervision of science teachers, students collected and documented specimens of frogs and toads. Information on the local histories of the various species was collected in some instances and, where appropriate, students reported the apparent local absence of amphibians after searching the countryside and interviewing residents. All specimens and data were deposited in the Newfoundland Museum. Data from the project added significantly to the knowledge of amphibian distribution in the province.

In the following species accounts, J. S. Bleakney's Herpetofaunal Sections (Bleakney 1958) are examined as they apply to the amphibian distribution on the island of Newfoundland (Figures 1, 3 and 5) and in Labrador (Figures 2 and 3).

Blue-spotted Salamander *Ambystoma laterale*

Only three specimens of this species have been collected from the province, all from Labrador (Figure 3). The first was a male taken by W. E. Beckel at Goose Bay on 25 July 1948 and reported by Bleakney (1954). Originally listed as *A. jeffersonianum*, the specimen was re-assigned to *A. laterale* when Uzzell (1964) revised this species complex. The second specimen was a juvenile taken by John Porter approximately 16 km south of Wabush on 22 September 1974 and reported by Cook and Folinsbee (1975). The third specimen was collected from a basement in Happy Valley, near Goose Bay, on 11 November 1981 (Frank Phillips, Provincial Wildlife Division, personal communication). There is also a recent and apparently reliable sight record of a Blue-spotted Salamander for Ugjoktok Bay, near Hopedale, by Bernard Chaulk of the Provincial Forestry Division (Frank Phillips, personal communication). The Wabush specimen and the Ugjoktok Bay sighting are from climatic regions designated by Bleakney (1958) as Herpetofaunal Sections (see caption of Figure 1) 6 and 7 respectively (see Figure 2) indicating a more boreal distribution for this species than previously thought.

Eastern Redback Salamander *Plethodon cinereus*

Bleakney (1958, p. 15) reported that the occurrence of a small salamander in the Lake Melville area was mentioned on several occasions in 1955 to National Museums of Canada worker Mr. W. J. Smith, and suggested that from the descriptions this salamander "must be *Plethodon c. cinereus*".

Packard (1866, 1891) made several references to a salamander he variously identified "with some doubts" (1866, p. 272) as "*Plethodon glutinosa*" and "*Plethodon glutinosus*", the Slimy Salamander. His observations were made just outside of what is now the province of Newfoundland, near the coast at Belles Amours, Quebec, approximately 22 km west of Blanc Sablon and the Labrador-Quebec boundary.

Packard's descriptions variously described "a little salamander . . . of a slate color, with a paler light dorsal band" (1891, p. 112), and "a salamander of a dark slate color, with a paler dorsal stripe" (1866, p. 272; 1891, p. 406). The descriptions may indicate the Two-lined Salamander as suggested by Cook and Preston (1979), but also seem to fit the red-backed or striped phase of the Eastern Redback Salamander. However, Packard (1891, p. 112) stated that one of the salamanders "ran into the water, to [his] great disappointment, just eluding [his] grasp". While fleeing to water is not unusual behavior for Two-lined Salamanders, it would not be expected of Eastern Redback Salamanders. An additional problem arises with the statement in Packard's 1866 paper (p. 272) that the salamander was "about six inches in length", possibly indicating the Blue-spotted Salamander, as suggested by Bleakney (1954).

It is possible Packard encountered more than one species of salamander and unaccountably merged the descriptions together. If his "*Plethodon glutinosus*" identification actually referred to a species he thought to be the Slimy Salamander, the creature in question was probably the "similar" but shorter-tailed Blue-spotted Salamander. The "little salamander . . . with a paler light dorsal band" may well have been the Two-lined Salamander.

Packard (1891, p. 106) also referred to "lizards" reported from "inland" that were "most probably *Plethodon glutinosus*", but it is unclear whether "inland" referred to Quebec or Labrador territory. Both the Blue-spotted Salamander and the Two-lined Salamander were first collected in south-central Labrador after Packard and Bleakney wrote their papers.

The status of Eastern Redback Salamander in Labrador must be regarded as hypothetical at best.

Two-lined Salamander *Eurycea bislineata*

The Two-lined Salamander has been collected at only two provincial localities, both in Labrador (Figure 3). The first collection was of a recently transformed juvenile taken by John Preston approximately 16 km northeast of Labrador City in mid-August 1972 (Cook and Preston 1979). The second collection was of several larvae by Dirk de Graaf in a small tributary of the Cache River in central Labrador on 17 August 1979 (de Graaf, Boles and Lovisek 1981). Both collections are from Bleakney's Herpetofaunal Section 6. The boreal nature of these records may indicate a widespread distribution in southern Labrador.

American Toad *Bufo americanus*

This species is widely distributed in southern Labrador, and in the Corner Brook area on the island.

In Labrador, American Toads occur to the northern limit of Bleakney's Herpetofaunal Section 6 (Figure 3). This distribution is supported by Packard (1891), Kindle (1924), Austin (1932), J. K. Doutt (unpublished summary of zoological field observations entitled "Field Notes of the Carnegie Museum (Philadelphia) Number 19; Expedition to Hamilton River, Labrador to Sandgirt Lake, June 22 – September 11, 1939"), Backus (1954), Bleakney (1954, 1958), Harper (1956), and my own records.

On the island, toad distribution is centered in the Corner Brook area in the vicinity of James Buckle's introductions (Figure 4). According to Buckle (personal communication), and as present distribution shows, the toads have dispersed naturally from introduction and transplant sites at an average rate of 0.3 to 0.4 km per year, with a maximum of approximately 1 km per year. (Throughout this paper, Buckle's figures for distance dispersed per year by each species are estimated values based on over twenty years of regular field observations plus an examination of present distributions).

In addition to natural dispersal, considerable human-assisted dispersal has taken place. The history of the American Toad on the island has been ascertained as follows. James Buckle, who brought the species there, made all his collections of young toads at Richmond Hill and Thornhill in the Toronto area. In 1960, approximately 100 newly-metamorphosed toads were released on the shore of a small pond near the Trans-Canada Highway just south of Corner Brook (U.T.M. 340193). (Introduction localities in this paper have been pinpointed to within 100 metres using Universal Transverse Mercator (U.T.M.) Military Grid References and 1:50 000 scale topographic maps issued by the Surveys and Mapping Branch, Department of Energy, Mines and Resources, Ottawa.) Road construction occurred at this introduction site soon afterwards, and toads were not seen there again. Buckle thereupon sent four new installments of young toads from Toronto to his father at

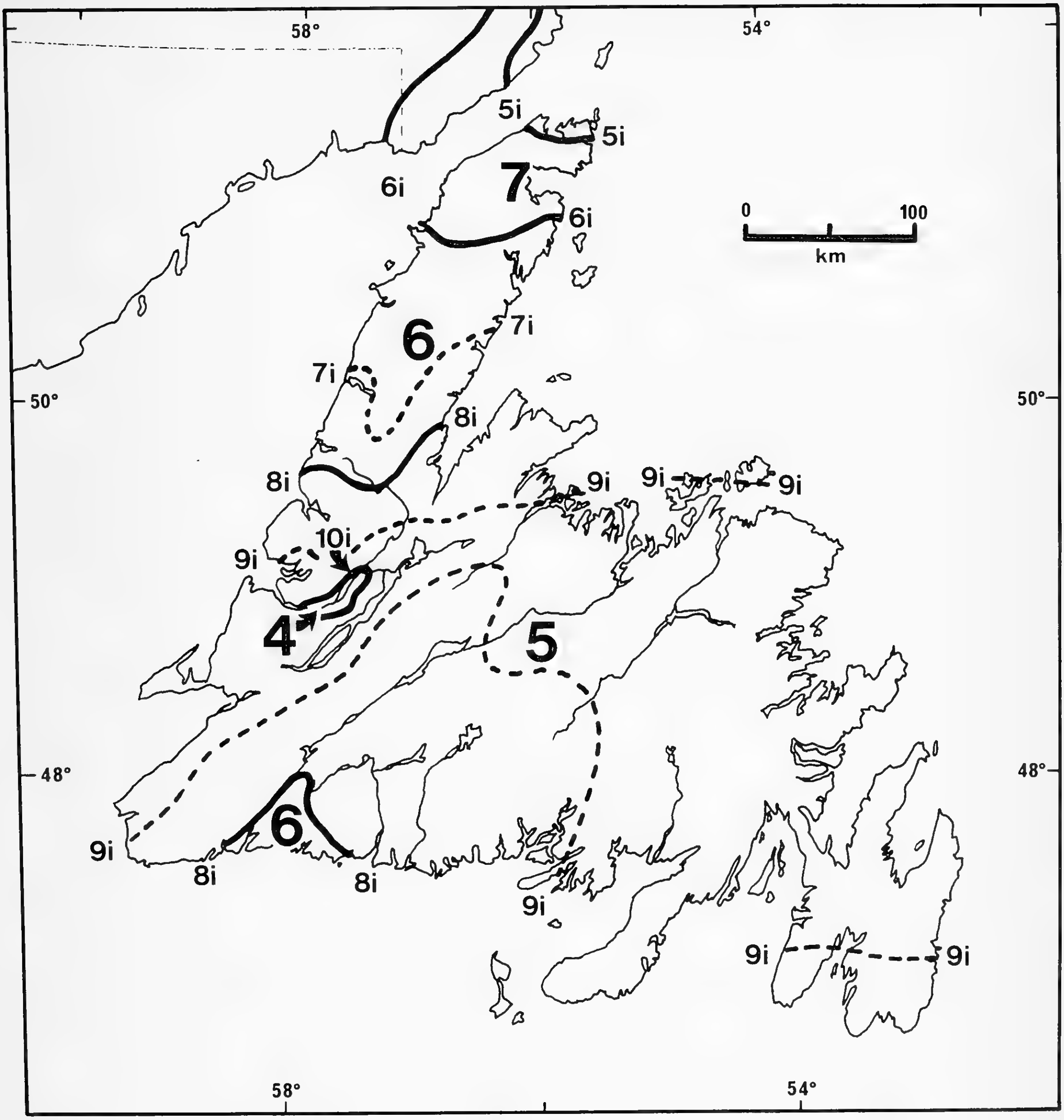

FIGURE 1. The island of Newfoundland showing Bleakney's (Bleakney 1958) Herpetofaunal Sections (numbered, and bounded by heavy lines) and Environmental Index isopleths (designated by numbered "i's"). Bleakney described a series of "herpetofaunal sections" (or regions) relating to amphibian and reptile distribution in eastern Canada. The boundaries of these sections were determined using a series of environmental temperature indices calculated by multiplying the length of the growing season by the mean July temperature at each of several locations. For simplicity, each number so calculated is divided by 1000. For Herpetofaunal Section 4, the environmental indices are 11 to 10; for Section 5 they are 10 to 8; for Section 6 they are 8 to 6; for Section 7 they are 6 to 5. Bleakney did not illustrate herpetofaunal sections for the island. They were plotted for this paper using Hare (1952).

Corner Brook (60 in 1963, 45 in 1964, 41 in 1965, and 55 in 1966), who released the toads in his garden on Valley Road (U.T.M. 303223). Because this release site had poor breeding potential, 3 adult and 29 one-year-old toads were moved in 1967 to a site 2.4 km northeast of Steady Brook bridge on the south side of the highway (U.T.M. 412238).

Since that time, much has happened. The known movement of toads from the Steady Brook bridge site is 4.5 km northeast to Little Rapids, 3.5 km southwest to the southwestern limit of habitation at Steady Brook village (including "Dogwood Station"), 0.5 km northwest across the Humber River (approximately 500 m wide at this point), and 2.5 km southeast of Steady Brook village up the gorge of Steady Brook stream (an elevation increase of approximately 250 m). The Steady Brook gorge record is based on a single sighting and may have been a toad moved by humans.

Dispersal in the Steady Brook area appears to be considerably limited by the terrain, which includes the deep, narrow valley of the Humber River with hills rising steeply to 300 m and 500 m to the northwest and southeast respectively, and a very narrow river gorge downstream (west) from Steady Brook village. Dispersal to the northwest, southwest and southeast is probably now stymied, but to the northeast it seems to be continuing. In 1970, approximately 150 young toads from Steady Brook were moved to Beaver Pond just northwest of the Trans-Canada Highway, approximately half-way along the southeast side of George's Lake (U.T.M. 172015). By 1977, the toads had dispersed 3.5 km northeast and southwest, and 2 km southeast to Rocky Pond. By 1978, toads had appeared at Blue Ponds Provincial Park 4 km to the northeast. Also in 1970, approximately 50 young toads from Steady Brook were moved to a ditch 1 km northeast of "Silver Birches" Salvation Army Camp near Pynn's Brook (U.T.M. 592353). They have established a tremendously successful breeding population in the area near the camp entrance.

In 1976, 100 tadpoles and six adults from Steady Brook were moved to the southwest end of Deer Lake (U.T.M. 500278). This population is now established and toads are breeding in the lake despite the constant presence of floating log booms destined for the paper mill at Corner Brook. In September 1977, 34 adult toads were "rescued" from an area of highway construction near George's Lake and released at Picadilly on the Port-au-Port Peninsula. Unconfirmed reports from local residents in August 1980 indicated toads were still present there. In 1978, approximately 1000 individuals (mostly tadpoles) from the "Silver Birches" camp area near Pynn's Brook were moved to roadside ditches on the Deer Lake Airport road. The same year there were at least two transplants outside the Corner Brook area. Approximately 80 young toads from George's Lake were moved to Boswarlos on the Port-au-Port Peninsula, and approximately 100 young toads from Steady Brook were moved to a small pond on the east side of the Trans-Canada Highway 1 km north of the entrance to Butterpot Provincial Park near St. John's. Repeated searches of the Deer Lake Airport road and Butterpot Park areas (by Buckle and Maunder respectively) have shown no evidence of toad survival at either site. The fate of the Boswarlos toads is unknown, although there have been some positive reports from local residents. In 1980, 75 small toads were moved from Steady Brook to a small farm owned by a Mr. Prowse and located at the bridge over the Humber River on the Northern Peninsula Highway at Deer Lake (U.T.M. 683490).

Other locations where toads have been reported include Benoit's Cove west of Corner Brook (one seen in 1978), Wild Cove Dump just northeast of Corner Brook (toads apparently put there, but not seen lately), and near the highway intersection at the extreme southeast corner of Humber Arm east of Corner Brook. Buckle reports that toads can now be found almost anywhere within the city limits of Corner Brook. An additional record comes from the Bonne Bay area approximately 70 km north of Corner Brook. Toads were heard trilling in an alder (*Alnus* sp.) swamp at the intersection of the Norris Point road and the Rocky Harbour cove road in Rocky Harbour in late May 1977. On 3 June of that year, a male was captured by Kevin Moore and Gregory Horne. The toad was photographed (photographs on file at Gros Morne National Park), measured and released. At the same time, two other toads were heard trilling at this location, and another was heard in a pond 1 km to the south. These individuals were transplanted to this location by humans, presumably from toad populations in the Corner Brook area.

It is certain that the considerable human-assisted dispersal of toads (and other amphibians) will continue to occur on the island. Adults and children alike seem compelled to move them from place to place. Many pockets on rural school buses, for example, now carry toads, and the presence of a significant breeding population of toads at the "Silver Birches" summer camp (which attracts campers from across the province) has obvious consequences. There is even one known instance of children attempting (with uncertain success) to sell toads on the highway at Steady Brook.

It seems that the American Toad is firmly established on the island. It can be expected to continue spreading at a steady rate on its own, and in a more

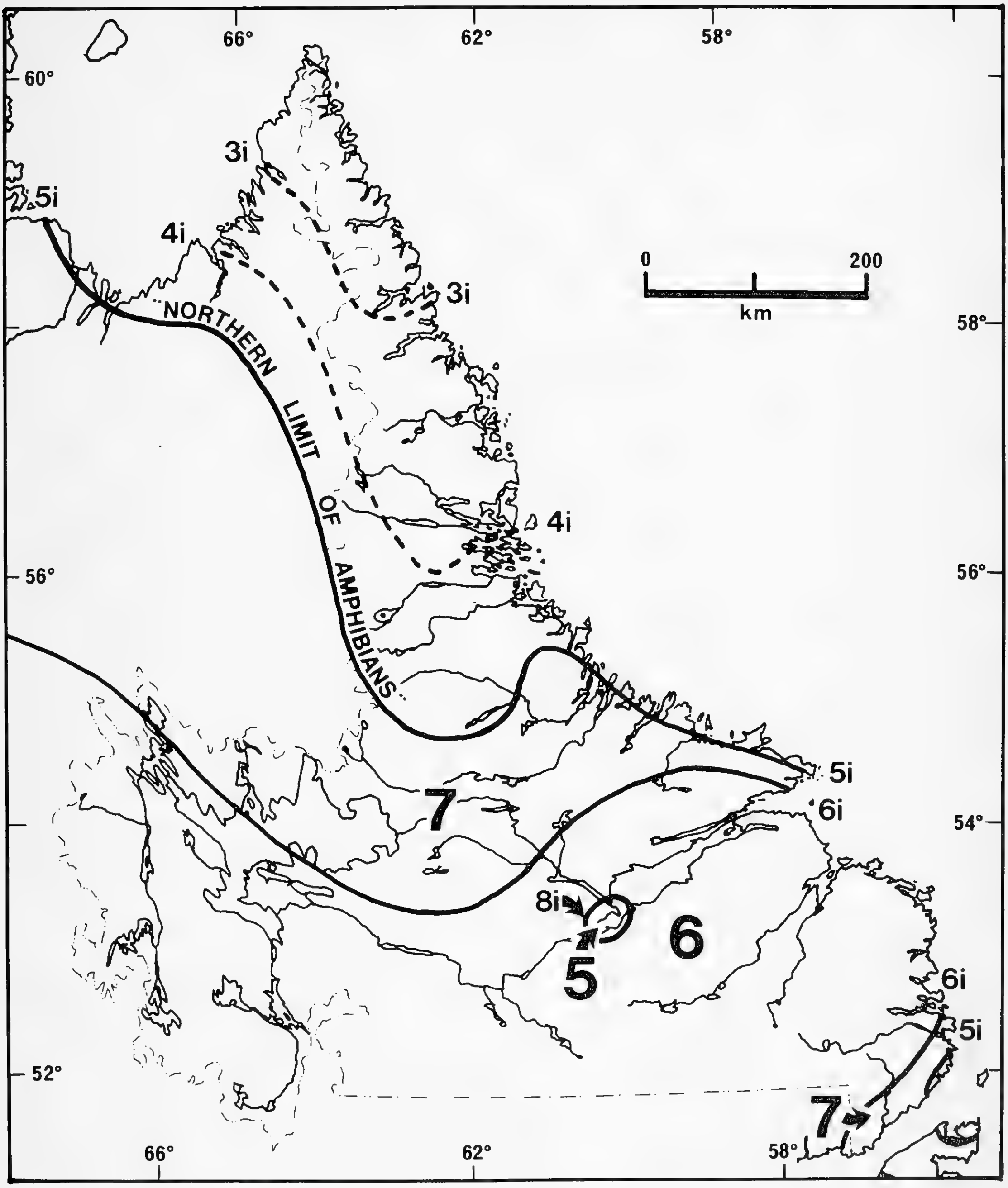

FIGURE 2. Labrador showing Bleakney's (Bleakney 1958) Herpetofaunal Sections (numbered, and bounded by heavy lines) and Environmental Index isopleths (designated by numbered "i's"). For explanation, see caption of Figure 1. Replotted for this paper using more complete and up-to-date climatic data from Wilson (1971).

erratic fashion over longer distances where humans are involved. If the species is unable to move into Bleakney's Herpetofaunal Section 7, as appears to be the case, toads will probably never populate the northern reaches of the island's Great Northern Peninsula (Figure 1).

Toads in the Corner Brook area disperse through any type of vegetation, including thick spruce woods (*Picea* sp.). Dispersal along lakeshores and watercourses is at approximately the same rate as through woods except where strong river currents sweep individuals along for a short distance.

No investigations of toad diet have been carried out in the province, but it is widely reported that strawberry beds (*Fragaria* sp.) are strikingly free of slugs in areas where toads are common.

Dytiscid water beetles have been observed preying on toad tadpoles at "Silver Birches". The degree of predation by Brook Trout (*Salvalinus fontinalis*), the only major freshwater fish of small water bodies in the Corner Brook area, is unknown; but it is known that toad tadpoles prosper in the local trout streams. Buckle reports that he found about 20 breeding toads killed and disemboweled by Common Crows (*Corvus brachyrhynchus*) at the "Silver Birches" breeding area in 1981.

Toads in the Corner Brook area breed in a variety of locations, including shallow ponds, roadside ditches, pools in gravel pits, mud flats, drained beaver ponds, lake shores, slow-moving brooks, and marshes. They are not particularly early breeders, laying after both Chorus Frogs and Wood Frogs. Calling began, typically, at "Silver Birches" on 18 May 1980. Breeding at higher altitude locations southwest of Corner Brook, such as Blue Ponds (above 200 m), takes place as much as two to three weeks later because of cooler temperatures. Calling begins when the temperature rises to approximately 15° C. Buckle and others found that once calling begins it will continue for a time even if the temperature drops. However, little calling takes place at night in the Corner Brook area because spring nights are generally very cold, with temperatures often approaching the freezing point. Midday is a common time to hear toads there. On the nearby mainland, Harper (1956) found American Toads breeding on 25 May 1953 at Sept Iles, Quebec and on 14 June 1953 at Carol Lake, Labrador. The same author found these toads began calling at approximately 13° C, nearly the same temperature as on the island. Calling continues sporadically well into summer near Corner Brook. Newfoundland toads appear to breed three years after they hatch as tadpoles, according to Buckle's observations at introduction sites.

Striped Chorus Frog *Pseudacris triseriata*

This species is found only in the Corner Brook area of the island (Figure 4). Specimens for introduction were collected by Buckle near Keel Street in the Toronto area. In 1963, 50 to 55 tadpoles were released at three locations in the vicinity of Steady Brook (14 to 19 at U.T.M. 395219, 18 at U.T.M. 402231, and 18 at U.T.M. 411238). No Chorus Frogs were located during subsequent midsummer visits to the area (Buckle 1971). However, in the early 1970's, visits to Steady Brook in early spring (when the frogs were calling) turned up a surprisingly healthy population.

In 1975, 75 tadpoles from Steady Brook were moved to a roadside pool at the west end of South Brook town (U.T.M. 536288). F. W. Schueler, A. Karstad and F. D. Ross collected two adults at this site on 3 and 6 May 1976. Chorus Frogs were still breeding in the pool in small numbers in 1981. However, Buckle could not find any in the spring of 1982. No dispersal from the pool was noted. Also, in 1975, a few tadpoles from Steady Brook were moved to Meadows Brook at the northeast end of Pinchgut Lake south of Corner Brook (U.T.M. 295090). At the same time, approximately 60 more tadpoles from Steady Brook were literally "discarded" into a cold, freshwater spring approximately 0.8 km southwest of the Meadows Brook site (U.T.M. 289087).

The first of the two transplants at Pinchgut Lake included Wood Frogs, and was not successful. The second of the two transplants was of Chorus Frogs only. It was soon forgotten because no one thought Chorus Frogs would actually breed in such extremely cold water. In 1980, Buckle was surprised to learn that they did indeed breed there and were flourishing. Chorus Frog tadpoles were also found in pools of warmer water in the same vicinity. Of course, the tadpoles in the warmer pools developed much more quickly than those in the spring. However, both groups appeared equally successful. The population at Pinchgut Lake is presently the most vigorous Chorus Frog population on the island.

In 1978, approximately 130 tadpoles from Steady Brook were moved to a site 2 km south-southwest of the Meadows Brook site at Pinchgut Lake (U.T.M. 289073). The success of this transplant has yet to be determined. Also in 1978, approximately 200 tadpoles from Steady Brook were moved to ditches along the Deer Lake Airport road. This transplant was not successful. In 1980, 20 to 30 tadpoles from South Brook were introduced to an open, wet area near the ferry terminal at St. Barbe, on the Great Northern Peninsula.

A surprising aspect of Chorus Frog existence in the Corner Brook area is the apparent ability of Wood Frogs to devastate Chorus Frog populations. The evidence is circumstantial, but may be worth considering. The 1963 introduction of Chorus Frogs at Steady Brook is a case in point. On the west side of the brook,

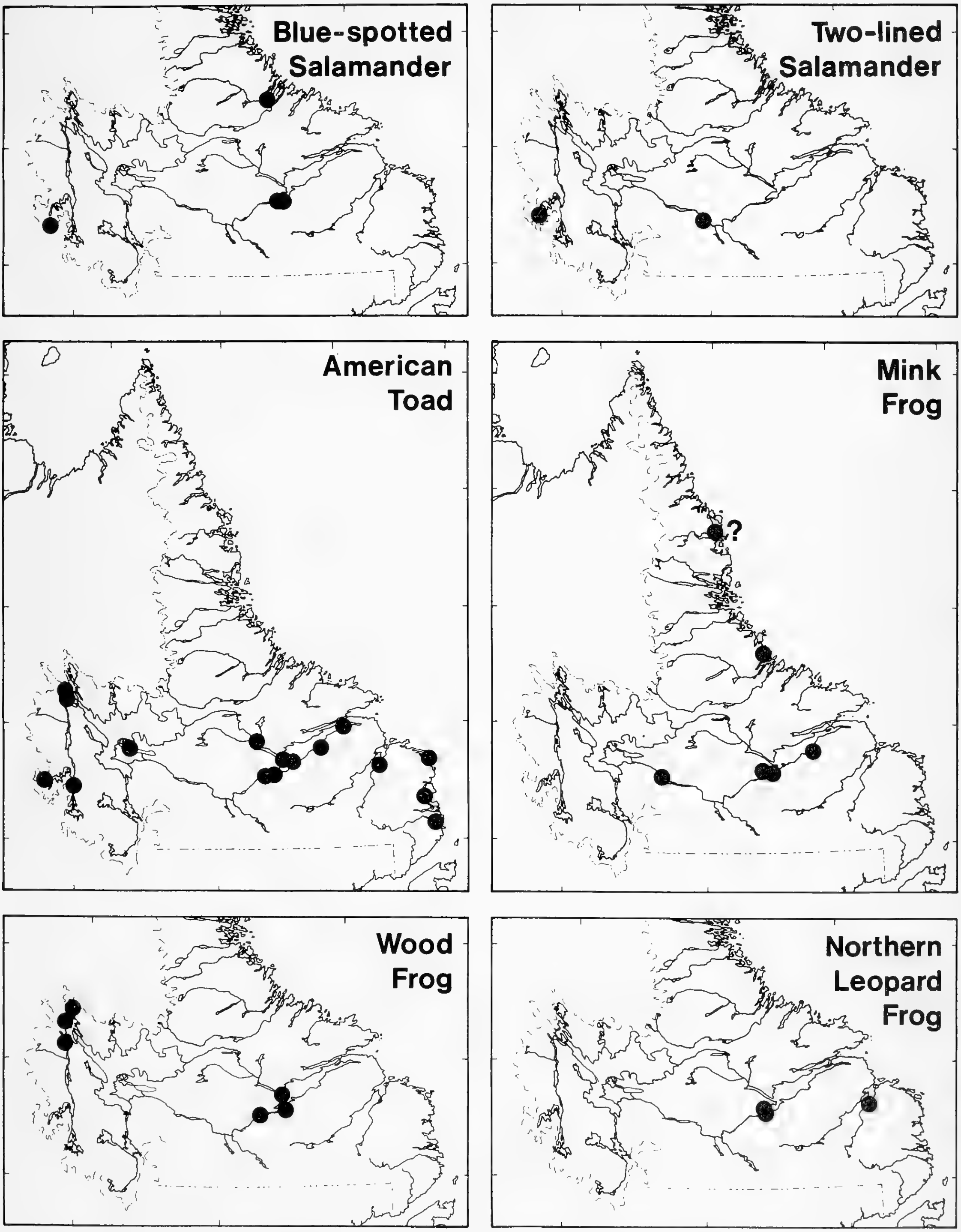

FIGURE 3. Distribution of amphibian species in Labrador. Dark circles indicate sites where species have been collected or verified.

Buckle released 14 to 19 Chorus Frog tadpoles. But, on the east side, along with 36 Chorus Frog tadpoles, he also released 50 to 55 Wood Frog tadpoles. The Chorus Frogs released on the west side of the brook gave rise to what was to become, by the late 1970's, a large and thriving population. But those released on the east side with the Wood Frogs were never seen again. Despite the initial success of the Chorus Frogs on the west side of the brook, their population began to decline rapidly as soon as Wood Frogs crossed into the brook (about 1978 or 1979). A striking example of this rapid decline occurred at a small pond below the Marble Mountain ski lift at Steady Brook. It was exclusively inhabited by Chorus Frogs until 1979. But searches in 1980 found none. Instead, the pond contained 52 Wood Frog egg masses. The situation was the same throughout the Steady Brook area. No Chorus Frogs have been recorded there since 1979.

A second case in point is the failure of Chorus Frogs at the Meadows Brook site at Pinchgut Lake (where Wood Frogs occurred), and the success of Chorus Frogs at the "cold spring" site and vicinity at Pinchgut Lake (where Wood Frogs do not occur).

These two cases cannot be satisfactorily explained by climatic factors, since the successes and failures occurred virtually side by side. Additionally, Steady Brook would seem an unlikely place to be affected since it has the most benign climate in the area. Habitat change, the likely cause of the gradual disappearance of Chorus Frogs at the established South Brook site, was not an apparent factor at Steady Brook, which has the most diverse Chorus Frog habitat of any introduction site.

The natural dispersal of Chorus Frogs in Newfoundland has been negligible. At Steady Brook, movement was less than a kilometre over the 16 years between 1963 and 1979, all this through continuously wet and open terrain. If Wood Frogs do, in fact, devastate Chorus Frog populations, it is likely that Chorus Frogs will eventually be extirpated on the island by advancing Wood Frogs (unless they are transported periodically to Wood Frog-free areas by humans).

Chorus Frogs are early breeders. Vocalization has been recorded by Buckle as early as 29 April at South Brook. Calling begins when the temperature reaches 12° to 13° C, but continues until temperatures drop as low as 8° C. The species can usually be heard as late as the first week of June.

Spring Peeper *Hyla crucifer*

Bleakney (1954, p. 166) reported a description related to him by a "naturalist-inclined M.D. student" of "tiny tree frogs with suction disc finger tips and huge vocal sacs" in a ditch near Menihek Lake Camp in Labrador. Bleakney thought the frog in question was a Spring Peeper. David Smith, of Hunter and Associates in St. John's, reported (personal communication) that he and fellow field-worker R. S. W. Bobbette heard what they believed was at least one Spring Peeper calling in the evening of 11 July 1980 at Thomas Brook in the Lower Churchill River Valley, Labrador. A specimen of this species was collected in 1974 by MacCulloch and Bider (1975) at a similar latitude, but far to the west, at Lac Nathalie, Quebec.

The status of the Spring Peeper in Labrador must still be regarded as hypothetical.

Green Frog *Rana clamitans*

In the province of Newfoundland, this species is known to occur only on the island (Figure 5). Its early history here is rather hazy. Jukes (1842, p. 187) states that "Not a frog, nor a toad, nor a lizard, nor a snake has ever been seen in the country". A quarter century later, Maret (1867) found "frogs" in ponds and lakes in the St. John's area. In 1922, Johansen (1926) found Green Frogs to be fairly common around St. John's, and noted that the frogs were "supposed to have been introduced (with hay ?) from Nova Scotia less than a century ago" and that "they [were] not found outside the Avalon Peninsula". The actual mechanism and date of introduction will likely remain a mystery.

The only previous effort to sort out the dispersal of the Green Frog in Newfoundland was made by Cameron and Tomlinson (1962). At the time of their study, the species occurred mainly over the central and eastern portions of the Avalon Peninsula, with scattered human-transplanted populations throughout the island.

During the course of "Project Frog", undertaken in 1979, a pattern of distribution emerged that loosely follows the well-established road and rail links on the island. Green Frogs are notably absent from the south coast of the island west of Baie d'Espoir (an area which still has no road or rail links except for a very recent connection at Burgeo), although there is a record of people keeping "frogs" as pets in Francois, and a record of an unsuccessful transplant to Grand Bruit. The species is also presently absent from the entire Great Northern Peninsula north of Sally's Cove, an area which has received basic road links only in recent years. Some might take this as an indication of the human influence on frog dispersal in the province. However, while human-assisted dispersal appears to be very significant, climatic conditions probably play an equally important and coincidental role. Green Frogs do not appear to occur more boreally than the outer limits of Bleakney's Herpetofaunal Section 5 (Figures 1 and 5). If this statement is accurate, it is unlikely that Green Frogs will ever be

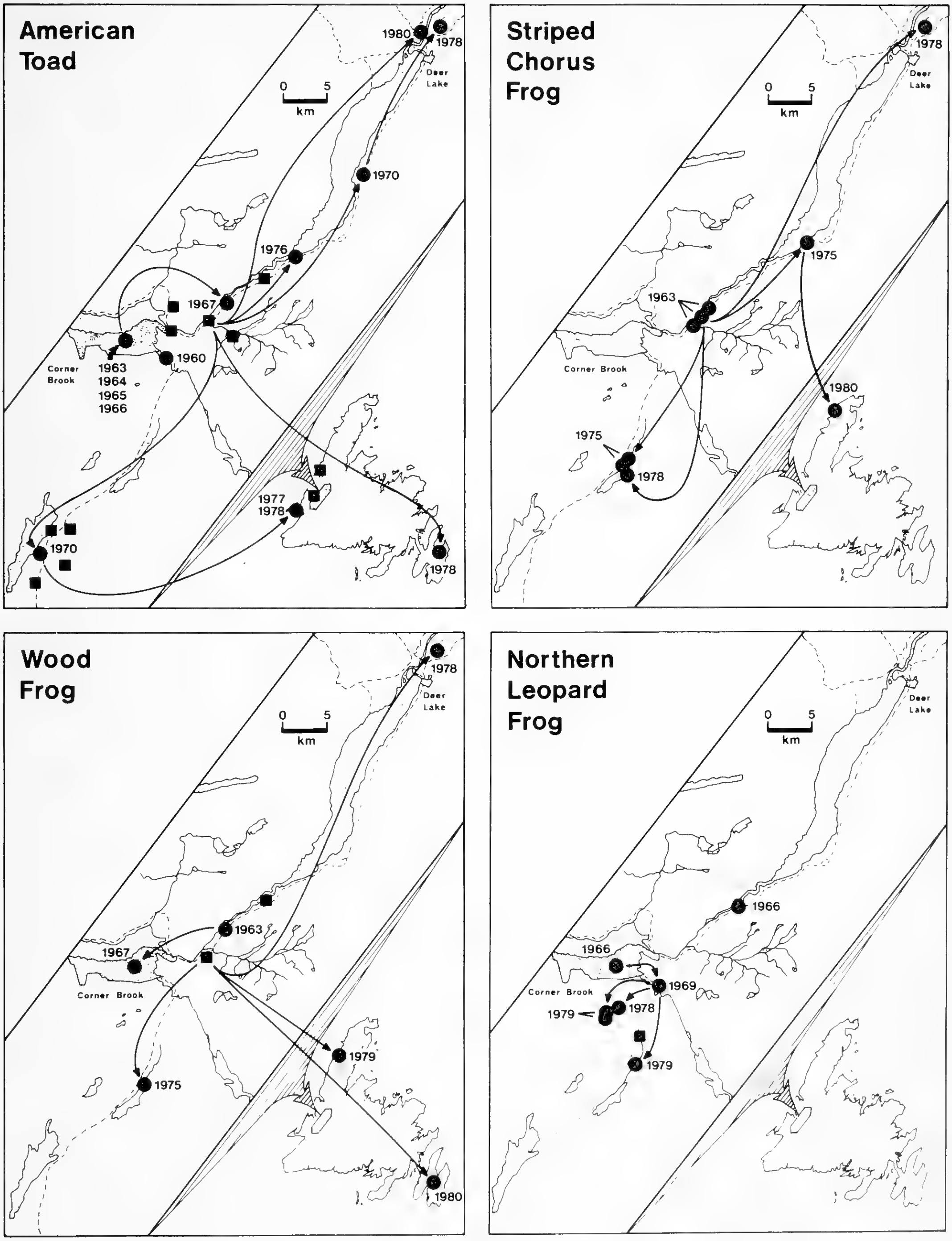

FIGURE 4. Dispersal of the recently introduced species on the island of Newfoundland. Dates indicate introductions or transplants to particular sites. Arrows indicate dispersal routes taken by transplanted stocks. Dark circles are introduction or transplant sites. Dark squares are sites to which introduced or transplanted populations have dispersed "on their own".

found in the Burgeo area on the south coast of the island, or on the Great Northern Peninsula.

As in the past, humans will almost certainly continue to be the main agents of Green Frog dispersal on the island. (According to Cameron and Tomlinson (1962), natural dispersal has averaged less than 1 km per year.) The Reverend Oliver Jackson transplanted Green Frogs to Bell Island (Wabana) "to show the children" (Ayre, 1938, p. 11). A population was transplanted to the Eastport Peninsula by Boy Scouts (who did this sort of thing often, according to Cameron and Tomlinson). About 1940, there is a record of a transplant to the Burin Peninsula (Cameron and Tomlinson, 1962). I have another record of frogs being brought to Jones' Pond near St. Lawrence "years ago", which may be the same record.

The origin of the Burin Peninsula transplants is unknown, but it is interesting to note that Green Frogs were introduced to the nearby French islands of Saint Pierre et Miquelon (specifically to Saint Pierre and the sub-island of Langlade) a few years before, in 1934 (Daniel Abraham, personal communication; Aubert de la Rue, 1937, p. 87). The species is now found throughout the French islands and evidence suggests that the present population there stems from the 1934 introduction (Daniel Abraham, personal communication).

A transplant to Springdale from the Burin Peninsula some time later is also known. Bleakney (1954) reported Green Frogs from Terra Nova village. Green Frogs have been noted at Carmanville "for about fifteen years". Sportsman and film-maker Mr. Lee Wulff, and family, brought Green Frogs to Winterhouse Pond in Daniel's Harbour (apparently an unsuccessful transplant) in 1955. At least two other unsuccessful transplants of Green Frogs to Daniel's Harbour have been made by others in recent years. Cameron and Tomlinson (1962) wrote that Mr. Leslie M. Tuck had "recently" reported Green Frogs from Port-aux-Basques and Port Saunders (none are now known to occur at the second site). Green Frogs have been transplanted to Burgeo on several occasions, the last time being in 1976 when five tadpoles were released. Apparently, no frogs have survived at Burgeo. There are numerous and widespread reports of additional transplants of two or three frogs at a time. None of these enterprises have met with known success, but indicate the public interest in moving frogs.

It seems certain that the Green Frog will continue to be successful on the island. It will likely continue to fill in the unoccupied areas within its spotty distribution. Overall, however, it may now be at the limits of its range in Newfoundland.

Cameron and Tomlinson (1962) noted that Brook Trout feed on Green Frog tadpoles. However, both species regularly inhabit the same ponds.

No one has studied the breeding biology of Green Frogs in Newfoundland. Pope (1944) found that Green Frogs in the Chicago area began egg-laying when the temperature reached 24°C. On the island, egg masses were collected by Cameron near Holyrood on 19 June 1960. The same author saw tadpoles that had overwintered on 2 July 1960 about 3 km inland from Cape Broyle. Tomlinson collected a tailed tadpole and an almost completely metamorphosed adult at Pouch Cove on 21 August 1961.

Mink Frog *Rana septentrionalis*

There are only four definite records for this species in the province, all from Labrador (Figure 3). Backus (1954) reported a specimen collected at Etagaulet Bay, Lake Melville, on 11 July 1950. Frank Phillips and Bruce Boles (personal communication) obtained a specimen (Newfoundland Museum catalogue number H-2) at Goose Cove on the Churchill River approximately 3 km above the mouth of the Metchin River in 1977. C. Schryburt, J. Mayes, R. S. W. Bobbette and D. Smith (D. Smith, personal communication) sighted five adults in a small pool on the Goose River near Goose Bay on 23 July 1980. Two were collected, but the specimens have since been lost. Frank Phillips (personal communication) reported the species to be widespread in the Goose Bay area. In addition, eggs, tadpoles and adults of this species were collected (NMC 2267-2268, 2270-2276) in 1952 by Sherman Bleakney at Mile 134 of the Quebec-North Shore Railway, just 24 km south of the Labrador border.

Packard (1866, 1891) reports a specimen from Okak that was identified as this species by E. D. Cope. Bleakney (1954) is cautious of this record, though in a later paper (Bleakney 1958) he states (p. 15) that "Recent collections have proved that Packard's report is not at all unreasonable". Hildebrand (1949), Wynne-Edwards (1952) and Backus (1954) all record this specimen as Wood Frog. Harper (1956) is skeptical of the record because of the extreme boreal nature (see Figures 2 and 3) of the Okak area. Indeed, the climate on the north coast of Labrador is far more severe than the climate in the Ungava Bay watershed to the west (Figure 2) where there is a Mink Frog record for Lac Aigneau (NMC 3209). In fact, the climate at Okak is more severe than it is even in the George River area on the east side of Ungava Bay where Wood Frogs reach the tree line and are the most boreal frogs otherwise reported on the peninsula (Bleakney 1954). An additional factor, with reference to the Okak record (which is from far beyond the tree line), is that the specimen was "presented . . . by one of the missionaries" (Packard 1866, p. 272), a statement which leaves in doubt the actual collection site.

This whole controversy causes wonder about the

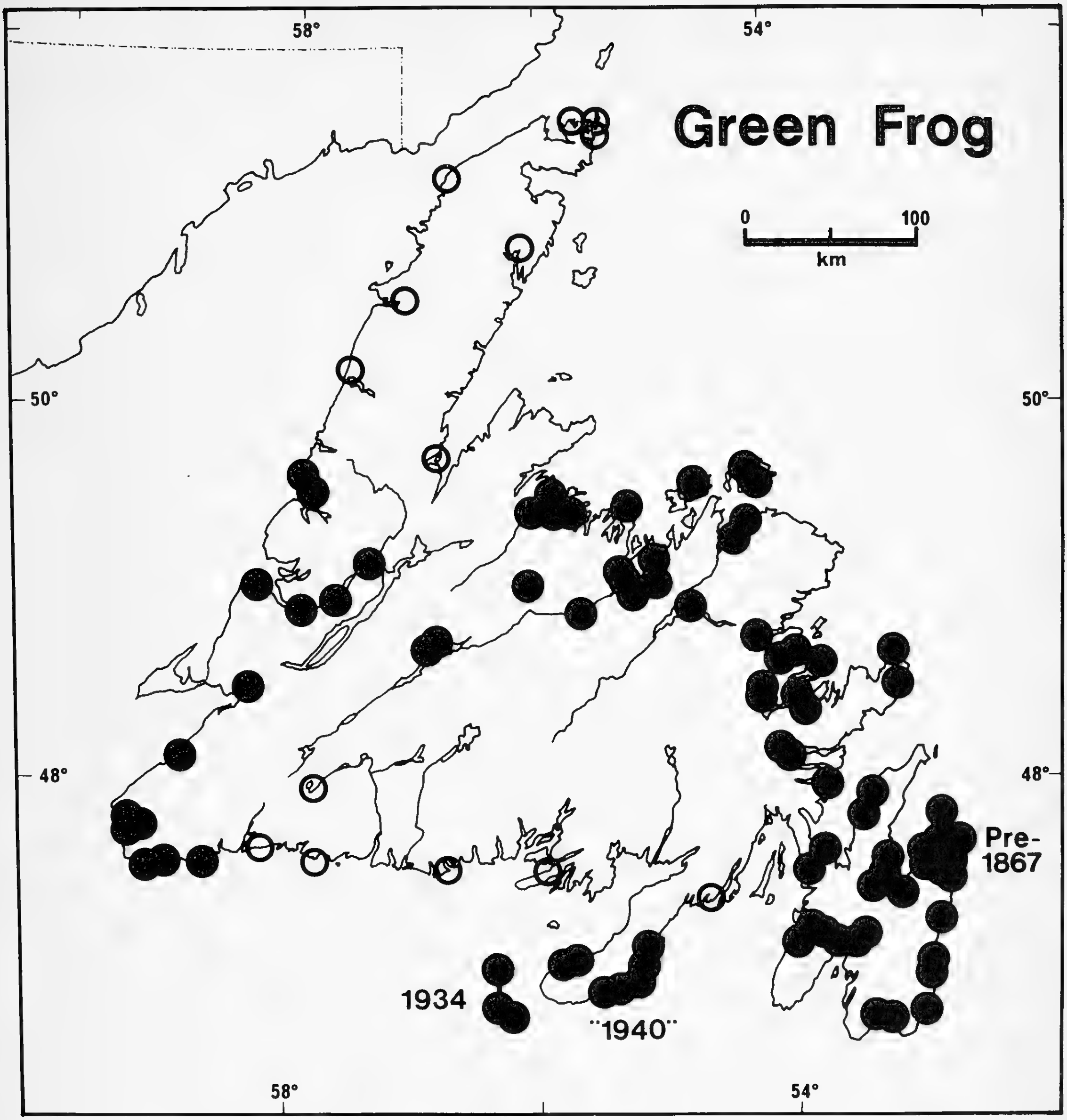

FIGURE 5. Distribution of the Green Frog (*Rana clamitans*) on the island of Newfoundland. Dark circles indicate sites where the species has been collected or verified in recent years. Open circles indicate sites where the species was sought but not found. Dates indicate known transplants, but all apparently stem from the "pre-1867" stock. Most of the information used to compile this map was contributed by "Project Frog".

other Mink Frog sightings reported by Packard (1891) for Stag Bay, Domino Harbour, Lewis Bay, and Henley Harbour to the south. Harper (1956) suggests that all of Packard's records may have referred to Wood Frogs, a species completely overlooked by him. Of interest, however, is a convincing 1976 sight record of a Mink Frog at Hopedale (Figure 3) by Eric Loring (personal communication). Loring reported what "looked like a small Green Frog".

Bleakney (1958) recorded Mink Frogs breeding between 17 and 23 June 1952 at Mile 134 of the Quebec-North Shore Railway, just south of the Labrador border.

Wood Frog *Rana sylvatica*

This species occurs in Labrador, and as an introduced species on the island.

In Labrador, the species occurs (Figure 3) at least in the western region and in the Lake Melville area (Backus 1954; Harper 1956; William Threlfall, personal communication). As suggested in the account of Mink Frogs, the reports of that species by Packard (1866, 1891) for Okak and the coast south of Lake Melville may actually have been reports of Wood Frog. Austin (1932) states that a Mr. Hettasch told him that "frogs" could be found on the Labrador coast as far north as Webb Bay just north of Nain. At least the northernmost of these "frogs" were probably Wood Frogs.

On the island the Wood Frog is found mainly near its introduction site in the Corner Brook area (Figure 4). The tadpoles used in the introduction were collected near Keel Street in the Toronto area. In 1963, 50-55 tadpoles were put in a roadside ditch 2.2 km northeast of Steady Brook bridge (U.T.M. 412238). Buckle found tadpoles numerous at the site in 1966 and 1967, and by 1968 found tadpoles as far as 0.8 km away. In 1967, 42 tadpoles from northeast of Steady Brook were put in a pool near the present site of the regional college in Corner Brook (U.T.M. 311210). By 1969, tadpoles were abundant at the site and, in 1976, adults were found there by F. W. Schueler, A. Karstad and F. D. Ross. Despite recent infilling of the pool, Wood Frogs were still present at the regional college in 1980. In 1975, over 200 tadpoles from Steady Brook were put at the northeast end of Pinchgut Lake at Meadows Brook (U.T.M. 295090). Buckle found Wood Frogs there in 1979. In 1978, approximately 1000 tadpoles from Steady Brook were moved to roadside ditches on the Deer Lake Airport road. In 1979, 100 tadpoles from Steady Brook were put 15 km into the country on the main woods road at Hawkes Bay on the Great Northern Peninsula. In 1980, two egg masses from Steady Brook were placed in a flooded fen on the Salmonier Line about 10 km north of St. Catherine's. The success of the last four transplants has not yet been determined.

Wood Frogs are firmly established on the island, at least in the Corner Brook area. The species disperses through thick spruce woods like the American Toad at a rate that Buckle has determined to average approximately 0.4 km per year.

Almost any pool will serve for breeding. Wood Frogs in the Corner Brook area lay eggs very early in the year, often in pools that skim over with ice within hours. Eggs have been seen as early as 29 April. Vocalization begins around this date and is usually finished by 21 May. At any given location the frogs can be heard for only a few days, after which time they become extremely hard to locate. Calling begins at approximately 7°C. As with other species, Wood Frogs will continue to call for a while after the temperature drops below this figure. Harper (1956) reports hearing Wood Frogs at temperatures as low as 1°C in Labrador. The same author noted the dates of first calling to be 25 May at Sept Iles, Quebec, and 5 June at Knob Lake, Labrador. At Fort Chimo, Quebec, Hildebrand (1949) reported egg masses at a stage where larvae would leave when the masses were shaken, on 21 June 1948.

Of the amphibians recently introduced to the island, Buckle has found the Wood Frog to be the most successful. Evidence for this includes its steady dispersal, and the ease with which it inhabits even the most marginal of habitats.

Northern Leopard Frog *Rana pipiens*

This species is found in Labrador and on the island. In Labrador, it is found (Figure 3) in the southcentral region near Lake Melville (Kindle 1924; Backus 1954; William Threlfall, personal communication) and at Paradise River on the coast (Austin 1932).

On the island, the species is found only near its introduction site in the Corner Brook area (Figure 4). The frogs used for introduction were collected near Malton Airport, Toronto. In 1966, 25 adults were released near the site of the present regional college in Corner Brook (U.T.M. 311210). Five more were released at the same time in a pond on the south side of the Trans-Canada Highway 6.5 km northeast of Steady Brook bridge (U.T.M. 447256) near Little Rapids. When Buckle wrote his 1971 paper, he was not aware that the introduction of this species had been successful. The introduction near Little Rapids seems, indeed, to have been a failure. The regional college site proved initially successful.

In 1969, after plans to build the college near the frog pond were revealed, 60 tadpoles from the site were put in a small pond southeast of Corner Brook near the Trans-Canada Highway (U.T.M. 349187). The college site was subsequently bulldozed, and there was no evidence of survival at the Trans-Canada Highway site. It was not until eight years later, in August 1977, that Joe Dunphy of Corner Brook caught an adult Leopard Frog at the Trans-Canada Highway pond. Since that time, the site has been seen to harbour a breeding population of Leopard Frogs, though there has been no dispersal at all to other locations. The threat of highway construction at this site arose in 1978, and 200 tadpoles were moved to Shoal Lake, almost 3 km from the highway south of Corner Brook (U.T.M. 303172). In 1979, two more transplants of tadpoles from the highway site were made to ponds south of Corner Brook. Approximately 500 tadpoles were put at Big Feeder Pond (U.T.M. 286164) and approximately 100 tadpoles were put at a small pond 1 km to the northeast (U.T.M. 290171). At the same time, approximately 500 tadpoles were put in an upstream section of Meadows Brook (U.T.M. 318117) which flows south into Pinchgut Lake.

So far, no construction has taken place at the highway site, and the population there is still flourishing. The fate of the 1979 transplants is not yet known. A search of the Shoal Lake site by Buckle in early June 1981 was unsuccessful, but tadpoles and year-old frogs were found there on August 1, 1982. Buckle also found Leopard Frog tadpoles in Meadows Pond, approximately 5 km southeast of Shoal Lake, in 1982. The tadpoles appear to have reached Meadows Pond by descending Whaleback Brook from Shoal Lake. From Meadows Pond, the species is likely to make its way down Meadows Brook into Pinchgut Lake.

Leopard Frogs in Newfoundland will move only short distances through swampy or damp terrain, and will not move at all through spruce woods, even to the next pond. Dispersal seems to require a continuous water connection. Buckle has observed Leopard Frog tadpoles being eaten by dragonfly (Odonata) larvae. They will live quite successfully with trout, and they seem to do best in clear pond water, rather than in muddy or boggy pools.

Leopard Frogs on the island are late breeders. Calling begins only when the temperature reaches 18° C. Eggs were first seen on 20 May 1979 and 18 May 1980. The breeding period is very short and is easily missed. Buckle has seen Leopard Frog tadpoles swimming lazily beneath the ice as late as 4 November although no overwintered tadpoles have yet been observed.

Acknowledgments

The origin of this study was the school-museum experiment that spawned "Project Frog". To the participating students and science teachers too numerous to list here, I wish to express my greatest appreciation for a job well done. I am deeply indebted to Jim Buckle of Corner Brook for sharing his field experience and knowledge so enthusiastically. My appreciation also to Jim's "family", Terry and Thelma Dunphy, and Joe Dunphy for their helpfulness and hospitality.

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Fish Predation and Other Distinctive Features in the Diet of Nogies Creek, Ontario, Largemouth Bass, *Micropterus salmoides*

JAMES G. HAMILTON[1] and P. M. POWLES

Biology Department, Trent University, Peterborough, Ontario K9J 7B8
[1]Present address: Booth Aquatic Research Group Inc., 532 Queen Street East, Toronto, Ontario M5A 1V2

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Fresh and back-calculated lengths and weights of fish prey pumped from 1252 Largemouth Bass (*Micropterus salmoides*) aged one to eight (95 to 500 mm TL) produced GM regressions of Y = .27x – 3.6 (lengths) and Y = .03x – 3.3 (weights) in the Nogies Creek sanctuary, 1977. The fish prey averaged only 3% of the predator's body weight, well below average available sizes, and below sizes reported elsewhere. Of the six main forage species, four showed a wide length range (15 to 125 mm TL) and significant positive correlation with their predator length. Contrarily, very narrow length ranges of 70 to 80 mm TL for Golden Shiner (*Notemigonus crysoleucas*), and 25 to 55 mm TL for basses, were consumed. Pumpkinseed (*Lepomis gibbosus*) was the most abundant prey, followed by Rock Bass (*Ambloplites rupestris*), perch (*Perca flavescens*), and several cyprinids. Next to the consumption of "small-packaged" fish prey, the most distinctive feature of Nogies Creek Largemouth Bass diet was the high predation on tadpoles. An inverse relationship was found between frog and fish diets; when frogs and tadpoles were important (up to 34% by weight, ages three to seven), fish were not. A small crayfish component (maximum 13%, at age six) and very small insect component (except for age one), characterised the Nogies Creek diet in 1977. Ages one and two took Ephemeroptera, Odonata, Pumpkinseed, and Yellow Perch, and their diet was distinct from older bass which were primarily fish/frog feeders. Bass fed from mid-April to mid-October, ceasing at 10°C water temperature.

Key Words: Largemouth Bass, *Micropterus salmoides,* fish predation, diet.

The feeding of Largemouth Bass (*Micropterus salmoidas*) in lentic habitats has been well described but only three U.S. reports deal with lotic populations, only two with fish predation, and there are few studies of the species in its northern range. In fact, only one other published study (Keast 1970) examines Largemouth Bass feeding in Canadian waters.

The food and growth of juvenile or young-of-year (YOY) Largemouth in Nogies Creek has already been described (Hamilton and Powles 1979). The object of the present study was to describe food of the adults, ages 1 to 8 and over, with emphasis on fish prey sizes ingested with increasing age. Lewis et al. (1974), described sizes of fish prey ingested by Largemouth Bass in the field and Lawrence (1958) and Tarrant (1960) showed a positive relationship between sizes of forage fish and the bass predator. But Wright (1970) failed to demonstrate this in the laboratory. Our studies were designed to document predation on Nogies Creek forage fish species to allow a future comparison with Muskellunge, and to test the validity of the "optimal foraging theory" within an open weeded lotic habitat for Largemouth Bass.

Methods

Nogies Creek is an Ontario provincial sanctuary in which environmental parameters and the fish community have been studied for some years. Specific past research projects have focussed on Muskellunge, Rock and Largemouth Bass (Crossman 1956, and Muir 1960). The sanctuary's size and characteristics have been described in Hamilton and Powles (1979). Its eutropic waters support dense aquatic plant growth and algal blooms throughout the summer, and oxygen may occasionally become low at the bottom (1 mg/L), but not limiting to fish life in the rest of the water column.

Trap net and seining studies were already available to evaluate the relative abundance of fish prey species in the community.

Field Methods

Bass were captured live, by boat-mounted electroshocker, similar to that of Novotny and Priegel (1974). Standard 6- and 8-foot trap nets were also employed during April 1977 to October 1976 and 1977. In the winter of 1977, gill nets were set under ice.

Bass, hand-netted after shocking, were anaesthetized in 1:10 000 parts $MS_{222\ TM}$ to facilitate the stomach pumping procedure. After loss of equilibrium, they were removed from the bath, weighed, measured and subjected to gastric lavage (Crossman and Hamilton 1978) and a scale removed for aging. The fish were allowed to recover and then returned to the water.

Partially digested fish species were identified by use of a reference collection of skeletons from the locality. A bone possessing unique characteristics (as the operculum in Newsome 1977) was removed from partially digested prey, and compared to a collection of disarticulated skeletons from Nogies Creek. The prey was then identified to species. Using various regression of bones on total length, a back-calculated original length of fish prey was obtained as in Newsome and Gee (1978), and Pikhu and Pikhu (1970). Lengths of fish prey were plotted as original lengths (mm TL), and weights were computed from previous records to allow direct comparison with other studies.

To determine changes in diet with size, each Largemouth Bass was assigned to a length group corresponding to an age-class.

Stomach samples were obtained from a total of 1252 Largemouth Bass, from one to eight years of age and over. The oldest fish captured was 12 years. A number of bass were captured more than once but all data were included in the analysis. Identification of prey was to species for all samples used in the partitioning analysis; otherwise, to Family or Order, in the case of partially digested organisms (except for fish). Largemouth and Smallmouth Basses were grouped together as one prey type "basses".

To compare the diet of Nogies Creek largemouth to diets in other communities, frequency and weight were chosen as a common denominator. Our samples were broken down by frequencies, and lengths were converted to wet weights. Weights of invertebrates were taken from Cummins and Wuycheck (1971) using average weights. Thus, an Ephemeropteran weight of 0.009 g and a Cladoceran weight of 3.5×10^{-5} were used to estimate weights of such small invertebrates. The weights of frogs ingested by bass were calculated from a length/weight series of formalin-preserved specimens, since all frogs were discarded from the stomach contents at the time of the gastric lavage.

Results

Fish predation

Of the 20 fish species in Nogies Creek, Pumpkinseed, *Lepomis gibbosus*, Rock Bass, *Ambloplites rupestris* and Yellow Perch, *Perca flavescens* were most abundant in 1977 along with Largemouth Bass (Table 1). Less numerous in the catches were Golden Shiners, *Notemigonus crysoleucas*, and Smallmouth Bass, *Micropterus dolomieu*. Occasionally, Carp and Yellow Bullheads, *Cyprinus carpio* and *Ictalurus natalis* occurred, along with 3 species of *Notropis*, though not all these species were trapped in 1977. Four species of frogs are common and numerous, and the invertbrate fauna (typical for the region), are quite diverse (see Hamilton and Powles 1979).

Largemouth Bass from 95 to 500 mm TL consumed fish prey ranging from 19 to 170 mm TL (Figure 1). A GM regression analysis (Ricker 1973) between length of bass and length of fish prey yielded the equation $Y = 0.27X - 3.6$, where Y is the total length of the prey and X the total length of the Largemouth Bass, both in mm. The correlation coefficient ($r = 0.67$) was significant at the 0.01 level and the 95% C.L. on $V = \pm 0.021$. For all fish prey, a linear regression characterized Nogies Creek Largemouth Bass. For Illinois, the shad prey relationship was curvilinear.

TABLE 1. Relative numbers of the common fishes taken over 428 trap-net-days in Nogies Creek, Ontario in 1977.

Pumpkinseed	*Lepomis gibbosus*	6655
Rock Bass	*Ambloplites rupestris*	3832
Yellow Perch	*Perca flavescens*	2170
Largemouth Bass	*Micropterus salmoides*	479
Muskellunge	*Esox masquinongy*	387
Golden Shiner	*Notemigonus crysoleucus*	321
Brown Bullhead	*Ictalurus nebulosus*	75
Smallmouth Bass	*Micropterus dolomieu*	7
Common Shiner	*Notropis cornutus*	6
Yellow Bullhead	*Ictalurus natalis*	1

Largemouth Bass, varying from 12 to 2100 g, showed the GM relationship between predator and weight of fish prey of $Y = 0.03X - 3.3$, where Y is wet weight of the prey and X, the weight of the Largemouth Bass in grams (Figure 2). This relationship was statistically significant ($p < 0.01$, $r = 0.62$) with the 95% C.L. on $V = \pm 0.002$. Within the size range examined, an average Largemouth Bass consumed a fish prey 3% of its own body weight in Nogies Creek. Again, the mixed prey line of Nogies Creek was linear relationship, while that for shad of Illinois (the only other comparable field data available) was curvilinear. Furthermore, the average weight of shad was for above the prey line for mixed prey of Nogies Creek.

When Nogies fish prey consumption of Largemouth Bass was broken down by length for each species (Figure 3), three clusters were apparent: 1) The length distribution of one group of prey species (Pumpkinseed, Rock Bass, Perch and Shiners) showed a uniform increase with predator size from 25 to 120 mm TL; 2) only intermediate sizes of Golden Shiner (70 to 90 mm) were consumed, and 3) the lower size-range of the Basses were ingested, from 20 to 60 mm TL. Poor positive correlations with length were thus obtained between both Golden Shiner ($r = 0.42$) and Basses ($r = 0.28$), as opposed to Pumpkinseed, Rock Bass, Perch and Shiners ($r = 0.98$, 0.87 and 0.73 respectively).

The most numerous fish species in the community was Pumpkinseed and these headed the prey list. There were 174 Pumpkinseed ingested by 753 Largemouth Bass over the 1977 feeding season (Table 2). Yellow Perch was the second most common fish prey species in spite of Rock Bass being more numerous in the waters (Table 1).

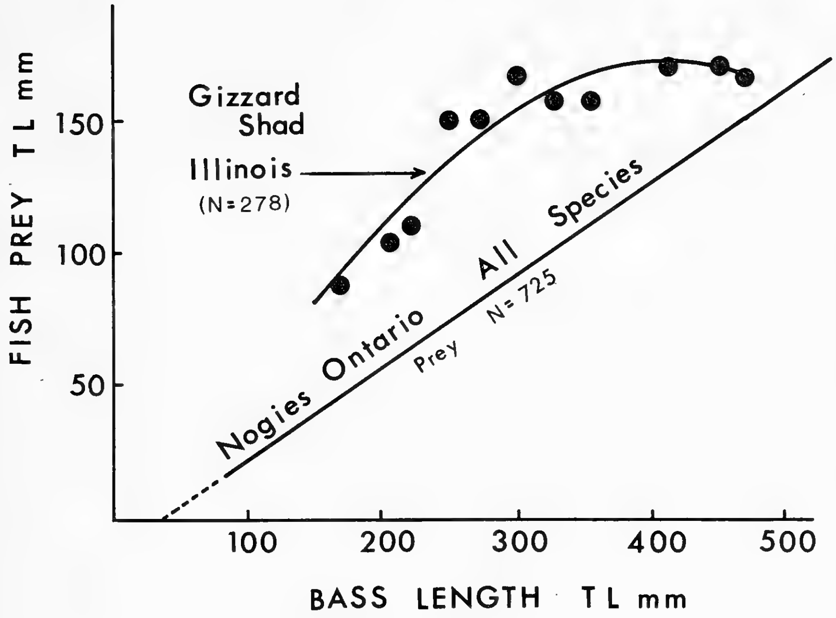

FIGURE 1. GM regression (Nogies Creek) and eye-fitted regression (Illinois) for fish prey and lengths of predator, the Largemouth Bass, *Micropterus salmoides*. (Gizzard Shad prey data from Lewis et al. 1974.)

Predation on perch was characteristic of all sizes of Largemouth, but 2- and 3-year olds (128 to 260 mm TL) ate slightly more perch than the larger sizes. Rock Bass were not eaten in quantities relative to their apparent abundance, but ranked third in importance by frequency. There was a tendancy for Rock Bass to be taken by the larger Largemouth Bass (over 305 mm TL). Of the less common species of fish prey (Table 1), Golden Shiners were taken reqularly by all ages except 1's, somewhat more frequently than would be suggested by their relative abundance in the community.

Other Food Organisms

Next to the "smallness" in the size of the fish food, the most distinctive feature of the diet of the Nogies Creek Largemouth Bass was the high frog component, particularly tadpoles (Table 2). All but the young (2- and 3-year olds) fed heavily on frogs, but ages 3 to 7 ate the most. Ages four and five were highest, with 76 tadpoles in 175 stomachs.

An interesting inverse relationship in the Largemouth Bass diet existed between frogs (tadpoles) and fish in this community (Figure 4.). In the stomachs of younger fish, tadpoles were a low component, 6%. As tadpoles built up in the diet with increasing age, the fish component decreased until age 5. Past age 5 the importance of frogs diminished and the fish contingent again became high.

The third principal component, insects, (particularly Ephemeroptera) were taken in large numbers by Largemouth Bass, but only by 1- and 2-year old bass. Older M. salmoides of Nogies Creek did not utilize this resource, nor did they consume many crayfish (25 in 753 stomachs, all ages), a common bass food.

Food Resource Overlap with Size

The type of food items ingested by different age groups of Largemouth Bass in Nogies Creek were compared statistically (Table 3), and the degree of overlap in the diets was assessed by the similarity coefficient, C_λ, as by Kislalioglu and Gibson (1977)

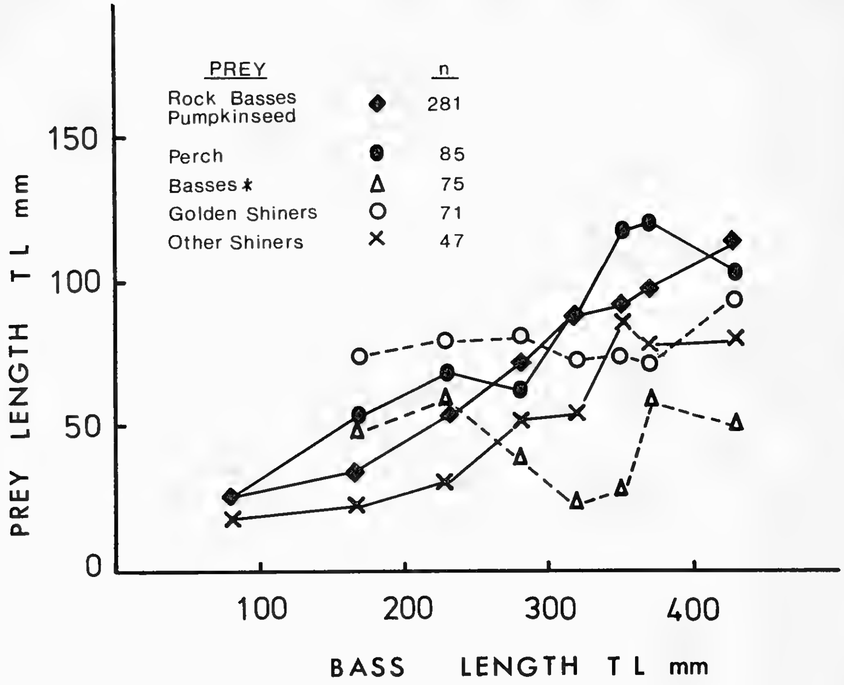

FIGURE 2. Relationships of individual prey species' lengths to length of predator, the Largemouth Bass, *Micropterus salmoides* in Nogies Creek, 1977. *Includes: largemouth and smallmouth.

and others. This coefficient varies from zero, when diets are completely distinct, to one, when the diets are similar in proportions of the prey groups or species. Thus, any value greater than 0.60 is accepted as indicating an overlap in diet.

Table 3 revealed that 1- and 2-year olds, while feeding on similar food, ate substantially different proportions of prey from all of the other age groups. From age 3 onwards, however, Largemouth Bass fed on similar proportions of the 12 main food items. The younger Largemouth Bass were responsible for most of the predation on Ephemeroptera and Odonata, as well as Pumpkinseed and Yellow Perch (Table 2). One other major difference was that age 3 fish and older ate crayfish, while the 1- and 2-year olds did not.

In summary then, 0-age largemouth from Nogies Creek ate mainly small and varied invertebrates (Hamilton and Powles 1979); 1- year olds ate tadpoles, small fish and invertebrates, and from age 3 onwards, the diets overlapped, being characterized by intake of six species of "small-sized" fish prey, a high proportion of frogs and tadpoles, followed by crayfish (of low importance).

Composition Through the Feeding Season

With regard to the length of the feeding season, some food was present in the guts from April to October (Table 4). Before the end of October (and before freeze-up) less than 50% of the stomachs contained food (52% empty in 1976, 70% empty in 1977). At mid-April, only four stomachs (20%) contained food, which was mostly vegetation. The length of the feeding season was thus estimated at about six months, mid-April through mid-October. The gill nets which we set under the ice in winter caught no Largemouth Bass, and so this conclusion is naturally

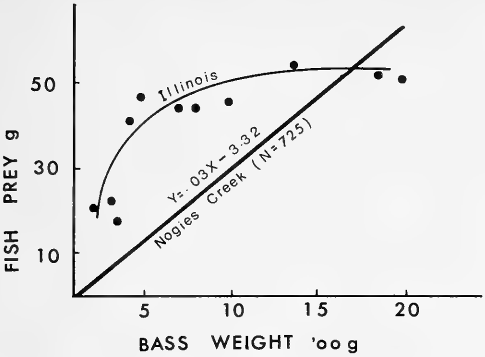

FIGURE 3. Weight of shad (Illinois, Lewis et al. 1974) prey and mixed fish-prey GM linear regression for Nogies Creek Largemouth Bass, *Micropterus salmoides*, 1977.

provisional. The other 16 empty stomachs (from April) were tightly contracted and contained heavy mucus secretions, suggesting that feeding had not occurred recently (Keast 1965). In May, feeding commenced on animal contingents, such as ephemeropterans Pumpkinseed, Golden Shiner, Rock Bass and Yellow Perch. Tadpoles were prominent in the diet along with the much smaller odonatan larvae. By June, ephemeropterans had diminished to less than 2% of the total number of food items that month, whereas tadpoles constituted 24% of the food items. Bolstered by large broods of free-swimming 0-year-old Largemouth Bass, the incidence of mixed large and Smallmouth Bass in the diet rose to 15% in June. Unidentified fishes, Pumpkinseed, Rock Bass, Golden Shiner and crayfishes were also important items in June (21.6%). In July, tadpoles (17.5%) and Pumpkinseed (17.8%) were the main food items, although Yellow Perch, Golden Shiners and Rock Bass were all of some importance. Gut contents in August were similar to those in July, although Pumpkinseed were much more important (26.1%) than tadpoles (9.4%). Fragments of vegetation were somewhat common in the diet of bass in August, amounting to 5.1% of a all food items in that month. In September, Pumpkinseed and tadpoles were again the two most frequently ingested food items (21.2 and 14.3% respectively), although Rock Bass and plant fragments represented a combined total of 25% of all stomach items.

In summary, the combined food frequencies (Table 4) over the study period indicated that ephemeropterans (all life stages, 18.8%) were the most frequent food items ingested by adult and juvenile bass in May. Tadpoles and older frogs (16.1%) represented the second most frequent food item, and these were eaten in June, July, September and October, but particularly June and October '76 and '77. Pumpkinseed (13 to 29%) were eaten mainly from July onward.

Discussion

The diet of Largemouth Bass in Nogies Creek Sanctuary was characterized primarily by a high fish component made up of prey less than 3% of the predator's weight. Unlike other areas, the young did not become steadily more piscivorous with increasing age. The 1-year olds ate a large number of small frogs and tadpoles, and this frog consumption continued over the life span of the Largemouth Bass, declining only past age five. This was probably a function of the Nogies Creek community, where frogs were extremely numerous, as were their tadpoles. In no other study of Largemouth Bass feeding was the consumption of tadpoles so high, nor the predation on crayfish so low. (Lewis et al. 1974; Seaburg and Moyle 1964; Snow 1971; and others). The frog diet appeared to complement a fish diet composed mainly of small-sized forage fish.

The only other largemouth study reporting lengths of fish prey was that of Lewis et al. (1974). The lengths of Gizzard Shad, the only fish prey measured, were considerably greater in relation to the predator, than the fish prey of Nogies Creek Largemouth Bass (Figure 1). The fish prey lengths were almost double those of Nogies Creek at the 300 mm TL predator length. The regression line for Gizzard Shad was curvilinear, whereas for our fish species it was linear for fish prey, as a whole, and for 4 of the six major prey species. The Gizzard Shad prey data of Lewis et al. (1974) when plotted on the same graph in fact, fell far above the Nogies' fish prey regression line, except beyond predator weight 1500 g. At a Largemouth Bass weight of 1800 g, the two prey regressions for Nogies and Crab Orchard Lake intersected, suggesting that the larger Gizzard Shad in Illinois waters were becoming increasingly unavailable, unattainable or not preferred. (Sevino and Stein 1982).

The other quantitative fish predation study directly comparable to ours (Lewis et al. 1974) showed that as Largemouth Bass increased in size, the prey (shad) length increased proportionately. The prey weight, expressed as a percentage of the predator weight, however, gradually decreased from 10% at 270 g to 3% at 1500 g. In the study by Lewis et al. (1974) this proportional reduction was probably a function, not of the maximum size of the prey (48 cm), but possibly of increased swimming speed of the prey as the size increased, or change in habitat of the larger shad. Within the length range of 175 to 484 mm TL, the average shad consumption was 6.2% of predator weight (Lewis et al. 1974).

TABLE 2. Percentage and numbers of organisms found in the stomachs of Largemouth Bass, *Micropterus salmoides*, in Nogies Creek, 1977, by size (age) group.

	Bass size mm TL (Age in bracket)																	
	50-127 mm (1)		128-203 mm (2)		204-260 mm (3)		261-304 mm (4)		305-336 mm (5)		337-360 mm (6)		361-380 mm (7)		380 mm 8 & over		Total	
Food items	%	Nos	%	Nos	%	Nos	%	Nos	%	Nos	%	Nos	%	Nos	%	Nos	%	Nos
FISH	60.0	(9)	78.0	(142)	83.9	(94)	51.1	(46)	50.6	(43)	49.6	(55)	75.9	(44)	92.0	(92)	69.7	(525)
Pumpkinseed	26.7	(4)	20.3	(37)	28.6	(32)	24.4	(22)	21.2	(18)	12.6	(14)	36.2	(21)	26.0	(26)	23.1	(174)
Yellow Perch	6.7	(1)	19.2	(35)	15.2	(17)	2.2	(2)	8.2	(7)	4.5	(5)	3.4	(2)	10.0	(10)	10.5	(79)
Rock Bass	6.7	(1)	6.0	(11)	4.5	(5)	3.3	(3)	10.6	(9)	10.8	(12)	20.7	(12)	33.3	(33)	11.4	(86)
Largemouth and Smallmouth Bass	—	(0)	3.8	(7)	11.6	(13)	2.2	(1)	3.5	(3)	2.7	(3)	1.7	(1)	3.0	(3)	4.2	(32)
Golden Shiner	—	(0)	4.4	(8)	11.6	(13)	11.1	(10)	2.4	(2)	9.1	(10)	10.3	(6)	9.0	(9)	7.7	(58)
Blackchin Shiner	—	(0)	2.7	(5)	4.5	(5)	4.4	(4)	3.5	(3)	—	(0)	1.7	(1)	2.0	(2)	2.7	(20)
Other fish species	—	(0)	7.7	(14)	8.0	(9)	2.2	(2)	4.7	(4)	4.5	(5)	5.2	(3)	6.0	(6)	5.7	(43)
Unidentified fish	20.0	(3)	21.4	(39)	18.8	(21)	6.7	(6)	3.5	(3)	9.9	(11)	8.6	(5)	13.0	(13)	13.4	(101)
FROGS	6.7	(1)	6.0	(11)	24.1	(24)	42.2	(38)	44.7	(38)	24.3	(27)	22.4	(13)	25.0	(25)	23.9	(177)
Tadpoles	6.7	(1)	5.5	(10)	19.6	(22)	41.1	(37)	41.2	(35)	19.8	(22)	20.7	(12)	13.0	(13)	20.2	(152)
Adult & juvenile	—	(0)	0.5	(1)	4.5	(2)	1.1	(1)	3.5	(3)	4.5	(5)	1.7	(1)	12.0	(12)	3.7	(25)
INSECTS	33.3	(5)	12.1	(22)	8.0	(9)	11.1	(10)	3.5	(3)	8.1	(9)	10.3	(6)	6.0	(6)	9.3	(70)
Ephemeroptera	26.7	(4)	7.1	(13)	0.9	(1)	2.2	(2)	—	(0)	3.6	(4)	3.4	(2)	1.0	(1)	3.6	(27)
Odonata	—	(0)	2.7	(5)	6.3	(7)	8.9	(8)	1.2	(1)	4.5	(5)	7.0	(4)	2.0	(2)	4.2	(32)
Other insects	6.7	(1)	3.3	(6)	0.9	(1)	—	(0)	2.4	(2)	0.9	(1)	—	(0)	4.0	(4)	2.0	(15)
CRAYFISH	—	(0)	—	(0)	0,9	(1)	2.2	(2)	2.4	(2)	6.3	(7)	13.8	(8)	5.0	(5)	3.3	(25)
Other invertebrates	—	(0)	1.1	(2)	2.7	(3)	1.1	(1)	—	(0)	—	(0)	—	(0)	—	(0)	0.8	(6)
Mammals	—	(0)	—	(0)	—	(0)	—	(0)	1.2	(1)	—	(0)	—	(0)	1.–	(1)	0.3	(2)
Vegetation	—	(0)	2.2	(4)	2.7	(3)	2.2	(3)	5.9	(5)	5.4	(6)	5.2	(3)	12.0	(12)	4.6	(35)
No. of Bass with food Items	15		182		112		90		85		111		58		100		753	

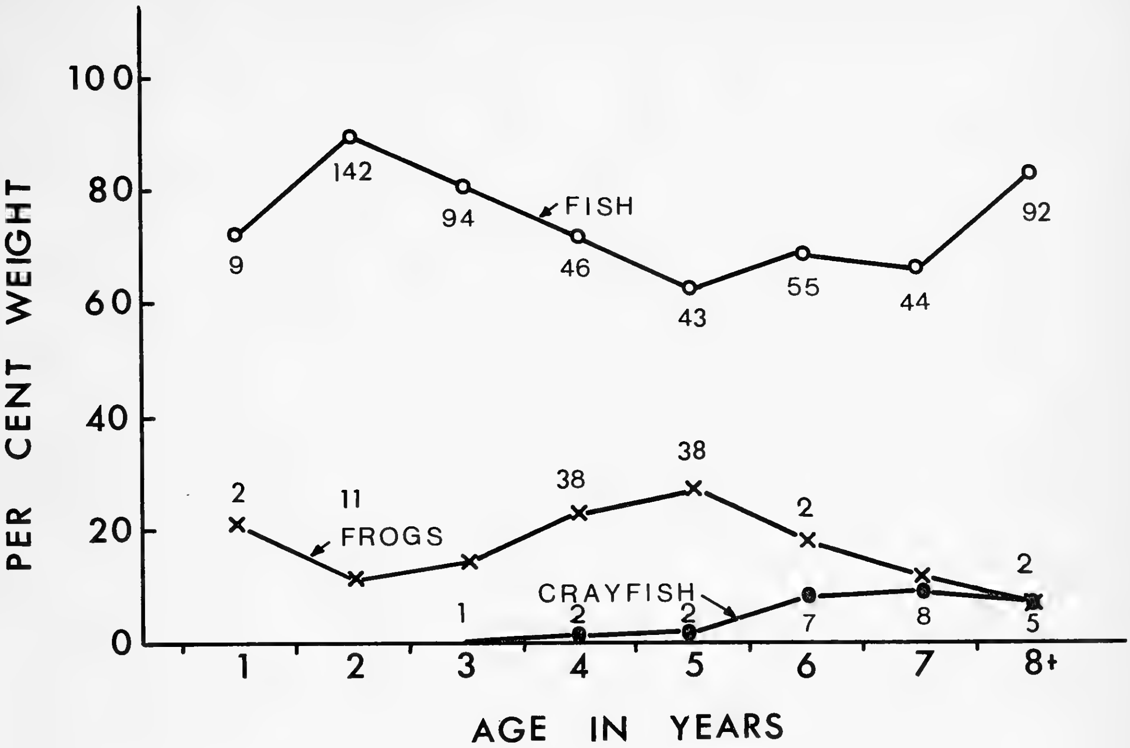

FIGURE 4. Relative weights of fish, frogs, and crayfish in the diet of Nogies Creek Largemouth Bass, *Micropterus salmoides*, 1977, by size and age-group.

In an experimental study, Werner (1977) reports that Largemouth Bass were able to consume fish 6.5% their own body weight, and obviously Lewis et al.'s (1974) samples verified this. Our Nogies Creek sampling suggested that the proportional weight of fish prey fell far below this level. Largemouth Bass of 1000 g took fish of only 2.5% of their own body weight, and bass of 2000 g consumed fish of 2.9% their body weight. Thus, it would appear that Nogies Creek bass did not feed at Werner's (1974) "maximum efficiency" (optimal foraging theory) level for fish prey. Unfortunately, there are no other field data published on prey size consumption for Largemouth Bass. Snow (1971) found prey to be mainly Bluegill, Bullheads and perch, but the weights of the fish prey organisms were not separated by predator size group, and more than half of the total food was crayfish, both by weight and frequency of occurrence. In Nogies Creek, frogs and tadpoles represent a high calorie diet (5 kcal per gram) as opposed to crayfish, at 2 kcal per gram dry weight (Cummins and Wuycheck 1971). The population thus ate small packages of high energy food rather than consuming the more typical higher weight components offered by crayfish. Snow (1971), for example, found 54.6% by weight (50% by frequency) of crayfish in Wisconsin Largemouth Bass. Generally, crayfish are not abundant in areas with detritus bottoms (Berrill 1978) such as Nogies Creek. Abundance of frogs and scarcity of crayfish probably explain the relatively heavy utilization of frogs and fish in 1976.

It is possible, though purely speculative, that the fast-growing muskellunge of the Nogies sanctuary, may "skim off" the larger prey species (Hourston 1952) leaving the smaller prey for Largemouth Bass. The other possibility is that predator success is reduced in the heavy vegetation (Savine and Stein 1982) and the smaller prey are relatively more numerous than the larger (older) fish prey.

The most efficient feeding would be achieved by ingesting larger forage as Largemouth Bass grow larger. Perhaps the tadpoles and frogs are relatively rich calorifically, and more easily digestible than centrarchids (no scales, thin skin), and being plentiful and slow, were easy to capture. This would have compensated for prey handling and smaller size of the food package in the energetics budget.

Seasonal feeding trends were rather usual or typical for bass populations. For example, spring feeding of

TABLE 3. Comparisons of the 12 main food items[1] eaten by different age classes of Largemouth Bass in Nogies Creek. The figures in the table are values for the similarity coefficient (C) as determined by Kislalioglu and Gibson (1977) in which 0.60 denotes overlap. (N = 753)

Age	1	2	3	4	5	6	7	8 & over
1	—	0.91*	0.07	0.10	0.06	0.11	0.13	0.09
2			0.31	0.23	0.22	0.30	0.33	0.27
3				0.77*	0.84*	0.89*	0.76*	0.64*
4					8.80*	0.72*	0.61*	0.47
5						0.86*	0.60*	0.52
6							0.82*	0.76*
7								0.90*
⩽ 8								—

*Denotes significant overlap in diets of the size classes.

[1] Pumpkinseed, Yellow Perch, Rock Bass, Bass (Largemouth and Smallmouth) Golden Shiner, Blackchin Shiner, tadpoles, frogs, ephemeropterans and odonatons (all stages), crayfish, and vegetation.

ephemeropterans and canibalism on basses (Table 4) were probably no more than a reflection of biotic changes in the community and in water temperature. Heavy weed growth by July in Nogies Creek may have protected some prey and hampered the predator, which are less manoeuvreable in dense weeds than are cyprinids. More energy is also expended by bass in pursuit of prey in an area with dense cover than in a sparsely covered area (Glass 1971). These factors, less available large food, and high energy costs pursuing prey, could have reduced fish feeding efficiency of the Nogies Creek bass, explaining the heavy exploitation of slow tadpoles from June to September.

Numbers, or frequency of prey items, while useful in qualitative comparisons characterizing a community's food resource, often produce a false proportion or account in terms of bulk diet constituents. For example, although in May ephemeropterans ranked 18% by frequency, they amounted to only 1.6% by weight in the total diet for that month.

In the case of fish prey, frogs and tadpoles, their importance was accentuated by documentation of weights. The fish component ranged from 91 to 66% by weight throughout the season, and frogs from 7.7 to 34% by weight, depending upon the sizes of the predator.

The length and weight breakdown of fish prey in this study certainly makes us cautious in supporting the "optimal foraging" concept for Nogies Creek Largemouth Bass. The community is of intermediate complexity, and productive, which should encourage predator stability (Glass 1971). Modified behaviour tactics are suggested on the part of basses and Golden Shiners, but we have no records on Muskellunge's fish predation. This study demonstrates the need for more community-based and controlled feeding behavioural studies for prediction and interpretation of feeding data.

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TABLE 4. Monthly percentage frequency of food items consumed by 1252 adult and juvenile Largemouth Bass in Nogies Creek, Ontario

Food items	Oct. 1976	Apr. 1977	May 1977	June 1977	July 1977	Aug. 1977	Sept. 1977	Oct. 1977	Total percentage (Actual frequency)
Pumpkinseed	—	—	6.7	10.4	17.8	26.1	21.2	23.5	14.6 (191)
Yellow Perch	—	—	2.6	1.1	11.6	15.6	5.4	5.9	6.9 (91)
Rock Bass	26.4	—	4.9	7.9	7.8	5.4	12.5	—	6.9 (90)
Basses*	—	—	—	15.8	4.1	6.2	5.4	—	5.7 (75)
Golden Shiner	4.3	—	5.1	4.0	9.0	5.1	1.8	—	5.4 (71)
Blackchin Shiner	—	—	0.8	2.5	6.3	1.4	1.8	—	2.4 (32)
Other fish	—	—	2.4	0.4	4.5	4.7	—	—	2.8 (36)
Unidentified fish	4.3	—	2.8	21.6	9.3	11.2	17.9	5.9	10.6 (139)
Tadpoles	17.4	—	6.7	24.3	17.5	9.4	14.3	17.6	13.9 (182)
Adult frogs	47.6	—	0.3	2.2	0.4	1.8	2.8	11.8	2.1 (27)
Crayfish	—	—	0.3	3.6	2.6	2.2	1.8	—	1.9 (25)
Ephemeroptera } all stages	—	—	61.2	1.4	—	1.4	—	—	18.8 (247)
Odonata	—	—	4.9	2.5	4.5	2.5	—	—	3.4 (45)
Vegetation	—	100.0	—	0.4	1.9	5.1	12.5	29.4	2.7 (36)
Other	—	—	1.3	1.9	2.7	1.5	3.6	5.9	1.9 (23)
Total No. food items	23	4	389	278	268	276	56	17	1311
Total No. largemouth bass examined	42	20	136	208	290	384	103	69	1252
Total No. of empty stomachs	21	16	33	75	108	155	50	41	499

*Largemouth and smallmouth combined

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Effects of Moose, *Alces alces*, on Aquatic Vegetation in Sibley Provincial Park[1], Ontario

D. FRASER[2] and H. HRISTIENKO[3]

Wildlife Research Section, Ontario Ministry of Natural Resources, Box 50, Maple, Ontario L0J 1E0

[1] Ontario Ministry of Natural Resources, Wildlife Research Section Contribution Number 81-15.

[2] Present Address: Animal Research Centre, Agriculture Canada, Ottawa, Ontario K1A 0C6, where requests for reprints should be sent.

[3] Present Address: Wildlife Branch, Manitoba Department of Natural Resources, Box 14, 1495 St. James St., Winnipeg, Manitoba R3H 0W9

Fraser, D., and H. Hristienko. 1983. Effects of Moose, *Alces alces*, on aquatic vegetation in Sibley Provincial Park, Ontario. Canadian Field-Naturalist 97(1): 57–61.

The effect of Moose (*Alces alces*) on aquatic vegetation was studied in Sibley Provincial Park, Ontario. Two small exclosures were built in preferred feeding lakes to protect vegetation from Moose. Both exclosures developed a dense growth of plants. In one, species palatable to Moose were much more abundant than in unprotected areas. The other lake supported very little vegetation outside the exclosure. Aquatic vegetation in a large preferred lake underwent a series of changes from the 1960's to 1980. *Nuphar variegatum* and *Potamogeton filiformis* largely disappeared, leaving the lake sparsely vegetated in some years and dominated by annuals in others. With recent reductions in Moose activity, *Nuphar* is becoming re-established. In the 23 lakes studied, *Nuphar variegatum* was absent or scarce in areas heavily used by Moose, but *Potamogeton foliosus*, an annual, was most common in such sites.

Key Words: Moose, *Alces alces*, aquatic plants, feeding behaviour.

With their remarkable appetite for twigs, Moose (*Alces alces*) can have a profound effect on the forest communities that provide the bulk of their diet (e.g., Janke 1976). Much less is known, however, about the influence of Moose on their aquatic habitats.

Isle Royale provides some of the best documentation. Evidently Water Lilies (Nymphaeaceae) were plentiful on the island in the early 1900's before Moose became established. By 1930, when Moose were particularly abundant, aquatic vegetation was greatly depleted: Water Lilies were "practically gone" and pondweeds (Zosteraceae) were scarce (Murie 1934). Aquatic vegetation had apparently recovered somewhat by 1960 (Krefting 1974), but was again depleted around 1970 (Jordan et al. 1973), corresponding to fluctuations in Moose numbers described by Peterson (1977).

Similar evidence was provided by Wright (1956) in New Brunswick. He used aerial photographs to estimate the abundance of Water Lilies in areas where Moose were common, and concluded that the plants were depleted in lakes accessible to Moose. He also recorded a depletion of Water Lilies around 1912 when Moose had been particularly abundant in the province.

In an experimental study, Aho and Jordan (1979) used exclosures to protect sections of ponds from Moose. At the end of the growing season, the standing crop was much greater in protected than unprotected areas. The only apparent effect on plant species composition was a relative increase in *Potamogeton pusillus* and *Lemna minor* in the protected parts of one pond.

While studying aquatic feeding by Moose, we realized that the animals had an important influence on both the abundance and species composition of aquatic vegetation. Here we describe this influence by reporting (1) a study using exclosures in two ponds heavily used by Moose, (2) plant succession in a well used lake, and (3) species composition of 23 lakes in relation to Moose activity.

Study Area

The study was done in Sibley Provincial Park, Ontario (48° 20′N, 88° 45′W), a 243-km^2 peninsula of principally boreal forest on the north shore of Lake Superior. The Park is closed to hunting and trapping, and supports conspicuous populations of Moose, White-Tailed Deer (*Odocoileus virginianus*), Black Bears (*Ursus americanus*), Beavers (*Castor canadensis*), and some Timber Wolves (*Canis lupus*). The Park includes 37 named lakes, plus numerous small, unnamed lakes and ponds. Most of the water bodies are <50 ha in surface area and have soft organic sediments; many are <2 m deep. Rock outcropping in the peninsula consists mainly of Precambrian sediments which impart a higher mineral content to the lake water than is common in granitic areas of the Precambrian Shield. Total alkalinity of the water is typically 15 to 150 ppm $CaCO_3$, with pH from 6.5 to 8.5.

Methods

During June 1978, a sturdy exclosure was built in each of two small lakes, called Lakes 7B and 24A, that were heavily used by Moose. (Locations on the UTM Grid are 5369100 m N, 370500 m E for Lake 7B, and

5358100 m N, 369800 m E for Lake 24A). Each exclosure covered 4.5 m^2 of lake bottom in about 50 cm of water. They consisted of steel pipes driven into the lake sediment, with cross bars secured by scaffolding clamps. The structure was covered in welded wire screening with openings 3 × 3 cm.

Exclosures were inspected several times in 1978 to 1980. Plants growing inside were harvested on 12 July 1979 and 29 July 1980 for Lakes 24A and 7B respectively. Lake bottom inside the exclosures was divided into 12 plots each 61 × 61 cm. The vegetation in each plot was uprooted by hand. It was then sorted by species; roots and rhizomes were removed from all species except *Eleocharis acicularis* (which has a very small root system); the number of stems was counted for all species except *E. acicularis* and the Characeae; and the wet weight of each species was recorded after the vegetation had drained in the air for 5 sec.

A strip of five control plots, also 61 × 61 cm, was marked out on each side of the exclosures in water of similar depth and over a similar type of substrate extending 1–4 m from the exclosure. Plants in these plots were harvested and treated in the same way. Plants elsewhere in the lake were examined to ensure that control plots were typical of similar parts of the lake.

Moose activity was studied from 1976 to 1980 in Joeboy Lake (UTM Grid 5370000 m N, 372500 m E), a known feeding area for Moose. Observations each year consisted of five to eight 3-h shifts between mid-June and mid-July, with half the shifts from 0600 to 0900 and half from 1800 to 2100. During shifts, an observer at a fixed shoreline location scanned the lake every 15 min and recorded the number of moose seen.

Cobus (1972) also studied Moose behaviour in Joeboy Lake in 1971. He recorded the number of Moose present in the lake in scans at 15-min intervals throughout daylight hours about 2 days per week. Because he presented his data by time of day for the early summer (his Fig. 3), it was possible to calculate the mean number of moose seen per scan from 0600 to 0900 and from 1800 to 2100. His results are based on about 12 mornings and 12 evenings from 1 June to 14 July.

In 1975 to 1979, we made occasional notes on the vegetation in Joeboy Lake in spring and early summer, and did a quantitative survey during 1 or 2 days during late summer (26 July to 3 September). Each survey was based on 342 to 410 non-permanent plots at about 3 m intervals along four transect lines which were traversed by canoe. Approximately the same lines were used each year. In each 75 × 75 cm plot, the observer estimated the percentage of lake bottom covered by each plant species as if seen from above. In 1980, the four lines were traversed more quickly, and notes were made on plant abundance.

Our entire study included 24 lakes in Sibley Provincial Park. Detailed information on Moose activity, lake surface area, mean water depth, shoreline type, organic content of the sediment, water chemical composition, and plant abundance will be given in a separate report. Briefly, preliminary study indicated that the relative amount of aquatic feeding in a lake could be assessed at the end of the feeding season from the amount of Moose tracks, trails, summer dung piles, and other signs around the lake perimeter. Therefore, Moose activity on the 24 lakes was rated subjectively from high (5) to none (0) based on these signs in August and early September, 1977. Records of moose sightings at the more accessible lakes generally agreed with the subjective ratings. Abundance of different species of aquatic plants was also estimated in each lake in late summer of 1977. A canoe or boat was paddled near the shoreline and in several lines criss-crossing the lake. Areas with <2 m of water were divided into convenient sections. Abundance of each plant species was estimated in each section as the approximate percentage of lake bottom covered by the plants as if seen from above without interference of other vegetation. Estimates from the sections were then combined to give estimated abundance in shallow water areas (<2 m) for each lake.

To determine the effect of Moose activity on vegetation, we did stepwise multiple regressions of the abundance of each plant species (expressed as percentage of all vegetation in the lake) on the Moose activity rating and other variables. Only plant species represented in 10 or more lakes were included. Logarithmic transformations were used to reduce skew in the distributions. One lake (Calcite Lake) was omitted because the indirect and direct measures of Moose activity did not agree. Because the many variables gave considerable opportunity for chance associations, the 1% level of statistical significance was used.

For all plants listed, voucher specimens were pressed and are located in the herbarium of the University of Waterloo, Waterloo, Ontario. Plant names follow Fernald (1950).

Results

Exclosures

Lake bottom inside the exclosures was trampled during construction in June 1978. In the Lake 24A exclosure, numerous small *Potamogeton alpinus* and *P. epihydrus* were growing by late summer of 1978, apparently from rhizomes which had grown into the exclosure from outside. When harvested in July 1979, the exclosure was crowded with plants. Expressed as weight per plot, the exclosure contained 10 to 20 times more *Potamogeton alpinus, P. epihydrus,* and Characeae than control plots, but similar amounts of *Eleocharis acicularis* (Table 1). Plots in the exclosure also

TABLE 1. Mean ± SD weight (g) of aquatic plants harvested from 12 plots in the exclosure and 10 unprotected control plots in Lake 24A.

Species	Exclosure	Control	P^1
Eleocharis acicularis	169 ± 83	190 ± 119	n.s.
Potamogeton alpinus	121 ± 93	5 ± 4	<0.002
Characeae	35 ± 20	3 ± 3	<0.002
P. epihydrus	27 ± 27	3 ± 3	<0.05
P. foliosus	5 ± 4	0 ± 0	<0.002
Najas flexilis	3 ± 3	2 ± 2	n.s.
Myriophyllum verticillatum	2 ± 4	0 ± 0	n.s.
Hippuris vulgaris	0 ± 0	1 ± 3	n.s.
P. berchtoldi	0 ± 0	1 ± 1	n.s.

[1] Statistical significance of the difference by the Mann-Whitney *U* test, 2-tailed.

contained more stems of *P. alpinus* and *P. foliosus* than plots outside ($P < 0.002$).

P. alpinus and *P. epihydrus* from the exclosure were more mature and had greater weight per stem. Exclosure plants had generally grown to the water surface and had developed floating leaves and fruit. Those outside were shorter, with only submersed leaves.

By July 1978, the 7B exclosure had developed a dense growth of *Potamogeton foliosus*. The rest of the lake was sparsely vegetated, mainly with small clumbs of the same plant. In 1979, the expected crop of *P. foliosus* failed to develop in Lake 7B and in several other lakes. The exclosure contained a sparse growth of Characeae, similar to the rest of the lake, plus a few stems of *Sparganium chlorocarpum* and *Sagittaria latifolia*. By July 1980, the last two species formed a dense growth in the exclosure, but the rest of the lake had almost no vegetation. Plant weights per plot averaged 1890 ± 920 g (mean ± SD) for *Sparganium chlorocarpum* and 30 ± 60 g for *Sagittaria latifolia* in the exclosure. There was almost no vegetation in the 10 control plots.

Joeboy Lake

There was a pronounced decline in Moose activity on Joeboy Lake between 1971 and the later years (Table 2). Cobus (1972) noted that Moose activity was highest in mid-June to mid-July. Therefore the inclusion of early June in his results, in contrast to our later results, could not account for the higher values in 1971.

TABLE 2. Number of 3-h observation shifts on Joeboy Lake during mornings and evenings, first and last dates of shifts, and mean number of Moose seen during scans of the lake in six years.

Year	Shifts	Dates	Mean no.
1971[1]	24	1 Jun-14 Jul	5.0
1976	5	21 Jun- 1 Jul	2.6
1977	8	21 Jun-14 Jul	0.4
1978	8	17 Jun-16 Jul	1.9
1979	7	25 Jun-17 Jul	0.7
1980	8	19 Jun-15 Jul	0.4

[1] Recalculated from Cobus (1972, Figure 3).

Residents of the area report an abundant growth of yellow Water Lilies (*Nuphar variegatum*) in the lake in the 1960s. Subsequently the plant was almost eliminated. Cobus (1972) considered *Potamogeton filiformis* the most abundant and preferred plant in the lake in 1971. He presented a map showing "dense beds" of the plant covering about 30% of the lake (his Fig. 1), and noted that Moose concentrated on these beds. Cobus listed the larger pondweeds (*P. amplifolius* and *P. richardsonii*) as second in importance to Moose in the lake, and *Nuphar variegatum* as third. Our 1975 survey showed only 6% of the lake's surface to be covered in vegetation. The dense beds of *P. filiformis* previously mapped by Cobus were largely devoid of vegetation, and the species was judged to cover less than 0.1% of the lake. Most specimens of *Nuphar* were very small (leaf diameter about 3 cm) and may have been seedlings.

Najas flexilis and *Potamogeton foliosus*, which grew as annuals, played a large but variable part in subsequent years. The 1975 survey estimated 6 to 7% plant cover. *N. flexilis* was the most common plant with 3% cover, followed by the large pondweeds at 2%. In 1977 and 1978, plant cover exploded to 42% and 55% respectively because of an abundant growth of *P. foliosus* and *N. flexilis* which together accounted for most of the vegetation. The larger pondweeds were next at 3%. *P. filiformis*, covering 1% of the lake, was much more common than in 1975 and 1976.

In 1979 there was a poor crop of pondweeds and an almost total failure of *P. foliosus* in several lakes. Reasons for this are unknown, but the late spring may have contributed. Plant cover in Joeboy was 4%. However, there were many large specimens of *Nuphar variegatum* (leaf diameter of 20-30 cm). In 1980, large *N. variegatum* were judged to cover 1% of the lake, and Moose were seen feeding steadily on the species for the first time since our observations began in 1976.

Based on the description by Cobus (1972), average water depth appeared not to have changed from 1971 to 1980. However, water depth declined from spring to late summer by 10-20 cm in most years, causing shallow shoreline areas to become exposed mud.

Comparison of Lakes

The abundance of *Nuphar variegatum* in the 23 lakes was closely related to Moose activity (Table 3). In the six lakes heavily used by Moose, *N. variegatum* comprised only 0.4 ± 0.8% of the vegetation (mean ± SD), compared to 7.1 ± 6.2% in the other 17

TABLE 3. Moose activity rated from high (5) to none (0), and abundance of two plant species expressed as percent of all aquatic vegetation in the lake for 23 lakes.

Lake	Moose activity	*Nuphar variegatum* (%)	*Potamogeton foliosus* (%)
7B	4.6	0.0	82.0
24A	4.4	2.0	4.0
Joeboy	4.3	0.1	56.0
Gardner	4.0	0.1	30.0
15D	3.7	0.0	13.0
Talus	3.1	0.01	0.0
Lizard	2.5	19.0	0.03
Ferns	1.6	2.0	12.0
Norma	1.6	8.0	0.0
Pickerel	1.5	7.0	2.0
7A	1.3	17.0	2.0
15A	1.3	0.7	3.0
Kay	1.2	5.0	0.0
Legend	1.0	0.6	0.0
Grassy	0.8	0.2	0.4
Holt	0.8	1.0	0.0
Sawbill	0.8	7.0	6.0
1A	0.6	3.0	2.0
Rita	0.6	13.0	0.01
13A	0.5	10.0	0.02
Helen	0.4	17.0	0.0
1B	0.3	5.0	0.1
Norwegian	0.3	5.0	9.0

lakes. Most specimens from heavily used lakes had small leaves (3-10 cm diameter), spindly petioles, and they rarely flowered. Conspicuous beds of *N. variegatum* were confined to lakes with little Moose activity. The Moose activity rating was the only factor included in the stepwise multiple regression ($r = -0.56$, $P < 0.01$).

Potamogeton foliosus was most abundant in the heavily used lakes (Table 3). It comprised 31 ± 32% of the vegetation in the six heavily used lakes (mean ± SD), but only 2 ± 4% in the other 17 lakes. Stepwise multiple regression included the Moose activity rating as the first factor ($r = 0.61$, $P < 0.01$), and total phosphorus in the water as the second factor ($r = 0.52$, $P < 0.01$) related to abundance of the plant.

Abundance of the other plant species was not significantly related to Moose activity. Relationships between plant abundance and other lake variables will be reported separately.

Discussion

These studies suggest that Moose have a complex influence on aquatic vegetation.

In some cases, presumably, the animals simply remove preferred food items by grazing. The dense growth of *Potamogeton alpinus* and *P. epihydrus* in one exclosure, and the initial growth of *P. foliosus* in the other, contrasted sharply with the sparse development of the same species in unprotected areas. Since these species are highly palatable to Moose (D. Fraser, unpublished data), their depletion outside the exclosure was likely due to grazing. *Eleocharis acicularis* is not a preferred food item, and was about equally abundant in protected and unprotected areas.

Some species are probably depleted by Moose through mechanical disturbance rather than grazing. Emergent species such as *Sparganium chlorocarpum* and *Sagittaria latifolia* normally contain substantially less sodium than submersed or floating-leafed plants (Boyd 1978), and do not appear to be eaten a great deal by Moose. Suppression of these species in the unprotected areas of Lake 7B was probably caused by repeated disturbance when Moose sought preferred vegetation. In some areas, Moose activity may also influence plant growth by increasing the turbidity of the water (Aho and Jordan 1979), or by causing disturbed sediments to settle on the vegetation.

Some plants appear to be particularly vulnerable to disturbance. Depletion of *Nuphar variegatum* by concentrated aquatic feeding has been mentioned repeatedly in the past and is fully supported here. Although not the most preferred species of aquatics (D. Fraser, unpublished data), *Nuphar* seem greatly affected by herbivory. For example, Seton (1953: 172) describes killing a bed of Water Lilies by repeated clipping of the leaves and petioles. Many other aquatic species, however, seem to survive substantial removal by herbivores (Aho and Jordan 1979).

In contrast to *Nuphar, Potamogeton foliosus* flourished in preferred feeding areas even though it is readily eaten by Moose (D. Fraser, unpublished data). Unlike most other pondweeds that usually developed from rhizomes or winter buds, *P. foliosus* commonly grew annually from fruit. This probably imparted a competitive advantage in areas where rhizomes are continually disturbed by Moose. Once the disturbance is removed, as in the exclosure in Lake 7B, *P. foliosus* would presumably be choked out by perennials.

In Joeboy Lake, the rapid changes of vegetation may have been influenced by the exceptionally shallow water and soft sediment as well as the activities of Moose. However, the depletion of *Nuphar variegatum* and the trend toward annuals (*Potamogeton foliosus* and *Najas flexilis*) are consistent with the apparent effects of Moose observed in other lakes.

Moose seem particularly attracted by lakes with a mineral soil substrate such as the clay-bottomed Lake 7B and the silt-bottomed Lake 24A (cf. Fraser et al. 1980). Such sites can be puzzling when first encountered. The intense Moose activity at Lakes 7B and 24A was obvious from tracks and trails, but 7B had very little vegetation, and 24A was dominated by *Eleocharis acicularis* which Moose rarely appear to eat. At first glance, one might suppose that these sites were unproductive aquatic habitat, and that Moose were attracted by something other than aquatic plants.

The exclosures show, however, that these are fertile sites that would be crowded with aquatic plants but for the devastating effect of the Moose. We suggest that Moose continue to use these areas despite their depleted vegetation because of some superior quality of the plants imparted by the mineral soil bottom. Science belatedly came to recognize that the sediment is important in the nutrition of aquatic plants (Hutchinson 1975: 276). Moose probably knew this long ago.

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Survival of Female Black Ducks, *Anas rubripes*, During the Breeding Season

JAMES K. RINGELMAN[1,2] and JERRY R. LONGCORE[3]

[1]School of Forest Resources, University of Maine, Orono, Maine 04469
[2]Present address: Colorado Division of Wildlife, 317 W. Prospect Rd., Fort Collins, Colorado 80526
[3]Maine Field Station, Patuxent Wildlife Research Center, U. S. Fish and Wildlife Service, University of Maine, Orono, Maine 04469

Ringelman, James K., and Jerry R. Longcore. 1983. Survival of female Black Ducks, *Anas rubripes*, during the breeding season. Canadian Field-Naturalist 97(1): 62–65.

The Mayfield method was used to estimate the survival rate of 19 radio-marked, female Black Ducks (*Anas rubripes*) in southcentral Maine during 1977-80. An overall survival rate of 0.74 was estimated for the 121-day monitoring period that included the pre-laying and laying, incubation, brood rearing, and post-rearing stages. No differences in survival rates were detected among these stages. Two instrumented hens were killed by Red-shouldered Hawks (*Buteo lineatus*) and a third was killed by an unknown predator. We found no evidence that the attachment of radio transmitters affected hen survival.

Key Words: Black Duck (*Anas rubripes*), biotelemetry, Maine, mortality, survival rate

To understand changes in waterfowl populations it is important to know how annual mortality is partitioned between hunting and non-hunting causes, as well as among specific periods of the annual cycle (Anderson and Burnham 1976:42). It is particularly important to obtain such information for the Black Duck (*Anas rubripes*), a heavily-hunted species that has declined in numbers and for which seasonal mortality estimates are lacking. Because of low band recovery rates during non-hunting periods and the difficulty in detecting deaths of wild, unmarked waterfowl, recent studies (Gilmer et al. 1974; Kirby and Cowardin in press) have used radio-equipped ducks to estimate survival during the breeding and post-breeding period. In the present study, we use biotelemetry to estimate survival rates of adult female Black Ducks in southcentral Maine breeding habitat.

Study Area and Methods

The 151 km^2 study area was located 30 km southwest of Bangor, Maine. The area supported 28-32 Black Duck pairs/year on 112 wetlands typical of the evergreen and deciduous scrub-shrub, deciduous forested, and emergent wetland types (Cowardin et al. 1979) found in the Northeast. Detailed descriptions of the study area are presented by Ringelman (1980).

Nineteen female Black Ducks were captured during 1977-80 (five in April, 10 in May, two in June, and two in July) with nest traps (Coulter 1958) and rocket nets (Wildlife Materials, Carbondale, Illinois: use of trade names does not imply U.S. Government endorsement of products). Birds were fitted with adjustable (Dwyer 1972) back-mounted radio packages (Cedar Creek Bioelectronics Laboratory) weighing 20-25 g with an effective range of 1.5-3.0 km. Transmitter life ranged from 20 to 120 days ($\bar{x}$ = 63). Hens were located 3-4 times/day from mobile tracking vehicles by conventional telemetry techniques. Locations of marked females were plotted on U.S.G.S. topographic maps (1:64 000) to a resolution of 1.0 ha. If a bird remained in an area for >2 days and its radio signal indicated inactivity, we visited the site and determined whether the duck was dead or alive and healthy. Rustrack (model 288) recorders coupled to receivers (AVM Company model LA12) and 3-element yagi antennas allowed continuous monitoring of 16 females. Recorder stations detected attenuations in radio signals that indicated duck activity.

Visual observations of radio-equipped females were made once every three days, and individuals were occasionally flushed to reaffirm that transmitters were not inhibiting flight. Field necropsies of marked birds were conducted to determine cause of death and general condition.

Survival rates were calculated by a method originally developed for determining nesting success (Mayfield 1961, 1975) and recently applied in survival studies of ducklings (Ringelman and Longcore 1982) and adult ducks (Kirby and Cowardin *in press*). Known days of survival represented days of "exposure", and time of death was estimated as one-half the interval between the last date the bird was known to have been alive and the date that death was confirmed. The breeding season was partitioned into four stages: pre-laying and laying, incubation, brood-rearing, and post-rearing. Unsuccessful nesters were assigned to the post-rearing period following their final nesting attempt. Because hens were captured before or during incubation, birds were assigned to the brood-rearing or post-rearing stages based on behavioral data obtained by telemetry. Estimates of the duration of the prelaying-laying (16 days) and incubation (26 days) stages were used to back-date reproductive phenology and determine exposure for these early intervals. Comparisons of survival rates follow procedures described in Johnson (1979).

Results and Discussion

Three of 19 instrumented Black Ducks died during the monitoring period; one during pre-laying and laying, two during post-rearing and none during incubation and brood-rearing (Table 1). Differences in survival rates could not be detected among stages ($p > 0.10$); thus the overall survival rate for the 121-day season was estimated as 0.74 (the probability of surviving 1 day, 0.99748, times itself 121 times). All dead birds had been killed by predators. Two ducks (one pre-laying, one post-breeding) were killed by Red-shouldered Hawks (*Buteo lineatus*), and a third female just completing the wing-molt was killed by an unknown predator. Another unmarked, incubating hen (not included in our estimate of survival) was killed by a Raccoon (*Procyon lotor*). All predator-killed ducks were in good body condition when recovered, exhibiting no lesions or other debilitating physical effects attributable to the transmitter packages, and two of those birds whose esophagi were examined had been feeding immediately before death.

Although it has been suggested that predation accounts for a small portion of nonhunting mortality in waterfowl (Stout and Cornwell 1976), it may have a disproportionately large effect on population levels by affecting nesting success (Duebbert and Lokemoen 1980) and sex ratios (Johnson and Sargeant 1977). Reduced survival rates of breeding and molting females, when examined in a computer simulation model, showed a potentially significant effect on the Black Duck population (Ringelman and Longcore 1980). Common predators of adult Black Ducks include large raptors (Mendall 1944, Wright 1954; Appendix II), Red Foxes (*Vulpes fulva*; Wright 1954: Appendix II), and Raccoons (Stotts 1959;168, Stotts and Davis 1960). Although Mendall (1944) reported no waterfowl remains in 14 stomachs of Red-shouldered Hawks in Maine, this species obtains most of its prey from wetland habitats (Bednarz and Dinsmore 1981). Thus Red-shouldered Hawk predation on Black Ducks in our study is not implausible.

It is important to assess the effects of instrumentation on survival because the validity of survival rate estimates derived from radio-equipped ducks is contingent upon marked ducks experiencing the same mortality factors as the wild, unmarked population.

We flushed instrumented females on over 30 occasions, and none exhibited reduced flight ability. Some hens preened excessively around the transmitter during the week following instrumentation, but this behavior was not apparent after a one-week acclimation period. However, we could not determine whether the death of the hen during the pre-laying and laying period, which occurred during the first week of instrumentation, was related to behavioral changes associated with instrumentation. Three Black Ducks (1 male, 2 females) with radio packages still attached one year following instrumentation, were observed on the study area and all were paired with new mates and behaving normally. One of these females that we recaptured was of average weight and body condition, and showed no skin abrasion or feather wear beneath the harness or transmitter. Habitat preferences of marked and unmarked Black Ducks on our study area were similar (Ringelman 1980:22).

Caution must be used when interpreting published accounts of the effects of transmitter packages on duck behavior and survival (Schladweiler and Tester 1972; Greenwood and Sargeant 1973; Gilmer et al. 1974; Kirby and Cowardin *in press*), because harness configuration, transmitter size and weight, temperament of individual birds, and especially the care taken in installing the harness may influence behavior and survival. A review of previous studies, along with our data on instrumented Black Ducks, leads us to conclude that the capture, handling, and instrumentation of free-living *Anas* species does not cause biased survival estimates during the breeding and early post-breeding seasons.

TABLE 1. Survival rates of radio-marked, female Black Ducks during four stages of the breeding season.

Period	N	Period length (days)	Exposure (days)	Deaths	Period survival rate	95% Confidence interval
Pre-laying and laying	18	16	278.5	1	0.94	0.84–1.06
Incubation	15	26	299.0	0	1.00	
Brood-rearing	6	45[a]	175.0	0	1.00	
Post-rearing	13	34[b]	438.5	2	0.86	0.69–1.07
Totals		121	1191.0	3		

[a] Length equals the average number of days that two radio-marked hens remained with broods (43–48 days).

[b] Length equals the average number of days birds were monitored during this period.

The breeding season survival rate (0.74) for Black Ducks does not differ ($P > 0.50$) from survival estimates obtained from radio-marked female Mallards (0.73) breeding in northcentral Minnesota (Kirby and Cowardin *in press*). These most recent biotelemetry data suggest that breeding and post-breeding season survival rates are lower than had been previously assumed (e.g. Cowardin and Johnson 1979, Ringelman and Longcore 1980).

Population management of waterfowl is accomplished primarily through regulatory manipulation of the harvest. Yet, to recognize *when* and *how much* the harvest should be restricted or liberalized, managers should know the magnitude and timing of seasonal non-hunting mortality. For adult female Black Ducks in Maine the average annual survival rate is 0.51, slightly lower than the continental mean, 0.56 (W. Blandin, Office of Migratory Bird Management, personal communication). Except for our estimate of Black Duck survival for the breeding season, other seasonal survival rates (post-breeding and molt, wintering, and hunting periods) are unknown. If we assume, for purposes of illustration, that these rates approximate those of the closely related Mallard (*A. platyrhynchos*), then the product of the four seasonal survival rates would be breeding — Black Duck, 0.74 × post-breeding - Mallard, 0.947 (Kirby and Cowardin *in press*) × hunting — Mallards, 0.811 (Anderson 1975; Johnson and Sargeant 1977) × wintering — Mallard, 0.919 (Cowardin and Johnson 1979) = 0.520, a value close to the average annual survival rate for female Black Ducks in Maine. In actuality, Black Duck survival rates probably differ greatly from those of the Mallard at many times of the year. Only after additional research is conducted on season-specific survival can we hope to comprehend the dynamics of the Black Duck population.

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Winter Movements of Arctic Foxes, *Alopex lagopus*, in a Petroleum Development Area

LESTER E. EBERHARDT,[1] ROBERT A. GARROTT,[2] and WAYNE C. HANSON[3]

[1]Applied Ecology Section, Pacific Northwest Laboratory, P.O. Box 999, Richland, WA 99352
[2]Group LS-6, Los Alamos National Laboratory, Los Alamos, NM 87545
[3]Dames and Moore, 800 Cordova Street, Suite 101, Anchorage, AK 99501

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A total of 35 Arctic Foxes (*Alopex lagopus*) were radio-tracked in the vicinity of the Prudhoe Bay oil field in northern Alaska from October 1979 through May 1980. Dispersal of Arctic Foxes from Prudhoe Bay appeared to take place in the fall and late winter–early spring periods. Most juveniles remained in their natal home ranges through at least January and relatively few individuals participated in fall dispersal. The late winter–early spring dispersal involved a large proportion of marked animals and may be related to breeding activities. Arctic Fox use of developed sites and associated garbage and handout food sources reached a peak in December when large concentrations of foxes were common around dumps and other development-related facilities. Foxes appeared to use well-defined areas and did not move freely between developed sites within the Prudhoe Bay area.

Key Words: Arctic Fox, *Alopex lagopus*, radio-telemetry, fall and winter movements.

Little information is available on the fall, winter, and early spring movements and activities of individual Arctic Foxes (*Alopex lagopus*). During this period Arctic Fox populations appear to be highly mobile with long-distance movements occurring (Eberhardt and Hanson 1978) and even mass migrations taking place in some regions (Wrigley and Hatch 1976).

Recently, large areas of Arctic Fox habitat have experienced intensive exploration for and development of petroleum resources. However, the impact of exploration and development activities on Arctic Foxes is poorly understood. This paper describes the results of a study on the fall, winter, and early spring movements of Arctic Foxes in the vicinity of the Prudhoe Bay oil field in northern Alaska. The purposes of this study are to document dispersal times of Arctic Foxes from Prudhoe Bay, the pattern of use of the Prudhoe Bay area by individual Arctic Foxes during winter, and the impact of winter petroleum-development activities on this species.

Study Area and Methods

The Prudhoe Bay oil field is situated on the northern coast of Alaska at 70°20′N. The area is characterized by long, cold winters; a flat, treeless topography; approximately 75 cm of snowfall (Selkregg n.d.), and the absence of direct sunlight from mid-November through mid-January. Petroleum-related development activities at Prudhoe Bay include the construction of an extensive network of gravel roads and collection pipelines; the drilling of wells; and the establishment and operation of personnel camps, airports, and petroleum processing centers. Garbage-holding bins, dumps, and incinerators, which attract Arctic Foxes, are associated with most development facilities and are located throughout the Prudhoe Bay area. Hand-feeding foxes is unlawfully practiced by some oil-field personnel.

The study was conducted from October 1979 through May 1980 on approximately 240 km^2 of extensively developed habitat. Because of the expense, only periodic visits were made to the study site; these included: 11 days in early October, 10 days in early December, 7 days in mid-January, 6 days in mid-March, and 1 day in late May. Arctic Foxes were live-trapped at personnel camps, dumps, and dens in October, December, January, and March. In addition, several adult and juvenile Arctic Foxes, which were captured in June and July 1979 during a study of juvenile behavior (Fine 1980), were monitored during our investigation. Captured foxes were anesthetized with a combination of ketamine hydrochloride and xylazine (Cornely 1979); identified as to sex; weighed; equipped with ear tags and streamers (Eberhardt and Hanson 1978); and, in most instances, fitted with radio-collars. Foxes were classified as adults or juveniles ($<$ 1 yr old) by annuli counts of the lower first premolar extracted during handling or, in the case of previously marked animals, by birth dates or past breeding performance.

Radio-collars operated on individual frequencies between 216.000 and 216.999 MHz, weighed approximately 3% of fox body weight, had an estimated life of at least 5 mo, and a range of approximately 2.5 km. Several individuals were refitted with new collars during subsequent trapping periods and could be followed for periods greater than 5 mo. In October, December, January, and March radio-collared foxes were located by triangulation from a single vehicle equipped with a null-peak yagi antenna system. An aerial search of the Prudhoe Bay area for radio-collared foxes was conducted in May with a light aircraft equipped with two yagi antennas. During each field period emphasis was placed on locating as many of the radio-collared foxes as possible. The Prudhoe Bay area was searched several times during each ground-tracking period. Radio-collared foxes were presumed to have left the study area if not located during two successive field trips. It is possible that some of the foxes assumed to have left the area actually had nonfunctioning radios; however, previous spring and summer experience with these radios (Eberhardt *et al.* 1982) demonstrated a low failure rate. The low environmental temperatures characteristic of the Arctic during the winter did not appear to adversely affect transmitter function, presumably because of the high insulative value provided by the long, dense fur of Arctic Foxes and our use of lithium batteries for the transmitters.

We realize that the lack of a radio signal provides only indirect evidence of the absence of a marked animal from the study area; however, the extreme expense of logistics, harsh weather conditions, and species behavioral characteristics [long movements in short periods of time (Eberhardt and Hanson 1978)] preclude intensive efforts at locating dispersing radio-collared foxes outside the immediate Prudhoe Bay area.

The term dispersal, as used in this paper, indicates only a movement of marked foxes away from Prudhoe Bay. It is not used in reference to any specific age group, nor does it imply that the dispersing individuals were a resident of the Prudhoe Bay area for any specific time period. It is possible that some foxes, particularly in late winter and early spring, were trapped and marked as they were moving through the Prudhoe Bay area.

Results and Discussion

A total of 35 Arctic Foxes (14 males and 21 females) were equipped with radio-collars and 12 (5 males and 7 females) with ear tags only. Eleven of the collared animals (5 juveniles males, 2 juvenile females, 2 adult males, and 2 adult females) were initially captured and fitted with radios during the summer prior to our investigation (Fine 1980). All radios installed during the summer were capable of functioning through the first few months of our study. In addition, five of these summer-caught individuals were recaptured and fitted with new radios at least once during our investigation. Table 1 summarizes data on radio-collared foxes, the expected life of radio-collars relative to the study period, and the dates of relocations.

It appears we were able to relocate foxes present in the Prudhoe Bay area that had functioning radio-collars. In only three instances did we apparently miss a radio-collared fox (foxes 780, 826, and 417) during one visit and subsequently locate it in the Prudhoe Bay area during a later visit (Table 1).

Dispersal

Radio-collared foxes disappeared and presumably dispersed from the Prudhoe Bay area during two time periods. The first period (fall) occurred between late August and late September. The second dispersal (winter-spring), involving a larger proportion of marked animals, began gradually after mid-December, accelerated sharply after mid-January, and continued through March (Table 2).

Indirect evidence of fall dispersal is based on the disappearance prior to October of two (adult male 879 and juvenile male 229) of the 11 foxes radio-collared during the summer (Table 1). Radios on these foxes functioned consistently throughout July and August and should have been working during our October and December trips if the animals were present. Radios installed on the other nine individuals at approximately the same time functioned through at least mid-January. In addition, adult male 879 definitely did disperse from the Prudhoe Bay area at some time because it was trapped in April 1982 near Baker Lake, Northwest Territories approximately 2000 km east of Prudhoe Bay.

Juvenile Arctic Foxes residing on or near our study area decreased their use of dens late in the summer (Eberhardt 1977; Fine 1980; Garrott 1980). Several other investigators have also noted a decreasing use of dens by juveniles in August and September and have related this to dispersal of young (Dementyeff 1958; Shibanoff 1958; Tchirkova 1958; Macpherson 1969). However, we found that most of the radio-collared juveniles did not actually disperse from their natal home range during this period. Out of seven juveniles collared during the summer, one male (229), noted previously, dispersed prior to October and a second (male 390) dispersed 8.4 km within the Prudhoe Bay area between mid-October and early-December. The other five juveniles, representing portions of two litters, remained in the vicinity of their rearing dens and were frequently located together through mid-January when, in most cases, their radios were due to stop. A juvenile female (417), refitted with new radio-collars twice, was located repeatedly on her natal home range through the end of the study in May.

Tchirkova (1958) related both the timing and distance of fall dispersal by juvenile Arctic Foxes to the availability of local food sources. If dispersal timing is related to food, then the readily available and heavily utilized "unnatural" food such as garbage and hand-

TABLE 1. Summary of Arctic Fox capture, radio-collar, and relocation data at Prudhoe Bay, Alaska during 1979-1980

Fox No.	Sex[1]	Age[2]	Period of Estimated Radio Life[3]	Study Periods Marked Foxed Relocated[4]							
				June	July	Aug.	Oct.	Dec.	Jan.	Mar.	May
381	M	A	June-February	*	*	+	*	*	*		
780	F	A	June-October	*	*	+		*	*		
879	M	A	July-December		*	*					
894	F	A	July-December		*	+	*	*	*		
390	M	J	July-February		*	*	*	*			
229	M	J	July-December		*	*					
687	F	J	July-February		*	*	*	*	*	*	
554	M	J	July-March		*	*	*	*	*		
417	F	J	July-May		*	*	*	*	*		*
407	M	J	July-December		*	+	*	*	*		
826	M	J	July-December		*	+		*	*		
430	F	J	October-February				*	*			
615	F	J	October-February				*	*			
261	F	J	October-February				*	*	*		
055	F	J	October-February				*	*	*	*	
850	F	J	October-February				*	*			
940	F	U	October-February				*	*	*		
915	F	A	October-February				*	*			
529	F	J	October-February				*	*			
347	F	J	December-April					*			
489	M	J	December-April					*	*		
523	F	U	December-April					*	*		
149	F	J	December-April					*	*		
361	F	A	December-April					*	*		
449	M	A	December-April					*			
752	M	U	December-April					*			
927	F	A	January-May						*	+	
100	F	J	January-May						*		
972	F	U	January-May						*	*	*
115	F	U	January-May						*		
863	M	J	January-May						*		
337	M	A	January-May						*		
042	M	J	January-May						*		
162	F	U	March-July							*	
994	M	U	March-July							*	

[1] F — female, M — male.

[2] A — adult, J — juvenile, U — unknown.

[3] Estimated 5 mo radio life. Some foxes were fitted with new radio-collars during the study.

[4] * — fox located, + — fox not searched for.

TABLE 2. Relocation rate of radio-collared Arctic Foxes at Prudhoe Bay, Alaska, 1979-1980.

	Study Periods				
	October	December	January	March	May
Number of foxes which should have had working radios[1]	10	18	20	15	10
Numbers of radio-collared foxed located[2]	6	16	7	1	2
Percentage of radio-collared foxed located	60	89	35	7	20

[1] Radio life estimated at 5 mo.

[2] Foxes located after their radios had exceeded expected life were excluded.

outs (Eberhardt 1977; Fine 1980; Eberhardt et al. 1982) at Prudhoe Bay may have influenced the dispersal times of resident juveniles.

The fall dispersal of adult male 879 occurred subsequent to his participation in the rearing of young. We have recorded one other instance in which a marked adult male dispersed, in this case 1246 km, sometime after raising young (unpublished data). Fall dispersal of adult male Red Foxes (*Vulpes vulpes*) has also been recorded (Storm et al. 1976, p. 31).

Both adult and juvenile Arctic Foxes dispersed from the Prudhoe Bay area between mid-December and March. Evidence of the winter-spring dispersal of foxes from Prudhoe Bay is based on a decrease in the proportion of radio-collared animals relocated (Table 2), a reduction in the amount of fox signs observed around petroleum development facilities, and decreased trapping success as winter progressed. The decline in the relocation rate of radio-collared foxes began after mid-December and continued through the remainder of the study (Table 2). During the latter part of the investigation trapping success decreased approximately 50% from 0.46 fox/trap-night (35 trap-nights) in October and 0.50 fox/trap-night (44 trap-nights) in December to 0.21 fox/trap-night (29 trap-nights) in January and 0.16 fox/trap-night (26 trap-nights) in March. The decrease in fox trapping success is probably a reflection of both fewer foxes and the fact that a proportion of the fox population residing in the vicinity of our heavily trapped areas was captured early in the study and became "trap-shy" during later trapping periods. However, we also repeatedly captured "trap-prone" animals, and these individuals disappeared as well in the latter part of the study.

Urquhart (1973), in a study of Arctic Fox use of mobile seismic camps in Canada, also noted a gradual decrease of fox use through the winter-spring period. He attributed the decline in fox numbers to a high winter mortality of juveniles and an avoidance of humans by adult foxes during the breeding season in February and March. Juvenile mortality did not appear to be a significant factor in the decrease in fox use of the Prudhoe Bay area since none of 19 radio-collared juvenile foxes were known to have died while on the study area. However, fox mortality has been important in the past at Prudhoe Bay when incidence of rabies was high (unpublished data). We believe the disappearance of large numbers of foxes from the Prudhoe Bay area in late winter and early spring was related to the establishment of territories for breeding purposes. This species has been shown to be territorial during the spring and summer months (Eberhardt et al. 1982).

Distances moved by some dispersing Arctic Foxes during the winter-spring period were extensive. Two adult males moved 781 and 2000 km to the east during this study and three other males from earlier tagging efforts at or near Prudhoe Bay (Eberhardt and Hanson 1978) moved between 338 and 901 km during the winter-spring periods.

Developed Site Use

The amount of developed site-use by individual Arctic Foxes during this study was variable but greater than observed during spring and summer studies (Eberhardt et al. 1982). Intensity of use varied from moderate in October, heavy in December, moderate in January, and very light in March. During December many foxes spent large amounts of their time on or near developed sites. One juvenile female (417) was located repeatedly over a 5-d period in December within the compound of a large oil processing center. Another juvenile female (687), a sibling of fox 417, moved back and forth between this processing center and a personnel camp 2 km away during the same time period. Both of these foxes used a much larger area prior to December, most of which was undeveloped.

Radio-collared foxes generally used well defined areas within the Prudhoe Bay study site. Only 2 of the 22 radioed foxes that were relocated at least once during subsequent trips to Prudhoe Bay made movements in the study area that exceeded normal home range movements as defined by summer radio-tracking data (Eberhardt et al. 1982). These animals, juvenile male 390 and juvenile female 615, moved 8.4 and 12.5 km, respectively. In addition a juvenile male, equipped with ear tags only, moved 14.3 km within the Prudhoe Bay study area.

Territorial defense by Arctic Foxes appeared to be less strong during the fall and winter when compared to spring and summer periods (Eberhardt et al. 1982). Concentration of fox activities around developed sites was common in the fall and winter and up to 21 foxes were captured and marked within a 63-ha area. During past winter studies in the Prudhoe Bay area up to 23 foxes were captured at a single dump in 7 d (unpublished data). Other investigators have reported large winter concentrations of Arctic Foxes near food sources (Chesemore 1968; Urquhart 1973).

A number of captured foxes were in poor condition. It was assumed that these individuals were either diseased or recent arrivals to Prudhoe Bay. Known resident foxes feeding on garbage were generally fat. Fall and winter movements of Arctic Foxes to Prudhoe Bay from a distance of up to 1000 km away have been reported (Wrigley and Hatch 1976; Eberhardt and Hanson 1978).

The fall and winter use of the Prudhoe Bay area by relatively large numbers of foxes has potential negative and positive aspects. The increase in fox-to-fox and fox-to-man contact is undesirable from the standpoint of disease transmission, particularly rabies, which is enzootic in the species (Crandell 1975). A number of Prudhoe Bay oil field personnel have been exposed to and treated for rabies during the fall and winter, especially in those years when the disease is epizootic. "Unnatural" food sources may contribute to the over-winter survival of some Arctic Foxes. Grace (1976) and Fuller and Keith (1980) have also speculated that dump-foraging by Gray Wolves (*Canis lupus*) may contribute to survival in that species.

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Habitat Selection and Food Habits of Marten, *Martes americana*, in the Northwest Territories

RICHARD J. DOUGLASS[1], LORNE G. FISHER[2], and MARNIE MAIR[3]

[1]613 West College, Bozeman, Montana 59715
[2]38 Belmead Gardens, Edmonton, Alberta, Canada T5N 1P6
[3]9847 83rd Avenue, Edmonton, Alberta, Canada T5N 1P6

Douglass, Richard J., Lorne G. Fisher, and Marnie Mair. 1983. Habitat selection and food habits of Marten, *Martes americana*, in the Northwest Territories. Canadian Field-Naturalist 97(1): 71–74.

Habit data were gathered at Chick Lake and Moon Lake, Northwest Territories on permanently marked transects by recording tracks. Marten selected different habitat in different seasons and study sites. Scats collected on transects showed food habits to be similar to other areas of North America in that voles were the major food of Martens. However Marten in the Northwest Territories appeared to be selective in species consumed in contrast to more opportunistic feeding habits reported for other areas.

Key Words: habitat selection, food habits, Marten, *Martes americana*, Northwest Territories.

Little is known about winter habitat selection and food habits of Marten, *Martes americana*, in northern environments. Although Marten prefer mature stands of coniferous forest (Seton 1929; Marshall 1951; de Vos 1952; Lensink et al. 1953; Francis and Stephenson 1972) it is not clear whether they select specific habitats within forests. There have been no reports published on winter food habits of Marten in the Northwest Territories. We had the opportunity to collect some data relative to their habitat selection and food habits in this area peripheral to a study designed for other purposes.

Objectives in this study were to determine if Marten selected specific habitats within coniferous forests during periods of continuous snow cover and to determine the prey of Marten during the same period.

We conducted this study in the northern boreal forest near Chick Lake and Moon Lake, Northwest Territories. Chick Lake (65°52′N, 128°07′W) and Moon Lake (65°37′N, 127°30′W) are located east of the Mackenzie River between Norman Wells and Fort Good Hope. The study area is covered by mature stands of Black Spruce (*Picea mariana*) with some intermixed Larch (*Larix laricina*) and Paper Birch (*Betula papyrifera*). Ground cover is predominantly lichen (*Cladonia* spp.), moss (*Aulocomium* sp.) with low densities of shrubs (*Ledum groenlandicum, Vaccinium vitis-idaea, V. uliginosum,* and *Salix* spp.), sedges (*Carex* spp.) and grass (*Calamagrostis* sp.).

Methods

We constructed 44 km (23.4 at Chick Lake and 20.6 at Moon Lake) of permanently marked transects, examining them every day it did not snow during spring 1973 (15 March to 1 May), fall 1973 (20 October to 1 December), spring 1974 (25 February to 28 March) and fall 1974 (21 October to 13 November). As tracks were recorded they were obliterated to avoid duplication of counts. Marten scats were collected during both years and habitat data were collected during 1974.

Habitat preference was examined by testing the following hypotheses:

H_0 the habit at Marten track crossings is not different than the overall habitat in which the tracks occur.

H_a the habitat at Marten track crossings is different than the overall habitat in which the tracks occur.

Habitat preference is inferred when the habitat at track crossings is found to be significantly different from that of the general habitat. Habitat variables were estimated at each Marten track crossing and at 0.2 km intervals along all transects. The distribution of classes of variables estimated at systematic points was considered to be representative of the overall habitat. Because we could be at the transects only during times of snow cover only variables measurable above the snow surface were recorded. These were tree dispersion (Cottam and Curtis 1956), tree height, and shrub density. We estimated tree dispersion and tree heights in meters (dispersion = the mean distance to the four nearest trees in quarters, and height = the mean height of the same four trees) and assigned them to seven dispersion and 11 height classes. We estimated shrub density according to the following classification: Class 1, shrubs present; Class 2, low density; Class 3, moderate density; Class 4, high density.

Information on the diet of Marten was obtained from the analysis of scats collected along transects. We identified prey remains to genera according to techniques developed by Mathiak (1938) and Day (1966), and with the aid of keys and a reference collection. We identified species of rodents by comparing teeth contained in scats with those of specimens collected in the study area. We did not attempt to identify the species of birds, invertebrates or plant material.

Results and Discussion

Habitat Preference

During the sampling sessions we estimated habitat variables where 2,214 Marten tracks crossed transects. We compared the distribution of habitat variables estimated at track crossings with the distribution of the same variables estimated in the systematic sampling (Table 1). These data were analyzed by a chi-square one-sample test (Siegel 1956) to determine whether habitat classes at track crossings were distributed randomly in respect to expected distributions. Except for tree dispersion and shrub density at Moon Lake during spring, the distribution of classes of habitat variables at Marten track crossings differed significantly from the distribution in the overall habitat. However, inter-area correlation coefficients were insignificant for all variables. This indicates that the

TABLE 1. Distribution of classes of habitat variables at Marten track crossings compared to the distribution of the same classes estimated in systematic surveys of transects. Significant values indicate that the habitat where Marten tracks were encountered was different from the overall habitat.

	Chick Lake				Moon Lake			
	Spring		Fall		Spring		Fall	
	Obs.[a]	Exp.[b]	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.
Dispersion (m)								
Classes								
>3.0	12	9.90	240	47.94	21	25.08	153	112.42
2.6- 3.0	10	26.40	72	127.84	50	47.88	102	214.62
2.1- 2.5	17	52.80	120	255.68	59	50.16	154	224.84
1.6- 2.0	49	26.40	152	127.84	50	57.00	245	255.50
1.1- 1.5	36	23.10	128	111.86	23	25.08	204	112.42
0.6- 1.0	33	11.55	80	55.93	11	15.96	133	71.54
<0.5	8	14.85	1	71.91	5	6.84	31	30.66
Total	165		799		228		1,022	
ΣX^2	(6df)104.45***		(6df)953.12***		(6df)8.75		(6df)223.90***	
Height (m)								
Classes								
0.0- 2.0	51	39.6	120	191.76	41	52.44	184	235.06
2.1- 4.0	57	70.95	239	343.57	116	93.48	388	419.02
4.1- 6.0	40	34.65	191	167.79	55	66.12	358	296.38
6.1- 8.0	13	9.9	144	47.94	11	11.40	82	51.10
8.1-10.0	2	6.6	96	31.96	5	4.56	10	20.44
10.1-12.0	2	3.3	8	15.98	0	0	0	0
Total	165		799		228		1022	
ΣX^2	(5df)11.54*		(5df)386.29***		(3df)9.84*		(3df)50.22***	
Shrub Density class[c]								
1	30	135.3	320	655.18	194	202.92	715	909.58
2	81	18.15	376	87.89	30	20.52	266	91.98
3	36	9.9	96	47.94	4	4.56	31	20.44
4	18	1.65	1	7.99	0	0	10	0[d]
Total	165		799		228		1,022	
ΣX^2	(3df)530.41***		(3df)1,170.21***		(2df)3.46		(2df)376.31***	

[a] Distribution of classes of habitat variables at track crossings

[b] Values based on relative availability of various classes based on transect results.

[c] 1=present 2=low cover 3=moderate cover 4=dense cover

[d] Shrubs existed in the area of this density class but none were encountered in the systematic sample.

*$p < 0.05$

**$p < 0.01$

***$p < 0.001$

distribution of variables at track crossings was inconsistent between areas during both spring and fall.

In most cases the distribution of habitat variables at Marten track crossings was different from the overall habitat (i.e. H_0 was rejected, suggesting that Marten selected sub-habitats within the forest for travel. However, the inconsistencies in distributions between areas are perplexing. Results may have been inconsistent as a result of: (1) interactions of the variables we examined with other environmental variables that we did not measure or could not incorporate in the analysis (e.g., snow depth, daily temperatures, changes in rodent densities and distribution); (2) variation in preferences demonstrated by individual Marten. Douglass (1977) showed that Yellow-cheeked Voles (*Microtus xanthognathus*) underwent small population fluctuations (0.5/ha to 5/ha) at Chick Lake and that fluctuations were asynchronous. Also, Marten tracks at Chick Lake were found in disproportionately high numbers in areas of low tree dispersion (Table 1), and captures of both Northern Red-backed Voles (*Clethrionomys rutilus*) and Yellow-cheeked Voles were found to be negatively correlated with tree dispersion (Table 2). Marten may have selected certain areas within the forest on the basis of the abundance and availability of prey rather than solely on the basis of the habitat structure. This is consistent with the higher Marten activity in areas of high prey abundance described by More (1978). If Marten in the Northwest Territories do select areas on the basis of prey abundance and availability, the spatially nonsynchronous population fluctuations of Yellow-cheeked Voles may have accounted for some of the inconsistencies in the habitat selection.

More research, possibly employing radio telemetry and multivariate analysis of habitats, is required to determine conclusively if Marten select habitats within the coniferous forest.

Diet

The frequency of occurrence of food items in scats does not necessarily accurately represent the importance of food items and should be used cautiously (Day 1966). However, these data do provide some insight into the diet of Marten and form a basis for comparison with other studies. Table 3 summarizes the occurrence of food items in 172 scats collected at Chick Lake and Moon Lake.

The diet of Marten at Chick Lake and Moon Lake was similar to that previously recorded in other studies (Lensink et al., 1955, Weckwerth and Hawley

TABLE 2. Correlation coefficients for the capture rate of three species of rodents in relation to tree dispersion at Chick Lake, Northwest Territories, during 1974.[a]

Species	Captures/100 Trap Nights vs. Tree Dispersion
Northern Red-backed Vole	–0.7913*
Meadow Vole	–0.2012
Yellow-cheeked Vole	–0.7717*

[a] Data are based on 23,000 trap nights on two 250-trap live-trapping grids.
*$p < 0.05$

TABLE 3. Percentage occurrence of food items in 172 scats collected during 1973 and 1974 and the relative abundance of 4234 small mammals live-trapped from 1973 through 1974 in the Northwest Territories.

Food Items	% Occurrence In Scats	% Relative Abundance In Live Traps[c]
Microtus pennsylvanicus	12.8	20.4
M. xanthognathus	17.4	22.1
Total *Microtus*[a]	75.6	42.5
Clethrionomys rutilus	13.4	55.4
Snyaptomys borealis	2.3	0.6
Phenacomys intermedius	2.9	0.4
Total non-*Microtus*[b]	26.7	56.3
Sorex spp.	1.2	0.7
Tamiasciurus hudsonicus	0.0	0.4
Zapus hudsonius	0.0	0.02
Lepus americanus	0.0	0.0[e]
Mustela erminea	1.2	0.1
Unidentified mammal	2.9	
Bird	4.1	
Invertebrates	32.0	
Plant: Seed	19.2	
Moss	28.5	
Wood	26.2	
Grass	21.5	
Lichen	11.0	
Leaf	4.7	
Spruce Needles	16.9	
Other	6.4	
Total Vegetation	58.1	

[a] This includes samples identified from hair. These could not be identified to species.

[b] This includes *C. rutilus, S. borealis, P. intermedius* and all unidentified non-*Microtus* specimens.

[c] From Douglass 1977. Numbers represent the total individuals captured at Chick Lake in 102,300 trap nights from 1973 through 1975.

[d] Because *Tamiasciurus hudsonicus* appears to be fairly untrappable in small traps this number probably underestimates their relative abundance. *Tamiasciurus hudsonicus* tracks in winter were generally more abundant than marten tracks.

[e] *Lepus americanus* was too large for our traps but numbers of tracks during winter were very low (much lower than marten tracks). No *Lepus americanus* were observed during trapping sessions.

1962, Francis and Stephenson 1972, Soutiere 1979). Voles (*Microtus* spp.) occurred most frequently (75%) in scats while all other cricetid rodents occurred in only 26.7% of scats. Other items that occurred at relatively high frequencies were invertebrates (32%) and plant material (58.1%).

We obtained a cursory examination of Marten prey selectivity by comparing the frequency of occurrence of small mammals in scats with their relative abundance in the environment. Small mammal abundance was determined during the summer months at Chick Lake (Douglass 1977, Table 2). During this time *Microtus* spp. populations were low (< 10/ha) and *Clethrionomys rutilus* populations decreased from a high in 1973 of ~41/ha to a low of 4/ha in 1974 (Douglass, unpublished data). All species encountered in scats were live-trapped in the forest. If these data collected during the summer accurately reflect abundance of small mammals in the study area during the winter, and if the prey analysis accurately reflects use of prey, then Marten were being very selective in the prey they consumed. *Microtus* spp. occurred in 75.6% of the scats but made up only 42.5% of the individuals captured in live traps during three summers (Douglass 1977). All other voles occurred in 26.7% of scats but comprised 56.3% of the individuals captured in live traps, suggesting that Marten at Chick Lake and Moon Lake preferred *Microtus* spp. over other voles. This contrasts with Lensink et al.'s (1955) results elsewhere that suggested Marten were opportunistic in their feeding habits and consumed rodents in approximately the same ratios as they occurred in the environment. However, Weckwerth and Hawley (1962) found that although Marten feed on most rodents opportunistically, *Microtus* appeared in scats more frequently than in traps.

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Taxonomy of the Gaspé Shrew, *Sorex gaspensis*, and the Rock Shrew,[3] *S. dispar*

THOMAS W. FRENCH[1,3] and GORDON L. KIRKLAND, JR.[2]

[1]N.Y. Cooperative Wildlife Research Unit, Cornell University, Ithaca, New York 14853
[2]Vertebrate Museum, Shippensburg State College, Shippensburg, Pennsylvania 17257
[3]Nature Conservancey, 294 Washington Street, Boston, Massachusatts 02108

French, Thomas W., and Gordon L. Kirkland, Jr. 1983. Taxonomy of the Gaspé Shrew, *Sorex gaspensis*, and the Rock Shrew *S. dispar*. Canadian Field-Naturalist 97(1): 75–78.

Sixty-seven Gaspé Shrews, *Sorex gaspensis*, from Mount Carleton Provincial Park, one from Moose Mountain near Bath, New Brunswick, and a Rock Shrew, *S. dispar*, from Quaggy Joe Mountain, Aroostook Co., Maine, were compared to previously reported, but more geographically separated, specimens of *S. dispar* and *S. gaspensis* using a stepwise discriminate analysis. Non-overlapping scattergram clusters, indicating significant morphological differences, suggest that these two shrews should continue to be recognized as distinct species.

Key Words: Gaspé Shrew, *Sorex gaspensis*, Rock Shrew, *Sorex dispar*, New Brunswick, taxonomy.

The Gaspé Shrew, *Sorex gaspensis*, was described from the Gaspé Peninsula of eastern Quebec (Anthony and Goodwin 1924) and has since been captured on Cape Breton, Nova Scotia (Roscoe and Majka 1976) and Mt. Carleton, New Brunswick (Peterson and Symansky 1963). The closely related Rock Shrew, *S. dispar*, occurs from the higher elevations of North Carolina and Tennessee northward along the Appalachians to Maine (see map in Kirkland and Van Deusen 1979). A disjunct population of *S. dispar* has also been reported from southeast New Brunswick (see map in Kirkland 1981). These two closely related species are distinguished primarily on the basis of size, *S. gaspensis* being significantly smaller in virtually all characters (Kirkland 1981, Kirkland and Van Deusen 1979).

The taxonomic status of *S. gaspensis* and *S. dispar* was studied by Kirkland and Van Deusen (1979) using a stepwise discriminant analysis of 18 morphological characters. Fourteen *S. gaspensis* from the Gaspé Peninsula and Cape Breton were available for comparison to 108 *S. dispar* representing four geographically distinct groups. These four groups were from North Carolina and Tennessee, Virginia and West Virginia, and mid-Atlantic states (New Jersey, Pennsylvania and New York), and New England (Vermont, New Hampshire, Massachusetts and Maine). The three Maine specimens examined were from Mt. Katahdin and South Branch Pond, Baxter State Park, Piscatoquis County, and Enchanted Pond, Somerset County. Specimens from the most northerly localities of *S. dispar* at Beaver Creek, Aroostook County, Maine (Godin 1977) and Riverside-Albert, Albert County, New Brunswick (Kirkland et al 1979) and the most southerly locality for *S. gaspensis* at Mt. Carleton, New Brunswick were not available for comparison. The nearest specimen localities of these two species in the Kirkland and Van Deusen (1979) analysis were thus approximately 300 km apart.

Kirkland and Van Deusen (1979) detected a north-south cline in size for *S. dispar* progressing from larger in the south to smaller in the north. *Sorex gaspensis* was, however, much smaller than the northernmost population of *S. dispar* and they concluded that *S. gaspensis* continued to warrant species recognition, as it was distinctly differentiated from all populations of *S. dispar* in the stepwise discriminant analysis and because the magnitude of size decrease was substantially greater than the rate of clinal size decrease detected in *S. dispar* populations.

This paper re-examines the taxonomic status of these two shrews in the light of new specimens acquired from localities in New Brunswick and Maine geographically intermediate to those represented in the previous study.

Methods

The new series of *S. gaspensis* was trapped by the senior author and two assistants, Beth Ann Sabo and Mark Dalton, on Sagamook Mountain, Mount Carleton Provincial Park and on Moose Mountain near Bath, New Brunswick. Mount Carleton, the highest point in New Brunswick, rises 820 meters above sea level. Trapping took place in various habitats throughout the park, although efforts were concentrated on the north face of Sagamook Mountain (alt. 792 m), located 3.4 km north of Mount Carleton and part of the same ridge system. On Mount Sagamook, seven traplines were set for varying lengths of time, between 16 June and 20 July, 1980. Snap traps were set for 10,602 trap nights and pitfalls for 985 trap nights. The more southerly location at Moose Mountain (alt. 381 m) was trapped for two nights between 21 and 23 July (122 snap trap nights). Also examined was the *S. dispar* reported from near Riverside-Albert, New Brunswick (Kirkland et al. 1979) and a new specimen (USNM 554224) from Quaggy Joe Mountain (345 m), Aroostook County, Maine.

Body measurements were made in the field but all cranial measurements were made by the junior author in the same way as described by Kirkland and Van Deusen (1979). These measurements were then compared to the data sets for *S. gaspensis* and *S. dispar* from Kirkland and Van Deusen's (1979) previous study using the same statistical procedures described in that study.

Specimens Examined

Specimens used in this study included 224 *Sorex dispar* and 23 *S. gaspensis* listed by Kirkland and Van Deusen (1979) and one *S. dispar* reported by Kirkland et al. (1979). The collection localities, numbers of specimens, and abbreviations for the collections housing the previously unreported specimens used in this study are listed below. The following abbreviations are used: NBM (New Brunswick Museum, St. John), SSC (The Vertebrate Museum, Shippensburg State College, Pennsylvania), TWF (Thomas W. French —Private Collection), and USNM (National Museum of Natural History, Smithsonian Institution, Washington, D.C.).

Sorex gaspensis (68) — NEW BRUNSWICK, Moose Mountain, near Bath, 1 (USNM 553302); Mt. Carleton Provincial Park, north slope of Mt. Sagamook, 67 (USNM 553242-553301; NBM 1843-1846; SSC 12018-12019; TWF 561).

Sorex dispar (1) — MAINE, AROOSTOOK CO., Quaggy Joe Mountain (USNM 554224).

Study Area

The forest type in Mt. Carleton Prov. park is primarily boreal with some areas transitional between boreal and mixed deciduous. The mature forests on

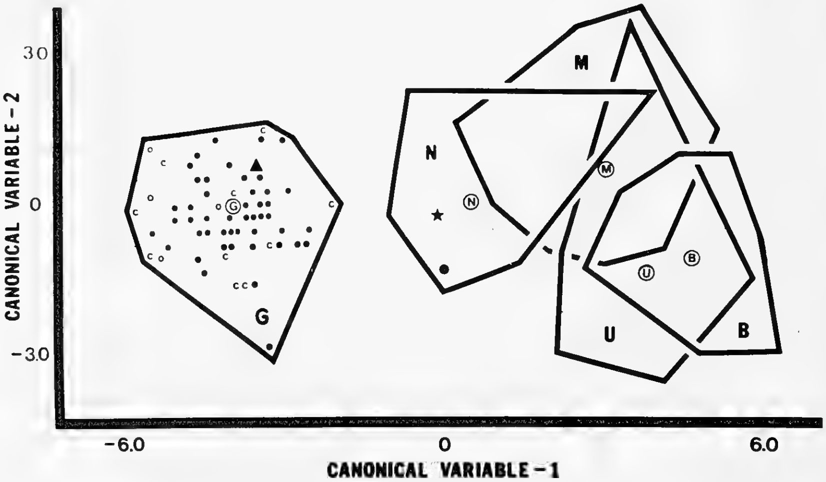

FIGURE 1. Relationships of 122 *Sorex dispar* and 58 *S. gaspensis* in five groups as plotted by discriminant function analysis (BMD P7M). Groups are represented as follows: G = *Sorex gaspensis*, (Quebec, N.B., N.S.); N = *S. dispar* from New England (Maine, H.H., Vt., Mass.) and Albert Co., N.B.; M = *S. dispar* from Mid-Atlantic states (N.Y., N.J., Pa.); U = *S. dispar* from W. Va. and Va.; B = *S. dispar* from Tenn. and N.C. The triangle represents the *S. gaspensis* from Moose Mt., the star represents the *S. dispar* from Albert Co., N.B., and the black circle in N represents the *S. dispar* from Quaggy Joe Mt. Within G, specimens from Quebec are represented by Cs, those from Nova Scotia by open circles, and those from New Brunswick by closed circles. Ten New Brunswick specimens do not appear as separate circles because of overlap of coordinate values. The centroids of the five groups are represented by circles enclosing the letters of the groups.

Mount Carleton and Sagamook Mountain are dominated by Black Spruce (*Picea mariana*), Yellow Birch (*Betula lutea*), Northern White Cedar (*Thuja occidentalis*), and Balsam Fir (*Abies balsamea*). Quaking Aspen (*Populus tremuloides) and Paper Birch (Betula papyrifera*) are dominant in disturbed areas. The understory consists predominantly of Striped Maple (*Acer pensylvanicum*), Red Maple (*Acer rubrum*), and Hobblebush (*Viburnum alnifolium*). Wild Sarsaparilla (*Aralia nubieaulis*), Oak Fern (*Gymnocarpium dryopteris*), Spinulose Woodfern (*Dryopteris spinulosa*), and Bunchberry (*Cornus canadensis*) comprise the major portion of the herbaceous layer. The talus layer in the Mount Carleton/Sagamook Mountain area is quite substantial and makes trapping along talus slopes difficult. The talus penetrates to a depth of 1.5-2.0 m and consists of large rounded boulders ranging from .4 to 1.3 m in diameter.

At Moose Mountain, the forest cover is a more mixed deciduous, second-growth type dominated by Beech (*Fagus grandifolia*), Sugar Maple (*Acer saccharum*), and Paper Birch. The understory consists of Hobblebush, Balsam Fir, and Striped Maple, while the herbaceous layer is dominated by Yellow Clintonia (*Clintonia borealis*), Red Trillium (*Trillium erectum*) and Canada Mayflower (*Maianthemum canadense*). At Moose Mountain, the talus layer consists of small, well consolidated rocks approximately 0.1 to 0.3 m across. Trapping was made easier by the fact that the talus layer averages only about 0.4 m deep.

Results and Discussion

Sixty-seven *Sorex gaspensis* were trapped on Sagamook Mountain between 290 and 488 m and one on Moose Mountain at about 335 m. Sixty-two of the Sagamook Mountain specimens were young of the year and five were adults. Three of the adults were males and both females were pregnant with six embryos each. The Moose Mountain specimen was a pregnant female with five embryos. These are the first embryo counts ever recorded from *S. gaspensis* (see Kirkland 1981).

Fifty-seven of the Sagamook Mountain specimens had undamaged skulls and were used in the statistical analysis. The inclusion of these specimens in the stepwise discriminant analysis program yielded scattergram clusters virtually identical to those reported in the previous study with all of the Mount Sagamook specimens clustering with *S. gaspensis*, and this species being still well differentiated from all populations of *S. dispar*.

The skull of the Moose Mountain specimen was

Table 1. Measurements for five external and 16 cranial/mandibular characters of Moose Mt., New Brunswick specimen (USNM 553302) and the ranges of measurements for these characters in 67 *S. gaspensis* from Mount Carleton Provincial Park, N.B. and 56 New England *S. dispar*. All linear measurements are in millimeters and weight is in grams.

		Range	
Character	Moose Mt.	Mt. Sagamook *S. gaspensis*	New England *S. dispar*
Total length	115	110 - 116	103 - 136.5
Tail Length	55	47 - 54*	46 - 61
Hind foot length	12.5	12 - 13	12 - 15
Body length	60	51 - 62	48 - 79
Weight	5.0	2.5 - 5.8	4.0 - 4.9*
Greatest length	—	16.2 - 17.3	17.3 - 18.3
Condylobasal length	—	15.85 - 16.70	16.45 - 17.70
Interorbital breadth	2.95	2.90 - 3.65	3.1 - 3.6**
Cranial breadth	—	6.50 - 8.15	7.5 - 8.3
Molariform tooth row	3.65	3.45 - 3.80	3.75 - 4.30**
Cheek tooth row	4.45	4.05 - 4.75	4.1 - 4.9
Total tooth row	6.75	6.55 - 7.00	6.8 - 7.6**
Incisor width	1.15	1.00 - 1.15	1.1 - 1.4
Canine width	1.5	1.40 - 1.65	1.4 - 1.8
Molar width	3.6	3.35 - 3.65	3.65 - 4.15**
Nasal length	6.1	4.15 - 6.10	5.60 - 7.25
Palatal length	6.6	6.2 - 6.8	6.6 - 7.5
Post-palatal length	—	7.10 - 7.75	7.30 - 8.35
Mandible length I	9.7	9.3 - 9.9	9.75 - 10.75**
Mandible length II	10.35	9.80 - 10.55	10.10 - 11.35
Mandible height	3.2	2.85 - 5.35	3.05 - 4.00

*Moose Mt. specimen exceeds range for character.

**Moose Mt. specimen is less than range for character.

damaged, so it could not be included in the initial analysis. Measurements of the greatest skull length, condylobasal length, cranial breadth, and post-palatal length of this specimen could not be obtained, so a second analysis using the 14 intact characters was made. In the new analysis, the Moose Mountain specimen clearly fell within the *S. gaspensis* cluster (Figure 1) but on the large end of the cluster. This individual is indeed a large *S. gaspensis* (Table 1) but only exceeds the extreme measurements of the 67 Sagamook Mountain specimens in tail length and equals the maximum measurements for incisor width and nasal length. Measurements of this specimen are less than the minimum measurements for 56 New England *S. dispar* (Kirkland et al. 1979) for five characters and equal to the minimum for one. Interestingly, the weight of this pregnant specimen exceeds the maximum for New England *S. dispar* but not for *S. gaspensis*. The *Sorex dispar* from Riverside-Albert, New Brunswick and the one from Quaggy Joe Mountain, Maine, clustered with New England *S. dispar* (Figure 1).

In view of the fact that the localities of the new specimens from Moose Mountain and Mount Carleton are intermediate between the nearest localities for *S. gaspensis* and *S. dispar* examined by Kirkland and Van Deusen (1979), it is significant that these new specimens do not plot as intermediate specimens in the discriminant function analysis (Figure 1). Instead, they are interspersed throughout the *S. gaspensis* polygon (G) among the previously examined specimens from Nova Scotia and Quebec. These results show that the morphological differences between *S. dispar* and *S. gaspensis* remain significant and essentially unchanged, even though the geographic distance between specimens of *S. dispar* and *S. gaspensis* has been greatly reduced (to as close as 45 km in the case of the Moose Mountain and Quaggy Joe Mountain specimens). Therefore, we conclude that *Sorex dispar* and *S. gaspensis* are separate and distinct species and should continue to be classified as such.

Acknowledgments

We express our appreciation to William Hooper, N. R. McKinley, and David Cartwright of the New Brunswick Department of Natural Resources, and to Leland McGaw and Robert Armstrong of the Department of Tourism, for their logistical assistance and for permission to trap within New Brunswick and specifically Mount Carleton Provincial Park. We are grateful to Blanchard MacDougall and the employees of Mount Carleton Provincial Park for their assistance. The field work for this project was conducted as a research internship of the Atlantic Center for the Environment, a division of the Quebec-Labrador Foundation, Ipswich, Massachusetts 01938.

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Home Range Size, Movements and Habitat Use in Two Moose, *Alces alces*, Populations in Southeastern Alaska

JOSEPH G. DOERR

United States Department of Agriculture Forest Service, Petersburg, AK 99833

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Fourteen radio-marked adult cow Moose (*Alces alces andersoni*) from two mainland populations in central southeastern Alaska were monitored for up to 29 months during 1978-81. Home range size during the study averaged 4030 ha (range 1280-7300 ha, n = 10), with three Moose exhibiting movements between separate seasonal home ranges. Riparian shrub and high-volume coniferous forests were preferred habitat during conditions of thick snow cover. River terrace Sitka Spruce (*Picea sitchensis*) stands were selected over mixed Western Hemlock (*Tsuga heterophylla*)-Sitka Spruce old-growth forests in both populations. Clearcuts under 30 years of age were utilized more heavily than unlogged old-growth forests.

Key Words: Moose, *Alces alces*, southeastern Alaska, clearcuts, old-growth forests.

Ecological studies of Moose in southeastern Alaska are lacking. Klein (1965b) and LeResche et al. (1974) discussed the spread of Moose to the mainland drainages of central southeastern Alaska in the last quarter of the 19th century, and Burris and McKnight (1973) described introductions of Moose in southeastern Alaska during the 1950's and 1960's. Kelsall and Telfer (1974) speculated on factors limiting Moose distribution in the moist temperate Western Hemlock-Sitka Spruce biome of western North America. This study reports on home range sizes, movements, and habitat use by telemetered cow Moose in two mainland populations of central southeastern Alaska.

Methods

During March 1978, seven adult cow Moose in the Thomas Bay Area (Figure 1) were immobilized from a Hiller 12J-3 helicopter utilizing a Cap-Char gun and a combination of etorphine (M-99, D-M Pharmaceuticals Inc., Rockville, MD) and xylazine hydrochloride (Rompun, Chemagro, Kansas City, MO). The Moose were fitted with radio transmitters (Wildlife Materials, Inc., Carbondale, IL) and numbered collars. After handling, diprenorphine (M50-50, D-M Pharmaceuticals Inc., Rockville, MD) was administered as an antagonist. During April 1979, 10 adult cow Moose were captured in a similar manner along the Stikine River drainage, downstream from the Canadian border, and were fitted with radio transmitters (TELONICS, Mesa, AZ) and numbered collars.

From April 1978 through September 1980, aerial searches were made approximately twice a month at Thomas Bay, utilizing a Cessna 180 with wing-mounted Yagi antennae. Similar searches were made along the Stikine River from May 1979 through October 1981, excluding the months from October 1980 through January 1981. Relocations were recorded on U.S. Geological Survey maps (1:63360) and described with respect to elevation, slope (0-35%, 36-75%, greater 75%), and habitat type. With two exceptions, no aerial flights were made during the Moose hunting season (15 September-15 October on the Stikine River and 1-31 October at Thomas Bay) to avoid negative public reaction from hunters. Approximately 10 percent of additional relocation data was obtained from helicopter flights and ground surveys utilizing a radio receiver and hand-held antenna. Hunters and local workers provided a few sightings as well; the latter were used in assessing home range size but not habitat selection.

Telemetered Moose were sighted during only 14 percent of 153 relocations at Thomas Bay and 26 percent of 241 relocations on the Stikine River from fixed-wing aircraft. This low observability was due to dense overstory cover. If visual contact was not made and if the suspected location overlapped on two or more habitat types, locations were recorded as "inexact." Telemetered Moose were visually located using a helicopter in September 1978 and December 1979, at Thomas Bay, and December 1979, on the Stikine River. Fall calf production of collared Moose was estimated from helicopter flights.

Home range was determined from the area of the polygon created by connecting temporally close, outside locations of each animal. Migratory Moose were defined as those having "two or more seasonally and spatially distinct ranges" (Mould 1976:6).

Observed home range size was plotted as a function of the number of telemetry relocations for each Moose. Rate of increase in home range size averaged 169 ha/relocation (range 29 – 374, n = 12) for the first

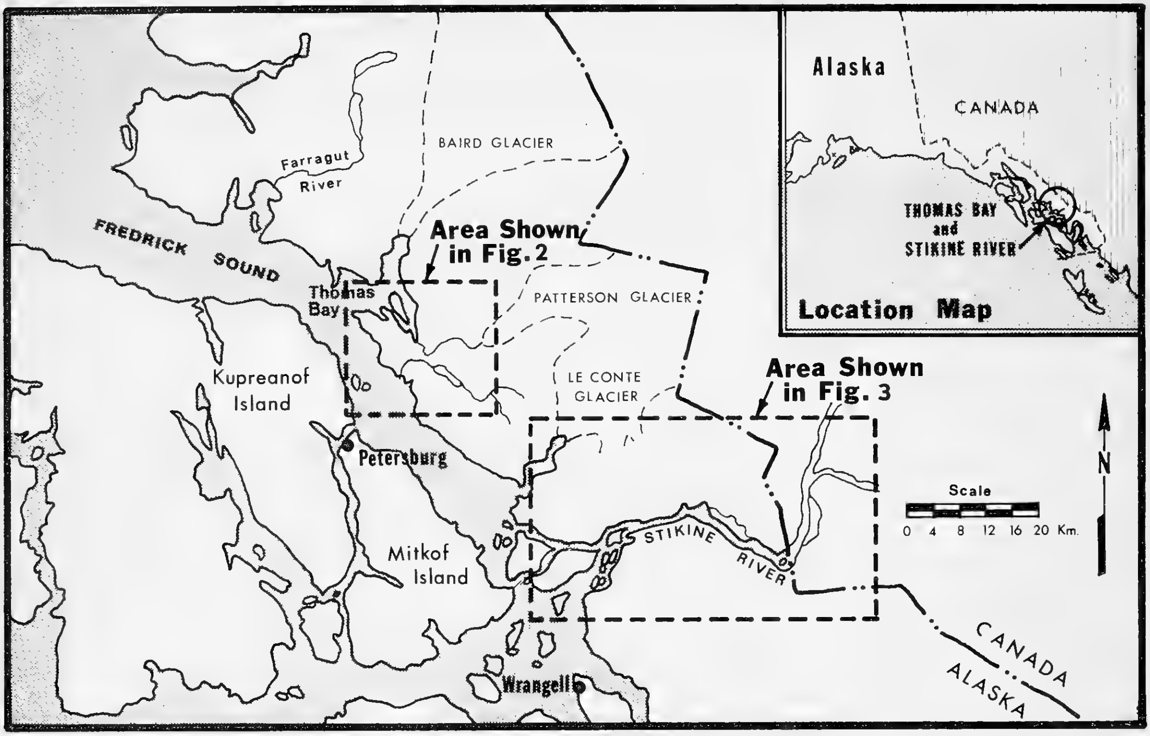

FIGURE 1. Thomas Bay and Stikine River study area.

ten relocations, 213 ha/relocation (range 36 – 626, n = 10) for the next ten relocations, 100 ha/relocation (range 0 – 346, n = 8) for the 21st through 30th relocations, and 43 ha/relocation (range 0 – 95, n = 6) for the 31st through 40th-plus relocations. I feel that the increase in total home range size with increased number of relocations is more a result of gradual changes in range use over a period of years than inadequate telemetry sampling during specific time periods. Total home range data are only analyzed for Moose with at least 25 relocations, recognizing that this reflects a somewhat conservative statistic for Moose movements over a specific number of months.

Percent area of different vegetation types within home ranges of Moose was calculated using a dot-grid. Seasonal habitat use at Thomas Bay was analyzed by separating the data into four periods: spring (April-May), summer (June-August), late fall-early winter (November-December), and winter (January-March). Data from September and October were insufficient for this analysis. Age-specific use of second-growth stands was evaluated at Thomas Bay by dividing the second-growth stands into age classes spanning seven-year intervals. Chi-square analysis was used to determine if habitat preferences, seasonal habitat use, and age related use of second-growth stands were evident in the data (Steel and Torrie 1960). The data were partitioned to avoid expected values less than five (Cochran 1954).

Plant classification followed Hultén (1968).

Study Area

The Thomas Bay study area is located between the LeConte and Baird Glaciers and includes the drainages of the Muddy and Patterson Rivers (Figure 1). The Stikine River study area includes the lower 50 km of the river as well as adjacent smaller drainages. Glaciers, icefields, vertical rock cliffs, talus slopes, alpine tundra, krummholz, estuarine meadows, muskegs, and floodplains are common in both areas. Coniferous forests are widely distributed from the beach to over 1000 m elevation. Three types of coniferous forests are recognized: old-growth, river terrace, and muskeg-scrub. Old growth is composed of Western Hemlock (*Tsuga heterophylla*) and Sitka Spruce (*Picea sitchensis*) with blueberry (*Vaccinium* spp.) as a major shrub understory species. These stands are characterized by large, live trees, large snags, high accumulation of woody litter, and an uneven forest age structure (Franklin et al. 1981), as well as substantial gross understory production and diversity (Alaback 1981).

River terrace forests on the Stikine River were typified by Spruce trees exceeding 76 cm dbh at variable spacing with a dense and varied shrub understory. Willows (*Salix sitchensis, S. alaxensis, S. interior, S. Barclayi, S. commutata*), Black Cottonwood (*Populus balsamifera trichocarpa*), alder (*Alnus crispa sinuata, A. oregona*), Salmonberry (*Rubus spectabilis*), Stink Currant (*Ribes bracteosum*), Red-osier Dogwood (*Cornus stolonifera*), Devil's Club (*Echinopanax horridum*), Highbush Cranberry (*Viburnum edule*), and Red-berried Elder (*Sambucus racemosa*) are common shrubs of the Stikine drainage with Willow, Black Cottonwood, and alder pioneering riparian shrub communities. Black Cottonwood forests of variable ages exist along the Stikine drainage with Spruce invading the older stands.

River terrace forests at Thomas Bay are typified by Sitka Spruce trees from 30 to 60 cm dbh and a variable *Vaccinium* shrub understory. Alder, Devil's Club, and Highbush Cranberry are often present in the younger river terrace forests, with Hemlock invading the more developed forests. Mixed stands of Sitka Willow (*S. sitchensis*), Black Cottonwood, and alder occur in appreciable quantities only in glacial riverwash soils and along logging roadsides. Alder thickets are common in slide areas and active floodplains.

Muskeg-scrub forests are composed of stunted Sitka Spruce, Western Hemlock, Mountain Hemlock (*T. Mertensiana*), Lodgepole Pine (*Pinus contorta*), and Yellow Cedar (*Chamaecyparis nootkatensis*) interspersed with muskegs and ponds containing a variety of plants, including sedges (*Cyperaceae*), ericacious shrubs, and Bunchberry (*Cornus canadensis*). Riparian sedge (*Carex* spp.) muskegs within the floodplain of the Stikine River are bordered and often interspersed with stands of willows, alder, and Red-osier Dogwood.

A soils-vegetation map, (F. R. Stephens, C. R. Gass, and R. F. Billings. 1968. Soils and site index in southeastern Alaska. Unpublished administrative study, USDA-Forest Service, Juneau, Alaska) was used to determine habitat availability at Thomas Bay. Site productivity of forest soils is measured by the total height that the average dominant and codominant tree will attain at 100 years of age. Site indices of Sitka Spruce range from 80 to 150 on sites classified as commercial forest soils.

The Alaskan portion of the Stikine River area has wilderness status and the habitat has not been appreciably altered by human activity. Conversely, Thomas Bay is in an area designated for intensive timber harvest. From 1951 to 1976, over 2500 ha were clearcut in the drainages of the Patterson and Muddy Rivers. Logging activity ceased in 1976, except for minor salvage sales: Approximately 650 ha of 10-to-25-year-old clearcuts were precommercially thinned from 1975 through 1980.

Clearcuts under 30 years of age have higher forage production and diversity than surrounding old-growth forests (USDA-Forest Service unpublished data, Petersburg Ranger District). Bunchberry, certain ferns, grasses, 5-leaf Bramble (*Rubus pedatus*), Salmonberry, alder, Trailing Black Currant (*Ribes lacustre*), and Red-berried Elder increase in early second-growth stages.

Both study areas are affected by a maritime climate with the average annual precipitation ranging from 200 to 400 cm depending on elevation and distance from saltwater (U.S. Department of Agriculture 1979). Snowfall normally occurs from November through April and is likewise influenced by elevation and proximity to saltwater. Periodic rains commonly occur throughout the winter at Thomas Bay and the delta region of the Stikine River, drastically altering snowpack. Snow often persists into May in the eastern portion of the Stikine River study area with little melting occuring during January through March. This snow is typically hard packed by wind action, often easily supporting Moose on its crust. By contrast, snow at Thomas Bay could seldom support Moose during this study. For a more detailed description of vegetation and climate see Taylor (1932), Klein (1965a), and Alaback (1981).

I estimate densities of approximately 2.3 Moose/km^2 in the best habitat of both study areas based on the number of marked to unmarked animals seen, pellet-group densities in trend transects, the number of animals sighted during optimum winter viewing conditions, and the level of hunter harvest. (USDA Forest Service unpublished data, Petersbury Ranger District).

Results

Home Range and Movements

Mean total home range sizes (Table 1) were comparable between both Thomas Bay and the Stikine River (4480 vs. 3840 ha, respectively, $P > 0.50$). Distances of maximum separation between all individual relocations (Mould 1979) averaged 13.2 km, for Thomas Bay Moose and 15.1 km for Stikine River Moose, an insignificant difference ($P > 0.50$). Three of the Stikine Moose were migratory, with winter home ranges that were significantly larger than their summer home ranges (930 vs. 210 ha, $P < 0.05$).

Observed movement patterns varied among individuals in each study area (Figure 2). At Thomas Bay, Cow 1 was consistently located within 0.8 km of the Patterson River, except when she moved inland 3.2 km to a heavily logged area adjacent to the Muddy River during a period of severe snowfall in March

TABLE 1. Home range sizes and straight-line distance of maximum separation between locations of telemetered cow Moose, Thomas Bay and Stikine River.

Moose No.	Dates of Location	No. Locations	Home Range Size (ha)	Distance Max. Separation (km)
Nomigratory:				
T1	3/78- 3/79	17	900	4.8
T2	3/78- 9/80	51	3530	11.4
T3[1]	3/78- 9/80	47	5140	18.4
T4[2]	3/78- 9/80	53	4770	9.9
T5[1]	3/78- 1/80	18	1850	12.6
S5[1]	4/79-10/81	43	7240	18.4
S78[1]	4/79- 9/80	26	3530	11.2
S84[1]	4/79-10/81	43	3050	11.3
S85[1]	4/79- 6/80	27	7300	20.0
Migratory				
S79	5/79-12/79	9	190	—
	1/80- 4/8/80	7	1200	—
	4/28/80- 9/80	10	160	—
	4/79- 4/81	29	2180	16.4
S81[1]	10/79- 5/21/80	14	1430	—
	5/28/80- 9/80	11	240	—
	4/79- 4/81	34	2320	16.8
S83	5/79-12/79	9	250	—
	1/80- 5/21/80	8	310	—
	5/28/80- 9/80	10	230	—
	2/81- 7/20/81	6	780	—
	7/31/81-10/81	5	200	—
	4/79-10/81	39	1280	11.8
$\bar{X}$ Thomas Bay	—	3 Moose[3]	4480 (± 843)[4]	13.2 (± 4.5)
$\bar{X}$ Stikine River	—	7 Moose	3840 (± 2450)	15.1 (± 3.7)

[1] Cows with fall calves

[2] Summer-winter ranges overlapped in 1978-79, but not in 1979-80

[3] Total home ranges only analyzed for Moose with more than 25 relocations.

[4] (± STD)

1979. Radio contact was subsequently lost with this individual. Cow 2 spent most of her time along the lower 6.4 km of the Patterson River drainage. Notable exceptions were from 26 April-27 July, 1978, 17 April-26 May 1979, and 12 June-10 July 1980, when she was found ca. 7.2 km farther inland along the Muddy River. Cow 5 was located by radio signal from April through September 1978, but only intermittently thereafter (visual sightings) due to radio failure. On 26 April and 28 June 1978, she was located on Ruth Island. All other locations were within 0.8 km of the Patterson River from its mouth to within 1.8 km of the glacier that is its source. Relocations of this Moose (n = 8) from April through September were within 2.8 km of saltwater, while nine relocations from November through March averaged 3.4 km distance from saltwater (range 0.8-6.4 km). This suggests that Cow 5 tended to move farther inland during winter months. On the other hand, Cow 4 was located 5.4 to 8.8 km inland along the Muddy River during the periods 27 June-2 November 1978, 26 May-2 November 1979, and 21 May-13 September 1980, excluding two summer locations in the Patterson drainage in 1978, and within 3.8 km of the mouth of the Muddy River during the remainder of the study period.

Cow 3 displayed the most wide-ranging movements of any telemetered Thomas Bay Moose, moving widely throughout the study area. From April through September in 1978 to 1980, she was generally located within 1.6 km of the Thomas Bay or Bock Bight shoreline, and swam at least twice to Ruth Island during the period late April to early June 1978 (Figure 2). From November 1978 to March 1979, Cow 3 inhabited a home range of 3030 ha that included portions of the lower Muddy and Patterson River drainages, as well as beach fringe forests and muskeg-scrub forests to 276 m elevation ca. 4.8 km south of the lower Muddy River. From November 1979 through March 1980, during a relatively moderate

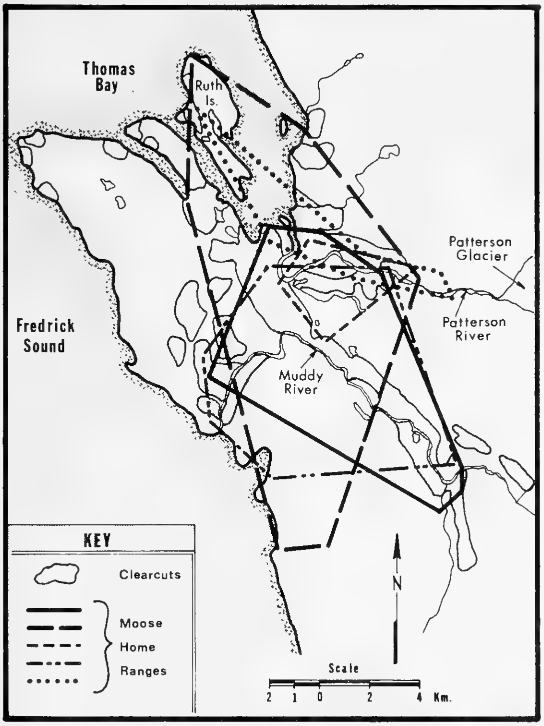

FIGURE 2. Location of clearcuts and total home ranges of telemetered Thomas Bay Moose.

winter, Cow 3 had an observed home range of only 250 ha confined to within 1.6 km of the southeastern shoreline of Thomas Bay.

Four of the telemetered Stikine River Moose has seasonally overlapping home ranges located primarily within the Stikine River Valley and lower Andrew Creek drainage (Figure 3). Of the three migratory Moose, Cow 81 occupied a summer home range in 1979 and 1980 along a tributary of Thunder Creek, 6.2 km north of its winter range on the Stikine River. Cows 79 and 83 wintered in the Stikine River Valley and lower portions of Andrew Creek and had small summer home ranges along the upper north fork of Andrew Creek. Both Moose returned to their winter home ranges in December or early January, with observed minimum distances between seasonal ranges equalling 5.6 and 4.6 km for Cows 79 and 83, respectively. Aerial reconnaissance surveys flown during excellent tracking snow conditions on 25 January 1980, and 4 March 1981, revealed no Moose tracks or sign in these summer home ranges and suggest that the drainage of the north fork of Andrew Creek beyond four km from its mouth is largely devoid of Moose during months of high snow accumulation.

Timing of movement to summer ranges varied among the individuals and the years. Cow 83 moved to her summer range between 21 and 28 May in 1980,and between 20 and 31 July in 1981. Cow 81 moved to her summer range between 4 and 12 June in 1979, and 21 and 28 May in 1980.

Several of the telemetered Moose made movements that reduced the possibility of contact with hunters during the bull Moose hunting season. Cows 5 and 85 were located in the Canadian portion of the Stikine River 4.5 and 2.6 km above the border on the last day of the season in 1979. Cows 5 and 84 left the floodplain of the river, where hunters concentrate, and moved into mature forests north of the river during the early portion of the 1981 season. During the 1979 and 1980 hunting seasons, Cows 79 and 83 were on their summer ranges in the relatively inaccessible upper north fork of Andrew Creek.

Habitat Use

Thomas Bay

Home ranges of telemetered Moose at Thomas Bay were largely restricted to relatively level, low elevation habitats containing a mixture of clearcuts, forests, and riparian habitats. Ninety-four percent of all relocations ($N = 179$) were at elevations under 77 m and 97 percent were on slopes from 0 to 35 percent. Only 11 relocations (6%) were more than 0.4 km from a clearcut or 0.8 km from the main course of the Muddy or Patterson River. Three of these relocations were in beach fringe old-growth during periods of high snow accumulation, while the remainder were in muskeg-scrub forests or low volume (site index less than 120) old-growth forests. Extensive tracts of old-growth above the river bottoms were largely unutilized by the collared Moose.

Total home ranges of telemetered Moose overlapped each other, and all home ranges were combined when testing for habitat preference and use. Relocations in glacial riverwash soils were significantly higher than expected, while relocations in muskeg-scrub forests and muskegs were significantly less than expected based on the proportion of these habitat categories in the combined home ranges of the telemetered Moose ($P < 0.005$). Use of Hemlock-Spruce forest soils was in proportion to their occurrence in the area (Table 2). Fifteen to 20 percent of the Moose relocations were in glacial riverwash soils compared to ca. 70 percent in Hemlock-Spruce forest soils.

Clearcuts from ages two to 30 and unlogged forests comprised 23 and 41 percent, respectively, of the combined home ranges of the Moose and accounted for 52 and 46 percent, respectively, of all exact relocations in commercial forest soil types. Based on these

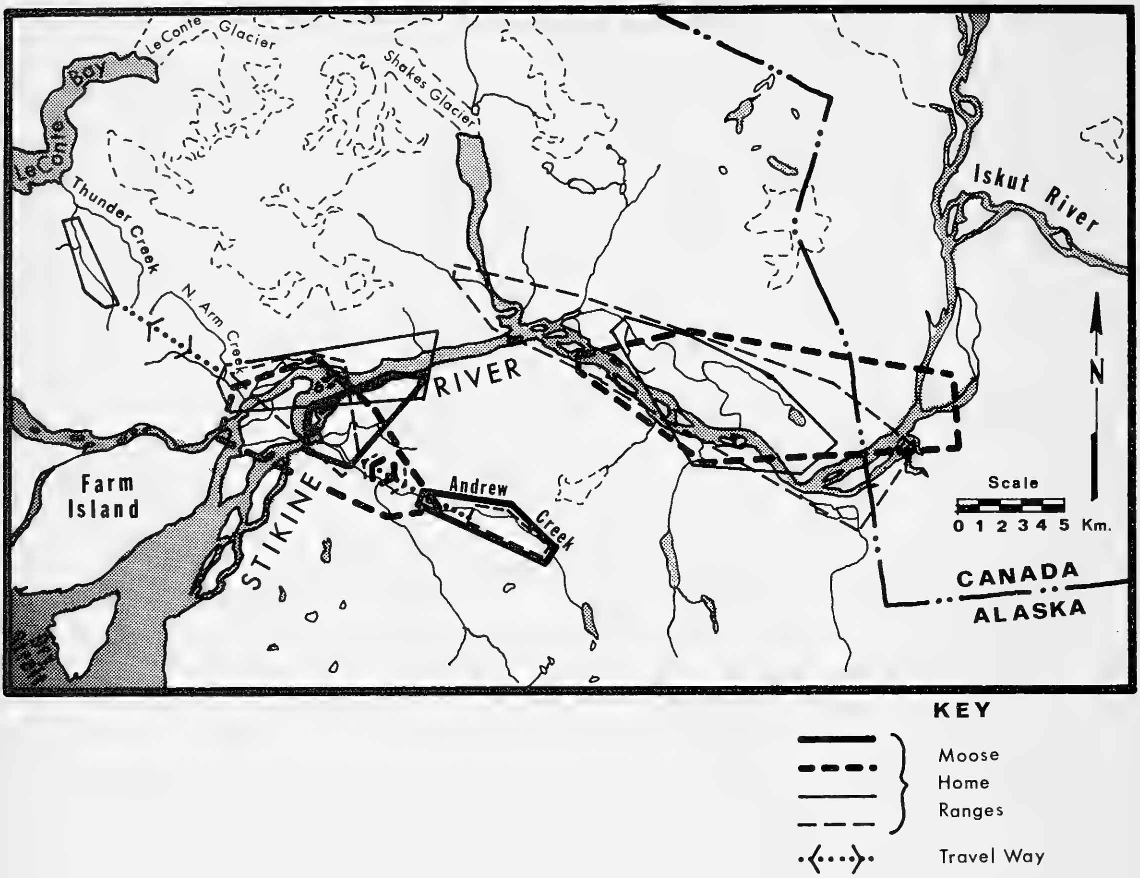

FIGURE 3. Location of home ranges of telemetered Stikine River Moose.

data, clearcuts were used significantly more than unlogged forests (P < 0.005). Differences in sightability between clearcuts and forests did not greatly affect the proportion of exact locations in clearcuts compared to forests as only seven telemetered Moose were sighted in clearcuts during fixed-wing flights. The proportion of relocations in river terrace soils was higher than expected, while the proportion of relocations in low volume forest soils was lower than expected (Table 2, P < 0.005).

Eighty-four percent of all exact relocations in river terrace soils were in unlogged stands compared to 25 percent of all relocations in old-growth soils with site indices from 120 to 150. The data suggest that unlogged river terrace forests were preferred over river terrace clearcuts (P < 0.005) and that clearcuts under 30 years of age on other forest soils were preferred over high-volume old-growth forests (P < 0.005).

Major differences in the proportion of relocations in glacial riverwash habitats, old-growth, clearcuts, and muskeg-scrub timber were observed with respect to season. Sample sizes during any period were small, however, and precluded a conclusive determination of seasonal use at Thomas Bay. We did detect a significantly (P < 0.025) higher percentage of relocations in muskegs, muskeg-scrub forests, and inexact locations associated with muskeg soils during January to March (34 %) and significantly lower use of the above habitats during November and December (3 %) compared to the entire year (16% overall). Likewise, the number of relocations in clearcuts compared to all exact relocations in forest soils was significantly (P < 0.025) lower in the months June to August (6 of 21) and higher in November and December (10 of 12) than the entire year (42 of 81 relocations).

Heavy snowfall conditions (150+ cm in open areas) were present during only four weeks of the Thomas Bay study in February and March of 1979. Of eight relocations during that period, two were in open scrub

TABLE 2. Summary of locations of five telemetered Thomas Bay Moose, April 1978-September 1980 by soil-vegetation type.

Soil-Vegetation Type	No. Locations	Percent Locations	Percent Area[a]
Riverwash (RW)	25	14	5
Hemlock-Spruce (F type)	108	62	64
Muskeg-Scrub (MF5)	8	5	16
Muskeg (M type)	2	1	13
RW-F Mixture[b]	12	7	—
M-F or MF-F Mixture[b]	18	10	—
Estuarine	0	—	1
Lakes, Ponds	0	—	2
	173		
F Types (62% of total)			
Uncut Forest	37	21	41
Clearcut (2 to 30 years)	42	24	23
Regrowth (31 to 70 years)	2	1	1
Uncertain[b]	27	16	—
RW-F, M-F, and MF-F Mixture (17% total)[b]			
Uncut Forest[c]	21	12	—
Clearcut (3 to 29 years)[c]	3	2	—
Uncertain	6	3	—
F Type (exact locations)			
River terrace soils	21	23	8
High-volume old-growth soils[d]	66	72	46
Low-volume commercial forest soils[e]	5	5	10
	92	100	

[a] Based on combined total home ranges of all Moose. Slopes greater than 75% accounted for 9% of the home ranges were excluded from calculations of area.

[b] Approximate location overlapped on more than one type.

[c] F type which could have contained the Moose.

[d] Site index greater than 119.

[e] Site index 80 to 119.

riverwash habitat, two in young river terrace forests, and four in old-growth forests within 0.5 km of saltwater.

Clearcuts of ages 2-8, 9-15, 16-22, and 23-29 comprised 12, 28, 51, and 9 percent, respectively, of all clearcuts within the combined home ranges of all the telemetered Moose. Moose relocations (N = 40) in these respective age categories were 3, 23, 68, and 8 percent of relocations in clearcuts. The observed proportion in each age category is not significantly different than would be expected based on the proportion of these categories.

Stikine River

Habitat data were gathered on nine Stikine River Moose, with seven Moose contributing the bulk of the relocations. All Moose were closely associated with riparian habitat. Only two of 246 relocations were more than 0.4 km from the floodplain of the Stikine River or the stream courses of Andrew, Thunder, or North Arm Creeks. Only six locations (two percent) were in *Tsuga-Picea* old-growth forests with a *Vaccinium* understory, one location was in a pond surrounded by *Tsuga-Picea-Vaccinium* forests, and eight inexact locations overlapped on such forests. Ninety-three percent of the relocations were in riparian shrub habitats, Spruce river terrace forests, Cottonwood forests, riparian sedge muskegs, or a mixture of these habitats. Two locations were on forested hillsides bordering the river with a dominant alder understory. The exact riparian plant community could not be identified in 55 percent of the relocations during April through November due to the complex mosaic of vegetative communities within the riparian zone, as well as the poor summer sighting conditions. During December through March, 43 percent of 57 relocations were in Spruce river terrace forests, 24 percent in riparian shrub habitats, 14 percent in Black Cottonwood forests, 3 percent in mixed Cottonwood-Spruce forests, 14 percent in inexact riparian habitat, and one location was in a sedge (*Carex* spp.) riparian muskeg. During December through March, 86 percent of the relocations were in the Stikine River Valley and 14 percent in adjoining drainages. During the rest of the year, 58 percent of the relocations were in the Stikine River Valley. These percentages are significantly different ($P < 0.005$) and indicate that Moose tend to concentrate in the Stikine River floodplain during winter months.

Cow 81 had a summer range between 150 and 300 m elevation, and Cows 79 and 83 had summer ranges located between 78 and 140 m elevation. Ninety-seven percent of the other relocations were under 78 m elevation. Only two percent of all relocations were on slopes exceeding 35 percent.

Discussion

Moose are closely associated with riparian habitat in many portions of their North American range (Sumanik and Demarchi 1977; Mould 1979; Houston 1968; LeResche et al. 1974; Peek 1974; Berg and Phillips 1974). In forests with limited riparian habitat, Moose tend to select early successional stands created by fire or logging, especially during the fall and early winter and in the spring (Krefting 1974; Peek et al. 1976; Eastman 1974; Bergerud and Manuel 1968; Hamilton et al. 1980). Moose populations may increase several fold when early seral stands are created in mature or climax forests (Bergerud and Manuel 1968; Peek et al 1976; Cowan et al. 1950; Bishop and Rausch 1974; Aldous and Krefting 1946; Geist 1971). By contrast, Moose often prefer conifer forests during periods of heavy snowfall (Peek et al. 1976; Eastman 1974; Knowlton 1960; Stevens 1970; Van Ballenberghe and Peek 1971; Brassard et al. 1974; LeResche et al. 1974; Peterson 1977).

In the Stikine River population, 94 percent of all relocations were in riparian habitat, including Spruce river terrace stands. At Thomas Bay, glacial riverwash soils, supporting quantities of Willows and Black Cottonwood, were preferred by Moose and accounted for 15 to 20 percent of all relocations. The preference for riparian communities is supported by observations of Klein (1965b) and LeResche et al. (1974) who noted a close association of Moose distributions in southeastern Alaska to mainland river drainages.

In both populations, riparian communities with tall deciduous shrubs and Sitka Spruce river terrace forests were important habitats of Moose during conditions of thick snow cover. At Thomas Bay where these habitats are limited, old-growth Spruce-Hemlock forests were also important winter range. River terrace forests were selected over old-growth forests in both populations.

At Thomas Bay, Moose selected soils with high Spruce productivity over poorer sites and favored clearcuts over unlogged old-growth stands. The presence of large clearcut areas in early stages of successions may be a factor accounting for the relatively high Moose abundance observed during the study. Cowan et al. (1950) noted that the removal of old-growth Engelmann Spruce (*Picea Engelmanni*) forest by fires in central British Columbia was followed by an increase of Moose and that the highest densities of Moose occurred in young second-growth areas.

Home range sizes and movements of Moose are highly variable among individuals and among various populations in North America (Ritchie 1978; Van Ballenberghe 1977; Phillips et al. 1973; Addison et al. 1980; Hauge and Keith 1981; LeResche 1974). Observed distances of movements tended to be shorter and home ranges smaller for southeastern Alaska Moose than those reported for Moose in Idaho (Ritchie 1978), arctic and boreal Alaska (Mould 1979; Van Ballenberghe 1977; Taylor and Ballard 1979), and Alberta (Lynch 1976; Hauge and Keith 1981).

Habitat management concerns vary between the two areas. The Stikine River population is highly dependent upon the vegetation produced within the Stikine floodplains, especially during winter months. Long-range effects of regulated water levels on the downstream riparian communities need to be determined to evaluate the impact of proposed dam construction on the Moose population.

The Thomas Bay Moose population extensively utilizes timber stands with site indices from 120 to 150 and clearcuts with high forage production. Alaback (1981) has shown that in unthinned clearcuts second-growth conifers dominate the site and deciduous browse and forb production is virtually eliminated 25 to 35 years after logging. Loss of early clearcuts, a preferred habitat, may have major impacts on the population. Long-range management of Moose at Thomas Bay should emphasize sustaining a mixture of high forage second-growth and forested winter habitat. The ability of precommercial thinning to prolong understory production and Moose utilization of second-growth stands needs to be studied.

Acknowledgments

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Notes

Northern Records of Risso's Dolphin, *Grampus griseus*, in the Northeast Pacific

HOWARD W. BRAHAM

National Marine Mammal Laboratory, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, Seattle, Washington 98115

Braham, Howard W. 1983. Northern records of Risso's Dolphin, *Grampus griseus*, in the Northeast Pacific. Canadian Field-Naturalist 97(1) 89–90.

On 12 March 1976 two Risso's Dolphins were observed in the Gulf of Alaska 450 km north of their reported summer range. This is the most northern verified record for this temperate species and represents the earliest annual sighting in the North Pacific.

Key Words: *Grampus griseus*, Risso's Dolphin, Gulf of Alaska, Northeast Pacific, Vancouver Island, British Columbia.

On 9 and 12 March 1976, while transiting from Seattle, Washington to Kodiak, Alaska aboard the NOAA ship SURVEYOR, I observed seven Risso's Dolphins (*Grampus griseus*) in three separate groups. In addition, R. Mercer, Northwest and Alaska Fisheries Center, Seattle, reported to me a sighting he estimated to exceed 2,000 individuals made while he was aboard the F/V TRES CHER on 3 August 1981 off Washington state (Table 1). The sighting on 12 March 1976 constitutes the northernmost record of Risso's Dolphin in the Pacific Ocean, and Mercer's sighting of the largest concentration reported from the Northeast Pacific.

Leatherwood et al. (1980) reviewed all information available on the species' occurrence in the eastern North Pacific through 1978. They included as the northernmost record accounts by Guiquet and Pike (1965) of several sightings at 50° N, 145° W between July and October, 1958-1960. Reimchen (1980) extended the range of the species (Table 1). In the western North Pacific, Risso's Dolphins have been reliably reported near the Kuril Islands, as far north as 51° N (Sleptsov 1961). *G. griseus* was also reported for the Aleutian Islands by Collins, Clark and Walker (1945) and Commander Islands at Lat. 54° N by Sleptstov (1952). Leatherwood et al. (1980) rejected as unsubstantiated reports by Collins et al. (1945) of Risso's Dolphins around the Aleutian islands. Tomilin (1957) similarly regarded the reports in Sleptsov (1952) of Risso's Dolphins in Commander Islands as unsupported. In addition, of the 13 species of dolphins and porpoises reported by Collins et al. (1945) and Sleptsov (1952) as occurring in the southern Bering Sea, eight are not documented in the literature (D.

TABLE 1. Recent sightings of Risso's Dolphins in the Northeast Pacific Ocean.

Date	Time	Location	Number of individuals	Water depth (m)	Source
12 March 1976	1040	55°49′N, 145°56′W	2	4000	Author's observation, this paper
27 March 1978	1500	54°11′N, 133°01′W	14	10-12	Reimchen (1980)
9 March 1976	1350	49°52′N, 128°37′W	2	183	Author's observation, this paper
9 March 1976	1338	49°50′N, 128°30′W	3	183	Author's observation, this paper
3 August 1981	1100	47°10′N, 125°20′W	2000+	290	R. Mercer, personal communication, February 1982

Rice, National Marine Mammal Laboratory, personal communication, May 1982), and therefore I believe them to be unsubstantiated.

Several coastal sightings and strandings have occurred along the west and northwest coast of North America, but most were south of Canada and occurred in summer (Guiguet and Pike 1965; Stroud 1968; Hatler 1971). The spring records included in Table 1 are 3-4 months earlier in the year than previously noted for the species in the northern portion of its range. These few sightings suggest that the northern limit probably does not exceed the southern portion of the Gulf of Alaska; the species constitutes a rare visitor to Alaskan waters as evidenced by the lack of strandings north of southern British Columbia.

The August 1981 record (Table 1) is of special interest because of the size of the sighting. The 2000+ estimated Risso's Dolphins were observed over an area 2-4 km long by 4 km wide. In association with these Risso's Dolphins were approximately 1000 Right Whale Dolphins (*Lisodelphus borealis*), 500 White-sided Dolphins (*Lagenorhynchus obliquidens*) and 30 Dall's Porpoise (*Phocoenoides dalli*).

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The Swamp Saxifrage, *Saxifraga pensylvanica*, a Rare Plant in Canada, Newly Discovered in Saskatchewan

VERNON L. HARMS

Biology Department and W. P. Fraser Herbarium, University of Saskatchewan, Saskatoon, Saskatchewan S7N 0W0

Harms, Vernon L. 1983. The Swamp Saxifrage, *Saxifraga pensylvanica*, a rare plant in Canada, newly discovered in Saskatchewan. Canadian Field-Naturalist 97(1): 91–93.

Saxifraga pensylvanica, the Swamp Saxifrage, is reported as newly discovered in the Saskatchewan Pasquia Hills. The Canadian records for this rare species are reviewed.

Key Words: *Saxifraga pensylvanica*, Swamp Saxifrage, Saskatchewan, rare plant.

In June 1981, during a botanical foray in the Saskatchewan Pasquia Hills, we made the rather startling discovery of Swamp Saxifrage, *Saxifraga pensylvanica* L. ssp. *pensylvanica* [about 1.2 km west of Km 21 (Mile 13) of the Fir River Road north of Veillardville (Sect. 2, Twp. 47N, Rge. 5N2M; 53°01′N, 102°38′W; elev. 1825′), very scarce on sedge hummocks in an open, marshy bog-fen; Harms et al. #29416 (SASK), see Figure 1]. Besides myself, the members of the field party included Patricia Sky, the Fraser Herbarium Technician, and local naturalists, Donald F. Hooper of Somme and Les Baker of Carragana, the latter actually being the first to sight this different-appearing plant. Some of the plant associates in the fen community were the codominant sedges: *Eriophorum viridi-carinatum* (Engelm.) Fern., *E. gracile* W. J. D. Koch, *Carex prairea* Dewey, *C. tenuiflora* Wahl., *C. lasiocarpa* Ehrh., *C. magellanica* Lam. var. *irrigua* (Wahl.) B.S.P., *C. diandra* Schrank, *C. canescens* Dewey, and *C. interior* Bailey; the dominant shrubs: *Betula glandulifera* (Regel) Butl., *Salix candida* Fluegge, *Salix* spp., and *Chamaedaphne calyculata* (L.) Moench; the more common forbs: *Menyanthes trifoliata* L., *Potentilla palustris* (L.) Scop., *Galium trifidum* L., *Lysimachia thyrsiflora* L., *Equisetum fluviatile* L., *Triglochin maritima* L., and *Caltha palustris* L. Other Saskatchewan rare plants found at the boggy Black Spruce treed borders of the same fen were *Pedicularis parviflora* Sm., *Cardamine pratensis* L. var. *palustris* Wimn. & Grab., and *Cypripedium calceolus* L. var. *pubescens* (Willd.) Correll.

The known range of *Saxifraga pensylvanica*, as extrapolated from Burns (1942) and a combination of current floras, has been from southeastern Manitoba, western and southern Ontario, and southern Maine, south to southeastern Minnesota, northern Missouri, Illinois, and western North Carolina. It is considered rare at least in most of the peripheral areas of its range. This species has been listed as rare in Canada (L. Kershaw, J. K. Morton, and J. Venn. 1976. Inventory of Rare and Endangered Vascular Plants of Ontario: Computer printout, Department of Biology, University of Waterloo, Ontario; Argus and White 1977; White and Johnson 1980). Canadian records appear

FIGURE 1. *Saxifraga pensylvanica* L. Collection from the Pasquia Hills, Saskatchewan.

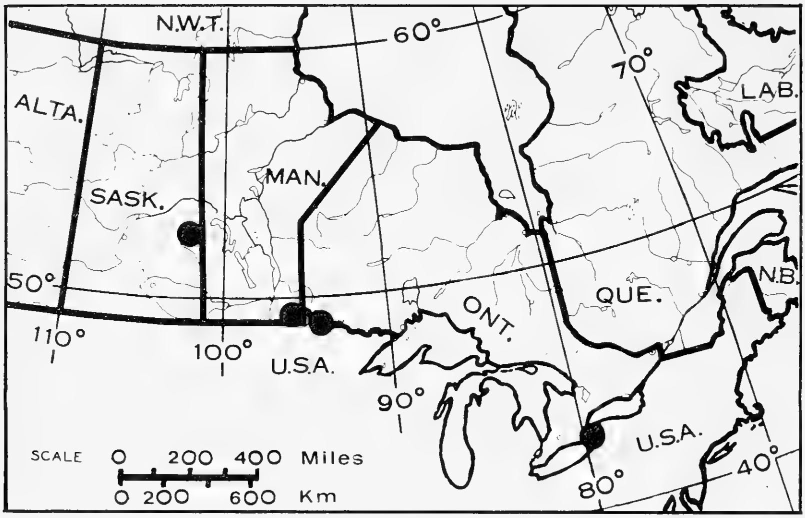

FIGURE 2. Canadian Distribution of *Saxifraga pensylvanica*.

quite limited for the plant, and it is reportedly scarce wherever found in this country. Macoun (1886) cited an early Ontario collection by David F. Day from "low places, near Fort Erie" (in Welland Co., 42°54′N, 78°56′W), but Looman (1973) indicated that a herbarium search by Dr. Bernard Boivin had failed to locate the Day specimens to substantiate that report. According to Looman, Boivin's (1966) inclusion of the species for Ontario was based only on the more recent collections by Ward and C. E. Garton from the Rainy River area of far western Ontario. Scoggan (1978) further cites it, however, from Long Beach in Welland County, Ontario (42°52′N, 79°23′W), based on a report by Zenkert (1934). I am unaware of any other Ontario records for the Swamp Saxifrage.

Looman (1973) recorded it from the Moose Lake area (49°12′N, 95°19′W), southeastern Manitoba, a location just across the Lake-of-the-Woods within 50 miles of the Rainy River station in Ontario. The recent White and Johnson (1966) listing of the Manitoba rare plants cites only this single locality for the species in Manitoba. It was omitted for any of the Prairie Provinces by Breitung (1957), Scoggan (1957), Budd and Best (1964), Boivin (1968), and even Scoggan (1978). Figure 2 shows the widely separated Canadian stations thus far recorded for the species.

The present record from the Saskatchewan Pasquia Hills represents a surprising and phytogeographically quite interesting find, marking a 640 km (about 400 mile) northwestward extension of the species' known range in Canada. The Saskatchewan Pasquia Hills, along with the Porcupine Hills and Duck Mountain upland, are parts of the Manitoba Escarpment, representing highlands that bordered the south shores of former Glacial Lake Agassiz. These hills are phytogeographically interesting for including northwestern outlier stations (relict populations?) of a number of plant species belonging to the Eastern Deciduous Forest Element (e.g. *Anemone nemorosa* L. var. *bifolia* (Farw.) Boivin, *Cypripedium arietinum* R.Br., *Mimulus ringens* L., *Polygala pauciflora* Willd., *Prunus pumila* L., *Trillium cernuum* L.). The new record of *Saxifraga pensylvanica*, while more disjunctly isolated, and thus a more striking example, than others in the above group, seems phytogeographically classifiable with them. It probably represents a persistent relict from the post-Pleistocene Climatic Optimum. At that time, associates of the present eastern deciduous forest appear to have extended their ranges considerably farther northwestward than at present, but have subsequently been largely eradicated by climatic deterioration. According to the hypotheses of Love (1959), and in apparent agreement with the more recent findings of Ritchie (1966, 1976) and other modern workers, this maximum northwestward extension of the eastern forest element into Saskatchewan is probably referable to the earlier, more moist part of the "Hypsithermal Period", dated at about 9000-6000 years B.P.

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Small Game Hunting Behaviour of Polar Bears, *Ursus maritimus*

GARY D. MILLER[1] and DONALD R. WOOLDRIDGE[2]

[1]Biology Department, University of New Mexico, Albuquerque, New Mexico, 87131
[2]Quintette Coal Ltd., 1508 102nd Ave. Dawson Creek, British Columbia V1G 2E2

Miller, Gary D. and Donald R. Wooldridge. 1983. Small game hunting behaviour of Polar Bears, *Ursus maritimus*. Canadian Field-Naturalist 97(1): 93–94.

An adult female Polar Bear (*Ursus maritimus*) was observed catching a small rodent and a subadult Polar Bear was observed hunting and catching a Willow Ptarmigan (*Lagopus lagopus*).

Key Words: Feeding behaviour, hunting behaviour, Polar Bear, *Ursus maritimus*.

The major prey of Polar Bears (*Ursus maritimus*) throughout the Arctic is seals. Polar Bears are most successful hunting seals on sea ice (Stirling 1974), but can also hunt seals in ice-free water (Furnell and Oolooyuk 1980). Each year the bears along the western coast of Hudson Bay are faced with three to four months of little or no ice cover (Stirling et al. 1977), and based on scat analysis, their diet shifts to include carrion, berries, grass, birds, and microtine rodents (Russell 1975). Polar Bears also encounter Porcupines (Jonkel 1968), but it is not known if they consume them. Polar Bears are known to take Canada Geese (*Branta canadensis*) on land, but most of their bird hunting is probably confined to open water (Russell 1975).

During field observations of bear deterrent and detection systems near Churchill, Manitoba, we observed two incidences of Polar Bears preying upon small game. On 30 October 1978 we observed an adult female successfully hunt a small rodent. Then on 4 November 1978 we observed a subadult female stalk and take a Willow Ptarmigan (*Lagopus lagopus*).

The adult female we were watching had a cub of the year with her. She was walking across an esker near a large willow thicket with her cub following 5 m behind. There was approximately 10 cm of snow. As they were walking, the adult stopped suddenly and watched the ground at her feet with her ears directed toward the ground. When she stopped, her cub also stopped and remained about 4 m behind her, watching. After watching and listening for 3 to 4 seconds, the mother raised up, lifted her front feet off the ground and then pounced down hard on the snow with her front feet together. She then bit the snow and came up with a small rodent (probably *Microtus pennsylvanicus*). She then resumed walking while chewing her catch and her cub followed immediately.

The second incident of hunting we observed involved a subadult female stalking a Willow Ptarmigan. The bear approached a willow thicket from downwind and moved slowly through the brush. She occasionally disappeared from view, apparently crouching slightly. Suddenly she sprang up and forward, landing front feet first about 1 m ahead of her initial jumping point. The willow thicket was covered with a layer of snow approximately 40 cm thick and the attack generated a considerable spray of powder snow. The bear then walked directly out of the thicket carrying the ptarmigan in her mouth. She proceeded onto a nearby frozen lake and consumed the kill.

During our research period (September to November 1978), large flocks of ptarmigan were seen briefly each day. Ptarmigan roost in the snow under willow cover and occasionally roost under the snow. Likewise, small rodents utilise tunnels under the snow once there is sufficient snow cover. Consequently, the bears probably locate such prey by smell and hearing rather than by sight.

Polar Bears are not notable consumers of birds or small mammals. Scat analyses have shown birds and small mammals among their food items (Russell 1975) but little is known about how the bears obtain such food. Our observations indicate that Polar Bears obtain small game opportunistically as in the case of the small rodent, but they also actively hunt small prey. The subadult bear was hunting through the willow thicket when she found and captured the ptarmigan. In Churchill, as in the rest of southern Hudson Bay, the ice-free period during the summer is relatively long. There may be 3 to 4 months during which bears cannot hunt seals from the sea ice and must live ashore along the coast. A bear's ability to find and capture small prey species during these ice-free months may be important for its survival during the ensuing winter.

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Birds First Described from Hudson Bay

C. STUART HOUSTON

863 University Drive, Saskatoon, Saskatchewan S7N 0J8.

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More than two centuries ago, Linnaeus, Forster and others first named 19 new bird species and 9 forms now recognized as subspecies from the vast territory then known as 'Hudson's Bay.' The nearly-forgotten collectors were James Isham, Andrew Graham, Alexander Light, Humphrey Marten and Thomas Hutchins. Changes in type locality designation are recommended for three species and one subspecies.

Key Words: Hudson Bay, history, collections, type localities, Marbled Godwit (*Limosa fedoa*), White Pelican (*Pelecanus erythrorhynchos*), Purple Martin (*Progne subis*), subspecies of Gyrfalcon (*Falco rusticolus obsoletus*).

Between the late 1750s and 1770s, a handful of Hudson's Bay Company fur traders collected bird specimens, 28 of which were given Latin names by Linnaeus and other early taxonomists. "These few people provided a remarkable concentration of early type specimens from one sparsely settled area.

This article emphasizes the full extent of the type locality, 'Hudson Bay', and corrects errors and omissions in five earlier reviews of pre-1800 work. Stevens (1936) mistakenly credited the Golden Plover to Edwards and the Greater Yellowlegs and Tree Sparrow to Forster; Baillie (1946) told of eight species when in fact there were 13; McAtee (1950) covered Edwards very well, but the Hudson Bay provenance poorly; Allen (1951) omitted any mention of James Isham or Alexander Light; Snyder (1963) suggested an overly restrictive type locality of 'northeastern Manitoba' for 13 species. None of the five had access to two important but limited-edition books which contain Isham's, Graham's and Hutchins' early bird observations from Hudson Bay (Rich 1949, Williams 1969).

The general type locality of 'Hudson Bay' used in the 5th *American Ornithologists' Union Check-List* (1957) is inadequate or misleading for several species, in addition to the geographic ambiguity inherent in the citation of a vast inland sea, up to 1600 km in length and up to 1000 km in width. Few ornithologists have appreciated that until 1870 the popular term 'Hudson's Bay (the possessive form here is no longer in official geographic use) designated an area of nearly 3.6 million km^2 extending west to the Rocky Mountains and draining into the bay (Rich 1967). In this area, officially named 'Rupert's Land' for 200 years, the people, as well as some of its birds and mammals, were sometimes called 'Hudsonians' (Hearne 1795). For example, when Joseph Sabine described the North American form of the Black-billed Magpie, now *Pica pica hudsonia*, from specimens collected 600 km inland at Cumberland House, he named it "*Corvus Hudsonius*, Hudson's Bay Magpie" (Sabine 1823). Histories of the Hudson's Bay Record Society similarly spoke of the 1714 negotiations "settling the boundary between Hudson Bay and Canada" (Davies and Johnson 1965).

Linnaeus (1758) thus was 112 years ahead of his time when he used the term 'Canada' for the type locality of the Blue Goose, Surf Scoter, Spruce Grouse, Sharp-tailed Grouse, and one subspecies of Golden Eagle — all of which came from Hudson Bay. Canada was not an official name until 1791, and only after the purchase of the Rupert's Land territory from the Hudson's Bay Company in 1869-70 was it correct to use 'Canada' for the area which encompassed Hudson Bay.

Before Hearne established the first Hudson's Bay Company (HBC) inland trading post at Cumberland House in 1774, Indians came many hundreds of miles to trade at the posts on Hudson Bay. Andrew Graham told how, before 1769, Indians were bringing him birds' "skins stuffed and dried . . . from inland" (Williams 1969). Although an individual bird can wander far from its breeding territory, knowledge of typical habitat and present distribution offers a strong probability that Isham's Marbled Godwit was collected far inland, perhaps along the Saskatchewan River. For similar reasons, an inland derivation is almost as likely for the Purple Martin, White Pelican, and perhaps the Whooping Crane, although Samuel Hearne (1795) mentioned that occasionally ("not very often") a few Whooping Cranes would visit the bay in spring. For at least the Marbled Godwit, Purple Martin, and White Pelican, 'Hudson Bay Territory' or Hudson Bay drainage basin' would be a more accurate description of the type locality than the present use of 'Hudson Bay' or Snyder's (1963) suggestion of 'Northeastern Manitoba'. For the remaining species to be listed, 'Hudson Bay' is not a misleading designation.

Thirteen of the new species for which the type locality of 'Hudson Bay' is given in the 5th *AOU Check-*

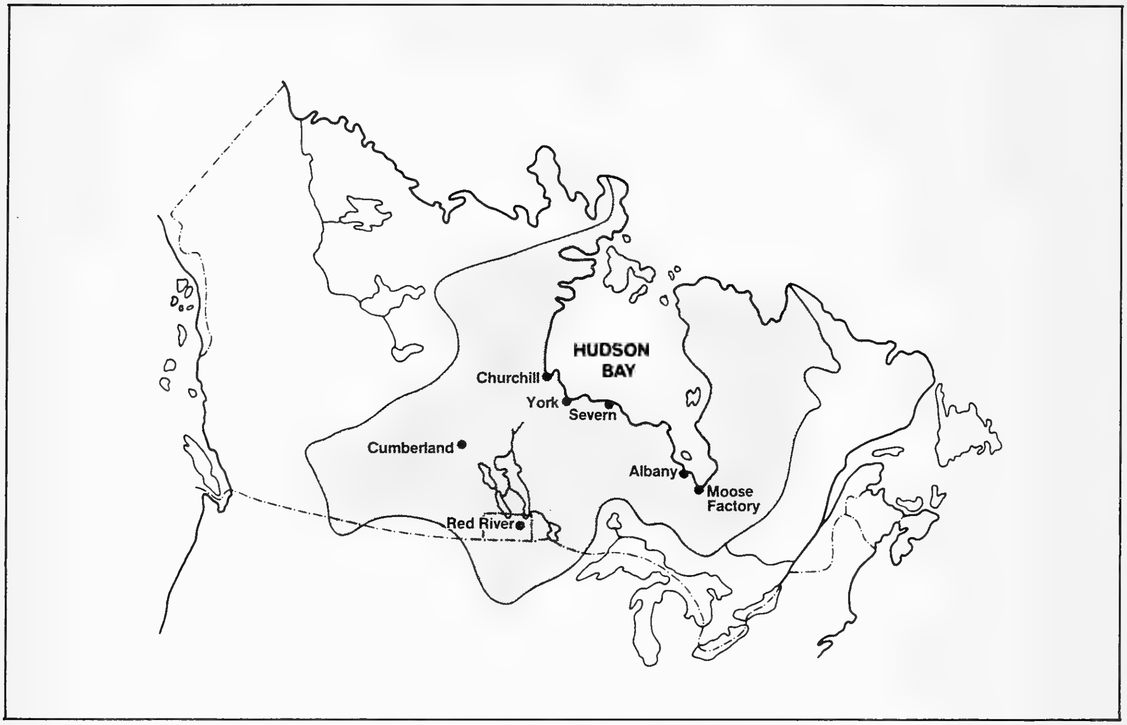

FIGURE 1. Extent of Hudson's Bay Territory, 1670–1870 (shaded area). Map redrawn from Encyclopedia Canadiana, edited by J. E. Robbins, 1957, with kind permission of the Grolier Society of Canada Limited.

List (1957) were collected by James Isham and illustrated in George Edwards' *A Natural History of Uncommon Birds*, volume 3 (Edwards 1750). They were among the first birds to receive binomial Latin names (Linnaeus 1758) as follows:

Ardea herodias	(= Great Blue Heron), page 143 in Linnaeus
Anas caerulescens	(= blue morph of Snow Goose, now *Chen caerulescens*), p. 124;
Anas perspicillata	(= Surf Scoter *Melanitta perspicillata*), p. 125;
Tetrao canadensis	(= Spruce Grouse *Dendragapus canadensis*), p. 159;
Tetrao phasianellus	(= Sharp-tailed Grouse *Tympanuchus phasianellus*), p: 160;
Ardea americana	(= Whooping Crane *Grus americana*), p. 142;
Ardea canadensis	(= Sandhill Crane *Grus canadensis*), p. 141;
Rallus carolinus	(= Sora *Porzana carolina*), pp. 153-154;
Scolopax fedoa	(= Marbled Godwit *Limosa fedoa*), p. 146;
Scolopax haemastica	(= Hudsonian Godwit *Limosa haemastica*), p. 147;
Tringa Fulicaria	(= Red Phalarope *Phalaropus fulicaria*), pp. 148-149;
Tringa lobata	(= Northern Phalarope *Phalaropus lobatus*), p. 148;
Hirundo subis	(= Purple Martin *Progne subis*), p. 192.

Isham's own observations, including mention of 39 species of birds, but only six of the above species, were not formally published until 1949 (Rich 1949).

Following up on Isham's collections, the Hudson's Bay Company in 1770 requested that its employees make a concerted effort to send more specimens back to England (Williams 1969, 1978). In 1771, Andrew Graham sent 64 skins of 39 species from Severn, augmented by 17 skins of seven species from Humphrey Marten at Albany, 17 skins of eight species from Moses Norton at Churchill, and two skins from Ferdinand Jacobs and surgeon Thomas Hutchins at York

Factory (Williams 1969). From the eight boxes of specimens, Johann Reinhold Forster the next year described five valid new species, with exact type localities (Forster 1772), the Eskimo Curlew from Albany, and the remaining four from Severn, as follows:

Scolopax borealis	(= Eskimo Curlew *Numenius borealis*), pp. 411 & 431-432 in Forster;
Strix nebulosa	(= Great Gray Owl), pp. 386 & 424-425;
Parus hudsonicus	(= Boreal Chickadee), pp. 408 & 430-431;
Muscicapa striata	(= Blackpoll Warbler *Dendroica striata*), pp. 406 & 428-430;
Emberiza leucophrys	(= White-crowned Sparrow *Zonotrichia leucophrys*), pp. 403-404 & 426-428.

John Latham (1785) first described the White Pelican in his *General Synopsis of Birds,* volume 3, based on two specimens from 'Hudson's Bay'. The pelican bill sent from Cumberland House by William Tomison, the full specimen sent via York Factory in 1771 and the specimen sent from Albany by surgeon Edward Jarvis about the same time may have been involved (Williams 1969). J.F. Gmelin (1789), in the 13th edition of *Systemae Naturae*, after the death of Linnaeus, bestowed the binomial of *Pelecanus erythrorhynchos.*

Andrew Graham in the 1770s wrote notes on 111 species of birds, and one version of his manuscript accompanied the collections. Thomas Hutchins later copied Graham's notes and added his own on another 11 species, and subsequently received inappropriate credit for Graham's observations as well as his own. The matter of authorship was sorted out and the observations of both men were eventually published together (Williams 1969, 1978).

Samuel Hearne (1795), probably a better naturalist than either Graham or Hutchins, provided the first recognizable description of what he called the Horned Wavey, but did not provide a Latin binomial for this small goose that was regular to the northwest of Churchill. Cassin (1861) named this goose for B.R. Ross, another HBC fur trader, some 66 years after Hearne's description.

Of the nine taxa now recognized as subspecies, each with the type locality of 'Hudson Bay,' two owe their provenance to another HBC employee, Alexander Light. His specimens, sent home to England even before those of Isham (Davies and Johnson 1965) were illustrated by Edwards (1743, 1747) in his first two volumes. The first was named by P.L.S. Müller (1776) in his supplement to *Systemae Naturae*, and the second by Gmelin (1789) in his 13th edition of *Systemae Naturae*, as follows:

Strix caparoch	(= Northern Hawk Owl *Surnia ulula caparoch*), p. 69;
Lagopus albus	(= Willow Ptarmigan *Lagopus lagopus albus*), p. 750.

Two other forms were named by Linnaeus from birds illustrated by Edwards in his first two volumes (1743, 1747). The first was an eagle shown with feathered tarsi but a white tail, brought alive to England by an unnamed "Gentleman employ'd in the Hudson's-Bay Company's Service" (Edwards 1743) and later designated on somewhat questionable grounds as the type for a subspecies:

Falco canadensis	(= Golden Eagle *Aquila chrysaetos canadensis*), p. 88.

The second, definitely an Isham specimen, was the one Hudson Bay taxon first described by Linnaeus (1776) in his 12th edition:

Falco hudsonius	(= Northern Harrier *Circus cyaneus hudsonius*), p. 128.

When Latham (1790) began using Latin binomials for the first time in his *Index Ornithologicus*, he named from a Hudson Bay specimen the North American form of the Whimbrel:

Numenius hudsonicus	(= Whimbrel *Numenius phaeopus hudsonicus), p. 712.*

Finally, Thomas Pennant (1785) in his first edition of Arctic Zoology described four more forms from Hudson Bay that were given the following Latin binomials by Gmelin (1789).

Colymbus cornutus	(= Horned Grebe *Podiceps auritus cornutus*), p. 591;
Tetrao rupestris	(= Rock Ptarmigan *Lagopus mutus rupestris*), p. 751;
Strix wapacuthu	(= Great Horned Owl *Bubo virginianus wapacuthu*), pp. 291-292;
Falco obsoletus	(= Gyrfalcon *Falco rusticolus obsoletus*), p. 268.

In the example of *F. r. obsoletus*, the type locality of 'Hudson Strait' given in the 5th *AOU Check-List* is incorrect, and should be changed to 'Hudson Bay' as first indicated by Pennant (1785). The error evidently arose through an unfortunate literal translation of Gmelin (1789), who used 'in freto Hudsonis' in the alternative wider Latin sense of 'the sea in general' (Simpson 1963: 256) for the Northern Harrier, Great Gray Owl, and Gyrfalcon, all of which had been sent from the bay — not the strait.

I hope the above material will correct some misconceptions and also give belated recognition to the fur traders who, two centuries ago, made important bird specimen contributions from a remote region of what is now called Canada.

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The Occurrence and Origin of Tiger Trout, *Salmo trutta* X *Salvelinus fontinalis*, in Ontario Streams

LARRY D. WITZEL[1]

College of Biological Sciences, University of Guelph, Guelph, Ontario N1G 2W1
[1]Present address: Ontario Ministry of Natural Resources, Nanticoke Fish Study, P.O. Box 429, Part Dover, Ontario N0A 1N0

Witzel, Larry D. 1983. The occurrence and origin of Tiger Trout, *Salmo trutta* x *Salvelinus fontinalis*, in Ontario streams. Canadian Field-Naturalist 97(1): 99–102.

Three natural hybrids of the Brook Charr (*Salvelinus fontinalis*) x Brown Trout (*Salmo trutta*) are described; the first published report of wild Tiger Trout from streams in Ontario. Examination showed that body vermiculation and the distribution of vomerine teeth were the most variable characters among hybrids. It was postulated that hybrids were probably more a result of an excited rival male Brook Charr intruding upon the spawning of paired Brown Trout, rather than from the actual spawning of Brook Charr with Brown Trout or the chance fertilization of trout ova by the downstream drift of charr milt.

Key Words: Brook Charr, Brown Trout, Tiger Trout, wild, intergeneric hybridization, fertilization, intraspecific spawning, hypothesis.

Since the pioneer work of Day (1882) several authors have reported on artificial hybrids within the family Salmonidae. These studies have included the Tiger Trout, a hybrid of the Brook Charr, *Salvelinus fontinalis* (Mitchill) and Brown Trout, *Salmo trutta* Linnaeus. Day's (1882) investigations characterized the Tiger Trout's sterility, distinct colouring, vermiculated body pattern, poor survival, and taxonomic characters as intermediate between those of the Brook Charr and Brown Trout. Subsequent studies by Alm (1955), Buss and Wright (1956, 1958), Susuki and Fukuda (1971, 1973), and Blanc and Chevassus (1979) have elaborated on these and other aspects of the Tiger Trout.

Brown (1966) described three Tiger Trout collected from streams in Montana over a 15 year period. Allan (1977) described the first Tiger Trout reported in Alberta. Despite this hybrids apparent rare occurrence in the wild, other feral specimens have undoubtedly been sighted, but, they either were not reported or were not recognized as different when captured. Fowler (1944) identified two specimens of Tiger Trout from a tributary of the Delaware River in 1932 as dwarf Brown Trout, however, a photograph accompanying Fowler's report would seem to indicate these fish were Tiger Trout.

This paper reports the first incidence of wild Tiger Trout from Ontario, a description of each specimen, and speculation on behavioural and biological events which could lead to the hybridization of Brook Charr with Brown Trout in nature. A search of the literature (on fish hybrids) compiled by Schwartz (1972) and Dangel et al. (1973) indicated that no one has observed Brook Charr spawning with Brown Trout, nor has there been an explanation of how these two species might hybridize in nature.

Ontario Tiger Trout

In Galt Creek near Aberfoyle, Ontario, I captured a Tiger Trout on 19 October 1978 while electrofishing for Brook Charr and Brown Trout. A written inquiry to all nine Ontario Districts of the Ministry of Natural Resources within the sympatric range of the charr and trout, and a search of records (by museum staff) at the Royal Ontario Museum (ROM) and the National Museums of Canada revealed that only two other wild caught specimens existed for Ontario (see Table 1) and that neither had been published. Both of these Tiger Trout were caught by anglers and donated to the ROM which lent them to the author for this study.

A Tiger Trout was recorded in a 1975 Ministry of Natural Resources stream survey report of Gibsons Creek near Turkey Point. However, this specimen and others allegedly caught by anglers from Gibsons Creek have not been authenticated (apparently neither specimens nor photographs of them were kept).

Characters of the Ontario Tiger Trout were measured or counted according to the methods of Hubbs and Lagler (1964). Vertebral counts were made from radiograms. Ontario Tiger Trout demonstrated close similarity in the characters examined (Table 1). Body vermiculations and the distribution of vomerine teeth showed the greatest variability among hybrids. These two characters were also among the most variable in

TABLE 1. Catch and numerical information on wild Tiger Trout from Ontario.

	Specimens		
Date of capture	21 July 1969	19 October 1978	19 May 1979
Location of capture	Potters Ck. Norfolk Co.	Galt Ck. Wellington Co.	Bighead R. Grey Co.
ROM catalogue number	27155	—	35744
Weight (g)	111.4	32.0	96.4
Lengths (cm)			
standard	19.6	—	18.2
fork	—	13.9	—
total	24.0	14.7	22.0
head	5.0	—	5.3
snout	1.3	—	1.4
orbit	1.1	—	1.2
Counts			
branchiostegals	11	—	12
gill rakers	17	—	18
principal dorsal rays	11	—	11
pectoral rays	13	—	12
vertebrae	59	—	60
pored lateral line scales	111	—	114
teeth on head of vomerine	2	—	4
teeth on shaft of vomerine	4	—	2
Body markings			
along dorsum	narrow circular bands	small irregular shaped dark spots	small irregular shaped spots
along side	circular bands aligned in a row	large irregular shaped dark spots	dark circular bands becoming wide irregular bands in caudal half
Age	2+	1+	2+

natural hybrids reported by Brown (1966) and Allan (1977).

There is little doubt that the Galt Creek specimen is a Tiger Trout as the body markings of this particular cross are quite distinct from either parent. Although different from each other (Figure 1), the appearance of the three Ontario hybrids resembles that of cultured Tiger Trout (Buss and Wright 1958) and wild specimens captured outside of Ontario (Brown 1966, Allan 1977).

Possible Methods of Hybridization

Ample opportunity for hybridization between the native Brook Charr and alien Brown Trout occurs where they co-exist in streams of southwestern Ontario. In southwestern Ontario, Brook Charr typically start to spawn one to two weeks before Brown Trout, but, the spawning activities of the charr generally overlap those of the trout by at least one week in most sympatric populations and up to three weeks in others (Witzel 1980). Interaction between charr and trout during reproduction is limited to a large extent by differences in preferred spawning sites (Reiser and Wesche 1977, Witzel 1980). Brook Charr, however, do occasionally spawn concurrently in the same areas as Brown Trout. This is more apt to occur where preferred spawning sites are limited or where spawners are concentrated below stream barriers.

In nature, cross-fertilization might occur by sperm drift in surface flow (Shuman 1950) or in intragravel water flow (Stuart 1954). However, spermatozoa quickly lose motility when introduced to water (Ginsburg 1963) and are not viable after only a few seconds of exposure (Shuman 1950). Chances of fertilization are also lessened by the dilution of milt during drift. Similarly, unfertilized trout ova quickly harden in water and become impregnable after about three minutes of exposure (Ginsburg 1963). Therefore, it is improbable that hybridization would occur from the dispersal of gametes by stream currents.

Both reciprocal crosses of the Brook Charr with Brown Trout have survival rates lower than intraspecific crosses. Of the two interspecific crossings, hybrid survival is best (4 to 63%) from female Brown Trout with male Brook Charr (Alm 1955, Buss and Wright 1956, Blanc and Chevassus 1979). The reciprocal cross is much less viable, with 0 to 0.5% survival to the fry stage under experimental conditions (Alm 1955, Buss and Wright 1956).

Brook Charr are not likely to actively spawn with Brown Trout in mixed pairs because of inherent differences in reproductive behaviour (such as courtship activities) which would likely disrupt intergeneric spawning. Although there is some evidence of interspecific intrageneric spawning in salmonids (Cordier-Goni 1939, Miller 1957), there is no direct evidence as judged from the literature cited by Schwartz (1972) and Dangel et al. (1973) that members of *Salmo* form spawning pairs with those of *Salvelinus*.

Hybridization would seem most likely to occur when one or more rival male Brook Charr (usually the smaller ones) that are not attended by a female charr, invade the spawning of paired Brown Trout, releasing their milt coincidentally with the discharge of eggs from the trout. Attempts at hit-and-run fertilization by non-attending male Brook Charr with other spawning Brook Charr have been observed widely in nature (Hazzard 1932, Smith 1941, Bridges and Mullen 1972). Intraspecific intrusions by rival males during conspecific spawnings have been witnessed in other trout as well (Greeley 1932, Hobbs 1937, Jones

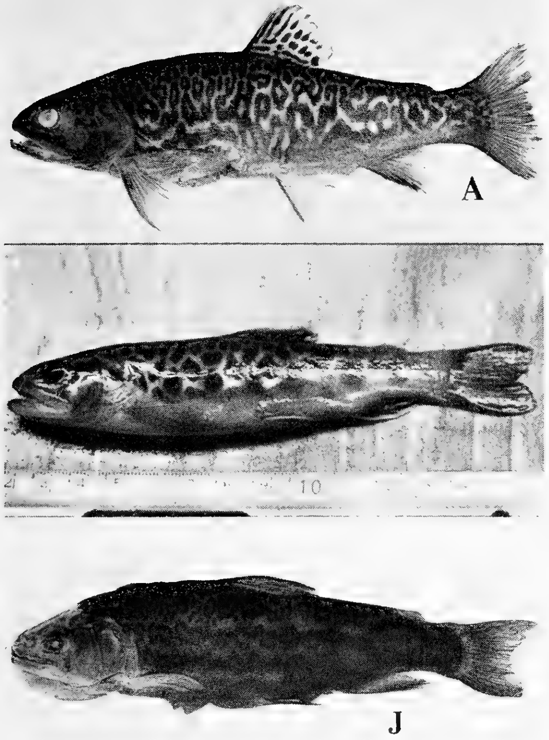

FIGURE 1. Wild Ontario Tiger Trout captured from the Bighead River (upper specimen), Galt Creek (middle), and Potters Creek (lower).

and Ball 1954). Such behaviour in species of sunfishes (*Lepomis:* Centrarchidae) has been referred to as "cuckoldry" by Gross (1979).

In Galt Creek, I have on at least one occasion observed several small male Brook Charr and Brown Trout without females, positioned peripheral to a riffle area (~ 6 m^2) where paired trout and paired charr were spawning. It seems conceivable in this situation for an inexperienced male Brook Charr, excited by the spawning activities of other fish, to discharge its milt upon the ova of a paired female Brown Trout, unseen and coincidentally with the release of milt by the attending male trout. In this way, several Brown Trout ova are likely to be fertilized by a male Brook Charr, yet, except for a brief moment, the spawning of the two species remains intraspecific.

Acknowledgments

I wish to thank the many district staff of the Ontario Ministry of Natural Resources who provided essential information on Tiger Trout. Dr. E. J. Crossman, Curator of the Department of Ichthyology and Herpetology, ROM, provided catch records and permitted examination of loaned museum specimens of wild Ontario Tiger Trout. I am grateful to L. Sztramko, S. Nepszy, and Dr. E. J. Crossman for their comments and criticisms of the earlier manuscripts. Barra Gots, Department of Zoology, University of Guelph, Guelph, Ontario was a co-discoverer of the Galt Creek Tiger Trout. This paper originated from studies on the reproductive biology of Brook Charr and Brown Trout which were supported by funds provided to Dr. H. R. MacCrimmon, Department of Zoology, University of Guelph by the National Research Council of Canada and the Ontario Ministry of Natural Resources.

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Two Sable Island Fungi, *Peziza ammophila* and *Hygrocybe turunda*, New to Nova Scotia

S. A. REDHEAD and P. M. CATLING

Biosystematics Research Institute, Research Branch, Agriculture Canada, C.E.F., Ottawa, Ontario K1A 0C6

Redhead, S. A., and P. M. Catling. 1983. Two Sable Island Fungi, *Peziza ammophila* and *Hygrocybe turunda*, new to Nova Scotia, Canadian Field-Naturalist 97(1): 102–103.

Peziza ammophila on dunes and *Hygrocybe turunda* on *Sphagnum* at Sable Island represent the first reports of these fungi from Nova Scotia and the first Canadian record of the *Peziza*.

Key Words: Sable Island, Nova Scotia, fungi, first records, *Peziza ammophila, Hygrocybe turunda*.

During a recent expedition to Sable Island (43° 56′ – 44° 00′ N, 59° 45′ – 60° 05′ W), N.S., to survey the vascular plant flora, the second author collected two fleshy fungi. *Peziza ammophila* Durieu et Montagne was found on the north shore, approximately 200 m east of West Point. It occurred in freshly deposited sand in an open dune sparsely covered with American Beach grass (*Ammophila breviligulata* Fernald). This is the first record of *Peziza ammophila* from Canada. Andersson (1950) gave a detailed account of this fungus with illustrations and mapped its distribution in the northern hemisphere. The first collections from North America (Florida) were described as *Peziza funerata* Cooke (1878). It has since been found on sand dunes in Michigan and in California (Seaver 1930, 1942). It occurs in a number of European countries, the British Isles and Morocco (Andersson 1950), and has been reported from Australia (Seaver 1930), South Africa (Ramsbottom 1926) and Argentina (Singer 1968). In all cases it has been found on shifting sand containing little humic material.

Hygrocybe turunda (Fr.) Karsten was collected on a thin *Sphagnum* cover over wet peaty sand with Large Bog Cranberry (*Vaccinium macrocarpon* Ait.), rushes (*Juncus balticus* Willd.) and Grass Pink Orchid (*Calopogon tuberosus* (L.) BSP) approximately 150 m N. of the weather station. It was also noted in similar associations at four other localities on the island. This species was not treated in Bird and Grund's (1979) Nova Scotian monograph of *Hygrophorus sensu lato*. In the earlier North American monograph, Hesler and Smith (1963) illustrated and reported it from Idaho, Massachusetts, Michigan, Montana, Oregon and Washington. Hesler and Smith also recorded it (sub *Hygrophorus turundus* var. *sphagnophilus* (Peck) Hesler and Smith) from Newfoundland. We confirmed this identification (see below). Collections from New Brunswick, northern Quebec and northern Ontario which extend the known range have also been seen.

Hygrocybe turunda is characterized by its bright scarlet colours which can fade to yellow, fuscous scales of varying development on the pileus and large spores (see Hesler and Smith 1963) which distinguishes it from the related *Hygrocybe cantharella* (Schw.) Murr. and *H. miniata* (Fr.) Kummer. *Hygrocybe cantharella* occurs in a variety of habitats, almost always with mosses and sometimes on *Sphagnum* of a loose consistency, often in shady coniferous forests. *Hygrocybe miniata* is usually found in hardwood forests on well decayed mossy logs. *Hygrocybe turunda* occurs in open locations on sand or mosses such as *Sphagnum* over sandy substrates, but in New Brunswick it occurred in exposed sites in a raised bog on *Sphagnum* of a compacted form with robust capitulae. This exposed habitat is reflected by its overall distribution. Outside of North America it has been reported from Greenland, Iceland, the Faeroes, parts of northern Europe and Japan (see Hesler and Smith 1963). In more southerly latitudes it is restricted to the higher elevations or other exposed cool sites.

Specimens examined: *Peziza ammophila:* N.S.: Sable Island, Aug. 25, 1981, P.M. Catling & W. Freedman (DAOM 180764). *Hygrocybe turunda:* Ont.: Algoma Dist., L. Superior Prov. Park, Rabbit Blanket L., Sept. 14, 1972, D.W. Malloch 14.9.72.15 (TRTC). Que.: Reserve Chibougamau, 15.75 km N. of Bochart on Hwy. 167, Aug. 29, 1976, J. Ginns & S. Redhead 2092 (DAOM 174756). N.B.: Kouchibouguac Natl. Park, Sept. 24, 1977, S.A. Redhead 2565 (DAOM 166758). N.S.: Sable Island, Aug. 25, 1981, P.M. Catling & W. Freedman (DAOM 180763). Nfld: St. Anthony, Aug. 12, 1951, D.B.O. Savile 2856 & J. Vaillancourt (DAOM 28523).

Acknowledgments

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Observations on Primary Dispersal of White Spruce, *Picea glauca*, Seed

JOHN C. ZASADA and DONALD LOVIG

USDA Forest Service, Institute of Northern Forestry, Fairbanks, Alaska 99701

Zasada, John C., and Donald Lovig. 1983. Observations on primary dispersal of White Spruce, *Picea glauca*, seed. Canadian Field-Naturalist 97(1): 104–106.

Primary dispersal of individual White Spruce (*Picea glauca* (Moench) Voss) seeds is described. Airborne time of seed accounted for 38% of the variation in the distance which filled seeds travelled from the parent tree. Observation of the flight paths of individual seeds indicated that seeds commonly attain heights greater than their cone of origin and that the distance of the landing point from the tree is not necessarily indicative of the distance traveled during primary dispersal.

Key Words: primary seed dispersal, White Spruce, *Picea glauca*

White Spruce (*Picea glauca* (Moench) Voss) depends on seed to naturally colonize disturbed sites. The dispersal of seed occurs in two phases (Watkinson 1978). During primary (phase I) dispersal, the seed travels from the parent tree to a site on the ground. During secondary (phase II) dispersal, the seed is moved along the ground surface by one or more agents. In the case of White Spruce, the greatest movement usually occurs during primary dispersal except when secondary dispersal occurs over snow or via water on flood plains.

Dobbs (1976) and Schlesinger (1970) concluded that the dispersal pattern for White Spruce follows the general pattern observed for winged seeds. That is, total seedfall decreases rapidly with distance from the seed source. Harper (1977) showed that seed dispersal for a number of species with different seed shapes and sizes generally can be described by the inverse square or cube laws. Van der Pijl (1972) discussed principles of dispersal in higher plants in detail and presented information on maximum dispersal distances for some tree species.

The methods used to study tree seed dispersal usually involve the placement of seed traps at regular intervals away from a seed source (Schlesinger 1970; Dobbs 1976). Schlesinger used this basic idea and released known quantities of seed from a standard height under ambient, but well-documented, weather conditions. Dobbs (1976) observed a combination of primary and secondary dispersal where over-snow movement probably contributed to the dispersal patterns reported.

This study examined the airborne path and time of individual seeds naturally dispersed from White Spruce cones. Although these observations are not conclusive, they provide additional insight regarding primary dispersal.

Methods

An individual tree located about midway along the eastern edge of a forest clearing was selected for observation. This tree was 18.5 m tall with cones in the top 3.1 m of the tree. The clearing was approximately 100 m wide and 200 m long, with the long axis oriented north and south. Seeds could not be followed distances greater than 100 m.

A cone was selected for observation, and the first seed that dropped from the cone was followed until it either landed or disappeared from sight. The time airborne was measured with a stop watch. The landing point was marked and its distance measured. The seeds were caught and cut open to determine if they were filled. A map was made of the airborne path of several seeds.

The flights of 50 seeds were actually observed and measured. This represented about one-half of the observations started. Some were not followed to their landing site, or were lost because they traveled up and out of sight, if the observer fell or was otherwise distracted. Linear regression was used to examine the relationships between airborne time and distance landed from the tree.

Observations were made during a 5-hour period (1100 hrs to 1800 hrs). The day was cloudless, with a slight but variable breeze during the observation period. Mean air temperature was 18°C.

Results and Discussion

About 38% (r^2= 0.38) of the variation in the distance traveled by filled seeds from the tree could be attributed to the time the seed was airborne. For empty seeds, the r^2 value was 61%. The shortest horizontal distance of a seed traveling from the tree was 2 m (Figure 1). Four percent of the seeds traveled more than 100 m. Mean distance travelled was 33 ± 24 m. Neither the distance traveled nor time airborne of 16% of the seeds could be determined because they were carried up and out of sight shortly after release from the cone. The shortest time airborne was 7 s; the longest was 125 s and this seed was still in flight 100 m

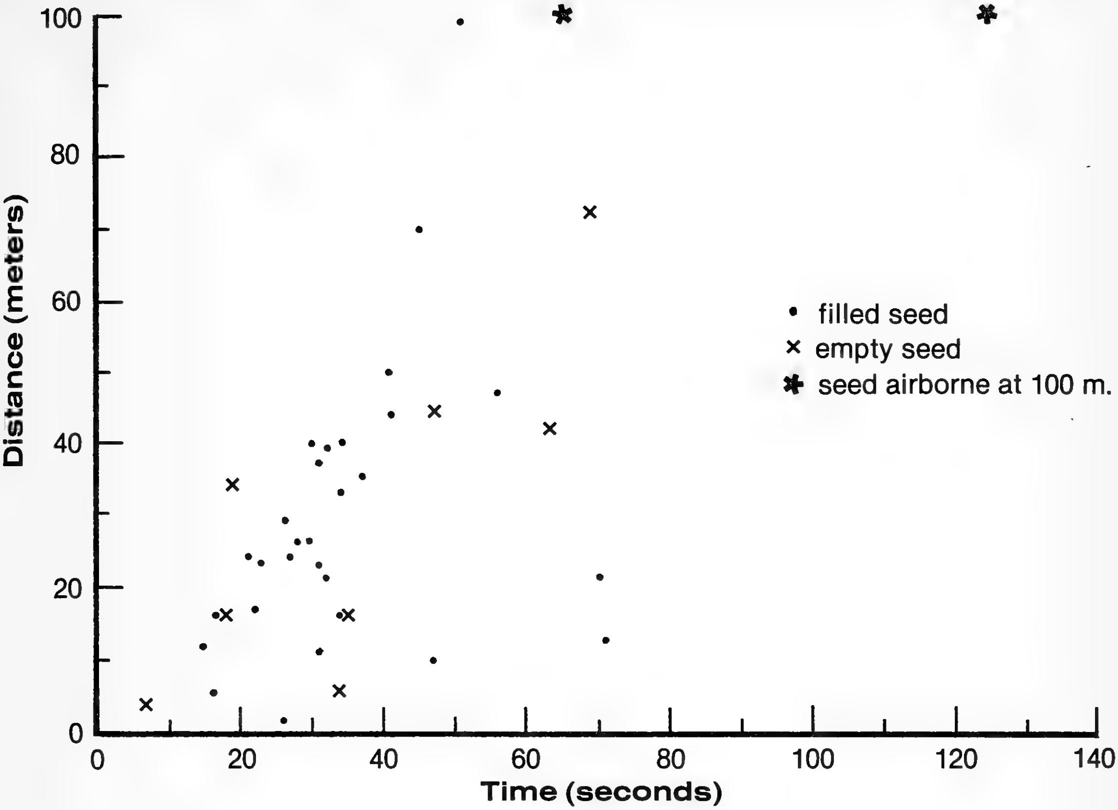

FIGURE 1. Relationship of airborne time and distance seed landed from tree for the primary phase of seed dispersal in White Spruce.

from the tree (Figure 1). Average time airborne was 38 ± 21 s. The average rate of fall was 0.6 ± 0.4 m/s (range 0.2 to 2.4). Schlesinger (1970) reported a rate of fall of 0.5 ± 0.1 m/s for White Spruce seed in still air.

The distance of a seed's landing from a tree did not necessarily indicate its actual airborne distance travelled. During flight an individual seed can follow a very circuitous path. The extent and nature of horizontal and vertical movement is determined by the wind and air turbulence encountered. An example is one seed that travelled about 121 m yet landed only 13 m from the tree. During dispersal, this seed experienced two periods of upward and three of downward flight (Figure 2).

The height reached by seeds traveling up and out of sight shortly after leaving the cone could not be determined. These observations, however, indicate that the greatest height attained by a White Spruce seed may exceed the height of the cone from which it came. These seeds have the potential for longer dis-

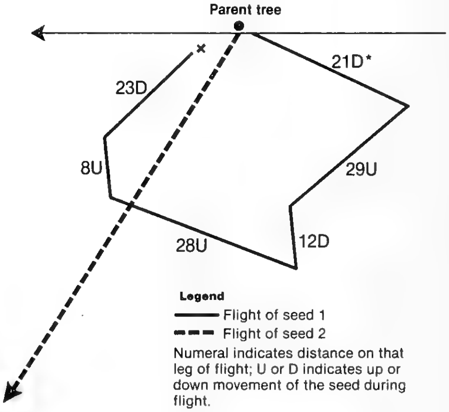

FIGURE 2. Flight path of two White Spruce seeds during primary dispersal (seed 1 landed 13 m from tree and was in flight 71 s; seed 11 > 100 m and > 125 s).

persal then seeds which fall directly to the soil surface during primary dispersal.

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A Golden-yellow Colored Sablefish, *Anoplopoma fimbria*, Caught off Quatsino Sound, British Columbia

D. A. NAGTEGAAL

Department of Fisheries and Oceans, Resource Services Branch, Pacific Biological Station, Nanaimo, B.C.V9R 5K6

Nagtegaal, D. A. 1983. A golden-yellow colored Sablefish. *Anoplopoma fimbria*, caught off Quatsino Sound, British Columbia. Canadian Field-Naturalist 97(1): 106.

A Sablefish, *Anoplopoma fimbria*, golden yellow in color, was captured south of Kains Island by the M/V VIKING SUNRISE on 27 May 1980.

Key Words: Sablefish, yellow.

On 27 May 1980, a 58 cm (FL) golden-yellow colored Sablefish, *Anoplopoma fimbria*, was captured 22.5 km due south of Kains Island. It was caught in Blackcod trap gear by the M/V VIKING SUNRISE at a depth of 550-730 m. The whole body of the specimen was yellow including the peritoneum and the underside of the gill cover, although the color of the iris of the eye was a normal black (Figure 1).

Adult Sablefish are usually slaty black or greenish gray on the dorsal surface and light gray on the ventral surface (Hart 1973). Juveniles are generally lighter on the dorsal surface and sometimes whitish in color on the ventral surface. This specimen could be labelled a partial albino since the iris of the eye was the normal color instead of the pink color commonly associated with true albinos. True albinism is an inherited condition in which the organism lacks an enzyme that is involved in the production of the dark pigment melanin (Villee and Dethier 1971) and affects the entire body color. The specimen is deposited in the British Columbia Provincial Museum (BCPM 980-509).

The morphometric and meristic characters of the yellow colored specimen do not deviate from the measurements of a normal Sablefish as described by Hart (1973). Specifically, the diagnostic dorsal fin and fin ray counts are 18 and 16, respectively. Examination of the specimen revealed that the peculiar pigmentation was not due to a pathological condition (personal communication, Dr. Ed Bilinski, Technology Services Branch, Department of Fisheries and Oceans). The skin appeared normal in areas lacking the black pigment and the flesh was not stained in spite of the presence of yellow pigmentation on the lining of the gill covers and on the skin. It is possible this abnormal pigmentation has a genetic origin.

One other yellow Sablefish has been recorded, off California (Phillips 1952), although it had some vestigial smudges of dusty black on the body. Phillips also recorded some "calico" Sablefish that had a mottled appearance of light gray and slaty black.

I thank Captain Inge Noringseth of the M/V VIKING SUNRISE for recovering the specimen. I am also grateful to Nev Venables, of the Pacific Biological Station, for his helpful assistance.

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Distribution of the Badger, *Taxidea taxus*, in Southwestern Ontario

WAYNE M. LINTACK[1] and DENNIS R. VOIGT[2]

[1]Ontario Ministry of Natural Resources, Huronia District Office, Midhurst, Ontario L0L 1X0
[2]Ontario Ministry of Natural Resources, Wildlife Branch, Research Section, P.O. Box 50, Maple, Ontario L0J 1E0

Ontario Ministry of Natural Resources, Wildlife Branch Contribution No. 81–13.

Lintack, Wayne M., and Dennis R. Voigt. 1983. Distribution of the Badger, *Taxidea taxus*, in southwestern Ontario. Canadian Field-Naturalist 97(1): 107–109.

Thirty records of Badgers (*Taxidea taxus*) were obtained from southwestern Ontario from 1972 through 1980. These data suggest Badgers are more common than reported earlier.

Key Words: Badger, *Taxidea taxus*, distribution, range records, Ontario.

Saunders (1932) reported on the presence of the Badger (*Taxidea taxus*) in Ontario near Grand Bend, Lambton County, in the late 1890s, but later they were considered extinct in southern Ontario by Cross and Dymond (1929). Snyder (1935) recorded a single Badger near Port Dover, Norfolk County, on 5 November 1934 and in 1948 the Royal Ontario Museum (ROM) received a Badger from Woodgreen, Mosa Township, Middlesex County (ROM No. 19 630). Bartlett (1955) reported five Badgers in Oxford Township, Kent County, and two in Aldborough Township, Elgin County, from June 1953 through May 1954. On 9 May 1961, a 7.7-kg male Badger was found killed on a road near Morpeth, Howard Township, Kent County (ROM No. 31 412). These records suggest the Badger is only rarely encountered in southern Ontario. However, J. D. McCabe (personal communication), a farmer and predator control agent for the Ontario Ministry of Natural Resources (OMNR), reported to us that he caught and subsequently killed or released 20-25 adult and immature Badgers in the Counties of Elgin, Middlesex, and Lambton during the past 25 years. We investigated these and other records. The purpose of this paper is to report the distribution of Badgers in southern Ontario based on records obtained from 1972 through 1980.

Methods

Occurrence of Badgers was investigated during the collection of more than 14 000 specimens of terrestrial furbearers from more than 200 trappers and hunters during a rabies research program. Staff from the Mammalogy Department of the ROM and 12 OMNR administrative districts were contacted for additional records. Records of badgers were entire animals, skulls or pelts observed by OMNR staff; sightings substantiated by OMNR staff with physical evidence; specimens in the collection of the ROM; accounts by trappers known by us to be reliable.

Results

Thirty records of Badgers were obtained that included 19 Badgers caught in traps set for Red Fox (*Vulpes vulpes*) or Raccoon (*Procyon lotor*); 5 killed on roads; 2 shot; 1 killed by clubbing; 2 sightings (involving a single Badger and 1 family group); and 1 caught by OMNR staff (B. Ellah personal communication). Ellah also observed diggings made by Badgers when he investigated the two sightings. One of these sightings was made by a farmer who reported shooting at two adult and three young Badgers. Ellah found five separate trails of Badgers leaving the sighting-location through a hay field. Nine of 19 trapped Badgers were caught in No. 220 or 330 Conibear traps set for Raccoons on trails, or at the entrances of ground burrows, baited cubbies or drainage tiles. One Badger was snared and nine were caught in leg-hold traps set for Red Fox. The sex ratio of the 18 Badgers that were sexed was 50:50. Badgers were recorded in Waterloo and Haldimand-Norfolk Regional Municipalities and the Counties of Kent, Lambton, Middlesex, and Grey (Figure 1).

Ontario specimens of Badgers

Kent County

1. Harwich Township, 42°25′N, 82°05′W, 8/4/80, road kill. 2. Orford Township, 42°35′N, 81°50′W, 20/10/80, male, trapped. 3. Camden Township, 42°35′N, 82°05′W, 11/79, male, trapped. 4. Zone Township, 42°40′N, 81°55′W, 11/79, male, trapped. 5. Zone Township, 42°40′N, 81°55′W, 11/79, male, trapped. 6. Dover Township, 42°25′N, 82°20′W, 3/79, female, trapped. 7. Howard Township, 42°30′N, 81°55′W, 9/9/78, killed by clubbing. 8. Orford Township, 42°35′N, 81°50′W, 10-11/78, trapped.

Middlesex County

9. Caradoc Township, 42°50′N, 81°30′W, 10/80, female, trapped. 10. Metcalfe Township, 42°50′N, 81°45′W, 10/80, road kill. 11. Caradoc Township,

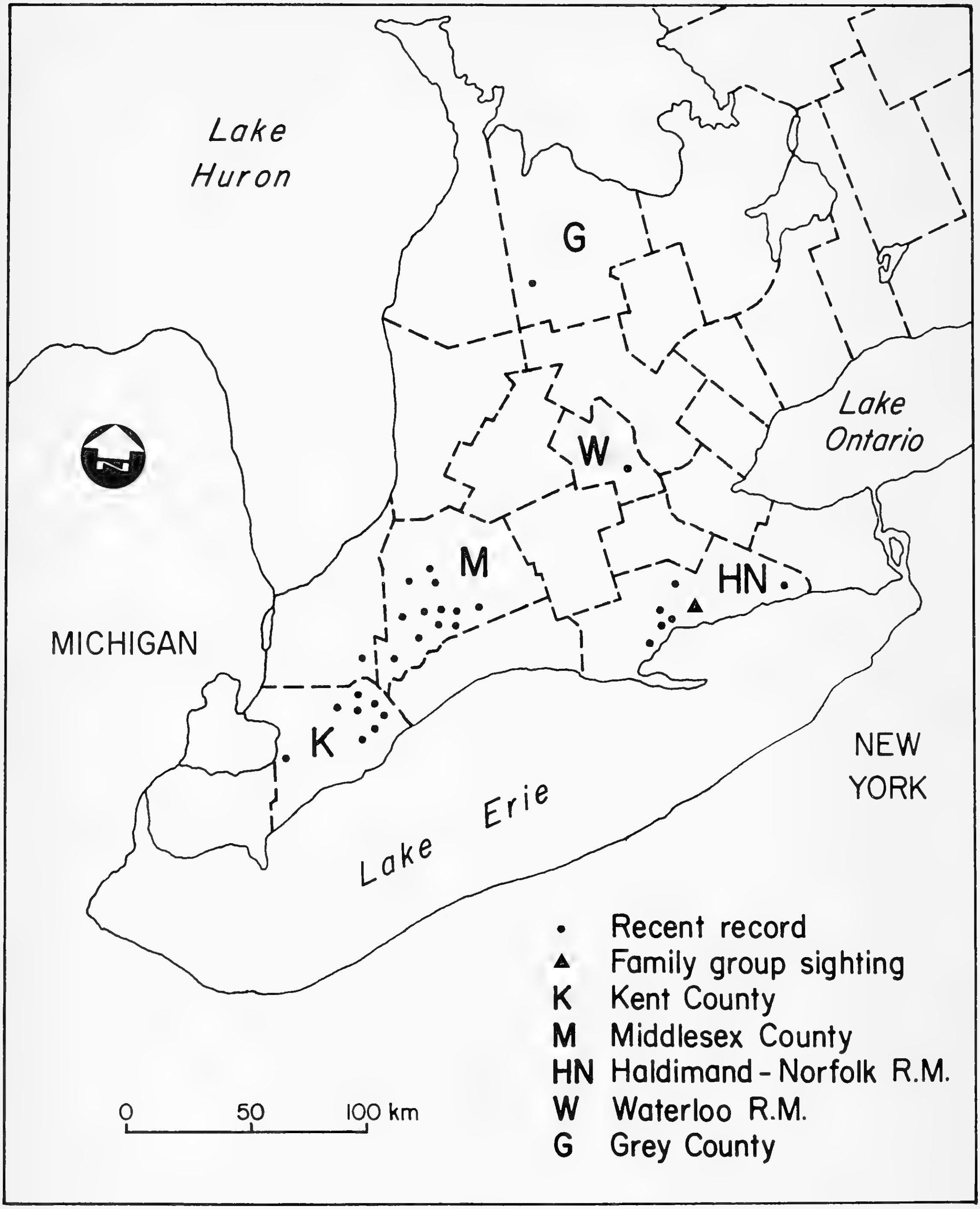

FIGURE 1. Records of the Badger in southwestern Ontario 1972-1980. Numbers correspond to specimens described in text.

42°50′N, 81°30′W, 11/80, male, trapped. 12. Mosa Township, 42°45′N, 81°45′W, 11/80, female, trapped. 13. Ekfrid Township, 42°45′N, 81°40′W, 11/79, trapped. 14. Adelaide Township, 43°00′N, 81°40′W, 11/79, female, trapped. 15. Caradoc Township, 42°50′N, 81°30′W, 7-8/78, shot. 16. Delaware Township, 42°50′N, 81°20′W, 10/78, male, trapped. 17. Westminster Township, 42°55′N, 81°15′W, 18/11/78, male, trapped. 18. Lobo Township, 43°00′N, 81°25′W, 10-11/77, female, trapped. 19. Lobo Township, 43°00′N, 81°25′W, 10-11/77, female, trapped. 20. Delaware Township, 42°50′N, 81°20′W, 10/76, female, trapped.

Grey County

21. Bentinck Township, 44°15′N, 80°55′W, 11/80, male, trapped.

Haldimand-Norfolk Regional Municipality

22. Town of Dunnville, 42°55′N, 79°40′W, 24/11/80, female, trapped. 23. Town of Simcoe, 42°50′N, 80°15′W, 6/78, sighting of 5. 24. Delhi Township, 42°50′N, 80°25′W, 6-7/77, sighting of 1. 25. Delhi Township, 42°50′N, 80°25′W, 6-7/77, road kill. 26. Delhi Township, 42°50′N, 80°25′W, 6-7/77, caught and released. 27. Delhi Township, 42°50′N, 80°25′W, 6-7/77, road kill. 28. Delhi Township, 42°50′N, 80°25′W, 6-7/72, road kill.

Regional Municipality of Waterloo

29. City of Kitchener, 43°25′N, 80°30′W, 26/8/79, male, shot.

Lambton County

30. Euphemia Township, 42°45′N, 81°55′W, 20/11/79, female, trapped.

Discussion

Our data suggest Badgers are found in southwestern Ontario near the north shore of Lage Erie. Distribution was similar to that suggested by Peterson (1966) and Banfield (1974). Most records were in Kent or Middlesex County and Haldimand-Norfolk Regional Municipality in areas with sandy or sandy loam soils.

Eight additional records in Kent and Middlesex Counties were reported by staff of the OMNR Chatham District from 1959 through 1978 (Kuja and McKay-Kuja, University of Toronto, unpublished data). The ROM has a record (ROM No. 27 559) of a Badger collected in 1956 from South Gower Township, Grenville County, in eastern Ontario, but we were unable to obtain any recent evidence of Badgers in that area.

The records of male Badgers from Grey County and Waterloo Regional Municipality were extra-limital for Ontario. These Badgers may have dispersed from more southern areas of Ontario. Messick and Hornocker (1981) reported that most young Badgers in Idaho disperse during their first summer for distances of up to 110 km.

In recent years, higher fur prices and a renewed interest in trapping has increased the harvest of Red Fox and Raccoon in southern Ontario which may have increased the number of incidental Badger catches. Only three of the 16 interviewed trappers had caught more than one Badger. Trappers that we interviewed recognized the rarity of a Badger catch and expressed reservations about killing captured Badgers. The pugnacious behaviour of Badgers (Banfield 1974) makes the release of uninjured individuals a difficult task for unprepared trappers. However, Badger specimens were popular as collection items; only six of 18 marketable Badger pelts were offered for sale at fur auctions.

The Badger is now classified as a furbearer in Ontario under the Ontario Game and Fish Act. The harvest season is from 15 October to 31 December and royalties are levied on all pelts which must also be sealed prior to sale. Our data suggest Badgers may be encountered in most counties in southwestern Ontario. Future changes in their distribution can be monitored from the harvest statistics of the OMNR.

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Responses of Two Groups of Mountain Goats, *Oreamnos americanus*, to a Wolf, *Canis lupus*

CHRISTIAN A. SMITH

Alaska Department of Fish and Game, Ketchikan, Alaska 99901

Smith, Christian A. 1983. Responses of two groups of Mountain Goats, *Oreamnos americanus*, to a Wolf, *Canis lupus*. Canadian Field-Naturalist 97(1): 110.

The reaction of two small groups of Mountain Goats, *Oreamnos americanus*, to the presence of a Wolf, *Canis lupus*, illustrates the importance and effectiveness of rocky terrain to the goats, and different responses in different situations.

Key Words: Mountain Goats, *Oreamnos americanus*, Wolf, *Canis lupus*, responses, habitat.

The Rupicaprini, including Mountain Goats (*Oreamnos americanus*), are well adapted to the exploitation of steep, rugged terrain, and their antipredator strategies rely on the distinct physical disadvantages of most mammalian predators in such habitat (Schaller 1979). A recent observation of the interactions of two groups of goats and a Wolf (*Canis lupus*) illustrates the importance of escape terrain to this ungulate species.

On 24 September 1981, two groups of Mountain Goats were being observed on a ridge in south coastal Alaska in the vicinity of Boca de Quadra, 55° 20′ N, 130° 30′ W. One group consisted of two adult females, two kids and one subadult (sex unknown), all of which were bedded in an area of broken rock interspersed with alpine vegetation on a 15-20° slope at 1100 m elevation 20 m below the ridge top. The second group consisted of a pair of adult females, each accompanied by a kid, and bedded on a smooth 30-35° slope of alpine vegetation 100 m below and 100-150 m south of the former group. About 50 m farther south was a steep rock outcrop, slope 45-50° approximately 30 m wide and 10-20 m high.

At 0942 a single adult Wolf trotted over the crest of the ridge downwind and 50 m south of the first group. The instant the Wolf appeared, the upper group bolted north along the ridge, remaining below the ridge crest in rocky terrain. The Wolf initially chased the goats, but after 100-150 m it ceased the pursuit. All five goats continued to flee at a panicked gallop, angled up along the slope and traversed 800-900 m before they crossed over the ridge out of sight onto an extremely sheer rock face.

In contrast to the first goats, the lower group rose quickly from their beds and walked at a deliberate but unhurried pace to the nearby rock outcrop. One pair climbed onto a narrow ledge approximately 5 m above the base and near the middle of the outcrop, making an approach by the Wolf difficult, if not impossible. The other pair moved to the base of the outcrop and backed up against a vertical rock face, thus preventing any flanking approach.

When the Wolf turned from the aborted chase, it briefly observed the four lower goats as they gained their positions on the rock outcrop. It then loped to the south along the ridge crest, making no attempt to approach the lower goats. It continued along the ridge until it became aware of my presence, then descended the slope into the subalpine forest and disappeared.

The different reactions of these two groups of goats may have been due to their relative positions when the Wolf appeared. The upper goats could have been effectively intercepted by the Wolf if they ran toward the rock outcrop. Their response was to flee to the nearest steep terrain, which was almost 900 m away. The lower group was able to reach adequate escape terrain before the Wolf could initiate an attack.

From an energy standpoint, the response of the lower group was obviously advantageous. This may explain why McFetridge (1977) reported 95% of all observations of nursery groups of goats in Alberta as being within 412 m of escape terrain and why studies in Alaska indicate that distance to cliffs is the single most important factor determining habitat use by goats (Schoen and Kirchoff 1982; author's unpubl. data).

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Occurrences of the Black-legged Kittiwake, *Rissa tridactyla*, in the Prairie Provinces and North-central United States.

ALAN R. SMITH[1] and E. KUYT[2]

[1]Canadian Wildlife Service, 115 Perimeter Road, Saskatoon, Saskatchewan S7N 0X4.
[2]Canadian Wildlife Service, Room 1000, 9942-108th Street, Edmonton, Alberta T5K 2J5.

Smith, Alan R., and E. Kuyt. 1983. Occurrences of the Black-legged Kittiwake, *Rissa tridactyla*, in the Prairie Provinces and North-central United States. Canadian Field-Naturalist 97(1): 111–113.

Fifteen records of Black-legged Kittiwakes (*Rissa tridactyla*) in the Canadian prairie provinces and four north-central American states are summarized. Ten records were made in late fall or early winter, and 12 were of young of the year. It is postulated that inexperienced birds are carried inland by low pressure systems moving out of the north Pacific.

Key Words: Black-legged Kittiwake, *Rissa tridactyla*, extralimital records.

The Black-legged Kittiwake (*Rissa tridactyla*) is one of the most maritime of gulls. Its breeding distribution is circumpolar and strictly coastal: from the shores of the Polar Basin south to Nova Scotia and France in the Atlantic and to the Kurile and Aleutian Islands in the Pacific Ocean. During the winter it is pelagic, occurring in offshore waters south of New Jersey and to northwest Africa in the Atlantic and to Japan and Baja California in the Pacific Ocean (Godfrey 1966). Its occurrence 1000 km from the nearest ocean in the Province of Alberta must therefore be considered unusual.

On 23 December 1979, during the Christmas Bird Count, we, with Duane Sept, found a dead Black-legged Kittiwake on a dyke at the Sundance Cooling Pond south of Wabamun Lake, Alberta (cf. Smith and Prach 1980). The bird was found frozen in a squatting position, in feather-perfect condition — strong circumstantial evidence that it had died recently and non-violently. The bird appeared to be extremely emaciated, suggesting that it had died of starvation. The skin of the bird, an immature, is in the collection of the Department of Zoology, University of Alberta (Catalogue Number UAMZ 5415).

Our recovery of the kittiwake marks the third known occurrence of this species in Alberta. Records in other prairie provinces and nearby states are also few: there are no records in Saskatchewan, one in Manitoba, one in Idaho, three in Montana, two in North Dakota and five in South Dakota (Table 1). These 15 records form a non-random pattern; all but three were in fall or winter (mainly November or December), and only one whose age was described was in adult plumage (unlike many gulls, Black-legged Kittiwakes have already assumed adult plumage in their second winter, Bent 1921).

The Wabamun Lake specimen was sent to Henri Ouellet of the National Museum of Natural Sciences for a subspecific determination. Ouellet (personal communication) referred the specimen to *pollicaris* of the Pacific Ocean but added that that "is a very poorly marked subspecies which . . . could not withstand the test of modern revision . . . on the basis of the criteria used to characterize it".

It is most likely that only the Manitoba record derived from Atlantic populations. Weather systems which could have carried these birds inland tend to move from west to east. One might speculate that kittiwakes which migrate south from their breeding grounds in November (Dementiev and Gladkov 1969; Bent 1921) are displaced by low pressure systems moving east out of the north Pacific. Some inexperienced immatures lose their orientation and move inland whereas the more experienced adults manage to remain on course. Birds arriving on the Great Plains would find little open water in November and even less in December, and they would be attracted to hydroelectric sites such as Garrison Dam or thermal electric sites such as Wabamun Lake, where open water is artificially maintained throughout the winter.

Munyer (1965) advanced a similar theory to explain the occurrence of the Ancient Murrelet (*Synthliboramphus antiquus*) in the interior of North America. He stated that "most of the records are directly or indirectly associated with weather disturbances over the Pacific coast". He added that "about two-thirds of the records are dated November or late October, presumably months of great migratory activity". Connelly and Gates (1981), in summarizing the inland occurrences of the Black-legged Kittiwake in the northwestern United States, found that one or more low pressure systems had moved across the Pacific Northwest within two weeks prior to each inland kittiwake record.

This explanation is consistent with the recovery of the Wabamun specimen and of two other records. On 10 December 1979 a low pressure area in northern British Columbia produced strong westerly winds

TABLE 1. Black-legged Kittiwake records for the prairie provinces and adjacent north-central states.

Location	Date	Number-Age	Type of Record	Source
ALBERTA				
Calgary	13 Nov. 1976	1 immature	found dying	Pinel and Riddell 1977
Beaverhill Lake	17 July 1977	1 adult	sighting	R. Ebel, pers. comm. 1980
Wabamum Lake	23 Dec. 1979	1 immature	found dead	Harris 1980
MANITOBA				
Churchill	11 June 1980	1 unknown	sighting	Gollop 1980
IDAHO				
Butte County	13 Feb. 1980	1 immature	found dead	Connelly and Gates 1981
MONTANA				
Ninepipe NWR	27 Apr. 1977	1 immature	collected	Rogers 1977
Fort Peck Dam	23-26 Dec. 1978	1 immature	photographed	Serr 1979
Broadview Marsh	June 1980	1 unknown	sighting	Serr 1980b
NORTH DAKOTA				
Garrison Dam	14 Dec. 1979 — 5 Jan. 1980	1 immature	sighting	Serr 1980a
McLean and Ward Counties	7 Sept. — 28 Nov. 1980	1 immature	sighting	Serr 1981
SOUTH DAKOTA				
Big Ben Dam	3-28 Nov. 1967	1 immature	photographed	Harris 1967
Fort Randall Dam	24 Nov. 1968	1 immature	sighting	Rose 1969
Lake Herman	5 Dec. 1969	1 immature	sighting	Harris 1970
Sturgis	20 Dec. 1969	1 immature	found dying	Schroeder 1970
Camp Crook	13 Dec. 1979	1 immature	sighting	Serr 1980a

along the Pacific Coast (Atmospheric Environment Service 1979). On 13 December an immature Black-legged Kittiwake was seen at Camp Crook, South Dakota, and the next day one was seen at the Garrison Dam in North Dakota (Serr 1980a). On 23 December the Wabamun specimen was found. It seems likely that these birds were part of the same movement.

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Breeding Records of Northern Shoveler, *Anas clypeata*, along the Northern Coast of Ontario

R. KENYON ROSS[1] and NORMAN R. NORTH[2]

[1]Canadian Wildlife Service, 1725 Woodward Drive, Ottawa, Ontario K1A 0E7
[2]Canadian Wildlife Service, 152 Newbold Court, London, Ontario N6E 1Z7

Ross, R. Kenyon, and Norman R. North. 1983. Breeding records of Northern Shoveler, *Anas clypeata*, along the northern coast of Ontario. Canadian Field-Naturalist 97(1): 113.

Breeding of Northern Shoveler on the Hudson Bay coast of Ontario was confirmed by the observation of two unfledged broods near the mouth of the Shagamu River. Records of broods, fledging status unknown, along the James Bay coast suggest breeding at low densities along that shore.

Key Words: Northern Shoveler, *Anas clypeata*, northern Ontario, breeding.

The Northern Shoveler (*Anas clypeata*) has been known to occur occasionally along the Ontario coasts of James and Hudson Bays (Manning 1952; Godfrey 1966), but its status has never been clarified. The nearest recorded breeding sites are as distant as Churchill, Manitoba (Jehl and Smith 1970), and Lilabelle Lake near Cochrane (D.G. Dennis, CWS, personal communication). In this note, we describe breeding records of the Shoveler from the Hudson Bay and James Bay coasts of Ontario.

On 8 August 1977, we encountered a flying female Northern Shoveler with three fully-feathered but flightless young on a pond near the mouth of the Shagamu River (55°51′N, 86°46′W). A male(420 g) and a female (410 g) were caught and photographed. Copies of the photos have been deposited with the National Museum of Natural Sciences in Ottawa. Later that day, a second family group (a female and four juveniles) was noted in the same vicinity. Considering the birds' age and occurrence near a river mouth, they could have hatched some distance upstream.

There are no confirmed breeding records of the Northern Shoveler along the James Bay coast although there are several records of broods with unknown powers of flight. R.H. Smith, in an unpublished report to the Canadian Wildlife Service, noted a brood of at least three young, apparently unfledged, on the Opinnagau River (54°12′N, 82°25′W) on 24 July 1944 and another brood of nine "well grown young" near Hook Point (54°52′N, 82°13′W) on 15 August 1944. Also, R.K. Ross observed a female with five flying young at Big Piskwamish Point (51°42′N, 80°35′W) on 18 August 1976. All these sightings indicate that the Shoveler breeds in small numbers along the James Bay shore.

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Black Bear, *Ursus americanus*, Predation on a Mule Deer Fawn, *Odocoileus hemionus*.

E. VERSPOOR

Faculty of Environmental Design, University of Calgary, Calgary, Alberta T2N 1N4

Verspoor, E. 1983. Black Bear, *Ursus americanus*, predation on a Mule Deer fawn, *Odocoileus hemionus*. Canadian Field-Naturalist 97(1): 114.

A Black Bear (*Ursus americanus*) attacked and killed a Mule Deer fawn (*Odecoileus hemionus*) in the Porcupine Hills region in southwestern Alberta, 28 May 1980. As Black Bear rarely attack ungulates, extreme spring hunger is the probable cause of the reported incident.

Key Words: Black Bear, *Ursus americanus*, predation, feeding behavior, Mule Deer, *Odocoileus hemionus*.

Most of the evidence of predation by Black Bears (*Ursus americanus*) on ungulates (Hatler 1972; Banfield 1974; Franzmann et al. 1980) is inferential. The only observation known to me was reported by Behrend and Sage (1974) of a Black Bear attacking and killing two White-tailed Deer (*Odecoileus virginianus*) while they were in a holding pen. Bacon and Burghardt (1976) do not even discuss predatory behavior in their paper on the ingestive behavior of the Black Bear. An attack by a Black Bear on a Mule Deer (*Odecoileus hemionus*) and her fawn which resulted in the capture and killing of the fawn is documented here.

The observations were made just before noon on 28 May 1980 in the Willow Creek drainage in the Porcupine Hills of southwestern Alberta at approximately 50°12′N, 114°01′W. A female Mule Deer and her fawn were observed to cross the head of a side valley off Willow Creek and to enter the aspen woods on the slope opposite. At the time they were headed south about ½ km north and upwind from the author and a friend. Shortly thereafter, cattle grazing in the aspen woods on the slope directly opposite were seen to move down into the valley bottom, vocalizing continuously. About 10 minutes later a Black Bear was seen chasing a Mule Deer and her fawn (presumably the deer observed previously) in the area vacated by the cattle. It was possible to observe the last 80-120 m of the chase after the animals emerged from the trees into the open. It ended with the bear knocking the fawn over and grabbing it by the neck with its jaws. The bear repeatedly bit the fawn on the head, neck, and back without killing it, and after a few minutes dragged the fawn by the neck into the woods out of sight. While being mauled and for about 15 minutes after being dragged from view, the fawn continued to give out distress calls. During the chase the female deer remained with the fawn; while the fawn was being mauled, it paced back and forth about 20-25 m away. After the bear dragged the fawn into the woods it disappeared from view.

The bear weighed an estimated 100 kg, and seemed thin and poorly nourished. It had noticeably darker paws and snout, and a light, almost grey coat. The fawn was small and therefore quite young, perhaps recently born. The observations were made at the time of year when Mule Deer give birth (Banfield 1974).

The success of the attack was probably fortuitous. The situation favored the bear as the deer approached upwind from it in the restricted visibility of the woods. These factors probably allowed the bear to go unnoticed. The bear may have been prompted to attack because of hunger. This would be consistent with its appearance and with the view that bears are generally undernourished in the spring until their more usual and abundant foods such as berries and insects become readily available (Banfield 1974).

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Sphagnum at Prudhoe Bay, Alaska

PETER D. SPATT

Institute of Polar Studies and Department of Botany, Ohio State University, Columbus, Ohio 43210.

Spatt, Peter D. 1983. *Sphagnum* at Prudhoe Bay, Alaska. Canadian Field-Naturalist 97(1): 115–116.

Four populations of *Sphagnum fimbriatum* Wils. ex. Hook, co-occurring with *S. girgensohnii* Russ., represent the first records of *Sphagnum* from Prudhoe Bay, Alaska. The highly calcareous substrates here are thought to limit *Sphagnum*, an acidophilic moss, in this part of the arctic coastal plains.

Key Words: *Sphagnum*, Arctic, Alaska, alkaline tundra.

The coastal plain at Prudhoe Bay, Alaska, has been surveyed extensively for its bryophyte flora (Murray and Murray, 1974, 1975; Rastorfer et al. 1973; Steere 1976, 1978; Walker et al. 1980). The area is essentially flat and composed mostly of wet tundra (Walker et al. 1980). The influence of the Sagavanirktok River makes it quite uniformly calcareous (Steere 1976). No *Sphagnum* species have ever been reported from Prudhoe Bay (B. Murray personal communication; Steere 1976, 1978, personal communication) and this has been attributed to the calcareous nature of the substrate (Steere 1976). The occurrences of small, local deposits of acid peat, however, have been noted (Steere 1976).

In August, 1981, *Sphagnum* was observed and collected in two localities along the western margin of Prudhoe Bay, in sites considered to be relatively acidic (Everett, personal communication; Walker et al. 1980).

Collection Site I. 18 July 1981. A single, circular (70 cm diameter) mat of *Sphagnum fimbriatum* (Spatt #450-453; all in ALA) raised 10-12 cm from the surrounding wet, low polygon tundra, was located approximately 0.5 km west of the West Dock Storage Pad and approximately 0.5 km south of the Beaufort Sea. Within and surrounding the mat were *Eriophorum* spp., *Petasites frigidis* (L) Fries, and *Salix rotundifolia* Trautv.

Collection Site II. 19 August 1981. Mixed populations of *S. fimbriatum* and *S. girgensohnii* were observed approximately 2 km south of Site I. Population A (Spatt #376- *S. girgensohnii*, 377- *S. fimbriatum*; ALA) was located along the margin of a pond on the side of a raised polygon. Other plants associated with this population were *Alectoria* sp., *Carex aquatilis* Wahl., *Cassiope tetragona* (L) D. Don., *Cladonia* sp., *Dactylina arctica* (Hook.) Nyl., *Dryas integrifolia* Vahl., *Peltigera* sp., *Salix pulchra* Cham., *Salix reticulata* L, and *Thamnolia* sp. Populations B (Spatt #382, 389- *S. fimbriatum*, 386- *S. girgensohnii*; ALA) and C (Spatt #390- *S. fimbriatum*; ALA) were located on a polygon ridge, with similar associated vascular and non-vascular plant species.

Sphagnum fimbriatum and *S. girgensohnii* are closely related wide ranging, circumpolar species. In North America they occur from the arctic south to the northern part of the continental United States (Andrus 1974). Both species prefer minerotrophic habitats and are commonly found in mineral soils of bogs and fens (Andrus 1974). *S. fimbriatum* has been previously reported from Barrow, Meade River, Navagapak Point, and Putu Camp on the Alaskan arctic coastal plains, and *S. girgensohnii* was reported from Barrow and Okpilak Lake (Steere 1978). The collections at Prudhoe Bay extend their ranges along the northern Alaskan coast and enhance understanding of the soils and flora of the region. The importance of *Sphagnum* spp. in the low arctic, a region in which Prudhoe Bay is located, is greater than in other arctic regions, especially the high arctic (Vitt and Pakarinen 1977).

Other populations of *Sphagnum* are likely to be found at Prudhoe Bay, especially in the area west of West Dock. This area has mildly to moderately acidic soils (Walker et al. 1980). *Sphagnum* is least likely to occur directly in the Sagavanirktok River delta or floodplain due to their highly alkaline substrates.

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I thank Barbara Murray, Jerry Snider, Roland Seymour, and Lee Klinger for their helpful comments, and Howard Crum for verifying the *Sphagnum* identifications.

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Northern Range Extension of the Two-lined Salamander, *Eurycea bislineata*, in Ontario

JAMES KAMSTRA

R.R. #5, Oshawa, Ontario L1H 7K5

Kamstra, James. 1983. Northern range extension of the Two-lined Salamander, *Eurycea b. bislineata*, in Ontario. Canadian Field-Naturalist 97(1): 116.

A Two-lined Salamander, *Eurycea bislineata*, was observed at the Onakawana River, 400 km north of the previous northernmost record in Ontario.

Key Words: Two-lined Salamander, *Eurycea bislineata*, northern range, Ontario.

On September 4, 1977, a single adult Two-lined Salamander (*Eurycea bislineata*) was found along the Onakawana River (50° 37′N, 81° 25′W) in Morrow Township of the Cochrane District, northern Ontario. This salamander was observed under unusual circumstances; it emerged from under a large log against which a fire had been built. The log was situated on a gravel substrate about 0.5 meters from a moderately fast flowing river six meters wide. The surrounding forest consisted mainly of Balsam Fir (*Abies balsamea*) and Black Spruce (*Picea mariana*).

The individual was about 8 cm in length, dull yellowish-brown dorsally with a broad dark lateral stripe. Its belly was bright yellow. There was no preserving material available so the specimen was released after being photographed. Identification of the photo was confirmed by Dr. Francis R. Cook, Curator of Herpetology, National Museum of Natural Sciences, Ottawa.

This locality, only 100 km south of James Bay, is 400 km north of Lake Temagami, the closest record of *E. bislineata* cited by Logier and Toner (1961). The next nearest records are from Quebec (Cook and Preston 1979): Lac Charon, 500 km ESE, and Rupert River, 600 km ENE of the Onakawana site. There is also a recent northern range extension into Labrador (Cook and Preston 1979.).

The Labrador and Onakawana records of Two-lined Salamander extend the range delineated by Conant (1975) in both a northeast and northwest direction, suggesting a more widespread distribution in the boreal forest of eastern Canada.

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A Second Record of the Deer Mouse, *Peromyscus maniculatus*, from Newfoundland

M. C. Bateman

Canadian Wildlife Service, Sackville, New Brunswick E0A 3C0

Bateman, M. C. 1983. A second record of the Deer Mouse, *Peromyscus maniculatus*, from Newfoundland. Canadian Field-Naturalist 97(1): 117.

Four Deer Mice, *Peromyscus maniculatus*, were collected from the Abitibi-Price Inc. Woods Camp, Southwest Brook, Newfoundland. The only previous record of the Deer Mouse on insular Newfoundland is 100 km southwest of this location.

Key Words: Deer Mouse, *Peromyscus maniculatus*, Newfoundland, second record.

Four Deer Mice (*Peromyscus maniculatus*) were collected at the Abitibi-Price Inc. Woods Camp, Southwest Brook, Newfoundland (48° 29′N, 58° 01′W) in early December 1981. The only previous record of the Deer Mouse on the Island of Newfoundland is from Broom's Brook in the Anguille Mountains (47° 56′N, 59° 10′W) (Gould and Pruitt 1969). Broom's Brook is approximately 100 km southwest of the present capture site.

A total of 5,900 trap nights (Museum Special and Victor snaptraps) from 29 August to 9 September 1980 and 31 August to 9 September 1981 between 2 and 27 km from the camp failed to catch any species other than Meadow Vole (*Microtus pennsylvanicus*), Masked Shrew (*Sorex cinereus*) and Eastern Chipmunk (*Tamias striatus*). Most trapping was done in mature Balsam Fir (*Abies balsamea*), Balsam Fir — White Birch (*Betula papyrifera*), and Black Spruce (*Picea mariana*) forest, although cutover (regenerating Balsam Fir and White Birch) and softwood scrub were also sampled.

The four specimens, trapped by company foremen after damaging supplies, were kept frozen until study skins were prepared in the Canadian Wildlife Service laboratory in Sackville, New Brunswick. Two specimens are in the Canadian Wildlife Service mammal collection at Sackville and two are at the National Museum of Natural Sciences, Ottawa (NMC 45720, 45721). Identifications were confirmed by Dr. van Zyll de Jong, Curator of Mammals, National Museum of Natural Sciences, Ottawa.

Acknowledgments

Specimens were collected during field work funded by Parks Canada, Atlantic Region. I thank Abitibi-Price Inc. for providing accommodation and freezer space, and G. Belyea for preparation of the study skins.

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Dwarf Clearweed, *Pilea pumila* (Urticaceae) — New to Nova Scotia

N. HILL and S. P. VANDER KLOET

Department of Biology, Acadia University, Wolfville, N.S. B0P 1X0

Hill, N., and S. P. Vander Kloet. 1983. Dwarf Clearweed, *Pilea pumila* (Urticaceae) — new to Nova Scotia. Canadian Field-Naturalist 97(1): 118.

We have documented the occurrence of Dwarf Clearweed, *Pilea pumila* (L.) Gray in the Cobequid Mountains of Nova Scotia.

Key Words: *Pilea pumila*, distribution, Nova Scotia.

On the 17 October 1980, seven fruiting specimens of Dwarf Clearweed, *Pilea pumila* (L.) Gray were discovered on a seepage slope in the rich maple-beech woods at West Branch, Pictou County, Nova Scotia (43°37′N, 63°04′W). Macoun (1884) listed several locations in New Brunswick and noted it was common in western Quebec and Ontario. Boivin in 1966 reported findings from Prince Edward Island. In their monographic treatment of the family Urticaceae for Canada, Bassett et al. (1974) do not record *P. pumila* for Nova Scotia. Our discovery, therefore, extends the range of *P. pumila* into Nova Scotia. Two plants were collected and have been deposited in the E. C. Smith Herbarium at Acadia University (ACAD).

Pilea pumila is an annual and depends on seeds to survive the winter. We combed the area from May to October in the following year but found no plants. It appears the population failed to maintain itself but it may persist dormant for several years in the soil.

Thompson and Grime (1979) predicted nonpersistent seed banks would occur in these areas where plant growth was curtailed by low winter temperatures and where vegetational gaps stayed open until spring. Thirty 6 cm × 5 cm soil cores were taken along the seepage slopes during July 1981, spread out in trays over sterilized sand, placed in the greenhouse and watered daily. After one year, no *Pilea pumila*, no *Impatient biflora* Walt. (Jewel Weed), nor any *Circaea alpina* L. (Enchanter's Nightshade) had germinated although the latter annuals are common along these seepage slopes. The bulk of the seedlings in the trays were sedges (*Carex* spp) and rushes (*Juncus* spp), and on the basis of core size and number, it is estimated that *Juncus* spp had 9286 Seeds/m^2 and *Carex* spp. had 2833 seeds/m^2.

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News and Comment

The American Association for The Advancement of Science: Arctic Division

The 34th Alaska Science Conference, with the theme: Alaska/Canada North: Neighbours in Science, will be held in Whitehorse, Yukon, September 28-October 1, 1983

First Announcement and Call for Papers

In 1982 the AAAS – Alaska Division changed its name to AAAS – Arctic Division in order to acknowledge the continual participation in the Alaska Science Conference of researchers from Yukon and Northwest Territories. The 1983 Conference will follow-up on this initiative by returning its activities to Whitehorse for the first time since 1968.

The program focus is intended to be very general while still reflecting transboundary topics in Northern Science. Technical and poster sessions in the broad area of scientific and technical research concerning northern people, the northern lands and marine environment, and resources development and management will be offered. Plenary Sessions will include one which highlights current research of special interest to the general public.

Projected Special Events and Symposia:

Caribou and Human Activity
Yukon River Basin Studies
Yukon Heritage and Museums Association 6th Annual Fall Conference Scientific contributions of early Yukon-Alaska Explorers September 30-October 2.
Science and Frontier Hydrocarbon Exploration – The Beaufort Sea Experience
Human Performance in the Cold
Ecological Land Classification
Wood as Fuel — Uses and Problems

Call For Papers

We plan to prepublish abstracts of the papers to be presented prior to the Conference. Authors wishing to present papers in the technical sessions should provide titles by May 15, 1983, and abstracts by July 15, 1983. Abstracts should not be longer than one double-spaced typewritten page with the title, author's name, and affiliation at the top of the page. Those interested in the poster sessions should provide titles by July 15, 1983. All correspondence should be addressed to:

Art Pearson
Conference Chairman
Box 4580
Whitehorse, Yukon
Y1A 2R8
(403) 667-4288

Position Available October

Migration Program Manager (Biologist). $11 000–12 750. Responsible for all field operations: banding, maintenance, boats, surveys; data analysis. Qualifications: banding eligibility, proven identification and banding competence, mechanical aptitude, supervisory ability, etc. Resume and three referees to Executive Director, from whom fuller advertisement available.

ARTHUR N. LANGFORD
Executive Director
Long Point Bird Observatory
P.O. Box 160
Port Rowan, Ontario N0E 1M0

Notice of Publication

The second part of the *Atlas of the Rare Vascular Plants of Ontario*, edited by G. W. Argus and D. J. White, will be published in July 1983 by the National Museum of Natural Sciences. It treats about 100 species in several important families including the ferns, Asteraceae, Ranunculaceae, and Scrophulariaceae.

The Atlas is available free-of-charge from:

The Rare and Endangered Plants Project
Botany Division
National Museum of Natural Sciences
Ottawa, Ontario K1A 0M8

The recipients of Part 1 of the Atlas will automatically be sent this and subsequent parts, but if one does not arrive in a reasonable length of time, the Museum should be contacted.

G. W. ARGUS

Gamma-Ray Irradiation of a Boreal Forest Ecosystem: The Field Irradiator – Gamma (FIG) Facility and Research Programs

JOHN E. GUTHRIE and JANET R. DUGLE

Environmental Research Branch, Whiteshell Nuclear Research Establishment, Atomic Energy of Canada Limited, Pinawa, Manitoba R0E 1L0

Guthrie, John E., and Janet R. Dugle. 1983. Gamma-ray irradiation of a boreal forest ecosystem: the Field Irradiator–Gamma (FIG) facility and research programs. Canadian Field-Naturalist 97(1): 120–128.

A long-term radiation ecology research project called Field Irradiator – Gamma (FIG) began at the Whiteshell Nuclear Research Establishment in 1968. The experimental area is in southeastern Manitoba and is located on the western edge of the Precambrian shield. The project studies the ecological effects continuous exposure to a gradient of gamma radiation has on a mixed boreal forest ecosystem. The gradient ranges from 1 to 460 000 times the natural background radiation level. This paper describes the forest, the gamma irradiator and its radiation field, and the research programs.

A long-term radiation ecology project called FIG, an acronym for Field Irradiator – Gamma, began in 1968 at the Whiteshell Nuclear Research Establishment (WNRE). WNRE is located in southeastern Manitoba, about 115 km from Winnipeg. The FIG project studies the ecological effects of continuous long-term exposure to gamma radiation on a mixed boreal forest ecosystem.

The investigations of the effects of exposure to ionizing radiation on individual organisms and populations under laboratory conditions are numerous. The number of radiation ecology studies carried out in the field, however, is much smaller.

Since the late fifties, several research projects have investigated the effects of ionizing radiation on plant and animal communities in natural ecosystems: an Oak-Pine forest (Woodwell 1963), a Mediterranean forest (Fabries et al. 1972), a desert (French et al. 1974.), a montane tropical rain forest (Odum and Pigeon 1970), a northern lake forest (Rudolph 1974; Zavitkovski 1977), and a pine plantation and old field (Platt 1963). One objective these projects share is to determine the amount natural background radiation must be increased to cause demonstrable ecological effects on free-living organisms, communities and ecosystems.

The effects on boreal forests of continuous exposure to gamma radiation have not, to our knowledge, been previously investigated. The Boreal Forest is an important biome in Canada since it occupies about one-third of our land mass. The studies previously cited may be only indirectly applicable to Canada, because they involved different groups of plants and animals exposed to climatic conditions not typical of Canada.

The first phase of the FIG project (pre-irradiation) started in 1968 and continued until 2 March 1973 when Phase II (irradiation) began. The recovery, or post-irradiation, phase will conclude the project. This paper describes the experimental forest, the gamma irradiator and its radiation field, and the various research programs.

The FIG Experimental Area

General

The FIG area (Figure 1) is on the property of the Whiteshell Nuclear Research Establishment (WNRE), at 50° 11′N, 96° 1′W and at 270 m above sea level. Established as an ecological preserve in 1968, it is 1 km in diameter, and surrounded by a 2.3 m chain-link fence and a 30 m wide firebreak. The only entrance into the area is a gate adjacent to the irradiator control building.

The area encompasses an ecotonal mixed boreal forest described as Lower English River type (Rowe 1972). Part of the area still shows the effects of logging carried out about 50 years ago, of forest fires as recent as 1961, and of more recent gravel-digging operations, which produced small marshes. The area also includes a Black Spruce-Sphagnum bog that drains from SSW to NNE. Beginning in 1968, extensive cataloging of the plants, small mammals and forest insects indigenous to the FIG area was carried out until the irradiator (Figure 2) was moved into the area and irradiation began in March of 1973.

Climate and Meteorology

The climate of FIG is that of the transition zone between temperate continental and boreal climates (Trewartha 1954.). The average annual precipitation in the area is 56 cm (38-50 cm as rain and about 130 cm as snow[1]). The long-term average extreme maximum and minimum temperatures are shown in Figure 3 (Davis and Reimer 1980).

Meteorological data collected in FIG include air temperature, dewpoint, humidity, wind speed, soil

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[1] 1 cm snow ~ 1 mm rain

FIGURE 1. Field Irradiator - Gamma (FIG) area. This mixed boreal forest, 1000 m in diameter and surrounded by a firebreak, is located in southeastern Manitoba. Irradiation has continued at 19 hours per day since 1973 March.

heat flux, net solar radiation, and precipitation (Reimer and Desmarais 1973).

Flora and Fauna

There are three general soil moisture regimes in the FIG area (Dugle 1972). The *wet* regime covers approximately 40% of the area of which *Picea mariana* (Black Spruce) — *Larix laricina* (Tamarack) — *Sphagnum* is the major association and Black Spruce the dominant tree. The *very moist* regime covers about 20% of the area. The major association in this area is *Abies balsamea* (Balsam Fir) — *Picea mariana* and *P. glauca* (White Spruce) — *Ledum groenlandicum* (Labrador Tea) with Balsam Fir as the dominant tree. The remaining 40% of FIG area is a *moist* regime supporting a mixed boreal forest association of *Populus tremuloides* (Trembling Aspen), the dominant tree, and *Betula papyrifera* (Paper Birch), smaller stands of *Pinus banksiana* (Jack Pine) and *Fraxinus nigra* (Black Ash) and scattered individuals of Balsam Fir, White Spruce, *Ulmus americana* (American Elm), *Populus balsamifera* (Balsam Poplar) and *Fraxinus pennsylvanica* (Green Ash). The Woodridge series soil type predominates in the moist regime, with sphagnum moss and peat in the wet portion. The drier locations consist of lacustrine sand overlying lacustrine clay, with the bog beginning at the eastern limit of the sand. A check-list of the flora of the WNRE area has been published (Dugle 1969a; Dugle and El-Lakany 1971) and voucher specimens are in the WNRE herbarium. An illustrated document on shrub flora, which also reports radiation effects, was compiled (Dugle et al. 1979).

The small mammal species studied in FIG (Iverson and Turner 1976) include mice, voles and shrews. Only those insect species living on the foliage and

FIGURE 2. FIG irradiation tower photographed in 1973, showing the 20 m tower, tower supports, beam stop, plantation, service road, and mixed boreal forest.

branches of Balsam Fir, Jack Pine, Paper Birch and Trembling Aspen were studied in detail. Present were 518 species in 111 families. A new aphid species, *Mansonaphis pinawae*, was first described from specimens found on Labrador Tea growing in FIG (Robinson 1973).

FIG Irradiator

The irradiator, designed and built at WNRE, is located in the center of the FIG area. It consists of a 20 m tower mounted between two supports (Figure 2) containing equipment such as an air compressor and a radiation sensor. A lead shield (castle) for the source is attached at the lower end of the tower. The tower can be tipped between its supports to lower it for maintenance. A triple-encapsulated ^{137}Cs source provides the gamma radiation field. Its effective source strength was 370 TBq. (10 000 Ci) when the irradiator was placed in service in March 1973.

Compressed air lifts the source from its castle to either of two irradiator positions, *panoramic* or *beam*, where it is held by an electromagnet at 20 m or 2 m heights above ground level. In the panoramic position, the ^{137}Cs source is at the top of the tower and the entire FIG area is irradiated. In the beam position, a collimated beam of gamma radiation is directed along a trolley track into a beam stop (Figure 2). The beam position may be used for acute irradiation of flats of plants or cages of small animals placed on moveable trolleys on the track. The source is returned to its castle by switching off the electrical supply to the electromagnet at the control building, allowing the source to descend on a cushion of air. In the event of a malfunction when the source is in the beam or pano-

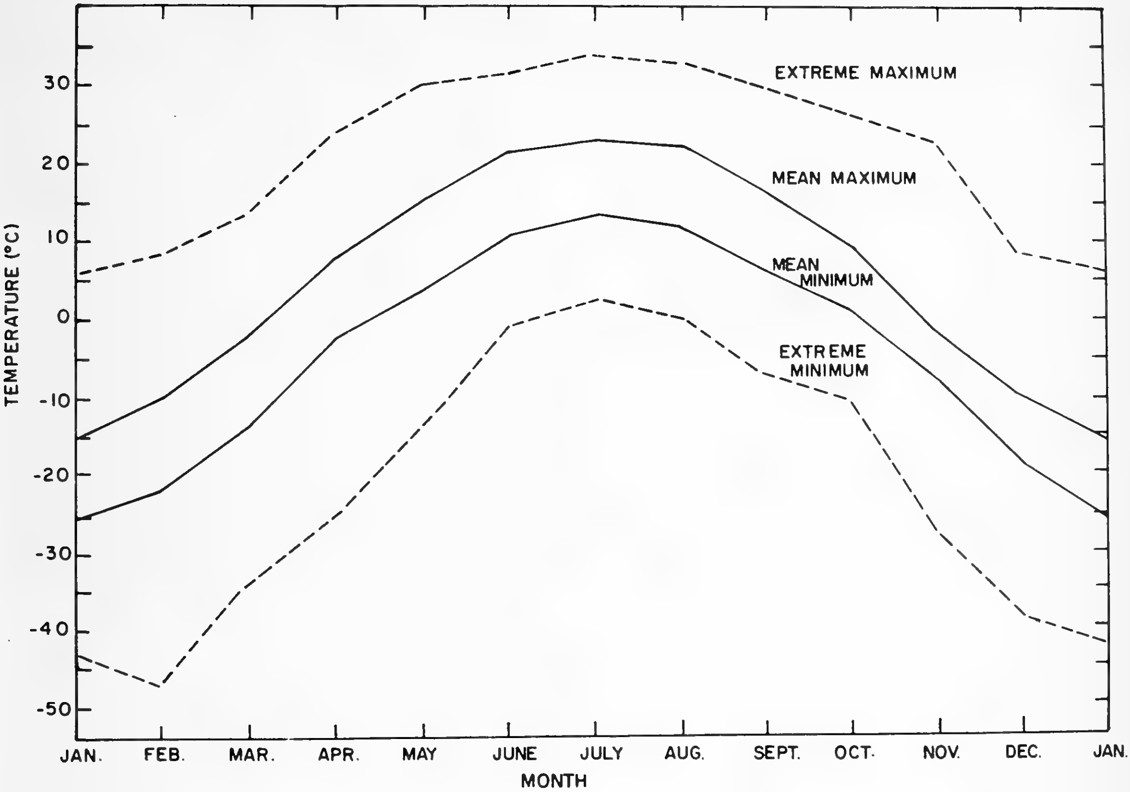

FIGURE 3. Long-term average and extreme maximum and minimum temperatures at WNRE (Davis and Reimer 1980).

ramic positions, the source automatically drops into its castle.

Radiation Field and Dosimetry

Lithium fluoride thermoluminescent dosimeters (LiF TLDs) measure radiation dose-rate at the experimental sites in FIG. Aluminum foil-wrapped packets of two LiF TLDs (Harshaw TLD-100) enclosed in plastic vials are located at ground level or at 1 or 2 m heights above ground in all botany quadrats, insect-sampling sites and other areas of particular interest. The maximum dose rate at ground level is 65 mGy/h,[2] at a distance of about 22 m from the ^{137}Cs source (about 12-18 m from the tower). The dose rate decreases with distance from the irradiator to 0.005 mGy/h at the perimeter fence. Figure 4 shows the individual dosimeter readings from several years and directions. Consequently, the variation is large.

FIG Research Programs

Botanical Research

The main effort of the FIG project is on plant ecology and biosystematics. Its objectives are to determine changes in plant associations taking place with time and at various dose rates, effects of radiation on plant species, especially mature trees and shrubs, combined effects of other stresses (cold, insects, drought) and gamma radiation, and the lowest dose rate at which any effect of gamma radiation can be detected on plant associations or species.

During the pre-irradiation studies, check-lists of plants present in the area and ecological descriptions of the several plant associations were prepared (Dugle 1969a; 1969b; 1972; Dugle and El-Lakany 1971). Published radiation sensitivities of trees were reviewed (El-Lakany 1971) and those of species or genera found in the FIG area were documented (Dugle and El-Lakany 1971). Several techniques were used to study the effects of radiation on individual plants and plant species, and on such successional changes as those affecting numbers of individuals and species diversity (Dugle and Thibault 1972; 1974).

A summary discussion of these techniques follows: the plant associations in FIG are natural ones with the exception of a cultivated strip about 5 m wide and 100 m long bordering an access road. This road runs

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[2] 1 m Gy/h = 100 mrad/h.

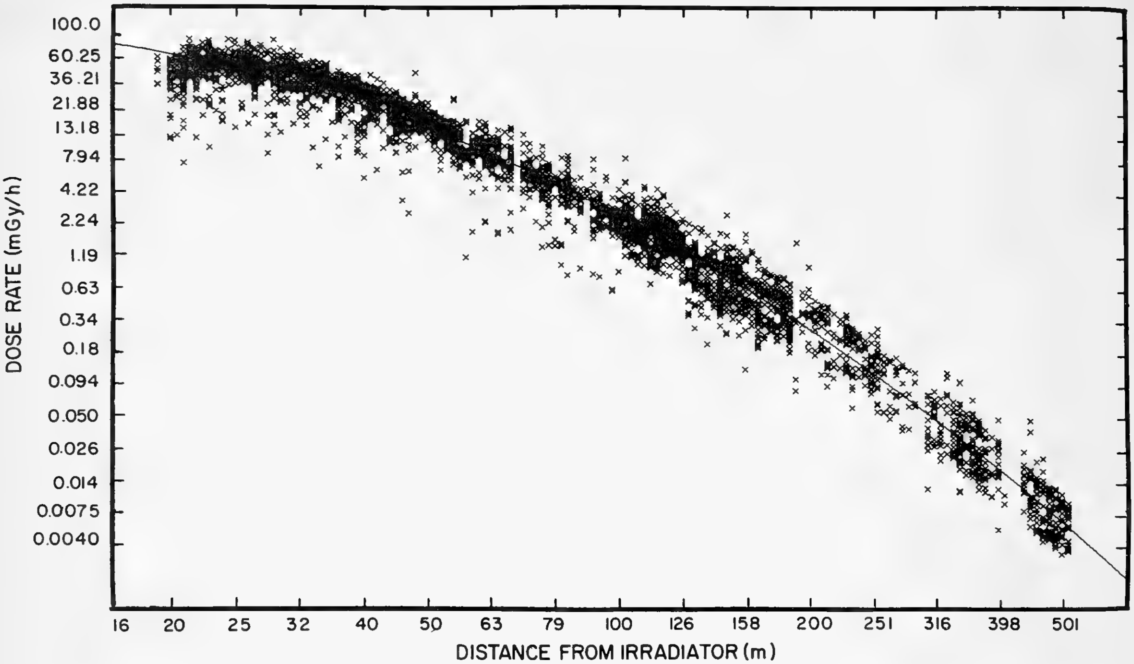

FIGURE 4. Computer-generated plot of dose rates (mGy/h) at various distances from the ^{137}Cs source in FIG. The line is a second order polynomial fit. The change in slope at around 20-30 m from the source is due to self-shielding by the tower and source.

from an old logging road to the irradiator located in the center of the FIG area.

A number of trees and shrubs planted in the cultivated strip were well established before the irradiation began. Regular survival counts, phenological observations and measurements of growth were made. The radiation sensitivities of several taxa growing in the strip were determined.

Eight representative associations of plants were selected for detailed study (Dugle 1961b; 1972). The methods used to analyze the 115 chosen quadrats were reported (Dugle and Thibault 1972; 1974).

A statistical analysis of forest type by category (random, aggregate, or uniform) was completed at the end of the pre-irradiation phase from quadrat tree maps listing the species, condition, diameter breast height (dbh) and exact location. The irradiation phase studies give results relevant to the ecological significance of radiation effects on individual tree species.

Changes in canopy cover of trees and shrubs are assessed in two ways — as part of the quadrat analysis studied annually, or as a study of marked individual trees or shrubs studied biweekly during the growing season and sampled annually (Dugle and Mayoh 1974). Some marked trees have been carefully measured at least once a year — the "age, height, circumference" trees. Thus, the effects of radiation can be observed on mature trees subjected to chronic radiation. After the tree dies, its annual rings are measured, allowing comparison with the concurrent control trees. For details of these analyses see Dugle et al. (1974) and Dugle and Thibault (1974).

Biosystematic studies provide baseline information on species, especially woody ones, indigenous to FIG. Much of the information is relevant to the radiation sensitivity of the species. Specific studies and the topics relevant to radiation effects are

1. Birch (Dugle 1966; 1969c; Dugle et al. 1979) — taxa present, chromosome information, morphology, hybrids, leaf chemistry.
2. Spruce (La Roi and Dugle 1968; Dugle and Bols 1971) — taxa present, morphology, chromosome information, hybrids, leaf chemistry.
3. Rose (Ziola and Dugle 1970; El-Lakany 1972a; 1972b) — taxa present, morphology, chromosome information, ploidy level, DNA content, hybrids.
4. Other shrubs (Dugle et al. 1979) — taxa present, identification, morphology, hybrids, ploidy levels.
5. Cattail (Dugle and Copps 1972) — taxa present, hybrids.
6. DNA (El-Lakany and Dugle 1972) — taxa present, DNA content of local plants.

Permanent plot (and miniplot) locations were randomly selected in each quadrat during the pre-irradiation phase using a stratified nested sampling design. Twenty plots per quadrat were established for annual study during all three phases of the FIG project (Dugle and Thibault 1972; 1974). Information collected during the plot and miniplot analysis was used for ecological and species effects studies. Many of the species effects were discovered through canopy, plot and general phenology and morphology descriptions. Radiation effects such as somatic mutations, growth-rate increase or decrease, and survival have also been described (Dugle et al. 1979).

Time and radiation dose rate are the controlled variables in studies of succession using the same plots since the start of the project. A cluster analysis (Parks 1970) with several variations was used for the ordination of the associations and their changes during irradiation. This type of analysis allows the use of presence and absence observations, in addition to numerical data. The dimensions of the analysis are large, approximately 10 000 quadrats (or plots) vs. 230 variables.

In addition, phenology and morphology were regularly checked during the growing season. Somatic mutations and voucher specimens of radiation-exposed plants are deposited in the WNRE Herbarium.[3]

Zoological Research

Changes in the presence/absence and abundance of small-mammal and phytophagous-insect species in FIG have been studied since 1969. An annual census of the numbers of small-mammal species and individuals was made using depletion trapping at permanent 8 × 8 station grids over a 30-day period (Iverson and Turner 1973). Four of these grids are inside, and the other four (concurrent controls) are outside, the FIG-enclosing fence. Several plant associations and dose rates are represented in these grids.

The presence/absence and abundance of herbivorous- and entomophagous-insect species inhabiting chronically irradiated stands of Aspen, Birch, Fir and Jack Pine were studied by randomly dividing the stands into five samples. Each sample consisted of five sub-samples each containing five randomly selected trees. Every year from 1969 to 1978 a cubic meter of branches and foliage of each of these trees was "beaten" during the first two weeks of July. The dislodged insects were caught on a cloth sheet, from which they were removed and preserved in vials. The insect samples were sent to Northern Forest Research Laboratory, Environment Canada, for identification.

A pre-irradiation breeding-bird survey was completed in 1972 (Seabloom 1975). A study of the breeding biology of House Wrens and Tree Swallows living in FIG was published (Zach and Mayoh 1982).

Other Research

Effects of loss of canopy on the microclimate in stands of Jack Pine and Balsam Fir were studied. In addition, there are the experimental programs carried out by members of university departments and federal government laboratories. The scope of these programs is wide, ranging from bog ecology (e.g., Longton 1972) to snail biosystematics (Pip 1977).

Discussion

Studies were or are being made on a number of different ecosystems of the effects of exposure to gamma radiation. Examples of these are summarized in Table 1: Oak — Pine forest (Whittaker and Woodwell 1968; Woodwell and Whittaker 1968), desert (Whicker and Fraley 1974), grassland (Fraley and Whicker 1973), tropical rain forest (Odum and Pigeon 1970), and ZEUS, a project studying the effects of chronic irradiation on small-mammal population dynamics (Turner and Iverson 1976). The radiation conditions and experimental protocol of these studies are compared in Table 1 (refer also to Hart 1980). Only four of the summarized studies are not located within the continental USA. Two of these, FIG and ZEUS, are in Canada, at WNRE.

The duration of some of the studies (Table 1) was as short as a few months. The lake forest biome studied in Wisconsin (Rudolph 1974; Zavitkovski 1977) most closely resembles that of the FIG project. However, it was only irradiated during one growing season and it differs in its experimental protocol. To our knowledge, the FIG project is the first long-term study of the effects of chronic irradiation on a boreal forest ecosystem.

Most of the studies of radiation effects on FIG flora and fauna are unpublished, since effects on plants and animals, and at the community level of the ecological hierarchy, are still occurring. The ecological changes that occurred within 50 m of the irradiator, where the radiation field exceeds 100 000 times background, were expected. Many woody plants are dead, and a different assemblage of species now comprises the ground cover. As a consequence, there were localized changes in the microclimate. So far, no evidence has been obtained that indicates small mammals and phytophagous insects were directly affected. They have, however, reacted to the changes in availability of food plants and habitat caused by radiation.

In general, the radiation sensitivities of the important FIG plant species are as anticipated. The effects of radiation on shrubs (Dugle et al. 1979) and of 18 months of irradiation on canopy cover (Dugle and Mayoh 1974) were reported.

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[3] WNRE Herbarium, Pinawa, Manitoba, ROE 1LO, Curator Janet R. Dugle.

TABLE 1. Comparison of field irradiation studies.

Project	Location	Dates of irradiation		Radiation source, strength, height above ground	Duration of radiation exposure				Controls	Remarks
		Started	Ended		Years	Summer (hours)	Winter (hours)	Cumulative (hours)		
Field Irradiator Gamma (FIG) Boreal forest	Pinawa, Manitoba, Canada	2 March 1973	C	^{137}Cs, 370 TBq, 20 m	1973	3 441	598	4 039	Control areas distant from irradiator and studied concurrently. Pre-irradiation studies — 1969 to 1972.	Winter dormancy. Average irradiation period is 19 h/d. Cumulative exposure as of 1 April 1981 = 56 135 hours.
					1974	3 463	3 541	11 043		
					1975	3 525	3 464	18 032		
					1976	3 535	3 408	24 975		
					1977	3 531	3 382	31 888		
					1978	3 433	3 456	38 777		
					1979	3 454	3 492	45 723		
					1980	3 307	3 549	52 579		
					1981		3 556	–		
Enterprise Radiation Forest Lake forest (Rudolph 1974; Zavitkowski 1977)	Enterprise, Wisconsin, U.S.A.	3 May 1972	16 October 1972	^{137}Cs, 370 TBq, 3 m	1972	2 333?	384?	2 717	Control areas distant from irradiator and studied concurrently. Pre-irradiation studies 1969 to 1971.	Winter dormancy. Forest irradiated for less than 20 h/d during early part of growing season because of problems with irradiator.
					1973	—		Recovery		
					1974	—	—	Recovery		
Mediterranean Forest (Fabries et al. 1972)	Cadarache, France	11 July 1969	C?	^{137}Cs, ~ 44 TBq, 3 m	1969	Not known	Not known	9 000	Not reported.	Summer dormancy. Cumulative exposure as of June 1970 = 14 000 hours.
					1970	Not known	Not known	See remarks		
Brookhaven Oak - Pine forest (Woodwell 1963)	Upton, New York, U.S.A.	22 November 1961	C?	^{137}Cs, ~ 352 TBq, 3.65 m	1961	3 650?	3 650?	—	Control areas. Pre-irradiation studies done in summer, 1961.	Winter dormancy.
					—		—			
					1980	—		133 000?		
Puerto Rico Radiation Forest Montane tropical rain forest (Odum and Pigeon 1970)	El Verde, Puerto Rico	19 January 1965	27 April 1965	^{137}Cs, 370 TBq, 2.5 m	1965	648	1 580	2 228	Control areas distant from irradiator and studied concurrently. Pre-irradiation studies 1961 to 1965.	
					1966	—	—	Recovery		
					1967	—	—	Recovery		
Mojave Desert Desert shrub (French et al. 1974)	Rock Valley, Nevada, U.S.A.	1964	May 1974, or C?	^{137}Cs, 1110 TBq, 15 m	1964	Not known	Not known		Control areas distant from irradiator and studied concurrently. Pre-irradiation studies done in 1964.	Summer dormancy. Varying-thickness shield used to flatten radiation field.
					1974	Not known	Not known	73 000?		
Short-Grass Prairie (Fraley and Whicker 1973)	Nunn, Colorado, U.S.A.	3 April 1969	C?	^{137}Cs, ~ 324 TBq, 1 m	1969	3 600	1 840	5 440	Control areas distant from irradiator and studied concurrently? Pre-irradiation studies?	Winter dormancy. Daily irradiation assumed to be 20 h/d; however, some periods at 24 h/d were reported.
					1970	3 660	3 640	12 740		
					1971	3 660	3 640	20 040		
					1972	1 460?	1 800?	23 300?		
Savannah River Irradiations. Old field Pine plantation (Miller 1968; McCormick and Golley 1966)	Aiken, South Carolina, U.S.A.	1965	C?	^{137}Cs, ~ 340 TBq, 1.3 m	1965 to 1968	See remarks	See remarks	See remarks	Concurrent controls and pre-irradiation studies.	Winter dormancy. Individual irradiations during each of the four seasons, one season per year. Source: field is uni-directional.
Zoological Environment Under Stress (ZEUS) Individual 1 ha meadows surrounded by mixed forest (Turner and Iverson 1976)	Pinawa, Manitoba, Canada	1 November 1981	C	^{137}Cs, 444 TBq, 10 m	1981	—	—	Irradiator commissioning	Adjacent meadows serve as concurrent controls. Pre-irradiation studies of vole populations 1967 to 1981.	Winter dormancy. Varying-thickness shield used to flatten radiation field.

Notes: (1) Information has been converted to similar units to simplify comparison. (2) Information inferred and not obtained from published work is indicated with a question mark (?). (3) C = continuing in irradiation phase. (4) Summer period is 1 April to 30 September; winter period is 1 October to 31 March. (5) Cumulative hours listed as of October 1 in each year. (6) 1 TBq = 27 Ci.

The third phase of the FIG project will begin when the radiation field is "turned-off" for the last time. This phase, recovery or post-irradiation, will be as ecologically interesting as the pre-irradiation and irradiation phases. It will give us the opportunity to study the recovery processes in an ecosystem damaged by prolonged exposure to an environmental insult.

Acknowledgments

The field and laboratory work of our colleagues and by the more than 50 summer students who have participated in the FIG project to date is gratefully acknowledged.

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Book Reviews

ZOOLOGY

Bears: Their Biology and Management

Edited by Clifford J. Martinka and Katherine L. McArthur. 1980. Bear Biology Association Conference Series No. 3. Bear Biology Association, Boise, Idaho. 375 pp., illus. No price given.

This volume comprises a selection of papers presented at the Fourth International Conference on Bear Research and Management held at Kalispell, Montana in 1977. In the past decade, considerable interest has developed in the biology of North American bears. This interest has been stimulated, sometimes with great emotional outcry, by such events as Grizzly Bear attacks on humans in Yellowstone and Glacier National Parks, a television special on the Polar Bear migration through Churchill, Manitoba, and increased Polar Bear problems at sites of oil, gas, and mineral exploration in the Arctic. With increasing contacts between humans and bears, it has become clear that proper management requires a more complete knowledge of certain species; published proceedings such as this serve a useful role in delineating what is known and in stimulating and directing future research.

The 60 papers are broadly divided into those dealing with ecology (55%), management (37%), and anatomy and physiology (8%). By species, 22 deal with Black Bears, 17 with Grizzlies (another seven are on the Eurasian Brown Bear, the same species as the Grizzly), six with Polar Bears, and four with the Japanese Black Bear. Although variation occurs within this collection, the quality is generally high. There is an appropriate mixture of papers dealing with "hard data" and supported opinion, and between descriptive and analytical presentations. Readers unfamiliar with Eurasian species will obtain a good impression of some of the serious management problems involving bears in the Eastern Hemisphere.

It is likely that bear biologists are already quite familiar with much of the information contained in these proceedings. Those less knowledgeable about bears, but interested in the broad fields of ecology and wildlife management (as this reviewer is), should find this volume interesting.

DAVID A. LOVEJOY

Westfield State College, Westfield, Massachusetts, 01086.

Mammalian Population Genetics

Edited by Michael H. Smith and James Joule. 1981. University of Georgia Press, Athens, Georgia, 380 pp., U.S. $25.00.

This book is a series of papers arising from a 1978 symposium depicting recent developments in the field of mammalian population genetics. Persons interested in ecological genetics of wild mammal populations will find cautious perusal (see below) of several papers informative (those by Schnell and Selander, Schwartz and Armitage, Massey and Joule, McClenaghan and Gaines). Broad subject areas include genetics and phylogeny, genetic variability and morphological variability, genetics and environmental characteristics, genetics on islands, and the Chitty hypothesis.

The fact that field biologists have ignored genetics and geneticists have ignored field biology is evident throughout this book. Also of alarming evidence is the ignorance of proper statistical analyses by many of the geneticists. Many authors have performed parametric statistical tests (analysis of variance, correlation and/or regression analysis) on genetic proportions (polymorphism, heterozygosity, known to be non-parametric) without arcsine-transforming their data set. Many have performed correlation and regression analysis on proportions with the same denominator and made ungrounded conclusions on the results. Few authors properly analyzed their data and as a result many of the conclusions made in this text may be erroneous.

Many references cited in the text are missing from the bibliography. Authors with the same last name and year of publication are cited in the text many times without first initials. Citations by the same author in the same year many times have no "a" or "b" suffix in the text but a suffix appears in the Literature Cited section.

New or corroborative items of interest throughout the text include: the lower genetic variability found on islands when compared to the mainland for 96 populations of 20 species may be primarily caused by founder effects during initial colonization; heterozygosity is usually positively correlated to body weight within a species; marine mammals usually have very low levels of genetic variability; reduced gene-flow and high levels of inbreeding may be the cause of low genetic similarity among pocket gopher populations; there usually are conflicting relationships among habitat heterogeneity, morphological variability, and genetic variability; genetic distance is seldom related to suspected phylogenetic distance; and gene frequencies and/or genetic variability, as determined by electrophoresis, were not related to age, sex, survival or reproductive success of marmots.

This text will stimulate new questions on mammalian genetics, but if mammalian geneticists go on analyzing their data sets as many have here, few of these questions will receive respectable answers.

RICHARD M. ZAMMUTO

Kananaskis Centre for Environmental Research, University of Calgary, Seebe, Alberta T0L 1X0.

Summer Birds of the Northwest Angle Provincial Forest and Adjacent Southeastern Manitoba, Canada

By Robert S. Ferguson. 1981. National Museum of Natural Sciences, Ottawa, Canada. Syllogeus No. 23, 23 pp. Free.

This is a factual, concise report of an intensive study conducted near the extreme southeastern corner of Manitoba between 25 May and 7 July 1978. In the course of collecting 191 specimens of 83 species for the Museum of Natural Sciences, Ferguson observed 155 species but mentions firm breeding evidence for only 18 species. He documents a modest eastward extension of range for the Marbled Godwit and Sprague's Pipit, but fails to relate this to the clearing of woods for fields and pastures. Immature Broad-winged Hawks were flying by 17 June, an incredibly early date.

Rowan's nearby study in 1920, a 3-day visit by Soper in 1940, and a 2-day visit by Godfrey in 1951, are mentioned in the introduction, but their observations are not summarized in the species accounts, which deal only with Ferguson's observations. Ferguson in fact lists 62 species not seen by Rowan, while Rowan listed 13 species not seen by Ferguson. The multi-authored *Birder's Guide to Southeastern Manitoba*, published by the Manitoba Naturalists Society in 1980, is not even cited.

Such lists of the birds of a given area once formed a major part of ornithology journals. *Syllogeus* presents a wide variety of single topics of varying length in a useful and inexpensive format, in this instance an excellent vehicle for sharing the results of a museum expedition with the interested public.

C. STUART HOUSTON

863 University Drive, Saskatoon, Saskatchewan S7N 0J8

Wildlife Population Ecology

Edited by James S. Wakeley. 1982. Pennsylvania State University, University Park, Pennsylvania. x + 385 pp. Cloth U.S. $18.50; paper U.S. $11.95.

This book is a compilation of 31 reprints of classical scientific articles used by most researchers studying ecology of wildlife populations. Wakeley has simply photocopied (most in whole, some in part) the most important contributions made in wildlife population ecology and republished them in this book. Eleven papers are reprinted from the *Journal of Wildlife Management*, three from *Ecology*, three from *Evolution*, and one or two from *American Naturalist, Auk, Condor, Endocrinology, Ibis, Journal of Animal Ecology, Journal of Applied Ecology, Journal of Mammalogy, Journal of Zoology, Science* and *Wildlife Monographs*. The photographic reproduction is excellent for most of these articles. A section entitled "Additional Readings" lists complementary articles to those appearing in the text.

In my opinion, Wakeley has selected a nearly perfect assemblage of papers for his subject. Most of the papers are used in wildlife ecology and/or population courses at colleges and universities throughout North America. Researchers in wildlife population ecology have probably read more than 75% of the papers and have probably been exposed to concepts of more than 95% of them.

I expect this book will receive wide use in wildlife ecology, especially with its attractive price. The book should be an excellent starting point for students and/or persons interested in wildlife population ecology. It should also serve well as a useful treatise for professionals who cite these papers in their own publications.

RICHARD M. ZAMMUTO

Kananaskis Centre for Environmental Research, University of Calgary, Seebe, Alberta T0L 1X0

Fish Gene Pools

Edited by N. Ryman. 1981. Proceedings of a symposium, Stockholm, January, 1980. Ecological Bulletins 34. FRN, Stockholm. 111 pp., illus. SK90.

Fish Gene Pools is a compilation of nine papers originally presented at an international symposium held at Stockholm, Sweden, in 1980. The central theme is the preservation of the genetic diversity of natural fish populations that are impacted by man's activities. Emphasis is placed on intraspecific variation, rather than variation among species, and the conservation of stocks of fish, rather than species. One of the book's objectives is to make fisheries scientists and managers aware that the genetic variation within and between natural fish populations is a valuable natural resource that needs to be protected. The authors provide the reader with a series of recommendations for the management of natural fish populations. These recommendations advocate a management strategy that minimizes further genetic erosion of natural fish populations.

The book has the usual pluses and minuses of multiauthored publications. The individual presentations are quite varied in their scope and quality as well as their relevance to the main theme of the book. I particularly enjoyed the papers by Allendorf and Phelps; Ryman; and Stahl. The

Allendorf and Phelps paper gives a very lucid discussion of the use of gel electrophoresis of enzymes as a tool for the study of intraspecific genetic variation. Little knowledge of population genetics is required to follow the main arguments of these papers, since basic concepts in population genetics are reviewed for the reader. Each paper is intended to stand on its own, and can be read independently. However, this approach has resulted in considerable repetition, especially in the methodology sections of some of the papers. Also, the general concern of most of the authors about the conservation of genetic fisheries resources is restated repeatedly, while not enough space is devoted to integrating the different points of view expressed by the population geneticist, ecologist, and fisheries manager.

The book is most effective in presenting some of the evidence that has recently come to light about the rich ecological and genetic diversity (mostly isozyme variation) within species. However, the taxonomic and geographic perspectives are not as broad as one might have expected from the title of the book. In fact, only three species of the same genus (*Salmo*) are discussed in any detail, and the geographic range is virtually restricted to Sweden and Norway, with one example from North America. Nevertheless, these examples serve to give the reader an appreciation of the ecological and genetic intraspecific variation found in natural fish populations, and to make a strong case for the conservation of this variation. The Scandinavian perspective is particularly relevant to Canada, since we too are the custodians of a rich variety of trout, charr, and salmon stocks.

The authors recommend that genetic fisheries resources be identified. It is clear from the book how to proceed with regard to biochemical variation, but the approach to be taken to genetic differences in local adaptation is not given the same emphasis. In general, the recommendations state laudable goals. However, the methods for achieving those goals need to be developed. For example, one of the recommendations states that "fisheries should be managed so as not to harm the genetic characteristics of populations through selective harvesting". The question remains, how this is to be accomplished? How does one balance the needs of the user with the concern of the conservationists?

Every fisheries manager should be exposed to the ideas expressed in this volume. I recommend this book, as well, to those interested in fisheries population genetics, but lacking the time or the inclination to read journal articles. The authors successfully relate basic population genetic concepts to fisheries management problems and made a strong case for the conservation of genetic fisheries resources.

PETER E. IHSSEN

Ontario Ministry of Natural Resources, Research Section, Fisheries Branch, Box 50, Maple, Ontario L0J 1E0

An Atlas of the Birds of the Western Palaearctic

By Colin Harrison. 1982. Princeton University Press, Princeton, New Jersey. 322 pp., illus. U.S. $25.00.

North American ornithologists who might expect the direct relevance of this atlas to be restricted to maps of species distribution shared by the Nearctic and Palaearctic may be missing an important reference source. Harrison's inclusion in his family discussions of ecological equivalents in continents outside the Palaearctic provides a goldmine of potential ideas for further research. Although the book is based on the western Palaearctic, many of the maps include species of the much less-known eastern Palaearctic. Thus, this book also serves as a brief introduction to the birds of much of Asia.

The book consists of a few introductory sections, followed by about 250 pages of maps and accompanying text, one page of further reading and indices to English and scientific names. The introductory sections are dominated by a discussion on interpreting the maps. This discussion includes problems posed by the technical difficulties of representing the curved surface of the earth on a flat page, problems posed by behaviour of strays and irruptive species, and factors influencing the distribution of a species. The atlas itself is arranged by family, each being introduced by a general account of it in the western Palaeartic and in the world as a whole, with considerable emphasis on "replacement" species in other continents, and of related species in other parts of the Palaearctic Subregion. In families represented through a major portion of this subregion, a map is shown of the breeding distribution of all species in it. Family discussions are followed by individual species accounts for the western Palaearctic itself. Each species is alloted a map of permanent, breeding and/or winter range, with arrows indicating direction of migratory movements, and accompanied by a paragraph on geographic and altitudinal range, habitat, and other information related to distribution. In families with distinct groups (subfamilies, large genera, and other obvious divisions) these groups are usually given a general write-up, often accompanied by an additional map. A drawing of each Palaearctic species mentioned in the text appears at the bottom of the page.

The map of the Yellow-billed and Common loons is Holarctic, but all other maps are restricted to the western Palaearctic or the Palaearctic as a whole. The maps, drawn by Crispin Fisher, have obviously been thoroughly researched, and contain few errors. The small donuts of seasonal colour in the midst of the permanent ranges of the Black-billed Magpie and Linnet appear to be slips of the paintbrush, and the dot of winter distribution shown in the Spitzbergen Islands for the tropical Chestnut-bellied Sandgrouse is an obvious error. The black-and-white drawings accompanying the text are generally pleasing, although a few (notably the larks, finches and sparrows) are distorted in shape, and the tarsi of the Arctic Tern are too long.

On the whole, the text is thorough and well written. The introductory section on factors affecting distribution in the Palaearctic is an excellent precis of the principles of biogeography as applied to any large land mass. Although this section contains numerous references to maps in the main part of the book, I found only one error in number — the Orange-tufted Sunbird mentioned on page 36 should have referred to map 583, not 584. I found only one other such numbering error in the whole book (the Pied/White Wagtail complex is mapped on map 422, not 393 as stated on page 208), and there are only about three other typographical errors in it. Other errors are equally scarce and minor. The statement that the Laurel Pigeon may be extinct on Gomera Island should have substituted the word extirpated, the word "Plover" after Killdeer is redundant, and the Cedar Waxwing does not breed only in eastern North America. I do not agree with all of Harrison's statements on ecological equivalents. If Blue-winged Teal indeed replace Gargeny on this continent, then this surely applies to the Cinnamon Teal also. Forster's Terns do, indeed, breed in parts of the western U. S. not occupied by Common Terns, but the breeding ranges of the two species overlap extensively, and ecologically Forster's Tern is much more similar to the unrelated Swift Tern than to the Common.

Such differences in interpretation and minor errors do not detract from the overall high quality of this book, and I found many intriguing differences between habits of species shared by our continents. For example, Horned and Eared grebes show much less overlap in breeding ranges in Europe than in Canada; Great Cormorants barely stray inland in Prince Edward Island, but breed on freshwater lakes in the Palaearctic; and Canada Geese introduced to Europe have evolved a northward moult migration in the British Isles, but a southward post-breeding migration in Sweden!

In short, this atlas should be standard fare on the shelves of European ornithologists. For North Americans, it offers far more than the peripheral distributional information that may be suggested by its title.

MARTIN K. MCNICHOLL

320 Markham Street, Toronto, Ontario M6G 2K9.

Arctic Animal Ecology

By Hermann Remmert. 1980. Springer-Verlag, Berlin. 250 pp., illus. U.S. $24.80.

This translation of a work by a German ecologist with fifteen years of experience on Spitsbergen promises to be a synthesis of information from all parts of the Arctic. It draws on an impressive range of sources, and uses section headings of good ecological generality. Unfortunately, though, some combination of author, translator, and publisher has made such a poor job of it that the result is an insult to the reader.

Technical problems abound. By my tally, almost half of the citations in the text are not given in the list of references. Figures have unexplained symbols, missing units, and superfluous data. Some do not show what they are supposed to, others seem to show nothing at all. A three-quarter page figure purporting to show the effect of caterpillar outbreaks on forests has tree-ring data but nothing on insects except for a line in the caption that says "minimum growth rates are usually connected with such outbreaks". A discussion of a freshwater lake in Iceland fed by warm springs is illustrated by a feeding diagram for the Bering Sea. A table supposed to "reveal very clearly the typical pauperization of arctic regions with respect to large decomposers" has no data on body size, no data on ecological function, no comparative data from the south, and no groups finer than "Diptera larv." or "Coleoptera ad.".

The style is emphatic throughout, with much use of words like always, impossible, obviously, completely, more often than not without justification in my opinion. Some extraordinary statements are made. Arctic diving birds are invariably soaked to the skin and their "feathers and extremities freeze as soon as the animals emerge from the water". Similarly, "poikilothermic organisms exhibit no active signs of life below freezing point (land and freshwater: 0°C, sea water: −1.7°C)". By contrast, "the Arctic is a favourable environment for all warm-blooded organisms".

In the section "Population Cycles" we are given a figure showing the Canadian fur-trade statistics for Lynx and "mountain hare", without acknowledgment of source and without critical comment, as evidence of a nine-year arctic cycle. There is no distinction made between cycle and simple variation. The summary figure for this discussion says nothing more than that populations in general can go up or down for many different reasons — it misses the point about cycles altogether. The section "Seasonal Migrations of Birds and Mammals" begins by saying that "the majority of birds breeding in the Arctic and a large proportion of the mammals leave the true Arctic in winter for other regions". There are no references to mammals and no examples until several pages later when we are told that "most arctic mammals remain in the same geographical region winter and summer". Elsewhere, the logic is of this standard: "If forest caribou and forest reindeer are in fact distinct species they must have evolved in different places and their similarities are thus analogies. Each of them must therefore be an individual species . . .".

There is hardly a page in the book that does not yield other examples of these kinds. The considered opinion of an experienced investigator can be a better integrator of disparate data than any other, and deserves much respect. However, in this case there are so many problems with logic and content and presentation that the result is most unsatisfactory.

JOHN MIDDLETON

Department of Botany, University of Dar es Salaam, P.O. Box 35060, Dar es Salaam, Tanzania

Handbook of Census Methods For Terrestrial Vertebrates

Edited by David E. Davis. 1982. CRC Press, Boca Raton, Florida. 397 pp., U.S. $140.00.

This guide should be useful to those wanting to estimate the abundance of amphibians, birds, mammals or reptiles in a habitat. It could be consulted as a starting-point reference (along with Schemnitz, S. D. 1980, *Wildlife Management Techniques Manual*) during planning, prior to a census of a species in a particular habitat.

This guide is a series of more than 150 short articles written by 160 authors. It features articles on 3 amphibians, 43 birds, 60 mammals, 4 reptiles and 32 habitats (for combinations of species). Each article was written by a researcher (address provided for direct inquiries) who has personally tested and recently published (since 1974) a scientific article on the use of the censusing method he discusses. Included in the discussions are many basic facts on the species or habitat concerned.

Each article may answer several questions: how many traps should be set?; how long should the traps be set?; what areas should be checked?; how accurate will the estimate be?; and/or where is more information on the species or habitat? A comprehensive chapter contains general methods usually used during census work (basically a reprint of Chapter 14 in Schemnitz 1980).

The index is very good — an important aspect of a handbook of this kind. The text reads with facility, is informative, and has few typographical errors.

Perhaps a problem with this book is its high price. Few researchers may want to obtain a personal copy whereas the guide will probably receive wide use as a reference.

Persons interested in beginning a study on a terrestrial vertebrate or habitat (a few aquatic species and habitats are discussed) should find this guide a useful reference.

RICHARD M. ZAMMUTO

Kananaskis Centre for Environmental Research, University of Calgary, Seebe, Alberta T0L 1X0.

EDITOR'S NOTE

The following two publications are only available in Chinese. The reviewers have combined linguistic and scientific backgrounds to provide a unique insight into the status of fisheries research in this vast and important geographic area.

The Fishes of the Islands in the South China Sea

By South China Sea Fisheries Institute, Xiamen Fisheries College, Institute of Oceanology, Institute of Zoology, East China Sea Fisheries Institute, South China Sea Institute of Oceanology, Beijing Natural History Museum, and Fisheries Institute of Hainan Administrative Region. 1979. Science Press, Beijing, China. xxv + 613 pp. Cloth ¥11.80; paper ¥7.80 (approximately $8.00 and $5.50 Canadian, respectively).

China faces on three seas, the Yellow, East China and South China Seas. Because of their richness, the faunas ranging from boreal to tropical and comprising over 2 000 marine species, are of wide ichthyological interest.

Although most of the larger ichthyological studies published in China in the last decade have been on freshwater fishes, several marine faunal works have been published in the 50's and 60's: Tchang Tchun-Lin *et al.* 1955. *Fishes of the Yellow Sea and Pohai, China.* Science Press, Peking. 362 pp., 206 fig.; Institute of Zoology et al. 1962. *Fishes of the South China Sea.* Science Press, Peking, 1184 pp.; Cheng, C.T. *et al.* (eds) 1962. *Economic fauna of China. Marine Fishes.* Science Press, Peking. 174 pp. 32 pls. and Chu Yuan-Ting. 1963. *Fishes of the East China Sea.* Science Press, Peking. 642 pp., 442 fig. These works are scientific in style. A popular guide series has also been started: Institute of Oceanology and Shanghai Natural History Museum. 1975. *Zhong Guo Hai Yang Yu Lei Yuan Se Tu Ji (The color pictorial guide to Chinese marine fishes).* 1. People's Press, Shanghai. 230 col. pl.

The Fishes of the Islands in the South China Sea covers the surrounding waters of the four groups of islands: Dongsha (Pratas Islands), Xisha and Zhongsha (Paracel Islands including Macclesfield Bank), and Nansha (reef islands around Investigator Shoal, roughly between 7° and 12°, west to Palawn of the Philippines and north to Borneo). As in all the other works mentioned, the text is naturally in Chinese, but scientific names in Latin are also included in the text, tables of contents, and captions.

The book consists of the following sections: a detailed table of contents including a list of contributors (31) and their responsible taxa, and illustrators (16); scientific descriptions including synonymies, keys to taxa, and other interesting information such as cooking recipes and medicinal uses; literature cited (10 pages, somewhat incomplete); a Chinese index; an index to scientific names in Latin; and colour plates (34 species) and black and white plates (96 species). There are accounts for 521 species. Compare this with 386 species for the Pacific coast of Canada (Y. Jean, A. Peden, and D. E. McAllister. 1981. British Columbia Provincial Museum Heritage Record Number 13).

The format of the book is excellent, and some features such as synonymies should be adopted for Canadian fish books. The use of multi-character keys is commendable; drawings, paintings and their printing quality good. The drawings, prepared by 16 artists in seven institutions, are remarkably uniform in appearance. Important morphological characters in the species description are under-dotted. Four species of Chinese fishes were run through keys to correct identifications without any difficulty. Aside from a handful of publications, all references predate 1975. Thus, references such as G. U. Lindberg and Z. V. Krasyukova, 1975, *Fishes of the Sea of Japan*, Zool. Inst. Acad. Naukk SSSR, were omitted. Some classifications are out of date, such as the use of Scopeliformes instead of Myctophiformes (J.S. Nelson's 1975, *Fishes of the world*, is not mentioned). A preliminary report of the deep-sea fishes of the South China Sea by Q. Cheng and M. Tian (1981 Studia Marina Sinica 18: 235-275, 32 text-fig., 1 pl.) recently added 34 new records for China.

Obviously *The Fishes of the Islands in the South China Sea* is an important contribution to science and will assist in managing fisheries and educating students. If translated, this and the previously mentioned faunal works would be of great service to western scientists. Canada, which is just developing the field of aquaculture, could profit from China's centuries of experience.

Readers may be interested to learn that a Chinese Society of Ichthyology was inaugurated 16 October 1979, which bodes well for the continued development of ichthyology in this ichthyologically rich country. A "Transactions of the Chinese Ichthyological Society" will be published by the Society.

DON E. MCALLISTER and C. T. SHIH

Vertebrate and Invertebrate Zoology Divisions, National Museum of Natural Sciences, National Museums of Canada
Ottawa, Ontario K1A 0M8

A Study of the Lateral-line Canals System and that of Lorenzini Ampullae and Tubules of Elasmobranchiate Fishes of China

By Yuanting T. Chu and Ching Wen Meng. 1979. Monograph of Fishes of China, No. 2. Shanghai Kexue Jishu Zhubanshe (Shanghai Science and Technology Press), Shanghai. 132 pp. 64 colour plates.

This book, in Chinese, but with a seven page abstract in English, is devoted to the study of the structure and arrangement of the lateral line system, the ampullae and tubules of Lorenzini, and Savi's sacs, as well as the phylogeny of elasmobranchs. The authors describe these epidermis-derived sensory systems in 73 species of sharks, rays, and skates found in the seas of China. They illustrate all but two in colour plates which show the lateral line of the head and often the body in blue, the ampullae and tubules of Lorenzini in red, and Savi's sacs in green. Many of these have never been depicted before. Based on the arrangement of these structures, and referring to the classification system of Woodward (1889, 1891), Jordan (1923), Whiteley (1937), Bigelow and Schroeder (1948-1952), Berg (1955), Romer (1966), Rass and Lindberg (1971), and Compagna (1973), the authors develop a new classification system for Chinese elasmobranchs and present a key and a phylogenetic tree with a geological time scale. Several taxonomic changes are made in their new system. *Galeorhinus japonicus* (Müller et Henle) is removed from Carcharhinidae and placed in Triakidae and *Triaenodon obescus* (Rüppell) from Triakidae to Carcharhinidae; *Rhinobatos granulatus* (Cuvier) is assigned to the genus *Scobatus* and *Dasyatis kuhlii* (Müller et Henle) to *Urolophoides*. A new family Cirrhoscylliidae is created to house *Cirrhoscyllium expolitum* Smith and Radcliffe, formerly of Orectolobidae.

Clearly this study makes important contributions to the sensory systems and classification of the Elasmobranchii.

It should be noted that this study appeared 16 years after the first of the series was published (Chu, Lo, and Wu, 1963: A study on the classification of sciaenoid fishes of China, with descriptions of new genera and species). Apparently the Chinese scientists have wasted no time in publishing studies that had been interrupted by the cultural revolution. Other works related to systematics known to us include Fauna Sinica, Economic Fauna of China, and monographs such as *The Fishes of the Islands in the South China Sea.*

DON E. MCALLISTER and C. T. SHIH

Vertebrate Zoology Division and Invertebrate Zoology Division, National Museum of Natural Sciences, National Museums of Canada, Ottawa, Ontario, Canada K1A 0M8

BOTANY

Shrubs of Ontario

By James H. Soper and Margaret L. Heimburger. 1982. Royal Ontario Museum, Toronto. xxxi + 495 pp., illus. $20.00.

The new *Shrubs of Ontario* is far more than a revised edition of the familiar *100 Shrubs of Ontario*, by the same authors. Whereas the usefulness of the earlier work was seriously limited by the omission of several major families, this new book provides thorough coverage of Ontario shrubs, ranging from the barely woody *Chimaphila* species to the usually arborescent *Sassafras*, and from Carolinian rarities restricted to the southernmost part of the province to arctic species occurring only along the shores of Hudson Bay. Naturalized species are also included.

This book is intended primarily for the identification of shrubs by persons with limited experience in plant systematics. However, its contents are sufficiently rich and diverse to make it a useful reference for professional plant taxonomists as well.

Families are arranged in the familiar sequence of Engler & Prantl; genera and species within each family are arranged alphabetically. There are dichotomous keys to the genera and species. Evaluation of the keys will require their use by many persons, but they are simply and lucidly written and in general appear to be very good. They are based largely on vegetative characters, and do not require material, such as both flowers and fruit, unlikely to be present on a single specimen. The only fault I have detected is that *Rhamnus cathartica* keys out under "Leaves all opposite" rather than "Leaves mostly opposite but some subopposite."

The species descriptions are detailed, and are accompanied by succinct "field checks." The illustrations, by Leslie A. Garay and Ronald A. With, are excellent. Locality dot maps indicate the distribution of the respective species in Ontario, and comments are numerous, on topics from traditional and modern utilization to variation in chromosome numbers.

Among the literature citations are some as recent as 1980. The nomenclature is consistently up-to-date. The authors have generally been conservative about accepting taxonomic departures from standard floras — poison ivy, for example, appears as *Rhus* rather than as *Toxicodendron* — but differing treatments in recent works are noted. The distributional data are likewise up-to-date, having been based on specimens examined at many Ontario herbaria, including recent accessions.

The treatment of *Salix*, having been prepared under the guidance of George W. Argus, essentially provides a much-needed taxonomic revision of this genus for Ontario. Other acknowledgments attest to the wide range of expertise represented in both the taxonomic treatments and the distributional data. The treatment of *Crataegus*, however, is based largely on the drastic "lumping" of Gleason & Cronquist, with further restriction to selected species, although the recent monograph by Phipps & Muniyamma is cited.

Proofreading has generally been good, but several lines on page 212 evidently were lost in the "stripping" process, with the result that some material on naturalized roses was omitted.

The size of this book, 25 × 17 cm, reflects an excellent balance between legibility of text and clarity of figures, and cost and bulk. By current standards, the price is quite reasonable.

In marked contrast to the several good wildflower guides and the plethora of tree-identification books, there have been no previous guidebooks really satisfactory for the identification of Ontario shrubs. I am pleased indeed that this need has been met by such a superb work as this.

JAMES S. PRINGLE

Royal Botanical Gardens, Hamilton, Ontario L8N 3H8

Die Küstenvegetation Ostkanadas

By Dietert Thannheiser. 1981. Ferdinand Schöningh, Paderborn, Germany. 202 pp., illus. DM 41.50.

This fine study dealing with the coastal vegetation of eastern Canada, is based on a three-year survey along the Gulf of St. Lawrence. Preliminary chapters outline the physical geography of the region (including an abundance of hydrological and meteorological maps) and explain the sampling methodology. The main portion of the book is devoted to a survey of the vegetation of three major coastal communities: salt marsh, sand dune, and strand. The physiography, associations, distribution, and community dynamics of each are covered. Illustrative material includes distribution maps of more than 30 species, detailed vegetation maps for selected localities, and association diagrams. The study is by no means definitive, but it should serve as an excellent basis for subsequent ecological studies of the relevant communities. The author is particularly commended for having his collections verified by a number of established taxonomists. The one real objection to the book is that it is in German, which may render it less accessible to the Canadian botanical community than it deserves to be.

A. E. STAHEVITCH

Biosystematics Research Institute, Agriculture Canada, Central Experimental Farm, Ottawa, Ontario K1A 0C6

Lichens: an illustrated guide

By Frank Dobson. 1981. 2nd edition. Richmond, England (distributed by Mad River Press, Eureka, California). 320 pp., illus. + plates. U.S. $18.70.

In Great Britain, and increasingly in Canada and the United States, there is a large number of serious amateur naturalists interested in mosses and lichens. This group is able and willing to use keys and fairly technical guide books to help them sort through the complexities of dealing with small organisms and their often microscopic characters. Yet, when all is said and done, there is nothing like a good illustration to provide the novice with corroboration of an identification. Dobson's "Illustrated Guide" to British lichens is addressed to those amateurs willing to use a hand lens and microscope, and even try a few simple chemical tests, but who need good photographs for reliably pinning down a name.

The book covers close to 450 frequently encountered lichens and some rarer species (out of approximately 1500 species) found in Great Britain. At least a third of the species covered do not occur in Canada, and less than half are common here; the book will therefore not be entirely reliable on this side of the Atlantic. Most species have been photographed in black and white, and 50 are illustrated in colour. Identifications are made with the aid of keys, first to groups of genera, then to genera, and finally to species.

I believe Dobson's book will serve the diligent British amateur lichenologist fairly well, but not before he or she becomes fairly familiar with many lichen genera. The key to groups and genera I found to be quite complex and unreliable. Actually, genera are not keyed out at all; they are instead listed together with superficially similar genera, with their distinguishing characteristics compared in a kind of table. This method will prove to be frustrating to those not able to eliminate a majority of the potential names through experience.

The author provides short descriptions of each genus and species; in most cases, I found them to be accurate. Each genus description includes drawings of asci and spores which, unfortunately, are not very good. In some cases, (as with almost all ascus drawings, and the spores of such genera as *Mycoblastus, Physcia,* and *Phaeographis*), the drawings are misleading. The line drawings are rather poor as a whole, especially when juxtaposed with the excellent black-and-white photographs, an area in which the author obviously excels. The colour photographs are also good, but are often somewhat "distant" for really useful comparisons. It is a pity that some of the lichens picked for photography were atypical (e.g., *Cladonia coniocraea, Lecanora rupicola,* and *Lobaria pulmonaria*).

The writing is clear and concise, but is marred by a number of grammatical errors apparently missed in the preparation of the second edition. For those owning the first edition (published in 1979), I would advise against buying the newer version. Very few changes have been made except to the index, which is now much more accurate and complete. A list of recent nomenclatural synonyms is also given in the second edition, following the recent checklist of British lichens by D. L. Hawksworth, P. W. James, and B. J. Coppins published in volume 12 of the "Lichenologist" journal.

In summary, I recommend the book to serious amateurs wanting a set of descriptions and good photographs of the common British lichens. Although the coverage of Canadian lichens is necessarily limited, Dobson's volume is one of the few places one can find illustrations of crustose species, and for this reason it will be of some value to Canadian readers.

IRWIN M. BRODO

National Museum of Natural Sciences, National Museums of Canada, Ottawa K1A 0M8

The Illustrated Flora of Illinois: Flowering Plants, Basswoods to Spurges

By Robert H. Mohlenbrock. 1982. Southern Illinois Univ. Press, Carbondale and Edwardsville. 234 pp., illus. U.S. $22.95.

In my earlier review of two books of this series, "Willows to mustards" and "Magnolias to pitcher plants," I presented a list of the nine titles published at that time (1982. Canadian Field-Naturalist 96: 235-6). To this list must now be added this tenth volume. "Basswoods to spurges" continues to follow a modified Thorne system of classification. Four orders are treated, namely, Malvales (families Tiliaceae, Sterculiaceae and Malvaceae), Urticales (Ulmaceae, Moraceae and Urticaceae), Rhamnales (Rhamnaceae and Elaeagnaceae) and Euphorbiales (Thymelaeaceae and Euphorbiaceae).

The cost is not given on the jacket, but I am informed by our library that it remains the same as the last volume. I pray that the escalating book prices are now stabilizing.

This volume follows the pattern established in the preceding volumes. It is dedicated to the author's eldest son, Mark William Mohlenbrock, who did all the illustrations. He has done a superb job. The outlines are sharp and clear, and stipple type shading is used for floral enlargements, fruits, seeds, etc., which accompany the overall illustration with magnifications listed in the caption. For each species synonyms are given and confusion in the application of names is explained and resolved. The maps use an arrangement and construction similar to the other volumes. Forty-two genera containing 103 species and 15 lesser taxa are dealt with in this volume. Some 27 of these species are either adventive from some other part of the United States or are introductions from somewhere else, mostly Europe. Most of these occur in 19 genera, of which nine consist only of weedy species.

The usual map of Illinois counties, and an introduction containing an explanation of the modified Thorne classification, follows the foreword. Because it differs from the customary Engler and Prantl system, the complete classification is given with Mohlenbrock's modifications indicated. The work is based on field studies, plus examinations of herbarium material from 11 listed herbaria and some unlisted private collections. Maps were prepared by the author's daughter, Ann, and the clerical work performed by his wife, Beverly, so the series is becoming a family affair.

Following the species descriptions, there is a list of "Species Excluded," mostly misidentifications, and then a numerical summary of taxa treated, a glossary, literature cited, and finally an index.

The key to the species of *Celtis* in Illinois deserves some attention. There are three species in Illinois, *C. occidentalis, C. laevigata,* and *C. tenuifolia*. Because the key employs leaf features, *C. occidentalis* comes out three times in the first four choices. *C. laevigata* and *C. tenuifolia* come out twice each. There are seven couplets. Visually it looks very odd indeed. Then, there are additional keys to separate the three varieties of both *C. occidentalis* and *C. laevigata*, and to separate the two varieties of *C. tenuifolia*. If these species seemingly intergrade as the author contends, then perhaps it would have been better to employ a comparative table, as done with Red and White Mulberry on page 88 and the hops on page 99. Incidentally, the same three species come out very easily in the key by Gleason & Cronquist (*Manual of vascular plants of northeastern United States and adjacent Canada.* Van Nostrand, 1963.) which uses leaf characters only.

Beyond my adverse reaction to the *Celtis* key, I have nothing but praise for this volume. Undoubtedly, the author's early decision to illustrate every species was an excellent one. Good illustrations of every species ensure the success of a flora; no matter how well a text is written, a picture is worth a thousand words.

JOHN M. GILLETT

Vascular Plant Section, National Museum of Natural Sciences, Ottawa, Ontario K1A 0M8

The Cacti of the United States and Canada

By L. Benson. 1982. Stanford University Press, Stanford, California. 1044 pp., illus., plus distribution maps. U.S. $85.00.

Although only four of some 152 cacti species which occur north of the Mexican border are found as native species in Canada, this book is of great interest.

The Cactus family has attracted much attention because of its many remarkable growth forms. Some species are treelike in aspect; numerous others are small and can readily be grown indoors in our northern regions. In more southern climates, fascinating displays can be found on rocky slopes in gardens, to say nothing of native habitats, where such species as the Organ Pipe Cactus, Barrel Cactus, Saguaros and Teddy Bear Chollas occur.

This book, written by the foremost student of North American cacti, is more than just keys and descriptions of cacti. It contains a wealth of information in its two parts. The first (about one-quarter of the book) includes chapters on the structure, physiology and chemical characters of cacti; a discussion of the origin and relationships of taxa within the family Cactaceae; a discussion of the nature of species, varieties, and hybrids; the author's policy in developing his classification of the North American cacti; herbarium and field methodologies, including techniques of specimen gathering and notes required; geographic distributions and environments in which cacti are found, including the relationship of floras and vegetation to world climate; the floras and floristic associations of North America; the uses of cacti; and the conservation of cacti. All are well illustrated.

The second part is a detailed treatment of the 18 genera of cacti found in North America, with keys, detailed descriptions of the genera and species, ecology, distribution, special comments, line drawings, photographs, and distribution maps. The maps present some difficulty to one not too familiar with the geography of the United States because there are no place names and they depict only state and county borders. This is softened somewhat by the inclusion of a series of general reference maps near the end of the book which name all the counties in the various states where the family has its main range. A section on documentation gives bibliographic references, synonomy, and citation of types and selected specimens.

Reference matter in the form of a glossary, references cited, the general reference maps, an index, and two fascicles of absolutely beautiful colour photographs complete the work.

This is a magnificent book which should be on the shelf of anyone interested in cacti. In addition, the introductory chapters will serve any introductory course in botany as a most useful text.

WILLIAM J. CODY

Biosystematics Research Institute, Agriculture Canada, Central Experimental Farm, Ottawa, Ontario K1A 0C6

ENVIRONMENT

The Nature of the Stratigraphical Record

By Derek V. Ager. 1981. Second edition. Halsted (Wiley), Somerset, New Jersey. 122 pp., illus. U.S. $17.95.

Stratigraphy, the branch of geology that treats the formation, composition, sequence and correlation of stratified rocks, forms the basis of our understanding of the earth's history. Ager believes that most stratigraphers have been immersed in the intricasies of the rock strata, and really have missed the geology for looking. He takes a more general overview by citing examples world-wide and drawing intercontinental comparisons of various geological formations. In doing so, he challenges the accuracy of some fundamental concepts that have shaped the science of stratigraphy from its beginnings.

The book is divided into seven short chapters, each of which focuses on one stratigraphical principle, and ends with Ager's rewritten principle. For example, every student of geology is familiar with the law of uniformitarianism (introduced in the mid 1700's) which dictates that "the present is the key to the past". In light of the vast number of biotic extinctions evident in the fossil record, uniformitarianism is not always applicable, which prompts Ager to write; "Paleontologists cannot live by uniformitarianism alone". In another chapter, Ager defines the "Principle of the Golden Spike" as a replacement for the International Code of Stratigraphic Nomenclature. Currently, geologists identify type sections, comparable to biological type specimens, for comparison and correlation of stratigraphic units of similar age from other regions. However, Ager points out that contemporaneous strata can differ due to local depositional or biotic factors, in turn superficially suggesting noncontemporaneity. Alternatively, he prefers to identify and correlate on the basis of marker boundaries (golden spikes) *between* rock units.

His thoughts are summarized in the eighth and final chapter. The overriding message, which prompted Ager to write the book, is simply to draw attention to the inadequacy of traditional, and perhaps outdated, stratigraphic concepts. He goes almost so far as to imply that concepts have shaped current geological thought, rather than geology shaping the concepts. On the scale Ager has chosen to view the stratigraphic record on, his point is well-taken. However I do not believe that geologists are nearly as blind as Ager may contend, since recent stratigraphy books do caution against short-comings of the concepts. Nonetheless, Ager's goal has been achieved, as evidenced by reactions to his first edition which "ranged from near ecstasy to something approaching scorn".

The book is written in an intelligible, sound, and, as intended, relaxing style, though at times it is too digressive. His examples and arguments provide provocative, stimulating, and interesting reading. Every geologist and hobbiest rock hound should have a copy on their bedside table. Unfortunately, I cannot recommend this book to non-specialists unfamiliar with the technical jargon, the geological timescale, and the very stratigraphical principles Ager chooses to rewrite.

Lastly, I must comment on the price. I find it excessive at $17.95 U.S. for a soft cover, mediocre paper stock, 122 pages, and 18 black and white plates. One's book budget does not go far at these inflated prices.

BARRY G. WARNER

Department of Biological Sciences, Simon Fraser University, Burnaby, British Columbia V5A 1S6

A Bibliography of the Natural History of Middlesex County, Ontario, to the Year 1980 with an Historical Introduction

By William W. Judd. 1981. Phelps Publishing Company, 87 Bruce Street, London, Ontario. 157 pp. $12.00.

This is a superb regional bibliography that covers the full breadth of natural history in Middlesex County. The compiler, W. W. Judd, is also the author most often cited — 20 of the 157 pages list his publications. I have only two criticisms. There are 17 pages of items by "Anonymous". Surely a little more digging in the archives of the organizations involved might have ascertained authorship of more of these items. Unfortunately, Judd fails to make clear to the casual reader that William E. Saunders was the son of William Saunders. Judd has researched a wide range of literature including some little-known and defunct journals in order to produce this useful and attractively printed list.

C. STUART HOUSTON

863 University Drive, Saskatoon, Saskatchewan S7N 0J8

NEW TITLES

Zoology

†**A. B. A. checklist: birds of continental United States and Canada.** 1982. By G. S. Keith, L. G. Batch, D. D. Gibson, R. G. McCaskie, C. S. Robbins, A. Small, P. W. Sykes, and J. A. Tucker. 2nd edition. American Birding Association, Austin, Texas. 80 pp. U.S. $9 plus U.S. $2.25 shipping.

Advances in marine biology, volumes 19 and 20. 1982. Edited by J. H. S. Blaxter, F. Russell, and M. Yonge. Academic Press, New York. 394 pp., and 448 pp. U.S. $16.50 and U.S. $65.

Animal — sediment relationships. 1982. Edited by P. L. McCall and M. J. S. Trevesz. Plenum, New York. c260 pp. U.S. $42.50.

Avian biology, volume 6. 1982. Edited By Donald S. Farner, James R. King, and Kenneth C. Parkes. Academic Press, New York. 512 pp. U.S. $65.

†**A bibliography of the sticklebacks (Gasterosteidae: Ostreichthyes).** 1982. By Brian W. Coad. Syllogeus No. 35. National Museum of Natural Sciences, Ottawa. 142 pp. Free.

The biology of Crustacea, Volumes 1 to 4. 1982. Editor-in-chief Dorothy E. Bliss. Volume 1: systematics, the fossil record, and biogeography. Edited by Lawrence G. Abele; volume 2: embryology, morphology, and genetics. Edited by Lawrence G. Abele; volume 3: neurobiology structure and function. Edited by Harold L. Atwood and David C. Sandeman; volume 4: neural integration and behaviour. Edited by David C. Sandeman and Harold L. Atwood. Academic Press, New York. 336 pp., 432 pp., 512 pp., and 352 pp. U.S. $38.50, U.S. $42.50, U.S. $49.50, and U.S. $36.

Biology of lampreys, volume 3. 1982. Edited by M. W. Hardisty and I. C. Potter. Academic Press, New York, 484 pp. U.S. $81.

Biology of the Reptilia, volume 12: physiological ecology. 1982. Edited by Carl Gans and F. Harvey Pough. Academic Press, New York. 570 pp. U.S. $79.50.

Bird migration in Africa: movements between six continents, volumes 1 and 2. 1981. By Kai Curry-Lindahl. Academic Press, New York. 444 pp., and 251 pp. U.S. $85 and U.S. $42.50.

†**The birds of Africa, volume 1.** 1982. By Leslie H. Brown, Emil K. Urban, and Kenneth Newman. Academic Press, New York. 536 pp., illus. U.S. $99.

*__A bird-finding guide to Ontario.__ 1982. By Clive E. Goodwin. University of Toronto Press, Toronto. 248 pp. Paper $12.50.

British Anthozoa: keys and notes for the identification of the species. 1981. By R. L. Manuel. Academic Press, New York. 250 pp. U.S. $18.

Canadian Atlantic offshore fishery atlas. 1982. Edited by D. J. Scarratt. Revised edition. Canadian Special Publication of Fisheries and Aquatic Sciences, 47. Supply and Services Canada, Hull. 101 pp. $8 in Canada; $9 elsewhere. Also available in French.

*__A celebration of birds: the life and art of Louis Agassiz Fuertes.__ 1982. By Robert McCracken Peck. Walker, New York. 178 pp., illus. U.S. $30.

The Columbia River salmon and steelhead trout: their fight for survival. 1981. By A. Netboy. University of Washington Press, Seattle. 180 pp. U.S. $13.95.

East African mammals: an atlas to evolution in Africa. 1982. By Jonathan Kingdon. Volume 3C: bovids, horned ungulates; volume 3D: bovids, horned ungulates (continued). Academic Press, New York. 404 pp. and 358 pp. U.S. $92.50 each.

Ecology of bats. 1982. Edited by Thomas H. Kunz. Plenum, New York. c410 pp. U.S. $49.50.

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Cover: White Malaxis, *Malaxis monophyllos* var. *diphyllos*, a new orchid for Canada, photographed by William J. Beese, see pp. 215–216.

The Canadian Field-Naturalist

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Movements of Collared Caribou, *Rangifer tarandus*, in Relation to Petroleum Development on the Arctic Slope of Alaska

KENNETH R. WHITTEN and RAYMOND D. CAMERON

Alaska Department of Fish and Game, 1300 College Road, Fairbanks, Alaska 99701

Whitten, Kenneth R., and Raymond D. Cameron. 1983. Movements of collared Caribou, *Rangifer tarandus*, in relation to petroleum development on the Arctic Slope of Alaska. Canadian Field-Naturalist 97(2): 143–146.

Between April 1975 and May 1978, 160 Caribou (*Rangifer tarandus granti*) on the Central Arctic Slope of Alaska were marked with either visual numbered collars or radio collars. Through 1979, 92% of the Caribou with radio collars were relocated repeatedly within this region. Only 59% of the Caribou with visual collars were relocated, but comparable data on radio-collared Caribou suggest that most of the unobserved number-collared individuals remained in the study area. Resighting patterns corroborate the existence of a distinct Central Arctic Caribou Herd. A significantly higher proportion of collared bulls than of collared cows was observed from the road system associated with the Trans-Alaska Pipeline and Prudhoe Bay Industrial Area. Bulls were also resighted more frequently from the road system, and they crossed through the road corridor more often; in contrast, bull and cow resighting patterns in off-road areas were not significantly different. Thus, the cow/calf segment of the herd appeared to avoid disturbed areas more so than did bulls. The heavily developed Prudhoe Oilfield was an effective barrier to both bulls and cows.

Key Words: Caribou, *Rangifer tarandus*, collared, movements, petroleum, development, disturbance.

Construction of the Trans-Alaska Pipeline (TAP) and development of oil reserves near Prudhoe Bay focused considerable attention on the possible disruption of Caribou movements and range use patterns. Results of systematic aerial surveys conducted since 1975 have shown that this region of the Arctic Slope is inhabited by a distinct Caribou subpopulation, the Central Arctic Herd (CAH) (Cameron and Whitten 1979, 1980). Seasonal movements of the CAH are principally north-south between winter range in the northern foothills of the Brooks Range and summer/calving range on the coastal plain along the Arctic Ocean. In addition, east-west movements along the Arctic coast occur during midsummer. Surveys conducted along the Dalton Highway (previously known as the TAP haul road) through 1980 indicate that abnormally few cow-calf pairs occupy habitats within or near the Pipeline Corridor and Prudhoe Bay Industrial Area (PBA), particularly during summer (Cameron et al. 1979; Cameron and Whitten 1980, unpublished).

In 1975 a complementary collaring program was undertaken to examine, in greater detail, the population characteristics of Caribou in the Central Arctic region and to assess any disturbance-related deviations in seasonal distribution and movements. This report deals with pertinent data gathered from collared Caribou between 1975 and 1979.

Study Area and Methods

The study area is on the Central Arctic Slope between the Canning and Itkillik rivers. The TAP Corridor is oriented north-south, roughly bisecting the study area, and the PBA lies near the Arctic coast at the origin of the TAP. Physiography and floristics of this region have been described by Spetzman (1959) and by Whitten and Cameron (1980).

Between April 1975 and May 1978, 160 Caribou were equipped with either visual or radio-transmitter collars (Table 1). Caribou were located opportunistically, generally within 20 km of the Corridor, and darted from a helicopter with Cap-Chur equipment. Anectine (Succinyl-choline choloride) was used to immobilize Caribou in 1975, and a combination of M99 (Etorphine hydrochloride) and Rompun (Diazinone) was used from 1976 through 1978; in the latter case the antagonist M50-50 (Diprenorphine hydrochloride) was administered to effect recovery. Visual collars consisted of red or blue background material with conspicuous yellow numbers on the top and sides. Radio-transmitter collars (Oceans Applied Research, San Diego, CA) used in 1975 were not

TABLE 1. Schedule of collar placement on CAH Caribou.

Date	Radio Collars	Visual Collars
April 1975	5F	10F, 10M
October 1975	4F	4F, 3M
April 1976	7F	44F, 3M
April-May 1977	12F	20F, 13M
May 1978	8F	13F, 4M
Totals	36F	91F, 33M

F = female, M = males

numbered, but some were color coded. All other radio collars (AVM Instrument Co., Champaign, IL) were attached to standard visual collars.

Caribou with visual collars were sighted incidental to routine ground surveys along the Dalton Highway (Cameron et al. 1979) and aerial surveys of the entire study area (Cameron and Whitten 1979), as well as during unscheduled trips and flights; no special effort was made to relocate any individual. Radio-collared Caribou were located on an opportunistic basis during most survey flights and were also specifically tracked from fixed-wing aircraft in November and February/March, and at approximately 10-day intervals between April and October each year. Crossings of the TAP Corridor were occasionally witnessed but were more often inferred from consecutive resightings.

Because sampling effort was presumed to be the same for all visual-collared individuals, any observed differences in resighting patterns between visual-collared bulls and cows and/or between road and off-road areas should reflect corresponding differences in distribution. Chi-square contingency analysis was used to test differences in the proportions of bulls and cows resighted. Mean rates of resighting and Corridor crossings were compared through Student's t-test, with the activities of individual Caribou serving as the sample unit. Significance was evaluated at the 95% confidence level.

Results and Discussion

Herd Identity

Transmitters used in 1975 functioned less than eight months, but all Caribou radio-collared that year were subsequently accounted for by known mortality, recollaring, or visual sightings. All but three radio transmitters used after 1975 were still operating in 1979. Of the 36 Caribou equipped with radio transmitters, one emigrated from the study area, two were not relocated, and 11 were never seen without the aid of radio-tracking equipment. Thus, only 22 (61%) of the radio-collared Caribou would have been resighted had they worn only visual collars, even though at least 33 (92%) were present in the study area.

Seventy-three of the 124 Caribou with visual collars (59%), including 22 of 33 males and 51 of 91 females, were observed at least once within the study area. These figures are similar to the proportion of radio-collared Caribou that would have been resighted without the aid of radio-tracking equipment. At least six different visual-collared female Caribou were later observed in either the Porcupine or Western Arctic Caribou Herds. Based on the radio collar findings, however, it is likely that most of the unobserved visual-collared Caribou remained in the Central Arctic area.

High rates of resighting of both radio- and visual-collared Caribou within the study area provide evidence for the discreteness of the CAH. At least 59%, and probably more than 90%, of the Caribou marked in the Central Arctic area remained within that area over a 4-5 year period. Demographic data, including population size, recruitment, mortality, and seasonal movements also indicate that the Central Arctic Herd behaves as a discrete unit (Cameron and Whitten 1979; Whitten and Cameron 1983). The few cases of known emigration of CAH Caribou support the contention that, while Alaskan Caribou occur in separate herds, interchange is sufficiently frequent that all Caribou in the state constitute a single breeding population (Skoog 1968). To our knowledge, this is the first fully documented report of inter-herd movements in Alaska.

Caribou Occupancy of the Tap Corridor and PBA

Based on the tendency for female Caribou and their calves to avoid the PBA and TAP Corridor (Cameron et al. 1979, Cameron and Whitten 1980), one might expect differences in the resighting patterns for collared cows and bulls observed from the TAP haul road. In fact, the proportions of visual-collared bulls and cows resighted at least once during surveys conducted from the road were significantly different (61% of the males and 35% of the females), while the proportions resighted during aerial surveys away from the road (39% of the males and 51% of the females) did not differ significantly.

The mean number of resightings per visual-collared bull (3.6) and cow (2.0) did not differ significantly. However, this comparison may be misleading, since cows apparently retained collars longer than did bulls. Most resightings of collared bulls occurred within the first calendar year, but cows were frequently seen two or three years after collaring (Table 2). Collars were attached loosely to bulls to accommodate neck swelling during rut and, consequently, may have slipped off during winter months when most adult bulls would have been antlerless. Overwinter loss of radio collars by bulls has been observed in other Alaskan Caribou

TABLE 2. Relationship of last resighting to date of collaring for visual-collared Caribou.

Cohort	Year Collared	Last resighting (years past collaring date)				
		<1	1	2	3	4
Males	1975	2	4	3	0	0
	1976	1	0	0	0	
	1977	9	1	0		
	1978	2	0			
		64%[1]	23%	14%	0%	0%
Females	1975	2	1	1	3	1
	1976	5	6	7	5	
	1977	8	4	3		
	1978	4	2			
		37%	25%	21%	15%	2%

[1] Percentage of last resightings occurring in year group.

(J. Davis and P. Valkenburg, personal communication). In contrast, collars on cows were tightly secured and were less likely to be lost during the antlerless period each summer.

Considering only Caribou that were resighted, and assuming collar retention only until last date seen, the resighting rates per unit time were significantly higher for bulls than for cows (X = 11.9 resightings/year per individual bull vs. X = 4.1 resightings/year per individual cow). When these adjusted resighting rates were subdivided into observations adjacent to and away from the road, the rate for bulls along the road was significantly higher than that for cows (X = 9.6 resightings/year vs. X = 2.4 resightings/year), while the rates away from the road did not differ significantly (X = 5.3 resightings/year vs. X = 3.0 resightings/year). Clearly, a higher proportion of the collared bulls was resighted from the road system, and those resighted along the road were seen more often than were the collared cows. Away from the road system there were no significant differences in bull and cow resighting patterns. These data are consistent with previous reports of cow/calf avoidance of the Corridor (Cameron et al. 1979; Cameron and Whitten 1980).

Crossings of the TAP Corridor

Crossings of the TAP Corridor also reflect differential use of the area by bulls and cows. A significantly higher proportion of visual-collared bulls than cows crossed the corridor (68% of all bulls resighted vs. 41% of all cows resighted). Among the visual-collared Caribou resighted, bulls also crossed more frequently (X = 6.3 crossings/year) than did cows (X = 2.1 crossings/year). However, recognizable bull groups were often observed on successive trips along the haul road, while individual cow groups were rarely seen more than once. Repeated crossings by collared bulls in such "resident" groups inflate the mean crossing rate for bulls and may not be an accurate reflection of annual crossing activity (i.e., seasonal migrations across the Corridor). Nevertheless, these data indicate greater use of the area by bulls. Unfortunately, baseline data are insufficient to determine if recent crossing patterns differ from those before road and pipeline placement. A comparison of seasonal movements by radio-collared cows and bulls, disregarding observations from the road, is required to determine if bulls actually do cross the Corridor more readily than cows.

Caribou Movements in Relation to the PBA

Midsummer movements of large post-calving aggregations of CAH Caribou have frequently included a gradual eastward drift along the Arctic coast during July, followed by a rapid westward movement and inland dispersal in early August (Roseneau et al. 1974; Roseneau and Stern 1974; Cameron and Whitten, unpublished observations). In the early 1970's such movements extended through the PBA (R. White, personal communication). Since 1975, however, no collared Caribou have been observed to move through the PBA during midsummer. On several occasions, large post-calving groups including both radio- and visual-collared Caribou have approached the oilfield complex from both the east and west but have fragmented and dispersed; only individuals or small groups (mostly adult males) actually entered the field.

Conclusions

Resightings of collared Caribou support the existence of a distinct Central Arctic Herd. The data also substantiate previous evidence that female Caribou avoid areas of petroleum-related activity within their range; bulls appear to be far less sensitive. Although reduced occupancy of the TAP Corridor by cows and calves suggests a concomitant decrease in crossing success, further study is required to determine if the Pipeline and/or haul road constitute a serious impediment to seasonal movements of Caribou. Nonetheless, the Prudhoe Bay Oilfield does appear to disrupt midsummer movements of CAH Caribou.

Acknowledgments

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An Estimate of the Black Scoter, *Melanitta nigra*, Population Moulting in James and Hudson Bays

R. Kenyon Ross

Canadian Wildlife Service, 1725 Woodward Drive, Ottawa, Ontario K1A 0E7

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On 26 and 27 July 1977, an aerial survey was made of the flocks of moulting Black Scoter (*Melanitta nigra*) off the northern shore of Ontario. On that flight, 88 700 moulting male Black Scoters were counted by means of aerial photography; such a total could represent up to 320 300 birds in eastern North America in the early fall. Only 7% of that number have been located during wintering ground surveys in the eastern United States. On regaining their powers of flight, most of the Black Scoter apparently moved from the Ontario shore to southeastern James Bay where they staged during August and September prior to the fall migration.

Key Words: Black Scoter, *Melanitta nigra*, James Bay, Hudson Bay, moulting, staging, migration.

Each summer moulting Black Scoters (*Melanitta nigra*) gather in large numbers at several locations off the James and Hudson Bay shoreline (Manning 1952; Manning and Macpherson 1952; Todd 1963; Bellrose 1978). A high proportion of those birds is found off the Ontario coast where their presence has long been known (Manning 1952), but no complete survey has previously been attempted. In late July 1977, the Canadian Wildlife Service undertook a photographic inventory of Black Scoter flocks along the Ontario shore to document flock size and distribution of this poorly-understood species. A population estimate has been generated from these results and this is compared to the relatively low counts made during surveys of the wintering areas along the eastern seaboard of the United States (Bellrose 1978).

Methods

The survey took place between 11:00 and 16:00 EST on 26 and 27 July 1977 from a DeHavilland Otter aircraft flying at approximately 160 km per hour at sufficient height (150 m asl.) to avoid causing diving by the ducks; clouds were scattered and visibility was very good. As the flocks were easily visible on the water, a total census was attempted by flying a ziz-zag course along the coast. The outer limit of flock distribution was determined by ranging up to 15 km offshore; no flock was detected more than approximately 10 km from the coast.

Each flock was photographed from an almost vertical angle using a hand-held camera (Hasselblad 500 EL, 250 mm lens, Ektachrome 200 Professional film ASA 400). An assistant estimated the size of the few small flocks that could not be accommodated along the flight line. The resulting transparencies were projected on gridded paper using a photographic enlarger and all distinguishable birds were marked and counted.

The timing of the survey was determined through ground observations of the Black Scoter flock at Longridge Point during July and August 1976. Numbers were seen to peak in late July and feeding activity tended to subside in midday thus reducing the probability of not counting individuals because they were submerged. Some birds were undoubtedly under water during the survey but the numbers missed were likely very small ($<5\%$); survey counts should be considered minima.

Results and Discussion

The survey revealed 88 700 male Black Scoters in three locations along the Ontario coastline (Table 1, Figure 1). The birds around Longridge Point and Shell Brook were grouped in a few larger flocks (Table 1), mostly within 2 km of shore. Those along the north James Bay shore (192 km of coast) formed much smaller groups which were widely scattered as far as 10 km offshore.

The presence of many moulting Black Scoters along the northern Ontario shoreline has long been known. H. G. Lumsden (*in* Bellrose 1978) estimated that 30 000 were present along the James Bay coast. Such results are similar to those reported here and imply that these are representative rather than chance concentrations. Other flocks have been reported along the shore of Manitoba (Bellrose 1978) and Québec (Manning and Macpherson 1952; Todd 1963; S. G. Curtis, CWS, personal communication). The most systematic records are summarized in Table 1 and Figure 1. S. G. Curtis' observations were made incidental to a survey of eel grass (*Zostera marina*) beds and so represent minimum estimates.

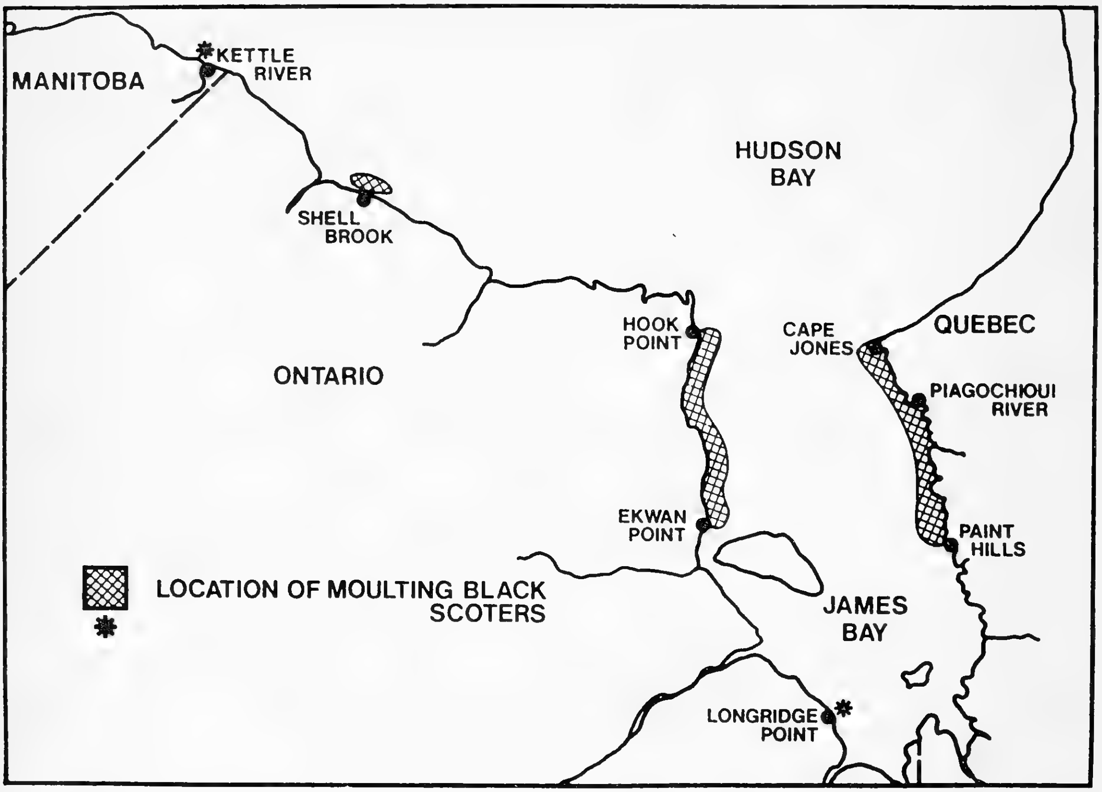

FIGURE 1. Known distribution of moulting Black Scoters in James and Hudson Bay.

TABLE 1. Numbers of moulting Black Scoters along the shoreline of James and Hudson Bay (to the nearest hundred birds).

Location	Co-ordinates		Total Numbers	No. of Flocks	Mean Flock Size	Survey Date	Source
	N	W					
Longridge Point	51°50′	80°42′	2 400	2	1 200	26 July 1977	This paper
Ekwan Point- Hook Point	53°16′ 54°53′	82°05′ 82°10	42 600	110	387	26 July 1977	This paper
Mouth of Shell Brook	55°55′	85°58′	43 700	12	3 642	27 July 1977	This paper
Mouth of Kettle River	56°99′	89°22′	2-3 000	N/A	N/A	4 August 1961	Arthur and Vaught, *in* Bellrose 1978.
Paint Hills to	53°00′	78°48′					
Mouth of Piagochioui River to	54°02′	79°02′	2 800	N/A	N/A	25 July — 6 August 1974	S. G. Curtis CWS (personal communication)
Cape Jones	54°38′	79°45′	16 700	N/A	N/A	25 July — 6 August 1974	" "

N/A — not available

The size of the population of Black Scoters represented by those post-breeding moulters may be estimated given the following assumptions on population dynamics and distribution:

(a) a stable population;
(b) 5 to 50% more moulters present along the Québec and Manitoba coasts (Table 1);
(c) an overall sex ratio of 1.67 males per female (Bellrose 1978);
(d) a fledging success range of 0.75 to 1.00 young per pair (cf. Hildén 1964; Bellrose 1978; Brown and Brown 1981)
(e) an overwintering mortality range for subadults of 65 to 70% (cf. Bellrose 1978);

Using all possible combinations of the limits of the population parameters, eight different estimates of population size can be generated; these yield a mean value of 259 300 birds (range, 203 300–320 300) in the early fall.

The seasonal distributions and movements of those Black Scoters are poorly understood. The breeding range was initially considered to be centred in Alaska (Kortright 1942); however, the breeding population of Black Scoters in Alaska has been estimated at 235 000, most of which apparently winter along the Aleutian Islands where approximately 250 000 adults and immatures have been noted (Bellrose 1978). Thus, it would appear that a different sub-population nests in the hinterland surrounding James Bay and Hudson Bay. Godfrey (1966) listed very few Canadian breeding records including several in southern Keewatin, Ungava, and Newfoundland. P. Lamothe, Québec Hydro (personal communication) observed breeding pairs in the Great Whale and Little Whale River basins in northern Québec in 1976. No confirmed breeding records have come from the Ontario Hudson Bay Lowlands, although H. Lumsden, OMNR (personal communication) has occasionally seen possible Black Scoter broods there, and on 21 and 22 May 1982 I observed four pairs on muskeg ponds north of Missisa Lake (52°40′N, 85°15′W).

Also unknown is the distribution of the subadult cohort. In Alaska (Palmer 1976) and Denmark (Joensen 1973), the subadults commence moulting during June in locations later used by moulting breeders. Subadults, however, do not moult in James and Hudson Bay, probably because ice conditions are too severe in May. Instead, they apparently remain along the coastlines of the Atlantic provinces and Québec (Palmer 1976). The estimated small number of subadults (mean 19 300, range 12 500–27 900) could well be dispersed along such an extensive shore.

After the Black Scoters on James and Hudson Bay complete their moult, the birds presumably move to wintering areas along the eastern seaboard of the United States. The chronology of the moulting flock at Longridge Point suggests, however, that this movement is not a direct one. In both 1976 and 1977, numbers declined during August (2500 — 1 August 1976, 800 — 28 August 1976, visual estimated; 2400 — 26 July 1977, 940 — 29 August 1977, photographic counts). The hiatus between their leaving the moulting grounds in August and arriving in more southern regions in late September and October (Quilliam 1973; Palmer 1976) suggests the existence of an intermediate staging area. The southeastern James Bay shoreline, especially around various of the outer islands, has consistently held high numbers of all scoter species, with counts apparently peaking during September. A scoter flock estimated at 100 000 birds, including many Black Scoters, was noted around the Cape Hope Islands (52°25′N, 78°45′W) on 12 September 1971 by G. Arsenault and D. I. Gillespie (A. Bourget, CWS, personal communication) and large flocks were observed by S. G. Curtis (personal communication) as far south as Charleton and Strutton Islands (52°5′N, 79°10′W) on 10 October 1972. Such large concentrations would accommodate not only birds from Longridge Point but also the much larger moulting flocks further north. S. G. Curtis (personal communication) had records of only approximately 4 000 scoters present around the islands of southeastern James Bay between mid-July and mid-August.

Black Scoters again seem to disappear on reaching their wintering grounds. Mid-winter inventories along the Atlantic seaboard of the United States have accounted for an average of only 22 000 Black Scoters (Bellrose 1978), i.e. as little as 7% of the wintering population estimated here. Some birds may winter in Hudson Bay as do the local Common Eider race (*Somateria mollissima sedentaria*), and a few may remain on the Great Lakes, but it is unlikely that those areas account for many birds. Instead, as suggested by the Atlantic Flyway Council (1964), it is more likely that numbers along the eastern seaboard have been greatly under-estimated because the mid-winter surveys were not designed specifically for scoters and other ducks which raft far offshore. The location of the missing birds is problematic, although the large concentrations along coastal Georgia and South Carolina (Stott and Olson 1972) suggest a likely area. Significant numbers might also be found along the Gulf Coast of Texas where the Black Scoter has recently become more common (Palmer 1976). More study is needed to solve this problem.

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Spatial Trends in Canadian Snowshoe Hare, *Lepus americanus*, Population Cycles

CHARLES H. SMITH

Department of Geography, University of Illinois, Urbana, Illinois 61801

Smith, Charles H. 1983. Spatial trends in Canadian Snowshow Hare, *Lepus americanus*, population cycles. Canadian Field-Naturalist 97(2): 151–160.

Population levels of the Snowshoe Hare (*Lepus americanus*) are well known to exhibit cyclic fluctuations. Little attention has been given to detailed analysis of the spatial trends associated with these, however, and in this work an argument and empirical foundation is laid for such studies. Data first reported as "The Canadian Snowshoe Rabbit Enquiry" in the 1930's and 1940's are reformulated and statistically summarized and mapped. Immediate results indicate: 1) the diffusion of the population level change "wave" across Canada is affected by topographic and ecological factors; and 2) a multi-nodal diffusion model is more appropriate than a single-nodal model in understanding the dynamics of the ten-year cycle system.

Key Words: population cycles, Snowshoe Hare, *Lepus americanus*, ten-year cycle, spatial analysis, time series analysis.

It has been well known since the late nineteenth century that a number of species of Canadian wildlife undergo regular nine- to ten-year period fluctuations in their population levels. What has not been so well appreciated, however, is the extent to which these fluctuations exhibit spatial regularities in addition to their temporal ones. In this work, data first published as "The Canadian Snowshoe Rabbit Enquiry" in a series of reports in the 1930's and 1940's (Elton 1933, 1934; Elton and Swynnerton 1935, 1936; Chitty and Elton 1937, 1938, 1939, 1940; Chitty and Chitty 1942; Chitty and Nicholson 1943; Chitty 1943, 1946, 1948, 1950) have been consolidated to a closer look at this aspect of the ten-year cycle condition.

Before 1950, all ten-year cycle studies involved localized field work or descriptive analyses of primary and secondary data. A review of the extensive literature surrounding the first approach is given by MacLulich (1937) and Keith (1963). Those following the second route concentrated on collecting information that could be used to demonstrate firmly that the population cycles in fact existed. One preferred mode of inquiry was the questionnaire study; this allowed compilation of qualitative information on population level trends over time that could be compared within a locational framework. Examples from this period include MacLulich's (1937) survey of Ontario snowshoe hare population trends, Chitty and Chitty's (1941) analysis of several arctic species, Elton and Nicholson's (1942a) study of muskrats, and the aforementioned Canadian Snowshoe Rabbit Enquiry. Other investigations featured retrieval and interpretation of secondary sources of data — mostly fur trade statistics (Cross 1940; Elton and Nicholson 1942b; Butler 1951) — or attempts to promote causal hypotheses based on correlative relationships (Huntington 1945; Rowan 1950).

Statistical analysis of the fur trade and other data began in the 1950's after Palmgren (1949) and Cole (1951, 1954) expressed concern that more effort should be applied to distinguishing between statistically significant cycles and random series. Moran (1952, 1953, 1954) led the way with examinations of game-bird data and Canada Lynx fur records. Butler (1953) criticized the remarks of Cole and presented evidence of both temporal and spatial population trends in a number of species.

It was some twenty years before further statistical measures were applied. Bulmer (1974) published an extensive analysis of several sources of serial data for a number of organisms. In addition to demonstrating the existence of cycles in many of these series, he also arranged his results in such a form as to indicate relative lag periods among the cycles of the creatures involved. This information was later used to present a model of cycle causation centering on the Snowshoe Hare (Bulmer 1975). Bulmer's findings were followed up by Smith and Davis (1981), who applied univariate and bivariate spectral time series analysis to examine nineteenth and twentieth century fur data for the Canada Lynx. The results confirmed and extended Bulmer's findings, and suggested an apparent long term shift in the location of the general nodal region representing highest negative phase lag of population cycling. For further information on the quantitative/statistical measurement of population cycles and a review of the various causal theories that have been entertained to explain them, consult Finerty (1980).

It is now established that; 1) population level cycles of near ten years' period exist in a number of Canadian wildlife populations, 2) there are phase lags in the cycles of these populations relative to one another, and 3) there are phase lags within species' cycles associated with varying geographic location within the range of the organism, i.e., the cycles also exhibit the spatial characteristics of a recurring diffusion process. Regarding the last point, no one has moved beyond the identification of this fact to determine whether the patterns of population level change over space can be used themselves to expose the cause of the phenomenon (though Fox, 1978, has presented an argument based on data aggregated at the provincial level that incidence of fire and population level change are correlated).

It seems crucial at this stage in the investigation of ten-year cycles that increasing attention be placed on the system-wide spatial-temporal characteristics of the phenomenon. It is not enough, though increasingly the fashion (note the reviews in Finerty 1980), to generate and test organismal, population, or even community level models of cycle relationships and consider the matter solved, because such treatments are unextendable to the discussion of continental-level patterns. This is a critical issue, because the most diagnostic structural aspect of the ten-year (and four-year) cycle condition is its (their) consistent and continuous expression across vast spatial reaches. The field and modelling approaches used to study population irruptions (and even cyclic irruptions) are unable to penetrate this problem, whose organizational basis appears to be at some higher plane of departure. More than likely, the condition has devolved gradually over time in response to some accidental interplay of biogeographical, and perhaps climatological/geophysical, forces of continental scale.

The preceding comments hold whether one believes the cycles to be internally generated or a response to some external driving function. In either case, one may assume that the large scale spatial-temporal characteristics of the condition (that is, phase lag relationships and the like) constitute information that can contribute to an understanding of the underlying causal element. Such modelling would start with the premise that observed cycle characteristics are a function of some causal factor whose effect varies over space (and time?) in some describable fashion. A sufficiently detailed model of the forces acting (as interpreted through the patterns of population change) might very well lead to direct identification of the factor itself, and to predictions at the organismal/population level concerning the varying effect of the agent on these over space that could be directly tested. This seems an ultimately more persuasive attack than is now being pursued, since all studies to this date alluding to a search for causes can only be considered analyses of the *effects* of the condition until they are logically linked to the continental scale interactions holding the system together.

Such modelling presupposes the availability of an appropriately detailed data base, and this is where the Canadian Snowshoe Rabbit Enquiry can be useful. This seventeen year long study was the most ambitious of the questionnaire-based efforts. In it, hundreds of observers across Canada were asked to submit yearly their impressions of whether the local populations of Snowshow Hare had increased, decreased, or exhibited no trend when compared to levels of the year before. Each year these data were plotted on a map of Canada and subjectively discussed. Inasmuch as this continental-level accumulation of information on spatial trends in population change is perhaps the most extensive and detailed of its kind in existence for any organism, it is somewhat curious that almost no use has been made of it. In the present work, it was used to generate a base for future spatial modelling approaches to the ten-year cycle problem; it is believed that such modelling will ultimately provide the framework within which a complete understanding of cycle causation can be constructed.

Methods

Consideration of how to deal with the seventeen years of data was constrained by several factors. First, most of the locations reporting only did so for portions of the entire seventeen year period. It was therefore impossible to study the spatial relationships of a simple set of series without much — too much — loss of information. Second, the results of the first six years of the study were mapped as area data rather than point data (in the last eleven reports, it was assumed the point symbol mapped represented the center of the area reported on). This necessitated my employing some mode of representation not biased in favor of one or the other original modes. Third, the base map upon which data had been plotted for the years 1931-32 through 1935-36 was replaced with a different projection in 1936-37 that was retained thereafter. The result was the necessity of devising a transformable sampling grid. Fourth, the absolute validity of each point datum was suspect on the basis of scale considerations: spatially and temporally local events might interfere with the assessment of greater scale trends. In addition to these constraints, there were the more general considerations of how to approach statistically the data of such a short series and how to represent the results graphically.

A two-step procedure was applied. In the first step, Thiessen polygons were constructed around the point data of the later maps and between the limits of the area data of the earlier ones. This method made it possible to transform all the data into areal distributions that in sum covered all of the study area. It was possible to determine whether the method treated both data representation forms equivalently, because luckily the results of one year of the original study were mapped in both forms (representational differences proved trivial).

Once the patterns of "increase," "decrease," and "no change" were established for the seventeen sets of data, a quadrat sampling grid was applied to each map. The size of each cell in the grid was determined under two constraints. The first involved the set of considerations associated with minimizing spatial sampling error, as outlined in Getis and Boots (1978). The second concerned the fact the original point and area data had been plotted on a row and column basis, with each "point" datum thereby representing an area of about 900 square miles. A grid cell length of some multiple of thirty miles was thus highly desirable from the point of view of ease of construction and interpretation. A three row by three column cell size was statistically satisfactory and provided a desired level of resolution. Moreover, this degree of smoothing was subjectively deemed appropriate for reducing noise effects. The resulting grid network contained 370 cells to cover the exact portion of Canada involved. Within each cell, the proportions of area covered by "increase" (plus), "decrease" (minus), and "no change" (zero) were tallied and then added together to generate a value within the range of plus one to minus one. This value was then assigned to a point representing the center of the cell. Seventeen years of data were thus transformed to a 370 by 17 matrix.

The first step in treating the 370 temporal series of seventeen values each was to eliminate those series for which too little original data contributed to the values obtained. Eighty of the series, most located along the study area periphery, were discarded on this basis. Values representing each element of the remaining series are in almost all cases derived from the effects of presence of one to several point data within the cell and/or all surrounding cells.

For each of the seventeen years, mean proportions of change for the country as a whole were then computed from the remaining 290 values. The resulting series is clearly cyclic, correlating at $r = 0.97+$ with a simple cosine series (a period of about 8.9 years provided the best fit).

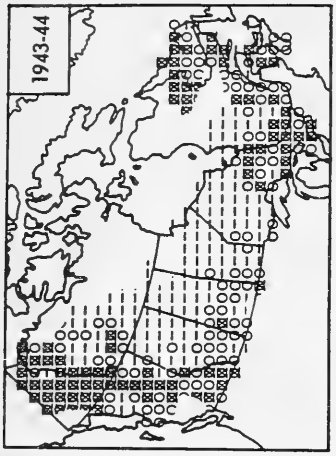
There is no wholly satisfactory solution to the problem of determining phase relationships for cyclic series of 8.9 years period among series consisting of only seventeen values. Three *ad hoc* methods were investigated to derive such values here. I first compiled 290 series of running totals, plus one for the national mean series. All series were next subjected to a linear regression operation through which gross serial trend was removed. Each detrended series could then be compared individually to the national mean. Method one consisted of directly comparing the relative position in each pair of series of all peaks, lows, and changes in residual sign, and dividing this integer total through by the number of comparisons. This gives a reasonably unbiased value for phase lag, but only when the residual series compared are unambiguously cyclic, not all of which were. Method two consisted of directly correlating each pair of series and deriving the Pearson correlation coefficient, r, between each. Since the value r is distributed as a cosine series, phase lag in years could be read by taking the arcosine of r, dividing this by 360 (degrees), multiplying the results by the period of 8.9 years, and reinstating the sign. This approach is slightly biased at large lags by the slight asymmetry of these series, and very biased at small lags for its inability to distinguish between phase response and noise. Method three involved an analysis of covariance between each pair of series under the assumption that the variance and mean of all series were equal. This assumption was, in fact, violated, though the variance of most of the series was close enough to that of the national mean series that the slight discrepancy could be ignored. Those few that did vary greatly were eliminated from further processing.

The third method described above produced results deemed the most acceptable overall among the three, and adopted to generate the phase lag values reported here. A final screening of the series emerging from this analysis followed, with a number more being eliminated for: 1) their failure to produce residuals that were significantly serially autocorrelated at the 0.025 level of significance (as indicated by the Durbin-Watson test statistic), or 2) their generation of a level of serial autocorrelation greater than that of a perfect cosine series of 8.9 years period (indicating the existence of a trend, but one of longer period than the national mean to which comparisons were being made).

Results

The graphic results of the compilations may be viewed in Figures 1 through 4. Figure 1 is a year by year reformulation of the original data as described above. Each symbol represents one 90 miles squared area; all 370 of the original grid cells are represented except where lack of nearby original data precluded interpretation. The three symbols represent ranges of mean trend in each area: a "–" represents values of –1.0 through –0.4 (strong decline); a "o", –0.3 through +0.3 (little or no trend); and a "⊠", +0.4 through +1.0 (strong increase).

Figures 2, 3, and 4 are maps of summary statistics for the seventeen year series. Figure 2 is an isoplethic map of phase relationships, where 0.0 years corresponds to the national mean. Locations with negative values cycle "ahead" of the national mean, locations with positive values, behind. Areas that tested noncyclic for the period of 8.9 years are shaded as such.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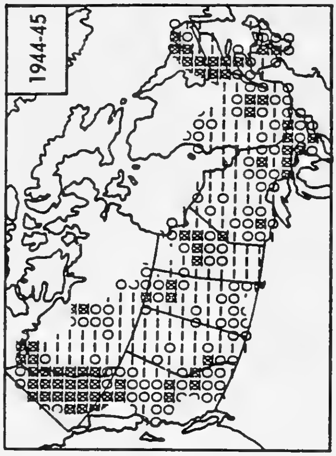
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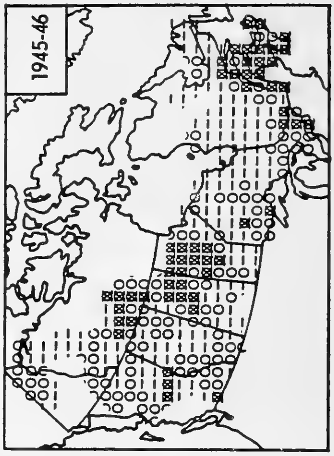
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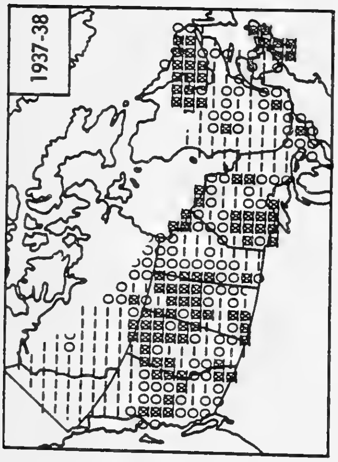
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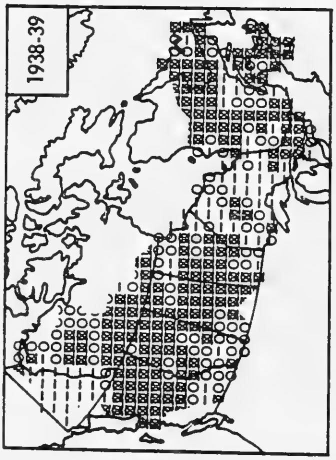
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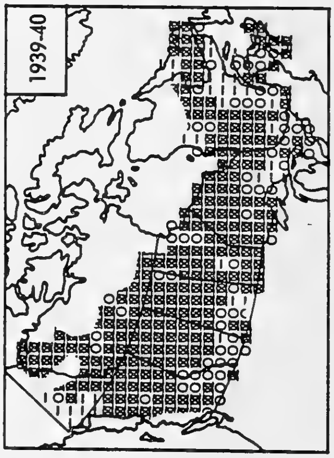
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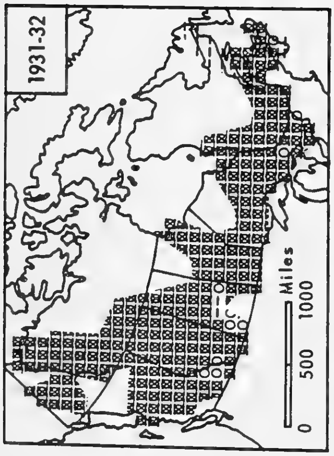
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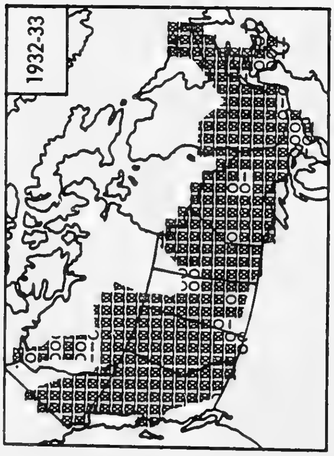
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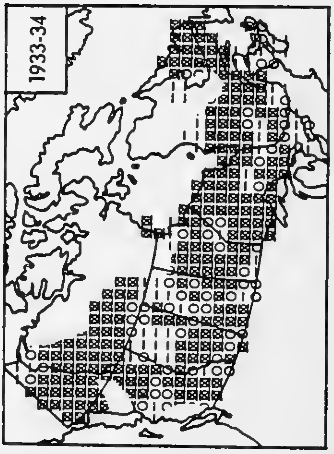
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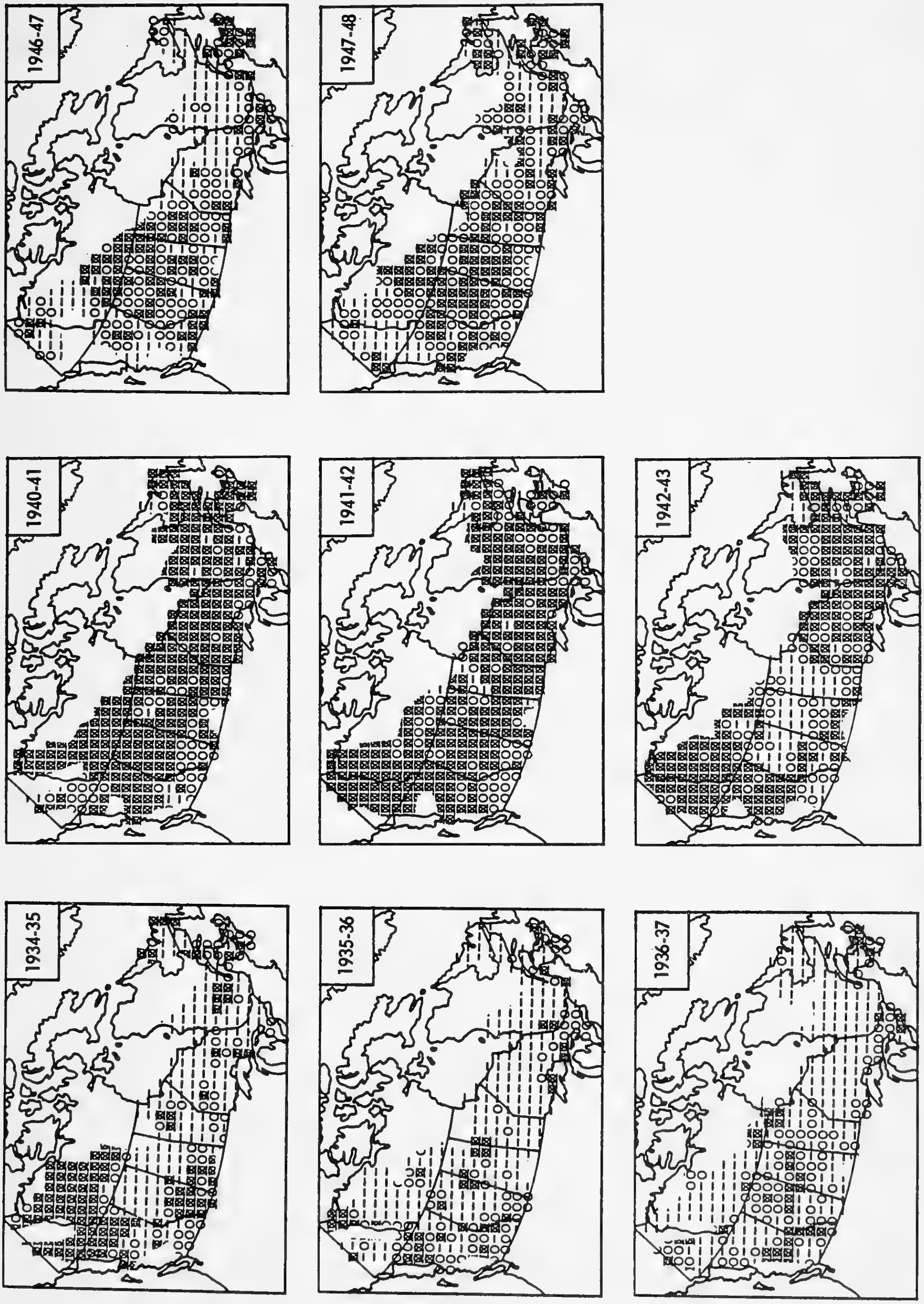

FIGURE 1. General trends in Snowshoe Hare population levels, 1931-32 through 1947-48. See text for explanation and key.

This map was constructed from 238 individual series lag values.

Figure 3 is an isoplethic map of a surrogate used to help interpret relative amplitudes of the cycle in different areas. To derive this map, the proportions of the "no change" category noted at each grid cell location each year have been totalled for the seventeen year period. This value is an imperfect but useful surrogate for amplitude because it can be assumed that observers were likely to note "no change" more often for areas whose populations fluctuated less obviously. All 290 values were used to generate this map.

Figure 4 is an isoplethic map of a surrogate statistic representing degree of non-random trend in the residuals of the detrended series. In most of the map, this can be considered to correspond to mean degree of cycle strength; in a few areas, however (notably the St. Lawrence Valley), trend was high despite lack of significant 8.9 years periodicity. This situation arises because the surrogate used here is the Durbin-Watson statistic, which measures trend only (and not cyclicity *per se*). Apparently, some parts of the study area were either undergoing long term population irruptions (unlikely) or were simply cycling in periods greatly varying from the 8.9 year national mean. Areas of the map that tested "no trend" at the 0.025 level of significance are labelled such; of the remaining areas, lower values signify clearer trend. All 290 values were used to generate this map.

Despite the many possible sources of error in deriving these summary maps, it is felt they do a reasonably good job of representing the original data. A further validity check on the data of Figure 2 was carried out by averaging the values mapped on a province-by-province basis. The results are listed in Table 1. These results correlate very highly (r = 0.930) with Bulmer's

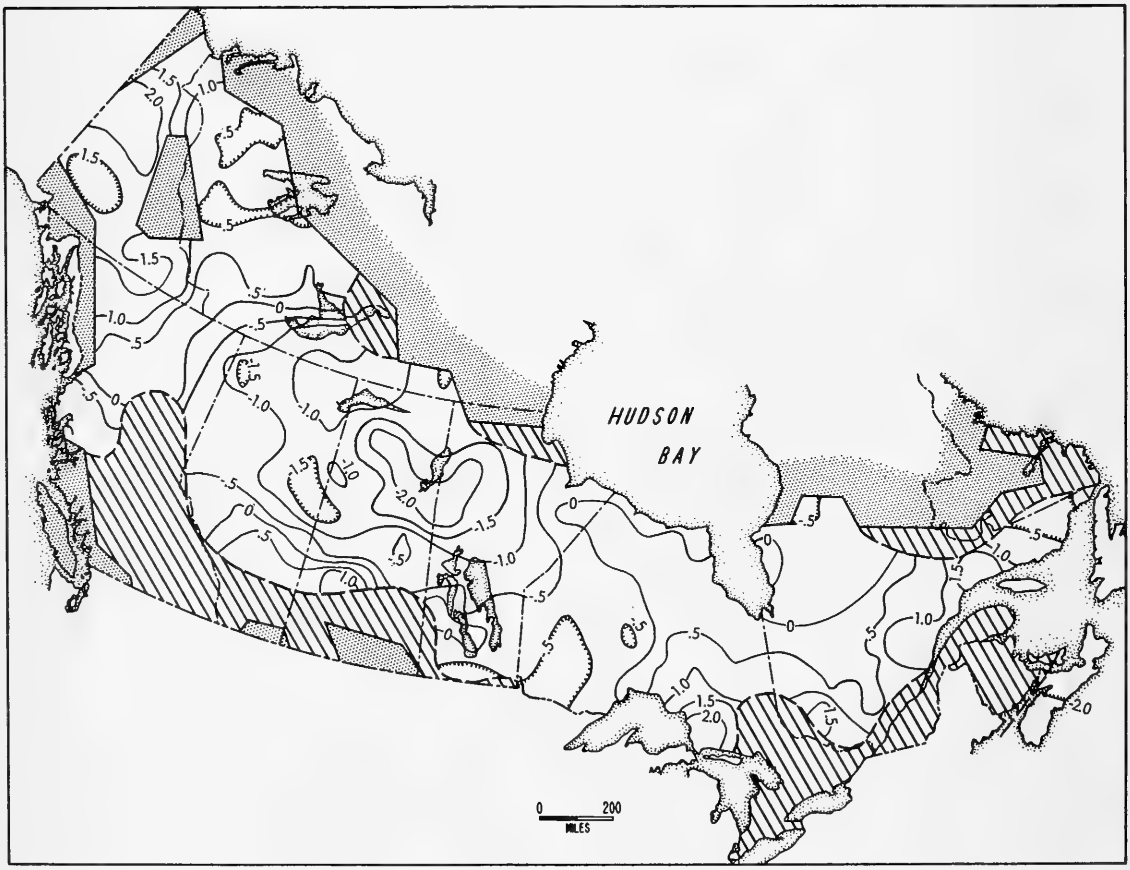

FIGURE 2. Geographic variation in Snowshoe Hare cycle phase, 1931-32 through 1947-48. Stippled shading signifies areas for which data were unavailable; diagonal shading signifies areas that did not cycle at the system mean of about 8.9 years period. See text for further explanation.

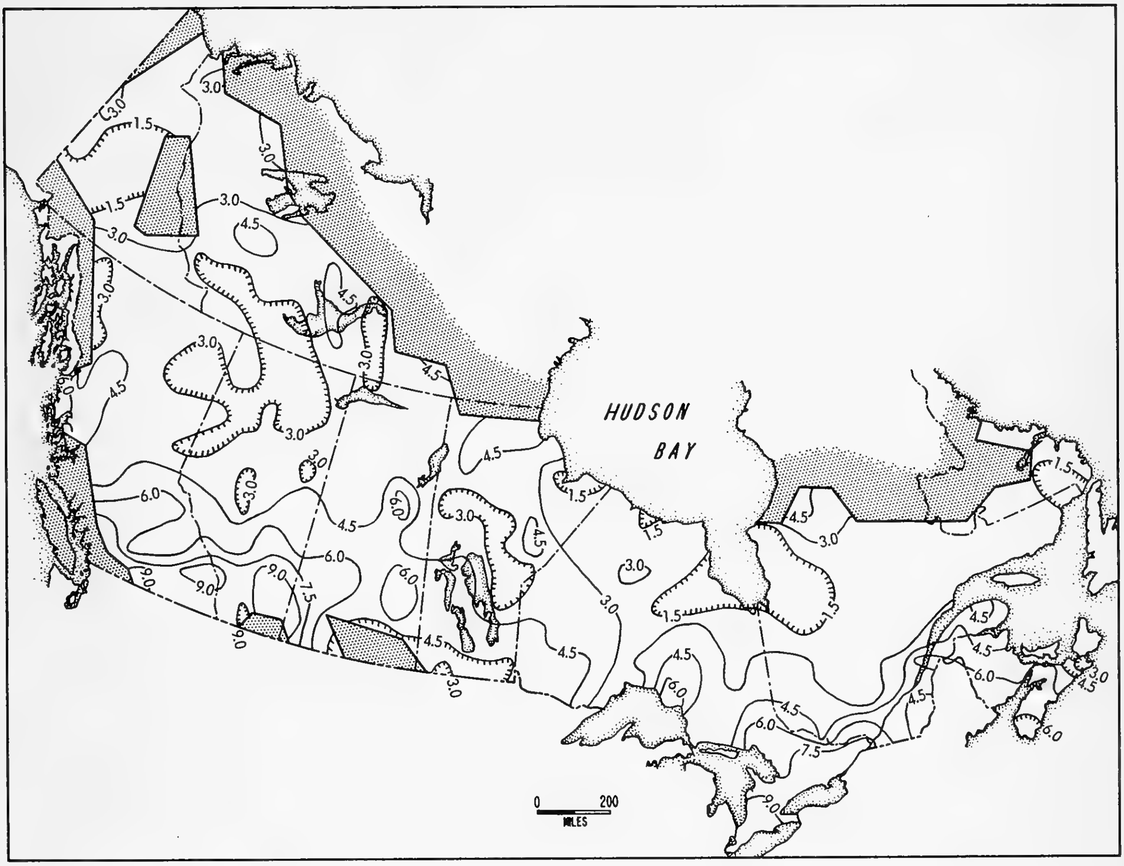

FIGURE 3. Geographic variation in Snowshoe Hare cycle amplitude, 1931-32 through 1947-48. Stippled shading signifies areas for which data were unavailable. Higher values here represent lower amplitudes; see text for further explanation.

(1974) provincial phase lag values for the Canada Lynx over the period 1919 to 1957, a good substantiation considering the two different types of data involved and the probability that Bulmer's results are spatially biased by his use of a national norm weighted unevenly by the varying sales volumes of furs for each province. In addition, data of Figure 3 show a trend similar to that subjectively assessed by Adams (1959). Still, it should be emphasized that only limited confidence can be attached to the specifics of pattern produced from such a short sampling period, regardless of the great cycle strength occurring in this case.

Discussion and Summary

Subjective descriptions of the trends visible in Figure 1 accompany the original reports. A full analysis of these and the other data presented here will only be possible within the context of particular spatial-temporal modelling attempts; for the present, however, several general trends can be pointed out. The low amplitude/degree of cycling in south central Canada has been recognized for some time; this is also true for southern British Columbia and parts of the Maritime Provinces. Here, however, Nova Scotia tests as strongly cyclic, and with a large negative phase lag (These patterns were also discovered in the Lynx data analysis in Smith and Davis 1981). A second trend, recognizable in all three summary maps, is a tendency for patterns visible at the southern limits of range to be repeated at the northern limits; thus, phase lag tends to increase, amplitude to decrease, and strength of cycle to diminish geographically southward or northward away from a strip extending across central Canada (this impression has been confirmed in a trend surface analysis not presented here).

A second set of interesting characteristics involves the rate of spread of the "wave" of population level change away from the main node in central Canada.

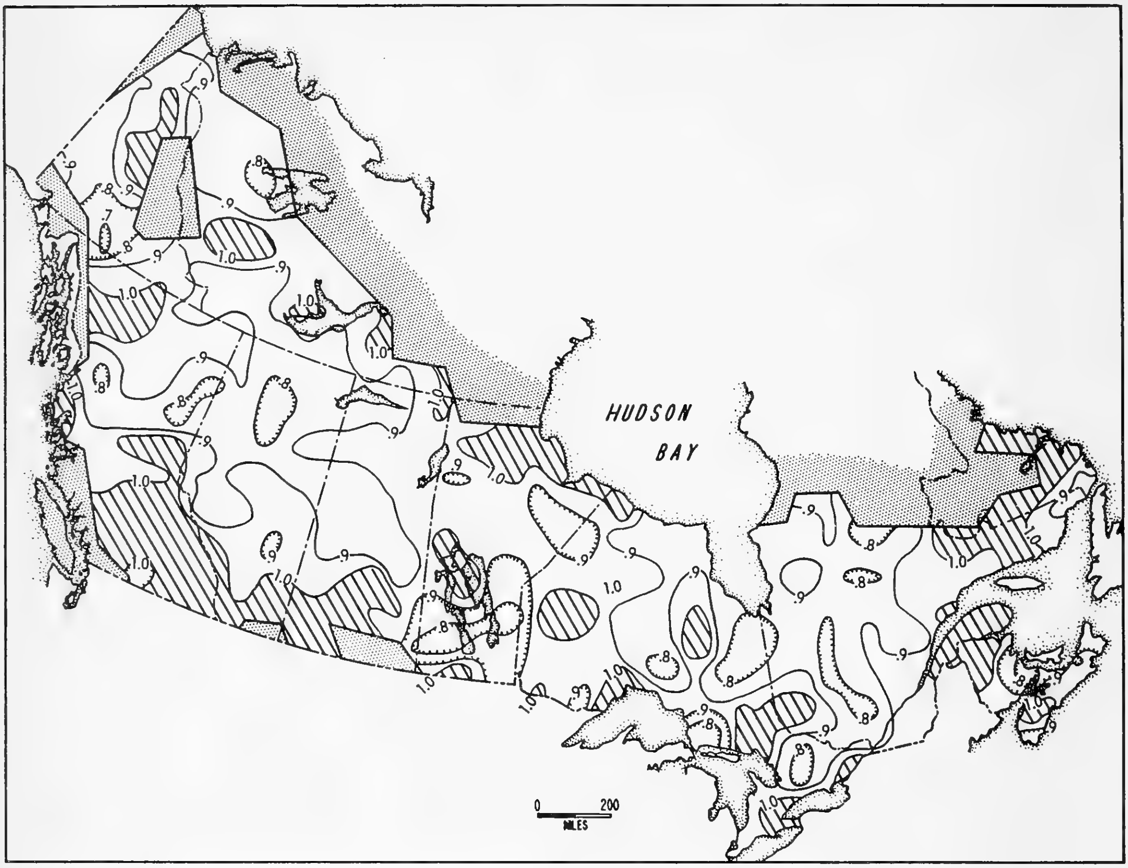

FIGURE 4. Geographic variation in non-randomness of Snowshoe Hare population trends, 1931-32 through 1947-48. Stippled shading signifies areas for which data were unavailable; diagonal shading signifies areas that did not pass the non-randomness test at the 0.025 level of significance (and are mapped as values of 1.0 or greater). See text for further explanation.

TABLE 1. Geographic variation in Snowshoe Hare cycle phase, 1931-32 through 1947-48, relative to the national mean, and aggregated at the provincial level. See text for further explanation.

Province	Lag (in years)
Nova Scotia	– 2.3
Manitoba	–0.8
Saskatchewan	–0.7
Alberta	–0.5
British Columbia	–0.1
Northwest Territories	0.0
Ontario	+ 0.4
Quebec	+ 0.5
Yukon Territory	+ 1.5

First, it is apparent the manner of spread is not one of a simple node away from which diffuses a single wave of population change. Instead, minor nodes of change seem to appear in advance of the wave emanating from the main node, generating their own waves of advance. These eventually meet along "divides." This aspect of system organization seems worth further consideration, perhaps from an epidemiological perspective.

Second, it appears the diffusion of population level change is in some way slowed by physiographic and/or ecological barriers. Figure 2 clearly shows the effect of the Rocky Mountains and the Great Plains on a wave of change emanating from its Boreal Forest origin. The meaning of this relationship is certainly not obvious. One might argue that it is indicative of a change in community interaction rates associated with lower population densities in suboptimal habitats, but the question then becomes how this spatial-temporal translation is effected and why it doesn't lead to an upset of standing phase relationships across the rest of the range. Moreover, it is difficult to defend central Alberta, for example, as being "suboptimal" habitat for the Snowshoe Hare. Nonetheless, this relationship does cast doubt on the likelihood of the simple external driving mechanism hypothesis of cycle causation, since it is difficult to consider this correlation between change in rate of diffusion and habitat change as a spurious relationship.

In brief summary, this treatment has two general purposes. The first is to suggest the need for a view of ten-year cycle dynamics in which system-wide patterns are given primacy in the consideration of causal relationships. Failure to follow this route may result in much wasted effort as the effects of cycle operation are confused with its causes. The second is to produce from the best sources available a data base that can be used to support such spatial modelling attempts in whatever form they might take.

Acknowledgments

I would like to extend my thanks to Dr. Arthur Getis of the Department of Geography, University of Illinois at Champaign-Urbana, for offering helpful suggestions during the course of this work, and to Mr. Phillip Schneider, for assistance in the preparation of the maps.

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Naturalization of the Rainbow Smelt, *Osmerus mordax*, in Lake Simcoe, Ontario

HUGH R. MACCRIMMON, ROBERT W. PUGSLEY[1] and BARRA L. GOTS

Department of Zoology, University of Guelph, Guelph, Ontario N1G 2W1
[1]Present Address: Lake Simcoe Fisheries Assessment Unit, Ontario Ministry of Natural Resources, Sutton West, Ontario L0E 1R0

MacCrimmon, Hugh R., Robert W. Pugsley, and Barra L. Gots. 1983. Naturalization of the Rainbow Smelt, *Osmerus mordax*, in Lake Simcoe, Ontario. Canadian Field-Naturalist 97 (2): 161–169.

The Rainbow Smelt (*Osmerus mordax*), naturalized in Lake Simcoe from *circum* 1960, is now an important component in the sport fishery. Estimated annual winter angling harvest increased from three smelt in 1962 to a peak of 234 865 fish in 1973, but has since been lower. Spring spawning runs were first noted in 1965, with peak numbers being taken by sport fishermen from 1970 to 1974. The structure of the spawning population has shown a change in dominance from age group I to III in 1965, to age groups II to IV in 1972, and almost exclusively to age groups II to III in later years. Mean total length for fish in age groups I to III declined from 1965 to 1970, but since that time growth rate has remained relatively constant. Fecundity, significantly related to total length ($P < 0.01$), ranged from 4 000 to 58 100 eggs. Most spawning in each year normally took place at night in the gravel riffles of tributary streams (190 eggs cm^{-2}) at water temperatures of 7 to 11°C. Some spawning (1 – 2 eggs cm^{-2}) also occurred along the lake shore at water temperatures of 5 to 7°C. Growth of the smelt population has been concurrent with increased eutrophication of Lake Simcoe and a decline in Lake Whitefish (*Coregonus clupeaformis*) and Lake Trout (*Salvelinus namaycush*) fisheries.

Key Words: angling harvests, population structure, growth rate, spawning, fecundity, naturalization, Rainbow Smelt, *Osmerus mordax*, Lake Simcoe.

With the exception of a few eastern Ontario lakes where the species is considered to be indigeous (Dymond 1944), the occurrence of the Rainbow Smelt (*Osmerus mordax*) in the Great Lakes and a number of inland lakes in the Great Lakes watershed westward to the Rainy River drainage is the result of naturalizations occurring since 1923 (Scott 1963; Scott and Crossman 1973). Of these inland lakes now supporting smelt populations, that in Lake Simcoe provides the most extensive fishery and is the best documented because of studies undertaken by the University of Guelph and the Ontario Ministry of Natural Resources.

The origin of the Lake Simcoe smelt is unknown but its presence since *circum* 1960 is almost certainly the result of accidental or intentional introduction by man. Natural movements of smelt from Georgian Bay to Lake Simcoe through the Trent Canal system were blocked by an 18.7 m waterfall (power dam) at the Big Chute. Fish moving through the same canal network from Lake Ontario would have required passage through 41 locks and a series of shallow warmwater lakes. Prior to the first appearance of the smelt in Lake Simcoe, it is believed to have been absent from the entire Trent waterway between the Big Chute and Lake Ontario. The species was subsequently recorded in the Gull and Burnt River drainages in 1963 and 1965, respectively (White, personal communication).

Smelt first appeared in the Lake Simcoe sport fishery in 1962. Winter creel records of the Ministry of Natural Resources have, since that time, provided a reliable picture of trends in the smelt population. The authors, in cooperation with the Lake Simcoe Fisheries Assessment Unit, have examined related biological phenomena occuring during the first 18 years of the smelt fishery.

Description of Study Site

Lake Simcoe, the sixth largest of Ontario inland lakes, lies 221.5 m above sea level (44°23′N, 79°18′W) with a surface area of 725 km², and mean and maximum depths of 17.2 and 41.8 m respectively (Anderson 1964). It forms a link in the 400 km Trent Canal system between Lake Ontario and Georgian Bay. The watershed is largely agricultural, but the shoreline is almost totally fringed by cottage and recreational development, plus several large towns. The eutrophifying effects of agricultural and domestic nutrient inputs are reflected by increasing algal blooms, localized hypolimnetic oxygen depletion, and a gradual shift in benthic communities (Veal and Clark 1970; Nicholls and MacCrimmon 1975). The lake supports a very substantial warmwater and coldwater sport fishery (MacCrimmon and Skobe 1970). Naturalization and growth of the smelt population has coincided with a decline in traditional Lake Trout (*Salvelinus namaycush*) and Whitefish (*Coregonus clupeaformis*) fisheries (DesJardine 1977).

Assessment of overall smelt abundance in Lake Simcoe is based on winter angling harvests estimated by the Ontario Ministry of Natural Resources from creel census data collected each year between 1962 and 1980. Field studies by the authors and Ministry personnel have been centred on a 54 km² section of the lake and the Sibbald Park Creek and Pefferlaw River tributaries (Figure 1). The lake area extends from Georgina Island to Jackson's point and northward to the 22 m depth contour. The 11 km shoreline is typically small stones (50%), sand (30%), and boulders (20%). Littoral substrates extend about 100 m offshore, but beyond, the bottom becomes mud except for several sand and gravel shoals southwest of Georgina Island.

Several small intermittent creeks discharge into the study area, the largest being Sibbald Park Creek which continues to flow until mid-summer. It drains about 1 km² of swamp but, at a distance of 300 m from the lake, becomes gravel and stone bottom and discharges through a sand beach to the lake. A permanent stream, the Pefferlaw River, drains 120 km² of mixed agricultural and idle land with upriver movement of fish from Lake Simcoe limited by a milldam 3 km from the mouth. The Pefferlaw River enters the lake about 8.4 km east of Sibbald Park Creek. Mature smelt enter both streams in most years.

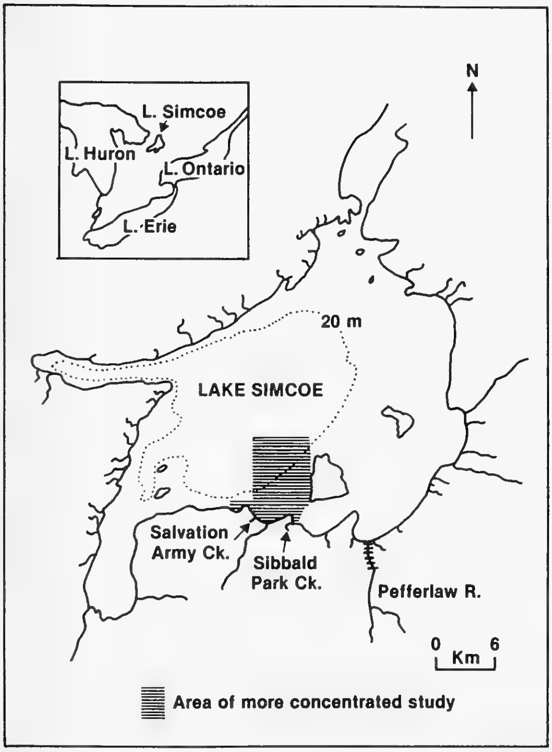

FIGURE 1. Lake Simcoe, showing area of more concentrated study.

Materials and Methods

Visual observations on the presence and relative abundance of smelt were made in the onshore waters of Lake Simcoe during the spawning season in 1970 and, thereafter, only in Sibbald Park Creek, the Pefferlaw River and along the adjacent shoreline. Detailed observation of spawning location, time, duration and success relative to environmental influences has focused on the former tributary. The first adult smelt to enter each evening were caught by monofilament gill net (120 mm bar measure) set in a semi-circle around the creek mouth at a water depth of 0.75 to 1.5 m in conjunction with a fine-meshed seine. Further nightly samples were taken at hourly intervals from the same location using a dip net. In addition, representative samples collected by the Ministry of Natural Resources during the spawning run at Sibbald Park Creek in 1974 and 1976 to 1980 were incorporated into the study. Distribution in the open waters of the lake was determined by means of monofilament gill nets of various meshes.

Biological features examined included total length (TL), age using scales taken one centimeter to the left of the insertion of the dorsal fin, gonadal condition, and fecundity using the dry weight method (Nagasaki 1958) checked by three actual counts.

The relative size of annual spawning runs along the lake shore and up tributary streams within the study area was based on a qualitative visual judgment and the nightly success of sport fishermen. On this basis, the numbers of spawners each year could be assessed as negligible, low, average or high. During the 1972 spawning season, actual spawning success was evaluated for lower Sibbald Park Creek and nearby lake shoals by placing weighted sections (30 × 30 cm) of gray-brown canvas on the lake and stream bottom substrates in eight locations each night from 26 April to 9 May. The canvas was retrieved the following morning and the eggs counted. Egg densities in the main spawning area in the upper creek itself were determined directly from bottom samples taken on 10 and 17 May.

Results

The first three Rainbow Smelt known to be taken from Lake Simcoe were caught through the ice by anglers during the winter of 1962. These fish were an age 3 female (TL 204 mm) from Kempenfeldt Bay on 22 January, an age 3 female (TL 221 mm) from Cooks Bay on 10 February, and an age 2 female (TL 241 mm) from Kempenfeldt Bay on 17 February caught at depths of 31, 12 and 32 meters respectively (Scott, personal communication). No smelt captures are known for 1963, but catches of 208 and 250 fish were reported in 1964 and 1965 respectively. In the spring of 1965, spectacular aggregations of mature smelt appeared suddenly at various onshore and stream locations around the lake. The first of these runs was noticed in late April and early May along the south shore of the lake just to the west of Jackson's Point (Holder, personal communication).

The abundance of smelt, as revealed by winter angling catches increased dramatically in succeeding years (Table 1). By 1970, the winter harvest had reached an estimated 54 829 smelt with spring spawning aggregations of mature fish evident on most sand and gravel beaches, and in most tributaries around the lake. A peak winter catch, estimated at 234 865 smelt, was reached in 1973. Both angler success (average: 0.42 fish per hour) and the contribution of smelt (41.9% by number) to the total winter harvest of all species also peaked in that year. Between 1973 and 1980, winter harvests have shown no trend with annual catches fluctuating between and estimated low of 40 567 fish in 1977 and a high of 145 636 fish in 1976. C.U.E. values follow a similar pattern (Table 1). After 1973, annual catches of smelt have made up less than 24% of the total winter harvest of all species by number.

Beginning in 1970, spring onshore aggregations of adult smelt have provided substantial and continuing annual catches by night-time seine and dip-net fishermen. Actual harvests are unknown, but spot sampling of the 1974 spring fishery revealed average nightly catches of 70 smelt (1.9 kg) per fishermen at a C.U.E. of 43 smelt per hour (DesJardine and Lawrence 1975). Total catches, however, undoubtedly have varied greatly from year to year.

Changes in structure of the adult smelt population between 1965 and 1980 as determined from an examination of stream spawning aggregations have been as follows (Figure 2). The spawning population of 1965 was composed essentially of age I, II and III fish in about equal numbers with a few age IV (4.4% of the sample) present. Thereafter, mature age I fish have been absent from spawning aggregations sampled except for a comparatively few fish in 1972 (0.8%), 1977 (9.8%) and 1980 (2.2%). A single age V female smelt appeared among the 1966 spawners sampled. Although several age V fish are represented in most annual samplings, their contribution to the spawning population since 1965 is low (2.8%). During the same 18-year interval, each of the age II and age III classes have been the most abundant, the latter representing a strong age II year-class in the preceding year. Only in 1972 was there a strong representation of age IV fish (37.9%). The strongest single age-class represented in any of the spawning aggregations to date was age II in 1980 (94.5%). All five age groups were present only in the 1972 and 1977 samples. The oldest smelt yet recorded for Lake Simcoe have come from the winter sport fishery in 1975 when an age VI male and an age VII female were caught (Table 2).

Table 1. Estimated numerical angling harvest of fish from Lake Simcoe during the 75-day winter fishery, 1962 to 1980.

	Osmerus mordax								
Year	Number	C.U.E.	% of Catch	*Salvelinus namaycush*	*Coregonus clupeaformis*	*Coregonus artedii*	*Perca flavescens*	Angler Hours	Total Catch (all species)
1962	3	—	—						
1963	0	—		2 588	92 945	43 155	14 040	335 081	152 728
1964	208	—	0.1	2 128	84 389	46 710	21 279	321 936	154 714
1965	250	—	0.1	1 123	153 338	92 602	14 277	401 981	261 590
1966	1 088	—	0.5	1 920	159 425	47 872	16 384	390 208	226 689
1967	—	—	—	—	—	—	—	—	—
1968	6 677	—	2.2	2 245	169 376	83 504	36 576	499 360	298 378
1969	—	—	—	—	—	—	—	—	—
1970	54 829	0.2	22.2	2 141	71 073	64 934	54 396	240 828	247 374
1971	161 330	0.3	34.2	945	43 209	99 039	167 274	471 797	471 797
1972	135 018	0.3	30.6	1 175	72 268	61 045	171 469	441 575	440 975
1973	234 865	0.4	41.9	745	43 400	65 908	215 319	560 253	560 233
1974	72 377	0.2	23.0	1 119	20 481	44 584	175 907	440 187	314 468
1975	99 000	0.2	17.7	1 200	11 000	152 000	295 000	459 000	559 000
1976	145 636	0.3	23.7	4 889	6 982	84 512	370 757	490 656	615 296
1977	40 567	0.1	10.1	5 452	3 006	193 168	161 108	432 220	403 547
1978	127 873	0.2	16.8	6 604	4 345	370 711	252 231	633 270	762 329
1979	83 634	0.1	15.1	5 329	8 834	222 715	233 306	583 270	553 905
1980	64 211	0.2	19.9	3 297	9 894	70 967	173 708	398 788	322 077

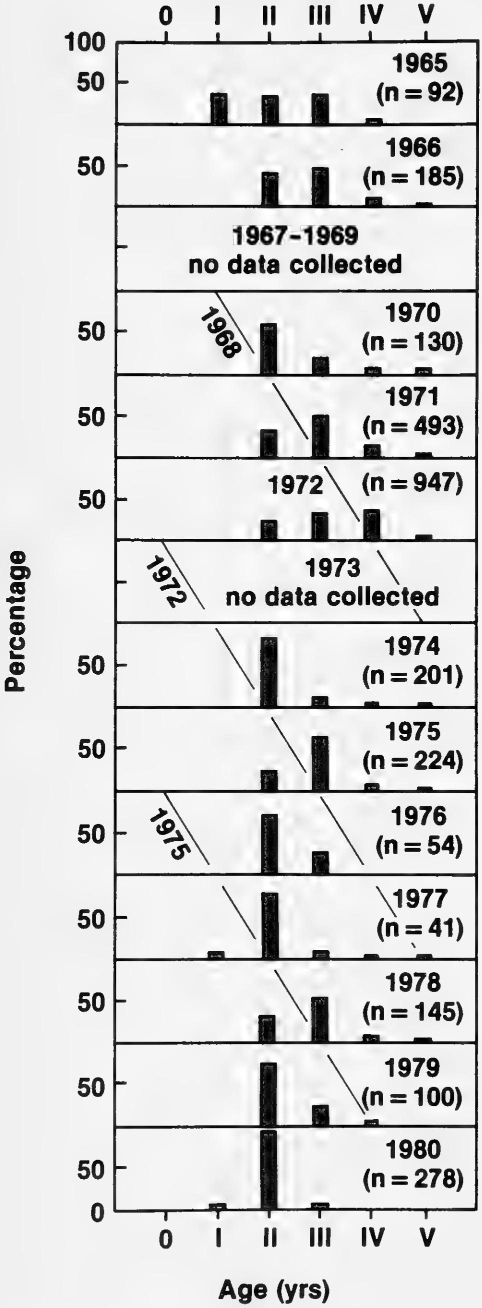

FIGURE 2. Year-class representation in spawning aggregations of smelt sampled in Lake Simcoe between 1965 and 1980. n refers to sample size. Diagonal lines follow the strong year-classes of 1968, 1972, and 1975.

The growth of Lake Simcoe smelt, using the more abundant age classes II and III for comparative purposes (Figure 3), was greatest in 1965 but had declined by 1970 to a rate which, despite annual variations, has not changed appreciably since that time. Examination of the three fish caught in 1962 also showed the rapid growth rate evident in the 1965 spawning population. No growth trend is apparent among the comparatively few fish in the fishery greater than age III. Mean total lengths of mature fish at spawning time are recorded in Table 2. Smelt as large as 267 mm in total length and 105 g have been recorded in winter angler catches. Scale annuli are formed after the spawning time, with 60% being formed by mid-June and 99% by mid-August.

Post-spawning mortalities of adult smelt were first evident in 1968 and became very widespread in 1969 (Skobe, personal communication). Since that time, substantial spring die-offs following spawning have been a regular annual occurrence around the lake. The most extensive of these is believed to be that occurring in April of 1980.

The observed spawning sequence begins in late winter each year when adult smelt become aggregated around the periphery of the lake at depths of 3 to 10 meters. At that time, the lake is still ice-covered and under stable winter stratification with epilimnetic temperatures of 3 to 4° C. Subsequent movement of adult smelt to onshore spawning areas commences at water temperatures of 4 to 7° C, usually in the latter half of April with the gradual disappearance of surface ice. During abnormally warm weather in February 1981, however, smelt gathered under the ice in the warmer effluents of the Sutton River and east shore (and probably other) creeks. In some years, prespawning inshore aggregations have been disrupted greatly by shifting ice and rough water.

Following onshore movements of adult fish to depths of 1.5 to 3 m, lake spawning commenced along sand beaches of water temperatures of 5 to 9° C for a period of up to 13 days. Spawning aggregations, however were dispersed if wave action became pronounced, or if water temperatures were consistently above 11° C. The more intense spawning generally took place in tributary creeks at temperatures of 7 to 11° C. Spawning in Sibbald Park Creek failed to occur in 1975 when the water temperature quickly rose to 12° C without a subsequent decline. Spawning did not occur in other spawning creeks, presumably also because of high water temperatures, but smelt remained numerous in shoal areas of the lake at depths of 1 m (9° C) where spawning did occur.

Subsequent to the break-up of spawning aggregations, the adult smelt gradually move to deeper water and, by mid-summer, become more-or-less randomly

TABLE 2. Age composition and mean total length (T.L.) of mature smelt in spring spawning aggregations in Lake Simcoe.[1]

	1965			1966			1970		
Age Group	Mean T.L.(mm)	N	%	Mean T.L.(mm)	N	%	Mean T.L.(mm)	N	%
I	138	(29)	31.5	—	—	—	—	—	—
II	192	(28)	30.4	173	(80)	42.3	148	(81)	62.3
III	198	(31)	33.7	174	(89)	48.1	169	(27)	20.8
IV	179	(4)	4.4	179	(15)	8.1	198	(13)	10.0
V	—	—	—	206	(1)	0.5	223	(9)	6.9
	177	(92)	100.0	175	(185)	100.0	163	(130)	100.0

	1971			1972			1974		
Age Group	Mean T.L.(mm)	N	%	Mean T.L.(mm)	N	%	Mean T.L.(mm)	N	%
I	—	—	—	110	(8)	0.8	—	—	—
II	161	(154)	31.2	162	(192)	20.3	159	(171)	85.0
III	169	(247)	50.1	172	(344)	36.3	171	(27)	13.5
IV	195	(74)	15.0	179	(359)	37.9	207	(2)	1.0
V	230	(18)	3.7	189	(44)	4.7	208	(1)	0.5
	173	(493)	100.0	173	(947)	100.0	161	(201)	100.0

	1975			1976			1977		
Age Group	Mean T.L.(mm)	N	%	Mean T.L.(mm)	N	%	Mean T.L.(mm)	N	%
I	—	—	—	—	—	—	141	(4)	9.8
II	156	(55)	24.6	154	(39)	72.2	160	(31)	75.6
III	170	(149)	66.5	176	(15)	27.8	178	(4)	9.8
IV	188	(18)	8.0	—	—	—	186	(1)	2.4
V	212	(2)	0.9	—	—	—	196	(1)	2.4
	168	(224)	100.0	160	(54)	100.0	161	(41)	100.0

	1978			1979			1980		
Age Group	Mean T.L.(mm)	N	%	Mean T.L.(mm)	N	%	Mean T.L.(mm)	N	%
I	—	—	—	—	—	—	143	(6)	2.2
II	152	(54)	37.3	154	(74)	74.0	152	(263)	94.6
III	164	(76)	52.4	176	(23)	23.0	167	(9)	3.2
IV	182	(9)	6.2	189	(3)	3.0	—	—	—
V	196	(6)	4.1	—	—	—	—	—	—
	162	(145)	100.0	160	(100)	100.0	152	(278)	100.0

[1] 1965, 1966 (Holder, personal communication); 1970-72 (Pugsley 1976); 1974 (DesJardine and Lawrence 1975); 1975 (Pugsley 1976; DesJardine 1979); 1976-1979 (DesJardine 1979); 1980 (Pugsley, personal communication).

distributed on or near the lake bottom at depths between 18 and 40 m. However, they may rise on occasion to break through the warm surface waters over considerable mid-lake areas. While the smelt were usually taken by summer netting in waters of 6 to 9° C, they have been taken in temperatures ranging up to 17.5° C during their ephemeral migrations to surface waters. During the late autumn and winter, the fish seem to become more closely associated with the bottom while seeking out the warmest water available.

Fecundity and egg deposition rates were examined for the Sibbald Park Creek population in 1972. Examination of 51 mature female smelt showed the gonads to account for 21.5% of the total body weight. The two ovaries typically varied greatly in size with the larger ovary (12.2% of body weight) being positioned in the anterior ventral left portion of the body cavity, and the smaller ovary being located in the posterior right ventral part of the coelom. Total ripe egg counts ranged from 4 000 to 58 100 ($\bar{x}$ = 19 191) and showed

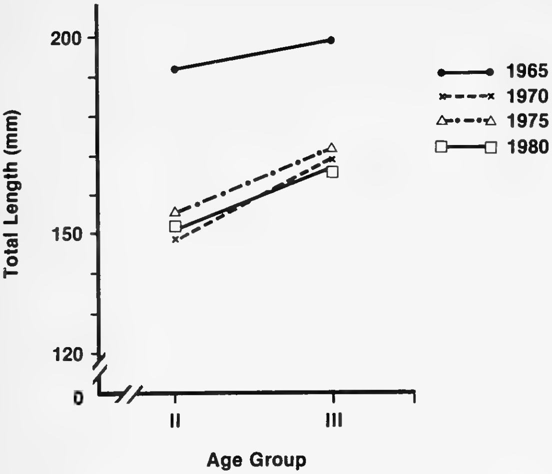

FIGURE 3. Mean total lengths of ages II and III Lake Simcoe smelt sampled from spring spawning aggregations in 1965, 1970, 1975 and 1980.

a significant relationship ($P < 0.01$) with total length as expressed by the equation, $\mathrm{Log}\ E = 3.4048 + 3.4087\ \mathrm{Log}\ L$ ($r = 0.89$). There was no evidence of the parasite *Glugea hertwigi* (Delisle 1972).

The density of eggs deposited on the onshore sand bottom adjacent to Sibbald Park Creek averaged only one to two eggs cm^{-2} in contrast to the creek bottom where numbers of eggs scattered over the humus and gravel were as high as 190 eggs cm^{-2}. Subsequent observations revealed that, one week after deposition, only those eggs adhering to protruding gravel or stones were alive. Survival rate of all eggs deposited on the creek bottom as estimated at 7.2%. After a similar time, none of the eggs deposited on the sand beach could be found. The survival of eggs dislodged by wave action is unknown.

The summer dispersal of young-of-the-year smelt was followed in 1980, using a Reckahns mini-wing trawl. Substantial numbers were found near the bottom at depths of 10 to 14 m at various lake locations, with 15-minute hauls, on occasion, yielding more than 700 young-of-the-year smelt.

Coincident with the naturalization of smelt in Lake Simcoe have been unique changes in the composition of the fishery which have been associated with the increasing eutrophication processes occurring in the lake (Nicholls and MacCrimmon 1975; DesJardine 1977). Principal changes in the composition of the winter angling catch occurring simultaneously with the rise of the smelt population have been a gradual decline in the abundance of Lake Whitefish (*Coregonus clupeaformis*) and a decrease in the numbers of native Lake Trout (*Salvelinus namaycush*), although the size of annual winter harvests of this latter species has been sustained by the release of hatchery-reared fish which now dominate the catch. On the other hand, catches of native Yellow Perch (*Perca flavescens*) increased progressively during the 1960's and early 1970's. Also, large increases in winter harvests of Ciscoe (*Coregonus artedii*)[1] have occurred in the late 1970's (Table 1).

Discussion

The sudden appearance of a large spawning population of smelt around much of the shoreline of Lake Simcoe in 1965, with nearly equal numbers of mature fish of age I, II and III, is clear evidence that fruitful spawnings occurred in 1962, 1963 and 1964. The breeding population must have been extremely small in these years in view of their negligible contribution to the winter sport fishery and the non-detection of spawning aggregations which have become so obvious since 1966, both onshore and in tributary creeks. The subsequent growth and stabilization of the smelt population confirms both the suitability of Lake Simcoe for the species, and the plasticity of the smelt to utilize the diverse habitat offered (MacCrimmon and Skobe 1970; MacCrimmon and Pugsley 1979).

The most notable biological changes in the smelt which have occurred since their naturalization in Lake Simcoe are, firstly, the pronounced change in age of maturity from I to II years which took place in the 1965 year class; secondly, a pronounced retardation in growth rate through ages II and III during the latter part of the 1960's; and, thirdly, a gradual increase in the population to peak abundance in 1973. Time to maturity and growth rate are no doubt related phenomena (Ivanova et al. 1969; Saunders and Powers 1970; Moulton 1974). The appearance of a few mature age I fish in the 1972, 1977, and 1980 spawning population represent a few precocious fish, which only in 1980 were above average size for their year-class. All of the above-noted three phenomena occurred within little more than a decade following the establishment of a self-sustaining population in the lake.

Since the peak abundance of smelt in 1973, as reflected by winter angling success (C.U.E. of 0.4 and 41.9% of total harvest), winter harvests have fluctuated greatly (40 567 to 145 636 fish), but no population trend is apparent. In view of the close relationship among C.U.E. values (0.1 to 0.3), percentage of smelt in winter angling catches (10.0 to 23.7%) and total

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[1] Likely all *C. artedii*, although a deepwater ciscoe ('trout herring') resembling *C. hoyi* was identified at one time (MacCrimmon and Skobe 1970).

annual harvests, it is reasonable to assume that the winter catch statistics now represent a fair measure of smelt abundance. During the late 1960's, however, actual smelt populations may have been higher than indicated from the winter creel data as the alien smelt was held in disdain by most traditional fishermen. By the early 1970's the smelt had been accepted as an important component of the sport fishery and virtually all captured fish retained regardless of size.

While the quantificaton of annual spawning numbers has not been attempted, intensive (night-time) general observations have shown a remarkable variability in the extent and duration of both onshore and creek spawning runs which undoubtedly affect year-class strengths. The principal environmental factor determining the onset and probably the duration of both onshore and creek spawning is undoubtedly water temperature (7 to 11° C for actual spawning), although other (undetermined) factors may regulate the absence, presence or abundance of spawning aggregations on a night-by-night basis even when water temperatures are satisfactory. While local flow conditions were observed to occasionally affect creek spawning, the adverse effects of wave action on the exposed sand beaches of the lake frequently affected not only spawning activity and duration, but the fate of the eggs deposited there. The effect on survival of eggs dislodged from shoal substrate by wave action is unknown, but the survival of ova in Sibbald Park Creek would seem to be limited to eggs adhering to well-oxygenated and unsilted substrate.

The observed annual fluctuations in year-class strengths during the past decade have not been correlated with any observed environmental parameter, but the dominance of the 1968 year-class in the 1970, 1971, and 1972 spawning populations illustrates the impact of one highly-successful spawning on the fishery. Large variations in the size and timing of local annual spawning aggregations are known to occur, but there is no apparent correlation between subsequent year-class strengths and what have been judged to be poor and good spawning years. A reasonable observation is that year-class strengths in Lake Simcoe would seem to be determined by spawning success rather than the numbers of spawners.

The two times of Smelt harvest from Lake Simcoe are the 75-day winter ice fishery and the spring onshore and creek sport netting operation during the spawning season. Because of the sporadic and unpredictable nature of the latter night-time fishery in and adjacent to many creeks around the lake, a meaningful census has proven to be impossible. Hence, the annual harvest of smelt from the lake is unknown. Using a mean weight of 23.5 g per fish for the estimated 234 865 smelt captured by winter angling during the peak year of 1973 (Pugsley 1976), the total harvest for the winter fishery totalled some 5 500 kg. If the assumption is made that spring sport netting yielded a like amount (probably a gross over-estimate), the annual harvest of smelt from Lake Simcoe would have reached 10 000 kg or 0.14 kg ha^{-1}. Actual weights harvested annually would, of course, vary not only with the numbers harvested but also with year-class strengths represented in the fishery. Angling intensity during the winter ice fishery is also a function of weather conditions causing unsafe ice conditions, drifting snow, and other factors that can affect accessibility to the offshore fishing grounds spread over much of the 72 519 ha lake surface.

Comparison of growth, maturity, fecundity and general biological characteristics of the Lake Simcoe smelt suggests no marked differences from other native and naturalized populations (Greene 1930; Ferguson 1965; Rupp 1968; Burbridge 1969; Lackey 1969). The principal environmental features that seem to have favored the establishment of the substantial naturalized smelt population in Lake Simcoe can be identified as, firstly, the presence of extensive creek and shoal spawning areas around the periphery of the lake; secondly, the extensive expanse of open-water with summer bottom water temperatures ($< 11°$C) favourable for smelt feeding and growth; and, thirdly, an abundance and diversity of food available for year-round utilization (MacCrimmon and Pugsley 1979).

The extent to which the accelerated process of eutrophication, which has been occurring in Lake Simcoe simultaneously with naturalization, has favoured establishment of the substantial smelt population is unknown. By 1970, changes in the benthic communities to favour more pollution-tolerant organisms had been detected (Veal and Clark 1970), while critically low dissolved oxygen was an eminent concern in some hypolimnetic areas prior to the 1977 autumn turnover (DesJardine and Lawrence 1979).

Whether-or-not pronounced changes in the native fish fauna (most obviously the Whitefish and Lake Trout) which have occurred coincident with naturalization of the smelt in Lake Simcoe can be attributed to the presence of the alien smelt, or to progressive eutrophication or overfishing, is a question of major management as well as biological interest. Although smelt have been cited as a probable cause of Whitefish declines in other waters (Cucin and Regier 1965), our present study has failed to identify any direct adverse effects of smelt on any of the coldwater fishes (Whitefish, ciscoes, Lake Trout) which contribute to the winter or summer fisheries.

Despite the seasonal presence of fish eggs (especially smelt and sucker, *Catostomus* sp.) and small fish) especially young-of-the-year smelt and Emerald

Shiner, *Notropis atherinoides*) in many of the smelt stomachs examined (MacCrimmon and Pugsley 1979) and the partly-piscivorous diet of smelt in most waters (Creaser 1925; Gordon 1961; Price 1963; Selgeby et al. 1978), neither the eggs nor young of the Whitefish, ciscoes or Lake Trout have been identified in the stomachs of Lake Simcoe smelt. While the absence of these (and most other common fish species) in the stomachs may be a problem of inadequate sampling, this is not believed to be the case. Rather it is felt that because of the broadly omnivorous and rather selective diet of the smelt, it is more probable that the suppression of any sympatric species in the lake would be the result of competitive pressure on specific food items required at some critical stage in the early development of other fishes (MacCrimmon and Pugsley 1979). Adequate data on the food and feeding of Lake Simcoe fishes to support this contention are simply not available.

On the basis of present knowledge, the decline of native Lake Trout and Whitefish, and the recent codominance of Yellow Perch and ciscoes in the winter sport fishery, would seem to be more closely related to changing environmental parameters and fishery patterns than to the introduction of smelt to the lake. The Rainbow Smelt now occupies a unique and seemingly permanent ecological niche in the Lake Simcoe ecosystem. While there is presently no evidence to suggest that the environmental requirements and bioecological features of the smelt are seriously in conflict with those of native species, their possible displacement of indigenous species is worthy of further investigation.

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Range Extensions of Vascular Plants from the Northern Yukon Territory

LES C. CWYNAR

Department of Botany, University of Toronto, Toronto, Ontario M5S 1A1

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Fifty-two vascular plant taxa are reported from the northern Yukon for either the first time or as range extensions. Four taxa are new to the flora of the Yukon: *Carex amblyorhyncha, Ceratophyllum demersum* (Hornwort), *Armeria maritima* ssp. *arctica* (Thrift), and *Artemisia biennis* (Biennial Wormwood). Forty-two are reported as the first records for the northern Yukon; 31 beyond Hultén's (1968) predicted range limits and 11 within. Range extensions are also reported for 10 taxa previously collected within the northern Yukon.

Key Words: range extensions, *Carex amblyorhyncha, Ceratophyllum demersum, Armeria maritima* ssp. *arctica, Artemisia biennis*, Yukon Territory.

During his studies of the Beringian flora, Eric Hultén visited the northern Yukon at a time when it was still poorly explored botanically. He later (Hultén 1968) noted that one of the most interesting areas remaining to be botanized in the Yukon was in the north around the upper Porcupine River because "the northern and southern extremities presumed for many plant ranges might merge there". The flora of the northern Yukon has proved to be rich (Welsh and Rigby 1971; Wein et al. 1974; Nagy et al. 1979), partly because of the varied topography and geology (Bostock 1961, Welsh and Rigby 1971) and partly because most of the northern Yukon has escaped the repeated glaciations of the Quaternary Period (Hughes 1972). Although these recent collections have confirmed Hultén's suspicion, they have not proved to be definitive.

In the summers of 1975-1978 I made 1550 collections of vascular plants from the northern Yukon, which I define as that area north of 65° latitude, corresponding with the important physiographic boundary of the Ogilvie Mountains. This paper describes those collections that are either the first for a taxon in the northern Yukon or extend a taxon's known range.

Collection Sites

The approximate location of collection sites is shown in Figure 1. The precise location and general character of each site is briefly described below.

1) Beaufort Sea coast, 69°30′N, 140°40′W, 3 m above sea level (a.s.l.), coastal sand dunes and beach.
2) Beaufort Sea coast, 69°30′N, 139°13′W, 3 m a.s.l., coastal sand dunes and beach.
3) Firth River, 69°21′N, 139°30′W, 150 m a.s.l., a rock knoll in mesic-xeric tundra in the vicinity of Richard S. McNeish's archaeological excavations.
4) Small un-named lake 2 km northeast of Trout Lake, 68°50′N, 138°44′W, 150 m a.s.l., tundra in north slope foothills of the British Mountains.
5) Dog Creek at junction with Black Fox Creek, 68°23′N, 138°46′W, 425 m a.s.l., tundra on limestone bedrock with well developed gallery forest of White Spruce along Black Fox Creek.
6) Hanging Lake, 68°23′N, 138°23′W, 460 m a.s.l., a lake perched in shale bedrock in tundra with a sparse vegetation cover within the drainage basin.
7) Barn Mountains, 68°25′N, 139°52′W, 760 m a.s.l., bedrock of shales and siltstones with collections from alpine meadows with lush growth, especially along streams.
8) Bonnet Lake, 68°12′W, 139°52′W, 600 m a.s.l., snowflushes on soft shale tundra slope.
9) McDougall Pass, Richardson Mountains, 67°41′N, 136°35′W, 300 m a.s.l., open White Spruce woods with some White Birch; thermokarst lakes and ponds scattered throughout.
10) Junction of Rat Indian Creek and Porcupine River, 67°34′N, 138°20′W, 300 m a.s.l., riverbank forests and thickets, river margins, and forested mountain slopes.
11) Old Crow Flats, 67°42′N, 139°08′W, 260 m a.s.l., shallow thermokarst lakes, marshy infilled lakes, and wet meadows.
12) Old Crow Flats, 67°52′N, 139°27′W, 260 m a.s.l., wet heaths and margins of thermokarst lakes.
13) Junction of Schaeffer Creek and Old Crow River, 67°50′N, 139°51′W, 260 m a.s.l., site of Schaeffer's cabin on riverbank, now somewhat overgrown but still a meadow.
14) Second Caribou Lookout, 67°35′N, 139°31′W,

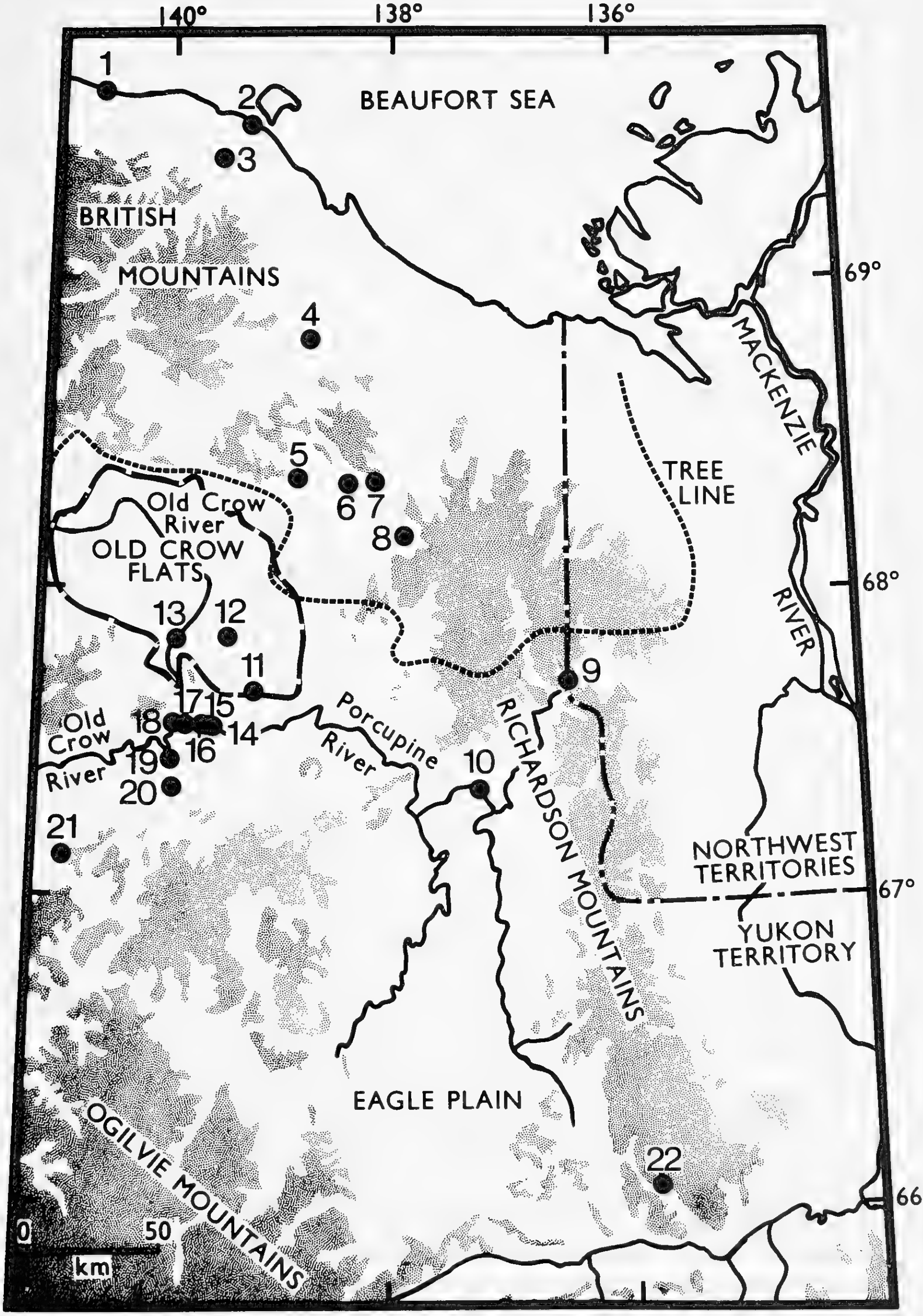

FIGURE 1. Location of collection sites from the northern Yukon Territory.

280 m a.s.l., an outcrop of shales and siltstones with few spruce trees and a sparse cover of dry heaths.

15) Old Chief, 67°35′N, 139°37′W, 260 m a.s.l., the site of intensive excavations by members of the Northern Yukon Research Programme, University of Toronto. Terrace slopes support White Spruce woods with *Salix glauca*. The uplands beyond the terraces are wet with numerous bogs and muskeg.
16) Klo Kut, 67°34′N, 139°41′W, 270 m a.s.l., site of the base camp for the Northern Yukon Research Programme. It lies on a meadow terrace between the Porcupine River and a small lake which abuts a limestone bluff.
17) Un-named thermokarst lake, 67°34′N, 139°45′W, 280 m a.s.l., marshy with scattered Black Spruce and some White Spruce.
18) Old Crow Village, 67°34′N, 139°49′W, 250 m a.s.l., collections made of weedy plants within the village.
19) Big Bluff, 67°29′W, 139°53′W, 275 m a.s.l., a long silt bluff along the Porcupine River.
20) Bluefish Basin, 67°22′N, 139°54′W, 280 m a.s.l., a wet plain with many bogs and thermokarst lakes and scattered stands of spruce, mostly black.
21) Bluefish Cave, 67°08′W, 140°47′W, 300 m a.s.l., limestone ridge with thick turf and scattered White Spruce.
22) Southern Richardson Mountains, 66°04′N, 135°50′W, collections made at various elevations from alpine tundra to low elevation closed White Spruce woods; the bedrock is limestone.

Vascular Plant Range Extensions

Fifty-two taxa are reported with sites, habitats, and collection numbers. Nomenclature follows Hultén (1968), but much of the pioneering work in the Yukon and Mackenzie District by A. E. Porsild and W. J. Cody (e.g. 1968) uses a slightly different nomenclature so I have added in parenthesis the latters's recent usage (Porsild and Cody 1980) where it differs. A set of voucher specimens has been deposited at the Canadian Department of Agriculture Herbarium (DAO) in Ottawa.

Four taxa are new to the flora of the Yukon: *Carex amblyorhyncha, Ceratophyllum demersum, Armeria maritima* ssp. *arctica,* and *Artemisia biennis*. Forty-two are the first records for the northern Yukon: 31 beyond Hultén's predicted range limits and 11 within. Range extensions are also reported for 10 taxa previously collected within the northern Yukon.

Lycopodiaceae

Lycopodium annotinum ssp. *annotinum*. Site 9: in mixed While Spruce-White Birch woods, *301*. This is the first record for the northern Yukon, extending the range northward over 200 km beyond Hultén's (1968) predicted limit.

Potamogetonaceae

Potamogeton filiformis. Site 9: in shallow water of sluggish stream, *296*. Although well within Hultén's predicted range, this collection is nevertheless a first for the northern Yukon.

Juncaginaceae

Triglochin palustris. Site 10. locally abundant on moist silty riverbank with *Carex aquatilis* ssp. *aquatilis* and *Eleocharis uniglumis, 920* and *926*; site 16: seepage area along silty riverbank, *1029*. This species reaches interior Alaska and the Mackenzie River Delta but it has not been previously recorded in the northern Yukon where Hultén predicted it would not be found. It is an easily overlooked taxon frequently mixed with sedges and spike-rushes on damp silty riverbanks.

Gramineae

Agropyron subsecundum (*A. trachycaulum s. lat.*). Site 10: common along riverbank, *893A*. This collection extends the species's range well north of Hultén's predicted limit in the central Yukon.

Beckmannia erucaeformis ssp. *baicalensis (B. syzigachne)*. Site 10: rare, only 3 plants in seepage area along steep silty riverbank, *981*. The first record for the northern Yukon, this collection lies well beyond Hultén's predicted limit in the central Yukon and west of collections from the Mackenzie Delta area.

Puccinellia Nuttalliana (P. borealis). Site 19: exposed dry silt bluff, *8*. An uncommon plant in Alaska-Yukon usually confined to alkaline soils in southwestern Yukon and southeastern Alaska. The first collection from the northern Yukon and outside of Hultén's predicted limit.

Trisetum sibiricum ssp. *sibiricum*. Site 10: locally common in a *Salix arbusculoides-Alnus incana* thicket along the Porcupine River, *953* and *1548*. Hultén (1968) does not report this taxon from North America although he did earlier (Hultén 1941-1950). The confused status of this taxon in North America will be clarified in a forthcoming paper (Cwynar, *in preparation*). This is the first report for the northern Yukon.

Cyperaceae

Carex amblyorhyncha. Site 15: bog margin, *224*; site 16: slumping winter road, *351A*. A little-collected subarctic plant, these are the first collections for the Yukon Territory and they fall within Hultén's predicted range.

Carex capitata. Site 15: *Sphagnum* bog, *223*: site 14: White Spruce woods, *1546*. Although within Hultén's predicted range, these are the first collections from the northern Yukon, well beyond previous collections in the central Yukon.

Carex disperma. Site 16: common along shaded, mossy intermittent stream, *1027*. This collection extends the range northward from collections south of the Ogilvie Mountains and westward from the Mackenzie Delta.

Carex Franklinii. Site 22: abundant on calcareous, turfy, open slope with a few White Spruce, *1288*. This apparently rare plant of calcareous habitats has been collected only 3 times before in the Yukon. Just within Hultén's predicted range, this is the first collection from the northern Yukon.

Carex rariflora. Site 16: slumping winter road, *346*; site 12: abundant in boggy pools, sedge meadows, and shallow margins of thermokarst lakes, *760, 804, 818*, and *819*; site 5: abundant in sedge meadow, *1056*. When Porsild (1974) described material for a flora of the central Yukon, he noted that this arctic species was rare in the Yukon and suggested that it was probably restricted to alpine habitats. These are the first collections from the northern Yukon where it is a common plant of sedge meadows along the margins of thermokarst lakes, especially in the Bluefish Basin and the southern half of the Old Crow Flats.

Carex rostrata. Site 11: common in shallow water, *758*; site 10: fringing lake margin, *910*, and sparse on wet silty riverbank, *927*. Porsild (1974) reported the first collections from the northern Yukon in the Ogilvie Mountains. My collections extend the known range northward into the southern part of the Old Crow Flats where Hultén predicted it would be found.

Eriophorum russeolum ssp. *rufescens*. Site 4: wet depression, *166*; site 12: in *Sphagnum* at edge of lake, *779*. This taxon was previously known from the Yukon at only one disjunct locality in the interior. These are the first records for the northern Yukon.

Eleocharis uniglumis. Site 10: locally abundant on wet silty riverbank, *895*; site 16: abundant on wet silty riverbank, *1016*. Previously collected infrequently in the southern Yukon, these are the first collections from the northern Yukon — several hundred kilometres north of previous collections and considerably beyond Hultén's predicted range.

Juncaceae

Juncus alpinus s. lat. Site 10: common on seepage area of steep silty riverbank, *986*. This collection extends the range northward from the central Yukon into the upper Porcupine River, outside of Hultén's predicted limit.

Luzula arcuata ssp. *unalaschensis*. Site 6: lakeshore, *1400*. Nagy et al. (1979) reported this species from a site just north of this one but they did not identify their collection to subspecies. This is the first record for the northern Yukon and it is within Hultén's predicted range.

Luzula rufescens. Site 15: rare in rich fen, *206*; site 16: common on margin of slumping winter road, *509, 510, 514*. The first records for the northern Yukon, they lie beyond Hultén's predicted limit. Cody and Porsild (1968) reported a collection from Canoe Lake in the northern Richardson Mountains, Northwest Territories. The Canadian collections thus appear to be contiguous with those from the principal range in Alaska.

Orchidaceae

Amerorchis rotundifolia (Orchis rotundifolia). Site 22: rich White Spruce woods, *1283*. This is the first record for the northern Yukon, extending the range from west-central Yukon.

Salicaceae

Salix interior. Site 10: common along cobbly riverbank, *903*; site 16: pioneering on riverbar, *566*. The first collections from the northern Yukon, well north of previous collections from west-central Yukon and beyond Hultén's predicted limit.

Betulaceae

Alnus incana ssp. *tenuifolia*. Site 10: forming thickets along riverbank, *946*. The first collection from the northern Yukon and beyond Hultén's predicted limit. This species was not found at several localities on the Old Crow River where it was looked for.

Santalaceae

Geocaulon lividum. Site 21: on limestone ridge with scattered White Spruce, *1134*. The first collection from the northern Yukon, it bridges the gap between previous collections from adjacent Alaska and Mackenzie District.

Polygonaceae

Polygonum amphibium ssp. *laevimarginatum (P.*

amphibium var. *stipulaceum).* Site 10: locally abundant on dry silty riverbank, *984*. The first collection form the northern Yukon and beyond Hultén's predicted range, it bridges the gap between Alaskan and Mackenzie District collections.

Polygonum caurianum. Site 10: common on cobble riverbank, *962*; site 16: cobble riverbank, *1023*. These are the first records from the northern Yukon for this easily overlooked species. Previously known in the Yukon from only 3 collections in the interior and southwest.

Chenopodiaceae
Monolepis Nuttalliana. Site 16: cobble riverbank where winter road crosses, *1022*. Hultén puts the limit of this species at the Yukon border from the Alaskan side, with a locality marked on the Porcupine River at the Alaska-Yukon border. This collection is therefore either the first or second for the Yukon and extends the range beyond Hultén's predicted limit.

Portulacaceae
Claytonia sarmentosa. Site 7: along stream through rich alpine meadow, *1367*. Well beyond Hultén's predicted limit, this is a significant range extension from previously reported localities in the southern quarter of the Yukon.

Caryophyllaceae
Arenaria longipedunculata (A. humifusa pro parte). Site 15: rare in wet crevices of limestone bluff, *1110*. The first record for the northern Yukon, well beyond Hultén's predicted limit.

Melandrium Taylorae. Site 10: common on dry upper riverbank, *906* and *929*; site 15: occasional along shaded stream, *1103*. This species has been recorded twice in the southwest corner of the northern Yukon as well as in the Mackenzie Delta area to the east. My collections lie beyond Hultén's predicted limits, bridging the gap between previously known collections and suggesting that the range is not as fragmented as shown by Hultén.

Ceratophyllaceae
Ceratophyllum demersum. Site 12: forming extensive mats in water 0.5 to 1.5 m deep around thermokarst lake, *761*. This species is new to the flora of the Yukon Territory. It is disjunct from the main boreal forest range which reaches Great Slave Lake in the Northwest Territories. Hultén shows several disjunct localities in interior Alaska.

Ranunculaceae
Ranunculus confervoides (R. aquatilis var. *eradicatus).* Site 16: common in shallow water of oxbow lake, *1092*. This is the first collection from the northern Yukon although it lies within Hultén's predicted limit. This collection together with Porsild's (1974) indicate that the populations in the southwest Yukon are not disjunct from those in the north as shown on Hultén's map.

Ranunculus scleratus ssp. *multifidus*. Site 22: mud flat at lake margin, *307*. Collected occasionally in the Yukon from south of the Ogilvie Mountains, this is the first collection in the north. Hultén shows an isolated collection from the Mackenzie Delta to the east.

Thalictrum sparsiflorum. Site 16: a solitary plant in a stand of Balsam Poplar on a terrace of the Porcupine River, *1014*. Considerably north of Hultén's predicted range, this is the second record for the northern Yukon, the other coming from the northern part of the Ogilvie Range.

Fumariaceae
Corydalis pauciflora. Site 22: common along stream draining late-melting snow patch, *1267*. Wein et al. (1974) extended the range from the British Mountains south into the central Richardson Mountains. My collection further extends the range to the southern Richardson Mountains towards collections from the Mackenzie Mountains.

Cruciferae
Eutrema Edwardsii. Site 22: along seepage channel through shale fellfield, *1191*. This collection lies outside of Hultén's limit and bridges the gap between localities in the northern Richardson Mountains and the Mackenzie Mountains.

Smelowskia borealis. Site 22: common on limestone scree, *1180*. Although collected several times in the northern Yukon near the Alaska-Yukon border, this is the first collection from the Richardson Mountains, extending the range eastward, as well as northward from the Mackenzie Mountains.

Saxifragaceae
Saxifraga foliolosa var. *foliolosa*. Site 6: gravelly lakeshore, *1430*. Although within Hultén's predicted range, this is only the third published collection from the Yukon and the first from the north.

Rosaceae
Geum macrophyllum ssp. *perincisum*. Site 18: weedy on riverbank, *1549*. This is the second collection for the northern Yukon and extends the range northward just beyond Hultén's predicted limit.

Potentilla pennsylvanica. Site 15: on south facing bluff dominated by *Artemisia frigida, 182*. This is the first collection for the northern Yukon and falls outside of Hultén's predicted limit.

Sanguisorba officinalis. Site 16: common along riverbank, *75*; site 10: abundant along riverbank, *970*. These collections extend westward the range from the Alaska-Yukon border to beyond Hultén's predicted range.

Halagoraceae
Myriophyllum spicatum (M. exalbescens). Site 12: commonly scattered in water 0.5 to 1.5 m deep in thermokarst lake, *755, 762*, and *800*. These are the first collections from the northern Yukon and they are within Hultén's predicted range.

Umbelliferae
Cicuta mackenzieana. Site 20: forming outer fringe of *Menyanthes* mat in thermokarst lake, *649*; site 17: scattered in marsh, *689*. These collections are within Hultén's predicted range and the first for the northern Yukon.

Pyrolaceae
Pyrola chlorantha. Site 22: locally abundant in White Spruce woods on limestone slope, *1287*. Previously collected in the Yukon from south of the Ogilvie Mountains, this is the first collection from the northern Yukon, north of Hultén's predicted limit in the Yukon and west of collections from the Mackenzie District.

Plumbaginaceae
Armeria maritima ssp. *arctica*. Site 1: coastal sand dunes, *411*. A coastal plant that rarely occurs inland, this taxon is new to the flora of the Yukon Territory although its occurence along the north coast was expected.

Boraginaceae
Lappula occidentalis (L. Redowskii var. *occidentalis)*. Site 14: abundant on south-facing silty bluff with *Artemisia frigida, 707*; site 10: dry, south-facing bluff, *980*. These are the first collections from the northern Yukon, extending the range north from Hultén's limit in the southern Ogilvie Mountains.

Scrophulariaceae
Veronica Wormskjöldii ssp. *alterniflora*. Site 22: occasional in lush growth of herbs and shrubs below late-melting snow patch, *1269*. This collection appears to be the first for the northern Yukon and extends the range north beyond Hultén's predicted limit.

Plantaginaceae
Plantago major var. *Pilgeri*. Site 10: occasional along silty riverbank, *916* and *917*. This is the first collection from the northern Yukon and only the second from the Yukon; the other is from near Dawson.

Campanulaceae
Campanula aurita. Site 22: in turf of open subalpine White Spruce stand on south-facing limestone ridge, *1169*. Previously reported from the westernmost extent of the Ogilvie Mountains in the southwest corner of the northern Yukon and from the vicinity of Rampart House of the Alaska-Yukon border, this collection lies beyond Hultén's predicted limit bridging the gap between collections from the eastern Brooks Range and the northern Mackenzie Mountains.

Compositae
Antennaria rosea. Site 14; under Balsam Poplar along rocky Pleistocene beach line, *195*. This is the first collection from the northern Yukon. It is beyond Hultén's predicted limit and extends the range northward from the central Yukon.

Artemisia biennis. Site 10: occasional along riverbank, *961*. This is the first collection for the Yukon Territory where Hultén did not predict its occurrence. It is probably an introduction arising from the boat traffic that historically entered the northern Yukon from the Mackenzie District via the Peel, Rat, Bell, and then Porcupine rivers.

Artemisia furcata (A. hyperborea). Site 1: coastal dunes, *403*. The first collection from the northern Yukon, extending the highly fragmented range northwestward from the Mackenzie District to the Yukon coastal plain.

Erigeron elatus. Site 15: wet areas of 20-30 year-old forest fire, *363*. The first record for the northern Yukon, it lies beyond Hultén's predicted limit.

Petasites palmatus. Site 22: locally common in rich spruce woods on side of moraine, *1225*. An uncommon plant in the Yukon, it has been collected only once previously in the north near the Old Crow River. This collection is the first for the Richardson Mountains and reduces the gap between the apparently disjunct populations in the northern Yukon and lower Mackenzie River area from the principal distribution farther south.

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Habitat Segregation by Stream Darters (Pisces: Percidae) in the Thames River Watershed of Southwestern Ontario

JOHN ENGLERT[1] and BENONI H. SEGHERS[2,3]

Department of Zoology, University of Western Ontario, London, Ontario N6A 5B7
[1]Present address: MacLaren Plansearch Corporation, Suite 401 – 750 West Pender St., Vancouver, B.C. V6C 2T7
[2]Present address: Kananaskis Centre for Environmental Research, University of Calgary, Seebe, Alberta, T0L 1X0
[3]Author to whom correspondence should be addressed

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Habitat segregation among five species of darters was studied in the Thames River watershed of southwestern Ontario during May–September in 1977 and 1978. Direct underwater observations and quantitative net sampling demonstrated that each species occupied a wide range of habitats; however, some degree of segregation was found. Rainbow (*Etheostoma caeruleum*) and Greenside (*E. blennioides*) darters predominated in riffles and Johnny (*E. nigrum*) and Blackside (*Percina maculata*) darters were found mainly in pools or raceways. Fantail Darters (*E. flabellare*) were common in both riffles and raceways.

Key Words: darter, *Etheostoma blennioides, Etheostoma caeruleum, Etheostoma flabellare, Etheostoma nigrum, Percina maculata,* Percidae, habitat segregation, Thames River, Ontario.

Six species of darters (Family Percidae, Subfamily Etheostomatinae) occur sympatrically in streams of the Thames River watershed in southwestern Ontario. Darters are small benthic fish in which the swim bladder is greatly reduced or absent. Habitat segregation was studied for five species: the Blackside Darter (*Percina maculata*), Johnny Darter (*Etheostoma nigrum*), Rainbow Darter (*E. caeruleum*), Greenside Darter (*E. blennioides*) and Fantail Darter (*E. flabellare*). The sixth species found in the Thames River watershed is the Least Darter (*E. microperca*) but it was excluded from this study because its small size and cryptic behavior in dense vegetation made observation difficult.

Few studies of the ecology and behavior of darter populations in Canada have been made. Resource partitioning has been examined in Johnny and Blackside darters in Manitoba (Smart and Gee 1979) and in Rainbow, Fantail, Johnny and Least darters in southern Ontario (Paine et al. 1982). The Greenside and Rainbow darters are restricted in Canada to southern Ontario (Scott and Crossman 1973) and the Greenside Darter has been classified as rare by McAllister and Gruchy (1977).

Study Areas and Methods

Using a faceplate and snorkel, direct underwater observations of darters were made mostly in Medway Creek, approximately 12 km north of London, Ontario, between May and September in 1977 and 1978. Medway Creek is a 36-km tributary of the Thames River and is characterized by a low gradient and diverse bottom ranging in composition from silt to boulder.

Darter habitats were categorized after Winn (1958a) as follows: a riffle is shallow, fast-moving water; a pool is deep, slow-moving water; a raceway is intermediate between riffle and a pool. For rocky bottoms, average stone diameter was estimated and substrate type was classified after Jenkins and Burkhead (1975): gravel, 0.3-8.0 cm.; rubble, 8.0-30 cm.

Because it was easy to differentiate male and female Rainbow Darters in the field (males have brighter blue and orange coloration), each sex was treated as a distinct group. Sexual differences in habitat selection may also occur in the other species (Lachner et al. 1950; Winn 1958a, b) but our attempts to sex them in the field were unreliable.

Quantitative data were collected by seining in a 360 m section of the Middle Thames River, approximately 24 km east of London, Ontario. The river is generally shallow (maximum depth following spring run-off is less than 2 m) and slow-moving (Bietz 1980). The sampling periods were 21-30 June and 25 August — 16 September 1978. A seine net 6.1 m long and 6.4 mm in mesh diameter was used. Each seine haul consisted of an approximately 11 m long sweep upstream and towards shore; four sites were sampled (Table 1). Water velocity was measured with a flow meter 4 cm from the bottom. The most common macrophytes were *Heteranthera dubia, Myriophyllum* sp., *Elodea canadensis, Potamogeton crispus* and *P. pectinatus* (Bietz 1980). The downstream raceway was slower and deeper than the upstream raceway. The cove site was adjacent to a section of stream similar to the upstream raceway site, but displayed greater variation in water velocity and depth.

TABLE 1. Habitat characteristics of darter collection sites in the Middle Thames River, Ontario (7 July, 1978). Water velocity and depth data are based on a series of measurements (¼, ½, ¾ distance) across the stream. s = standard deviation; C = coefficient of variation.

		Habitat			
		Downstream Raceway	Riffle	Upstream Raceway	Cove
Water velocity (m/sec)	$\bar{x}$	0.029	0.244	0.074	0.138
	s	0.022	0.056	0.023	0.106
	C	75.9%	23.0%	31.1%	76.8%
Water depth (cm)	$\bar{x}$	34.6	21.8	21.4	24.9
	s	9.5	3.0	4.7	9.0
	C	27.5%	13.8%	22.0%	36.1%
Vegetation cover (%)		30	15	45	50
Substrate type		silt, gravel	gravel rubble	rubble	silt, gravel

Results

Underwater observations in Medway Creek revealed that Greenside and Rainbow darters were usually the most common species in riffle areas. Greenside Darters generally occurred over rubble and Rainbow Darters over gravel bottoms. Female Rainbow Darters were found in both raceways and riffles whereas male Rainbow Darters were common only in riffles. Fantail Darters were also found in riffles but unlike Greenside or Rainbow darters were more abundant in shallow water (i.e. < 35 cm). Fantail Darters were most common in riffles or raceways with a rubble bottom. Johnny and Blackside darters occurred mainly in pools or raceways but could also be observed in the relatively quiet waters along the edge of riffles or behind large rocks. Blackside Darters showed no clear preference for any particular substrate; however, Johnny Darters were most common over sand or silt bottoms.

In the Middle Thames River there were no apparent seasonal changes in habitat utilization from June to September and thus the quantitative data from the two sampling periods were combined. Because some collection sites were seined more frequently than others, the results were standardized by dividing the raw data by the number of seine hauls at each site (catch per unit effort, see Table 2). Seining was most difficult in the riffle site due to the high water velocity. The rubble bottom of the upstream raceway also reduced seining efficiency as did the macrophytes in the cove site. Consequently, more emphasis was placed on comparing darter abundance within than among the different collection sites.

In the riffle site, Rainbow and Greenside darters were the most abundant species; surprisingly, female Rainbow Darters were significantly more common than males ($\chi^2 = 4.83$, $p < 0.05$). They were also more common in the downstream raceway ($\chi^2 = 11.04$,

TABLE 2. Number of darters captured in the Middle Thames River, Ontario (June 21-30 and 25 August — 16 September 1978) expressed as the catch per unit effort. Numbers in parentheses are the percentage of the total catch of each species occurring at the different sites. Male and female Rainbow darters are tabulated separately; for comparisons among species these data should be summed.

Site	Number of seine hauls	Total darters	Catch per unit effort					
			Blackside	Johnny	Rainbow (F)	Rainbow (M)	Greenside	Fantail
Downstream Raceway	23	419	4.9 (49.0)	3.5 (46.1)	3.2 (32.7)	1.7 (20.5)	4.9 (31.2)	0.1 (1.9)
Upstream Raceway	20	223	0.2 (2.0)	1.0 (13.2)	2.1 (21.4)	3.2 (38.6)	2.4 (15.3)	2.3 (44.2)
Riffle	12	101	0.6 (6.0)	1.2 (15.8)	2.0 (20.4)	0.9 (10.8)	2.8 (17.8)	0.9 (17.3)
Cove	15	279	4.3 (43.0)	1.9 (25.0)	2.5 (25.5)	2.5 (30.1)	5.6 (35.7)	1.9 (36.5)
Totals	70	1022	10.0	7.6	9.8	8.3	15.7	5.2

$p < 0.01$), but less common than males in the upstream raceway ($\chi^2 = 4.57$, $p < 0.05$). The greatest proportion of Blackside and Johnny darters occurred in the downstream raceway; Rainbow and Greenside darters were also common at this site. Most of the Fantail Darters were caught in the upstream raceway; however, Rainbow Darters were the most abundant species. The cove site contained a large proportion of the total catch of all five species. Presumably, this reflects in part the large variation in habitat characteristics at that site.

Discussion

Differences in behavior and morphology may have resulted in some variation in catchability among the different darter groups. Blackside Darters are usually less benthic than the other species (Englert 1979; Smart and Gee 1979) and therefore may be more vulnerable to seining. Another potential source of sampling bias is the antipredator behavior of the different species, e.g. in response to a splashing stimulus Greenside Darters normally show a greater avoidance distance and Fantail Darters have a greater tendency to dive under cover than the other species (Englert 1979). Nevertheless, these data do provide a general description of the main habitat and relative abundance of each species in the upper Thames River watershed.

The findings here generally support the existing literature on darter populations elsewhere. Winn (1958a) found Greenside, Rainbow and Fantail darters in fast rubble or gravel riffles. Fahy (1954) and Miller (1968) observed Greenside Darters in algae-covered rocky riffles and raceways. Fantail Darters have been reported in fast riffles (Lake 1936) and rock riffles (Page and Schemske 1978). Winn (1958a) observed Johnny and Blackside darters in slower and deeper raceways; however, Smart and Gee (1979) found wide tolerances for water velocity and substrate type by both species. Lachner et al. (1950) captured Blackside Darters in riffles, but near the shoreline, where much vegetation was present and water velocity was reduced.

In Ontario, Paine et al. (1982) reported that Rainbow and Fantail darters were the dominant species in riffles and Johnny and Least darters were dominant in weed beds. Similarly, Grant (unpublished manuscript), seining in Medway Creek near our study site, found Johnny Darters in bare pools and vegetated stream edge habitats whereas Greenside, Rainbow and Fantail darters were captured primarily in riffles.

It appears these five species of darters partition the available physical environment to some extent by segregating into different habitats. In the Thames River watershed, the critical riffle habitat often appears limited, especially during periods of low water level in the summer. This may force a greater overlap in habitat among the different species than expected. During periods of high water in the spring, however, these species may segregate more strongly due to major differences in their reproductive behavior (Winn 1958a, b).

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Aquatic Plants in Lake Superior Provincial Park in Relation to Water Chemistry[1]

D. Fraser[2,4] and J. K. Morton[3]

[1]Ontario Ministry of Natural Resources, Wildlife Research Section, Contribution No. 82-01.
[2]Ontario Ministry of Natural Resources, Wildlife Research Section, Box 50, Maple, Ontario L0J 1E0
[3]Department of Biology, University of Waterloo, Waterloo, Ontario N2L 3G1
[4]Present address: Animal Research Centre, Agriculture Canada, Ottawa, Ontario K1A 0C6

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Species of submersed and floating-leafed aquatic plants and chemical composition of the water were studied in 14 lakes on the Canadian Shield in Lake Superior Provincial Park, Ontario. Most lakes were carbonate-poor and had typical softwater floras. Two lakes of higher alkalinity contained several hardwater species that were rare elsewhere in the park. Winter de-icing salt affected water chemistry in several roadside lakes, but had little apparent influence on plant species composition.

Key Words: aquatic plants, Canadian Shield, water chemistry, salt.

Despite considerable work in other environments, there has been little study of aquatic vegetation in relation to water chemistry on the Canadian Shield. Species lists for some southern Shield areas are given by Aiken and Gillett (1974), Crowder et al. (1977), and Miller and Dale (1979). Moyle's (1945) study of aquatic vegetation in relation to water chemistry included some Shield areas in northeastern Minnesota.

In the following study, we recorded species of aquatic plants and water chemical composition in 14 Shield lakes in Ontario. Because several of the lakes were near a major highway, the study also gives some information on vegetation in lakes contaminated with highway de-icing salt.

Study Area

The study was done in Lake Superior Provincial Park, a 1555-km^2 area on the east shore of Lake Superior. The Park is dominated by boreal forest in the north and Great Lakes-St. Lawrence forest in the south (Rowe 1972). Outcropping rock consists mainly of igneous and metamorphic rocks of early Precambrian age, as well as some more recent volcanic and sedimentary formations (Ontario Division of Mines 1971). The Park has a rugged terrain with elevations ranging from 200 to 600 m. Many of the lakes have rocky shorelines and mineral-poor water.

An 85-km section of Trans-Canada Highway runs through the Park. Because of icy road conditions between November and April, rock salt (NaCl) is applied at a rate of 30 to 40 tonnes/km of highway each winter, as estimated by highway officials.

Of the 14 lakes studied (Table 1), 11 were chosen because of easy road access, and because they gave a variety of sizes, depths, and shoreline types. Boulder Lake was included because previous study (Ontario Ministry of Natural Resources, unpublished data) indicated a relatively high total alkalinity. North and South Tugboat Lakes were included because their contact with sedimentary rock was expected to produce relatively mineral-rich water.

Methods

Each lake was visited once between 19 July and 7 August 1980. The observer paddled slowly around the shoreline in a canoe, zig-zagging over all areas where vegetation could be seen. All submersed and floating-leafed plants were noted, and their abundance in the lake was scored subjectively from rare (1) to abundant (7). Voucher specimens were pressed and deposited in the herbaria of the University of Waterloo and Lake

TABLE 1. Geographic location of the 14 lakes, and minimum distance from the Trans-Canada Highway

Lake	Location		Distance from highway (km)
Doc Greig	47°29′N,	84°48′W	<0.1
Rustle	47°32′N,	84°48′W	0.3
Sickle[1]	47°34.5′N,	84°49′W	<0.1
Crescent	47°17′N,	84°33′W	0.8
Collette	47°43′N,	84°49′W	<0.1
Mom	47°33′N,	84°48′W	<0.1
Kenney	47°17′N,	84°34′W	<0.1
Dead Otter	47°38′N,	84°48′W	<0.1
Moose	47°50′N,	84°53′W	<0.1
Rabbit Blanket	47°45′N,	84°50′W	<0.1
Mijin Pond[1]	47°41′N,	84°49′W	<0.1
Boulder[1]	47°52′N,	84°52′W	<0.1
South Tugboat[1]	47°35′N,	85°1.5′W	15
North Tugboat[1]	47°35.5′N,	85°2′W	15

[1]Names assigned, for the purpose of this study, to unnamed lakes.

Superior Provincial Park. Some species in North Tugboat Lake were recorded merely as "Present" or "Absent" because of the limited time available at that location.

A 1-L mid-lake surface water sample was collected from each lake. Water was analyzed for specific conductance, total alkalinity (equal to bicarbonate alkalinity), and for other major cations and anions (Table 2) at the Ontario Ministry of the Environment laboratory, Rexdale, Ontario, according to standard laboratory techniques (Ontario Ministry of the Environment 1975).

Latin names of plants follow Fernald (1950) except where more recent work has indicated a need for revision. Common names have been included where available. For plants considered to be rare in the study area, known ranges were checked from Scoggan (1978) and by consulting specimens in the herbaria of the National Museum of Canada in Ottawa (CAN), of the Biosystematics Research Institute, Agriculture Canada in Ottawa (DAO), of the Department of Botany, University of Toronto (TRT), and of the Department of Biology, University of Waterloo (WAT).

Results and Discussion

Most of the lakes had "soft" water (TA < 40 ppm, as defined by Moyle (1945)) typical of granitic areas of the Canadian Shield (Table 2). North and South Tugboat Lakes were slightly more alkaline, presumably because of carbonates in the sedimentary and volcanic bedrock in their area. In most lakes, Ca and bicarbonate (as reflected by TA) were the major ions, and their levels were closely correlated (Figure 1). However, Moose Lake, Mijin Pond and Boulder Lake had very high levels of Na and Cl, presumably derived from salt applied to the highway in winter (Table 2). These lakes had higher levels of Ca than would be expected based on TA (Figure 1). Extra Ca may have been introduced into these lakes by an ion exchange between soil and ground water caused by the high levels of dissolved NaCl. The four lakes located more than 0.1 km from the highway had very low levels of Cl compared with the other ten lakes. Much of the Cl in the study lakes is probably derived from the highway.

TABLE 2. Water chemistry of the 14 lakes, including total alkalinity (TA) in ppm of $CaCO_3$, specific conductivity (SC) in μmhos/cm, and other cations and anions in ppm

Lake	TA	SC	Na	K	Ca	Mg	Cl	SO_4
Doc Greig	4	28	0.9	0.4	2.2	0.6	0.6	8.0
Rustle	7	33	0.9	0.2	3.6	0.6	0.6	7.5
Sickle	8	41	2.0	0.5	3.8	0.8	2.7	6.5
Crescent	8	32	1.2	0.5	2.8	0.6	0.2	7.0
Collette	10	95	9.6	0.7	5.6	0.6	15.5	8.0
Mom	12	65	3.3	0.5	5.8	1.1	4.7	9.5
Kenney	16	75	5.3	0.7	5.4	1.3	7.3	7.5
Dead Otter	17	70	3.5	0.6	7.2	1.3	6.0	7.5
Moose	21	315	42	0.8	13.2	1.8	78.0	11.0
Rabbit Blanket	22	80	2.9	0.7	8.4	1.4	4.7	8.0
Mijin Pond	25	230	28	0.5	13.2	1.3	48.0	10.0
Boulder	40	265	24	0.7	20	2.6	46.0	13.0
South Tugboat	48	100	2.6	0.3	11.2	3.2	0.5	6.0
North Tugboat	53	130	2.9	0.6	15.8	3.7	0.5	11.0

Submersed and floating-leafed plants in the 14 lakes are listed in Table 3. Typical emergent species, not listed in Table 3, included *Eleocharis palustris* (Spike-rush), *Equisetum fluviatile* (Horse-tail), *Hypericum ellipticum* (St. John's-wort), *Sium suave* (Water-parsnip), *Sparganium chlorocarpum* (Bur-reed), *Typha latifolia* (Common Cat-tail), *Dulichium arundinaceum* (Three-way Sedge), *Iris versicolor* (Blue Flag), and *Sagittaria latifolia* (Arrowhead). *Cardamine pensylvanica* (Bittercress) was found growing partly submersed in a cold-water seepage area in Kenny Lake. *Myriophyllum tenellum* may be more common in the Park than Table 3 indicates: although flowering specimens were first noted in Doc Greig Lake near the end of the field work, small non-flowering stems seen in other lakes may have belonged to the same species.

Potamogeton illinoiensis is somewhat outside its known range in Ontario. It was found only in Kenny Lake, which is immediately beside the highway, and could have been introduced by the considerable human activity in the area. *Utricularia purpurea* is also well north of its known range in Ontario. It was found only in Collette Lake, and was totally submerged in 2 to 4 m of water. The unusually clear water of Collette Lake allowed the plant to be seen at these depths. It would easily be overlooked if it occurred at similar depths in other lakes in the area.

Myriophyllum farwellii is listed as a rare vascular plant in Ontario by Argus and White (1977). However, it was reasonably common in two lakes in our area, and also common in a northern Ontario lake about 120 km to the east (Fraser et al. 1980).

Alkalinity of the water appeared to be the major factor influencing the plant species composition of the different lakes. The two most alkaline sites, North and South Tugboat Lakes, contained several species not found in the more softwater lakes, and not collected previously in the Park (Table 3). Of these, *Potamogeton pectinatus, P. foliosus, P. richardsonii* and *Elodea canadensis* are listed as hardwater plants by Moyle (1945), and occur in other lakes of similar alkalinity in the Lake Superior area (unpublished data). Similarly, Swindale and Curtis (1957) include *Potamogeton pectinatus, P. richardsonii* and *Myriophyllum exalbescens* in a group of species found in mineral-rich water.

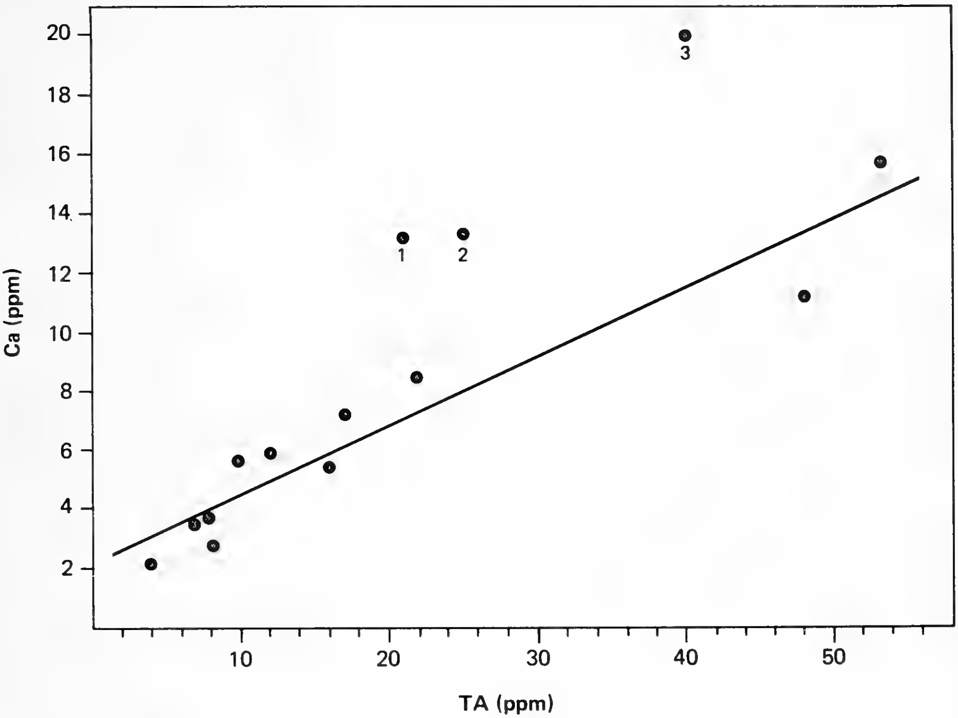

FIGURE 1. Relation between Ca and TA in the water of 14 lakes in Lake Superior Provincial Park. The regression line is based on 11 lakes, omitting (1) Moose Lake, (2), Mijin Pond, and (3) Boulder Lake, which had unusually high levels of Ca relative to TA. The anomaly is likely related to the high levels of Na and Cl, presumably derived from highway salt, in these three lakes.

Lakes of lower alkalinity generally included typical softwater species such as *Lobelia dortmanna, Eriocaulon septangulare, Scirpus subterminalis,* and *Isoetes echinospora* (Table 3). *Potamogeton epihydrus* was one of the most abundant pondweeds. These features are similar to the softwater Shield flora described in Minnesota by Moyle (1945), in softwater Ontario lakes by Miller and Dale (1979), and in the three most mineral-poor lakes studied by Crowder et al. (1977). Also, Keddy (1981) noted similar species in the very soft water of Axe Lake near Georgian Bay, Ontario, and Swindale and Curtis (1957) included *Eriocaulon septangulare, Potamogeton epihydrus,* and *Myriophyllum tenellum* in their group of plants with softwater affinities. *Sparganium angustifolium, Nuphar variegatum* and *Nymphaea odorata* were common in the softwater lakes studies here, but are also common in more alkaline waters in the Lake Superior area and elsewhere (unpublished data).

Despite their high NaCl content and high specific conductivity, Moose Lake, Mijin Pond, and Boulder Lake retained a flora fairly typical of other lakes of similar alkalinity. However, *Scirpus subterminalis, Isoetes echinospora* and *Lobelia dortmanna* were absent from the three salt-rich lakes although common in other lakes, including Rabbit Blanket Lake which had similar alkalinity. This may have been a chance effect, or it may be related to the salt content of these lakes. In southern Ontario, concentrations of highway salt appear to have caused major changes in roadside floras (Catling and McKay 1980). In lake water, however, highway salt forms more dilute solutions and presumably has less pronounced effects on the vegetation.

TABLE 3. Submersed and floating-leafed aquatic plants in the 14 lakes, with lakes arranged in order of decreasing alkalinity. Plant abundance was scored subjectively from rare (1) to abundant (7). Presence (P) was noted if abundance could not be estimated. Plants at the top of the list were found mainly in lakes of high alkalinity, those at the bottom mainly in lakes of low alkalinity

	North Tug-boat	South Tug-boat	Boulder	Mijin Pond	Rabbit Blanket	Moose	Dead Otter	Kenny	Mom	Collette	Cres-cent	Sickle	Rustle	Doc Greig
Callitriche verna (Water-starwort)	1													
Potamogeton pectinatus (Sago Pondweed)[1]	3													
P. foliosus[1]	P	2												
P. richardsonii (Red-head Pondweed)[1]	3	3												
Eleodea canadeusis (Waterweed)[1]	5	5												
Myriophyllum exalbescens (Water Milfoil)[1]	5	5												
Najas flexilis[1]	P	5	3			3	3							
Potamogeton amplifolius	P	5				5	6	3						
P. gramineus	3	5	3		5		4			3				
Characeae (algae)	1	4		7	3	5	5				3	5		
Hippuris vulgaris (Mare's-tail)[1]	3		3		2		6					3		
Potamogeton robbinsii			7											
Myriophyllum farwellii (Water Milfoil)[1]			3			3								
Potamogeton praelongus (White-stem Pondweed)			5					1						
P. alpinus[1]			5									5		
P. epihydrus	5			3	5	1	5	5	3	3	5	6	5	
Utricularia vulgaris (Bladderwort)	P		5	6	3		5				5	5	4	
Sparganium angustifolium	3		3		3	3	4	3	1	4		5	1	3

TABLE 3 (*continued*).

	North Tug-boat	South Tug-boat	Boulder	Mijin Pond	Rabbit Blanket	Moose	Dead Otter	Kenny	Mom	Collette	Cres-cent	Sickle	Rustle	Doc Greig
Potamogeton natans		3		4	3	5	5						4	
Eleocharis acicularis		2	3			7			1	3	4	7	5	
Myriophyllum alterniflorum (Water Milfoil)					3		3	3		2				
Sparganium fluctuans							5							
Potamogeton illinoiensis[1]								3						
Utricularia intermedia			4	1	1	6	5				6	7	4	
U. minor[1]						4	1				3			
U. purpurea[1]											3			
Nymphae odorata (Fragrant Water-lily)			5	7			6						7	
Nuphar variegatum (Bullhead-lily)			5	7	3	6	6	3	4	3	4	1	5	2
Eriocaulon septangulare (White buttons)				4	3		3	3	1	4	5		7	5
Polygonum amphibium (Water-smartweed)						1								2
Potamogeton spirillus[1]												5		
Ranuculus reptans (Creeping Spearwort)												5		
Scirpus subterminalis (Swaying Rush)[1]					7		6			1			1	
Isoetes echinospora (Quillwort)					2					3		3		2
Lobelia dortmanna (Water-lobelia)					3		5	5		1	5			5
Myriophyllum tenellum (Water Milfoil)														5

[1] Additions to Lake Superior Provincial Park Plant checklist

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Avian Breeding and Occurrence Notes from the Sutton Ridges Area of Northeastern Ontario.

R. D. JAMES,[1] J. A. DICK,[1] S. V. NASH,[1] M. K. PECK,[2] and B. E. TOMLINSON[3].

[1]Department of Ornithology, Royal Ontario Museum, 100 Queen's Park, Toronto, Ontario M5S 2C6
[2]25 Stewart St., Oakville, Ontario L6K 1X3
[3]P.O. Box 1524, Bracebridge, Ontario P0B 1C0

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After two summers of fieldwork on birds in the Sutton Ridges area of northeastern Ontario, we report breeding range extensions for seven species, and probable extensions for four species; the first breeding records from the northern Hudson Bay Lowland for seven species, and additional information on the breeding, possible breeding or occurrence for 27 species. A previously published error is corrected.

Key Words: Sutton Ridges, Hudson Bay Lowland, birds, breeding range, distribution.

The Sutton Ridges are a series of discontinuous Precambrian rock outcrops lying in a northwest-southeast orientation from a point about 80 km south of Winisk (54°37′N, 84°59′W) to 150 km southeast (54°05′N, 84°04′W). The geology and vegetation are outlined by Sjörs (1961). The Ridges are completely surrounded for many kilometers by the Hudson Bay Lowland (HBL) roughly corresponding in extent to the Hudson Bay Lowland Forest Region of Rowe (1959). This lowland is a relatively flat plain covered with extensive fens and bogs, that extend among the ridges. Associated with the relatively dry upland ridges are more extensive stands of spruce forest than is usual in the surrounding wetlands. Also, in this subarctic environment, the only deciduous trees occur as isolated groves in the shelter of the ridges. The unique character of the vegetation is reflected in a recent report of five species of vascular plants from the Ridges previously unknown in Ontario (Riley 1979).

The birds of this area were formerly studied by D. H. Baldwin, who visited Sutton, Hawley and Aquatuk lakes areas in 1962, 1964 and 1965 as described by Schueler et al. (1974). Additional fieldwork was undertaken in 1980 and 1981 to add to our rather meagre knowledge of northern Ontario birds in general and to try to answer specific questions raised by previous fieldwork. J. A. Dick, S .V. Nash and B. E. Tomlinson spent from 2 June to 5 July 1980 at Aquatuk Lake (54°22′N, 84°33′W), and Tomlinson remained there until 15 August. R. D. James, S. V. Nash and M. K. Peck surveyed the Kiruna Lake area (54°30′N, 84°55′W) from 9 June to 16 July 1981, with Peck remaining until 10 August.

The HBL occupies one-quarter of the northern part of Ontario, but apart from the aforementioned studies in and around the Ridges, Canada Goose studies at Kinoje Lake, and work along the coasts of Hudson and James bays, no intensive studies have been published about any of this virtually uninhabitated region. Thus, we have considered all species reported from the drier ridges as well as from the intervening and nearby lakes and lowlands readily accessible on foot from the ridges. The following species accounts outline breeding and occurrence records supplementing those previously reported by Schueler et al. (1974). Some additional information of interest, particularly as related to nesting, has been included. Unless otherwise indicated, general statements about the known northern extent of species ranges in the HBL come from Godfrey (1966) and more specific statements about the numbers of records available and their distribution in Ontario come from Peck and James (1983) or Peck and James (Breeding birds of Ontario: nidiology and distribution. Vol. 2: passerines. *in preparation*). Specimens are deposited in the Royal Ontario Museum (ROM) and the numbers quoted are ROM catalogue numbers. The "Photorecord Number" assigned to pictures in ROM files is abbreviated to "PR". ONRS refers to the Ontario Nest Record Scheme.

Species Accounts

COMMON LOON *Gavia immer*. Although known to summer north to Hudson Bay, a female with an egg in the oviduct (Schueler et al. 1974) and a nest record from Kinoje Lake (ONRS) about 250 km farther south were the only evidence of breeding in the HBL of Ontario. A nest with two eggs was found 11 June 1980 (12647) and pairs with young were seen 3 July, 6 July (2 young each) and 15 July (1 young) 1981. A single downy young with several large scars and partially paralyzed legs and feet (possibly the result of a Northern Pike, *Esox lucius*, attack) was secured 15 July 1981 (140115).

GREAT BLUE HERON *Ardea herodias*. A single individual seen 19 June 1980 was about 350 km north of the nearest known nesting (Cray et al. 1980) at 51°40′N, 87°37′W. As the Ridges are about the same latitude as heronries in northwestern Ontario (McLaren and McLaren 1981a), this observation suggests the possibility that Great Blue Herons breed in the HBL where records are currently lacking.

NORTHERN PINTAIL *Anas acuta*. Although widespread along the north coast, records of breeding from the HBL interior are few. Baldwin saw a female with 8 young on 5 July 1964 at Aquatuk Lake (unpublished journal p. 64) and a female with 5 young on 19 July 1964 on the Sutton River south of the Warchesku River (journal p. 94). A female with 9 downy young (three collected, 139855-57) on 25 June 1981 represents only the third inland HBL breeding record available to us.

RING-NECKED DUCK *Aythya collaris*. This species was not seen at Hawley Lake in 1964 or 1965 (Schueler et al. 1974). But K. Reynolds (in Lee 1978) is reported to have considered this species the most abundant duck at Hawley Lake by 1975. However, although we initially identified some ducks we saw as being of this species, all collected birds were verified as being Lesser Scaup (see below) and we have no definite record of Ring-necked Duck in either 1980 or 1981, and there is no verified record of this species in the Sutton Ridges.

LESSER SCAUP *Aythya affinis*. One of the most numerous of ducks seen in both 1980 and 1981. However, all males had atypically dark backs, and breeding females did not have distinct white patches at the base of the bill, such that they all appeared at first glance to be Ring-necked Ducks. Three males (140027-29) and two females (140009, 140027) were collected. One female 29 June 1981 had 9 collapsed follicles, and the other on 2 July 1981 had 5 collapsed follicles. Eight flightless young 13 Aug. 1980 (one collected 137128) and 2 eggs from a nest 2 July 1981 (12725) represent the first documentation of breeding in the HBL in Ontario.

COMMON GOLDENEYE *Bucephala clangula*. Both males and females were seen nearly every day in 1980, but less often in 1981. The occurrence of this species throughout the HBL in summer (Godfrey 1966) and the presence of several tree cavities of sufficient size to accommodate this species suggests that they could breed in the Ridges area. However, no evidence of breeding was obtained and we are aware of no HBL breeding records except at Moosonee.

SURF SCOTER *Melanitta perspicillata*. Small numbers were observed throughout the summers of 1980 and 1981. Flightless young were secured 8 and 18 July 1980 (137131-33) and a group of seven flightless young was photographed 5 August 1981 (PR 1255). These represent only the second and third breeding records in Ontario. With the first record from Shagamu Lake (Simkin 1963) and one record from Churchill (Faanes 1981) we still have only a poor idea of the extent of this species' range in the HBL.

WHITE-WINGED SCOTER *Melanitta fusca*. We saw single birds on several occasions in 1981, but no evidence of nesting was seen. The only nest record in the HBL away from the Churchill, Manitoba, area (Faanes 1981) was at Cool Lake (54°30′N, 85°08′W), about 15 km west of Kiruna Lake.

HOODED MERGANSER *Lophodytes cucullatus*. Distinctively barred speculum feathers of this species were found in a Tree Swallow (*Tachycineta bicolor*) nest in 1980, but the ducks themselves were not seen. This species is not known to breed anywhere in the HBL, although they occur casually north to Churchill (Jehl and Smith 1970).

COMMON MERGANSER *Mergus merganser*. Females with 9 flightless young on 16 July and 24 July 1981 represent the first breeding records for the Ridges area, and one of only half a dozen breeding locations for the entire HBL. One young was collected 16 July 1981 (140126).

RED-BREASTED MERGANSER *Mergus serrator*. A female with 7 young was seen 6 August 1981. This represents the first breeding reported from the Ridges and, except in the Churchill area, only the second in the HBL.

BALD EAGLE *Haliaeetus leucocephalus*. Baldwin observed this species in 1964 at Hawley Lake (Schueler et al. 1974) and single adult birds were observed once in 1980 and several times in 1981. These observations indicate the possibility of breeding near the large Sutton and Hawley lakes, although no nests have been reported from the HBL.

GOSHAWK *Accipiter gentilis*. Although Goshawks were believed to occur throughout the HBL in the breeding season, there was only one previous breeding record north of Lake Nipigon in Ontario. A recently-fledged young was photographed in burned spruce forest 29 July 1981 (PR 1259) indicating that the 1964 record at Aquatuk Lake was not just an isolated incidence far north of the known range of this species.

GOLDEN EAGLE *Aquila chrysaetos*. On 21 June 1981 we located a large nest (2-3 m high) about 25 m up on a cliff face (PR 1260-62). The nest was not in use, but showed distinct layers as if used over several years. A small new stick platform was built on a ledge adjacent to the base of the large nest, and many Golden Eagle feathers were present in and about the nests. An immature Golden Eagle left the nest area as we approached. This is the fourth known nest site we are aware of that may still be active in Ontario or the entire HBL.

AMERICAN KESTREL *Falco sparverius*. Three individuals were seen together 11 June 1981 and a single bird 12 June 1981. No nests of this species are known from the HBL in Ontario or elsewhere, and these birds did not appear to remain in the area to nest.

SHARP-TAILED GROUSE *Tympanuchus phasianellus*. Numerous males were heard calling about Kiruna Lake in June 1981 and barely-flying young were obtained 31 July (140138) and 2 August 1981 (140140). This is the second breeding site known from the HBL in Ontario and about 300 km north of previous records. An additional breeding record is known from the HBL in Manitoba (McLaren and Renaud 1980).

SANDHILL CRANE *Grus canadensis*. We observed four birds 19 June 1981 and heard one 25 June 1981. These are the first reports from the Ridges, although the species is widespread in the HBL (Lumsden 1971; Riley, 1982).

KILLDEER *Charadrius vociferus*. A single pair was found in the same area on 2 July and 13 July 1981. They were very agitated and giving distraction displays, which strongly suggests that they were nesting. Breeding is known from coastal areas at Churchill (Jehl and Smith 1970), Winisk and Attawapiskat (Schueler et al. 1974) but previously unrecorded from the HBL interior.

GREATER YELLOWLEGS *Tringa melanoleuca*. The first nest to be documented in the province was at Aquatuk Lake 1 July 1980 (Nash and Dick 1981). Flightless juveniles taken at Kiruna Lake 4 July (139878) and 15 July 1981 (139905) document another breeding area. These are the only HBL records we are aware of and only one other Ontario breeding has been reported (McLaren and McLaren 1981a).

LESSER YELLOWLEGS *Tringa flavipes*. This species was encountered in pairs almost every day in late June and July 1981. Although no nests or young were seen, the birds were very agitated and one gave a distraction display on the ground. Undoubtedly they were breeding in the Kiruna Lake area. We are aware of only two other breeding sites in the HBL, at Aquatuk Lake (Schueler et al. 1974) and Fort Severn.

SHORT-BILLED DOWITCHER *Limnodromus griseus*. Two birds together on 22 June 1981 were feeding and not alarmed by our presence. A single bird collected (139852) had only slightly enlarged gonads. The subspecies of this and other dowitchers from northeastern Ontario requires further study. Although the salmon-coloured underparts and spotting are restricted as in *griseus*, the tail bars and dorsal coloration are most similar to *hendersoni*.

BONAPARTE'S GULL *Larus philadelphia*. The only nest records in Ontario for this species are from south of the HBL. Baldwin collected a female with an unshelled egg in its oviduct at Hawley Lake (Schueler et al. 1974) and we secured a female 23 June 1981 (139981) with three very large ova ready for ovulation. These birds were apparently preparing to nest nearby, about 300 km north of their previously reported range in Ontario, although they are known to nest also near Churchill (Jehl and Smith 1970).

BLACK TERN *Chlidonias niger*. This species apparently occurs "fairly commonly" in the southern parts of the HBL (P. Prevett, OMNR, undated checklist of birds of the HBL). Two adults were seen at Aquatuk Lake 11 June 1980. McLaren and McLaren (1981a) recorded four birds north to latitude 53° 50′N and the species has apparently bred near Churchill (Jehl and Smith 1970). They may occasionally breed in the Ontario HBL where no records are presently known.

MOURNING DOVE *Zenaida macroura*. An immature female 1 July 1981 (140023) and an adult male 12 July 1981 (140095) were collected in the Ridges about 600 km north of their known breeding range. Despite the male being in breeding condition and actively calling, we feel that these were probably only wandering individuals, as this species is known to wander widely (Godfrey 1966).

NORTHERN HAWK-OWL *Surnia ulula*. Three separate pairs with 3, 3 and 2 partially-fledged young were encountered 8 June, 21 June and 6 July 1981, respectively. One of the three young on 21 June was still in a very shallow nest cavity 2 m high in the top of a spruce snag at the edge of a river. The nest cavity, completely open on top, was 8 cm deep and the tree 24 cm wide at the nest. Although the species is known to range north to this latitude, only one bird was noted by Baldwin in

1964 and 1965 (Schueler et al. 1974) and none was seen in 1980. These breeding records (PR 1268-75) are about 500 km north of any previous documented reports and we know of no others in the HBL. A scarcity of suitably large nesting cavities did not seem to be a problem at this latitude.

LONG-EARED OWL *Asio otus*. On 14 July 1981 a partially fledged young was photographed near an obviously used nest in dense spruce forest (PR 1263-67). The nest was within a large growth of Dwarf Mistletoe (*Arceuthobium pusillum*) adjacent to the trunk of a Black Spruce (*Picea mariana*) about 5 m from the ground. This mistletoe was hollowed out from the top down through half the growth to form a platform of 35 × 60 cm that was open to one side as well as on top. This is the fourth nest record we are aware of in northern Ontario, some 650 km north of any previous Ontario record, and 350 km north of what was believed to be their northern limits in the province. Although we saw no large stick nests in trees that could be taken over by owls, there was no shortage of these mistletoe growths.

COMMON NIGHTHAWK *Chordeiles minor*. No nesting records yet exist for this species north of Moosonee (the only HBL site) and Sandy Lake. However, birds were present all summer at Kiruna Lake, and a female with ova enlarged to 4 mm was taken 20 June 1981 (139965). We believe they were breeding in the Ridges in 1981.

THREE-TOED WOODPECKER *Picoides tridactylus*. A nest record at Moosonee, a young bird from Aquatuk Lake 2 July 1980 (137177), and a nestling from Kiruna Lake 8 July 1981 (139887) are the only breeding records we are aware of for the HBL except from the Churchill area (Jehl and Smith 1970).

OLIVE-SIDED FLYCATCHER *Contopus borealis*. Although Godfrey (1966) indicated a range north almost to the Ridges, specific breeding records are lacking north of the latitude of Moosonee. We secured a female with an unshelled egg in the oviduct and one freshly collapsed follicle 10 July 1981 (140080) indicating that the birds, present throughout the summer, were breeding.

ALDER FLYCATCHER *Empidonax alnorum*. This species was not recorded in the Ridges area by Baldwin (Schueler et al. 1974), but males were singing on territory throughout the summers of 1980 and 1981. As yet we are aware of only one documented breeding site in the HBL at Fort Severn.

EASTERN KINGBIRD *Tyrannus tyrannus*. Two different adult birds were seen 14 June (139936) and 22 June 1981. Although well north of their known breeding range at the latitude of Moosonee, these observations, a sighting at Winisk (Schueler et al. 1974) and sightings at Churchill (Jehl and Smith 1970) suggest the possibility of occasional breeding much farther north in the HBL.

BOREAL CHICKADEE *Parus hudsonicus*. The species is known to summer north to the limit of trees, and to breed at Churchill (Jehl and Smith 1970). A single fledged young collected 12 July 1981 (139898) provided the first breeding record north of Fort Albany in Ontario.

BROWN CREEPER *Certhia americana*. On 15 July 1981 a family group of at least five birds was seen, and a single recently-fledged young was collected (139904). This observation is about 250 km north of their known breeding range. Single individuals also were seen at Aquatuk Lake in 1980, Winisk in 1965 (Schueler et al. 1974) and they were present at about the same latitude in eastern Manitoba (McLaren and McLaren 1981a, b), suggesting that sparse populations are to be found throughout the forested regions of the HBL.

WINTER WREN *Troglodytes troglodytes*. Several birds were heard singing throughout the summers of 1980 and 1981. Two adult males in breeding condition were collected 24 and 29 June 1980 (137248-49). A recent record from 54° N in the Manitoba Lowland (McLaren and Renaud 1980) also suggests that there are sparse populations in the forested portions of much of the HBL, well north of their previously known range.

GOLDEN-CROWNED KINGLET *Regulus satrapa*. On 2 July 1980 a female with an unshelled egg in its oviduct (137266), taken near Aquatuk Lake, provided the first evidence of breeding in the Sutton Ridges. Later in July 1980 a pair was observed carrying food to an apparent nest. On 15 July 1981 what appeared to be a family group was seen, and on 25 July 1981 young were found in a nest (12726, collected after use). These birds were some 300 km north of the nearest known summer populations in eastern Ontario. They have recently been found at the same latitude in eastern Manitoba (McLaren and McLaren 1981a, b) and we suspect that they breed throughout the spruce forests of northern Ontario.

RUBY-CROWNED KINGLET *Regulus calendula*. Although the range of this species was believed to include the whole of the HBL, a nest with eggs found 22 June 1981 (12713) represents the first breeding record north of Fort Albany or Big Trout Lake in Ontario.

SWAINSON'S THRUSH *Catharus ustulatus*. Not a single individual was encountered at Kiruna Lake in 1981, although they were among the commonest species about Aquatuk Lake in 1980. Schueler et al. (1974) reported a juvenile male (94524) from Hawley Lake. Since that catalogue number actually belongs to an adult male that record is erroneous. Sightings north to Churchill (McLaren and Renaud 1980), and nest records from Winisk and Fort Severn indicate that their range includes the whole of the forested portions of the Lowland.

HERMIT THRUSH *Catharus guttatus*. Baldwin collected a stubby-tailed male of this species (94525) at Hawley Lake 16 July 1964 (not reported in Schueler et al. 1974). We collected a recently fledged female 8 July 1981 (139888). These are the first documented breeding records for this species north of the latitude of Fort Albany in Ontario, and with a record from Churchill (Jehl and Smith 1970) indicate a range throughout the treed portions of the Lowland.

CEDAR WAXWING *Bombycilla cedrorum*. Birds in breeding condition were taken in 1964 (Schueler et al. 1974) and in 1980 (137276-77), and they have been seen in the HBL of northeastern Manitoba (McLaren and McLaren 1981b). These birds were about 200 km north of their previously outlined breeding distribution.

NORTHERN SHRIKE *Lanius excubitor*. A family group of recently fledged juveniles was encountered 12 July 1981. This confirmed breeding by this species in Ontario (James 1981), and with an earlier sighting (Manning 1982) is one of only two HBL records apart from Churchill area breeding (Jehl and Smith 1970).

SOLITARY VIREO *Vireo solitarius*. A single singing male was heard 21 June 1981, well north of the species known breeding range. From its behavior we consider the bird to have been a non-breeding wanderer.

MAGNOLIA WARBLER *Dendroica magnolia*. Several singing and apparently territorial males were encountered about Aquatuk Lake in 1980. Two males collected 27 June 1980 (137295-96) were in breeding condition. McLaren and McLaren (1981a, b) have reported this species at the same latitude in eastern Manitoba. These observations suggest a more widespread population in the HBL than previously supposed.

BLACK-THROATED GREEN WARBLER *Dendroica virens*. A single male was singing one evening at Kiruna Lake 14 June 1981, well north of the species' normal range. We assume that this was a non-breeding wanderer.

PALM WARBLER *Dendroica palmarum*. A nest with five young was located 10 July 1981. Although within the known range of this species, this is the first confirmed breeding record in the HBL of Ontario north of Attawapiskat. A single nestling (139896) and the used nest (12723) were retained. The subspecies was *palmarum* as expected (Godfrey 1966).

COMMON YELLOWTHROAT *Geothlypis trichas*. A single bird was seen 5 June 1980, well north of the species' known range, so apparently only a wandering bird.

PURPLE FINCH *Carpodacus purpureus*. One to three birds were seen on four separate occasions during June 1981, but as Kiruna Lake is well north of their known breeding range we assume they were non-breeding wandering birds. We are aware of no breeding records for the HBL as yet.

WHITE-WINGED CROSSBILL *Loxia leucoptera*. A recently fledged young was collected 15 July 1981 (139906). Although known to summer through all but the extreme northern HBL breeding records are so few that no other specific reports are available in Ontario north of Lake Superior.

COMMON REDPOLL *Carduelis flammea*. A single flock of about 20 birds observed on 6 July 1981 was the only record during 1980 or 1981. We saw no evidence of breeding. Baldwin saw none in the Ridges area on his three visits (Schueler et al. 1974).

Discussion

The breeding records we reported beyond the northern limits outlined in Godfrey (1966) were of Lesser Scaup, Common Merganser, Long-eared Owl, Olive-sided Flycatcher, Brown Creeper, Hermit Thrush, and Golden-crowned Kinglet. Information suggesting probable breeding beyond known limits was also given for Common Nighthawk, Winter Wren, Cedar Waxwing and Magnolia Warbler. These reports probably do not represent range extensions, but rather an expansion of our knowledge about these birds.

The first confirmed breeding records from the northern portion of the Hudson Bay Lowland for Common Loon, Sharp-tailed Grouse, Greater Yellowlegs, Northern Hawk-owl, Boreal Chickadee, Ruby-crowned Kinglet, Northern Shrike, Palm Warbler, and White-winged Crossbill, plus probable breeding of Killdeer, Lesser Yellowlegs and Alder

Flycatcher, indicate that a lack of work in a region where travel and access are difficult has limited our understanding of the status of many species.

Although the nearest known breeding records for many of the above species are much farther to the south, we do not believe that those from the Sutton Ridges represent isolated populations occupying a widely disjunct environment. Apart from Golden Eagle, the species we encountered were not specifically using dry upland sites. Forested areas of importance to species such as Brown Creepers and Golden-crowned Kinglets would be available along the banks of larger rivers throughout the Lowland. Although they may be very irregularly distributed, these species are probably to be found throughout the Lowland wherever suitable habitat is available.

The ridges, however, appear to be important to a number of species. The diversity of habitats and the more extensive forest sites could well be necessary for the maintenance of peripheral populations of several species such as Winter Wrens and Magnolia Warblers. As they are the only hills of high elevation for many kilometers in any direction, the ridges provide nest sites for Golden Eagles, now considered endangered in Ontario. The large size of trees on dry and protected sites may be of considerable importance at this latitude in Ontario for woodpeckers, and in turn for Northern Hawk-owls, Tree Swallows and other species which rely on cavities for nesting. The unique nature of these hills must be considered significant, but additional fieldwork will be required to fully assess their value to bird life in the Lowland

The appearance of a number of species in the Ridges suggests that nesting populations, if not actually present there, are likely to be found in many other areas of the Lowland where breeding records are currently lacking. These species include Great Blue Heron, Common Goldeneye, Hooded Merganser, Bald Eagle, American Kestrel, Black Tern, Eastern Kingbird, Solitary Vireo, Common Yellowthroat and Purple Finch. On the other hand, the almost total absence of Redpolls, whose breeding range is reported throughout most of the northern HBL (Godfrey 1966), indicates that apart from the north coast, whence virtually all breeding records come, they are extremely locally distributed in summer.

In the subarctic environment of the Ridges, some birds at the periphery of their ranges may not breed every year if weather conditions are unfavourable. Common Nighthawks and Olive-sided Flycatchers, for example, were not seen in 1980 when snows and freezing temperatures lasted through most of June. On the other hand, with temperatures over 20° C by mid-June of 1981, birds were nesting early and species such as Common Snipe (*Gallinago gallinago*), American Robin (*Turdus migratorius*), Lincoln's Sparrow (*Melospiza lincolnii*), White-crowned Sparrow (*Zonotrichia leucophrys*), and Dark-eyed Junco (*Junco hyemalis*) apparently attempted second broods.

The list of species recorded in the Sutton Ridges area now totals 101 species (see also Schueler et al. 1974) of which there is some evidence of breeding for 76 species. Specific nesting or breeding information, however, has been obtained for only 57 species.

Acknowledgments

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A Patterned Fen on the North Shore of Lake Superior, Minnesota[1]

PAUL H. GLASER

Limnological Research Center, University of Minnesota, Minneapolis, Minnesota 55455
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A patterned fen near Grand Marais, Minnesota, is relatively isolated from the other patterned peatlands in Minnesota and occupies an unusual physiographic position. Despite the close proximity of mineral ridges the central strings and flarks have vegetation and water chemistry indicative of poor fen rather than rich fen. Peat accumulation has apparently slowed the rate of water seepage through the central patterned area, causing a decline in forest growth where water has ponded on the surface. Flark development may have been initiated by localized flooding along the contour interval, which would then accentuate the string/flark pattern by its effect on production and decomposition rates. Local peat accumulation at Grand Marais has apparently created hydrological conditions similar to those found in the other patterned fens in Minnesota that are isolated from mineral soil by vast expanses of peatland.

Key Words: patterned fen, Minnesota, Lake Superior, peatlands.

Across the boreal zone patterned fens or aapamoor are consistently marked by networks of elongate pools (flarks) and narrow sinuous ridges (strings) oriented perpendicular to the slope (Sjörs 1961, Washburn 1979). The recurrence of this pattern across this broad region of diverse climate, topography, and flora suggests that a common mechanism initiates the development of aapamoor, although the complex interplay between the various physical and biological mechanisms remains to be elucidated. One approach to this problem is the study of patterned fens in atypical settings, where the influence of unusual climatic or topographic factors on pattern development may be clearly discernible.

In North America, patterned fens reach their southern limits on the vast peatlands covering the beds of Glacial Lakes Agassiz, Upham, and Aitken in northern Minnesota (Heinselman 1963, 1970; Glaser et al. 1981). Eastward in Minnesota, mire patterns gradually disappear as peatlands become restricted to small depressions, suggesting that pattern formation is inhibited in smaller peatlands by the increased effect of runoff from the adjacent uplands. An important exception to this relationship is a small patterned fen located 2.4 km northeast of Grand Marais along the north shore of Lake Superior. The Grand Marais fen occupies a narrow valley and receives runoff directly from the adjacent mineral ridges. An examination of this fen was undertaken to determine the effect of its physiographic setting on the development of its vegetation and water chemistry.

The Study Area

The North Shore Highland of Minnesota is formed by southeastward-dipping ridges that rise 270 to 450 m above the shores of Lake Superior (Wright 1972). The ridges are underlain by Keweenawan basalts and diabase and are thinly mantled by glacial till. From Tofte to Grand Marais the ridges are separated by narrow troughs that contain numerous lakes and peatlands wherever drainage is obstructed. Near Grand Marais a patterned fen has developed in the largest of these troughs, which is about 1 km wide. The surface of the fen is 12 to 50 m below the crest of the ridges, which are underlain by basalts and mantled by silty to fine-sandy glacial till (Green 1972).

Most of the fen slopes westward and presumably drains into the Fall River, which begins immediately downslope from the central area of mire patterns. A small tributary of the Little Devil Track River also originates from the extreme northeastern portion of the fen, but the contour interval of 20 ft (6 m) on the topographic maps is too coarse to register the limits of its drainage area.

The climate of Grand Marais and vicinity is strongly influenced by Lake Superior. The regional climate is cool-temperate, with a mean annual temperature of 2-3°C. The mean temperature for January is -10°C, and for July is 15°C (Hovde 1941; Baker 1963, 1965). The growing season averages 136 days, and the yearly precipitation is 62.7 cm.

The Grand Marais Fen is located within the mixed conifer-hardwood forest of the Great Lakes Region (Cushing 1965; Braun 1950). The upland ridges that surround the Grand Marais Fen are forested with *Populus tremuloides* (Trembling Aspen) and *Abies balsamea* (Balsam-fir). The rich understory under the canopy is composed of *Rubus parviflorus* (Thimbleberry), *Clintonia borealis* (Corn-lily), *Aralia nudicaulis* (Wild Sarsaparilla), *Pteridium aquilinum* (Bracken), *Aster macrophylus* (Large-leaved Aster), and *Streptopus roseus* (Rose Mandarin).

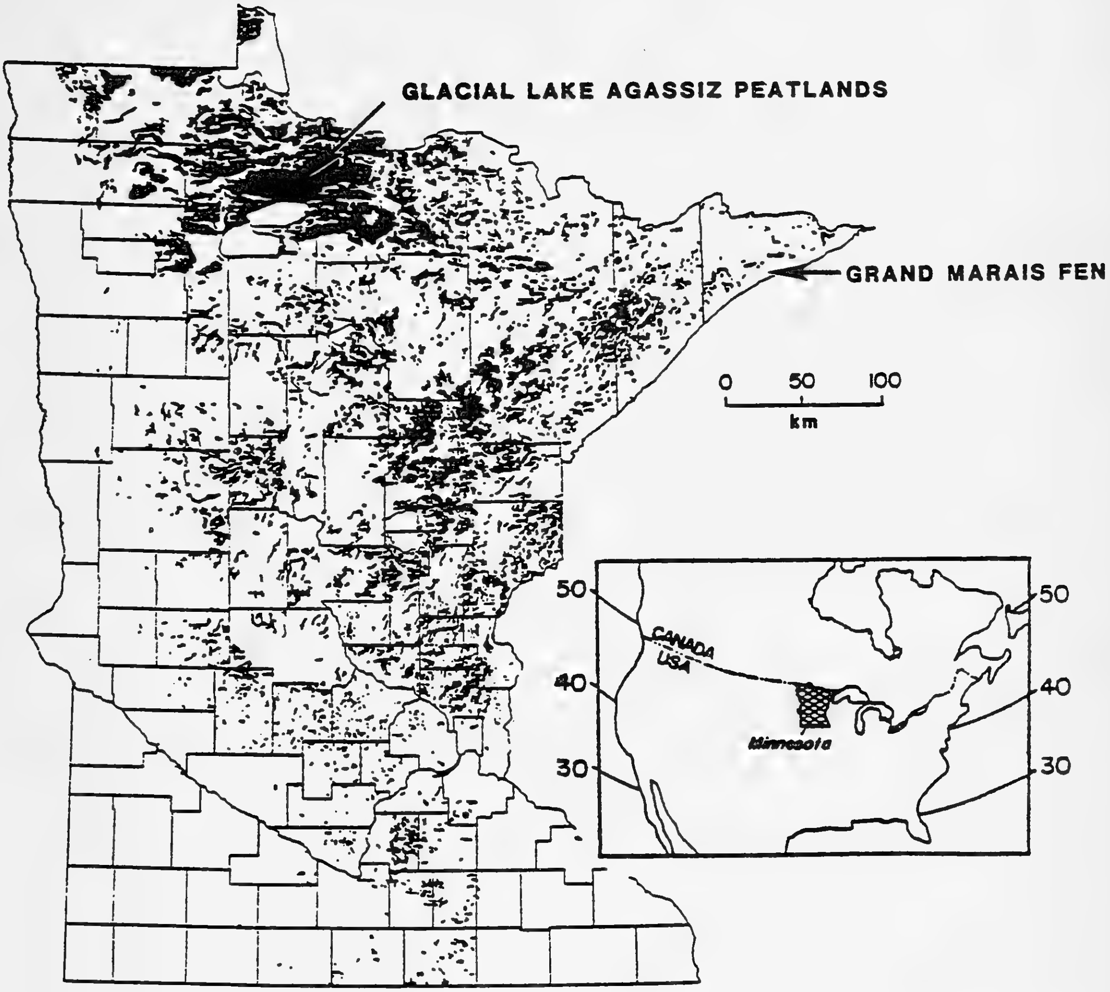

FIGURE 1. Map of Minnesota showing the location of the Grand Marais Fen in relation to other peatlands, which are shaded black.

Methods

Aerial photographs with a scale of 1:15 840 were first examined to determine whether other patterned fens were present within the north shore area of Minnesota. The Grand Marais Fen was then visited on 27 July and 3 August, 1979. A general collection was made of all vascular plants and bryophytes found in the central patterned area. Several representative stands were then described by means of relevés (Shimwell 1971; Westhoff and van der Maarel 1973). A plot was laid out in each stand, and all species within the plot were recorded by stratum. Visual estimates of cover and abundance were made for each species. A complete set of vouchers is deposited in the University of Minnesota Herbarium. Nomenclature follows Fernald (1970) for the vascular plants and Crum and Anderson (1981) for bryophytes except for *Sphagnum*, which follows Andrus (1980).

A water sample was taken from each relevé plot and analysed for pH with a Radiograph 29 pH meter. Specific conductivity standardized to 20°C was measured with a Radiograph CDM2^{d} conductivity meter, and Ca^{2+} concentration was determined by atomic absorption and ICP emission spectroscopy.

Results

The Grand Marais fen consists of a wet marginal lagg, an inner swamp forest, and a central patterned area with strings and flarks. The marginal lagg is dominated by *Thuja occidentalis* (White Cedar) and *Alnus rugosa* (Speckled Alder) whereas toward the interior *Picea mariana* (Black Spruce) is dominant. The spruce trees become progressively restricted to sinuous peat ridges toward the center as the swamp forest gives way to patterned fen. The central strings and flarks are clearly distinguished by their characteristic species assemblages and landform patterns (Figure 2; Table 1 and 2).

The flarks are progressively better developed toward the center of the fen as first *Carex limosa* (Sedge) and then *Rhynchospora alba* (Beak-rush) attain dominance. The central flarks are characterized by relatively flat, wet carpets of *Sphagnum majus*, with *Carex limosa*, *Rhynchospora alba*, *Menyanthes trifoliata* (Buckbean), *Scheuchzeria palustris*, *Utricularia cornuta* (Bladderwort), and *Drosera intermedia* (Sundew). In places, pools of standing water occur with mud bottoms and a sparse cover of *Menyanthes trifoliata* and *Utricularia intermedia* (Bladderwort).

The string vegetation also varies continuously from the margins to the interior of the patterned area. Along the margins, strings are dominated by *Carex rostrata* (Sedge) and *Carex lasiocarpa* (Sedge), which also grow profusely in the hollows. Only *Picea mariana* is restricted to the string-like ridges in this area. Toward the center, however, the strings are more sharply defined by well-developed hummocks of *Sphagnum magellanicum*, *S. fuscum*, and *S. rubellum*, with *Aulocomnium palustre* and *Polytricum juniperinum* var. *affine*. An apron of *Sphagnum angustifolium* commonly spreads out from the lower margins of these strings and merges with the adjacent flark. The strings contain stunted trees of *Picea mariana*, with an understory of *Carex pauciflora* (Sedge), *C. paupercula* (Sedge), *Smilacina trifolia* (Three-

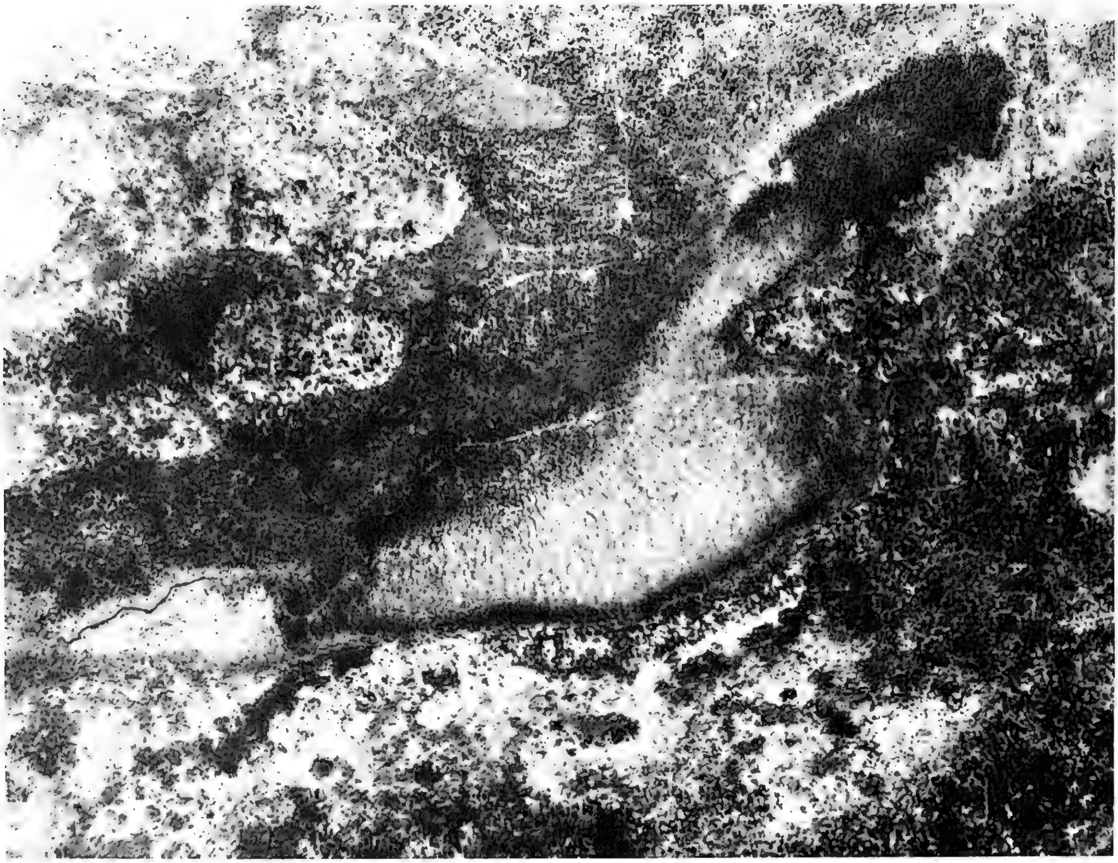

FIGURE 2. Panchromatic aerial photograph (scale 1:15 840) of the Grand Marais Fen showing the central area of mire patterns.

TABLE 1. Representative Flark Relevé. The symbols after each species indicate cover and sociability. Details are in the footnote.

Rhynchospora alba	3.3
Drosera intermedia	2.2
Carex limosa	2.2
Menyanthes trifoliata	1.2
Drosera rotundifolia	1.2
Sarracenia purpurea	1.2
Sphagnum majus	5.5

Additional species: *Pogonia ophioglossoides* +.2; *Utricularia cornuta* +.2; *Scheuchzeria palustris* var. *americana* +.1; *Andromeda glaucophylla* +.1; *Smilacina trifolia* +.1; *Kalmia polifolia* +.1; *Chamaedaphne calyculata* +.1; *Carex rostrata* +.1; *Vaccinium oxycoccos* +.1; *Eriophorum tenellum* +.1.

Cover symbols: +, sparsely present; 1, plentiful but small cover value; 2, very numerous, or covering 1/20 of area; 3, any number of individuals covering ¼-½ area; 4, any number of individuals covering ½-¾ area; 5, covering more than ¾ area.

Sociability symbols: 1, growing singly, isolated individuals; 2, grouped or tufted; 3, in small patches, cushions; 4, in small colonies, in extensive patches, or forming carpets; 5, in pure populations.

TABLE 2. Representative string Relevé. The symbols after each species indicate cover and sociability. For key see Table 1.

Andromeda glaucophylla	1.1
Kalmia polifolia	1.2
Chamaedaphne calyculata	1.2
Vaccinium oxycoccos	1.2
Carex paupercula	1.1
Carex pauciflora	1.2
Picea mariana	1.1
Larix laricina	1.1
Sphagnum angustifolium	3.3
Sphagnum magellanicum	3.3
Sphagnum fuscum	1.2
Aulocumnium palustre	1.2

Additional Species: *Carex limosa* +.1; *Menyanthes trifoliata* +.1; *Drosera rotundifolia* +.1; *Sarracenia purpurea* +.1; *Smilacina trifolia* +.1; *Carex rostrata* +.1; *Ledum groenlandicum* +.2; *Gaultheria hispidula* +.1; *Eriophorum tennellum* +.1; *Polytricum juniperinum* var. *affine* +.2; *Dicranum polysetum* +.2; *Pleurozium schreberi* +.2.

leaved False Solomon's-seal), and the bog ericads. The best developed strings have a moist substrate, with the water table approximately 30-40 cm below the surface.

The mire waters of the strings and flarks at Grand Marais have chemical properties indicative of poor fen. The pH ranges from 4.8 to 4.9, the specific conductivity ($K_{corr.}$) ranges from 14 to 50 uhmo, and the Ca^{2+} concentration from 1.1 to 3 mg/L. No distinction is apparent between water chemistry of the central flarks and strings. The low values for Ca^{2+} concentration and specific conductivity overlap with values expected for ombrotrophic bogs (Heinselman 1970), but the pH values are indicative of transitional poor fen with weakly minerotrophic water (Sjörs 1950; Heinselman 1963, 1970).

Discussion

Despite the nearby source of mineral upland, the vegetation and water chemistry of the strings and flarks at Grand Marais exhibit typical poor-fen properties. The flarks are dominated by *Carex limosa* and *Rhynchospora alba*, which have a wide range of tolerance for pH and dissolved salts (Sjörs 1963). Only a few minerotrophic indicators are present, such as *Carex rostrata* and *Menyanthes trifoliata* (*sensu* Heinselman 1970), and these species have a low population density. Conspicuously absent from the central flarks are *Carex lasiocarpa*, *Carex livida* (Sedge), *Triglochin maritima* (Arrow-grass), *Carex leptalea* (Sedge), *Scorpidium scorpiodes*, *Campylium stellatum*, and other indicators of minerotrophy that are common in the flarks of the Glacial Lake Agassiz mires (Glaser et al. 1981). The relatively low values for pH, specific conductivity, and Ca^{2+} concentration of the mire waters in the central patterned area at Grand Marais further indicate poor fen.

The poor-fen properties of the central strings and flarks suggest that surface runoff from the surrounding slopes does not penetrate very far into the interior of the patterned area. This effect seems only possible if the central area of patterns is higher than the margins of the fen. The contour interval of 20 ft (6 m) on the topographic maps is too coarse to register such a rise, but the general orientation of the patterns is not indicative of convex surface. The apparently limited influence of mineral-rich runoff from the overlooking ridges is therefore difficult to understand.

Elsewhere in Minnesota patterned fens are restricted to water tracks that drain across the vast peatlands of glacial lakes Agassiz, Upham, and Aitken. The surface waters in these patterned tracks have significantly lower pH and Ca^{2+} concentrations than those of waters draining immediately downslope from mineral soil (Heinselman 1963, Glaser et al. 1981), indicating that the waters have been depleted of ions by either adsorption on peat particles or dilution from the point source. Thus aapamoor in Minnesota are consistently related to a decrease in minerotrophy, although the precise relationship between pattern formation and water chemistry is not clear. Low levels of Ca^{2+} concentration and alkalinity are not necessarily an essential prerequisite for pattern formation, because string and flark patterns are also common in mires with richly minerotrophic waters in the more northerly and continental climate of Alberta (Slack, Vitt, and Horton 1980).

The occurrence of a single patterned fen on the North Shore Highland of Minnesota is apparently the result of local peat accumulation, which has restricted the infiltration of surface runoff, causing a decline in forest growth where water has ponded up on the surface. The flark patterns may have been initiated by local flooding along the contour interval in the manner observed by Boatman and Armstrong (1968) and Boatman and Tomlinson (1973) on bogs in Scotland. Flooding would then alter the pattern of peat accumulation and decomposition, accentuating the linear pool and ridge pattern. Flark development at Grand Marais, however, does not seem to be initiated by such degradative processes as corrosive oxidation (Lundqvist 1951; Sjörs 1963), frost heaving (Tanttu 1915; Auer 1920), or solifluction (Anderson and Hesselman 1907; Pearson 1960; Pearsall 1966) that have been suggested for the origin of pool patterns in other peatlands. Various hypotheses of pattern development have stressed the development of strings by frost action (Auer 1920), linear growth of plant clones (Sjörs 1946), or the collection of flotsam windrows in sinuous bands following a flush of runoff (Tanttu 1915; Drury 1956; Thom 1972). These hypotheses do not seem to be applicable to Grand Marais, where pool formation seems to be the primary process, as indicated by the scattered occurrence of small well-developed flarks near the margins of the swamp forest, where the hummocks have an amorphous shape.

Thus, aapamoor formation at Grand Marais seems to be caused by the accumulation of peat, which has reduced the influence of minerotrophic runoff and seepage, favoring the local ponding of water on the peatland surface. The other small peatlands in this region of relatively high precipitation and surface runoff are apparently more directly influenced by quicker movement of surface drainage, favoring species assemblages and rates of peat production and decomposition unfavorable for pattern development.

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Habitat Usage of Two Woodland *Buteo* Species in Central Ontario

EDWARD ARMSTRONG[1] and DAVID EULER

Ontario Ministry of Natural Resources, Queen's Park, Toronto, Ontario M7A 1W3
[1]Present Address: Ministry of Natural Resources, P.O. Box 730, Cochrane, Ontario P0L 1C0

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Habitat use by Broad-winged Hawks (*Buteo platypterus*) and Red-shouldered Hawks (*B. lineatus*) was studied from 1977 to 1979 in central Ontario to determine how these birds could be affected by shoreline cottage development. The Broad-winged Hawk was the most commonly observed raptor in the study area, followed by the Red-shouldered and the Red-tailed Hawks (*B. jamaicensis*). Broad-winged Hawk nests were found in immature deciduous-dominated mixed forests, while Red-shouldered Hawk nests were usually located in mature deciduous forests. There were no significant differences between the macrohabitat selection of these two species although the microhabitats immediately surrounding the nests did differ. Red-shouldered Hawks appeared more susceptible to disruption of breeding habitat caused by cottage development because of their preference for dense, continuous forests. Broad-winged Hawk territories contained both forested and open areas, the latter used for perching and territorial interactions. These *Buteo* species appear to occupy mutually exclusive territories, both interspecific and intraspecific.

Key Words: Broad-winged Hawk *Buteo platypterus*, cottage development, habitat use, Ontario, Red-shouldered Hawk *B. lineatus*.

In central Ontario, Red-shouldered Hawks (*Buteo lineatus*) and Broad-winged Hawks (*B. platypterus*) are sympatric in the Great Lakes–St. Lawrence forest region, with the Red-shouldered near the northern limit of its range (Godfrey 1966). This area is experiencing a high demand for cottage development. Although studies of habitat use and overlapping territories have been conducted on open-country raptors (Weller 1964; Schnell 1968), these relationships have rarely been examined for forest-dwelling hawks (Titus and Mosher 1981). Across North America, Red-shouldered Hawk populations generally appear to be declining, while those of the Broad-winged Hawk remain high and stable (Brown 1971; Fyfe 1976; Tate 1981). As part of a study to examine the impact of lakeshore cottage development on wildlife populations and habitat, we compared the habitat use of these two raptors.

Study Area and Methods

The study area was in central Ontario within 60 km of Dorset (45°15′N 78°54′W) (Figure 1). It lies in the Great Lakes–St. Lawrence forest region (Rowe 1972) and is characterized by a mixture of eastern hemlock (*Tsuga canadensis*), balsam fir (*Abies balsamea*), white pine (*Pinus strobus*), sugar maple (*Acer saccharum*), red maple (*A. rubrum*), white birch (*Betula papyrifera*), and American beech (*Fagus grandifolia*). Both coniferous and deciduous shorelines are present, but the former grade into deciduous forest at varying distances from the shoreline.

During field work between 1977 and 1979, potential raptor nests were located. Nests were monitored for reproductive activity beginning in early May. Nesting chronology and presence of nestlings were based on ground observations. Nesting success was evaluated on the basis of the number of young of fledging age per nest (Postupalsky 1977). Habitat characteristics around the nesting sites were measured after nesting. Studies of the microhabitat were conducted within 0.04 ha circles around the nests, following James (1971) and MacKenzie and Sealy (1981). Numbers of shrubs and shrub species, and % shrub conifer composition were measured on 1.75 m wide transects which crossed each circle. A shrub was defined as any woody species less than 8.0 cm diameter at breast height (dbh) and more than 1.5 m in height. The number, species, diameter class, % conifer composition, and canopy height were recorded for all trees within the circle. Ten 1 m × 1 m plots were established randomly within the circle, and the percentage of volume occupied by foliage within the ground (0-1.5 m), shrub (1.5-9.0 m) and tree (> 9 m) layers (Willson 1974) above these plots was estimated and averaged. These values were summed for each layer to produce a measurement of total vegetation volume. Canopy volume, the product of (0.10) (tree volume) (canopy height) was calculated. The occurrence of foliage in each corner of the column was also noted and totalled by layer for all plots, giving a maximum cover score of 40. Nest height, tree height, and nest tree dbh were recorded.

Macrohabitat studies were conducted within circles of 3.14 ha (radius of 100 m) around the nesting site. The circle was divided into 10 × 10 m squares and cover-mapped to determine the area occupied by

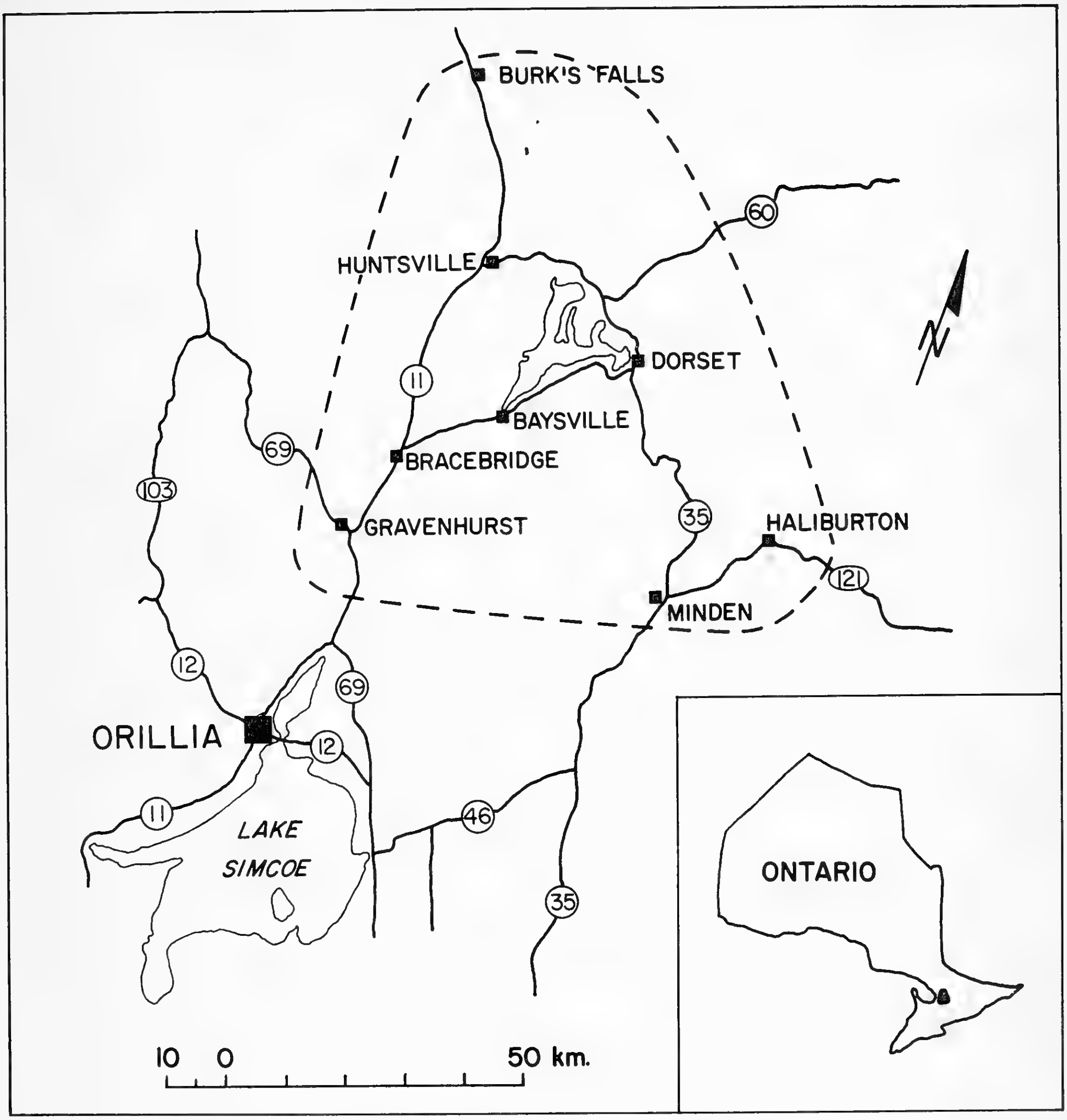

FIGURE 1. Central Ontario study area (bounded by dashed line) in relation to Lake Simcoe, showing major settlements and highways (route number circled). Inset shows position of area within Ontario.

coniferous and deciduous forest, water, open area, and man-made clearings. The % slope, aspect, elevation, and distances to the nearest lake, man-made clearing, and water body were recorded. The position of the nest tree on the slope in relation to the nearest body of water (lake position) and the local terrain (valley position) were recorded on a linear scale of 1 (lowland) to 6 (upland plateau). The type of water body closest to the nest was also recorded on a linear scale from 1 (seasonal stream) to 7 (lake). A Development Index (DI) for the nearest 100 m section of lake shoreline was measured, calculated as the greatest length of linear cleared shoreline.

Data for Red-shouldered and Broad-winged Hawk nests were analysed using Discriminant Function Analysis (DFA) (Dixon 1975) to select the habitat variables that most clearly differentiated the nesting sites of these raptors according to sample variance (James 1971; MacKenzie and Sealy 1981). The stepwise DFA selects, one at a time, those variables which best discriminate among the two groups of nests, and provides an F-Matrix to test significance. While the variables which provide maximum discrimination can be used to plot observations and group means according to two canonical variables, we were primarily interested in determining the habitat variables involved. Microhabitat and macrohabitat measurements were analysed separately to examine nest site selection and nesting habitat selection respectively. Data were re-entered if a nest was used in more than one year. We acknowledge the possible bias with small samples.

Micro- and macrohabitat characteristics were similarly measured around known perching sites of the Broad-winged Hawk, and compared with nesting sites by DFA. All perching sites used more than once and a random selection of all remaining sites were studied.

Field staff recorded observations of raptors opportunistically during the breeding season, following a modification of Craighead and Craighead's (1956) technique. Data recorded included general forest type and density, proximity to cottage development, and perching site. Habitat coverage was not uniform, but was dependent on other field activities.

Results

Nesting Chronology

An inventory of 101 potential nests resulted in the documentation of 27 active Broad-winged Hawk nests and nine Red-shouldered Hawk nests. Nest building was observed in early May for the Red-shouldered and from early May through mid-June for the Broad-winged Hawk (Figure 2). Most activity involved garnishing the nests with coniferous twigs. Many nests had been built in a previous year. As nests were only observed from the ground, it was not possible to ascertain the precise time of hatching. Nestlings of the Red-shouldered Hawk were observed as early as the third week of May, while young Broad-winged Hawks were observed in the second week of June. Fledging was observed in early July for the Red-shouldered Hawk and from mid- to late July for the Broad-winged Hawk. Back-dating suggests initial egg laying in late April for the Red-shouldered Hawk and mid-to late May for the Broad-winged Hawk (Matray 1974; Wiley 1975).

Habitat Characteristics

The DFA indicated that the nest microhabitats of these two raptors were separated by four habitat variables: number of trees, ground cover, nest height, and percent coniferous trees (Table 1) ($F = 7.31$, df = 4, 31, $P < 0.05$). All Red-shouldered Hawk nests and 88.9% of Broad-winged nests were classified correctly using

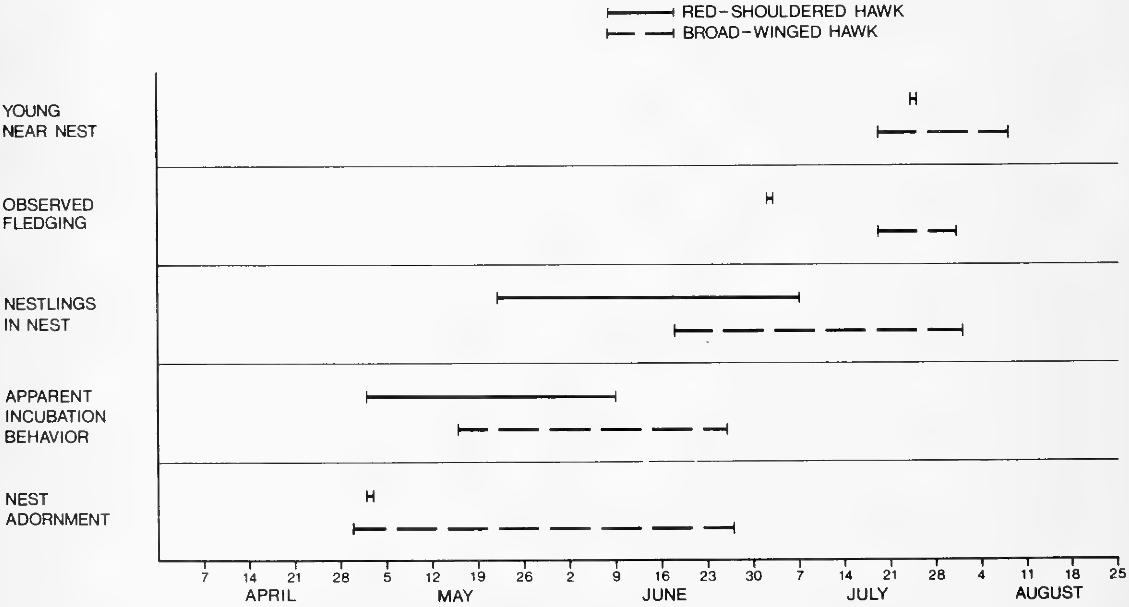

FIGURE 2. Temporal trends in observed nesting activities of Broad-winged and Red-shouldered hawks; 1977 to 1979 data combined.

TABLE 1. Microhabitat characteristics (mean ± SD) of Broad-winged and Red-shouldered Hawk nests, and Broad-winged Hawk perching sites.

Habitat Characteristic	Red-shouldered Hawk Nest (9)[1]	Broad-winged Hawk Nest (27)	Broad-winged Hawk Perching Site (17)
Canopy height (m)	24.4 ± 3.5	21.0 ± 2.7	11.4 ± 8.9
No. shrub species	2.6 ± 0.7	3.3 ± 1.0	3.8 ± 2.3
No. shrubs	22.7 ± 12.8	18.1 ± 12.8[3]	28.2 ± 25.9
Coniferous shrubs (%)	8.0 ± 12.2	16.3 ± 24.3	11.4 ± 17.3
No. tree species	3.0 ± 1.7	4.8 ± 1.5	2.6 ± 2.1
No. trees	17.7 ± 6.3[2]	28.6 ± 8.6	13.2 ± 12.1
No. small trees (8-32 cm dbh)	12.0 ± 7.5	24.6 ± 10.0	11.6 ± 11.1
No. large trees (32 cm dbh)	5.7 ± 2.9	4.0 ± 2.8[3]	1.5 ± 1.8
Coniferous trees (%)	10.7 ± 13.6[2]	17.6 ± 22.8	14.4 ± 25.0
Ground cover	25.7 ± 9.5[2]	29.4 ± 5.4	31.7 ± 8.0
Shrub cover	26.9 ± 10.4	27.6 ± 6.6[3]	10.5 ± 10.9
Tree cover	37.3 ± 2.3	34.1 ± 4.8	7.1 ± 10.9
Ground volume (%)	16.1 ± 9.2	18.0 ± 6.8	29.6 ± 14.1
Shrub volume (%)	15.6 ± 6.1	18.1 ± 6.2[3]	8.4 ± 9.4
Tree volume (%)	29.6 ± 7.0	31.4 ± 10.0	4.6 ± 7.3
Canopy volume[4]	72.4 ± 20.4	64.9 ± 21.0[3]	9.9 ± 16.3
Vegetation volume (%)	57.6 ± 12.2	66.6 ± 15.4	41.8 ± 22.6
Nest tree height (m)	23.1 ± 5.2	21.1 ± 2.6	—
Nest tree dbh (cm)	48.3 ± 11.6	44.2 ± 16.2	—
Nest height (m)	14.0 ± 3.6[2]	11.8 ± 2.8	—

[1] Sample size.

[2] Variables included in the discriminant function of Red-shouldered and Broad-winged Hawk nests.

[3] Variables included in the discriminant function of Broad-winged Hawk nesting and perching sites.

[4] (Tree volume x canopy height) ÷ 10

these criteria. This separation characterized Red-shouldered Hawk nesting habitat as mature, open deciduous forest with low ground cover, and Broad-winged Hawk habitat as dense, deciduous-dominated, mixed forest with higher ground cover. Some Red-shouldered Hawk nests were also located in the latter type of habitat.

Macrohabitat characteristics for nests of these raptors differed only for elevation ($F = 7.93$, $df = 1, 35$, $P < 0.05$) (Table 2). Separation was only fair: 86% and 57% of the Broad-winged and Red-shouldered Hawks respectively were correctly classified.

Five microhabitat variables were included in the DFA between Broad-winged Hawk nests and perching sites: number of shrubs, shrub cover and volume, number of large trees, and canopy volume (Table 1) ($F = 59.83$, $df = 5, 38$, $P < 0.05$). All sites were correctly classified using these variables. Three macrohabitat variables were useful in differentiating nesting and perching sites: area of man-made clearings, distance to clearing, and slope (Table 2) ($F = 21.6$, $df = 3, 41$, $P < 0.05$). Most sites (88.9%) were classified correctly, using these criteria.

The Broad-winged Hawk nested in several species of tree including white birch, yellow birch (*Betula alleghaniensis*), and sugar maple (Table 3). The Red-shouldered Hawk nested in three species, primarily yellow birch and American beech.

Nesting Success

Of the 16 Broad-winged Hawk nests for which either nesting failure or the presence of young near fledging age were documented, 14 fledged young. Fledging success averaged 1.5 young per nest and 1.7 young per successful nest. The highest number of young fledged per nest was 3. Five of six Red-shouldered nests with documented outcomes were successful. Fledging success was 1.8 young per nest and 2.2 per successful nest. Highest number of young fledged per nest was also 3. Some nests of both species were not located until young had already hatched, possibly introducing some biases to the nesting success calculations (Mayfield 1961).

Raptor Observations

Totals of 577 Broad-winged and 64 Red-shouldered Hawk observations were made in both years from May through early September. A small number of Red-tailed Hawks (20) were also observed. Although there are obvious biases inherent in using casual observations, such observations yield general infor-

TABLE 2. Macrohabitat characteristics (mean ± SD) of Broad-winged and Red-shouldered Hawk nests, and Broad-winged Hawk perching sites.

Habitat Characteristic	Red-shouldered Hawk Nest (9)[1]	Broad-winged Hawk Nest (27)	Broad-winged Hawk Perching Site (17)
Lake position (1-6)	4.9 ± 1.4	4.2 ± 1.6	3.5 ± 2.1
Valley position (1-6)	3.2 ± 1.3	3.3 ± 1.5	3.2 ± 2.0
Distance to lake (m)	223.9 ± 146.8	215.1 ± 232.1	491.4 ± 357.7
Distance to clearing (m)	27.8 ± 18.2	42.1 ± 30.2[3]	1.3 ± 2.2
Distance to man-made clearing (m)	137.8 ± 158.3	180.0 ± 301.9	6.0 ± 16.8
Distance to water (m)	62.3 ± 38.5	51.5 ± 30.8	31.3 ± 34.5
Type of water (1-7)	5.1 ± 1.9	4.8 ± 2.0	4.5 ± 1.2
Slope (%)	21.3 ± 11.6	26.7 ± 16.9[3]	14.4 ± 11.1
Area coniferous forest (100 m^2)	11.8 ± 12.2	28.9 ± 51.7	16.2 ± 26.2
Area deciduous forest (100 m^2)	262.9 ± 29.1	231.4 ± 71.8	161.0 ± 60.2
Area water (100 m^2)	17.9 ± 35.2	35.5 ± 30.3	58.8 ± 54.8
Area opening (100 m^2)	40.4 ± 28.5	52.5 ± 40.6	133.2 ± 46.3
Area man-made clearing (100 m^2)	31.6 ± 26.7	26.1 ± 25.7[3]	89.9 ± 37.3
Shore Dev. Index	0.7 ± 0.7	0.8 ± 0.9	—
Sine of aspect	0.4 ± 0.7	-0.1 ± 0.8	0.3 ± 0.8
Cosine of aspect	-0.1 ± 0.7	0.1 ± 0.7	-0.2 ± 0.6
Elevation (m)	295.5 ± 60.9[2]	350.4 ± 48.8	362.5 ± 24.4

[1] Sample size

[2] Variables included in the discriminant function of Red-shouldered and Broad-winged Hawk nests.

[3] Variables included in the discriminant function of Broad-winged Hawk nesting and perching sites.

mation on habitat use (Table 4). Most Broad-winged Hawks were located by sight and most Red-shouldered Hawks by sound. Significantly more Red-shouldered Hawks were found in dense forests than Broad-winged Hawks which were more common in forest areas with openings ($x^2 = 66.6$, $P < 0.001$). Greater proportions of Red-shouldered Hawks were also sighted in locations away from shores ($x^2 = 21.4$, $P < 0.001$). Red-shouldered Hawks were observed significantly more often in uncottaged areas than were Broad-winged Hawks ($x^2 = 14.7$, $P < 0.001$). The most commonly observed Broad-winged Hawk perching sites were power lines, while those of Red-shouldered Hawks were deciduous trees. Casual observations revealed that most territorial interactions occurred at forest canopy openings such as shorelines, powerlines and roads.

Discussion

Broad-winged Hawks were the most commonly observed raptors in the study area, outnumbering Red-tailed Hawks approximately 18 to 1. As both are relatively conspicuous because of their perching and soaring habits, this figure probably reflects relative abundance. However, the secretive behaviour and preference for closed forest of the Red-shouldered Hawk reduces its visibility, so that it is likely more common than the ratio (7.2:1) of Broad-winged to Red-shouldered Hawk observations suggested.

The Red-tailed Hawk is typically an open-country nesting bird (Gates 1972; McInvaille and Keith 1974), although it is adapted to a wide range of habitat conditions (Beebe 1974). Its nesting habitat is quite different from that of the other two species (Titus and Mosher 1981). Most observations of this raptor were made at perching sites along roadsides and in areas with open beaver meadows and swamps. Our limited behavioural observations suggest that Broad-winged Hawks react aggressively to the Red-tailed Hawk, as do Red-shouldered Hawks (Campbell 1975).

Both Broad-winged and Red-shouldered Hawks frequent deciduous, upland forests near riparian or lakeshore habitat. The Broad-winged Hawk often frequented partially open forests like those along roadways, while the Red-shouldered Hawk was almost totally restricted to closed forests. These two species had no significant differences in general nesting macrohabitat. Inclusion of elevation in the discriminant function seemed to be a result of sampling bias, as several Broad-winged Hawk nests and most

TABLE 3. Tree species used for nesting by Red-shouldered and Broad-winged Hawks

Species	Number Nests	
	Broad-winged Hawk	Red-shouldered Hawk
White birch	7	0
Yellow birch	5	4
Sugar maple	4	1
American beech	0	4
Red oak	3	0
Large-toothed aspen (*Populus grandidentata*)	2	0
White pine	1	0
Trembling aspen (*Populus tremuloides*)	1	0
Eastern hemlock	1	0
Basswood (*Tilia americana*)	1	0
Other	2	0
TOTAL	27	9

TABLE 4. Locations of observations of Broad-winged and Red-shouldered Hawks, 1978-1979

Habitat Description	Number of Observations	
	Broad-winged Hawk	Red-shouldered Hawk
Forest Type		
Coniferous	24	3
Coniferous dominated mixed	49	1
Mixed	111	13
Deciduous dominated mixed	137	16
Deciduous	232	29
Forest Density		
Dense	162	43
Some openings	291	14
Many openings	81	3
Location[1]		
Lakeshore	96	4
Backshore	259	52
Over lake	57	1
Road edge	289	9
Cottage Description		
Cottaged	47	1
Near cottaged	153	7
Uncottaged	340	55
Perching Site		
Coniferous	13	6
Deciduous tree	70	2
Dead tree or hydro pole	37	2
Hydro wire	73	1
Ground	4	1

[1] 551 observations, some overlap.

Red-shouldered Hawk nests were in one area of low elevation. General habitat conditions for both species included location on a slope near a natural clearing, close to a water source, in a predominantly deciduous forest. This association with slope and water was not due to emphasis on field work conducted near lakeshores, as nests were located and studied away from shores. Broad-winged Hawk nests in the mid-western U.S. and nests of both species in the eastern U.S. show similar relationships with water and clearings (Keran 1978; Titus and Mosher 1981). Discriminant function analysis of nesting sites of four woodland raptor species in Maryland showed that Broad-winged and Red-shouldered Hawk nest sites could not be differentiated along the first discriminant function (weighted to distance to water and nest height), but they were separated along the second discriminant function (weighted to basal area, dbh of nest tree, and distance to nearest opening) (Titus and Mosher 1981).

More specific habitat selection was involved in the precise nest location. Red-shouldered Hawk nests were usually found in areas with fewer but larger trees, and lower ground cover and conifer composition. Their nests were generally higher and nest height was important in the discriminant function. Red-shouldered Hawk habitat was thus typically mature, open deciduous forest, while Broad-winged Hawk habitat was younger, deciduous-dominated mixed forest. In southern Ontario, the Red-shouldered Hawk nests in similar habitats to those found in this study (Campbell 1975), although elsewhere they nest primarily in riparian areas (Stewart 1949; Portnoy and Dodge 1979; Galli et al. 1976). In this study, Red-shouldered Hawk habitat (nest sites and occupied breeding ranges) fell into two broad categories: lowland riparian and upland deciduous. The Red-shouldered Hawk nested in only three species of tree, principally beech and yellow birch. The three species used here also were the most commonly used nest trees in southwestern Quebec (Morris et al. 1982). Beech or other species of birch have been commonly used elsewhere as nest trees (Stewart 1949; Henny et al. 1973; Campbell 1975). The Broad-winged Hawk nested in a variety of trees, but predominantly white birch, yellow birch, and sugar maple. Early studies indicated that trees were used mainly in accordance with their abundance (Burns 1911).

The overlapping of the nesting habitats of these two species would most likely occur in the moist slopes and valleys alongside waterbodies. The Red-shouldered Hawk appears to have the advantage in competition for nesting sites, because it begins nesting earlier (Burns 1911; Henny et al. 1973; Matray 1974; Portnoy and Dodge 1979). Red-shouldered Hawk nests were generally higher than those of Broad-winged Hawk nests, unlike the reverse situation in western Maryland (Titus and Mosher 1981). Newton (1976) suggested that, where nesting sites are abundant, interspecific competition may only result in the displacement of one species to another site in the home range with no effect on breeding density. This would not likely be the case with these raptors, because of the aggressive interactions observed. Occupied territories appeared to be almost mutually exclusive.

Both the Red-shouldered and Broad-winged Hawks require continuous forest areas. The Red-shouldered needs a minimum of 10 ha (Galli et al, 1976) and possibly as much as 2500 ha of generally forested habitat (Bednarz and Dinsmore 1981). It was rarely seen outside of dense forest cover, while the Broad-winged often was.

The DFA of perching and nesting sites of the Broad-winged Hawk verified that open areas are important to that species. Nesting and perching sites were differentiated on the basis of clearing size and adjacency, and slope. Exposed sites such as dead trees, transmission line wires, and exposed deciduous branches are preferred perching sites. Road edges, beaver meadows and lakeshores were all frequented. Similar clearings are used in Minnesota and Wisconsin (Keran 1978).

Although large-scale clearing of the forest would be detrimental, the existing degree of cottage development may not seriously disrupt Broad-winged Hawk breeding habitat. Territories, which appeared to be distinct and non-overlapping, were separated and defended along openings in the forest canopy, whether roadways, clearings, or shorelines. Most intraspecific interactions took place near such areas. The Broad-winged Hawk seems to defend exclusive home ranges as does the Red-shouldered Hawk (Craighead and Craighead 1956; Newton 1976), with the defended "activity centre" including a breeding, nesting and feeding territory (Keran 1978). If open areas are necessary to divide territories, the presence of lawns, roads, and hydro lines that occur with cottage development may slightly increase the potential number of Broad-winged Hawk territories in an area.

Aside from major habitat alteration, one of the other major effects of cottaging on the Broad-winged Hawk may be human disturbance. This species is most conspicuous in late May, probably due to activity associated with nest establishment. As the first major influx of cottagers occurs at that time (Victoria Day weekend), nest disturbance or desertion could result. The site tenacity of most raptors is weakest at the time of territorial establishment which could make it one of the most critical periods for nest desertion (Fyfe and Olendorff 1976). Heavy recreational use in Wyoming has had significant negative impacts on nesting buteos (Craighead and Mindell 1981).

The Red-shouldered Hawk did not respond positively to cottage development, although it often nested close to clearings and, in some cases, roads. Proportionally more sightings of this raptor occurred in uncottaged areas. Cottage roads that encircle lakes 50 to 100 m from the shore could fracture and isolate potentially valuable riparian and lakeshore habitat. The importance of nesting sites near permanent or seasonal water has also been documented elsewhere (Wiley 1975). The nesting success rate of the Red-shouldered Hawk is directly proportional to the distance between adjacent sites (Henny et al. 1973). This suggests that, if available breeding habitat were lost to cottage development, the response could be a compaction of the breeding population and a decreased reproductive success.

A nesting population of the Red-shouldered Hawk had not been documented previously in the study area (Peck 1979). We documented 9 nesting attempts of this species although it is considered to be declining in central Canada and elsewhere in its range (Brown 1971; Fyfe 1976). It appeared to be widely distributed in the study area, as there are large areas of suitable habitat and Red-shouldered Hawks were observed in areas where nests were not located. Given its general population status and the fact that nest trees may be limiting factors in otherwise suitable habitats (Titus and Mosher 1981), the effects of cottaging on habitat quality must be carefully considered in the context of its overall status.

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Dependence of Clark's Nutcracker, *Nucifraga columbiana*, on Conifer Seeds during the Postfledging Period

STEPHEN B. VANDER WALL[1] and HARRY E. HUTCHINS[2]

[1]Department of Biology, Utah State University, Logan, Utah 84322
[2]Department of Forest Resources, Utah State University, Logan, Utah 84322

Vander Wall, Stephen B., and Harry E. Hutchins. 1983. Dependence of Clark's Nutcracker, *Nucifraga columbiana,* on conifer seeds during postfledging period. Canadian Field-Naturalist 97 (2): 208–214.

We studied the behavior of Clark's Nutcracker (*Nucifraga columbiana*) at two times during the postfledging period. First, we observed nutcrackers recover stored Whitebark Pine (*Pinus albicaulis*) seeds in subalpine areas at Grand Teton and Yellowstone National Parks, Wyoming, USA, during June and July of 1979-1981. Seeds from caches were the only food items that we saw adults feed to their young. Of 163 caches located by adult nutcrackers, 20% contained germinating seeds. Juvenile nutcrackers learned to find caches by locating germinating seeds, and so became independent of their parents about mid-July. Second, we observed the behavior of nutcrackers foraging on Piñon (*Pinus monophylla*) and Limber (*Pinus flexilis*) pine cones in the Raft River Mountains, Utah, USA, from August-October in 1978 and 1980. Juveniles began foraging on cones in mid-August and first cached seeds in early to mid-September, both forms of behavior occurring 2-3 weeks later than in adults. Juveniles foraged significantly more slowly than adults in late August and early September, but after 15 September their foraging rates were similar. Juveniles were highly aggressive towards foraging adults prior to 7 September, but not thereafter. We conclude that Clark's Nutcrackers depend heavily on conifer seeds throughout the postfledging period.

Key Words: Clark's Nutcracker, *Nucifraga columbiana*, conifer seeds, caching, seed-recovery, juvenile, behavior.

Clark's Nutcrackers (*Nucifraga columbiana*) depend extensively on conifer seeds during the winter and the breeding season. This dependence takes several forms. First, conifer seeds make up 70-100% of the diet in November to April ($n = 281$ stomachs; Giuntoli and Mewaldt 1978). Second, Clark's Nutcracker is one of the earliest breeding passerines in temperate regions, with egg laying occurring from late February to mid-April. Early breeding is thought to occur, however, only following large conifer seed crops (Vander Wall and Balda 1981). Third, nestling nutcrackers are fed conifer seeds almost exclusively (Johnson 1900; Bradbury 1917; Mewaldt 1956). The seeds for all these activities come from caches made during the fall, and nutcrackers must leave a region if seeds are unavailable for storage (Davis and Williams 1957, 1964; Vander Wall et al. 1981).

Vander Wall and Balda (1981) argued that dependence on conifer seeds is an integrated component of a highly specialized seed-harvesting and storing syndrome, and that level of dependence is a key factor in the evolution of specialized food-storage behavior in certain corvids. In this paper we examine dependence of Clark's Nutcracker on conifer seeds during the postfledging period (from fledging to the post-juvenile molt), and discuss this dependence in the context of the model of seed-caching behavior developed by Vander Wall and Balda (1981). During this period nutcrackers engage in two important activities. First, nutcracker family groups congregate from May-July at communal cache areas where adults search for cached seeds and care for young.[1] Second, from August to November, juveniles learn to forage on conifer cones and store seeds for the winter. Tomback (1978) briefly discussed Clark's Nutcracker postfledging behavior, and Volker and Rudat (1978) described postfledging behavior of Eurasian Nutcrackers (*Nucifraga caryocatactes*).

Study Areas and Methods

Cache-recovery behavior and cone-foraging behavior were studied in two separate areas where nutcrackers foraged for the seeds of different pines.

(1) The recovery of cached Whitebark Pine (*Pinus albicaulis*) seeds was observed at Surprise and Amphitheater lakes (2960 m elev.) in Grand Teton National Park and Mt. Washburn (2700-2900 m elev.) in Yellowstone National Park, Wyoming. These areas are dominated by Whitebark Pine, but Subalpine Fir (*Abies lasiocarpa*), Engelmann Spruce (*Picea engelmannii*) and Lodgepole Pine (*Pinus contorta*) also occur. Quantitative data were gathered on 13 and 15 July 1979, 27 and 30 June, 1 July and 16-18 July 1980, and 17-19 June 1981.

Adults and juveniles searching for cached Whitebark Pine seeds were observed at close range (usually <20 m). All bill-probes into the substrate were assumed to be cache-recovery attempts. The number

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[1] We operationally define "young" as nutcrackers dependent on their parents for food; the term "juvenile" refers to nutcrackers from independence to the completion of postjuvenile molt.

of successful (one or more seeds recovered) and unsuccessful cache-recovery attempts was recorded for each foraging bird. The time to find a cache was measured with a stopwatch, and the distance traveled while searching was estimated in meters. Digging techniques used and numbers of seeds recovered were recorded. Following each successful cache recovery the excavation was inspected for unrecovered edible seeds, spoiled seeds, and germinating seedlings. The fate of recovered seeds was recorded as: 1) shelled and eaten or placed in sublingual pouch at the cache site, 2) shelled and fed to young at the cache site, 3) transported (in bill or pouch) intact away from the cache site, and 4) re-cached. The presence and behavior of attendant young were noted.

(2) Cone-foraging adult and juvenile nutcrackers were observed at two sites in the Raft River Mountains of northwestern Utah from August to November of 1978 and 1980: a Limber Pine (*Pinus flexilis*) stand along a north-facing ridge (2525 m elev.) overlooking Clear Creek drainage (described in Lanner and Vander Wall 1980), and a piñon-juniper (*Pinus monophylla-Juniperus osteosperma*) woodland (1825-2450 m elevation) occupying a south-facing slope.

Foraging rates of adults and juveniles were determined by measuring with a stopwatch the time required to remove Piñon or Limber pine seeds from cones (search time), and to shell and ingest the edible contents (handling time). Mean search time of adults during an observation period was calculated as the unweighted mean of individual foraging observations in which three or more seeds were extracted. Foraging data were gathered at 5-7 day intervals throughout the fall to monitor changes in foraging rates as cones ripened, and to determine differences in adult and juvenile foraging rates as juveniles gained foraging experience. Qualitative differences in adult and juvenile foraging behavior were noted. All agonistic encounters and the ages of participants were recorded.

Results

When the subalpine cache areas became accessible to us in early June, nutcracker family groups were already present. At this time most young were strong and skilful fliers, but they were still completely dependent on adults for food.

Adult Cache-Recovery Behavior

Adult nutcrackers frequently searched for caches in loose aggregations of 2-10 birds, but within these groups each individual foraged independently and, for the most part, ignored other birds. Two patterns of search were used to locate cached seeds. Birds frequently flew or hopped directly to a cache site, probed in the ground with their bills, and extracted seeds as if they knew the cache location. They also engaged in relatively prolonged searches which entailed slow deliberate inspection of the ground surface. Distance travelled during prolonged search ranged from 3-50 m ($\bar{x} \pm SD = 12.0 \pm 9.8$ m, $n = 45$) at a mean rate of 0.19 m/sec (SD = 0.09 m). Only 36% of prolonged searching bouts ended in cache discovery ($n = 105$).

Nutcrackers retrieved seeds by either probing vertically with the bill (86.5% of observations, $n = 148$), flicking debris aside with lateral movements of the bill (8.1%), or a combination of the two (5.4%). Lateral bill movements were used only in areas overlain by forest litter. Probe holes averaged 1.2 × 2.1 cm in diameter ($n = 23$) with a mean depth of 2.5 cm ($n = 14$). Recovered caches ranged in size from one to 14 seeds ($\bar{x} \pm SD = 3.37 \pm 2.39$ seeds, $n = 155$). Nutcrackers spent an average of 25.7 sec at cache sites (range = 1 – 224 sec, SD = 42.9 sec, $n = 43$). Time at a cache site was correlated with number of seeds retrieved ($r = 0.48$, $P < 0.05$). The percent of probes resulting in cache recoveries was 31.5% in mid-June (1981), 33.3% in late June and early July (1980), and 82.4% in mid-July (1979). Overall success rate was 44.1%. These rates were calculated from data collected in different areas during different years, so they cannot be taken as a reliable trend in recovery success rate through the season.

At least 32 of the 163 caches located by adults contained one or more germinating seeds. Nutcrackers located germinating seeds soon after the seed stem or hull broke through the soil surface. Nutcrackers detached the seed from its stem, shelled it, and ingested the remaining contents before excavating the area around the stem to find other seeds. Most germinating seeds were located during prolonged search, and we suggest that birds employing this behavior are searching for germinating seeds.

The proportion of recovered caches containing germinating seeds changed significantly during the summer ($X^2 = 32.6$, $P < 0.001$). Germinating seeds did not occur in caches recovered in mid-June ($n = 41$), but in late June and mid-July 61.1% ($n = 36$) and 43.5% ($n = 23$) of the caches, respectively, contained germinating seeds. Whitebark Pine seeds apparently began germinating between mid and late June during the years of this study. Bibikov (1948) reported that sprouting Cedar Pine (*Pinus sibirica*) seeds were frequently taken by Eurasian Nutcrackers during June and July, and Bossema (1968) found that many, if not all, acorns eaten by the jay (*Garrulus glandarius*) in June and July were taken from seedling oaks (*Quercus* sp.).

Nearly 55% of all recovered seeds were shelled at the cache site and either eaten or placed in the sublingual pouch (these actions were not always distinguishable).

In the latter case, seeds were then transported out of the cache area and presumably fed to young. Of the remaining seeds, 34.5% were placed in the sublingual pouch, transported short distances (usually <100 m), shelled, and either eaten or fed to young, 8.2% were opened at the cache site and fed directly to begging young, and 2.7% were immediately re-cached in new sites.

Following cache recoveries we inspected 95 excavations for undiscovered seeds. Only five edible seeds remained. These seeds were from three caches and accounted for 1.6% of the total seeds cached. One of these seeds was frozen to the substrate. We suspect that the bird left seeds because of disturbances by the observers and begging young at the other two caches. Eight mouldy seeds were left at or near cache sites.

Nutcrackers generally concentrated their search effort where snow had recently melted: 43.2% of all searches began within 1.0 m of snow, and 69.2% began within 5.0 m of snow. On several occasions nutcrackers pecked through ice and snow at the edge of the snow pack to recover seeds. One nutcracker spent 75 sec to break and remove ice 1.0 cm thick to reach a cache situated 2.0 cm behind the edge of a snow bank. As nutcrackers tended to forage near the periphery of the melting snow pack, centers of cache-recovery activity shifted markedly during the course of the summer.

Behavior of Young on the Cache Area

While adult nutcrackers searched for cached seeds, groups of young usually waited in nearby trees. Young frequently gave *kra-a-a* calls similar to those given by adults but higher pitched and repeated more frequently (20-30 times/min). When adults approached with small loads of shelled seeds in their pouches, the young flew or hopped toward the adults and began giving the hunger call (cf. Mewaldt 1956), a frantic *near*. If the adults arrival was not observed by the young, the adult gave soft *near* or *nert* calls to which the young responded with hunger calls and rapid approach. As a young approached an adult its wings were held partially outstretched and quivered rapidly. The mouth was gaped wide and the head titled slightly upward. The adult then ejected seeds from its pouch with quick jerks of the head and, holding the seeds one at a time in the tip of the bill, inserted them deep into the young's mouth. Each young typically received 3-7 whole seeds in quick succession. We never saw adults feed young anything other than Whitebark Pine seeds.

At 24.2% of adult cache recoveries, young hopped along the ground 1-5 m behind the adult, giving the high-pitched *kra-a-a* or hunger calls. Adults ignored these young, but when a cache was located the 1-4 young frequently crowded too close and were driven back with pecks to the face. Whole seeds were fed to the young individually as they were removed from the cache and shelled. On three occasions young were fed a mouthful of snow.

Young nutcrackers from different broods roosted and moved about independently. Young from one brood were occasionally attracted to and approached begging birds in a nearby brood, but these young were ignored or driven away by adults.

Young nutcrackers regularly "foraged" on their own between feedings. They probed into needle clusters, removed exfoliating bark, and manipulated a wide variety of inedible objects (e.g. twigs, pebbles, old cone cores). Young that followed foraging adults frequently examined excavations made by them, probed into the holes, and manipulated seed shells and mouldy seeds near the hole.

During mid-July we saw young nutcrackers locate four caches; all contained germinating seeds. At this time many young appeared independent, and the vocalizations of most young were indistinguishable from those of adults. Young occasionally foraged near other young or adults but these foraging associations lacked the integrity of family groups. Two young observed for over 90 min were not visited or fed by adults. Although several feedings of young were observed, most of these were of a bird that stayed near and appeared dependent on an adult.

Cone-foraging Behavior of Adults

The behavior of adults foraging on cones is briefly summarized here for comparison with juvenile cone-foraging behavior.

Prior to mid-August most foraging is for arthropods and seeds cached the previous fall, but in late July and early August adult nutcrackers begin foraging on ripening conifer cones. At this time the seeds of preferred pines (e.g. Piñon and Limber pines) are not fully developed, having dry weights only 5-35% and caloric values (per g ash-free dry weight) 60 to 90% those of mature seeds (Vander Wall unpublished data). By mid-August, seeds were 25-60% of their mature weight and 85-95% of their mature caloric value, and birds were frequently observed foraging in the tree-tops.

A nutcracker grasps the base of a cone with its feet and hammers with its bill between the overlapping cones scales. The head is then twisted to the side and the bill, acting as a lever, pries the scales apart. After several such prying movements, a seed is exposed and extracted with the bill. Starting in the last few days of August, seeds may be deposited in the sublingual pouch to be stored later.

Seed extraction rates changed predictably during the course of the harvest period. For Piñon and Limber pines, extraction rates in mid-August were 1-2 seeds/min. As cones dried and seeds ripened, the adult seed extraction rate steadily increased to a peak of 7-12 seeds/min in late September, when most cones opened. The seed extraction rate decreased to <6 seeds/min from mid-October through November as the seed crop became depleted. The pattern is similar for Whitebark Pine (Hutchins and Lanner 1982).

Development of Cone-foraging and Seed-handling behavior in Juveniles

Juvenile nutcrackers were first seen foraging on Piñon Pine cones on 14 August in 1978 and on 19 August in 1980. On Whitebark Pine, juvenile foraging was first observed on 15 August in 1980.

During the first few weeks of cone foraging, juvenile behavior differed both quantitatively and qualitatively from that of adults. Until 15 September, juvenile seed extraction rate was significantly slower than that of adults (t-test, $P<0.05$, Figure 1) with juveniles frequently requiring 2-4 times longer to extract a seed. Juvenile nutcrackers hammered less forcefully than adults, did not concentrate hammering at a specific point, did not always direct hammering between the cone scales, and in general appeared less coordinated than adults. Juveniles failed to extract seeds in approximately half their foraging attempts. As juveniles gained foraging experience and cones dried and began to open, the differences between adult and juvenile seed extraction rates and foraging behavior disappeared. This occurred between 15 and 23 September for birds foraging on Piñon Pine in 1980.

Seed handling time also differed between adults and juveniles. Mean handling time for adults remained fairly constant during the course of the harvest season: 9.6 sec/seed (SD = 4.5 sec, n = 813) for Limber Pine and 19.4 sec/seed (SD = 10.7 sec, n = 241) for Piñon Pine. As juveniles usually broke seeds during the extraction process, handling times by juveniles prior to 7 September were difficult to document. Adults seldom break seeds after late August. Limited data (n = 10) suggest that prior to 7 September juveniles required a mean of 20.5 sec (SD = 12.3 sec) more than adults to handle seeds. Long handling times for juveniles prior to 7 September were due to excessive manipulation of seeds in the bill and difficulty in cracking the seed coat and in separating the contents from the seed coat. However, juveniles rapidly gained proficiency. After 12 September, they handled seeds at mean rates of 10.5 sec/seed (SD = 6.3, n = 30) for Limber Pine and 23.5 sec/seed (SD = 8.9, n = 6) for Piñon Pine; not significantly different from adults (Mann-Whitney U-test, $P<0.05$).

Adult nutcrackers were first seen filling their sublingual pouches with Piñon seeds on 27 August 1978 and 2 September 1980, an indication that seed storage had begun. For Whitebark and Limber pines, nut-

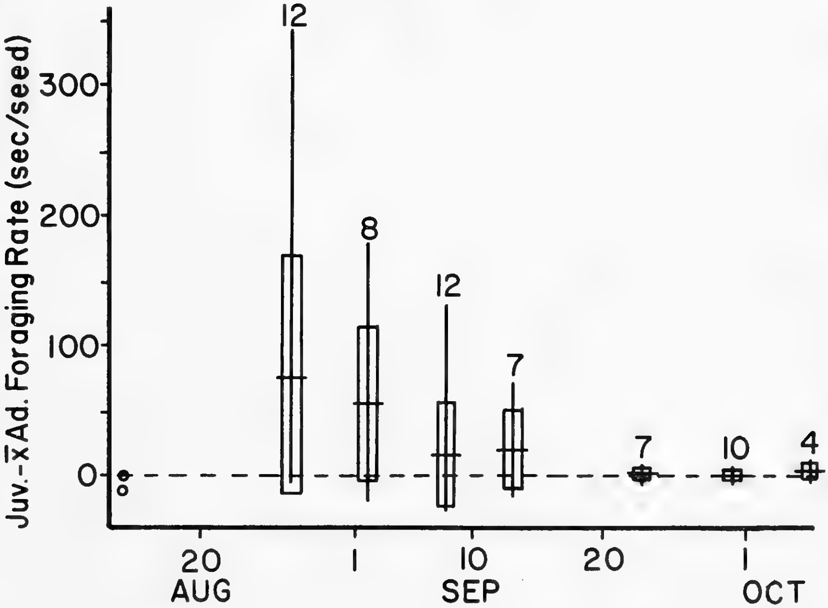

FIGURE 1. Juvenile minus adult foraging rate from 26 August to 6 October on Piñon and Limber pines. Vertical line is the range, horizontal line is the mean, and vertical bar is ± 1 SD. Number of foraging observations is given above vertical line. Two juvenile foraging observations on 14 August are represented in circles.

crackers first placed seeds in their pouches on 15 August in 1980 and 26 August in 1978, respectively. The first juvenile observed putting seeds into its sublingual pouch did so on 7 September, but this behavior was not commonly observed until 23 September. Although seed caching behavior in corvids appears to be innate (Ligon and Martin 1974), juvenile nutcrackers in the years of this study did not begin to store seeds until 2-3 weeks after adults had begun to do so.

Juvenile Aggression

We observed 145 aggressive interactions among nutcrackers foraging on Piñon Pine in 1980. In 106 of these, the ages of both participants were determined. Adults interacted aggressively 71 times, adults were aggressive toward juveniles 6 times, and juveniles were aggressive towards adults 29 times. To test whether the observed frequency of interactions between age classes was significantly different from random, we calculated expected frequencies of interactions using a binomial distribution. We assumed that the proportion of adults (p) in the population was 0.80. This value was selected for two reasons: 1) it approximated the actual proportion of adults on our study site at the time the data were collected and 2) this value gives the highest probability of failing to reject the null hypothesis (i.e., aggressive interactions between age classes were random). Juveniles were aggressive toward adults more frequently than predicted by chance ($X^2 = 19.94$, $P < 0.001$).

Juvenile aggression towards adults was very high on 19 and 26 August and rapidly decreased to zero by 7 September (Figure 2). Aggression among adults persisted throughout the harvest season at a low level and adult aggression toward juveniles was low and fluctuated erratically.

In all cases ($n = 145$), agonistic interactions began with the aggressor attempting to supplant a foraging bird. Most aggressive attempts (90.4%) were successful, resulting in the aggressor assuming the foraging station. Adults resisted juvenile attempts at displacing them only twice and juveniles failed to supplant adults only once ($n = 29$).

Discussion

Young nutcrackers are dependent on their parents for an unusually long time. The exact age of young observed in this study was not known, but assuming

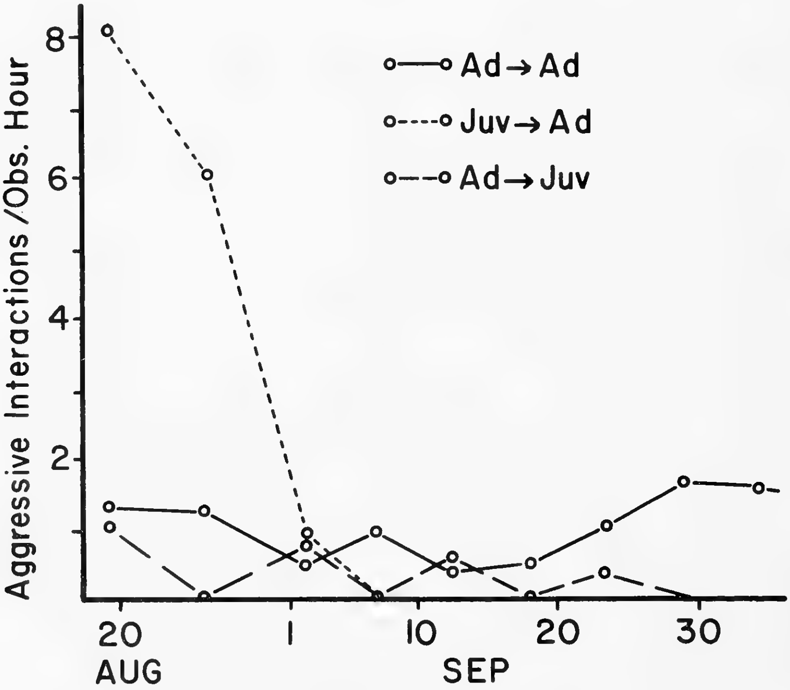

FIGURE 2. Aggressive interactions per observation hour (adjusted to adult-juvenile ratio of 80:20, see text) between adult and juvenile nutcrackers foraging on Piñon Pine from 19 August–4 October 1980. Infrequent adult-adult aggression continued into November.

eggs hatched in mid-April (e.g. Mewaldt 1956) nutcrackers achieving independence in mid-July were 13-14 weeks old. Volker and Rudat (1978), working with individually marked Eurasian Nutcrackers, found that young separated from their parents at 15-17 weeks of age. These periods of dependence are much longer than those found in most other passerines (Skutch 1976).

The extended period of parental care in nutcrackers is probably related to the unusual food supply on which the young depend. The seeds that make up the bulk of the diet of young nutcrackers are hidden in the soil, available only to the adults that recover them by remembering where they put them (Vander Wall 1982). Since young birds cannot efficiently forage for these seeds, they have no alternative but to rely on adults for food. As a consequence of this behavioral constraint, the development of the young's foraging ability lags behind that of other behavior; e.g. by mid-June young nutcrackers are excellent fliers not easily distinguished from adults, though still dependent on them for food.

When seeds begin to germinate, by late June in Whitebark Pine, they can be located and utilized by any foraging bird. It is at this time that young are first able to forage for seeds and make a significant contribution toward satisfying their energy demands. Young nutcrackers apparently acquire the ability to locate germinating seeds through observational learning and socially facilitated behavior (Alcock 1969; Clayton 1978). Young, following their parents or other adults, may observe the adult pattern of search, see germinating seeds, and examine the excavation and seed shells at cache sites. Feedings, which frequently take place at the cache site, may reinforce the association between germinating seeds and a food source. [Alcock (1969, p. 320) suggested that "the interaction between observational learning and a bird's reinforced socially facilitated experience could assist in the development and expression of a bird's behavioral repertoire."] Young nutcrackers achieve independence about the same time that they acquire the ability to find germinating seeds, processes that may be causally related. How long juveniles rely on germinating seeds is unknown, but since nutcrackers typically follow the receding snow pack to recover seeds, and since the snow pack may persist into August in alpine areas, it is probable that in many years germinating seeds can be utilized until mid-August, when foraging on new cones begins.

Clark's Nutcracker and several other seed-caching corvids are thought to be the primary dispersal agents for several species of wingless-seeded pines (Vander Wall and Balda 1977, 1981; Tomback 1978; Lanner and Vander Wall 1980; Lanner 1982; Hutchins and Lanner 1982). In an area less that 500 m^2, we located 50 groups of one-year old seedlings, all, we suspect, germinated from nutcracker caches. While the exploitation of germinating seeds by nutcrackers may reduce the effectiveness of dispersal, this effect appears to be small, as the critical period during which germinating seeds may be destroyed appears to be very short, perhaps only 2-3 days following emergence.

Unripe cones are difficult for nutcrackers to open, the task requiring considerable strength and skill. The development of juvenile cone-foraging skills, measured by mean search time (Figure 1), requires about four weeks to achieve the level of adults. Much of the juveniles' improvement, however, is due to the drying and opening of cones (in Piñon and Limber pines), which greatly increases the foraging rate of all birds. Seed caching by juveniles begins 2-4 weeks later than in adults. This has important implications for juvenile winter survival because, relative to adults, the quantity of seeds stores by juveniles is likely to be small, and juveniles may not be able to store enough food to ensure survival through the winter in years of low to medium cone crops.

Ashmole and Tovar (1968), Fogden (1972), and others have suggested that a long period of parental care is common in birds requiring a high degree of skill for foraging success. During this period of parental care the young develop foraging skills. Clark's Nutcrackers, however, do not extend parental care into the fall seed harvest. Apparently, Clark's Nutcracker has become so specialized at harvesting and storing conifer seeds that its entire annual cycle is dependent on its stored seed reserves (Vander Wall and Balda 1981). By the onset of the seed harvest adults must be free from their young to devote most of their time to harvesting and storing seeds. Consequently, juveniles must acquire cone-foraging skills on their own or through interactions with adults that are not necessarily their parents.

Juveniles were aggressive toward foraging adults during the early portion of the seed harvest, a behavior which probably increased their access to seeds. Juvenile aggression may have been due to high hunger levels, a probable consequence of their slow, inefficient foraging. Breaking into cones frequently took juveniles 2-5 min of constant hammering, an activity demanding much energy. Many foraging attempts ended in failure. It is possible that, while learning to forage on cones, juveniles were on the verge of starvation.

Food-deprived birds may interact aggressively at a limited food source (Hinde 1952; Roth 1971), although others (e.g. Andrew 1956; Wiley and Hartnett 1979) have argued that there may be no direct link between food deprivation and aggression. Aggressively displacing foraging adults may help juveniles maintain a positive energy balance. This supposition is supported by the observation that juvenile aggression ceased by 7 September (Figure 2), about the time that juvenile foraging rates approached those of adults (Figure 1). Juvenile Steller's and Piñon jays also typically dominate adults (Brown 1963; Balda and Balda 1978).

This study extends the findings of Vander Wall and Balda (1981) by demonstrating that Clark's Nutcracker depends heavily on conifer seeds throughout the postfledging period. Conifer seeds, which are fed upon by young, juveniles and adults, appear to have had a pervasive role in shaping the natural history of Clark's Nutcracker. This high level of granivory, exceeded by few other bird species, is made possible by the high nutritive value of conifer seeds (Botkin and Shires 1948; Lanner 1981) but has necessitated some ancillary adaptations of parental and foraging behavior to be successful.

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Notes

White Malaxis, *Malaxis monophyllos* var. *diphyllos*, an Addition to the Orchids of Canada from the Queen Charlotte Islands, British Columbia.

WILLIAM J. BEESE

MacMillan Bloedel Limited, 65 Front Street, Nanaimo, British Columbia V9R 5H9

Beese, William J. 1983. White Malaxis, *Malaxis monophyllos*, var. *diphyllos*, an addition to the orchids of Canada from the Queen Charlotte Islands, British Columbia. Canadian Field-Naturalist 97(2): 215–216.

Two collections in 1981 and 1982 extend the range of *Malaxis monophyllos* var. *diphyllos*, approximately 2000 km southeast of those described from the Aleutian Islands, Alaska.

Key Words: White Malaxis, *Malaxis monophyllos* var. *diphyllos*, Queen Charlotte Islands, range extension.

During vegetation sampling for a forest habitat type classification in the Queen Charlotte Islands, I discovered a variety of White Malaxis or Adder's-mouth, *Malaxis monophyllos* (L.) Schwartz var. *diphyllos* (Chamisso) Luer, previously described only from the Aleutian Islands in Alaska. This new record represents a disjunct population approximately 2000 km southeast of its known range (Figure 1).

The first collection was made on September 11, 1980 in a topogenous bog at 390 m elevation on southeastern Graham Island, 10 km north of Queen Charlotte City, B.C. (53° 19′N, 132°07′W). The specimens had passed the flowering stage, so a positive identification was not possible. A second collection at the same locality on June 16, 1981 procured several flowering specimens. My identification of them as *M. monophyllos* was confirmed by Dr. Roy L. Taylor, Director of the Botanical Garden at the University of British Columbia, Vancouver, who determined them to be the variety *diphyllos* from Luer (1975). Two specimens have been deposited in the University of British Columbia herbarium. The species is new to the flora of the Queen Charlottes, and the variety is new to Canada.

Collected specimens are 15-20 cm tall, arising from an ovoid corm 1-1.5 cm in diameter, with two leaves of nearly equal size sheathing the stem. The flowering spike is a raceme of up to 60 small yellowish-green flowers with the lip uppermost, as in the typical variety.

The presence of two robust leaves distinguishes this plant from the typical variety, which has a single leaf or occasionally two leaves, with the second being very inconspicuous. Hultén (1968) did not recognize the variety *diphyllos* in the Flora of Alaska, nor did Scoggan (1978) in the Flora of Canada. A third variety, var. *brachypoda*, was collected previously in several locations in coastal B.C. (Szczawinski 1959). It differs

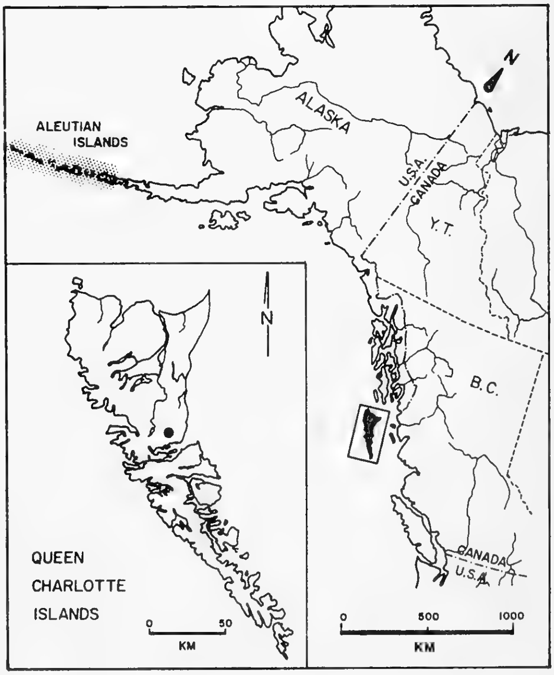

FIGURE 1. Previous known distribution of *Malaxis monophyllos* var. *diphyllos* is shaded with the new locality indicated with a solid circle on the map inset.

from the other varieties in that the flowers are inverted, so that the lip is lowermost. This variety is not recorded on the Queen Charlotte Islands; however, a second species, *Malaxis paludosa* (L.) Sw., is found there (Calder and Taylor 1968). It is generally a much smaller plant with fleshy leaves and is not easily confused with *M. monophyllos*. Both species of *Malaxis* are rare in British Columbia or at least poorly collected because they are an inconspicuous element of the plant associations in which they occur.

My collections were made on a site representing a transition between bog and closed coniferous forest. The open, scrubby tree canopy included *Tsuga heterophylla, Tsuga mertensiana, Thuja plicata* and *Chamaecyparis nootkatensis. Vaccinium ovalifolium, V. alaskaense* and *Menziesia ferruginea* were the most common shrubs present. *Malaxis* occurred in a lush herbaceous patch in a small colony of scattered individuals. Associated vascular plants included *Veratrum viride, Dodecatheon jeffreyi, Athyrium filix-femina, Montia sibirica, Lysichiton americanum* and *Carex anthoxanthea*. A dense carpet of bryophytes including *Rhizomnium glabrescens, Leucolepis menziesii* and *Conocephalum conicum* occupied most of the ground surface where *Malaxis* was present. *Sphagnum* spp. were notably not abundant. Plants were rooted in a surface soil horizon of well decomposed, black, mucky humus overlying deep peat layers of moderately decomposed *Sphagnum* and *Carex*. Observations of *M. monophyllos* in other localities in the Queen Charlottes have not as yet been made.

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Extensive Overland Movement of Pintail, *Anas acuta*, Brood and Attempted Predation By Hawks

DAVID C. DUNCAN

Department of Zoology, University of Alberta, Edmonton, Alberta T6G 2E9

Duncan, David C. 1983. Extensive overland movement of Pintail, *Anas acuta*, brood and attempted predation by hawks. Canadian Field-Naturalist 97(2): 216–217.

A Northern Pintail (*Anas acuta*) was observed moving her one-day-old brood approximately 5.2 km overland. The hen and brood survived predation attempts by a Northern Harrier (*Circus cyaneus*) and a Swainson's Hawk (*Buteo swainsoni*).

Key Words: Northern Pintail *Anas acuta*, brood, overland movement, predation, hawk, Alberta.

Duck broods may undertake frequent and substantial overland movements (Evans et al. 1952; Ball 1973), with the hen apparently initiating such movements (Dzubin and Gollop 1972). Among North American ducks, Northern Pintails (*Anas acuta*) are reported to have one of the highest brood mobilities (Evans et al. 1952; Diem and Lu 1960). Sowls (1955) noted a Pintail hen moving her brood over 700 m the first day after hatch and Sayler (1962) recorded a Pintail brood travelling almost 5 km prior to fledging. Overland movements are thought to result in considerable duckling mortality (Sayler 1962; Dzubin and Gollop 1972; Ball 1973), often attributed to predation. The following observation involved the movement of a Pintail hen and her one-day-old brood over flat, grazed, prairie near Brooks, Alberta. They left Kininvie South Lake, the same waterbody from which Giroux (1980) observed broods of Canada Geese (*Branta canadensis*) moving overland.

Early on 6 June 1981, a radio-marked Pintail hen took her newly-hatched brood of seven ducklings from their nest to Kininvie South Lake, a distance of

350 m. At 11:40 the next day, the hen and brood were located and sighted about 500 m west of Kininvie South Lake. After this initial observation, I tracked the hen from a vehicle at a distance of 0.5-1 km.

About 1 h after the initial sighting I approached to within 50 m of the hen, causing her to fly from her brood and perform distraction displays. As I withdrew to about 500 m, the hen rejoined her ducklings and continued walking. At this time they were 1.1 km northwest of Kininvie South Lake.

Two and a half hours later, the hen and her brood crossed a road, enabling me to count seven ducklings. The hen and her brood had been travelling north-northwest, parallel to and about 500 m west of a trail and ditch which lead towards another waterbody, Kininvie Flat. Ten min after this, the hen was sighted heading directly for Kininvie Flat, having altered her course to northeast. As the hen approached Kininvie Flat, I moved to within about 300 m.

At 16:10 a female Northern Harrier (*Circus cyaneus*) dove at the hen and brood. The hen stood in an alert posture and quacked as the hawk swooped to within 0.5 m. The hawk landed about 10 m away from the hen. Both stood their positions for approximately 5 min after which the hen and her brood continued walking towards Kininvie Flat and the hawk flew off.

About 15 min later a Swainson's Hawk (*Buteo swainsoni*) dove at the hen and landed 10 m away. After a few minutes the hen again proceeded towards Kininvie Flat and the hawk flew away. Neither hawk made any further attack. At 17:00 the hen and brood reached the edge of Kininvie Flat and I observed that all seven ducklings were still present.

The total distance walked was about 5.2 km while the shortest distance between the lakes is 4.3 km. Estimated time for the movement was 6 h, an average speed of 0.9 km/h. The hen generally traversed open prairie although for brief periods she walked in the taller cover of a dried lake bottom and along a buried pipeline. The hen and brood were very difficult to observe, particularly when the hen crouched low after being disturbed. On a number of occasions the hen was observed tilting her head to the side as if to look up. Overall, the movement appeared directed and the hen well-oriented.

Kininvie South Lake, the waterbody vacated by the hen, is shallow and prone to dry up in certain years. In 1981, however, ample water persisted due to mid-summer water input, and many duck broods, including Pintails, fledged on the lake. Kininvie Flat is larger with a more stable water level and less emergent vegetation. Hens generally move their broods to intended rearing areas when the ducklings are young (Ball 1973, Talent et al. 1982). The movement may have been in response to human disturbance as the hen was separated from her brood for some time the previous day when I attempted to count her ducklings.

A number of Pintail nests in the Brooks area are located farther than 1 km from water (unpublished data). Thus, substantial overland movements by newly-hatched ducklings must be common. Although such overland travel entails an increased risk of predation by terrestrial mammals, its survival value must generally be greater than the risk (Eriksson 1978). Overland movements may be less hazardous in sparsely-vegetated areas such as grazed, mixed prairie because of decreased probability of separation of ducklings from the hen. Four days after the movement described here, the hen was found alone on Kininvie Flat, her brood having apparently died in the interim.

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Predation by Fish and Common Mergansers on Darters (Pisces: Percidae) in the Thames River Watershed of Southwestern Ontario

JOHN ENGLERT[1] and BENONI H. SEGHERS[2,3]

Department of Zoology, University of Western Ontario, London, Ontario N6A 5B7
[1]Present address: MacLaren Plansearch Corporation, Suite 401-750 West Pender St., Vancouver, B.C. V6C 2T7
[2]Present address: Kananaskis Centre for Environmental Research, University of Calgary, Seebe, Alberta, T0L 1X0
[3]Author to whom correspondence should be addressed

Englert, John, and Benoni H. Seghers. 1983. Predation by fish and Common Mergansers on darters (Pisces: Percidae) in the Thames River watershed of southwestern Ontario. Canadian Field-Naturalist 97(2): 218-219.

A survey of potential predators of darters in the Thames River watershed near London, Ontario revealed that darters were rarely consumed by other fish species; however, they did appear to be an important food resource for Common Mergansers (*Mergus merganser*) during their spring migration.

Key Words: darter, *Etheostoma blennioides, Etheostoma caeruleum, Etheostoma flabellare, Etheostoma nigrum, Percina maculata, Micropterus dolomieui, Ambloplites rupestris, Esox lucius, Semotilus atromaculatus, Mergus merganser,* predation, food habits, Thames River, Ontario.

Five species of darters are common in the Thames River watershed of southwestern Ontario: the Blackside Darter (*Percina maculata*), Johnny Darter (*Etheostoma nigrum*), Rainbow Darter (*E. caeruleum*), Greenside Darter (*E. blennioides*), and Fantail Darter (*E. flabellare*) (Englert and Seghers 1983).

There is a paucity of information available on predation on stream darters. Reports of predation on specific darter species in streams include Creek Chub (*Semotilus atromaculatus*) preying on Johnny Darters (Moshenko and Gee 1973), Northern Pike (*Esox lucius*) on Blackside Darters (Hunt and Carbine 1950), Mottled Sculpins (*Cottus bairdi*) (Koster 1936) and Smallmouth Bass (*Micropterus dolomieui*) (Lachner 1950) on Fantail Darters, Spotted Bass (*M. punctulatus*) on Johnny Darters (Smith and Page 1969), Pickerel (*Esox americanus*) on Spottail Darters (*E. squamiceps*) (Page 1974), *Cottus carolinae* on Snail Darters (*Percina tansi*) (Starnes 1977), and juvenile Burbot (*Lota lota*) on Iowa (*E. exile*) and Johnny Darters (Hanson and Qadri 1980). Darter species are often lumped together as prey items, e.g. stream dwelling Smallmouth Bass were found to be feeding on unidentified darter species by Surber (1941), Tate (1949), and Swor and Bulow (1975) and Metzelaar (1928, 1929) reported predation on darters by Brook Trout (*Salvelinus fontinalis*), Brown Trout (*Salmo trutta*), and Rainbow Trout (*S. gairdneri*).

A potential avian predator on stream darters is the Common Merganser (*Mergus merganser*) which stops on the Thames River system during its spring migration northwards. This species is known to search under stones for food (Lindroth and Bergstrom 1959) and was reported by Salyer and Lagler (1940) to feed on darters in Michigan streams.

Study Area and Methods

Potential fish predators from Medway Creek and the Thames River (middle and north branches) near London, Ontario were sampled in daylight hours during the summers of 1977 and 1978 and their stomach contents examined. Fish were captured mainly by angling but bag seining, electroshocking, and gill netting were also employed.

A total of 17 Common Mergansers were shot on the Thames River (north branch) during April in 1977 and 1978 and examined for evidence of predation on darters.

Results and Discussion

Few darters were consumed by other fish species and the only identifiable species was the Blackside Darter (Table 1). Darters are apparently not an important summer food resource for Smallmouth Bass or Rock Bass (*Ambloplites rupestris*); their chief food was crayfish. Samples of Northern Pike and Creek Chub were too small to assess their importance as predators. Both species were often observed in the same habitat as Johnny and Blackside Darters (relatively deep and quiet water; see Englert and Seghers 1983). The low incidence of predation on darters by other fish species may reflect the rich repertoire of antipredator behavior of darters (Englert 1979). Various escape tactics may render these species relatively immune to attack by larger fish. Also, we cannot rule out the possibility that darters are consumed more

TABLE 1. Evidence of predation on darters in Medway Creek and the Thames River near London, Ontario.

Predator	Number Examined	Number Containing Fish	Number Containing Darters	Number of Darters and Species
Smallmouth Bass	77	13	1	1 unidentified
Rock Bass	55	7	1	2 Blackside
Northern Pike	5	3	1	1 Blackside
Creek Chub	17	0	0	—
Common Merganser	17	12	5	6 Greenside 5 Rainbow 3 Blackside

frequently in fall and winter when alternate invertebrate prey become scarce.

The analysis of the diet of the Common Mergansers reveals that these birds feed on darters during their stop in this area and that at least three species of darters, Greenside, Rainbow, and Blackside, are vulnerable. Interestingly, the first two species are predominantly riffle species (Englert and Seghers 1983). Common Mergansers also fed on Yellow Perch (*Perca flavescens*) and unidentified species of suckers and cyprinids.

In our study area, darters undoubtedly are preyed upon by other bird species (heron, kingfisher), mammals, and perhaps reptiles. Our extensive field observations would suggest that such occurrences are quite rare; however, this deserves further study.

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Water Meal, *Wolffia arrhiza* (Lemnaceae) in Saskatchewan

J. LOOMAN

Research Station, Research Branch, Agriculture Canada, Swift Current, Saskatchewan. S9H 3X2

Looman, J. 1983. Water Meal, *Wolffia arrhiza* (Lemnaceae) in Saskatchewan. Canadian Field-Naturalist 97(2): 220–222.

Wolffia arrhiza, an addition to the flora of Canada, was found in Saskatchewan in 1981 in a slough north of Pierceland. Further surveys in 1981 and 1982 revealed it in five additional localities. This is the first report of the species in North America.

Key Words: *Wolffia arrhiza*, Lemnaceae, new records, distribution, ecology.

Recently, Cody reported the occurrence of *Wolffia columbiana* Karsten in Manitoba (Cody 1980), where it was found in several ponds in Riding Mountain National Park. Cody's report was the first record of the genus *Wolffia* in the Prairie Provinces. Previously *Wolffia* was known only from Southern Ontario and Quebec (Scoggan 1978).

In August 1981, while collecting *Lemna minor* L. and a sample of water for analysis from a slough north of Pierceland, Saskatchewan, I found that a large amount of plant material had passed through the strainer used to separate *Lemna* from the water sample. Examination of this plant material showed that it consisted of small, rootless fronds and might be a species of *Wolffia* (Looman 22928, 6 August 1981, SCS).

Microscopic examination of the fronds revealed they were round to ovate or globose in outline, 0.5 to 1.0 mm in diameter; the upper surface was slightly convex, the lower surface rather strongly convex, and without distinguishing features (Figure 1). The slightly flattened surface showed epidermal cells of 10 to 16 μm, with very thick walls, averaging 4 μm. The numerous chloroplasts were very small. Staining with iodine showed numerous stomata in young cells, but in old cells only a few stomata became visible, and sometimes none at all.

The Canadian species of *Wolffia* were described by Dore (1957), the genus *Wolffia* by Daubs (1965) who includes the Eurasian *W. arrhiza* (L.) Wimm. Descriptions of this species were also available to me in Heukels and Wachter (1962), Tutin et al. (1980), and Bentham and Hooker (1947). Illustrations were provided in Heimans et al. (1965) and Fitch et al. (1949).

Employing the various characters used in the above descriptions as well as those observed on my specimens, the following key could be constructed.

1. Thallus distinctly flattened above,
with a single terminal papilla;
punctate; epidermal cells 20-30 μm *W. punctata*
Thallus not distinctly flattened,
rounded to globose or ovate 2
2. Upper surface with 1 to 3 papillae
along the median line; epidermal
cells 40 to 60 μm, thin-walled *W. columbiana*
Upper surface without papillae;
epidermal cells 10 to 16 μm,
thick-walled .... *W. arrhiza*

This indicates that my specimens belong to *W. arrhiza* (L.) Wimm. (not *W. arhiza* Wimm. sensu Scoggan 1978). The thick cell walls are not mentioned in any of the descriptions, but Daubs (1965) mentions a distinct border around the exposed surface of *W. arrhiza*. Under high magnification, 100-X or more, the thick walls do indeed give the impression of a "border".

Comparison of my specimens with those of *W. columbiana* (Cody 24555) shows that the latter are, on an average, much larger, and have large, thin-walled epidermal cells. Cody (1982 personal communication) notes: "There is no question but what your specimens are quite different from the *Wolffia* I collected at Riding Mountain National Park. Yours are much smaller than mine and tend to have flattened sides which makes them look almost cylindrical, and in

TABLE 1. Chemical analysis of water in which specimens of *Wolffia arrhiza* were collected.

Coll. No.	Ec	N	Na + K	Ca + Mg	Cl	Abundance
22937	0.96	5.30	59.0	128.0	24.5	+
23036	0.63	1.12	34.3	81.6	41.5	+
23038	0.42	1.22	34.0	59.3	16.5	+
23037	0.38	4.72	46.5	41.5	30.2	+++
22928	0.35	4.35	59.0	19.6	29.5	+++
22936	0.33	2.80	29.0	44.7	34.5	+

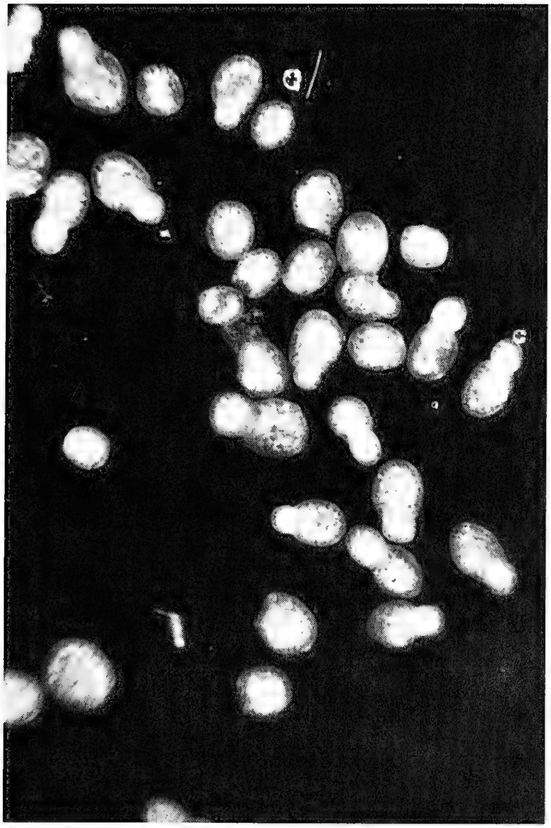

Figure 1. *Wolffia arrhiza.* 12× magnification

addition, are covered with distinct fine markings."

The fine markings are caused by the thick cell walls, and are clearly visible under low magnification. The "flattened sides" are also caused by the thick cell walls, and under high magnification show up as the "border" used by Daubs (1965) as a distinguishing feature of *W. arrhiza* (Figure 2).

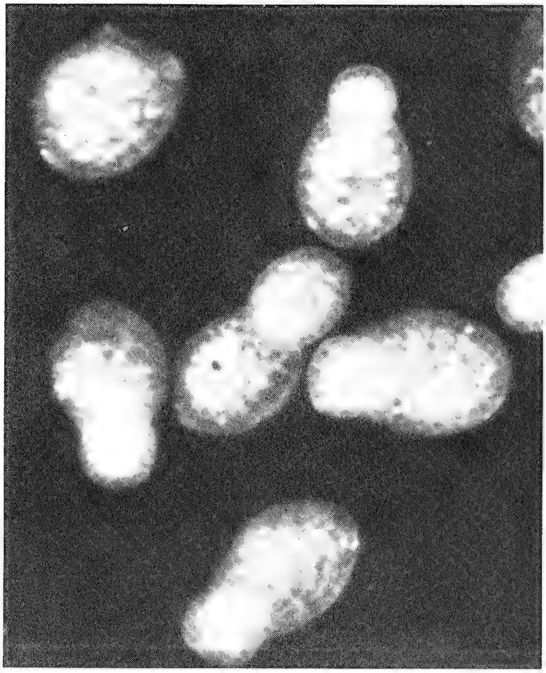

Figure 2. *Wolffia arrhiza,* 24× magnification; showing the border effect caused by the thick cell walls

Wolffia arrhiza has not previously been reported from North America. It is widespread in Europe, but lacking in the Scandinavian countries and the northern USSR, and is also known from Africa, Asia and Australia. Its occurrence at about 54°30′N is, therefore, close to its northern limits in Europe.

A survey in August 1981 of 25 bodies of water along a line from Fort Qu'Appelle in the south to Prince Albert in the north revealed the presence of *W. arrhiza* in two other locations; a small lake 8 km northeast of Perigord (Looman 22937, 31 August 1981, SCS), and in a slough 10 km south of Prince Albert (Looman 22936, 31 August 1981, SCS). In both locations the surface of the water was covered with a mat of *Lemna minor*, but in neither location was *W. arrhiza* as plentiful as in the Pierceland slough.

A further survey was made in September 1982 along a line from Prince Albert to Pierceland, and then south to St. Walburg. In more than 50 sloughs and lakes samples of the *Lemna* vegetation were taken and strained, but only in three locations was *Wolffia arrhiza* present. The locations are: 20 km north of Debden (Looman 23036, 11 September 1982, SCS); 11 km north of Pierceland (Looman 23037, 12 September 1982, SCS), and 5 km north of Red Cross (Looman 23038, 12 September 1982, SCS).

Except for the second location north of Pierceland, where the species was very abundant, *W. arrhiza* occurred only in small numbers.

Cody (1980) posed the question whether *W. columbiana* is indigenous or whether it was introduced to Riding Mountain. He noted that the species occurred in six beaver ponds, but was absent from other, sometimes adjacent, ponds. The same question arises about the occurrence of *W. arrhiza*. It occurred abundantly in two bodies of water, sparingly in four more, but was absent from numerous other sloughs and lakes in the same areas.

Phytosociological studies of aquatic plant communities in Europe place *Wolffia arrhiza* in duckweed communities; Lemnetea, which occur in "... polluted waters containing some chlorine. Pollution can be caused by rotting foliage and may be anthropogenic." (Westhoff et al. 1946). Knapp (1948) considers the communities indicative of "... water rich in nutrients ...",; Heukels and Wachter (1952) mention "... high in nitrogen ...".

Chemical analyses of the water in which I collected *W. arrhiza* shows these to be moderately to highly rich in nutrients, relatively rich in chlorine, and moderate to high in $N\text{-}NO_3$ and/or $N\text{-}NH_4$.

As evident in Table 1, a high nitrogen content does not guarantee abundance of *Wolffia*. It is quite possible that the water of 22937 (Prince Albert) is somewhat too high in nutrients; it is on the borderline of brackish. If this is so, it might well explain the apparent absence of *Wolffia* spp. in the prairie waters. Most of these, when high in N, are brackish or even saline.

Although habitat conditions may explain the distribution of *W. arrhiza*, and possibly that of *W. columbiana*, as presently known, the question of whether *Wolffia* is an indigene is not answered. However, as noted by den Hartog and Segal (1964), most of the truly aquatic plants die rapidly when dried out. As *Wolffia* is possibly the most "aquatic" of the aquatic plants, transport by water fowl over more than short distances seem unlikely.

This implies that both *W. arrhiza* and *W. columbiana* are indigenous in their respective areas, and in turn, poses another question: what caused the isolation of the two areas from the main distribution areas of the species?

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'Facing In' is not General to all Gulls Nesting on Cliffs

EDWARD H. BURTT, JR., and WILLIAM CHOW

Department of Zoology, Ohio Wesleyan University, Delaware, Ohio 43015

Burtt, Edward H., Jr., and William Chow. 1983. 'Facing in' is not general to all gulls nesting on cliffs. Canadian Field-Naturalist 97(2): 222–224.

Herring Gulls (*Larus argentatus*) nesting on cliffs lack the cliff-facing behaviour found among incubating and brooding kittiwakes. The result strongly suggests that cliff-facing is another of the kittiwake's behavioural specializations to its unusual and potentially dangerous nesting habitat.

Key Words: Black-legged Kittiwake, *Rissa tridactyla*, Herring Gull, *Larus argentatus*, nesting behaviour, cliff-facing.

Parental Black-legged Kittiwakes (*Rissa tridactyla*) show a number of behavioural adaptations that reduce the chance of the egg or chick falling from its nest (Cullen 1957). Among such adaptations is a pronounced tendency to face the rock wall during incubation and a significantly greater tendency to face the rock wall during brooding (Burtt 1975; Hodges 1975). By facing the cliff, a brooding kittiwake places its body and especially its legs between the chicks and the abyss. The position restricts the chick's movement. Is cliff-facing a behavioural product of the kittiwake's evolutionary adaptation to its precipitous nest site or is cliff-facing a general reaction to vertical topography, a reaction found among all species of gulls?

Herring Gull (*Larus argentatus*) chicks reared on cliff ledges behave like kittiwake chicks (Emlen 1963).

Cross-fostering experiments suggest that the altered behaviour is a product of experience at the cliff nest, but whether the chick's behaviour is a product of habitat similarities or similarities in parental behaviour is unclear. Hence, we address the question of the evolutionary origin of cliff-facing by studying the behaviour of Herring Gulls at nest sites comparable to those of kittiwakes.

Kittiwakes typically nest on tiny ledges on sheer cliffs, but may occupy ledges up to 45 cm wide (Coulson 1963). Herring Gulls commonly nest on flat ground, but a few occupy slopes and a very few occupy cliff ledges 40-50 cm wide (Emlen 1963). If cliff-facing were a generalized reaction to vertical topography, then cliff-nesting Herring Gulls should face the rock wall when incubating and brooding. If cliff-facing is a specialized evolutionary adaptation of the kittiwake, then Herring Gulls, few of which nest on cliffs, would be unlikely to face the rock wall during incubation or brooding. We report the orientation of incubating and brooding Herring Gulls nesting on cliffs and compare their orientation to that of kittiwakes and that of Herring Gulls nesting on sloping and flat ground.

Between 6 and 26 July 1979, we observed unmarked Herring Gulls at individually identified nests on Kent Island, New Brunswick, Canada. Our study area included 11 nests on cliffs, ground whose angle of inclination was 75-90° above the horizontal; 10 nests on slopes, angle of inclination 35-55° and 20 nests on flat ground, inclined 15° or less. Because so few nest sites were on slopes and cliffs, we were unable to statistically evaluate orientation of adults at individual nests. However, orientation at no nest differed strikingly from the pattern for that topographical category, nor was any category dominated by data from one nest. Hence, we have combined orientational data from all nest sites within a particular topographical category.

To maximize the sequential independence of observations we recorded an adult's orientation only once a day. The effect of sun angle (Lustick et al. 1978) and wind (Gochfield 1978; D. E. Miller, personal communication) on orientation and posture of sitting gulls was minimized by collecting data only within 0.5 hr of solar noon (sun nearly overhead) on days with wind speeds less than 2.5 ms^{-1}.

A gull that sat with breast feathers contacting the nest's contents was "incubating" if the nest contained only eggs, or "brooding" if the nest contained at least one chick. With its long axis within 45° of perpendicular to the cliff or upslope, a gull was "facing in" when its head was toward the cliff or upslope, and "facing away" when its tail was toward the cliff or upslope. If the long axis was between "facing in" and "facing away", the gull was oriented "parallel".

All nests on cliffs and slopes were along the island's eastern shore, which runs approximately north-south. Hence, a gull that was "facing in" was also facing west. Nests on flat ground were also near the eastern shore. A gull nesting on flat ground was considered "facing in" if its longitudinal axis was within 45° of an east-west direction and the head west of the tail, "facing away" if the head was east of the tail, and "parallel" if its longitudinal axis was within 45° of a north-south direction and facing either north or south. Regardless of topography at the nest site, gulls oriented "parallel" and facing north were not differentiated from those oriented "parallel" and facing south.

If incubating and brooding Herring Gulls orient randomly, half of the individuals will be "parallel", one-quarter "facing in", and one-quarter "facing away". On flat ground both incubating and brooding adults oriented randomly (Table 1) with no change in the orientation of adults before and after hatching (Chi-square test for independence, Table 1, $\chi^2 = 3.01$, df = 2, $0.25 > p > 0.1$). On slopes and cliffs, incubating gulls tended to "face away", but brooding adults oriented randomly in both habitats (Table 1). The difference in orientation before and after hatching was not significant on slopes (Table 1, $\chi^2 = 0.49$, df = 2, $0.9 > p > 0.75$) nor on cliffs (Table 1, $\chi^2 = 0.99$, df = 2, $0.75 > p > 0.5$).

Topography at the nest site had no significant effect ($\chi^2 = 1.58$, df = 2, $0.5 > p > 0.25$) on the proportion of incubating Herring Gulls "facing in", nor was topography a factor in the orientation pattern of brooding adults ($\chi^2 = 1.94$, df = 2, $0.5 > p > 0.25$).

Unlike incubating and, especially, brooding Black-legged Kittiwakes, orientation of incubating and brooding Herring Gulls is essentially random, despite a slight tendency for incubating slope- and cliff-nesting gulls to "face away". The smaller body size and more agile flight of kittiwakes enables them to nest on extremely narrow ledges. Differences in the width of nesting ledges may partially explain the orientional differences, Kittiwakes frequently cannot "face away", because the tail cannot be accommodated by the narrow nesting ledge. Herring Gulls nesting on wider ledges are not subject to this spatial, morphological constraint. However, room for the tail cannot explain the preference of adult kittiwakes for "facing in" over "parallel", or the significant change in adult orientation at hatching.

The data refute the hypothesis that cliff-facing is a generalized reaction of larids to vertical topography. Regardless of topography, Herring Gulls display essentially random orientation. Furthermore, the significant change in orientation of adult kittiwakes following hatching of their eggs cannot be simply a reaction to topography. Cliff-facing appears to be another

TABLE 1. Orientation of incubating and brooding Herring Gulls at topographically different nest sites.

Topography of Nest Site (number of nests)	Adult's Activity	Orientation of Adult*			χ^2 (df = 2)
		"Facing in"	"Parallel"	"Facing Away"	
Flat (20)	Incubating	37	87	32	2.40
	Brooding	20	28	17	1.56
Slope (10)	Incubating	38	53	55	15.61**
	Brooding	18	27	23	3.62
Cliff (11)	Incubating	30	69	51	6.61***
	Brooding	15	40	18	0.99

*If random, 25% of the gulls will be "facing in", 50% "parallel", and 25% "facing away".
**Significantly nonrandom, $p < 0.01$
***Significantly nonrandom, $0.05 > p > 0.01$

of the many behavioural and morphological specializations (Cullen 1957; McLannahan 1973) of the kittiwake to its unusual and potentially dangerous nest site. The data say nothing about the proximate control of cliff-facing, but argue strongly for evolution by kittiwakes of a capacity to respond to the cliff wall and failure of such a capacity to evolve among species of gull whose nesting habitat, like the Herring Gull's, is usually flat. A few species of larids, Glaucous Gull (*Larus hyperboreus*), Thayer's Gull (*L. thayeri*), and Iceland Gull (*L. glaucoides*), frequently nest on cliffs where they show behaviour similar to that of kittiwakes, but also nest on flat ground where their behaviour resembles that of Herring Gulls (Smith 1966). These species may provide insight into the origin and function of cliff-facing.

Acknowledgments

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A River Otter, *Lutra c. canadensis*, of Record Size

JAMES D. LAZELL, JR.

The Conservation Agency, 8 Swinburne St., Jamestown, Rhode Island 02835

Lazell, James D., Jr. 1983. A River Otter, *Lutra c. canadensis*, of record size. Canadian Field-Naturalist 97(2): 225–226.

A male otter, *Lutra c. canadensis* (Mammalia: Mustelidae), from Lynnfield, Essex Co., Massachusetts, measures 1321, 470, 129, 21, and is thus at least a percent larger than various published maxima for this form. The baculum is 102, the maxillary row 39.0 and the carnassial 12 by 10 mm. The specimen is Yale Peabody Museum (YPM) 4405.

Key Words: River Otter *Lutra c. canadensis*, size, dentition, baculum.

On 17 April 1977 I collected a road-killed, male River Otter on Route 128 just west of exit 31, just within the western limit of both the town of Lynnfield and Essex County, Massachusetts. The specimen was fresh and skinned immediately. The skull was badly broken and therefore the measurement I give (Table 1) for total length is probably unduly precise; the total length is about 132 cm or approximately 52 inches (4 feet 4 inches). The animal was not weighed but was judged at least 10 kg. The prepared skin is shown in Figure 1. I follow Hoffmann (1976) in use of the generic name *Lutra*.

TABLE 1. Maximum sizes for *Lutra c. canadensis* in the literature and measurements of YPM 4405 in millimeters.

Source	Total	Tail	Hind Foot
Hamilton (1943)	1100	400	100
Bailey (1946)	1045	330	105
Jackson (1961)	1220	475	133
Peterson (1966)	1300	500	140
Doutt et al. (1977)	1200	440	132
YPM 4405	1321	470	129

In popular literature some very large sizes are given for otters in general. For example, Trimm (1977) claims individuals "measuring up to 55 inches in length and weighing up to 30 pounds." Although he is, by implication, writing about North American River Otters, he cites no source and does not imply that he means the eastern form, *Lutra c. canadensis*.

Maximum size data from five standard sources for *L. c. canadensis* are given in Table 1. Hall (1981) does not give data for subspecies; his measurements for the entire species include the large races of Canada and Alaska. Hall gives the maxima 1300, 507, 146; these measurements exceed YPM 4405 in tail and hindfoot, but the total length is still 1.5 percent below this Massachusetts individual. Hall and Kelson (1959, p. 948) give the maxillary tooth row of the Alaskan *L. c. mira*, a form distinguished by its large skull, as 38.8 mm. This is close to the 39.0 mm maxillary row of YPM 4405 (Figure 2).

Friley (1949) gives the average length of the baculum for oldest adults as 96.1 mm; his maximum is 106.4; the baculum of YPM 4405 is 102.1 mm (Figure 3). Stephenson (1977) gives a maximum of 106.9 mm. The present specimen is thus in excess of six years of age.

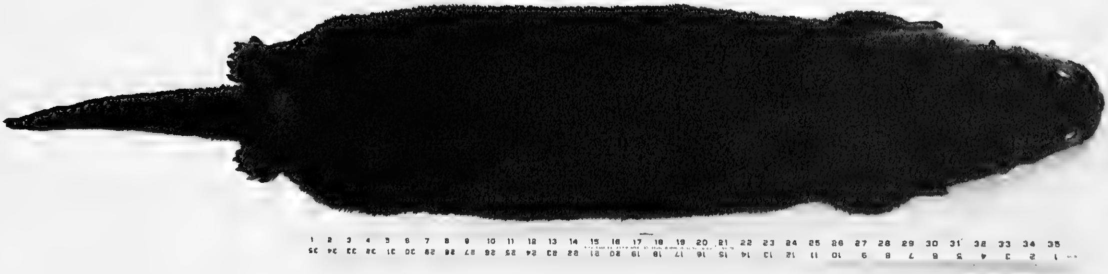

FIGURE 1. Skin of the male river otter, YPM 4405, prepared to the measurements of the carcass. The scale is a yardstick.

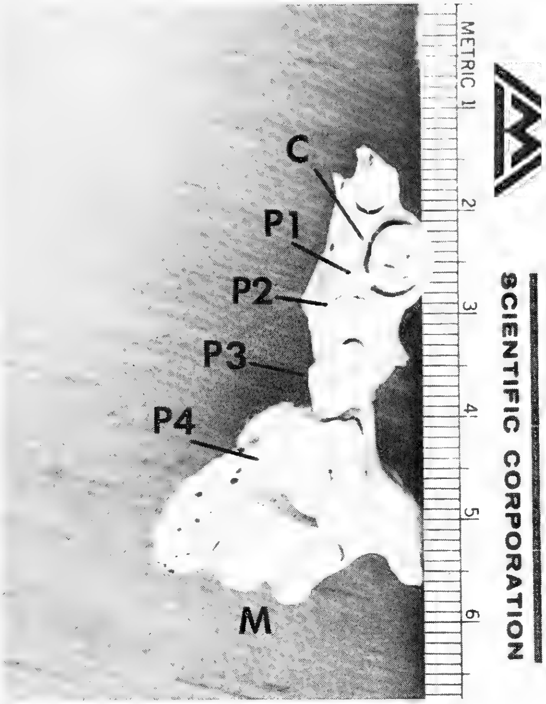

FIGURE 2. Left maxillary tooth row of the river otter, YPM 4405. The first tooth on the maxilla is the canine: C. There are four premolars: P1-P4. There is but one upper molar present in the family Mustelidae: M.

Godin (1977, p. 234) says males grow larger than females and may attain 130 cm. He gives tail and hind foot maxima as 50 cm and 15 cm, respectively. These measurements seem suspiciously round and even; I do not believe they were taken from an actual specimen. Similarly, Waters and Rivard (1962) say no more about the size of otters than they attain "three feet or more," and have a maximum tail length of "fifteen inches" (p. 105).

The photographs of YPM 4405 were made by Constance A. Rinaldo. The specimen was salvaged on Massachusetts permit 475, held by me.

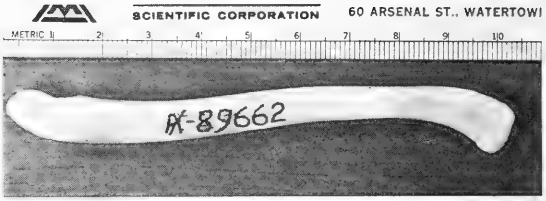

FIGURE 3. Baculum or os penis of the river otter YPM 4405 (A-89662 is a field number).

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News and Comment

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

The 105th Annual Business Meeting of the Ottawa Field-Naturalists' Club will be held in the auditorium of the Victoria Memorial Museum Building, Metcalfe and MacLeod Streets, Ottawa on Tuesday, 10 January 1984 at 2000 h.

FRANK POPE
Recording Secretary

The Alfred B. Kelly Memorial Fund of the Province of Quebec Society for the Protection of Birds, Inc.

Annual Research Grants up to $1,000 will be available for studies pertaining directly to Quebec ornithology. Applications will be accepted from any interested person regardless of place of residence.

Applications must be postmarked by 15 February, 1984. Applicants will be notified of the committee's decision by 31 March 1984.

For application forms write to
Marianne G. Ainley
P.Q.S.P.B. Research Committee
4828 Wilson Avenue
Montreal, Quebec
Canada H3X 3P2

Announcing a Canadian Forestry and Wildlife Management Symposium

A symposium on the integration of forestry and wildlife management in Canada will be held May 7, 8, 9 and 10, 1984 at the University of British Columbia near Vancouver. Knowledgeable speakers will address such topics as the legal basis for integrated resource management, the implementation process in various jurisdictions, the needs of resource users, and means of solving problems inhibiting integration. The program will be aimed at forest resource administrators and managers, and participation of field foresters and biologists is emphasized. Those wishing to receive a more detailed description of the symposium now and pre-registration materials in January 1984, contact T.C. Dauphiné, Canadian Wildlife Service, 1725 Woodward Drive, Ottawa, Ontario, K1A 0E7 (613-998-4693).

Notice of Motion to Amend the Constitution of The Ottawa Field-Naturalists' Club

It is proposed that Article 1, now reading:

"NAME AND STATUS

This Club shall be known as The Ottawa Field-Naturalists' Club. It is a non-profit organization incorporated under the laws of the province of Ontario (1884).

All assets and other accretions . . ."

be amended to read as follows:

"NAME AND STATUS

This Club shall be known as the Ottawa Field Naturalists. It is a non-profit organization incorporated under the laws of the Province of Ontario (1884).

All assets and other accretions . . ."

This is notice of a motion, proposed by Roger Taylor and seconded by Joyce Reddoch, to be presented at the 105th Annual Business Meeting.

Explanatory Note: The purpose of this motion is to remove the word "The", the hyphen, the apostrophe and the word "Club" from the organization's name. Writers frequently forget these items and an editor's job is appreciably simplified if they are removed from the official name.

E. F. POPE
Recording Secretary

The Ottawa Field-Naturalists' Club Awards

This is a call to members for nominations for the following OFNC awards:

1. *Honorary Member* — in recognition of contribution in marked degree to the successful working of the Club, or of outstanding contribution to Canadian natural history, generally over a period of time.
2. *Member of the Year Award* — for the member judged by Awards Committee to have contributed the most to the Club in the previous year.
3. *OFNC Service Award* — in recognition of the member who has contributed significantly to the smooth running of the Club in that year.
4. *Conservation Award* — in recognition of a member's recent, outstanding contribution to the cause of conservation.
5. *Anne Hanes Natural History Award* — in recognition of an outstanding contribution by an amateur to our knowledge, understanding and appreciation of the natural history of the Ottawa Valley.

Nominations for any of these awards should be sent to W.K. Gummer, Chairman, Awards Committee, 2230 Lawn Avenue, Ottawa, K2B 7B2 (Phone 596-1148) by 15 December, 1983.

Call for nominations for the Council of the Ottawa Field-Naturalists' Club

A nominating committee has been chosen by the Council to nominate persons for election to offices and membership of the Council for the year 1984, as required by the Constitution.

We would like to remind Club members that they also may nominate candidates as officers and other members of Council. Such nominations require the signatures of the nominator and seconder, and a statement of willingness to serve in the specified position by the nominee. Nominations should be sent to the Nominating Committee, The Ottawa Field-Naturalists' Club, Post Office Box 3264, Postal Station C, Ottawa, Ontario K1Y 4J5, to arrive no later than 15 December 1983.

The Committee will also consider any suggestions for nominees which members wish to submit to it by 15 December 1983. It would be helpful if some relevant background on the proposed nominees were provided along with the suggested names.

ROGER TAYLOR
Chairman, Nominating Committee

Herpetology Position Available at the Royal Ontario Museum

A curatorial position in herpetology is available in the Department of Ichthyology and Herpetology, Royal Ontario Museum, Toronto, Ontario. Appointment will be at senior Assistant Curator or Associate Curator level. Ph.D. graduate in herpetology with field, research, collection, and communications skills and experience. This is a tenure stream, permanent position.

Starting date — 1 July 1984. Closing date for receipt of applications and all documents — 15 March 1984.

For further details, write Dr. E. J. Crossman, Chairman, Search Committee, Department of Ichthyology and Herpetology, Royal Ontario Museum, 100 Queen's Park, Toronto, Ontario, Canada M5S 2C6.

Editor's Report for 1982

In 1982, *The Canadian Field-Naturalist* 95(4) was mailed 7 April, 96(1) on 21 July, 96(2) on 30 September, 96(3) on 14 December. The concluding issue of volume 96 was edited and completed to page proof (articles and notes) and galley (news and comments, tribute and book reviews) by the end of the year but was not published until 18 April.

The number of manuscripts submitted in 1982 is about equal to each of the past two years (Table 1). The percentage of manuscripts accepted is up marginally, perhaps partly attributable to an increase in the quality of submissions as a result of the efforts of the previous editor, Lorraine Smith (1972-1981). Acceptance totals for 1982 submissions are incomplete as many manuscripts are still with authors for revision. Acceptable revisions of a few pre-1982 submissions during the past year have modified totals given in the Editor's Report for 1981, *The Canadian Field-Naturalist* 96(2): 220–223, Table 4.

The number of manuscripts published in *The Canadian Field-Naturalist* volume 96 is given by field of study in Table 2. The number of pages of research (46 articles and 31 notes) was 384 (334 pages of articles and 50 of notes). News and Comment (including the Editor's Report, the Annual Report of the Ottawa Field-Naturalists' Club, and tributes to W. K. W. Baldwin and C. M. Sternberg) accounted for 37 pages, Book Reviews (including new titles) 90 pages additional notices (Instructions to contributors) for 3, and the annual Index 16 pages. The number of reviews and new titles published were: zoology 39 and 173, botany 14 and 64, environment 23 and 110, miscellaneous 14 and 44, young naturalists 0 and 13. Further comment and comparisons between 1981 and 1982 from Wilson Eedy follow this report.

In 1982, associate editors Charley Bird (botany), Ed Bousfield (invertebrates), Tony Erskine (ornithology), Charles Jonkel (predator-prey relationships), Bill Pruitt (mammalogy) and Steve Smith (entomology) were joined by Don McAllister (ichthyology) and Stan Van Zyll de Jong (mammalogy). Tony continued his role as super-associate by directly contacting referees and returning manuscripts requiring revisions to authors for all bird manuscripts, though final acceptance remains with the editor, as it does for all material. Tony has agreed to continue in this manner for one more year, through 1983. George La Roi continued as co-ordinator for *The Biological Flora of Canada* series. No manuscripts were accepted for this in 1982, though a number are assigned and should soon be completed. E. Wilson Eedy continued as Book Review editor and Harvey Beck again compiled the index. The collective time and effort spent by all of these associates is staggering, vital to the production of the journal, and rewarded only by their dedication to the maintenance of its particular contribution to the dissemination of knowledge of natural history in Canada.

Special thanks are also due to Wanda Cook and, at the end of the year, Glen Keenleyside, for long hours spent reading manuscripts and proof-reading galleys and page proof, and to Thérèse Lapierre for typing. Bill Cody added a 34th consecutive year to his legend as Business Manager and was, as usual, a tower of strength and conscience behind the editor. Ron Bedford, chairman, and the publications committee, and Dan Brunton, president, and the council of the Ottawa Field-Naturalists' Club, have provided encouragement and forums to discuss an evolving publications policy. During the past year the report of the ad hoc committee on publications was thoroughly examined and the resulting guidelines and policy statement is published in *The Canadian Field-Naturalist* in this issue.

The National Museum of Natural Sciences, National Museums of Canada, have continued to

TABLE 1. Summary of manuscripts submitted and accepted by *The Canadian Field-Naturalist*

Year Submitted	Number of manuscripts		Percent Accepted
	Submitted	Accepted	
1975	167	123	74
1976	147	93	63
1977	137	88	64
1978	149	93	62
1979	148	93	63
1980	137	89	65
1981	136	91	67
1982	138	54	

TABLE 2. Number of manuscripts published in *The Canadian Field-Naturalist* 96(1982) by major field of study.

Subject	Number of Manuscripts	
	Total	(Articles + Notes)
Research		
Mammals	29	(16 + 13)
Birds	27	(17 + 10)
Amphibians and Reptiles	4	(2 + 2)
Fish	4	(2 + 2)
Invertebrates	3	(1 + 2)
Plants	10	(8 + 2)
Total research	77	(46 + 31)
Tribute	2	(2 + 0)
Grand total	79	(48 + 31)

provide space and support for the journal and I am particularly indebted for these to Henry Ouellet, Chief of the Vertebrate Zoology Division, and Chuck Gruchy, Acting Director. M.O.M. Printers in Ottawa again printed *The Canadian Field-Naturalist*, and individual acknowledgment is due Emil Holst and Ed Finnigan for their efforts.

All research articles and notes, and all special articles, submitted to *The Canadian Field-Naturalist* are reviewed not only by one or more associate editor(s) but also usually one, almost invariably two in ornithology, external referee(s). The latter, by giving freely, promptly, and most often anonymously, of their time, are essential to the peer evaluation system on which the general quality of this journal, like any scientific publication, depends. The following list, compiled with the aid of A. J. Erskine for ornithology reviewers, includes those to whom we are indebted for comments on one or more papers during the 1982 calendar year:

R. M. Alison, C. D. Ankney, G. Argus, M. Armbruster, P. J. Austin-Smith, P. W. Ball, A. W. F. Banfield, J. C. Barlow, J. Bartonek, T. S. Baskett, J. Bassett, T. D. Beacham, J. Bedard, F. Bellrose, J. Bendell, J. R. Bider, D. M. Bird, J. S. Bleakney, H. Blockpoel, D. A. Boag, C. E. Bock, E. Broughton, R. G. B. Brown, D. F. Brunton, D. G. Busby, C. A. Campbell, R. W. Campbell, P. Catling, J. Christie, C. S. Churcher, W. J. Cody, B. Collins, F. Cooke, M. Crete, E. J. Crossman, A. Cyr, C. Dersle, J.-L. DesGranges, G. Divoky, E. H. Dunn, A. Dzubin, R. Y. Edwards, D. Faber, E. B. Fenton, M. A. D. Ferguson, J. C. Findlay, C. D. Fowle, B. Freedman, R. W. Fyfe, G. Geen, W. E. Godfrey, J. B. Gollop, S. W. Gorham, P. K. Gregory, C. R. Harington, B. Harrington, G. E. Hartman, T. Hauge, C. J. Henny, P. Hicklin, D. J. T. Hussell, R. Ireland, R. D. James, J. R. Jehl, P. A. Keddy, L. Keith, J. P. Kelsall, G. L. Kirkland, W. Klenner, R. W. Knapton, A. C. Kohler, E. Kott, C. J. Krebs, E. Kuyt, D. Laubitz, L. deK. Lawrence, S. Leatherwood, M. R. Lein, A. R. Lock, R. C. Long, H. G. Lumsden, C. D. MacInnis, W. J. Maher, D. Mallock, J. Maunder, R. A. McArthur, M. K. McNicholl, R. McNeil, I. A. McLaren, P. L. McLaren, L. R. Mewaldt, A. L. A. Middleton, J. S. Millar, F. L. Miller, E. Mitchell, W. A. Montevecchi, M. T. Myres, J. S. Nelson, R. W. Nelson, R. W. Nero, L. Oliphant, H. Ouellet, R. S. Palmer, W. B. Parama, D. B. Peakall, P. A. Pearce, M. R. Peterson, P. M. Peterson, R. L. Peterson, G. Power, P. M. Powles, W. B. Preston, J. Ranch, J. Reddock, T. E. Reimchen, M. E. Riske, C. S. Robbins, R. J. Robertson, R. K. Ross, S. Rowe, J. P. Ryder, J.-P. Savard, D. B. O. Saville, S. G. Sealy, V. H. Schaefer, F. W. Schueler, G. Scotter, D. E. Sergeant, N. R. Seymour, M.W. Shoesmith, H. C. Smith, J. N. M. Smith, P. R. Stepney, K. W. Stewart, L. G. Sugden, P. S. Taylor, R. Taylor, C. F. Thompson, J. W. Thomson, B. Threlfall, C. E. Tull, N. A. M. Verbeek, K. Vermeer, D. Vitt, P. J. Weatherhead, R. Weeden, R. D. Weir, M. W. Weller, D. A. Welsh, D. V. Weseloh, D. D. Williams.

FRANCIS R. COOK
Editor

Summary of Book Review Activities: Volume 96, 1982

The ever increasing number of titles in natural sciences has caused steady increases in the numbers of new titles listed and books reviewed over the years. Within five years a 40% increase in titles listed and almost 50% increase in books received have been recorded. Interestingly the number of reviews received and published has fluctuated from 50 to 86 throughout the period. This illustrates the two most significant difficulties for the Book-review Editor: identifying an appropriate, willing reviewer for each of so many books, and having reviews completed within a reasonable time period.

In 1982 we have added a section for young naturalists to our new titles. This results from a strong commitment to environmental education and the knowledge that the future of any organization relies on the commitment of young, new members.

The following table summarizes book review activities for 1981-82:

	Volume 96 1982	Volume 95 1981
Book Reviews Published	90	71
Books Received	107	92
Book Reviews Completed	71	86
New Titles Listed	404	361

WILSON EEDY
Book-review Editor

A Publication Policy for The Ottawa Field-Naturalists' Club

The Ottawa Field-Naturalists' Club (OFNC) has published *The Canadian Field-Naturalist* (and its predecessors) for over a century. In recent years involvement with publications has increased dramatically with the introduction of *Trail & Landscape* in 1967, *The Shrike* in 1976, and various Special Publications from time to time. Until now no formal policy underpinning these publications has existed. The question of the need for such a policy was broached some time ago and, following numerous discussions, the Council of the OFNC approved in November 1978, the setting up of an Ad Hoc Committee on OFNC Publications to be charged with ". . . a broad mandate to examine any aspect of existing OFNC periodicals that it considers to be relevant . . ." together with some specific questions to be addressed. The committee, comprising Dr. R. A. Foxall (chairman), Dr. F. R. Cook, Dr. I. M. Brodo, Mr. H. L. Dickson (secretary), was formed in November 1979 and submitted its report to Council in October 1980. This report was reviewed by the Publications Committee in December 1980, following which both the report and the Publication Committee's response to it were reviewed at a joint meeting of Council and the Ad Hoc Committee in January 1981. As a result of this meeting, the Executive Committee was asked to prepare a draft of a Publications Policy based upon the Ad Hoc Committee report and its subsequent reviews. This draft policy, submitted to Council in May 1982, was given intensive clause-by-clause study within the Publications Committee which, in turn, submitted a recommended revision to Council in November 1982. On December 8, 1982 Council approved (with some amendments) this revision which forthwith became the OFNC Publications Policy. The text of this policy is printed here in its entirety.

R. E. BEDFORD
Chairman, Publications Committee

The Ottawa Field-Naturalists' Club Publications Policy: February 1983

A — INTRODUCTION

Although The Ottawa Field-Naturalists' Club has been involved with publications almost since its inception, it has never enunciated a formal publications policy governing their production. With the gradual increase in the number and diversity of these publications, it has become desirable to formulate such a policy. An ad hoc committee was set up in 1978 to examine the status of the publications and to advise and recommend on their future courses. It is from the report of this committee, presented in 1980, that this Publications Policy has evolved.

The Ottawa Field-Naturalists' Club currently publishes three periodicals and, from time to time, books or monographs as Special Publications. The three 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* and appears quarterly. *Trail & Landscape*, with five issues annually, is a less formal periodical geared to providing articles pertaining chiefly to the natural history of the Ottawa area and to providing information aimed at the local membership. *The Shrike*, a specialized bimonthly newsletter, reports to the bird-watching community on bird sightings in the Ottawa District. Special Publications embrace material better suited to separate publication.

This document outlines the policy governing publication of each of the above-mentioned items.

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 by annual budget.

(1) — Objectives:

(a) to be the official publication of The Ottawa Field-Naturalists' Club, as described in the Constitution.

(b) to 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".

(c) to publish refereed scientific papers by amateur and professional naturalists or field-biologists reporting observations and results of investiga-

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

tions in any field of natural history provided that they are original, significant, and relevant to Canada.

(d) to publish news, comments, review articles, book reviews, and other such material that is in accord with objectives (a)-(c).

(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 natural sciences knowledge 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) — *The Canadian Field-Naturalist* Reserve Fund:

The Canadian Field-Naturalist Reserve Fund ensures that, in the face of an economic disaster within The Ottawa Field-Naturalists' Club, the journal would have sufficient funds to publish one further volume and, thus, enough time to make other publishing arrangements. The Fund 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 the more casual and less scientifically-oriented readership of *Trail & Landscape* and this publication's conscious effort to educate interested lay persons concerning the natural history of the Ottawa area.

Trail & Landscape is published five times a year and is available to all local members, on demand to members outside the Ottawa district, and to institutions on subscription. It is managed by annual budget.

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

(1) — Objectives:

(a) to encourage the membership to make and to publish natural history observations that are related to the Ottawa District.
(b) to promote and to report on Club activities and the participation of the membership in such activities.
(c) to provide information and articles of interest regarding the natural history of the Ottawa area.
(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 members on an issue-by-issue basis.
(b) the effort required by editorial staff to obtain sufficient appropriate material.
(c) the results from member 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 is a newsletter dedicated to the interests of bird-watchers which is available, by subscription only, to The Ottawa Field-Naturalists' Club members and to the general public. It should be self-sustaining to the extent that the subscription fee should cover production, printing and mailing costs.

(1) — Objectives:

(a) to provide periodic reviews and analyses of recent bird sightings in the Ottawa District.
(b) to serve as a depository for local bird observational data, these data to be made available for scientific research purposes.
(c) to offer birding advice and to provide notice of programs and activities of interest to local birders.

(2) — Achievement of the Objectives:

Useful indicators for the achievement of the objectives for *The Shrike* include the following:

(a) the number of subscribers.
(b) the number of contributors of observations and the extent to which their observations are representative of the Ottawa District throughout the year.
(c) unsolicited comments by subscribers on an issue-by-issue basis.
(d) the number of requests for access to the data base.
(e) adherence to a regular publication schedule.

Responsibility for overseeing the production of *The Shrike* rests with the Publications Committee. The Birds Committee will assist by providing guidance for the publication.

(3) — *The Shrike* Data Base:

The data deposited with *The Shrike* shall be made available to any person or group requesting them for scientific purposes. Within reason, in order to be useful, these data should be verified and accumulated in a form making them readily accessible to a researcher. Several programs have been written to provide output of these data in the form of potentially useful graphs and tables. Data entries are at the expense of The Ottawa Field-Naturalists' Club.

E — SPECIAL PUBLICATIONS PROGRAM

The Club has three regular publications — *The Canadian Field-Naturalist, Trail & Landscape,* and *The Shrike*. 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.

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 liason 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, Trail & Landscape,* and *The Shrike.*
  (ii) the Business Managers of *The Canadian Field-Naturalist* and *Trail & Landscape.*
  (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.

(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) each Editor will be invited to meet occasionally with Council to keep Council informed on the progress of the publications.
(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 prior to type-setting for his or her information.

**taken from The Ottawa Field-Naturalists' Club By-laws.

Book Reviews

ZOOLOGY

The Mammals of Minnesota

By Evan B. Hazard. 1982. University of Minnesota Press, Minneapolis. xii + 280 pp., illus. Cloth U.S. $39.50; paper U.S. $15.95.

As the first complete work dealing with the mammals of Minnesota in 30 years, this work is a significant contribution. Seventy-eight (plus three extirpated) species are discussed. Except in the case of *Peromyscus maniculatus bairdii* and *P. m. gracilis*, subspecies are not treated in the text itself, but the subspecies found in the state are listed in an appendix. The large total number of species is a reflection of the variety of habitats in Minnesota; taiga, deciduous forest, pine forest, and prairie are the major types present.

Species accounts comprise the bulk of the book. These include standard metric measurements, descriptions of the whole animal and the skull, statements on range, habitat, natural history, and relationship to people, and a distribution map. A listing of pertinent references for each species, by author and year, is also included; the full citations are in the extensive 57 page bibliography which includes many general works as well as those specific to Minnesota. The bibliography includes citations through 1981. The distribution maps show county lines with the locality symbols centered on the appropriate townships from which specimens have been collected or recorded. This method of noting distribution is especially useful for the larger counties and for rare species. Overall, many areas of the state are poorly known. Hazard's book clearly shows what is currently known and will likely stimulate further study. For many species, a black and white sketch of the animal and/or its skull are also included.

A well-written and informative introductory section of eight pages describes mammalian characteristics, Minnesota habitats, and the use of scientific collections of mammals. The text also includes a useful glossary of anatomical and ecological terms and bracket keys to skulls and whole specimens (or skins). Overall, the keys are workable, but those unfamiliar with skull anatomy would benefit from a general figure naming the various bones and foramina. Most of these terms are defined in the glossary or pictured within the key, but no comprehensive figure is included.

As with most state or regional books, this work is intended for students, professionals, and the general reader. It should be of value to all these individuals as it is well-written, up-to-date, and provides easy access to the literature. Lastly, it is a pleasure to note that the book contains very few typographical errors.

DAVID A. LOVEJOY

Biology Department, Westfield State College, Westfield, Massachusetts 01086

Mammals of the National Parks

By Richard G. Van Gelder. 1982. The Johns Hopkins University Press, Baltimore, Maryland. xvi + 310 pp., illus. Cloth U.S. $24.50; paper U.S. $8.95.

This book introduces mammal-watchers to the commonly seen species of mammals in America's national parks and monuments. It also discusses the parks themselves including suggestions on where to see particular species.

Part One (162 pages) describes 48 parks and monuments, mostly in the western United States and Alaska. Maps are included for those parks providing good mammal-viewing. These maps are redrawn from National Park Service maps and show most main roads, visitor centers, and certain major features such as mountains or the various localities referred to in the accounts. Comments on the likelihood of seeing each species (e.g. readily observed, seldom seen) are included. Park accounts include a mammal checklist with notations indicating extirpated, introduced (non-native), and re-introduced species.

Part Two is a 135 page treatment of the mammals themselves. Although all taxonomic groups are mentioned, those species and species-groups most likely to be seen are emphasized. Therefore, shrews, moles, bats, mice, rats and pocket gophers are discussed only briefly. Wood rats (*Neotoma*) and the Brazilian Free-tailed Bat (whose evening flight from their nursery colony in Carlsbad Caverns National Park is an impressive sight) are the only mammals in the above groups which are discussed in depth.

An introductory section includes useful hints on observing and photographing mammals and general information on national parks and monuments.

Designed for the amateur, the treatment is non-technical and common names are used throughout (an appendix lists scientific names). The book is well-written, easy to use, and nearly completely free of typographical errors. In addition to being a useful guide for anyone interested in mammal-watching within the park system, this book is interesting and informative in its own right. I recommend it highly.

DAVID A. LOVEJOY

Biology Department, Westfield State College, Westfield, Massachusetts 01086

The Fisher: Life History, Ecology, and Behavior

By Roger A. Powell. 1982. University of Minnesota Press, Minneapolis. xvi + 217 pp., illus. U.S. $19.50.

Like the wolverine, the fisher is perceived as a mysterious, almost mythological animal, which lives a secretive existence in the forests of North America. Surprisingly, a considerable amount of research has been completed on this member of the mustelid family; however, few books deal with the fisher in a comprehensive manner. Powell has successfully written a book which appeals to the general public, as well as the scientific community. This is a most difficult task, one which few authors successfully accomplish.

Through 10 chapters Powell examines the ecology and biology of the fisher. He relies heavily on his own research and experiences with captive and free-ranging fishers. Powell complements the text with a fairly extensive literature review. The chapters discuss: taxonomy; anatomy; life history (including a succinct review of the theories of delayed implantation); distribution and population density; general habits, home range and movements; food habits; hunting and killing behaviour; and the fisher's relationship to humans. Powell undertakes to integrate population, habitat and behaviour data throughout the book. This integration is limited only by virtue of the fact that his review of the fisher in the context of a much larger ecological system is cursory.

Many myths about the fisher have evolved through the ages. Powell works to dispel some and clarify others. This is evident in the chapter on the predator-prey relationship of the fisher and the porcupine. One myth is that fishers turn over porcupines and kill them by attacking the soft, unprotected ventral surface.

Of six major predators, (ie. wolf, coyote, mountain lion, lynx, bobcat, and fisher) Powell reports that the fisher is the best adapted species to deal with porcupines. Unlike the other predators, the fisher is built low to the ground, which allows it to directly attack the face and head area of the porcupine. In addition, the fisher is powerful enough to inflict substantial wounds to the face and head, but is agile enough to avoid the porcupines tail during a confrontation. Once the porcupine is killed or immobilized, the fisher then turns it over and feeds on the soft, unprotected ventral surface.

The book is illustrated with black and white photographs, and black line ink drawings and maps. A reference list is provided.

I recommend this book to all who are interested in the biology and ecology of the fisher. It is an excellent introductory reference.

PAUL A. GRAY

Northwest Territories Wildlife Service, Yellowknife, Northwest Territories X1A 2L9

A Bird-finding Guide to Ontario

By Clive E. Goodwin. 1982. University of Toronto Press, Toronto. 248 pp. $12.50.

Authors who attempt regional bird-finding guides must necessarily face the question of what to include, and the more difficult question of what to leave out. For an area as vast as the whole of Ontario the prospect is daunting indeed. Clive Goodwin has in one small volume presented a list of the better known birding areas in Ontario along with detailed information on how to get there, when to go, and what one might reasonably expect to see.

This book covers everything that would be expected from such a guide, including brief descriptions of habitats, weather, a bird-life chronology, tips for visitors, and a checklist. Central to the book, and occupying 75% of the pages, are the lists of birding localities. To make this more manageable Goodwin has subdivided Ontario into six regions corresponding, more or less, to major ecological zones. The localities in each region are arranged alphabetically; the space devoted to each being roughly equivalent to its birding productiveness. An outline map of each region is provided to show the relative position of the places mentioned.

There are a few points readers should keep in mind when using the book. There are a few typographical errors, which presents no serious problem. The complexities of some of the directions make it imperative that the appropriate road or street map be available. The confusion is compounded by some inaccurate street names: in the Ottawa account, on page 150, Moodie Drive is called Moodie Street, and nine (9) lines later Moodie Road. On the same page Carling Avenue is once referred to as Carling Street.

Apart from the six regions, maps of an additional six specific locations are shown. Their choice seems random — why those six at the expense of all the other locations? Many more maps, perhaps at the expense of a few sewage lagoons, would be helpful and could have reduced the confusions resulting from the written directions. The birds associated with certain localities are sometimes inaccurate. In the Richmond section, page 151, the swamp (actually a fen), contrary to Goodwin's statement contains few rails besides the Yellow Rail, but does have a large colony of Sedge Wrens (not mentioned). The Richmond fen, like several places listed, is also said to have "many other species" but there is no hint to what they might be. Almost anywhere will have "many other species". In the Systematic Lists of the species, Goodwin's warning that the abundance designations could be misleading to the unwary should be echoed. White Pelicans are listed as a rare summer resident in the north but only because of a breeding colony at Lake of the Woods. It would not be a "hoped for" species at Moosonee.

What Goodwin has tried to do is compile in one volume a list of the places where the local experts do their birding. Overall he has produced a usable manual which would be most useful to an average birder planning a trip to, or within, Ontario. The binding appears strong and the book could probably tolerate the abuse of several camping trips. The price seems a bit high for a book with few maps and no pictures but may be well worth the cost in saved time and gas when hunting for a certain birding spot.

BRUCE DILABIO

62 Grange Street, Ottawa, Ontario K1Y 0N9

The Amphibians and Reptiles of Manitoba

By William B. Preston. 1982. Manitoba Museum of Man and Nature, Winnipeg. 128 pp., illus. $9.95 plus $1 postage.

Most people probably do not associate the province of Manitoba with amphibians and reptiles. If they do, they probably think of the large communal hibernacula of the red-sided garter snake which have been widely publicized. The Manitoba herpetofauna, however, is surprisingly large for the climate. Thirteen species of amphibians and eight of reptiles occur in the province, concentrated mainly in the south, although some species such as the Wood Frog range very far north. Two species, the Common Garter Snake and Northern Leopard Frog, are so abundant that they have been harvested commercially, necessitating regulations. This fauna is a mix of eastern species reaching their western range limits (e.g. Blue-spotted Salamander, Green Frog), western species at their eastern limits (e.g. Plains Spadefoot, Plains Hognose Snake), and a few essentially transcontinental species (e.g. Painted Turtle, Common Garter Snake). If nothing else, Preston points out to citizens of Manitoba and elsewhere the richness of this assemblage. As one who got his professional start in herpetology in Manitoba, I welcome this publication.

Bill Preston had three objectives in writing this book: to provide easy identification of species in a regional guide format, to provide up-to-date information on amphibian and reptile biology, and to point out areas where knowledge is lacking. He has succeeded admirably in the first of these, and to a lesser degree in the other two.

Preston's book is written from his long experience as a naturalist and professional herpetologist. This is evident from the fact that most of the excellent black-and-white and colour photographs of both animals and habitats were taken by the author himself. Preston also livens up the text in many places by recounting personal experiences. Finally, he departs from the usual format of popular field guides by referring to scientific literature in the text, using the literature citation style of scientific journals. This does not interfere at all with readability, yet allows one access to more in-depth treatment of a subject.

This book is short but extensively illustrated. Its organization is straightforward and fairly conventional. Introductory sections briefly cover such topics as general features of biological nomenclature, basic biology of amphibians and reptiles, the Manitoba environment, and the distribution of amphibians and reptiles in Manitoba. The bulk of the book is devoted to individual accounts of all 21 species, each account including a photograph of the species, description of the animal and its geographic distribution, and coverage of basic natural history (habitat, food habits, breeding, etc.). Maps showing locality records of each species are also included, but are all grouped together, somewhat inconveniently, at the back of the book.

Preston ends with a brief glossary, a list of all literature cited in the text, and a list of other general books for the beginning herpetologist. He also includes a list of hypothetical species whose ranges approach Manitoba and might therefore be recorded there sometime in the future. I was also pleased to see a description of how to preserve specimens, a list of French common names, and separate keys for the identification of living and of preserved tadpoles.

The major problem with this book is that it is *too* short. This has two undesirable effects. First, the individual sections are so short as to make for very jumpy reading in places. Second, several important topics are given too brief a treatment or left out entirely. For example, the section on amphibian biology makes no mention of anuran vocalizations or paedogenesis (neoteny) in salamanders. Both are mentioned in individual species accounts but seem to me to be of such a basic nature that they warrant more general treatment. Similarly, the discussion of ectothermy and thermoregulation omits consideration of costs, benefits, and adaptive significance of these phenomena; this is unfortunate, especially in view of the general misunderstanding of these concepts by lay people. Most noteworthy, however, is that there is no section dealing with factors limiting abundance and distribution of north temperate amphibians and reptiles, and physiological and ecological responses made to these factors. Surely this is one of the most important areas of research that Canadian herpetology should address.

I discovered few errors in reading this book. The only factual one concerns excretory products of amphibians and reptiles. According to Packard (1966, American Naturalist 100: 667–682), reptile embryos and adult amphibians both excrete mainly urea. Preston, however, indicates that the former excrete uric acid (actually the main excretory product of adult squamates) and that the latter excrete ammonia (which is actually excreted only by aquatic amphibian larvae). A very minor error (possibly typographical) is the word "hemipene", instead of hemipenis, among terms defined in the glossary. Preston also refers to the spadefoot as *Scaphiopus* and to Australian hylid frogs as *Hyla*, rather than *Spea* and *Litoria* respectively as is currently the fashion. However, this is really more a matter of systematic opinion than an error.

My remaining quibbles with this book are mainly matters of style. Preston frequently switches from first to third person when referring to himself. Descriptions of full species ranges outside Manitoba are not consistently given in the individual species accounts; sometimes only the particular subspecies distribution is given. Standardized common names do not always correspond exactly to the subspecies names given. For instance, the section introducing colubrid snakes pairs standardized common names of species with scientific names of full species. I question the need for standardized common names, at least for subspecies, but if they are to be used, they should be used consistently.

Overall, I think this book serves an important function. It represents the first popular summary of modern information on Manitoba's amphibians and reptiles. If it spurs interest in these two groups and encourages people to be more concerned about conserving them and adding to our knowledge of their natural history and distribution, it will play a valuable role. Bill Preston is to be congratulated for making this first step.

PATRICK T. GREGORY

Department of Biology, University of Victoria, Victoria, B.C. V8W 2Y2

Aquatic Insects and Oligochaetes of North and South Carolina

Edited by A. R. Brigham, W. U. Brigham, and A. Gnilka. 1982. Midwest Aquatic Enterprises, Mahomet, Illinois. 837 pp., Illus. U.S. $39.50.

Close on the heels of many a worthy predecessor comes this latest addition to a library of information on aquatic insects. With so many texts now available it is becoming increasingly difficult for students and professionals alike to choose the best and most appropriate one for their needs. In a somewhat negative way this new book helps to narrow down the choice.

Originally conceived as a guide for pollution biologists, at the Duke Power Company, the book is still very much an in-house publication. This is primarily the result of two major restrictions that have apparently been designed into the book. First, as the title states, this is a study of aquatic insects of the Carolinas, and the relevance of much of the descriptive sections and most of the keys is restricted to this region. In fact much of the fauna of the northeastern U.S. and certainly most of eastern Canada lies beyond the scope of this work.

The other major restriction arises as a result of the unidirectional orientation of the book to pollution biologists. One can only assume that pollution biologists do not deal with anything other than the larval stages since, except for the Coleoptera and Hemiptera, only the larvae are considered. It is interesting to speculate what these biologists do with pupal stages encountered in their studies.

The inclusion of the oligochaetes in this work, considering the above orientation is easy to comprehend. However, by the same rationale one would also expect inclusion of other groups commonly encountered in the course of pollution studies, such as molluscs, crustaceans, amphipods, and isopods. None of these appear and as a result the treatment of the groups is neither a complete account of the aquatic insects nor a comprehensive treatment of organisms encountered in pollution studies. Rather, the book falls somewhere in between, fulfilling neither consideration completely.

Within the area it does cover, the book treats its subject matter in considerable detail. Each chapter has a general description and diagnosis of the families in the order, as well as an extensive treatment of their life histories, though the latter may dwell at length upon only one, often well researched, genus. This is followed by a discussion of taxonomic problems within the family, including histories of synonymies and a discussion of the more useful taxonomic characters. Some chapters, though by no means all, include detailed tables of ecological and habitat data, information that can often be invaluable when used in conjunction with the keys.

A short checklist of species in the Carolinas preceeds the main part of each chapter — the keys to genera, and, where applicable, to species. Unfortunately in compiling these keys no real consistency occurs from chapter to chapter. As a result, in some orders keys are provided to all the genera of eastern North America, while in others, only genera occurring in the Carolinas are considered. Keys to species (not all genera are keyed to species level) are much more consistent and in virtually all cases are only for those found in the Carolinas. In most cases these are a synthesis of existing keys, often merely a contraction of more regional treatments to include only the local species. The only major addition is that taxonomic changes that have occurred since these keys were first published (in some cases nearly 40 years ago) have been incorporated, thus reducing confusion, particularly for those unfamiliar with the groups. The keys are on the whole well illustrated though occasionally those redrawn from other sources have suffered. Finally, a few mistakes, such as mislabelled illustrations are in evidence though these are no more frequent than in most books of this kind.

Perhaps the most noteworthy point about the book, and that which distinguishes it from others of its kind, is in its design. Bound in an easily disassembled looseleaf format, it provides for easy addition of future revisions and changes (purchased at extra cost) thus keeping the book up-to-date.

For those working on the fauna of the Carolinas and their immediate surroundings, this book will no doubt serve as a more than adequate guide to the fauna. However, for those outside this area, and in particular in eastern Canada, the use of this book as a single source is not recommended. At most, it should be used only in addition to other sources, where applicable, to round out the information already available.

REIN JAAGUMAGI

Department of Entomology, Royal Ontario Museum, 100 Queen's Park, Toronto, Ontario M5S 2C6

Falcons of the World

By T. J. Cade. 1982. Comstock/Cornell University Press. Ithaca, New York. 192 pp., illus. U.S. $38.50.

No one should be surprised that Tom Cade, a man with a lifelong fascination for birds of prey, especially falcons, has written a book on his favourite subject. However, as an apprentice in the study of falcon biology who can only benefit from Cade's rich experiences, I am particularly pleased that he has produced more than just a coffee-table book.

The book is divided into two sections. The first consists of ten chapters describing the special characteristics of the genus *Falco*, classification, distribution and migration, feeding adaptations, size and flying performance, hunting success, reversed size dimorphism, social behaviour and reproduction, and finally, the falcon's relationship with man. The second section provides us with descriptions of 39 species, perhaps only 38 if Cade's conclusion about *Falco kreyenborgi* is correct, and maybe even less if his desire for further taxonomic research on African species, in particular, is fulfilled.

In fact, this latter point really reveals what I liked about the book. Using it as a forum to present ideas to stimulate new research, Cade has provided in his book a fresh approach to each chapter. For example, what is the real purpose of bony tubercles in the nares? Does the nasal secretion serve in some nutritional capacity? Does rangle aid in the removal of the koilin?

I was especially interested in Cade's explanation of the long-standing controversy, reversed size dimorphism in birds of prey, which I believe can only stand as yet another untested hypothesis. The author seems convinced that the "big mother" hypothesis, i.e. big mothers . . . big offspring . . . better survival. (K. Ralls. 1976. Quarterly Review of Biology 51: 245-276) is applicable to raptors. As far as I know, there is no evidence for this as yet. In fact, a recent paper (D. M. Bird and P. C. Laguë. 1982. Canadian Journal of Zoology 60: 71-79) showed that physically smaller handreared American Kestrels (*Falco sparverius*) laid larger eggs than parent-raised birds. This may be an artifact of captivity, but there also is no evidence indicating that larger eggs produce larger fledglings more capable of surviving. Hence, I do not think we have seen the end of this great debate.

I agree with Cade that "copulation in falcons has become ritualized into another form of courtship display" and hasten to add more evidence. Spermatozoa can remain viable in the Kestrel oviduct up to 12 days (D. M. Bird and R. B. Buckland. 1977. Canadian Journal of Zoology 54: 1595-1597). Why should this be so if every copulation need result in sperm transfer?

Another section I fancied was Cade's argument for the existence of falconry. I have heard many arguments for and against this sport, some based on fact and others on pure sentiment, but I have never read a more eloquent and soundly based one as that put forth by Cade. This is required reading for anyone with strong feelings on the subject.

It is understandably difficult to cover everything on a given topic, but I was surprised that little or nothing was mentioned of the falcon's remarkable eyesight, nor the Kestrel's astounding ability to fix its head in one position while its body undergoes various gyrations, allowing it to maintain a "fix" on prey while hovering or sitting on a moving perch. Also, finding falcon eggs to be as beautifully coloured as the birds themselves, I would have liked a word or two describing them for each species (where known).

My criticisms of the editing are relatively minor. In fact, throughout the entire book, I found no more than two dozen typographical, grammatical and spelling errors. The only annoying aspect of the writing style (which may not have been the author's fault) was the inconsistency of the reference system. In some places, *et al.* was used and in others not. This even occurred on the same page, e.g. p. 120. Frequently, the periods at the ends of sentences preceded the reference which was not always in brackets.

The range maps are extremely useful and a welcome addition. If Cade's plea for further research on many species is heard, then these will undoubtedly change. For example, five years ago, I received a brood of orphaned American Kestrels from as far north as the east coast of James Bay (well above that shown on Cade's map), and to top that, in the summer of 1982, I observed a male Kestrel perched on a hydro line beside the airport in Fort Chimo in Ungava Bay! As an aside, some readers may be confused by the lack of referencing for a few of the maps covering two species.

Besides Cade's authoritative writing, the book is richly endowed with 40 full-page colour paintings. I personally like R. David Digby's style, which is to be expected because I also favoured D. M. Reid-Henry's work (the former studied under the latter) above seven other artists in an earlier raptor book. Some readers might have liked to see both sexes and the immature plumages presented for each species (where warranted), but with the painstaking hard labour incorporated into each painting, I think this is asking too much. Digby's work is impressive and indicates he is no stranger to falcons.

In summary, my criticisms of the book are largely miniscule when one considers the author is sharing with us more than 40 years of experience in observing both wild and captive falcons. As a "student of falcons", I devoured the book and examined it with a fine-tooth comb. It has without doubt much to offer to those with an unquenchable curiosity for knowledge of these magnificent birds and to those with a refined appreciation for superb artwork.

DAVID M. BIRD

Macdonald Raptor Research Centre, Macdonald Campus of McGill University, Ste. Anne de Bellevue, Quebec H9X 1C0

BOTANY

Survey of Canadian Herbaria

By Bernard Boivin. 1980. Provancheria No. 10, Université Laval, Québec. Louis-Marie, Université Laval, Québec. Available from the author at Herbier Louis-Marie, Université Laval, Québec. 187 pp. $10.

This book includes descriptions of 404 Canadian herbaria, both past and present, with 335 being institutional, 69 private, and 248 still presumed active today. The author's three-fold objectives for the book were: 1) to provide information about the research capabilities of Canadian herbaria, 2) to suggest the herbaria that might contain specimens for particular research needs, and 3) to provide information on locations of voucher specimens for previous studies. The nature and purposes of herbaria in general, previous herbarium surveys relevant to Canada, objectives and methodology of the present survey, and its format, are briefly described respectively in four short introductory chapters. The actual descriptions of Canadian herbaria follow the introductory chapters and comprise the main text. The book concludes with a brief chapter attempting to give some statistical summaries, an appendix reproducing some facsimiles of relevant historical documents, and a relatively extensive alphabetical index giving the herbarium acronyms and/or names, institutions, collectors, and plant taxa mentioned in the text.

In the main text body, the included herbaria are alphabetically arranged and cross-referenced by their official and previously used acronyms, owner's names (if the herbaria are private), and cities where located. The herbarium descriptions vary considerably from very brief (3-5 lines) to relatively extensive (½-2 pages). Information is usually given on date of origin (and sometimes also considerable history), size, area of concentration, main collectors, comments on exchanges and loans (but only in reference to Department of Agriculture, Ottawa (DAO) and the author), and some abbreviated references to information about the particular herbarium.

This survey represents the results of a 30-year compilation of information about various Canadian herbaria by the author, a prodigious compiler, who obviously invested much time and effort on this task. Included is much useful and interesting historical information about various herbarium collections in this country. It has performed a valuable service in recovering and preserving such historical knowledge as part of our botanical heritage, aside from its stated primary objective of providing information on Canadian herbaria as resources for research.

This publication is not, however, the even-handed and updated review of all present-day herbaria across the country that readers might expect. It was admittedly a personalized compilation and biased by the author's own interests and his rather informal information-gathering methods, which consisted mainly of personal impressions and notes accumulated during his herbarium visits and studies spanning 30 years. The result, although highly informative and often fascinating in many details, is a distinctly uneven coverage of Canada's herbaria, both in terms of the amount of detail included and the recency of much information. Some herbaria seem very well described (e.g. CAN, DAO, MFJB, MT, MTMG, QFA, QK, TRT), but others are much less thoroughly reviewed. Sometimes the descriptions of particular herbaria appear fragmentary, subjective or uncertain, or scarcely if at all updated from information that must have been obtained 15, 20 or even 30 years ago (or often with only a size-amendation from *Index Herbariorum* Edition 6, 1974). The lists of "main collectors" given with each herbarium description appear particularly non-uniform and in fact often seriously distorted with regard to inclusions vs. exclusions and to the recency of information. For some herbaria, the "main collectors" listed are strictly historical including none (or very few) more recent than 20-25 years ago, but for other institutions the lists may even include collectors up to the late 1970s. Obviously the author's symbol-annotated alphabetical list of Canadian collectors in his extended concluding index can hardly be more consistent and complete than the individual lists from which it was compiled.

One might have expected the author of a publication, professing by its very title to be a national survey of herbaria, to have made a determined and systematic effort to update his information prior to publication and to attempt giving a roughly equivalent treatment of all herbaria across the country. A form letter requesting needed information circulated to all curators (not just a selected few) might have avoided much of the excessive unevenness evident in this survey. But as a curator himself, this reviewer can attest that no such communication concerning at least his herbarium was received during the last 14 years.

This *Survey of Canadian Herbaria* represents an interesting and informative work of considerable historical value that is certainly recommended to readers. It should not, however, be uncritically accepted as an accurate, even-handed and up-to-date assessment of Canadian herbaria today or of the collectors associated with them.

VERNON L. HARMS

The W. P. Fraser Herbarium, University of Saskatchewan,
Saskatoon, Saskatchewan S7N 0W0

The Rare Vascular Plants of the Yukon

By G. W. Douglas, G. W. Argus, H. L. Dickson and D. F. Brunton. 1981. National Museum of Natural Sciences, Ottawa, Canada. Syllogeus No. 28. 61 pp. (English), 64 pp. (French) + 35 pages of maps. Free.

This is one of a series of publications dealing with the rare plants of the various Canadian provinces and territories: #14(1977) Ontario; #17(1978) Alberta; #18(1978) Nova Scotia; #20(1979) Saskatchewan; and #27(1980) Manitoba.

For their purpose, the authors consider a rare plant as "one that has a small population within the area under consideration. It may be restricted to a small geographical area, where it may be locally common, or it may occur in low numbers over a wide area".

In this volume, 313 species (about a quarter of the known flora) are considered as rare in the Yukon Territory. For each species the following information is presented: reference (herbarium location of specimens or bibliographic citation), distribution (both total and within the Territory), reference to distribution maps, if any, habitat, status elsewhere in its range where it is rare, and sometimes additional comments, and a Yukon distribution map.

Works such as this offer a challenge both to the amateur and the professional not only to find new sites and thus extend the known ranges of the species listed, but also to add new species to the list. In the process, some species may be found to be more frequent than hitherto supposed, and thus might have to be dropped from future lists, and species new to the province or territory may be found. From a conservation point of view, works such as this help point out the areas which might be considered of special interest, and thus receive protected status. The work is a welcome and useful contribution to our knowledge of one of the most interesting regions of Canada.

Additions, suggested deletions, comments and corrections are requested by The Rare and Endangered Plants Projects, Botany Division, National Museum of Natural Sciences, Ottawa, Ontario, K1A 0M8.

WILLIAM J. CODY

Biosystematics Research Institute, Agriculture Canada, Central Experimental Farm, Ottawa, Ontario K1A 0C6

Weeds

By W. C. Muenscher, with foreword and appendices by P. A. Hyppio. 1980. Second edition. Comstock Publishing Associates, a division of Cornell University Press, Ithaca. xviii + 386 pp., illus. U.S. $29.50.

The appearance of a new version of a classic textbook must always create ambivalent feelings. On the one hand there is the pleasure of seeing a familiar, well-proven work available once more, but on the other there is the question of whether it has been brought up-to-date adequately, and, perhaps more painfully, if indeed the old classic is capable of being updated or if it should have been allowed to die with its original author.

Walter Leopold Conrad Muenscher, the original author of *Weeds*, was born in Germany in 1891, moved to the United States as a child, and taught at Cornell from 1916 to 1954. He died in 1963. The first edition of *Weeds*, a handbook of "the commonest weeds of the Northern United States and Canada", appeared in 1935, long before the advent of modern herbicides. A second edition appeared in 1955. In preparing it, Muenscher faced the dilemma of how to handle the burgeoning field of chemical weed control. In retrospect, he was probably wise in deciding to omit all mention of it, save in his preface, and to keep the emphasis in the handbook on weed identification. Nevertheless this does lead to quaint paragraphs, redolent of another era, that say, for example: "Control — Hand hoeing (5), hand pulling (4)". The numbers refer to paragraphs in the 17-page chapter on "The Control of Weeds", which deals almost exclusively with methods of mechanical control. On the positive side, this is an area which is all too easily overlooked to-day, and which should be of increasing importance to home gardeners and certainly to those with a heightened awareness of the hazards to the environment of the indiscriminate use of herbicides.

The publication under review is a "Reissue" of this 1955 Second Edition with a new foreword and three new appendices by Peter Hyppio, Curator of the Herbarium and Extension Botanist at the L. H. Bailey Hortorium of Cornell University. These, respectively, explain the reissue, give a translation from the scientific names used by Muenscher to "current nomenclature", list a "standardized common name" for each of the weeds mentioned in the book, and provide a 1½ page bibliography of sources for the "current nomenclature" and "common names" that Hyppio adopts. In addition the foreword indicates that typographical errors have been corrected.

Is the reissue a success or should the book have been allowed to die? Paradoxically, I believe the answer to both questions is "no". If the appendices are really needed, then surely the reader deserves to have this information in the text and not have to check every single scientific name to see if it is still in current usage. Likewise, if a standardized list of English-language names is really needed, as, for example, to meet the dictates of the Weed Science Society of America, then surely the user should have this name highlighted typographically in the text.

In general, Hyppio has done a good job in his appendices, but he fails to draw the distinction, which would have been possible in Appendix I, between scientific name changes which represent corrections (e.g. *Eragrostis minor* for "*E. poaeoides*" or the author citation for *Stellaria media* as "(L.) Vill." instead of "Cyrill"), and those which merely reflect a change in taxonomic judgement, which is not necessarily accepted by all botanists. An example of the latter is his adoption of the genus *Toxicodendron* and his recognition of the different races of poison ivy as distinct species even although Mulligan and Junkins (1978, Le Naturaliste canadian 105: 291–293) have provided evidence that specific rank is inappropriate. This leads to his use of *T. radicans* and *T. rydbergii* where others would use *Rhus radicans* subsp. (or var.) *radicans* and *R. radicans* subsp. (or var.) *rydbergii*. Indeed Hyppio seems, in this case, to have confused two taxa that Muenscher correctly distinguished. Muenscher has "*R. microcarpa* Steud.", "*R. radicans* L.", and "*R. radicans* L. var. *rydbergii* Small". Hyppio treats the first two as synonymous (*T. radicans*) and the last as *T. rydbergii*. It is evident, however, from the distributions given by Muenscher coupled with the work of Gillis (*Rhodora* 73: 72–159, 161–237, 370–443, 465–540, 1971) which included typification of the epithet *radicans*, that in current nomenclature these are, respectively, *R. radicans* L. subsp. *radicans*, *R. radicans* subsp. *negundo* (Greene) McNeill, and *R radicans* subsp. *rydbergii* (Small ex Rydb.) McNeill.

In some other cases Hyppio has been much more conservative in maintaining Muenscher's nomenclature than one would expect, as, for example, when he retains white cockle or white campion in the genus *Lychnis* (as *L. alba*) rather than placing it, as is usual to-day, in the genus *Silene*, beside its oft-confused look-alike, night-flowering catchfly (*S. noctiflora*). (In *Silene*, it has to be called *S. latifolia* Poiret (= S. pratensis (Rafn) Godron & Gren.)). One evident failure to correct Muenscher's nomenclature is in the genus *Euphorbia*, where *E. maculata* L. applies to what Muenscher calls *E. supina*, whereas his *E. maculata* is correctly known as *E. nutans* Lag.

In any revision, however, errors and omissions are inevitable, and are not the final arbiter of its worthwhileness. A wider issue is whether Muenscher's taxonomic treatment is not so dated as to make a mere nomenclatural appendix inadequate for present-day needs. In part, this *is* the case. For example, Muenscher makes no reference to the widespread prairie and northern plains dock *Rumex pseudonatronatus* Borbas. He includes *Polygonum erectum*, which appears to be a sporadic plant of native habitats to-day, yet omits the abundant, weedy *P. achoreum* Blake. The two species are well distinguished by Mitchell and Dean (1978, N.Y. State Museum Bulletin 431: 38-42) and Muenscher clearly illustrates the former, even though it seems certain that in describing the habitat and distribution he is referring to the latter. Likewise, although Muenscher lists only one dark-flowered dog-strangling vine or swallow-wort, which he calls *Cynanchum nigrum* (incidentally, another incorrect name that is over-looked), two readily confused species seem almost as widely distributed in the northeastern U.S. and adjacent Canada; in the segregate genus *Vincetoxicum*, these are correctly known as *V. nigrum* (L.) Moench and *V. rossicum* (Kleopov) Barbarich (cf. McNeill, 1981, Le Naturaliste canadien 108: 237–244.). Further examples can readily be found, particularly in long-confused genera such as *Atriplex* and *Chenopodium*.

Yet, for all its defects, Muenscher's work remains a very usable classic. It is one of the few weed manuals with identification keys; the coverage is good; the brief descriptive and distributional notes are helpful and the historic approach to weed dissemination, "ecology", and control still has a relevance to our understanding of weed biology. The book is not dead. This reissue, for all its faults, is probably worth its price, even in U.S. dollars. What would be even better, however, would be a third edition, or a new book unashamedly building on Muenscher, that would take account of recent advances in our understanding of the variation, taxonomy and distribution of the weeds of the Northern United States and Canada. Perhaps Dr. Hyppio will one day provide us with it.

J. MCNEILL

Department of Biology, University of Ottawa, Ottawa, Ontario K1N 6N5

ENVIRONMENT

Nature Conservation Day

Compiled by T. J. Beechey and B. L. Raad. 1981. Proceedings of a symposium, 26 March 1980. Ontario Ministry of Natural Resources, Toronto. 86 pp. $2.

This seminar featured speakers from provincial and other agencies concerned with protection of natural areas. Absence of participants from Parks Canada and the Canadian Wildlife Service (National Wildlife Sanctuaries) is notable. These agencies play a role in nature protection within Ontario, and could have added a national perspective to the discussions.

The Minister's message stated that the seminar was a success, with the objectives of increasing awareness, acquainting different agencies with mandates and programs, commemorating achievements, identifying needs and problems, and exploring innovative approaches. However, the true success of the seminar should be best judged by problems solved and innovations adopted. With the proceedings published one year after the seminar, actions taken within that year could have been summarized.

The Director of the Parks and Recreational Areas Branch presented a short historical introduction to provincial parks, and related legislation and policies. Unfortunately, the significance and substance of the acts and policies were not adequately described. For example, the Endangered Species Act of 1971 was mentioned, but its provisions for natural area protection were not explained.

The Manager of the Planning Section of the same branch attempted to explain the inventory of natural areas. The reader was thrown into a sea of agency jargon which is poorly defined. The reader encounters terms such as "landscape representation", "ecosystem representation", "representation principle", "life science framework", "earth science features", and others.

The concepts of biological versus physical features in this chapter were confusing. Besides biological features, the "life science framework" included substrate, moisture, microclimate and landform patterns. The relationships of various types of reserves, parks, zones and classes was also confusing for those not imprinted on the appropriate jargon.

By contrast, the late Mr. Coffin, Executive Director of the Niagara Escarpment Commission clearly defined the jargon used by the commission. The reader must not assume that similar terms used by different agencies have similar definitions. Mr. Coffin tackled the problem of similarities to Ministry of Natural Resources jargon directly.

Mr. Coffin clearly defined the commission's principles, objective, activities and mechanisms for natural area protection. The General Manager of the Federation of Ontario Naturalists, Director of Conservation Authorities, and Projects Director of the Nature Conservancy of Canada also presented clear, concise descriptions of their agencies' principles, objectives, programs and organization. The water management mandate of the Conservation Authorities was logically connected with their activities in natural area preservation. The discussion of joint projects by the Authorities, the Conservancy and the Federation were especially pertinent to the seminar's objectives. Six representatives of the Nature Conservancy of Canada (other than the Projects Director) also made presentations. The information in these presentations was insufficient and fragmentary. The viewpoints were largely redundant with repeated calls for improved inter-agency coordination and cooperation.

The New England Field Director of the Nature Conservancy provided a concise, factual and clear explanation of the perceived need for nature protection in the United States, government's response, and the Nature Conservancy's objectives, organization and programs. The appendix of background information on the natural area inventory program was very useful. Other chapters would have benefitted from such appendices.

The summary of the panel discussion reiterates the problems identified earlier, and provides some solutions. The Ministry of Natural Resources appeared reliant on one provincial plan, blueprint or strategy to solve the problems of inter-agency coordination and cooperation. However, regional, provincial and federal governments, Federation of Ontario Naturalists and the Nature Conservancy of Canada answer to different constituencies. Alignment behind one provincial strategy may be difficult. A forum for open discussion between agencies, as recommended by Dr. Fowle of the Nature Conservancy of Canada, could be critical to solve identified problems.

This compendium of viewpoints should be read by naturalists, biologists, and system planners who want a concise overview of natural area protection in Ontario. Students will find it a good starting point for a more thorough study of this subject.

MICHAEL A. D. FERGUSON

Department of Renewable Resources, Government of the Northwest Territories, Frobisher Bay, Northwest Territories X0A 0H0

The Mitigation Symposium: A National Workshop on Mitigating Losses of Fish and Wildlife Habitats

Co-ordinated by G. A. Swanson. 1980. General Technical Report RM-65. U.S. Department of Agriculture, Fort Collins, Colorado. 685 pp.

Mitigation is not a new concept. In fact, it was conceived in the U.S. Congress and developed under the auspices of the Fish and Wildlife Coordination Act in 1934 (see L. M. Krulitz's paper entitled Federal Legal Background for Mitigation). However, it has evolved as a legitimate science/art only in the last two decades. And although such rapid evolution should be applauded, it has not emerged without problems, which range from variability in biological techniques and definitions to legal and political issues. Therefore, it was with pleasure that I read this volume, a fine attempt to deal with many of the outstanding questions surrounding mitigation.

The objectives of this symposium were:

(1) "To review the magnitude, and the seriousness of the losses to fish and wildlife habitat as a result of changing land and water use with particular emphasis on federal development projects.
(2) To review the extent to which these habitat losses are being and have been mitigated, and
(3) To develop strategies, and practical recommendations, for minimizing fish and wildlife habitat losses and achieving more effective mitigation."

To meet these objectives, 124 papers and poster session presentations were prepared and published in the proceedings. The volume is divided into numerous sections which deal with: the concept of mitigation; coastal zone wetlands; inland wetlands; economic considerations; mining, oil and gas; water developments; planning, evaluation, inventory of habitat and impacts; surveys of mitigation problems and impacts; power projects; terrestrial management techniques; aquatic management techniques; legal and political considerations; transportation systems; state perspectives; and poster session papers. The vast majority of the papers in the proceedings are case history analyses of specific land and water management projects.

Before readers review the case histories, I strongly recommend that the 16 papers comprising the first section be read. It is important that the reader grasp the concept of mitigation. L. R. Jahn's paper is particularly valuable because it contains a succinct summary of the conference proceedings, and a definition of mitigation. Jahn reports that mitigation can be defined to include:

(1) "Avoiding the adverse impact altogether by not taking a certain action or parts of an action (preventative).
(2) Minimizing impacts by limiting the degree or magnitude of the action and its implementation.
(3) Rectifying the impact by repairing, rehabilitating or restoring the affected environment.
(4) Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action.
(5) Compensating for the impact by replacing or providing substitute resources or environments."

The disappointing aspect of this volume is that only two papers were presented by Canadian participants. B. Stubbs and B. Markam discuss wildlife mitigative measures for oil and gas activity in Alberta, and K. G. Peterson reviews benefit-cost analysis techniques as a basis for compensation and mitigating decisions for hydroelectric projects in British Columbia. Given the vast array of development projects of all sizes now underway or planned for in Canada, it would be extremely useful to conduct a similar symposium focusing on Canadian issues.

The text is supplemented with black and white photographs, maps, and black ink sketches. Most of the technical papers contain a literature cited section.

I recommend this volume to all professionals concerned with resource management and interested in mitigation.

PAUL A. GRAY

Northwest Territories Wildlife Service, Yellowknife, Northwest Territories X1A 2L9

Natural Heritage: Classification Inventory, and Information

By A. E. Radford, D. Kay, S. Otte, L. Otte, J. R. Massey, P. D. Whitson, and contributors. University of North Carolina Press, Chapel Hill. 485 pp. U.S. $25.00.

The need for a standard system to inventory areas of natural significance is well recognized. Many types of inventories have been proposed, the IBP system being most notable. Radford and his colleagues have developed a system from their North Carolina experiences and present their methodology and its fundamentals in the present volume. As noted by the authors, the primary purpose of the book is for "... diversity inventory use in natural areas by conservationists, heritage workers, and students of flora and fauna and for habitat analysis of special sites by advanced students of systematics, ecology, and species biology. A system of classification for ecological diversity and inventory procedures was developed as a basis for effective and efficient use of resources and field time. The classification system was designed as a usable and useful tool, of practical and theoretical relevance ...".

The system described is as detailed as any produced for ecosystem inventory. Seven components form the basis of the inventory: Climate, Soils, Geology, Hydrology, Topography, Physiography, and Biology. Each component has seven major subcomponents: System, Subsystem, Class, Subclass, Generitype, Type, and Population type (Site type).

Learning any new system entails trial, error, study and comparison. The system proposed here has reduced much of the frustration by defining the terms used and by having a very tight methodological framework which must be followed. The end product of the inventory is a Natural Area Diversity Summary, which contains the Community Diversity Summaries for each of the seven components. These summaries enable different areas to be compared.

The methodology presented certainly does not profess to be perfect. Certain problems do exist, such as the detailed level of investigation required to perform these inventories and the need for repeated surveys at different times of the year. The botanical aspects of a natural area are heavily emphasized, due to the area of specialization of the originators.

Initially the book implies that anyone with a bit of interest or training could undertake an inventory. However, that is definitely not the case as stated later in the book (p. 95): "basic inventory should be made by professionally trained naturalists..." Why wait so long to indicate this major point?

The book proposes to aid management of natural areas. However, it only succeeds in providing a great wealth of information on how to conduct baseline surveys. It is simply a handbook for inventories. A great deal of further research would be necessary in order to effect proper management decisions.

The book is large, has good print size and is easy to read, free of typographical errors. The only printing problem is that italicized Latin names are difficult to distinguish.

ROBERT WOODS

Canadian Forestry Service, Environment Canada, Ottawa, Ontario K1A 1G5

Estimation of Density from Line Transect Sampling of Biological Populations

By Kenneth P. Burnham, David R. Anderson, and Jeffrey L. Laake. 1980. Wildlife Monographs 72. The Wildlife Society, Washington. 202 pp. U.S. $4.00.

In order to make inferences about the abundances of populations, field researchers often use line transects, recording the distances and angles at which individuals are sighted. The five parts of this valuable volume synthesize available knowledge about this technique. The first part discusses basic concepts and quantitative background. Following a reader's guide which anticipates a diverse audience ranging from biological technicians to statisticians, methodological problems associated with experimental design and data collection are considered. An outline of the mathematical and statistical background underlying the methods leads to the second part, dealing with robust estimation methods. Topics covered include a variety of estimators and their assumptions, and tests for goodness of fit, useful in the different types of observations, together with a number of exemplar data sets. The third part examines the statistical estimation theory for these robust methods, including maximum likelihood, generalized linear models, relative efficiencies of estimators, and results from computer simulations. The final two parts include comments on other estimators and appendices of supplementary information and examples. Different aspects of the book will appeal to different users. The authors have prepared their material with this in mind by attending to both biological and statistical issues. The emphasis on methods robust to the failure of underlying assumptions makes good sense. The extensive examples, illustrations, and literature citations are all welcome features. Overall, this work succeeds in achieving the stated objective of providing "a rigorous, comprehensive, and practical reference on line transects". As such, it is a worthwhile addition to a monograph series with a tradition of authoritative and yet inexpensive volumes.

PATRICK COLGAN

Department of Biology, Queen's University, Kingston, Ontario K7L 3N6

MISCELLANEOUS

A Celebration of Birds — The Life and Art of Louis Agassiz Fuertes

By Robert McCracken Peck. 1982. Walker and Co., New York. xiii + 178 pp., illus. U.S. $30.00.

In the autumn of 1982 the Academy of Natural Sciences, Philadelphia presented a travelling exhibition of the art of Louis Agassiz Fuertes (1874-1927), showing many of his works for the first time. *A Celebration of Birds*, written by the Academy's Vice-President, was planned to accompany this exhibition, which will be shown in numerous cities across North America during 1983-84. Peck, who is both an art historian and a naturalist presents a well researched, readable, fascinating account, focusing in three separate sections on Fuertes: the man, the artist, and the naturalist.

Fuertes, named after the Swiss-born Harvard zoologist Louis Agassiz, was the son of a civil-engineering professor at Cornell University. He was born in Ithaca, and lived all his life there. A childhood interest in animals led to his painting them in his early teens. Fuertes studied and collected birds, but never killed them just for the sake of it. His passion for birds was so overwhelming that by the time he became a student at Cornell University in 1893, it was evident that subjects such as philosophy and mathematics just could not compete with vertebrate zoology.

Whilst still a university student Fuertes met two people who greatly influenced his life. A fortuitous coincidence led to his meeting Elliott Coues, the uncle of one of his friends from the university "Glee Club" and one of the foremost American ornithologists of the time. This chance encounter led to an exhibition of his work at the annual meeting of the American Ornithologists' Union (A.O.U.) in 1895. The following year Fuertes attended an A.O.U. meeting for the first time, and met many of the leading ornithologists of the late 19th century.

At the same A.O.U. meeting Fuertes met the painter Abbott Thayer, who proved to be another major influence on his life and art. Thayer, who was known for his controversial theories of protective coloration in animals suggested that Fuertes join him the following summer for a training session. The two became friends and Fuertes subsequently spent many happy days with Thayer and his family.

Fuertes was a good field ornithologist and took advantage of all opportunities to escape from his studio and spend time out of doors, near his home in Ithaca, with Thayer in New Hampshire, and to participate in expeditions to various parts of the world. His first extended journey was to Alaska in 1899 as a member of the now famous Harriman Alaska expedition. Others quickly followed: Texas in 1901, the Bahamas in 1902, the western states in 1903, the Magdalen Islands, Quebec, in 1909, the Yucatan in 1910, and Colombia in 1911 and 1913.

During World War One, money was scarce for expeditions and natural history work in general. This was the only period of his life when Fuertes was not inundated with commissions for bird paintings and illustrations. The need to feed his growing family, plus a request from the National Geographic Society, induced Fuertes to branch out and begin to paint mammals. While his series of mammal plates for *National Geographic Magazine* were successful, Fuertes' first love remained bird art and he returned to this as soon as possible. With the end of the war commissions for bird art increased again, and soon Fuertes was busier than ever.

In the early 1920s Fuertes was widely sought after as lecturer by various natural history and conservation societies. In 1922 his association with Cornell was formalized and he became "resident lecturer" at his Alma Mater. His demanding schedule prevented him venturing far afield for a while and he had to decline the offer to accompany an expedition of the American Museum of Natural History to Peru in 1923. Three years later the Field Museum (Chicago) mounted a large expedition to Abessynia. This was an opportunity Fuertes was not willing to forego. The eight month trip was to be his last expedition. In August 1927 Fuertes was killed in an automobile accident near his home.

A Celebration of Birds is also a celebration of the genius of Fuertes. Practically every page has either a black-and-white or a colour illustration. These demonstrate Fuertes' progress as artist-naturalist. Most are so breathtakingly beautiful that they tend to divert the reader's attention from Peck's interesting, informative text. Peck made skillful use of primary material, consisting of the letters and journals of the artist. The book contains a useful chronology, and a section on the major collections of Fuertes' work, in addition to a list of the illustrations in the book. The "Notes" and "Selected Bibliography" are well arranged and useful, not only for references, but also for further research. This is a superbly illustrated, well written, reasonably priced book with one major fault. It is too short!

MARIANNE GOSZTONYI AINLEY

History and Philosophy of Science Program, McGill University, Montréal, Québec H3A 1G5

Aleksander Tamsalu, 1891-1960: a Botanist in Exile

By John B. Lord. 1980. Technical Bulletin No. 11. Royal Botanical Garden, Hamilton. 127 pp., illus. $3.50 plus $1 postage.

Aleksander Tamsalu was an Estonian botanist and agronomist who is still recognized in his native land as an able and productive student of plant communities. His professional career, as described by John Lord in this brief and poignant but thorough and balanced study, was in part frustrated by his inability to recognize or properly manage some of the opportunities which came to him and also by events outside his control which forced the abandonment of some major projects.

Son of a successful farmer with some English ancestry (the family surname was originally Tomson), Tamsalu early evinced great interest in natural history. His father refused to encourage the lad's academic bent, so Tamsalu was channelled into vocational pursuits, becoming for a time an elementary school teacher. Deciding in his early twenties on a career in plant science, and barred from a conventional university career because of his lack of a maturity certificate, he worked his way through the Institute of Agriculture in St. Petersburg. He completed both the high school and college level programs in his nine years there, finishing with the equivalent of a Master's degree in 1921.

This accomplishment was achieved despite the loss of his eldest son and the trauma of the Russian Revolution, during which he rose from a minor clerkship in the city's Central Railroad Office to the post of Railroad Commissar for the Petrograd Region. His success was all the more remarkable in view of his loathing of Bolshevism, which at one point led to his arrest, brief detention, and a spirited discussion of political philosophy with Lenin himself. Declining a teaching post with the Institute, Tamsalu returned to Estonia, which had secured its independence in 1918. In his haste to leave, he neglected to retrieve his hard-won maturity certificate from the files of the Institute, an oversight that was to hamper him for years.

During the 1920's and early 1930's, Tamsalu was briefly assistant director of an agricultural station and a teacher of agronomy at an agricultural school. Personality clashes with colleagues were partly to blame for his loss of both positions. His unorthodox research techniques, which stressed field work with little time given to the literature and minimal publishing, won him little support. Lord points out that Tamsalu was a mere amateur in purely botanical research, his formal preparation having been in field crop production.

By 1931, at the age of 40, Tamsalu was seemingly at a dead end in his chosen field. Virtually no one would read his research papers, and he was compelled to fall back on schoolteaching to keep his family fed. He then met Theodor Lippmaa, a near contemporary, who was professor of botany at the University of Tartu and a pioneering phytosociologist. Tamsalu was unable to begin doctoral work under Lippmaa because he could not secure a copy of his maturity certificate. Not until 1940 would this matter be resolved. He did, however, begin doing field work under Lippmaa's close supervision and guidance. He contributed with others to a vegetation map of Estonia and became Lippmaa's most trusted and productive associate.

In the late 1930's, fortune seemed to shine on Tamsalu. He was invited to teach in Finland at twice his Estonian salary, but elected to stay with Lippmaa. In the spring of 1940, Lippmaa elected to move on to other projects, and Tamsalu was placed in charge of the vegetation survey project. His appointment was contingent upon his securing his doctorate, but the way finally seemed clear, since the requisite credentials had finally arrived from Leningrad.

Then the roof fell in. The Russians seized Estonia in the summer of 1940, and Tamsalu's hard-won post was swept away. Tamsula, his wife and daughter were deported to a German labor camp, where his wife died. Tamsalu and his daughter ultimately reached the American zone of occupation at war's end. He and his daughter lived and worked in a succession of Displaced Persons camps until she was able to emigrate to Canada in 1948. Tamsalu himself arrived in Connecticut in 1949.

His years there were not happy. He had several jobs as a manual laborer and spent most of his free time carrying out field research projects which he had set for himself. He hoped to impress some prospective employer with his talents as a botanical researcher. He was never at home with English, however, and most of those asked to review his manuscripts admired his determination and the scope of his work while finding fault with the manner in which he carried it out. Virtually no one had heard of Lippmaa, and Tamsalu could produce no credentials. Tamsalu's research methods were unfamiliar or, at best, dated to American colleagues, and he often seemed to be unaware of the relevant literature in his field. His foreign nationality precluded his being considered for any posts with the federal government, something Tamsalu could not understand. Growing desperate, and aware that his advancing age might mitigate against securing a scientific post in America, Tamsalu accepted the only offer he did have, that of skilled laborer at the Royal Botanical Gardens in Hamilton, Ontario, with the understanding that full-time work as a researcher would be his if budgetary considerations made it possible. After a bit more than a year at the RBG, Tamsalu's demonstrated abilities as researcher and collector finally won him a full-time post as an ecological plant researcher. He had undertaken herculean tasks for a man of his age, however, and the cumulative strains upon his reserves of strength and health were too much. A variety of ailments rapidly took their toll. Tamsalu was naturally disappointed that none of his American or Canadian manuscripts were ever published.

As Lord points out, Tamsalu was never a theoretician of botany, but rather an indefatigable describer of plant communities. He faithfully followed the Lippmaa method until the day he died, failing to appreciate the fact that his mentor's theories had, while "greeted with polite curiosity ... certainly never gained widespread attention in North America." Yet Tamsalu did leave behind a legacy of accomplishment. The RBG Herbarium contains nearly 10 000 specimens collected by Tamsalu, who "remains by far its most prolific contributor." When in 1965 a text on the distribution of vegetation in Estonia was finally published, Tamsalu was acknowledged as the chief contributor of vegetation maps to the project. Lord's text concludes with a detailed explication of the Lippmaa method, extracted from Tamsalu's letters and unpublished papers.

KEIR B. STERLING

Pace University, Pleasantville, New York, USA 10570

NEW TITLES

Zoology

*The amphibians and reptiles of Manitoba.** 1982. By William B. Preston. Manitoba Museum of Man and Nature, Winnipeg. 128 pp., illus. $9.95 plus $1 shipping.

The animals' who's who. 1982. By Ruthven Tremain. Scribner, New York. xvi + 336 pp., illus. U.S. $17.95.

*The barn owl.** 1982. By D. S. Bunn, A. B. Warburton, and R. D. S. Wilson. Buteo Books, Vermillion, South Dakota. 280 pp., illus. U.S. $32.50.

Birds of prey. 1982. By Emma Ford. Batsford, Newton Centre, Massachusetts. 64 pp., illus. U.S. $8.95.

†**Breeding birds of Ontario, nidiology and distribution, volume 1: non passerines.** 1983. By George K. Peck and Ross D. James. Royal Ontario Museum, Toronto. xii + 321 pp., illus. $25.

†**Crabs and their relatives of British Columbia.** 1982. By Josephine F. L. Hart. Handbook 40. British Columbia Provincial Museum, Victoria. 267 pp., illus. $5.

*Eastern chipmunks: secrets of their solitary lives.** 1982. By L. Wishner. Smithsonian Institute Press, Washington. 144 pp., illus. U.S. $17.50.

The ecology of whales and dolphins. 1982. By David E. Gaskin. Heinemann, Exeter, New Hampshire. xii + 460 pp., illus. U.S. $45.

Elephants. 1982. By S. K. Eltringham. Blandford, New York. x + 262 pp., illus. U.S. $15.99.

†**The Empidoidea (Diptera) of Fennoscandia and Denmark, II: general part, the families Hybotidae, Atelestidae, and Microphoridae.** 1983. By M. Chvála. Fauna Entomologica Scandinavica Volume 12. Scandinavian Science Press, Klampenborg, Denmark. 279 pp., illus. 200 Dkr.

Ethology: its nature and relations with other sciences. 1982. By Robert A. Hinde. Oxford University Press, New York. 320 pp., illus. U.S. $19.95.

Fishes of the Minnesota region. 1982. By Gary L. Phillips, William D. Schmid, and James C. Underhill. University of Minnesota Press, Minneapolis. x + 248 pp., illus. Cloth U.S. $25; paper U.S. $12.95.

†**Good-bye bugs! A practical guide to coping with insects in the great outdoors.** 1983. By Allen West and Bev Smallman. Grosvenor House Press, Toronto. 144 pp., illus. $8.95.

The great whale book. 1981. By John Kelly, Scott Mercer, and Steve Wolf. Acropolis, Washington. 116 pp., illus. U.S. $7.95.

Hibernation and torpor in mammals and birds. 1982. By Charles P. Lyman, John S. Willis, Andrés Malan, and Lawrence C. H. Wang. Academic Press, New York. xii + 320 pp., illus. U.S. $37.50.

IUCN amphibian — reptile red data book, part 1 (Testudines, Crocodylia, Rhynchocephalia). 1982. By the International Union for Conservation of Nature and Natural Resources. Unipub, New York. 480 pp. U.S. $20.

IUCN mammal red data book, part 1 (new world). 1982. By the International Union for Conservation of Nature and Natural Resources. Unipub, New York. 560 pp. U.S. $20.

Jellyfish and other sea creatures. 1982. By Oxford Scientific Films. Putman's, New York. 32 pp., illus. U.S. $8.95.

†**Just bats.** 1983. By M. Brock Fenton. University of Toronto Press, Toronto. x + 165 pp., illus. Cloth $25; paper $9.95.

Lords of the Arctic: a journey among the polar bears. 1982. By Richard C. Davids. Macmillan, New York. xx + 140 pp., illus. U.S. $29.95.

†**Make prayers to the raven: a Koyukon view of the northern forest.** 1983. By Richard K. Nelson. University of Chicago Press, Chicago. xvi + 292 pp., illus. U.S. $25.

Mammals of the southwest. 1982. By E. Lendell Cockrum. University of Arizona Press, Tucson. 176 pp., illus. Cloth U.S. $11.95; Paper U.S. $5.95.

*Marine birds and mammals of Puget Sound.** 1982. By A. Angell and K. C. Balcomb, III. University of Washington Press, Seattle. xiii + 145 pp., illus. U.S. $14.50.

Marine fish larvae: morphology, ecology, and relation to fisheries. 1982. Edited by Reuben Lasker. Washington Sea Grant Publications, Seattle. 132 pp., illus. U.S. $8.50.

Mountain in the clouds: a search for the wild salmon. 1982. By Bruce Brown. Simon and Schuster, New York. 239 pp. U.S. $12.95.

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Their Excellencies the Governor General and Mrs. Edward Schreyer

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Editor: Francis R. Cook, Herpetology Section, National Museum of Natural Sciences, National Museums of Canada, Ottawa, Ontario K1A 0M8
Copy Editor: Louis L'Arrivée; **Assistant to the Editor:** Barbara Stewart
Business Manager: Mr. W. J. Cody, Box 3264, Postal Station C, Ottawa, Ontario, Canada K1Y 4J5
Book Review Editor: Dr. J. Wilson Eedy, R. R. 1, Moffat, Ontario L0P 1J0
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The Canadian Field-Naturalist

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The Tropical Fish Fauna in Cave and Basin Hotsprings Drainage, Banff National Park, Alberta

JOSEPH S. NELSON

Department of Zoology, The University of Alberta, Edmonton, Alberta T6G 2E9

Nelson, Joseph S. 1983. The tropical fish fauna in Cave and Basin Hotsprings drainage, Banff National Park, Alberta. Canadian Field-Naturalist 97(3): 255–261.

The Cave and Basin Hotsprings drainage in Banff National Park has been the site of introduction of various tropical aquarium fishes. A collection made in May 1981 indicated that there has been a change in the species present since 1968. A review of past collections and a description of the present tropical fish fauna, Mosquitofish (*Gambusia affinis*), Sailfin Molly (*Poecilia latipinna*), and Jewelfish (*Hemichromis bimaculatus*), is presented. The first two poecilliid species are well established and occur in places in dense numbers; the last cichlid species is relatively rare (at least in May). The highest temperature recorded where fish were found was 30° C in Basin Spring. Mosquitofish occurred at this site. Two native species found with the tropical fishes were Longnose Dace (*Rhinichthys cataractae*), most common in the outlet of one small cave at 24° C, and Brook Stickleback (*Culaea inconstans*) in quiet shoreline waters with aquatic plants in temperatures up to 21° C.

Key Words: Mosquitofish, *Gambusia affinis*, Sailfin Molly, *Poecilia latipinna*, Jewelfish, *Hemichromis bimaculatus*, Longnose Dace, *Rhinichthys cataractae*, Brook Stickleback, *Culaea inconstans*, tropical fishes, Cave and Basin Hotsprings, Banff National Park.

The Cave and Basin Hotsprings site in Banff National Park is historically important as part of the small area acquired in 1885 which became Canada's first national park. Before man's activities in the area the native fish fauna consisted of Longnose Dace, *Rhinichthys cataractae* Valenciennes, and perhaps Brook Stickleback, *Culaea inconstans* (Kirtland). Individuals of several other species native to the Bow River may have utilized the outlet area. Several species of tropical fishes have been reported from the drainage. One, the Mosquitofish, *Gambusia affinis* (Baird and Girard), was established by the government for mosquito control in 1924 while the others were introduced by local aquarists, at least in part as an unauthorized experiment and to serve as breeding stock for their aquaria. It is a fauna which although artificial and incongruous with a national park is established and unique in Canada. This paper reports the current status of the tropical fish fauna in the Cave and Basin drainage and, because of the uniqueness of the fauna in Canada, describes the collecting sites. Unfortunately, in the absence of detailed biological studies prior to the introductions, it will probably be impossible to know the full impact of the introductions upon the system, either in introducing other exotic organisms or in causing the extirpation of indigenous organisms. The hotsprings may contain or may have contained an endemic subspecies of Longnose Dace and is one of the sites for a snail of very restricted distribution, the Banff Springs Physa, *Physa johnsoni* (Clark 1973, 1981).

Methods

Intensive sampling was conducted 16 and 17 May 1981, using fine mesh dipnets of various sizes. General observations were made on 17 May 1980, 18 May 1981, and 5 August 1982. Twelve collections, each consisting of at least several dipnet attempts, were preserved; many other collections were made and the contents examined for new species and then released. Care was taken to try not to permanently change the existing populations through over-collecting in the springs or habitat disturbance. The 12 preserved collections were made at eight general sites (Figure 1). All specimens are catalogued in the University of Alberta Museum of Zoology (UAMZ 4613-4615; 4631-4640).

In fin-ray counts, the last ray is defined as consisting of two ray elements, following Hubbs and Lagler (1958); the last element is unbranched while the preceding one is branched in the three tropical fishes (in the Mosquitofish, the bases of the last two elements, comprising the last ray, are distinctly separ-

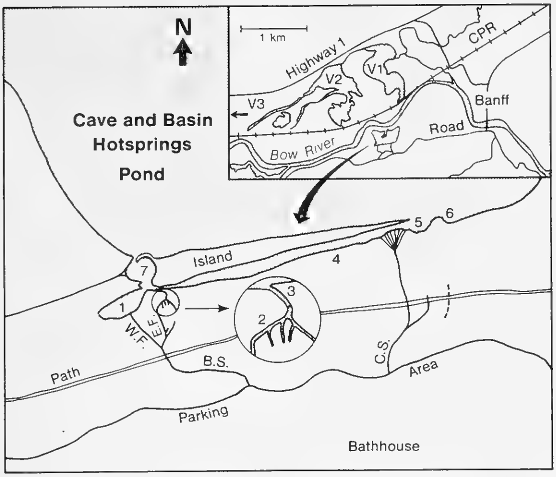

FIGURE 1. Diagrammatic map showing collecting sites 1-7 (eighth at western outlet and not shown) in Cave and Basin Hotspring drainage. Water level and spring courses are made from field notes of May 1981, and are intended only to show the relative position of various features. The origin of the springs is not shown. Slight change in water level would modify the shoreline contour. Inset map shows the general location of the drainage. B.S. = Basin Spring (E.F. = East Fork; W.F. = West Fork); C.S. = Cave Spring; V1-V3 = First to Third Vermilion Lake.

ated). Scale counts were taken from behind the top of the gill cover insertion to the end of the hypural plate (the few scales on the caudal fin were excluded).

Elevations in the description of the study area were taken from Site Plan, NWB 71/R42, of the former Department of Indian Affairs and Northern Development (scale 1 inch = 50 feet). Temperature was measured with a hand-held laboratory thermometer and temperature and conductivity with a YSI model 33 S-C-T meter.

Study Area

The Cave and Basin Hotsprings drainage, consisting of hotsprings and a shallow pond (or marsh) draining into the Bow River, is situated about 1-1/2 km southwest of the Banff townsite, immediately south of the Bow River and at the base of Sulphur Mountain. The pond, situated at about 51° 10'20"N, 115° 35'35"W, and an elevation of about 1382 m, lies within Pleistocene and Recent deposits of the Bow Valley while the springs arise from the western portion of the Sulphur Mountain thrust fault bordered by Upper Devonian formation to the west and undifferentiated rock to the east (Price and Mountjoy 1972).

Three main thermal springs exist, Pool Springs to the southeast, Basin Spring to the southwest, and Cave Spring in the middle (only the latter two, which were investigated, are shown in Figure 1). Pool Springs, described by van Everdingen (1972: 25-26), arise higher on the mountain than the other two (behind Cave Spring on the east side of the Bathhouse), consist of two relatively small sulphurous springs, and enter the pond at the east end. Cave Spring arises behind the eastern portion of the Bathhouse, south of the present parking area. These two springs are piped beneath the parking area (which lies at an elevation of 1400 m in this area), an expansion of the Sundance Road, emerge on the north side (Basin Spring runs a short distance through the conduit), cross a combination footpath and horse trail at an elevation of about 1390 m, continue down a steep hillside, and enter the pond through various channels (several, which are not shown in Figure 1, are underground and enter the pond at or near pond level through small caves). Changes, some man-made, have occurred in the drainage system (e.g., differences occur in the stream course depicted in maps prepared by the former Department of Indian and Northern Affairs in 1971, W. D. Reynolds in 1976, and myself in 1981). Recent channels are sometimes apparent by a white precipitate (e.g., dotted line in Figure 1).

The shoreline adjacent to the pond area generally has a soft bottom. There are two outlets to the pond which cross a path beneath small bridges and enter the Bow River. The eastern outlet has a small amount of surface flow through a beaver dam; the western outlet, located about halfway along the northern shoreline, is blocked off by earthfill with the pond side being almost 1 m higher than the river level at the time of the study (an outlet a short distance upstream on the Bow River drains a marshy area adjacent to the Cave and Basin Pond).

Van Everdingen (1972: 21-25) gives a physicochemical description of the springs. He notes that the flow in the Basin Spring is less than in the Cave Spring but its temperature and total dissolved solids is higher (a maximum of 34.5 vs. 32.8° C and 1828 vs. 1040 ppm). His data suggest that the coolest period is about May when discharge is relatively high. Pritchard (1971) noted one of the springs to vary from 30° C to 26° C during its course but to vary only 1° C (26 to 27) at one site during a period when air temperature varied from -20° C to 32° C.

History of Fish Collections

Eigenmann (1895) made the first known fish collections in the area. In 1892 he collected five species from the Bow River at the Banff townsite and in Echo Creek (= Vermilion Creek, the outlet of Vermilion lakes on the other side of the Bow River from the Cave and Basin area) (Figure 1). He referred to a tributary of the Bow from the hot sulphur springs and reported that Longnose Dace, given as *Rhinichthys dulcis*

(Girard), were very abundant (and common in the adjacent Bow River). Nichols (1916) described a new subspecies of Longnose Dace, *Rhinichthys cataractae smithi*, on the basis of five specimens collected in 1915 from the Cave and Basin Hotsprings having, by his counts, a relatively low number of lateral line scales. Mosquitofish, *Gambusia affinis*, were introduced into the Cave and Basin Hotsprings outflow in 1924 for mosquito control and Mail (1954) reported them to be thriving.

Aquarists began introducing tropical fishes into the drainage at least by the autumn of 1960 when several pairs of all-black (permablack) Sailfin Molly, *Poecilia latipinna* (Lesueur), were the first, as far as is known, to be added (C. Yarmoloy, personal communication); this is the only known introduction of this species. There is some feeling that earlier introductions of fishes may have been made by local aquarists but this is unsubstantiated. The first documentation of the unauthorized introduction of aquarium fishes into Cave and Basin Hotsprings was made by McAllister (1969), who, on the basis of collections made in June and August of 1968, reported the presence of four species of exotic fishes in addition to the Mosquitofish, namely: Guppy, *Poecilia reticulata* Peters, the all-black variety of Sailfin Molly, *Poecilia latipinna* (Lesueur), Green Swordtail, *Xiphophorus helleri* Heckel, and Convict Cichlid, *Cichlasoma nigrofasciatum* (Günther). The swordtails introduced were of the typical red aquarium variety but they apparently reverted to the wild green color in the pond and were always rare (C. Yarmoloy, personal communication). Of about 600 individuals collected for McAllister's (1969) study, the Guppy was about four times more numerous than Mosquitofish which in turn were about nine times more numerous than either the molly or swordtail. Only four Convict Cichlids were obtained and he noted reports of Angelfish, presumably *Pterophyllum scalare* (Lichtenstein), being present. As far as is known, the Angelfish along with the three-spot gourami variety of the Blue Gourami, *Trichogaster trichopterus* (Pallas), and Siamese Fighting Fish, *Betta splendens* Regan, were introduced into waters east of Cave Spring (Pool Springs?); the Gourami did breed but died out when the flow was turned off (C. Yarmoloy, personal communication). No native fishes were obtained in the 1968 collections.

J. C. Ward (1974. *The fishes and their distribution in the mountain national parks of Canada*. Manuscript Report prepared for Parks Canada by the Canadian Wildlife Service, Calgary. 41 pp. + appendices) made two collections from the Cave and Basin waters after 1968 but failed to find any Green Swordtails (he recorded Longnose Dace and Brook Sticklebacks). In 1976, W. D. Reynolds (1976. *A report on Cave and Basin interpretive research*. Manuscript Report to Director, Western Region Parks Canada. 53 pp.) noted the continued presence of Mosquitofish and Black Sailfin Molly, the absence of Green Swordtail and Convict (= Zebra) Cichlid (a temporary diversion of the hotspring outflow was one factor he noted as being responsible for their disappearance), and the appearance of Jewelfish (*Hemichromis bimaculatus* Gill). The Jewelfish is thought to have been established from the introduction of a single breeding pair (C. Yarmoloy, personal communication). Reynolds found the Mosquitofish to occur generally throughout the spring-influenced areas while the Molly was restricted and the Jewelfish very limited. Based on recent communication with W. D. Reynolds and C. Yarmoloy, it seems fairly certain that the report of the Guppy still being present in Reynolds' report is in error; unfortunately, no specimens of what were thought to be Guppies at the time were saved. Reynolds also found Brook Sticklebacks to be numerous in the shallow regions of the pond but to be absent where the exotic fishes occurred. He did not obtain any Longnose Dace but noted C. Yarmoloy's observations of their presence at the base of the Cave and Basin outflow from about June to August (the presumed spawning time) and at the northern part of the pond, near the outlet, at other times. In addition to my study, fish from the Cave and Basin drainage were also collected in 1981 by J. Lanteigne, biologist on contract to the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), assisted by A. Westhaver and F. McAllister, in mid-September in a study of the Longnose Dace. In addition to Longnose Dace, they obtained Mosquitofish and Sailfin Molly in the warm-water area (Mosquitofish outnumbered the molly about 3 to 1). Brook Trout, *Salvelinus fontinalis* (Mitchill), were present in the pond near the beaver dam of the eastern outlet (J. Lanteigne, personal communication).

Results

Collecting Sites and the Fishes

The collecting sites of this study are described below. The number in parentheses after a species name indicates the number of specimens preserved in dipnet sampling (not just obtained or seen). Inevitably, a collecting bias exists with dipnetting in determining the ratio of one species to another. The black Sailfin Molly, while much more conspicuous than the pale-colored Mosquitofish, was faster in swimming away and thus more unlikely to be caught in open water; extra effort was made to ensure collecting some mollies, when present, when only Mosquitofish might otherwise be caught. Although I lack data on the degree of this bias from differential escapes (which could be obtained from large but possibly destructive seine hauls), it was apparent in a few areas that the molly outnumbered Mosquitofish yet the catch data suggested the opposite. It did seem apparent, however, that Mosquitofish were more abundant and widespread than the molly in the pond and springs.

Water temperatures are given for the time of making the collections. The air temperature was relatively cold, generally 5° C; a light snow and rain had fallen the night before commencing the study. Temperatures from some adjacent waters not influenced by thermal springs were 5-1/2° C in the adjacent Bow River, 7½° C in a recently flooded beaver pond slightly over 1 km west of Cave and Basin, and 5-1/2° C in a nearby pond possibly at the head of the small creek entering the southwestern part of the Cave and Basin Pond. Conductivity readings were 1880 μmhos/cm (average) in Basin Spring (collecting sites 1 and 2), 1100 in Cave Spring and at collecting site 6 (both values are very similar to that found by van Everdingen, 1972), and 1550 in the main part of Cave and Basin Hotsprings pond adjacent to site 7. In contrast, the Bow River was 120 and the above mentioned ponds to the west were 115 and 190, respectively.

Tropical aquatic plants (of various ones, at least a Tape Grass, *Vallisneria spirilis*, and a Bushy Pondweed, *Najas microdon*, appear to have been introduced with the tropical fishes, (C. Yarmoloy, personal communication) and some native plants were green and abundant in some areas influenced by the thermal springs. Vegetation elsewhere was brown.

SITE 1. West Fork of Basin Spring and adjacent bay. This branch of Basin Spring is the larger of the two branches and enters a shallow, marshy, soft-bottomed bay through a relatively straight channel with swift current. Mosquitofish occurred a short distance up the channel in the 30° C water. Mollies were abundant in much of the bay, even where the depth was only 2-5 cm. A sharp temperature change occurred proceeding from the deepish area along the north shoreline (18° C) to as little as 1 m away in the bay (27° C). Both areas had Mosquitofish and Sailfin Molly, but shallow backwater areas at 15° C did not. Mosquitofish (30 ♀, 3 ♂, 37 young) and Sailfin Molly (6 ♀, 2 ♂, 26 young) were in the bay; two dead Jewelfish (1) were seen. On 5 August 1982, some 15 dead adult Jewelfish and numerous dead young were in very shallow and heavily vegetated water in the bay; most of the adults had red breeding coloration.

SITE 2. Middle East Fork Basin Spring. This site is located between the base of the hill on the upstream end where water cascades over impassable chutes and a small falls on the downstream end formed by sticks and probably also impassable. Above the path the temperature was 33° C in Basin Spring, but was 30° C at the start of this section where Mosquitofish occurred and 27° C at the end. Four very small springs with clear water (in contrast to the slightly milky-colored water of Basin Spring) arise from the hillside below a windfall and enter this section (shown in circled inset of Figure 1); the upper three are shorter than the lowest one and have their sources within about 1.5 m of each other and are about 2 m in length. The second lowest spring, with a 10 cm wide slit-like opening (just large enough to get an aquarium net partially inside), was 22° C and rich in algae; young Mosquitofish (10) and a few adults were dipnetted from within the opening and a red-colored fish, possibly a Jewelfish in breeding color, was seen entering it. The uppermost of the four springs was 23° C and also contained small Mosquitofish. Many adult Mosquitofish (2 ♀ and 2 ♂) and several Jewelfish (1) in non-breeding color were present in the main spring channel. Aquatic vegetation covers the four small springs and much of the main channel in the summer.

SITE 3. Lower East Fork Basin Spring. This section of the spring has a wide channel and is between the small falls noted above and the entrance of the spring into the marshy bay of the pond opposite the western end of the island (a very small drop in water level of the pond would join this island to the shore and drain the bay). Temperature varied from 27 to 26° C. Based on visual observation, the Mosquitofish (25 ♀, 9 ♂) greatly outnumbered the molly (1 ♀, 1 ♂), but the latter were present in good numbers.

SITE 4. Shoreline between Basin and Cave springs. This site was along the marshy shoreline, below a small cliff and adjacent to small caves. Brook Sticklebacks (2) were common by the bank in the aquatic plants where the water was 19° C and Mosquitofish were abundant nearby. No Sailfin Mollies were observed but in one small cave to the east where the temperature was 20-1/2° C there were a few mollies (1 ♂) along with numerous Mosquitofish (25 ♀, 5 ♂).

SITE 5. Cave east of Cave Spring. Cave Spring was 26° C at the path and entered the pond in numerous trickles (22° C) radiating out in a conical pattern. No fish were observed in this Spring but a few Mosquitofish were in a small pool adjacent to the path and Mosquitofish, Sailfin Molly, and one Jewelfish were observed off the fan-like mouth. The cave (no higher than 30 cm) at the collection site immediately to the east of Cave Spring opened at about pond level in rock below a knoll. Its floor was heavily covered with empty snail shells. The current from the cave was strong and had an estimated discharge of about twice that of Basin Spring. The temperature was 22-1/2 -24° C in the mouth; a few meters offshore in the pond it was 17° C. In collections made on 16 and 17 May the Mosquitofish (53 ♀, 6 ♂) were more numerous than

Sailfin Molly (5♀, 4♂). Of the various sites, Longnose Dace (6) were commonest here and swam in and out of the cave along with the tropical fish. The six Longnose Dace were obtained by specifically netting individuals sighted; they are relatively rare compared to the other fish and no young were observed. Most of the Longnose Dace were orange-colored in part of the snout and mouth area and were assumed to be males in breeding condition.

SITE 6. Spring about 3 m east of Site 5. This 20-1/2°C spring has a slow current emerging from the hillside. Only Mosquitofish (7♀, 3♂) were captured or seen.

SITE 7. Bay between island and west shore. This relatively deep bay was 21°C and had a small 8°C creek (probably temporary) entering from the west. A slight current exists at the northern constriction with the island. The greatest diversity of fish was obtained in this bay. Collections made on 16 and 17 May yielded five species, namely Mosquitofish (18♀, 7♂, 8 young), Sailfin Molly (1♂, 16 young), Brook Stickleback (13), Jewelfish (1), and Longnose Dace (1).

The temperature along the west shoreline of the pond decreased from 21°C at Site 7 to 13-1/2°C a short distance away, opposite a coniferous forest, to 11°C past a sedge marsh near the northern shoreline. No fish were seen along this shoreline past the island.

SITE 8. Western outlet channel. There was no surface drainage through this blocked off outlet and the dam was about 15 cm higher than the pond level. Only Brook Sticklebacks (6) were dipnetted on the pond side of the elongated and deep channel.

Description of the Fishes

MOSQUITOFISH: The meristic characters of 205 specimens over 1.0 cm SL are as follows:

Dorsal fin rays			Anal fin rays			Lateral scale rows				
5	6	7	8	9	10	29	30	31	32	33
2	201	2	7	188	10	2	43	131	28	1

The first and usually the second rays of the dorsal fin are unbranched. The first two (or rarely three) rays in the anal fin are relatively short and the first three rays are unbranched. The third to fifth rays of the male are elongated to form the gonopodium. In females the origin of the dorsal fin is about even with, or slightly in front of, the insertion (posteriormost part of base) of the anal fin while in males the anal and pelvic fins are farther forward than in females (the insertion of the anal fin is well ahead of the origin of the dorsal fin).

Males are smaller and more slender than females. The largest females were 4.4 cm SL (3) with most females being between 2.8 and 3.8 cm (all size ranges were present). The largest male was 2.8 cm with most males being 1.8-2.3 cm. The smallest Mosquitofish captured was about 7 mm SL. The largest number of eggs was 88 in a 4.4 cm female; females between 3.0 and 4.0 cm usually had 15-55 fertilized eggs. Most had all their embryos at about the same level of development (e.g., either younger than the eyed stage, eyed, or with embryos well developed) but many had various stages present.

SAILFIN MOLLY: The meristic characters of 42 individuals are as follows:

Dorsal fin rays			Anal fin rays		Lateral scale rows			
12	13	14	8	9	25	26	27	28
3	16	23	6	36	4	9	26	3

The origin of the dorsal fin in the female Sailfin Molly is about even with the pelvic fin insertion and far forward of the anal fin origin. In males the pelvics are slightly farther forward than in females and the modified anal fin is well within the pelvic fins and its origin is about even with the dorsal fin origin. Many of the scales in the dorsal and ventral regions have a microscopic depression near the focus (this is the pit organ or neuromast; the Mosquitofish lack this character although a weak trace of it was found in one individual).

The largest female Molly was 5.0 cm SL and the largest male 3.3 cm. Males over 2.9 cm had developed the enlarged dorsal fin (the sailfin). Snelson (1982) notes that males with the large sail-like dorsal fin are typically 5.0-5.5 cm SL, unlike small mature males which are phenotypically similar to females except for the gonopodium. The smallest Molly captured was 8 mm. The largest number of eggs, 90, occurred in the 5.0 cm female. Of the relatively few mature females examined, most had 15-60 embryos which were at various stages of development.

A wide diversity of color patterns was present in the Mollies. The jet black (commonest), checkered black, marbled black, and golden (very rare) strains were present.

JEWELFISH. The four Jewelfish examined (4.6-6.6 cm SL) each had 14 spines and 11 soft rays in the dorsal fin, three spines and nine soft rays in the anal fin, and 24 or 25 lateral scale rows on the body.

BROOK STICKLEBACK. The number of dorsal, anal, and pectoral rays of the 21 individuals (2.7-4.6 cm SL) are within known values for this species from other localities (Nelson, 1969). Thirteen individuals have five dorsal spines and eight have six spines; all have both pelvic spines.

LONGNOSE DACE. The eight specimens were 3.35-5.4 cm SL. Longnose Dace at Cave and Basin Hotspring are of special interest because of the possibility of an endemic subspecies being or having been present. It is unknown, at present, whether or not existing specimens are descendant from the population which existed before man-made changes to the system or when Nichols (1916) did his study. The relationship between Bow River and Hotspring Dace is unknown but there is a belief that movement between the two areas does take place (C. Yarmoloy, personal communication). If such an exchange does occur the question remains as to whether or not the original population made such a migration or whether it died out and was replaced by Bow River stock. It is notable that the Dace were most concentrated in current from a cave at 24° C (D. E. McAllister, personal communication, states that collections in his care were taken in temperatures as high as 26° C). This is an unusually high temperature for Longnose Dace and well above, to my knowledge, that which Bow drainage dace ever otherwise encounter. C. B. Renaud, University of Ottawa, is studying the taxonomic status of the Cave and Basin Dace at the National Museum of Natural Sciences, Ottawa.

Discussion

The tropical fish fauna in Cave and Basin Hotspring drainage presently consists of the livebearing and salt-tolerant Mosquitofish and Sailfin Molly which are well established. Adult Jewelfish, which are aggressive, territorial egg-layers exhibiting strong parental care, are relatively rare and very secretive. Although no young were obtained in May they are very common under the parental care of the adult in the summer months (C. Yarmoloy, personal communication). Apparently there is a heavy mortality during the winter but it would appear that a viable population has been established. The Guppy, Green Swordtail, and Convict Cichlid, present in 1968, appear to be no longer present.

Mosquitofish, native to the Gulf of Mexico (inland to Illinois) from northern Mexico to Florida and north on the Atlantic coast to New Jersey, have been introduced to many places in the western United States (Lee et al. 1980) and throughout the world (e.g., Africa, Europe, Australia, and New Zealand) for mosquito control (Welcomme 1981). It is the most widespread and abundant tropical fish in Cave and Basin drainage and has been taken nearby in the warm spring area of Third Vermilion Lake (Bow Valley Naturalists 1978). This species has been observed under the ice in the Cave and Basin pond whereas the Sailfin Molly has not (C. Yarmoloy, personal communication).

Two subspecies of Mosquitofish are generally recognized (e.g., Hubbs 1961): *G. a. holbrooki* (Girard), the Atlantic coastal form (New Jersey to Florida) with more black speckles, especially in males (black males have been obtained in aquaria), 7 dorsal fin rays, and 10 anal fin rays, and *G. a. affinis* (Baird and Girard), the inland form (primarily Mississippi drainage to the Rio Grande) with a paler body, 6 dorsal fin rays, and 9 anal fin rays. The specimens taken from Cave and Basin had a pale body with a few black speckles usually on the caudal fin (and on other parts) in both males and females. In fin ray counts they also resemble *G. a. affinis*. Mail (1954) stated that the Cave and Basin Mosquitofish were imported from California and Moyles (1976) noted that the subspecies introduced into California seems to be mostly *G. a. affinis*.

The Sailfin Molly, exhibiting many variations in color patterns which are bred for by aquarists, prefers warmer waters than the mosquitofish and is native to Gulf of Mexico drainage from Yucatan Peninsula in Mexico to Florida and north on the Atlantic coast to North Carolina. It has been introduced in three southwestern states of the United States (Lee et al. 1980) and in several other parts of the world either for mosquito control or through releases from aquaria (Welcomme 1981). It seems probable in the Cave and Basin Hotsprings Pond that the checkered black, marbled black, and golden color strains have reverted from the permablack form, the only one known to have been introduced.

The Jewelfish is native to western, central, and northeastern Africa. The only record given for introduction by Welcomme (1981) is for Florida where it occurs in canals in Dade County (Lee et al. 1980). The Cave and Basin record is the only other known occurrence in the wild in North America.

The Guppy, introduced in the 1960's and perhaps also in the early 1970's, was never very common and never fully established; it was probably gone by 1976. The relatively high numbers compared to Mosquitofish noted in McAllister (1969) may be the result of collecting bias. Although the habitat may not be suitable for the Guppy it is also possible that the aggressive (and more cold-tolerant) Mosquitofish was involved in preventing their continued existence. Myers (1965) notes cases of reduction and extinction of several fish species in various parts of the world where Mosquitofish had been introduced (and calls attention to the existence of other fish species equally capable of mosquito control which are not as destructive to other fishes). Lee et al. (1980) reported that Mosquitofish caused the extirpation of many rare, localized populations of native fishes in the southwestern United States. In contrast, the Sailfin Molly survives, perhaps, by being a faster swimmer than the Mosquitofish and thereby better able to avoid aggressive advances of the latter.

As far as known, with the exception of Mosquitofish possibly being in Third Vermilion Lake, tropical aquarium fishes are presently established in Banff National Park only in Cave and Basin drainage.

There appears to be no difference in the meristic characters examined with those known in other populations. Given the successful introduction of three tropical fish species so far north it would be of interest to determine the breeding pattern during the year, under the markedly variable photoperiod existing at this latitude.

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Observations on Home Range Sizes, Movements and Social Organization of Lynx, *Lynx canadensis*, in Riding Mountain National Park, Manitoba

L. N. CARBYN and D. PATRIQUIN

Canadian Wildlife Service, 9942 - 108 Street, Edmonton, Alberta T5K 2J5

Carbyn, L. N., and D. Patriquin. 1983. Observations on home range sizes, movements and social organization of Lynx, *Lynx canadensis,* in Riding Mountain National Park, Manitoba. Canadian Field-Naturalist 97(3): 262–267.

Of a total of five Lynx (*Lynx canadensis*) captured, three were radio-collared and their movements studied. All radio-collared Lynx were later killed by trappers adjacent to the park. Home ranges for two females averaged 156 km² and that of a single male was 221 km². These figures are higher than reported in the literature. Two females travelled with their kittens together for a short interval. Riding Mountain National Park does not appear to be large enough to sustain a viable Lynx population over time, and reinvasion of Lynx from outside areas may be necessary to maintain populations.

Key Words: *Lynx canadensis*, Lynx, home range sizes, movements, Riding Mountain National Park.

Although widely distributed in Canada and important as a commercial fur animal, the social behaviour of Lynx has not been extensively studied. Several studies have centred on food habits (Van Zyll de Jong 1966; Nellis and Keith 1968; Bergerud 1971; Nellis et al. 1972; Brand et al. 1976; Parker 1980).

Data on home ranges and movements have been obtained from trapping and recaptures (Saunders 1963), snowtracking (Brand et al. 1973) and radio-tracking (Berry 1973; Koehler et al. 1979; Mech 1980; Parker, in preparation). Mech (1980) compared the methods and concluded that radio-tracking overcomes difficulties inherent in the other methods.

This paper describes the movements of Lynx captured and radio-collared in Riding Mountain National Park. Data were collected secondarily to other large carnivore studies on wolves and coyotes.

Description of Study Area

Riding Mountain National Park, 2944 km² in size, is located in southwestern Manitoba (Figure 1), approximately 200 km northwest of Winnipeg. The Park is surrounded by agricultural lands and as such forms an isolated wilderness system.

Bailey (1967) described 12 main cover types within four vegetational associations. These associations are grassland areas, interspersed through the western portion of the park, two subcomponents of the boreal forest and northern elements of deciduous forests (Rowe 1972). Predominant vegetation are aspen (*Populus tremuloides*) and mixed forest stands. Relief, drainage and fire history govern plant cover in localized areas. Within historical times, haying, cattle grazing and logging contributed to human-induced changes, however such activities have ceased in recent years.

Interspersed throughout the park are numerous ponds, lakes and a few streams. In the northern and eastern portions of the park the plains are deeply incised by streams flowing across an escarpment along the eastern portion of the park. Westward the terrain blends into the prairies and forms a plateau with a series of gently undulating hills.

Methods

Lynx were captured in No. 4 or No. 14 leg hold traps incidental to capture programs for Wolf (*Canis lupus*) and Coyote (*Canis latrans*). Trapped Lynx were anesthetized with equal porportions of phencyclidine hydrochloride and promazine hydrochloride at dosages of 1 mg of each drug per kg of Lynx weight. Captured Lynx were measured, weighed, ear-tagged, radio-collared and then released. Radio fix locations were monitored with a Maul M5 aircraft and plotted on topographical maps. Home range sizes and distances between fixes were calculated using a Hewlitt Packard 9830 desk computer. Fixes were sequentially numbered to detect whether spread of locations reflected movements within a home range or dispersal to new areas. Efforts were made at each relocation to see the animals and record group sizes of females with kittens. All radio fixes of the females were from the winter (November–April) period and only 4 of the 49 fixes of the male were from the August-October period, the remainder covered the winter period.

Results

Five Lynx were captured and three of these were radio-collared. Two animals from different family groups and a lone animal were radio-collared (Table 1). Radio-marked Lynx were studied over periods ranging from 86 to 228 days, and in one case recovery

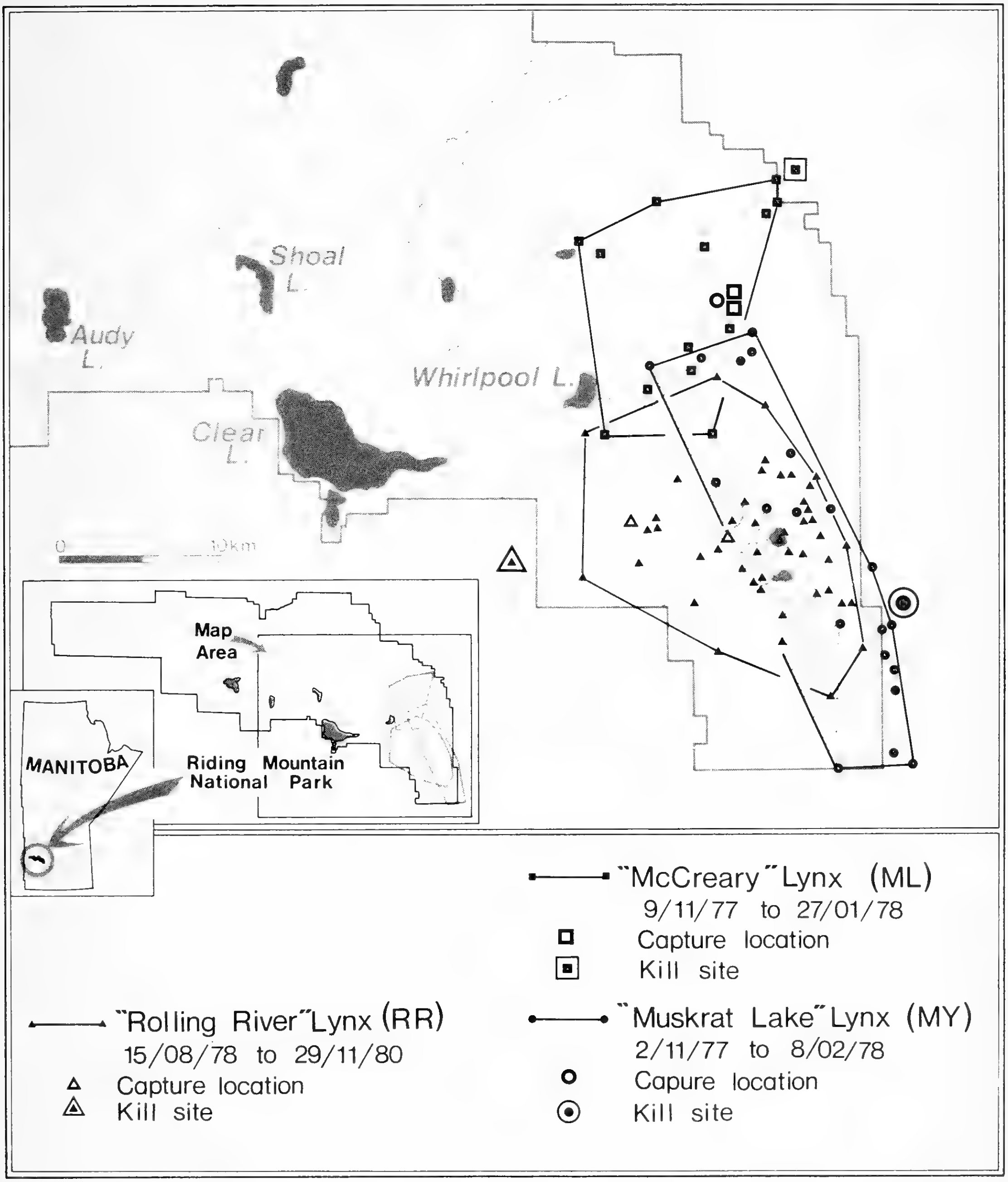

FIGURE 1. Home range delineations of radio-collared Lynx studied in Riding Mountain National Park, Manitoba.

TABLE 1. Monitoring frequency, social status, movements, and home ranges of Lynx radio-collared in Riding Mountain National Park

						Monitoring Frequency (days)		Distances between fixes (km)				
						Total period	Intervals 3 days	Total	3 day intervals			
Sex	Age	Social status	Weight (kg)	Capture date	No. of fixes	$\bar{x}$ ± S.D.	$\bar{x}$ ± S.D.	$\bar{x}$ ± S.D.	$\bar{x}$ ± S.D.	Sample Size	Home range km^2	Fate
Female MY	Adult	Travelling with two kittens when captured	13.6	9-11-77	14	5.5 ± 7.8	2.4 ± 0.7	5.6 km ± 3.5	4.8 km ± 2.9	n = 8	138	Female and one kitten trapped 27-1-78; fate of 1 kitten unknown.
Female ML	Adult	Travelling[1] with two kittens when captured	10.9	2-11-77	22	4.6 ± 6.3	2.4 ± 0.7	4.3 km ± 3.0	3.1 km ± 1.9	n = 13	177 (118)[3]	Female trapped 8-02-78; fate of three kittens and second adult unknown.
Male RR	Adult	Travelling alone	15	15-8-78[2]	49	4.7 ± 8.3	1.6 ± 0.7	4.8 km ± 3.8	3.8 km ± 2.2	n = 34	221	Monitoring stopped 31-03-79. Animal trapped 29-11-80.

[1] This family group was joined on 9 January 1978 by a second adult with kitten. The group of five Lynx travelled together until 8 February 1978 when the collared Lynx in the group was captured.

[2] First captured (but not collared) 22 September 1976.

[3] Adjusted to include inside points only (see Figure 1).

of a Lynx occurred 836 days after capture (Table 1).

An adult female (ML) weighing 10.9 kg was captured on 2 November 1977. There was no evidence that the female was still nursing her young. This animal travelled with two kittens, and based on 14 radio fixes covered an area of 138 km^2 (Figure 1). These three animals were joined by two others (non-collared) which from aerial observations appeared to be a female with kitten. On five different occasions, spanning a period of 30 days (9 January to 8 February) these five animals were seen travelling together. The radio-collared female was killed by a trapper outside the park on 8 February 1978.

Another adult female (MY) was captured 9 November 1977 and weighed 13.6 kg. A kitten, travelling with her and weighing 8.2 kg was captured at the same time. Home range, based on 22 fixes, covered by these two Lynx was 177 km^2 in size (Figure 1). Based on inside points only (see exclusion of shaded area) the home range was 118 km^2. A trapper killed the animal 27 January 1978.

An adult male (RR) weighing 15 kg was captured and radio-collared 15 August 1978. This animal had been previously trapped and ear tagged on 22 September 1976, but was not radio-collared at that time. This Lynx was killed by a trapper adjacent to the park 29 November, 1980. Home range (15 August 1978 to 29 November 1980) of this male was 221 km^2 (Figure 1).

Locations of radio fixes were plotted (Figure 1) and the time intervals listed (Table 1). Mean distance between fixes for adult females were 5.6 km and 4.7 km respectively and 4.8 km for the male. Since time intervals between monitoring dates were often widely spaced apart the distances for winter months were recalculated to include fixes which were obtained within three day intervals. Average distances between fixes in three day periods were 4.8 km, 3.1 km and 3.8 km for the two females with kittens and for the male respectively. Actual distances travelled probably were considerably longer.

Discussion

The status of Lynx populations in the past within Riding Mountain National Park has been uncertain. The species was not listed by Green (1932). Soper (1953) believed that only a few individuals migrate from time to time into the park. Soper did not see much evidence of the species while conducting field work in the 1940's. Other previous records indicate the often sporadic abundance of the species.

During the duration of this study Lynx were reported only for the eastern portion of the park. Intensive winter field work was carried out in the western portion on wolf/ungulate studies and on Showshoe Hare (*Lepus americanus*) (Leonard 1979, Poll 1981, Parks Canada and C.W.S. unpublished reports). Observers failed to see any sign of Lynx at that time. Since then wardens (A. Cochrane, personal communication) have seen a few Lynx in the winter 1980/81 in the western portion of the park. Concentration of Lynx in localized pockets were also found in Newfoundland (Bergerud 1971), Alberta (Brand et al. 1976) and Minnesota (Mech 1980). One trapper around the park reported trapping 16 Lynx in a restricted area (about 3 km^2) over a short period of time (January, early February) in 1982 (P. Paquet, personal communication). From observations elsewhere in Manitoba it appears that the provincial Lynx harvest peaked in 1978/79 and since then numbers have declined (R. Stardom, personal communication). Harvest statistics have revealed that the peaks begin in the northwestern portion of the province and move progressively outward from that focus. The peak in Lynx pelt production in the western part of the province, including the RMNP area, occur 4-5 years after the harvest has peaked in the Pukatawagun/Nelson House area. The province-wide peak in pelt production appears to occur when Lynx numbers are high over the greatest area. This study was conducted at a time when Snowshoe Hare numbers were at or near peak levels in the eastern portion of the province and Lynx in the park could have dispersed from more northerly areas. The Snowshoe Hare population in the park previously peaked in 1970/71 and was rapidly increasing by 1978 (Poll 1981, unpublished CWS report). In the early to mid 1970's Lynx were seen on several occasions by L. Carbyn and G. Trottier in the central portion of the park. Warden observations for that period suggest only sporadic distribution of Lynx (Kingsley and Stelfox 1978, CWS unpublished report). Fur returns for the province of Manitoba indicated record high Lynx catches for 1971 (R. Stardom, personal communication). South of Manitoba Lynx began appearing in Minnesota in 1972 (Mech 1980) which probably dispersed from the north.

The general absence of large numbers of Lynx in the early 1970's and increase at a time when the Snowshoe Hare cycle was increasing could explain why the home range sizes reported here are larger than any reported to date in the literature. Previously the largest home range sizes for female Lynx ranged from 51-122 km^2 (Mech 1980). Female Lynx home ranges in Riding Mountain were 156 km^2 and unlike Minnesota Lynx, the females in this study were travelling with kittens. These figures are based on comparable methods in home range delineation as described by Mech (1980). If only the inside points of the home range perimeter (see Figure 1) are used in the aerial calculations then average female home range sizes would be 128 km^2.

Calculation of territory size and home ranges for carnivores requires more detailed attention. In Wolf studies within the Park (Carbyn 1980, unpublished CWS report) a large number of fixes in relatively small territories were plotted at five fix intervals to determine asymptotes at which upper limits of territories were defined. This approach probably is less applicable to social units or individuals with large home ranges. However, since only small numbers of radio fixes were available for Lynx in this study, it is likely that the larger territory sizes, using outside points only, are more representative of true home range sizes. The home range of the single male (221 km^2) was similar to the range reported for Minnesota. Extensive radio-tracking in saturated Lynx populations in Nova Scotia resulted in much smaller territory sizes (G. Parker, personal communication).

Mech (1980) suggested that spatial organization of Lynx in Minnesota was similar to that of Mountain Lions, *Felis concolor*, (Seidensticker et al. 1973) but differed from Bobcat (*Felis rufus*) (Bailey 1974). That is, female Lynx ranges tend to overlap both spatially and temporally, whereas male ranges to not overlap with other males or with females. In this study both females with kittens were caught at the same locations and ranges overlapped. The range of RR male Lynx overlapped with the territory of ML female, but this could have been as a result of the loss of ML female from her range, since monitoring of the male's movements occurred after the female's death. Our data therefore are inconclusive as to whether male/female ranges were separated, although results do imply this to be the case.

Radio-tracking of Lynx indicated that the park population is vulnerable to outside non-park oriented activities. All five captured Lynx, including the three radio-collared animals, were killed by trappers. High human-induced Lynx mortality was also reported in the radio-collared Lynx in Minnesota (Mech 1980). We believe that in years of low Lynx numbers and high trapping pressures it is possible that the entire population in the park could become extirpated and numbers may then have to be replenished from movements by Lynx from other areas. Under present conditions, therefore, it does appear that the park may not be large enough to sustain a viable Lynx population over time, when a combination of factors such as high trapping pressures around the periphery of the park and low hare densities coincide and persist for a number of years. Further research would be required for clarification.

Degree of dependence of kittens on their mother is important in setting harvest regulations. In this study kittens travelled with adult females well into midwinter. Judging from teat size it is improbable that young were still nursing. It was not possible to determine when kittens begin to establish their own home ranges or become separated from the parent. Trappers in northern Alberta recognize the vulnerability of family groups to trapping and take advantage of it by setting several traps in specific areas. Cases have been reported where only adult females were caught and kittens froze to death at the side of the dead parent (P. Galbraith, personal communication). Parker (1980) stated "hunting success must be an important learned behaviour by kittens during their first year of life. The extent of mortality among kittens, whose mother is trapped early in winter is completely unknown." Our observations agree that this could be an important factor in management of the species. The fact that we observed two adult females travelling with their kittens, would suggest that under some circumstances the loss of one female may lead to the adoption of the surviving kittens by other adults in the group. Because of the economic importance of this species, we urge further research on its social behaviour for better understanding of life history as a basis for effective management.

Acknowledgments

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An Ecological Study of *Cypripedium passerinum* Rich. (Sparrow's Egg Lady-slipper, Orchidaceae) on the North Shore of Lake Superior

C. J. KEDDY[1], P. A. KEDDY[2], and R. J. PLANCK[3]

[1]644 Chapel St., Ottawa, Ontario K1N 7Z9
[2]Department of Biology, University of Ottawa, Ottawa, Ontario K1N 6N5
[3]Limnoterra, 275 Lancaster St. W., Kitchener, Ontario N2H 4V2

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An ecological study of *Cypripedium passerinum* Rich. was conducted in the summer of 1979 on the north shore of Lake Superior near the mouth of the Pic River. Here *C. passerinum* occurs in sand dune complexes in a wide variety of habitats ranging from open grass-covered dunes to stabilized dunes with *Picea glauca* forest. Details of morphology, phenology, growth, reproduction and habitat are presented for the 52 groups of plants (899 plants) found. *Cypripedium passerinum* begins to flower in mid-June and immature capsules can be found in early July. Flower mortality was caused by insect damage (1%) and an unknown agent (12%). High capsule set in undamaged flowers (99%) suggested autogamy was occurring and experimental pollination studies supported this. Seed dispersal is not synchronized in any manner — both dehisced and undehisced capsules of the previous year were found in July. *Cypripedium passerinum* may take approximately 15 years to flower from seed. Four species from three insect orders (Hymenoptera, Diptera, Lepidoptera) fed on *C. passerinum*. Examination of 42 groups of flowering plants showed that only five contained seedlings and that within-group recruitment was largely the result of vegetative reproduction alone. Seedlings were found only in early successional habitats within the dune complex. The habitat occupied by *C. passerinum* is a changing environmental mosaic, and this has important implications for species management.

Key Words: *Cypripedium passerinum,* rare species, autecology, Lake Superior, sand dunes, orchids, lady-slipper, reproduction.

Cypripedium passerinum Rich. (Franklin's or Sparrow's Egg Lady-slipper) is one of the few members of the orchid family that grows within the Arctic Circle. Its North American distribution is continuous from Alaska to James Bay, south to Lake Winnipeg, southwestern Saskatchewan, northwestern Montana and eastern British Columbia (Luer 1975; J. L. Riley, personal communication). The two most disjunct pockets are found at the mouth of the Pic River (48° 36′N, 86° 18′W) in Ontario, 400 km south of the more or less continuous range in the Hudson Bay lowlands, and in the Mingan Islands (50° 15′N, 63° 30′W) near the north bank of the St. Lawrence River, isolated from the main range by 900 km.

Figure 1 shows the Ontario range of *C. passerinum.* The disjunct station at the mouth of the Pic River, on the north shore of Lake Superior, is the most southerly location for this species in Ontario. In this area, the species was first reported north of the Pic River by Macoun (1888) in the 1800's and was later relocated in 1964 by Soper (1965). In 1976 it was also found south of the Pic River, in Pukaskwa National Park, by a team of botanists from the University of Toronto (P. M. Catling, personal communication).

Because of its disjunct populations mentioned above, *C. passerinum* was included on the list of rare plants of Ontario (Argus and White 1977) and on the list of rare species in the Canadian flora (Kershaw and Morton 1976). It was subsequently excluded from the atlas of the rare vascular plants of Ontario (Argus and White 1982) because the disjunction is not as great as originally thought, as shown by botanical exploration in the intervening region; but this does not diminish the significance of the population at the Pic River (G. W. Argus, personal communication). As with most rare species, little was known about the ecology of *C. passerinum.* Therefore, Parks Canada had insufficient information on which to base management decisions regarding this species in Pukaskwa National Park. The principal object of this study was to obtain basic ecological data on the reproductive biology and habitat of this rare species.

Methods

A 'group' refers to a cluster of one or more plants spatially distinct from other such clusters by at least 1 m. Three clusters, although less than 1 m from one another, were recognised as groups because of obvious habitat differences. Since the distribution of *C. passerinum* near the Pic River was poorly known, the search for groups continued throughout the study. Therefore, for each characteristic studied, sample size was deter-

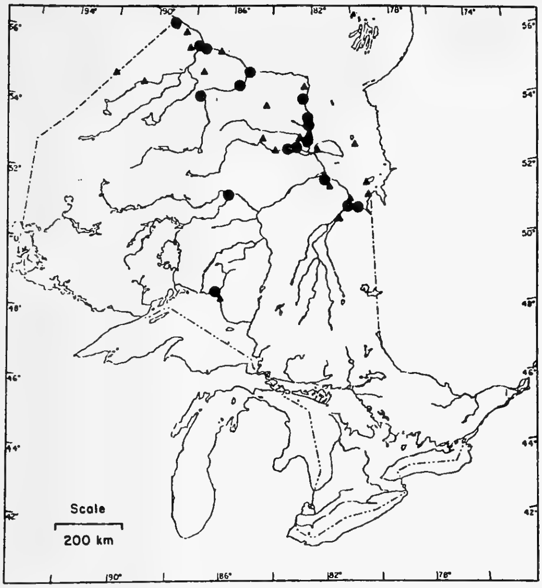

FIGURE 1. Distribution of *C. passerinum* in Ontario based on herbarium specimens (circles courtesy G. W. Argus, Botany Division, National Museum of Canada, and triangles generously provided by J. L. Riley).

mined by the number of plants or groups found at the time the characteristic was observed or measured. Field work was carried out 6 June to 19 July, 1979.

To obtain information on growth in previous years, rhizomes were examined on 26 flowering or large vegetative plants distributed among 22 groups. Surficial debris and sand were gently brushed aside to reveal the shallowly-buried rhizomes. Distances between stalk scars (Figure 2), depth, and direction of growth were noted. Mean annual growth increments were calculated for 5-year intervals up to 1975-1979.

Floral development was observed for flowering shoots in 34 groups. The relative contribution of sexual and asexual reproduction to group expansion and maintenance was first determined for 20 flowering groups. Seedlings were identified by a gradually tapering rhizome less than 1 cm long. In groups where seedlings were not obvious, the rhizome of the youngest plant was examined by carefully loosening the soil around it. Based on experience gained from these 20 groups, the presence/absence of seedlings in the remaining 22 flowering groups was determined without disturbing the soil, through observations of size, morphology and distance to other plants.

Several procedures were carried out in an effort to determine the insect pollinators of *C. passerinum*. The exit holes at the base of the column in 10 flowers were plugged with cotton in order to trap pollinators in the lip. The lips were examined several times a day for a number of days after the exits were plugged. Secondly, insects were collected from nearby plants to be examined for the presence of *C. passerinum* pollen, but these were lost in transit. Thirdly, six hours (during both daylight and dusk) of four days during the peak of flowering were spent observing the flowers for insect activity.

The success of self-pollination in producing swollen ovaries was investigated. Fine mesh bags were tied over 12 unopened flowers as tightly as possible without constricting the stalk. After the flowers opened, ten were self-pollinated and two were left untouched as control plants. The mesh bags were immediately replaced following manipulation.

Insect larvae found on *C. passerinum* were reared on leaves from nearby plant species to obtain adults for identification. The presence/absence of vascular plants, mosses and lichens within a 30 cm-diameter ring around *C. passerinum* plants was recorded for 40 groups. Common names for vascular plants were obtained from Fernald (1950) and Gleason (1968).

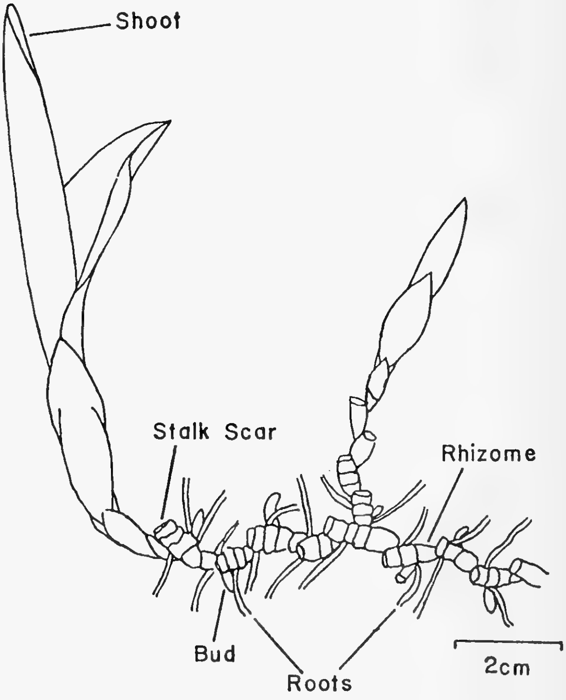

FIGURE 2. Morphology of a plant of *C. passerinum* from the mouth of the Pic River.

Results

Distribution

Fifty-two groups (899 plants) were found at the Pic River, 22 to the south and 33 to the north. Groups varied in size from one to 137 plants and, typically, were composed of both clones and separate individuals. More detailed information on distribution is recorded in Keddy (1979. An Ecological Study of *Cypripedium passerinum* and *Listera borealis*. Report to Parks Canada, Ontario Region, Cornwall, Ontario. 126 pp.). Although other sandy shorelines in Pukaskwa National Park were explored during the period of peak flowering, no new locations were found.

Morphology

C. passerinum is a perennial species with a horizontal rhizome which grows a new segment each year and produces a leafy aerial shoot at its tip. In the specimen examined (Figure 2), two roots were produced by each annual segment. Buds on the rhizome develop into lateral branches. After many years and much branching, a rhizome network is formed and many apparently separate plants may be interconnected beneath the sand surface forming a large clone.

Rhizomes generally grow parallel to the soil surface. The older portion of the rhizome tends to occur slightly deeper than the most recent portion, likely due to sand and litter accumulating above it over the years. At those sites where sand was obviously accumulating (sand rained down during field work), the rhizomes were growing at a 45° to 60° angle from the horizontal plane, rather than parallel to it. Rhizomes were buried deepest in moss-covered areas, where they occurred at the interface between a dark organic layer and 5 to 9 cm of partially decayed moss. Rhizomes were shallowly buried (2.5-4 cm) where the surface was sand or litter.

Plants can be approximately aged by counting the stalk scars (one scar per year); however, after several years, the oldest part of the rhizome rots and disintegrates. Thus, ages determined by rhizome examination may underestimate the actual age of old plants. The oldest rhizome visible was 23 years old, indicating that the group was of an even greater age. Rhizomes older than 17 years were found in six of the 22 groups examined. Mean annual rhizome increment (calculated for 5-year intervals, up to 1975-1979) ranged from 3 mm to 18 mm (avg. 10 mm).

Floral Development and Capsule Production

The following scale was used to quantify floral phenology:

1. flower not yet visible
2. flower visible but unopened
3. lateral petals open
4. dorsal sepal raised, exposing lip opening
5. flower wilted

On 5 June, all plants resembled green pencils up to 5 cm high with two or three leaves visible. Stem elongation and leaf production gradually occurred, and flower buds (stage 2) were first observed 14 June. Individual flowering shoots ranged in height from 9 to 40 cm (n = 200). Flowers opened and were receptive to pollinators (stage 4) about a week later. There is considerable variation in phenology; some flowers were not fully open by 11 July. Wilting (stage 5) occurred between two and eight (usually four or five) days after flower opening. A few days later, the ovary was obviously swollen but by 19 July none had reached its full, mature size.

Figure 3 shows floral development for flowering plants in two groups selected to illustrate the amount of variation observed. The most rapid development occurred on an open, grass-covered dune; this group is not shown in Figure 3 since it was found on 30 June with wilted and dried flowers, and the date these plants reached stage 5 could not accurately be determined. Rapid development also occurred in a warm, sheltered area behind a high dune (A in Figure 3). The slowest rate of development was observed in dense shade beneath a low *Picea glauca* (White Spruce) canopy (B in Figure 3). Dates for seed maturation

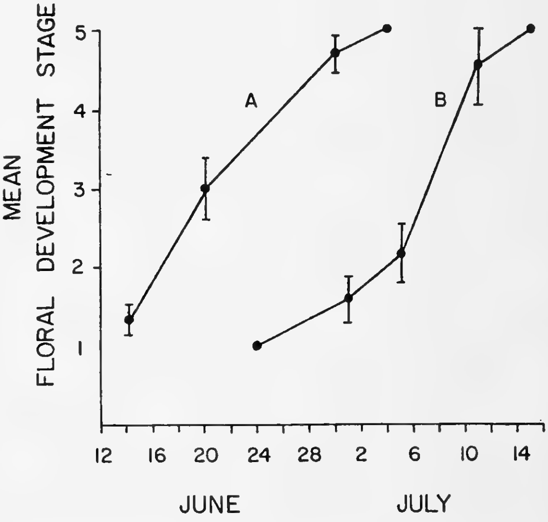

FIGURE 3. Mean floral development stages (with 95% CI) for two representative *C. passerinum* groups: A = sheltered leeward slope of dune, B = level site with dense *P. glauca* canopy (stage 1-flower not visible, 2-flower visible but unopened, 3-lateral petals open, 4-lip open, 5-flower wilted).

remain to be determined. The time of capsule opening and seed dispersal varies.

Typically, plants produce one flower or capsule per stalk. Only two double-flowered plants were found. A total of 256 flowers were produced by the 29 groups observed. Flowers were naturally damaged in two ways. The ovaries of 1% (3/230) were partially eaten by caterpillars. The flower and/or the peduncle of 12% (27/230) turned brown and wilted as a result of an unknown agent. Excluding those plants which were either manipulated for experimental purposes (26) or naturally damaged (30), 200 remained. Of these, 198 (99%) set capsules.

Pollination

The flowers of *C. passerinum* are white and have a light, sweet fragrance emitted by the lateral petals. It appears that the purple-dotted and yellow-tipped column serves to guide insects into the lip. Lines of purple dots inside the lip then probably guide them past the stigma, the anther and to the exit holes on either side of the column base. The size of the exit hole, 2.5 x 3.0 mm in *C. passerinum,* restricts the size of the pollinator.

No insects were observed visiting *C. passerinum* at the peak of flowering and no insects were trapped in flowers whose exits were plugged. Most *Cypripedium* species are particularly attractive to bees (Stoutamire 1967), but only two bee species were found in the vicinity of *C. passerinum* (on *Rosa acicularis*, Rose). One was clearly too large to fit into the lip. The second, slightly smaller, was released into the lip, but got trapped and was much too large to use the exit holes.

Swollen ovaries were produced on both self-pollinated and control plants. The capsules were still immature when the study ended; thus, seed production from these experiments could not be determined.

Seed Production and Dispersal

Large numbers of small, light-weight, wind-dispersed seeds are produced in each capsule. Capsule opening and seed dispersal is not synchronized among plants in groups of *C. passerinum* and seed dispersal occurs over a period of time. Capsules produced in the previous year remain attached to the plant through the winter. All stages of seed dispersal, from completely vacant capsules to capsules not yet open and full of seeds, were observed in capsules that had overwintered. Capsules produced during this study were not mature by 19 July.

Seedlings

An examination of stalk scars on the rhizome of the smallest plant at one site showed that it had been growing for at least 15 years and yet the plant had probably not reached flowering age (the stalk scar diameters were much smaller than those of nearby flowering individuals).

Seedlings had recently established in only five of the 52 groups found, although flowering plants were present in 42. Thus, within-group recruitment was largely the result of vegetative reproduction alone.

Herbivore Damage

Only insect herbivores were observed feeding on *C. passerinum* and eight plants (<1%) were damaged. Two species of moth (*Apantesis celia, Archips* sp.), one species of sawfly (*Nematus* sp.) and one species of leaf miner (Diptera, section Acalyptratae) were found. Both *A. celia* and *Archips* sp. fed on *C. passerinum* leaves. Larvae of *Archips* sp. also destroyed two flowers by chewing through the ovary. Despite an intensive search, these larvae were not found on any other species in the vicinity of *C. passerinum* plants; however, they were successfully reared on *Linnaea borealis* (Twin-flower), a nearby plant, indicating that they were not species-specific feeders. The sawfly larva chewed holes in the leaves and ate half the ovary of one plant. The leaf miners were found two to a leaf between the epidermal layers.

Habitat

Across Canada, *C. passerinum* is generally a plant of stream banks and lakeshores — habitats which are unstable but always present (Luer 1975). Both north and south of the Pic River, *C. passerinum* occurs in dune complexes formed from lactustrine sands deposited by the Pic River during glacial times (Zoltai 1967).

The dunes north of the Pic River form the largest shoreline dune complex on the Canadian shore of Lake Superior. It extends for 1200 m in a band 300 m wide with dunes reaching heights of up to 20 m above the mean water level of Lake Superior. Part of this complex is stabilized by a forest of *Picea glauca* with some *Thuja occidentalis* (White Cedar). Other areas are stabilized by a variety of species including *Ammophila breviligulata* (Beach Grass), *Elymus mollis* (Wild Rye), *Equisetum hyemale* (Scouring Rush), *Populus balsamifera* (Balsam Poplar), *Cornus stolonifera* (Red Osier Dogwood), *R. acicularis*, *Juniperus horizontalis* (Creeping Cedar), *J. communis* (Juniper) and *Arctostaphylos uva-ursi* (Bearberry). In a few areas, unstable sand is advancing upon the forest behind the dunes. *Cypripedium passerinum* was found in a variety of areas ranging from dunes stabilized by *A. breviligulata* to the shady, sheltered forest behind the dunes.

South of the Pic River, in Pukaskwa National Park, the sand dune complex is smaller in a real extent and has less topographic variation. Most of the dunes are forested by *P. glauca* with some *Larix laricina* (Larch) and *T. occidentalis*. Between the lake and the forest, and in open pockets within the forested dunes, *A. uva-ursi*, *J. communis*, *J. horizontalis*, *P. balsamifera*, *Shepherdia canadensis* (Buffalo Berry), *E. hyemale* and *Prunus pumila* (Sand Cherry) stabilize the sand. Other typical sand dune species such as *Arabis lyrata* (Rock Cress), *Festuca saximontana* (Rocky Mountain Fescue) and *Anemone multifida* (Anemone) are also present. Beneath the trees, moss carpets (largely *Pleurozium schreberi*) are commonly formed where the terrain is flat. *Cypripedium passerinum* was found in a variety of areas, ranging from open sand between trees to mossy *P. glauca* forest.

Table 1 shows that *C. passerinum* is most frequently associated with *L. borealis*, *Carex concinna* (sedge), *Pyrola secunda* (One-sided Pyrola) and *Pleurozium schreberi*, and only two lichens.

Mature plant vigour, an indicator of habitat suitability, varied among groups. Plants in most groups had green leaves, robust rhizomes and vertical stalks. Four groups, in open dry areas and densely shaded areas (the two successional extremes), were less vigorous.

The five groups with seedlings occurred in a variety of habitats, but a narrower range of habitats than is occupied by mature plants. One seedling site occurred under a *P. glauca* canopy with the ground covered by a thick layer of needles, a second occurred on a dune crest stabilized by *A. uva-ursi* and *J. communis* with a partial *P. glauca* canopy, a third under a canopy of *J. communis* with needle litter, a fourth on a dune with *A. breviligulata* and the last in a mixture of sand and litter in a clearing in the transition from forest to open dunes. Thus, seedings were found in early successional habitats in the dune complex. None were found at sites with moss cover.

TABLE 1. Vascular plants, mosses and lichens associated with *C. passerinum* (n = 40).

Species	Frequency (%)
Vascular Plants	
Linnaea borealis (Twin-flower)	58
Carex concinna (Sedge)	38
Pyrola secunda (One-sided Pyrola)	32
Equisetum hyemale (Scouring Rush)	30
Juniperus communis (Juniper)	30
Fragaria virginiana (Strawberry)	28
Cornus canadensis (Bunchberry)	25
Arctostaphylos uva-ursi (Bearberry)	18
Mitella nuda (Mitrewort)	18
Goodyera repens (Rattlesnake Plantain)	15
Rosa acicularis (Rose)	15
Solidago hispida (Goldenrod)	15
Mosses	
Pleurozium schreberi	60
Abietinella abietina	21
Drepanocladus uncinatus	14
Plagiomnium cuspidatum	14
Lichens	
Cladonia rangiferina	8
Cetraria islandica	3

Variation in the suitability of sites occupied by seedlings was also evident. Very dry weather in July resulted in browning and shrivelling of all seedlings at the site on the open grass-covered dunes and many of those on the dune crest established by *A. uva-ursi* and *J. communis*. Although the above-ground portion of the plants died, the rhizome and roots may have survived. Seedlings remained green where some canopy protection was available.

Discussion

Although the flowers of *C. passerinum* are apparently designed to attract insect pollinators (Stoutamire 1967), the high percentage of flowers setting capsules (99%, 198/200 flowers not attacked by insects or the unknown agent) suggested that self-pollination might be occurring. This was supported by the results of the pollination experiments which showed that *C. passerinum* is self-compatible. A detailed investigation of flower morphology (Catling 1980) showed that, in contrast to other *Cypripedium* species (e.g. *C. reginae*, Showy Lady-slipper), the anthers of *C. passerinum* are in contact with the margin of the stigma allowing self-pollination.

Self-pollination is rare in orchids (Sanford 1974). In species such as *Epipactis helleborine* (Helleborine) where 100% capsule set occurs regularly, it is suspected that self-pollination occurs. In other species, such as *Platanthera blephariglottis* (White Fringed Orchid), per cent capsule set may be commonly low (A. A. Reznicek, personal communication). Several years of observations on *C. reginae* indicate that typically less than 5% of the flowers set capsules (G. Harvais, personal communication). Curtis (1954) determined per cent capsule set for several *Cypripedium* species over twenty years with the following results: *C. calceolus* var. *parvi-florum* (Small Yellow Lady-slipper), 49%; *C. calceolus* var. *pubescens* (Large Yellow Lady-slipper, three habitats), 40-70%; *C. reginae*, 23%; *C. candidum* (White Lady-slipper), 22%. In comparison to these figures, per cent capsule set recorded for *C. passerinum* is very high (86%, 198/230, taking into account those flowers damaged naturally).

According to Pijl and Dodson (1966), the known pollinators of other *Cypripedium* species are bees. They list the following examples: *C. arietinum* (Ram's Head Lady-slipper)–*Megachile* sp., *C. calceolus* (Yellow Lady-slipper)–*Andrena* sp., *C. calceolus* var. *parviflorum*–*Ceratina* sp., *Zaodontomerus* sp.. Based on the characteristics of typical bee flowers that they give, *C. passerinum* may also be visited by bees although none were observed during this study. Pollinators, if any, would be of a size to escape via the flower exit holes (2.5 × 3.0 mm).

Flower mortality caused by both insect damage (1%) and the unknown agent (12%) is insignificant in determining the success of sexual reproduction. While sexual reproduction is required for group establishment, its importance in group maintenance is small as shown by the small percentage of flowering groups with seedlings (12%).

The number of years required from germination to flowering presumably varies with environmental conditions. The period required for other *Cypripedium* species has been recorded by Curtis (1943): *C. acaule* (Stemless Lady-slipper), 10-12 yr; *C. reginae*, 14-16 yr; *C. calceolus* var. *pubescens*, 9 yr. It appears that *C. passerinum* may require at least 15 years to flower. This is consistent with the observations of other species. While stalk production and the resulting stalk scars on the rhizome can be used as age indicators for older plants, it has been suggested that seedlings could be aged by counting the constrictions on the roots (Curtis 1943). In *C. passerinum* however, the roots were uniform, showing no constrictions; thus this method cannot be used. Nor can vegetative plants be aged by counting the number of leaves produced.

Except for minor insect damage, herbivores appeared to have little effect on *C. passerinum*. Herbivores known to feed upon other *Cypripedium* species include deer (Stuckey 1967), mice, snails and slugs (Reynolds 1976).

The dunes at the mouth of the Pic River provide a wide range of stages in sand dune succession, ranging from open, unvegetated sand through dunes with *A. breviligulata* to dunes densely forested with *P. glauca* and *L. laricina* with a thick moss carpet. All seedlings occurred at sites representing early stages of succession, with needle litter or sandy surfaces. Despite abundant seed production at moss-covered sites, no seedlings were observed there, suggesting that conditions at these sites may no longer be suitable for seed germination. (Curtis (1943) found that seedlings of *C. reginae* which germinated in *Sphagnum* moss turned brown and died before they reached two years of age. He suggested that the acidity of the moss was too great for development and observed that germination was best on the peat surface below the moss.)

Grubb (1977) discussed the importance of the regeneration niche in explaining the distribution and abundance of plants, emphasizing the rarity of ideal conditions for recruitment. Orchids generally have rather specific seed germination requirements (Arditti 1967; Harvais 1973; Stoutamire 1974; Ernst et al. 1970). Given that *C. passerinum* sets abundant, easily dispersed seed, but that only 12% of the present flowering groups contain seedlings, it seems that *C. passerinum* recruitment may be largely limited by the rarity of suitable conditions for seedling establishment. Rarity in time must be considered as well as rarity in space. Some sites within the dunes may well be more suitable than others, but such spatial variation may be inconsequential relative to the temporal variation in rainfall, temperature and soil characteristics. Thus the distribution and population size of *C. passerinum* might be limited more by the rarity in time than the rarity in space of suitable conditions for establishment.

Morrison and Yarranton (1974) have emphasized the vegetational heterogeneity found during primary sand dune succession. Our observations suggest the following general relationship between colony development and succession. As succession proceeds, habitat quality of a site for seedling establishment and growth decreases while habitat quality for mature plants increases, up to a point, and then decreases. The relationship between succession and plant distribution on the dune complex is such that only a portion of the complex at any one time may be a habitat for *C. passerinum* and, of this portion, only a small fraction may be suitable for seedling establishment. To better understand the present distribution, research on (1) seedling habitat requirements, (2) the fungal symbiont(s), and (3) survivorship in different habitats is necessary.

In protecting species that occur in an environmental mosaic, such as *C. passerinum*, it is not sufficient to merely protect those sites which are presently suitable for the species. The area must be large enough to provide similar sites as the environment changes over time with climatic fluctuations or vegetation succession. That is, the protected area must be large enough to accommodate changes in both space and time. The larger the area available to the species, the greater the probability that *C. passerinum* will survive at the Pic River.

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Comparison of Great Blue Heron, *Ardea herodias*, Reproduction at Boot Island and Other Nova Scotia Colonies

TERRY E. QUINNEY

Department of Biology, Acadia University, Wolfville, Nova Scotia B0P 1X0
Present address: Department of Zoology, University of Western Ontario, London, Ontario N6A 5B7

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Nesting behaviour and reproductive success of Great Blue Herons (*Ardea herodias*) on Boot Island, Nova Scotia, are reported for 1977 and 1978. Forty-two pairs bred in 1977 and 26 pairs in 1978. Mean clutch sizes were 4.6 and 5.0 and averages of 2.6 and 3.1 young were fledged per pair in 1977 and 1978, respectively. Additional colonies censused showed that fledging success in Nova Scotia was among the highest reported. Great Blue Herons were sensitive to human disturbance, particularly early in their nesting cycle. However, marine islands in Nova Scotia that usually are free from human disturbance and less susceptible to predation but are close to adequate feeding areas, provide superior heron breeding habitat.

Key Words: Great Blue Heron, *Ardea herodias*, breeding, clutch size, fledging success, human disturbance, predation.

Great Blue Heron fledging success reported for Tobacco Island, Nova Scotia (McAloney 1973) is among the highest reported (Vermeer 1969; Pratt, 1970, 1972, 1974; Henny and Bethers 1971; Henny 1972; Werschkul et al. 1977; English 1978; DesGranges et al. 1979; DesGranges and Laporte 1979, 1981). Approximately 70% of the known Great Blue Heron colonies in Nova Scotia, including Tobacco Island are on marine islands (A.D. Smith, Canadian Wildlife Service, personal communication). Is Tobacco Island representative of Great Blue Heron colonies which are free from human disturbance and close to adequate foraging areas? To answer this question, I chose to study marine island colonies that had similar (Bon Portage Island) and contrasting environments (Boot and Pinnacle Islands) to that of Tobacco Island. Because only McAloney (1973) and Pratt (1974) attempted to census all nests at various times in a given colony, information is still lacking about the influence upon numbers of young fledged of such variables as clutch size, hatching success, predation, annual fluctuation in numbers breeding, size, and location of colonies. I provide data on these variables, determine the number of young fledged in several Nova Scotia Great Blue Heron colonies and compare these results with data from other locations.

Study Area

Boot (45°08′N,64°16′W) and Pinnacle (45°23′N, 64°07′W) Islands are located in the Minas Basin of the Bay of Fundy. Waters surrounding these islands are extremely turbid owing to the nature of sediments and strong tidal action. In contrast are Bon Portage (43°28′N,65°45′W) and Tobacco (45°01′N,62°55′W) Islands that lie about 3-4 km off the coast in the Atlantic Ocean. Waters around these islands are relatively clear as there is little suspended sediment. Also, spring tides rise as much as 15 m around Boot and Pinnacle Islands but only 4.5 m above the low water mark around Bon Portage and Tobacco Islands. This is particularly important for the Minas Basin herons. For example, numerous tidal pools and streams are exposed at low water in three estuaries near Boot Island and are used for foraging (Quinney and Smith 1980). Great Blue Herons nested 4-12 m above ground in the tops of White Spruce, *Picea glauca*, or Balsam Fir, *Abies balsamea*, trees on all of the islands. All of these islands have been occupied by breeding herons for at least 10 years and all were uninhabited by people except for lighthouse keepers on Bon Portage Island.

Methods

To determine the fate of as many eggs and nestlings as possible, nesting Great Blue Herons were observed almost daily on Boot Island in 1977 after egg-laying began. Two hundred and thirty-five hours were spent observing unobstructed nests from blinds that had been set up on the ground prior to nest construction. Nests were also examined by climbing the trees or using an extension ladder; these visits were restricted to a maximum of 2 hours per day. In 1978, I examined nests to determine the onset of laying but postponed more intensive study until most laying was completed and incubation was well underway. I also measured some nestlings every 2-3 days in both years to follow their growth (Quinney 1982). The Bon Portage Island heronry was censused twice during the 1977 breeding season (31 May and 6 July) and at two week intervals in 1978. An observation blind, 10 m above ground, was erected in the centre of the Bon Portage Island colony in October 1977, after the departure of the herons, for observations during the following breeding season. The Pinnacle Island heronry was censused on 29 June 1978, approximately one week before the first nestlings were expected to fledge. Chi-square analysis and Mann-Whitney U-tests (Sokal and Rohlf 1969) were used to determine statistical significance.

Results

Unless otherwise stated, results pertain to Boot Island. First eggs were laid on 13 April 1977 and 20 April 1978. Forty-two breeding pairs initiated clutches in 1977; 20 clutches were lost owing to Common Crow, *Corvus brachyrhynchos*, predation, and 14 of these pairs laid replacement clutches in new nests. This resulted in 36 nests from which at least one nestling hatched. One hundred and sixty-seven eggs were laid in the 36 successful nests and 76 were laid in the 20 nests that failed to produce any young. I determined the outcome of all but 18 of these 243 eggs. In 1978, 26 breeding pairs produced 26 clutches and 25 pairs produced at least one nestling. The outcome of all but 13 of the 131 eggs laid was known. Hatching dates were known or extrapolated for 70% and 92% of all the nestlings in 1977 and 1978, respectively. Forty-three and 35% of all nestlings hatched during 25-28 May in 1977 and 1978, respectively. However, despite this relative synchrony of the peaks in hatching between years, hatching was later in 1978 ($X^2 = 40.6$, $p < 0.001$; Table 1). Intervals from first to last hatching of eggs in a given clutch were 4-8 days in five nests from 1977 and 1978. Maximum ages at which eight nestlings first flew from the colony were 48, 51, 52, 54(2), 57(2), and 59 days. Newly-fledged juveniles joined the adults on their foraging grounds by the last week in July. Further details of nesting phenology and behavioural development of nestlings are presented elsewhere (Quinney 1979).

Twenty to 27% of the eggs failed to hatch in Boot Island nests where at least one nestling hatched. However, most of these failures were not due to predation, and nestling survivorship to fledging was 80-86% (Table 2). There were no differences ($p > 0.05$) between years in the number per nest, of eggs that hatched, that failed to hatch, or were lost to predators, or were missing, or in the numbers of nestlings that fledged or died. Clutch sizes and fledging success of Boot Island Great Blue Herons are compared with other Nova Scotia marine island colonies in Table 3. Some of the 1977 Boot Island clutches were from replacement clutches and this probably was the major factor contributing to the lower clutch size ($p < 0.01$) in 1977 compared with 1978. Replacement clutches are often smaller than initial ones (Lack 1954: 32). Clutch sizes were also lower on Tobacco Island in 1971 (McAloney 1973) than on Boot Island in either 1977 or 1978 ($p < 0.01$). However, 22% of the nests that later had nestlings on Tobacco Island had clutches of three eggs. On Boot Island, no incubated nests contained a clutch of less than four eggs. Colony sizes, clutch sizes and fledging success of Great Blue Herons in Nova Scotia are compared with other localities in Table 4. Fledging success in Nova Scotia has higher than averages reported elsewhere.

TABLE 1. Nestling hatch dates on Boot Island.

	May		June	
	9-16	17-24	25-1	2-9
1977	11	34	47	2
1978	0	14	44	27

TABLE 2. History of Boot Island nests where Great Blue Heron nestlings hatched. Percentage of total eggs laid in parentheses.

	1977	1978
Nests	36	25
Eggs laid	167	126
Eggs hatched	134 (80)	93 (74)
Eggs predated	7 (4)	2 (2)
Eggs disappeared	13 (8)	10 (8)
Other egg losses[1]	13 (8)	21 (17)
Nestlings fledged	107 (64)	80 (63)
Nestlings dead	27 (16)	13 (10)

[1] Eggs addled, damaged by adults, broken by handlers, and nestlings dead in pipped eggs.

Discussion

Fledging success of Boot Island Great Blue Herons was among the highest reported. Furthermore, with the exception of Bon Portage Island in 1978 (when only 10 pairs bred), the numbers of young fledged from the four Nova Scotia colonies mentioned was very similar even in different years. Tobacco Island thus appears to be representative of comparably-sized marine island colonies. On Boot Island in 1977, my presence in the colony during egg laying facilitated crow predation of heron eggs. If disturbed before the clutch was complete or serious incubation had begun, the herons took flight from their nests sooner and remained absent for longer periods than during incubation (see also Milstein et al. 1970). In 1978, I made brief visits to the Boot Island colony to determine the number of breeding pairs and the onset of laying but daily nest examinations were postponed until most laying was completed. In my opinion, this approach was responsible for the much lower incidence of predation during egg laying in 1978. Tremblay and Elli-

TABLE 3. Clutch sizes and fledging success of Great Blue Herons in Nova Scotia.

Location	Year	Mean clutch size $\bar{x} \pm$ SD	Breeding pairs	No. fledged/ breeding pair	No. fledged successful nest[1]
Tobacco Island[2]	1971	4.2 ± 0.9	42	2.6	3.1
Pinnacle Island	1978	—	41	2.7	2.8
Bon Portage Island	1977	4.8 ± 0.6	50	3.0	3.2
	1978	4.7 ± 0.8	10	1.0	1.7
Boot Island	1977	4.6 ± 0.6	42	2.6[3]	3.0
	1978	5.0 ± 0.5	26	3.1	3.3

[1] Nests where at least one young fledged.
[2] McAloney 1973.
[3] Assumes renesting by 14 pairs after Common Crow predation.

son (1979) showed that visits to Black-crowned Night Heron *Nycticorax nycticorax* colonies just before and during laying provoked abandonment of newly constructed nests and either predation of eggs or abandonment of eggs followed by predation. Crows were the principal egg predators. The disturbances I created during egg laying in 1977 on Boot Island may also have contributed to the decline in the number of breeders during the following year. Tremblay and Ellison (1979) also showed a higher percentage of empty nests in frequently visited colonies. The presence of the aerial observation blind in the Bon Portage colony in 1978 may have contributed to the decreased number of breeders compared with the previous year. The poor success of herons on Bon Portage Island in 1978, when most egg losses were caused by predation, may have been related to the small number of breeding pairs. DesGranges (1979) suggested that one of the advantages of colonial nesting in Great Blue Herons was that larger colonies offered more efficient protection of the clutch because the proportion of peripheral nesters in the colony decreases with increased size of the colony.

The apparent relationship between human disturbance and numbers breeding is not a simple one. Numbers in the Boot Island colony decreased from 50 to 26 pairs between 1970 and 1976 when the colony was censused only once annually, late in the nestling period, to determine numbers of breeders (C. K. Coldwell, Acadia University, personal communication). In the colony of Audubon Canyon Ranch, California, there were decreases of 30% between 1968 and 1971 in numbers breeding (Pratt 1974), even though Pratt observed nests from an observation point 90-185 m distant. The colony was never entered and thus effects of disturbance by the observer appeared negligible. Mallette (1972; cited in Pratt 1974), from a statewide survey of heronries conducted from 1969-1971, showed that of 109 heronries active in 1971, only 32 had been active in all three years. Lack (1954) com-

TABLE 4. Great Blue Heron reproduction in North America.

Location	Latitude (° N)	No. colonies	Mean no. breeding pairs/colony	Mean clutch size	Mean no. fledged/ breeding pair	Mean no. fledged/ successful nest[1]	Source
California	38	1	52	3.4	1.6	2.1	Pratt (1974)
Oregon	44	26	—	4.2	2.0	2.6[2]	Henny & Bethers (1971)
	43-45	5	93	—	—	2.4	Werschkul et al. (1977)
	44-45	7	35	—	2.0	2.4	English (1978)
	45	1	27	4.5	1.9-2.3	2.3-2.7	Blus et al. (1980)
Nova Scotia	43-45	4	35	4.7	2.5	2.9	McAloney (1973) Quinney (this study)
Quebec	45-49	22	29	4.5	1.9	2.3	DesGranges and Laporte (1981)
Alberta	49-56	27	21	5.0	2.2-2.3	2.6[3]	Vermeer (1969)

[1] Nests where at least one young fledged.
[2] Based on 32 nests in a colony of 55 nests.
[3] Based on 1 colony only.

mented that switching between colonies of some pairs of Grey Herons *Ardea cinerea* occurs, and mortality on the wintering grounds and during migration could further decrease breeding populations. Assuming that Great Blue Herons begin breeding as 2-year-olds, Henny (1972) estimated that 1.9 young must be fledged per breeding pair to maintain stable populations in the northern United States and southeastern Canada. The Nova Scotia colonies mentioned in this paper fledged an average of 2.5 young per pair. However, the number of breeding pairs on Boot and Bon Portage Islands fluctuated considerably from year to year. Although the effects of human disturbance should not be understated, these fluctuations are probably the result of a number of factors. I urge heron observers to exercise caution, particularly early in the nesting cycle of these birds. Nevertheless, the high fledging success suggests that marine islands in Nova Scotia, that are largely free from human disturbance and thereby less susceptible to predation but are close to adequate foraging areas, provide superior heron habitat.

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Vascular Plants of the Hayes Sound Region, Ellesmere Island, Northwest Territories[1]

J. BRIDGLAND[2] and J. M. GILLETT[3]

[1]Contribution No. 16 from the Cape Herschel Project, Geological Survey of Canada.
[2]Department of Biology, Memorial University, St. John's, Newfoundland A1B 3X9
[3]Botany Division, National Museum of Natural Sciences, Ottawa, Ontario K1A 0M8

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Recent collections of 109 species bring the total known vascular flora of the Hayes Sound Region to 117 species. Of 22 species new to the region, *Carex amblyorhyncha* and *C. scirpoidea* are reported for the first time from Ellesmere Island. Analysis of factors controlling the distribution of plants in the region indicates that the current climate is the principal factor contributing to the diversity of the flora.

Key Words: Arctic, vascular plants, floristics, continentality, Hayes Sound, Ellesmere Island.

The Hayes Sound region (79° N, 77° W) on east central Ellesmere Island, has been of interest to botanists since the first collection of plants were made there over 120 years ago. Few records, however, have been published for the region since the early 1900's. We report here the floristic results of three independent botanical studies made in the Hayes Sound region during the summers of 1979-1980. J. B. was based at Cape Herschel, from 20 June to 29 July 1979, and again from 19 May to 16 June 1980. J. M. G. accompanied by M. J. Shchepanek, visited Alexandra Fiord from 12 to 24 July 1979, in order to conduct floristic studies in the region. In 1980 a group from the University of Toronto and Dalhousie University initiated a several-year ecosystem study at Alexandra Fiord. Their floristic results (Hill and Ball. 1980. Vascular plants at Alexandra Fiord. Pp. 105-108 *in* Ecology of a high arctic lowland oasis, Alexandra Fiord, (78° 53′N, 75° 65′W), Ellesmere Island, N.W.T., Canada. 1980 Progress Report. *Edited by* J. Svoboda and B. Freedman. Departments of Botany, University of Toronto and Dalhousie University. 109 pp.), are included here.

Physiography

The Hayes Sound Region (Figure 1) occupies approximately 15 000 km² of central Ellesmere Island. Physiographically, the region comprises a series of plateaux, dissected by deep glacial fiords and outlet glaciers of the central Ellesmere Island ice cap. The ice cap rises to altitudes in excess of 2 000 m and occupies nearly two-thirds (9500 km²) of the landscape. The region lies at the northern tip of the Precambrian Shield. The crystalline basement rocks, including gneiss, granulite, amphibolite and granite, are unconformably overlain by Proterozoic and Paleozoic sedimentary rocks – sandstone, shale, dolomite, limestone, conglomerate and breccia. The basement rocks are exposed at the head of Sverdrup Pass, and along the east coast, south of Knud and Bache Peninsulas (Christie 1962, 1967, 1972; Frisch et al. 1978). In addition to being glaciated by the ice cap to the west, areas on the east coast have also been inundated by glacier ice flowing from the north. This flow deposited tills, including calcareous Paleozoic rocks and marine sediments on top of the plateaux — at 285 m on Cape Herschel and at 550 m on Pim Island (Christie 1962; Blake 1977). Studies of raised coastal features and lake sediments (Blake 1978, 1981) indicate that terrestrial habitats were available for plant colonization by approximately 9000 years B.P.

History of Exploration

Central Ellesmere Island is not now inhabited, but excavations in the Bache Peninsula region have shown it was occupied by Inuit of the Arctic Small Tool tradition from more than 4000 years B.P. until approximately A.D. 1000, and subsequently by early Thule-culture Inuit of western arctic origin until 1700 A.D. (Schledermann 1978; Schledermann and McCullough 1980). While Smith Sound, named by Baffin and Bylot in 1616, was probably visited by the European whalers who hunted the North Water of Baffin Bay from the mid-1700's to the mid-1800's, records of its navigation date from 1852 when Inglefield sailed briefly into Kane Basin searching for Franklin (Taylor 1964). The first white man to report visiting Ellesmere Island was Dr. I. I. Hayes, surgeon on Kane's expedition of 1853-55, who sledged across to Cape Fraser on the northwest shore of Kane Basin from that expedition's winter quarters in Greenland. He discovered Hayes "Sound" between Knud and Thorvald Peninsulas and believed it ran across what is now known as Ellesmere Island, separating Ellesmereland, to the south, from Grinnell Land, to the north. While the existence of the "sound" was disproved by both Peary and Sverdrup, the name Hayes Sound persisted in botanical literature until the late 1940's to describe the southwest coast of Kane Basin and we see no reason to discard it.

Botanical exploration on the east coast of Ellesmere Island dates from 1861 when Hayes (1867) noted *Salix arctica, Saxifraga oppositifolia* and *Festuca ovina* at Cape Fraser. At Cape Isabella, he somewhat rapturously reported grass, moss, poppies, and buttercups, and collected "a nosegay of bright flowers, which are so pleasing an association that they will not find place in the 'botanical collections', but rather in another collection, -mementos" (Hayes 1867, p. 423). These in fact appear to be the only collections he brought back from Ellesmere. Durand (1863[4]) published records of nine species collected by Hayes at Cape Isabella and Gale Point.

H. C. Hart, naturalist on the British expedition of 1875-76 led by G.S. Nares, made a major contribution to botanical knowledge of the Hayes Sound area (Hart 1880). He collected 31 species from Cape Sabine at the east end of Pim Island and 56 species from four localities on the south shore of Hayes Sound. Hart found a great difference between the floras of the south shore of Hayes Sound and Grinnell Land, and judged that Hayes Sound was an important barrier to plant migration.

The Greely expedition wintered on the north side of Pim Island during its tragic retreat from Fort Conger in 1883, but its members were so close to death from

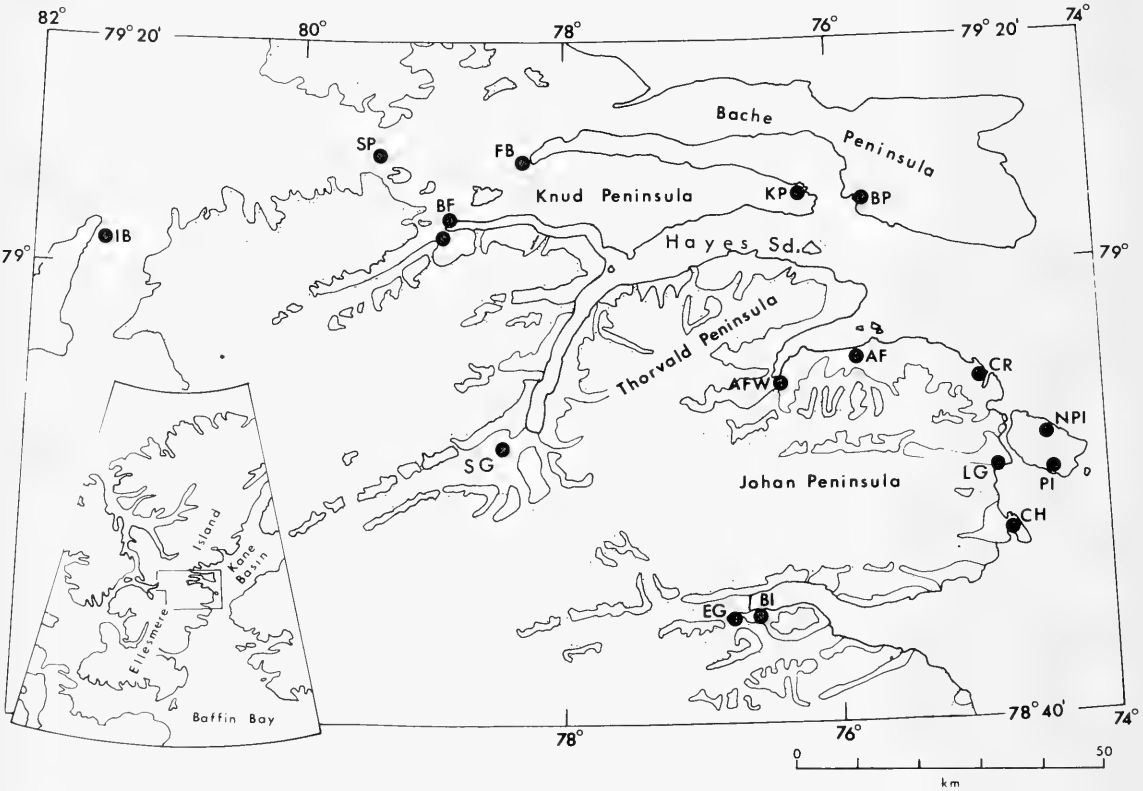

FIGURE 1. Collecting localities: AF - Alexandra Fiord Post area, 78° 53′N,75° 50′W; AFW - West end of Alexandra Fiord, 78° 49′N,76° 25′W; BI - Baird Inlet, 78° 29′N,76° 31′W; BF - head of Beitstad Fiord, 79° 04′N, 78° 50′W and 79° 03′N, 78° 53′W; BP - Bache Peninsula (former R.C.M.P. post), 79° 06′N, 75° 45′W; CH - Cape Herschel, 78° 37′N, 74° 42′W; CR - Cape Rutherford, 78° 50′N, 74° 55′W; EG -Ekblaw Glacier, 78° 29′N,76° 46′W; FB - Flagler Bay (estuary at end of Sverdrup Pass), 79° 10′N,76° 10′W; IB - Irene Bay (Thumb Mountain area), 79° 02′N,81° 30′W; KP - Knud Peninsula, 79° 02′N, 76° 10′W; LG -Leffert Glacier, 78° 42′N,74° 47′W; NPI - North side of Pim Island, 78° 41′N, 74° 25′W; PI - Pim Island, 78° 41′N, 74° 25′W; SG - Stygge Glacier nunatak, 78° 44′N,78° 29′W; SP - Sverdrup Pass, 79° 11′N,79° 25′W and 79° 09′N,79° 25′W. Stippled area ice-covered.

starvation that their only records of plants there were saxifrage and rock tripe used, in desperation, as food (Greely 1886).

In 1898-99 the Second Norwegian Arctic Expedition in the Fram, under the command of Otto Sverdrup, wintered at Fram Harbour at the west end of Pim Island. H. G. Simmons, botanist on the expedition, made substantial collections of localities between Pim Island and the present site of the Alexandra Fiord police post, and between the mouth of Flagler Bay at the head of Beitstad Fiord. In total, he reported 80 species for the region. Simmons' work was a landmark in the botany of Arctic North America. He reviewed all previous collections from Ellesmere Island in light of his own, so that when he published his Flora of Ellesmereland (Simmons 1906), it was better known floristically than any other island of the Canadian Arctic Archipelago. His analysis of plant distributions throughout the archipelago (Simmons 1913) concluded that, while the majority of plants in the flora immigrated into the archipelago from the mainland after the last glacial maximum, areas of Ellesmere Island appeared to have harboured plants during that period.

Despite numerous visitors to the region, botanical records since Simmons are sparse. A. P. Low (1906) reported a few species at Cape Sabine collected in 1903. W. E. Ekblaw, botanist on D. B. MacMillan's 1915-17 Crocker Land Expedition, confined his collecting to northwest Greenland (Ekblaw 1918). M. O. Malte visited the Bache Peninsula R.C.M.P. post in 1927 while preparing, with C. H. Ostenfeld, a flora of the Canadian Arctic. The deaths of both men prevented completion of this work and only a few records were published posthumously (Malte 1934).

Expeditions visiting the area in the 1930's, during which plants were apparently collected (Taylor 1964), included the Oxford University Ellesmereland Expedition in 1934-35, the expeditions of D. Haig-Thomas in 1937-38 and of J. M. Wordie in 1937, and the Danish Thule and Ellesmereland Expedition of 1939-40. Polunin's (1940) summary of botanical exploration on Ellesmere mentions only the last of these, during which no vascular plants were collected. Haig-Thomas (1940) stated only that a large number of vascular plants were deposited "at the Natural History Museum", presumably in London. Porsild (1955, 1964) made no reference to any collectors working on the east side of Ellesmere Island.

Climate

The climate of eastern Ellesmere Island is dominated by a semi-permanent cold circumpolar vortex situated over the Queen Elizabeth Islands. The cold arctic air mass is disrupted in the Hayes Sound Region principally by incursions of warmer, moister maritime-arctic air masses associated with cyclonic systems originating in the Labrador Sea moving north through Baffin Bay (Maxwell 1980).

Members of Sverdrup's expedition collected copious weather data while overwintering in Rice Strait between September 1898 and July 1899. The mean temperature for that period was −18.9° C. The mean monthly temperature rose above freezing in June (1.67° C) and July (2.86° C) (Mohn 1907). The R.C.M.P. post at Bache Peninsula provided the first year-round records of weather for the region. From 1930 to 1933 the mean annual temperature was −15.6° C (Department of Transport 1944). June, July, and August were the only months with mean temperatures above freezing, with temperatures of 2.7°, 5.0°, and 3.3° C (36.8°, 41.4°, and 37.9° F) respectively. The mean annual precipitation during this period was 6.05 cm (2.38 in) rain in July and August and 71.4 cm (28.1 in) snow falling mainly in September and November.

Weather data for Cape Herschel are available for the period from June 1973 to December 1974, when it was a station for climatological studies of the North Water Polynya in northern Baffin Bay (F. Muller, H. Blatter, R. Braithwaite, H. Ito, A. Ohmura, K. Schroff, and A. Zust. 1975. Report on North Water Project activities, 1 October 1974 to 30 September 1975. Swiss Federal Institute of Technology, Zurich and McGill University, Montreal; F. Muller, W. Bachmann, P. Berger, H. Blatter, R. Braithwaite, J. Crawford, C. Dutter, H. Ito, S. Ito, G. Kappenberger, H. Müller, A. Ohmura, G. Schriber, K. Schroff, H. Siegenthaler, A. Zust, and J. Weiss. 1976. Report on North Water Project activities, 1 October 1975 to 30 September 1976. Swiss Federal Institute of Technology, Zurich, and McGill University, Montreal.) The mean temperature during this period was −14.0° C. While mid-winter mean monthly temperatures were found to be 5° to −8° warmer than those at Resolute, reflecting the warming influences of Baffin Bay and the North Water Polynya, the summer mean temperatures were not appreciably different from those at Resolute or at other arctic stations. Precipitation from June 1973 to July 1974 was 265 mm, 100 mm greater than the annual precipitation at Resolute.

Aviation weather reports were made concurrently at Alexandra Fiord and Cape Herschel between 11 June and 24 July 1979. During this period, Alexandra Fiord had a mean temperature of 4.0° C, with a mean daily range of 5.9° C. Cape Herschel had a mean temperature of 2.2° C, with a mean daily range of 4.2° C. Figure 2 shows the mean daily temperatures for both stations. At the same time, Cape Herschel received 12 cm of fresh snow and had traces of precipi-

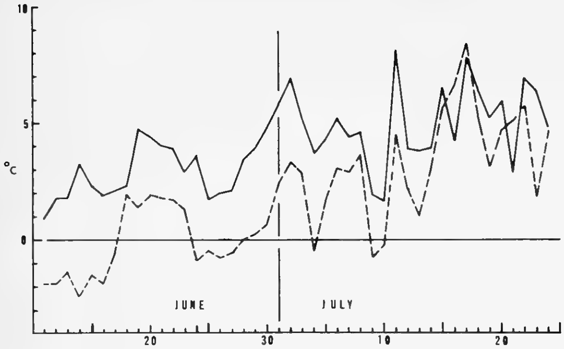

FIGURE 2. Mean daily temperature for Alexandra Fiord (solid line) and Cape Herschel (broken line) from 11 June to 24 July 1979.

tation on seven different occasions, while Alexandra Fiord had traces of precipitation on only two occasions. Cape Herschel was much windier than Alexandra Fiord, having an average wind speed of 18.0 km/h as opposed to 2.4 km/h for the latter station. Both stations had similar amounts of total cloud cover, at an average 6/10 of the sky in 87 observations at each station. The average low cloud cover at Cape Herschel was 4.7/10, while at Alexandra Fiord it was 4.0/10. This mostly reflects the higher incidence of coastal fog at Cape Herschel, which had fog at the station ten times while Alexandra Fiord had fog only once.

Annotated Checklist

For each of the species reported here, the collector is indicated either by name or by our own collection numbers. Collections with numbers between 18050 and 18425 were made by Gillett and Shchepanek. Their first set of voucher specimens is deposited at the National Museum of Canada, Ottawa (CAN); duplicate sets will be distributed. Bridgland's 1979 collections have numbers between 400 and 750; his 1980 collections are prefixed by 80-. The first set of these are deposited at the Biosystematics Research Institute, Ottawa (DAO). Two collections made in 1980, by Svend Funder, of the Geologisk Museum, Copenhagen, while attached to the Geological Survey of Canada field party, are deposited with Bridgland's collection at DAO. Critical specimens of species reported by Hill and Ball (1980) were verified by Gillett, and are deposited at the University of Toronto Erindale Campus (TRTE). Thane Anderson's collections from Beitstad Fiord were verified by Bridgland, and remain in Anderson's personal collection at the Geological Survey of Canada. Collections made in 1981 by W. Blake, Jr., were identified by Bridgland, and are deposited at DAO. All *Drabae* were determined or verified by G.A. Mulligan.

Simmons' (1906) records of species not collected by ourselves have been included in parentheses, where they have been verified or otherwise unconditionally accepted by both Polunin (1940) and Porsild (1964).

First records for our region are preceded by an asterisk (*). Species reported for our region by Simmons or Polunin but not mapped as such by Porsild (1964) are preceded by a plus mark (+).

With the exception of the genus *Draba*, where we have followed the taxonomy of Mulligan (1970, 1971, 1974a, 1974b, 1976), and in the Caryophyllaceae, we have followed the classification and nomenclature of Porsild (1964).

Cystopteris fragilis (L.) Bernh. AF: *18111*, Hill and Ball (1980); BP: *18348A*; CH: *682*. Rare. Apparently restricted to xeric igneous rocks in our area, much as reported by Barrett and Teeri (1973) from Devon Island.

Dryopteris fragrans (L.) Schott. AF: Hill and Ball (1980). Rare. Also reported by Simmons (1906), this acidophile is at the northern limit of its range in our region.

(*Woodsia alpina* (Bolt.) S.F. Gray) Simmons' (1906) report from Cape Viele in the vicinity of Alexandra Fiord remains the only record from Ellesmere Island (Polunin 1940; Porsild 1964). Barrett and Teeri (1973) reported it from Devon Island so it may still be found in our area.

Woodsia glabella R. Br. AF: *18109*, Hill and Ball (1980); AFW: *18373*; CH: *Blake* 1981; CR: *18411*. Rare, in rock crevices and gravel on cliffs and outcrops, also on dry tundra.

Equisetum arvense L. AF: *18424*, Hill and Ball (1980); CH: *537, 586*. Occasional. In wet sedge-moss meadows and along streams.

Equisetum variegatum Schleich. AF: *18257, 18420*; CH: *589*; SP: *18069*. Occasional. Generally, dwarfed plants were found in wet moss and in shallow water and once on the gravel slope of an esker.

Lycopodium selago L. AF: *18141*, Hill and Ball (1980); EG: *Blake* 1981. Occasional on dry *Cassiope-Vaccinium* heath and in sedge meadows.

Alopecurus alpinus L. AF: *18253*, Hill and Ball (1980); CH: *653, 674*; FB: *18088*; KP: *18224*; SP: *18065*. Occasional. Scattered on wet mineral soil and moss, and dominant only once where it grew with *Poa glauca* below a bird cliff.

Arctagrostis latifolia (R. Br.) Griseb. AF: *18249, 18324, 18416, 18423*, Hill and Ball (1980); CH: *590, 671*. Occasional, in moss and *Salix* hummocks in wet sedge moss meadows and at pond margins.

**Calamagrostis purpurascens* R. Br. SG: *Blake* 1981. Rare.

Colpodium vahlianum (Liebm.) Nevski AF: Hill and Ball (1980); CH: *475, 503*. Rare, on moist mineral soil and submerged at edge of tundra ponds.

(*Deschampsia pumila* (Trin.) Ostf.) Simmons' collection of *Aira flexuosa* from Fram Harbour was reclassified by Polunin (1940) as this species. A sterile plant (*480*), which had the habit of the species as illustrated in Porsild (1964, figure 5f), was found growing in cracks on a salt-spray swept rocky island off Cape Herschel.

**Dupontia fisheri* R. Br. AFW: *18369*. Rare. Sandy border of a glacial stream.

**Festuca baffinensis* Polunin CH: *544*. South-facing raised sandy beach.

+*Festuca brachyphylla* Schultes AF: *18414*, Hill and Ball (1980); CH: *531, 763*; LG: *Blake* 1981. Occasional on dry unstable sand and by ponds on raised gravel terraces.

+*Hierochloe alpina* (Sw.) R. & S. AF: *18145*, Hill and Ball (1980). Rare. On rocky, sandy moraine.

Phippsia algida (Sol.) R. Br. AF: Hill and Ball (1980); LG: *Blake* 1981; PI: *748*. Rare. At Pim Island it was found uncharacteristically on dry clay barrens on the plateau, although the site may have late snow cover.

**Pleuropogon sabinei* R. Br. AF: Hill and Ball (1980); CH: *430, 654*. Rare. At Cape Herschel this grew as scattered single plants on wet mineral soil in seepage and streams.

Poa abbreviata R. Br. AF: *18054, 18158*, Hill and Ball (1980); BP: *18347A*; CH: *456, 507, 568, 577, 631, 785*; IB: *18310*; KP: *18228*; SP: *18083*. Common on rock outcrops and gravel; occasional in moss by pools.

Poa alpigena (Fr.) Lindm. var. *colpodea* (Fr.) Schol. AF: *18149*; CH: *672*. Rare in wet moss meadows.

Poa arctica R. Br. AF: *18114, 18248A, 18254, 18329, 18363*, Hill and Ball (1980) as ssp. *caespitans* (Simm.) Nannf.; CH: *435, 505, 564, 627, 634*; EG: *Blake* 1981; LG: *Blake* 1981. Occasional on gravel and mineral soil in seeps and streams.

Poa glauca M. Vahl AF: *18256, 18419*, Hill and Ball (1980); BF: *409*; CH: *80-176B*. Occasional on sandy and gravelly slopes. At Cape Herschel it was found on frost hummocks with *Alopecurus* on ledges and screes below a bird cliff.

+*Poa hartzii* Gand. AF: *18106A*; SG: *Blake* 1981. The Alexandra Fiord collection comes from a wet pond margin.

+*Puccinellia angustata* (R. Br.) Rand & Redf. AF: *18167*, Hill and Ball (1980); FB: *18099*; IB: *18311*; LG: *Blake* 1981; SP: *18195*. Occasional on unstable gravel slopes and beach mud.

+*Puccinellia phryganodes* (Trin.) Scribn. & Merr. AF: *18383A*, Hill and Ball (1980); CH: *650*; IB: *18312*; KP: *18216*. Occasional by muddy estuaries, sea beaches, and brackish pools.

**Trisetum spicatum* (L.) Richt. AF: Hill and Ball (1980); CH: *Blake* 1981. Rare.

**Carex amblyorhyncha* Krecz. AF: Hill and Ball (1980). Rare. This is the first record of this species occurring on Ellesmere Island. Porsild (1964, map 81) shows one record for the Queen Elizabeth Islands on Axel Heiberg Island. Barrett and Teeri (1973) found it on Devon Island.

Carex atrofusca Schk. AF: *18271A*; IB: *18293*; KP: *18231*; SP: *18200*. Occasional. On wet gravel, muddy polygons and in moss.

**Carex bigelowii* Torr. AF: Hill and Ball (1980); AFW: *18378*; SP: *18067*. Rare. On sandy stream banks and wet tundra. These collections represent the third report of this species from Ellesmere Island. Porsild (1964, map 84) shows it at Eureka, and Brassard and Beschel (1968) report it at Tanquary Fiord. Otherwise it is known in the Queen Elizabeth Islands only from Dundas Harbour (Polunin 1940).

**Carex capillaris* L. AF: *18252, 18263*, Hill and Ball (1980); AFW: *18372*; BP: *18346A*; EG: *724*; IB: *18280*. Occasional. Chiefly on dry tundra, gravel slopes, and sandy ledges of cliffs. At Bache Peninsula it was found on a wet mossy pond margin.

(*Carex glacialis* Mack.) Reported by Simmons (1906) from Feilden's collections in Hayes Sound as *C. pedata*. The same specimen was assigned to *C. glacialis* by Polunin (1940) after the two species were separated by Mackenzie.

Carex maritima Gunn. AF: *18176*, Hill and Ball (1980); BP: *18344A*. Rarer than expected. The Alexandra Fiord collection was found on a dry raised beach terrace. Böcher (1954) found it to be continental in Southwest Greenland, occurring only in the interiors of the deepest fiords.

Carex membranacea Hook. AF: *18245, 18361, 18362, 18418*, Hill and Ball (1980); CR: *18407*; IB: *18278*. Common. Wet meadows, margins of ponds and from frost cracks on gravel beaches.

Carex misandra R. Br. AF: *18170, 18264, 18362A, 18412*, Hill and Ball (1980); AFW: *18376*; BP: *18355*; CH: *459, 483, 533, 547, 591, 611, 638*; EG: *703*; NPI: *18402, 18403*; SP: *18068*. Common, locally abundant. The most abundant *Carex*, occupying a variety of habitats from dry to very wet tundra.

Carex nardina Fr. var. *atriceps* Kük. AF: *18157, 18171, 18270*, Hill and Ball (1980); BF: *Anderson* 1980; CH: *603*; EG: *720*; IB: *18294*; NPI: *18399*; KP: *18227, 18242*; SP: 18085. Common. Almost always present as scattered tufts on arid till, moraines, and gravel and rock slopes.

+*Carex rupestris* All. AF: *18159*, Hill and Ball (1980); IB: *18302*; NPI: *18401*; SP: *18084*. Occasional, locally abundant. At Alexandra Fiord it forms extensive mats on arid raised beach terraces along with *Dryas*, *Salix*, and *Saxifraga oppositifolia*.

**Carex scirpoidea* Michx. AF: *18105, 18260, 18261, 18271*, Hill and Ball (1980). At pond margins on rocky wet tundra. This is the first record for Ellesmere Island. The only other record for the Queen Elizabeth Islands is Polunin's (1940) report from Dundas Harbour on Devon Island.

+*Carex stans* Drej. AF: *18415*, Hill and Ball (1980); BF: *418*; BP: *18342A, 18349*; CH: *487, 587*; IB: *18276, 18279*; NPI: *18405*; SG: *Blake* 1981; SP: *18203*. Common on wet mossy meadows and at pond margins, occasionally in drier habitats.

Carex ursina Dewey AF: Hill and Ball (1980). This replaces their record of *Carex* cf. *glareosa* Wahlenb. (Dr. J. Svoboda, personal communication). Simmons (1906) reported it from Cocked Hat Island which is north of Pim Island.

+*Eriophorum angustifolium* Honck. AF: *18151*; AFW: *18368*; CH: *493*; SP: *18189*. Rare. On mossy pond margins at Cape Herschel and mixed with *E. scheuchzeri* in a wet meadow in the Sverdrup Pass.

Eriophorum scheuchzeri Hoppe AF: *18246*, Hill and Ball (1980); AFW: *18366*; BI: *694*; CH: *670*; IB: *18275*. Common in wet places, almost always in water.

Eriophorum triste (Th. Fr.) Hădac & Löve AF: *18151*, Hill and Ball (1980) as *E. angustifolium* ssp. *triste* (Th. Fr.) Hult.; AFW: *18368*; CH: *451, 474, 485, 510*; IB: *18277*; KP: *18218*; SP: *18070*. Common by streams and on wet tundra; not found in water like the two preceding species.

Kobresia myosuroides (Vill.) Fiori & Paol. AF: *18172*, Hill and Ball (1980). Occasional in tufts on raised beach ridges.

**Kobresia simpliciuscula* (Wahlenb.) Mack. AF: *18417*, Hill and Ball (1980). Rare. By ponds on raised beach terraces. Porsild (1964, map 68) gives only two other localities for this species on Ellesmere Island.

**Juncus albescens* (Lge.) Fern. AF: Hill and Ball (1980). Rare.

Juncus biglumis L. AF: Hill and Ball (1980); AFW: *18370*; CH: *501, 534, 621, 680*; FB: *18100*; SP: *18073, 18198*. Occasional to common on wet gravel and moss.

Luzula confusa Lindebl. AF: *18149, 18156, 18332, 18413*, Hill and Ball (1980); BI: *697*; CH: *460, 567, 576, 606, 690, 767*; EG: *737*. Common to ubiquitous on moss or damp ground, generally not far from water.

Luzula nivalis (Laest.) Beurl. AF: *18250*, Hill and Ball (1980) as *L. arctica* Blytt; BP: 18359; CH: *425, 469, 499, 500, 539, 562, 574, 614, 623, 780*; CR: *18410*. Common to ubiquitous on moss and muck on seepy slopes and near late snowpatches.

+*Salix arctica* Pall. AF: *18133, 18135, 18136, 18137*, Hill and Ball (1980); BF: *412*; BI: *691*; BP: *18351, 18352*; CH: *450, 490, 559, 765*; EG: *727, 756*; FB: *18086*; IB: *18272, 18273, 18283*; KP: *18210, 18229*; NPI: *18397, 18398*; SG: *Blake* 1981; SP: *18060, 18061*. Ubiquitous. Most prevalent in dry to mesic sites where it was protected by drifted snow in winter.

Oxyria digyna (L.) Hill AF: *18104*, Hill and Ball (1980); BF: *Anderson* 1980; CH: *431, 454, 488, 513, 608*; IB: *18304*. Occasional on pond margins, mossy seeps, heaths and meadows.

Polygonum viviparum L. AF: *18259*, Hill and Ball (1980); AFW: *18377*; CH: *502, 518, 540, 597*; EG: *708*; NPI: *18392*; SP: 18204. Common. Usually at margins of ponds and creeks but also in soil-covered hollows of outcrops and cliffs where it generally made better growth.

**Arenaria humifusa* Wahlenb. AF: Hill and Ball (1980). Rare. Otherwise known only from Harbour Fiord on Ellesmere (Simmons 1906) and otherwise only from Resolute in all of the Queen Elizabeth Islands (Porsild 1964, map 147).

Cerastium alpinum L. AF: *18365*, Hill and Ball (1980); BF: *411*; CH: *465, 543, 569, 601, 610, 762*; FB: *18098*. Occasional as scattered individuals on dry tundra, on sand and gravelly till; rare on moss or at pond margins. ssp. *lanatum* (Cham.) Aschers. & Graebn. AF: *18337*. On patches of soil in rocky tundra.

Cerastium arcticum Lge. CH: *593, 740*. Rare. In wet moss of meadows and seepage slopes.

Cerastium regelii Ostenf. CH: *Blake* 1981. Rare. Reported from Pim Island and from the vicinity of Cape Rutherford by Simmons (1906) as *C. alpinum* forma *pulvinatum*. Polunin (1940) assigning Simmons' plant to this species erroneously describes it as common everywhere on Ellesmere Island, which is how Simmons (1906) described the typical form of *C. alpinum*. Porsild (1964, map 141) accepted Simmons' record.

+*Minuartia rubella* (Wahlenb.) Hiern. (=*Arenaria rubella* in Porsild (1964)). AF: *18268, 18315*, Hill and Ball (1980); BF: *408*; BP: *18354*; CH: *453, 515, 584, 683, 743*; FB: *18096*; NPI: *18388*; SP: *18066, 18079*. Common to ubiquitous in almost all xeric habitats, especially on raised beach terraces.

(*Sagina intermedia* Fenzl) Cocked Hat Island, which is just north of Pim Island, was the only locality in all of Ellesmere where Simmons (1906, p. 119) found this species. The record is accepted by Polunin (1940, p. 207) who found the species common as far north as Craig Harbour, and by Porsild (1964, map 145).

Silene acaulis L. var. *exscapa* (All.) DC. AF: *18147*, Hill and Ball (1980); AFW: *18367*; CH: *604*; LG: *Blake* 1981; NPI: *18396*; SG: *Blake* 1981. Occasional, never abundant; on well-drained till and sand slopes, usually with some seepage or by streams. Simmons' (1906) observation that the species favours south-facing slopes in our area was found to be true.

Silene involucrata (C. & S.) Bocq. ssp. *involucrata* (= *Melandrium affine* in Porsild (1964)). AF: *18107, 18364*, Hill and Ball (1980); KP: *18215*. Rare. Rock crevices, gravel and mucky soil.

Silene uralensis (Rupr.) Bocq. ssp. *apetala* (L.) Bocq. (=*Melandrium apetalum* ssp. *articum* in Porsild (1964)). AF: Hill and Ball (1980); BP: *18348*; CH: *444, 521, 581, 626*; FB: *18089*; IB: *18296*; SG: *Blake* 1981; SP: *18191*. Occasional to common, occurring usually in moss on seepy slopes or by streams and ponds.

+*Stellaria humifusa* Rottb. AF: *18382*, Hill and Ball (1980); KP: *18223*. Rare, on muddy sea beaches with *Puccinellia phryganodes*.

Stellaria longipes Goldie s.l. AF: *18057, 18132, 18169, 18316*; BP: *18358*; CH: *426, 457, 498, 565, 622, 784*; FB: *18097, 18101*; IB: *18308*; KP: *18240*; SG: *Blake* 1981; SP: *18066A*. Occasional and rarely in flower. While determination to the collective species was generally easy, the lack of flowers usually made further identification impossible. *S. longipes* was found in a variety of habitats from moss in seeps, on cliffs and by creeks where it grew as scattered stems, to mucks, small patches of soil among rocks and on coarse gravel where it grew in scattered tufts. The Stygge Glacier specimen was *S. crassipes* Hult. *S. laeta* Richards. was found at Beitstad Fiord (*406*) growing on steep unstable sand of a raised beach. *S. monantha* Hult. was found in similar habitats at both Beitstad Fiord (*415*) and Cape Herschel (*535*), and was reported from Alexandra Fiord by Hill and Ball (1980). *S. crassipes* Hult. and *S. laxmannii* Fisch. were reported by Böcher (1951b) who redetermined Simmons' material.

Ranunculus hyperboreus Rottb. AF: Hill and Ball (1980); BP: *18339*; CH: *482*. Rare. In brackish pool and in crevices on a small rocky salt-spray swept island.

(*Ranunculus nivalis* L.) Although he thought it was probably overlooked, because of its similarity to *R. sulphureus*, Simmons (1906, p. 110) listed this species as uncommon but definitely present in the Hayes Sound area.

(*Ranunculus pygmaeus* Wahlenb.) Simmons' (1906) report of this species from Fram Harbour was accepted by Polunin (1940) and Porsild (1964, map 172). Simmons found it did not flower before autumn.

Ranunculus sulphureus Sol. CH: *443, 476, 572, 648, 782, 786*. Common at Cape Herschel on wet seepy slopes in moss, and on mineral soil, and in water at the margins of ponds.

Papaver radicatum Rottb. AF: *18056, 18317*, Hill and Ball (1980) as *P. lapponicum* (Tolm.) Nordh. ssp. *porsildii* Knaben; CH: *428, 436, 455, 462, 495, 511, 560*; FB: *18087*; IB: *18307*; LG: *Blake* 1981; SP: *18077, 18194*. Common on sand and gravel; occasional or sparse on moss and wet tundra.

(*Arabis arenicola* (Richards.) Gel.) Reported by Simmons (1906) from Beitstad Fiord, and accepted by Polunin (1940) and Porsild (1964, map 197).

Braya purpurascens (R. Br.) Bunge AF: *18051A, 18063, 18168*, Hill and Ball (1980); CH: *773*; FB: *18092*; IB: *18290, 18286, 18309*; KP: *18211, 18220C*; SP: *18063, 18206*. Common. Mainly in open gravelly places and on frost polygons.

Cardamine bellidifolia L. AF: *18333*, Hill and Ball (1980); CH: *423, 522*; NPI: *18387*. Rare. Single plants in crevices on granite outcrops and on patches of soil among rocks.

Cardamine pratensis L. var. *angustifolia* Hook. AF: Hill and Ball (1980); CH: *643, 655, 662*. Rare. At Cape Herschel this was always sterile. Its best growth was in a wet moss meadow dominated by the moss genera *Calliergon* and *Meesia*. Scattered dwarf individuals were found in nearby ponds and brackish areas of streams.

Cochlearia officinalis L. AF: *18174, 18383*, Hill and Ball (1980) as *C. fenestrata* R. Br.; CH: *481, 651*; FB: *18094*; KP: *18212, 18213*. Occasional on sea beaches and a small salt-spray swept island.

**Draba adamsii* Ledeb. AF: *18180B, 18181*. Rare. This circumpolar high-arctic species collected here on a beach in moss, is known from the western islands of the Queen Elizabeth group and from Pearyland (Mulligan 1974a).

Draba alpina L. AF: *18106, 18381*, Hill and Ball (1980) as *D. alpina* and *D. adamsii*; CH: *508, 551A, 637*; FB: *18090*; NPI: *18385*; PI: *750*; SP: *18064*. Common. The second most common *Draba* in the region, occurring as stunted individuals on wet soil and moss, by streams and ponds, and on wet tundra polygons.

+*Draba cinerea* Adams AF: *18155, 18422A*, Hill and Ball (1980); NPI: *18400A*. Rare. This was found on rocks and sandy moraines. These collections and those of Barrett and Teeri (1973) complete the eastern range of this species in the Arctic Archipelago, which was mapped by Mulligan (1971, figure 6).

Several collections of Simmons' were assigned to this species by Polunin (1940, p. 245).

Draba corymbosa R. Br. *ex* D.C. (= *D. bellii* in Porsild (1964)). AF: *18173, 18180A, 18331, 18381*, Hill and Ball (1980); BF: *410*; BP: *18341*; CH: *557, 744*; IB: *18284, 18295*; KP: *18221B, 18225*; PI: *749*; SP: *18064*. Ubiquitous. The most common *Draba* of the area, always present in the mesic to xeric microhabitats of the cobble barrens of the raised beach terraces.

+*Draba fladnizensis* Wulf. AF: Hill and Ball (1980); EG: *717, 722A*. Rare. At the Ekblaw Glacier station this grew in moss on a south-facing gneissic cliff dominated by *Vaccinium* and *Empetrum*. Although collections at DAO and CAN indicate its northern limit in the vicinity of Coutts Inlet on northern Baffin Island (Mulligan 1974b, figure 11), Simmons (1906) reported it as rather common in the Hayes Sound region, having collected it at seven localities between what is now Alexandra Fiord and Pim Island.

**Draba glabella* Pursh AF: Hill and Ball (1980). Rare. This report is the second for Ellesmere Island. Porsild (1964, map 193) shows it present on Axel Heiberg Island. Mulligan (1970, fig. 1) shows its northernmost Canadian locations as Bylot Island and the Borden Peninsula. We have not seen Brassard's collection (Brassard and Beschel 1968) from Tanquary Fiord which is at Queen's University (QK).

Draba lactea Adams AF: *18164*, Hill and Ball (1980); BF: *414*; BP: *18345*; CH: *556, 607B*; CR: *18408*; EG: *722B*; KP: *18211, 18220A*; NPI: *18400A*; SP: *18081*. Occasional. On a variety of substrates from dry sand to rocks and moss in wet meadows.

+*Draba nivalis* Liljebl. AF: *18110, 18133B, 18165*, Hill and Ball (1980); CH: *684A*; LG: *Blake* 1981. Occasional. Not shown for our region by Porsild (1964, map 188) or Mulligan (1974b, figure 16), but Simmons (1906) reported it as locally abundant in the Hayes Sound region. It was found in wet places, from mossy creek banks to ledges on outcrops.

Draba oblongata R. Br. (includes *D. groenlandica* E. Ekm. in Porsild (1964) according to Mulligan (1974a)). AF: *18055, 18133A, 18175, 18180A, 18380*, Hill and Ball (1980); BF: *407*; BP: *18343*; KP: *18220B, 18221A*; SG: *Blake* 1981; SP: *18080, 18205*. Occasional. On sand and gravelly raised beach terraces.

+*Draba subcapitata* Simm. CH: *440*; FB: *18095*. Rare. By maps in Porsild (1964, map 190) and Mulligan (1974b, fig. 19), this is the first record for east-central Ellesmere Island. Simmons (1906) reported fragmentary fruiting specimens which seemed to represent this species from Cape Rutherford and Pim Island. Our specimens were found on wet sandy gravel.

Erysimum pallasii (Pursh) Fern. AF: Hill and Ball (1980); BF: *Anderson* 1980. Rare. Simmons (1906) reported it from the same two localities.

Eutrema edwardsii R. Br. AF: Hill and Ball (1980); CH: *512, 554*. Rare. At Cape Herschel this was found on wet sandy gravel of a raised beach.

**Halimolobos mollis* (Hook.) Rollins AF: *18258*, Hill and Ball (1980). Rare. On a gravel slope. This is the second record for the Queen Elizabeth Islands, the other being at Lake Hazen (Powell 1961). It is known also from Etah in Greenland (Böcher et al. 1968; Porsild 1964, map 198).

+*Lesquerella arctica* (Wormsk.) Wats. AF: *18053*, Hill and Ball (1980); BF: *Anderson* 1980; IB: *18287*; SG: *Blake* 1981. Rare, on gravel.

Saxifraga caespitosa L. s.l. AF: *18166*, Hill and Ball (1980); NPI: *18390*. ssp. *uniflora* (R. Br.) Porsild CH: *441, 570, 582, 585*. Occasional, in wet moss on gravel terraces, rock outcrops and seepy slopes. Found once in a sedge-moss meadow.

Saxifraga cernua L. AF: *18243, 18379*, Hill and Ball (1980); CH: *442, 514, 583, 640, 661, 675, 688*; FB: *18093*; KP: *18217*; LG: *Blake* 1981; PI: *751A*. Common, on wet mineral soil, in creeks and mossy seeps. Always dwarfed. The Cape Herschel material always had bulbils in place of the apical flower.

Saxifraga flagellaris Willd. ssp. *platysepala* (Trautv.) Porsild CH: *427, 434, 449, 458, 550, 605*. Occasional at Cape Herschel. Mostly on wet mineral soil, but also in damp to wet moss on cliffs and by streams.

Saxifraga foliolosa R. Br. AF: Hill and Ball (1980); BI: *696*; CR: *18406*. Rare in moss along streams and pond margins.

**Saxifraga hirculus* L. var. *propinqua* (R. Br.) Simm. CH: *80-406A*; SP: *18192*. Rare in mesic to wet sedge meadows.

Saxifraga oppositifolia L. AF: *18134*, Hill and Ball (1980); BF: *402*; CH: *463, 479, 489, 685, 766, 771*; FB: *18091*; IB: *18297*; KP: *18234*; LG: *Blake* 1981; NPI: *18386*; SG: *Blake* 1981; SP: *18074*. Ubiquitous. In almost every plant community but the very wettest. It made its best growth on raised gravel terraces where it was dominant. A white-flowered plant was found at Cape Herschel (*766*).

Saxifraga rivularis L. AF: *18160, 18163*, Hill and Ball (1980); NPI: *18391*. Rare in wet places among coarse boulders and rocks.

+*Saxifraga tenuis* Sm. AF: *18108, 18326*, Hill and Ball (1980); CH: *439, 445, 532, 573, 625, 742, 769, 778*; EG: *710*; NPI: *18389*. Common, in all the habitats listed for it by Porsild (1964), and in an *Empetrum*-heath at the Ekblaw Glacier site.

Saxifraga tricuspidata Rottb. AF: *18244, 18269, 18421*, Hill and Ball (1980); BF: *Anderson* 1980; CH: *571, 600, 686*; LG: *Blake* 1981. Occasional, locally abundant, on dry gravel and sandy cliff ledges. It dominated the south-facing slope of a raised delta not far from the 1979 Pim Island site.

Dryas integrifolia M. Vahl AF: *18052A, 18162*, Hill and Ball (1980); BF: *405, 416*; CH: *492, 519, 602, 755, 761*; EG: *734*; IB: *18282*; SG: *Blake* 1981; SP: *18076*. Ubiquitous. Abundant and dominant with *Saxifraga oppositifolia* on dry tundra barrens where it tends to favour frost cracks, *Dryas* is found in practically all plant habitats in this region. It often forms hummocks in mesic graminoid meadows.

Potentilla hyparctica Malte AF: *18138, 18318*, Hill and Ball (1980); CH: *424, 509, 561, 635*; EG: *718*; NPI: *18384*. Common on turfy hollows and ledges of outcrops and cliffs.

**Potentilla nivea* L. ssp. *chamissonis* (Hult.) Hiit. AF: Hill and Ball (1980) as *P. hookeriana* Lehm. ssp. *chamissonis* (Hult.) Hult.; BP: *18340*; IB: *18303*. Rare on dry shingle slopes and a muddy gravel beach.

**Potentilla pulchella* Pursh BF: *417*. Rare on dry stable silty gravel of a raised beach in barrens dominated by *Salix*.

Potentilla rubricaulis Lehm. SG: *Blake* 1981. Simmons (1906) excluded *P. nivea* from the Hayes Sound region after careful study by him showed that all of his collections of the latter were in fact this species. Reported by Malte (1934) from Bache Peninsula as *P. pedersenii*, and listed for our area by both Polunin (1940) and Porsild (1964).

**Potentilla vahliana* Lehm. AF: Muc (1980. Vascular plant communities. Pp. 12-28 *in* Ecology of a high arctic lowland oasis, Alexandra Fiord (78° 53′N, 75° 65′W) Ellesmere Island, N.W.T., Canada. 1980 Progress report. *Edited by* J. Svoboda and B. Freedman. Departments of Botany, University of Toronto and Dalhousie University.); CH: *80-405*; SP: *18082, 18197*. Rare. The collection from Cape Herschel came from a south-facing *Carex stans* meadow.

Empetrum nigrum L. AF: Hill and Ball (1980) as ssp. *hermaphroditum* (Lge.) Böch.; EG: *729, 752*. Rare. This acidophile is at the north end of its range in our area. At the Ekblaw Glacier site it was codominant with *Vaccinium* on a south-facing gneissic cliff.

**Epilobium arcticum* Samuelss. BF: *413*. Rare. One specimen, left from the previous season, was found on dry silty gravel of a south-facing raised beach. This is the third record of this species, both for Ellesmere Island and for the Queen Elizabeth Islands. Otherwise known only from Lake Hazen and from Van Hauen Pass (Brassard and Longton 1970).

Epilobium latifolium L. AF: *18144, 18425,* Hill and Ball (1980); BF: *Anderson* 1980; CH: *517, 523*. Rare, locally abundant on gravelly sand by streams.

Cassiope tetragona (L.) D. Don. AF: *18140*, Hill and Ball (1980); BF: *401*; CH: *520, 693, 759, 775*; EG: *754*. Occasional, locally dominant. Possibly undercollected in parts of our area. Dominant on slopes covered by snow in winter but snowfree in summer. Isolated plants occur in hollows on stony barrens and gravelly moraines.

+*Pyrola grandiflora* Rad. AF: Hill and Ball (1980). Also reported by Simmons (1906).

Vaccinium uliginosum L. var. *alpinum* Big. AF: *18113, 18314,* Hill and Ball (1980) as var. *microphyllum* Lge.; BF: *Anderson* 1980; EG: *754*. Occasional. Locally dominant with *Cassiope* or with *Cassiope* and *Empetrum* on acidic cliffs and outcrops; also common on soil among boulders and snowpatches.

(*Pedicularis arctica* R. Br.) Though missing from our area in Porsild (1964, map 295), we accept Simmons' record on the basis of his picture (Simmons 1906, pl. 2).

Pedicularis capitata Adams AF: *18102, 18262*, Hill and Ball (1980); BF: *404*; IB: *18288*. Rare. On moist to wet sand and rocky slopes.

Pedicularis hirsuta L. AF: *18103, 18146, 18248*, Hill and Ball (1980): CH: *496, 516, 781*; KP: *18233*; SP: *18062, 18190*. Occasional to common. The most common *Pedicularis* in the region, occurring mainly in wet meadows, in mossy hummocks by creeks and on mossy seepage slopes.

+*Pedicularis lanata* Cham. & Schlecht. IB: *18281*. Rare. At Irene Bay this species was found widely scattered on dry tundra. Reported by Malte (1934) from Bache Peninsula.

**Pedicularis sudetica* Willd. IB: *18274*. Rare. Beside a wet muddy stream in a meadow.

Campanula uniflora L. AF: Hill and Ball (1980); CH: *Funder* 1980; LG: *Blake* 1981. Rare. On silt on a south-facing slope at Cape Herschel.

Antennaria ekmaniana Pors. EG: *698, 758*. Rare. This species, a calciphobe near the northern limit of its range here according to Porsild (1964), was found once on dry sandy ledges of a south-facing gneissic cliff.

**Arnica alpina* (L.) Olin ssp. *angustifolia* (Vahl) Maguire LG: *Blake* 1981. Rare.

Erigeron compositus Pursh IB: *18306*; SG: *Blake* 1981; SP: *18078*. Rare. On a muddy gravel beach and on a gravel kame.

+*Taraxacum phymatocarpum* J. Vahl AF: Hill and Ball (1980); CH: *525*; IB: *18305*; SP: *18196*. Occasional, on gravel slopes.

Excluded Species

The following species are indicated on maps in Porsild (1964) as occurring in our area. We question the origins of the reports or differ in our taxonomic concepts and exclude them for the present.

Deschampsia brevifolia R. Br. Simmons' *Poa evagens* from Fram Fiord on the south coast was redetermined as this species by Polunin (1940). The origin of Porsild's dot in our area is unknown.

Carex glareosa Wahlenb. var. *amphigena* Fern. Simmons (1906) reported the species as rare from the Hayes Sound region. While Polunin (1940, p. 116) accepted the record, leaving the variety in question, he cast doubt on it on the basis of the habitat reported by Simmons. Porsild (1964, map 82) appears to have accepted the record and to have assigned it to this variety. This northernmost record should perhaps be excluded pending verification.

Armeria maritima (Mill.) Willd. Simmons (1906) reported this from Fram Fiord on the south coast. Porsild (1964, map 279) put it at Fram Harbour.

Antennaria compacta Malte. The only previous record of an *Antennaria* being collected in our region is a single collection from the mouth of Flagler Bay made by Simmons (1906, 1913) which was assigned by him to *A. alpina* L. No other collection is mentioned by either Malte (1934) or Polunin (1940) who placed Simmons' collection tentatively in *A. labradorica* Nutt. Revising the genus for northwest Canada, Porsild (1950) made no mention of the plant collection by Simmons, but excluded all of Polunin's (1940) records of *A. compacta* from the eastern Arctic. In 1955, however, Porsild (p. 182) equated Simmons' *A. alpina* "not L." (sic) from Melville Island to *A. compacta* Malte and listed (p. 50) *A. ekmaniana* as present on Ellesmere Island. Both *A. compacta* and *A. ekmaniana* are mapped for our region in the 1957 edition of Porsild's Illustrated Flora of the Arctic Archipelago but neither that publication nor Porsild (1955) gives any record of any botanical collection on the east coast of Ellesmere Island.

Taraxacum hyparcticum Dahlst. and *T. pumilum* Dahlst. We prefer to follow the taxonomic concepts of Simmons (1906, p. 20) and Polunin (1940, p. 368) and combine these species of Dahlstedt's with *T. phymatocarpum*. Porsild (1964) recognized both species and mapped both for our area, even though Dahlstedt's redeterminations of Simmons' material showed the latter species to be found only in Grant Land and on the South Coast.

Discussion

The known vascular flora of east-central Ellesmere Island now numbers 117 species of which 109 were collected in the summers of 1979-81. Of these recently collected species, forty-two are not shown on maps in Porsild (1964) as occurring in our area. Of this forty-two, twenty have been reported for the area by either Simmons (1906) or Polunin (1940).

Factors affecting the floristic diversity of the Hayes Sound Region include the edaphic and climatic heterogeneity of the region and the vegetational history of adjacent regions.

Simmons (1906) recognized that the presence, in the Hayes Sound Region, of both acidic and calcareous rocks increased the number of species found there. In fact, however, the flora includes only five species which could be considered acidophiles. *Dryopteris fragrans, Hierochloe alpina* and *Empetrum nigrum* do not occur north of Hayes Sound on Ellesmere Island. *Lycopodium selago* and *Vaccinium uliginosum* cannot be obligate acidophiles since they occur in northern Ellesmere (Brassard and Longton 1970). Thirty-five of our species are listed by Porsild (1964) as calciphiles, of which *Poa abbreviata, Carex rupestris, Draba subcapitata, Erysimum pallasii, Saxifraga caespitosa* and *Potentilla vahliana* are said to be pronouncedly calciphilic. The presence of littoral habitats in the region is responsible for the occurrence of halophytic species such as *Dupontia fisheri, Carex maritima, C. ursina, Stellaria humifusa, Puccinellia phryganodes,* and *Cochlearia officinalis*.

The role of regional climate in determining the distribution of plants in the Hayes Sound region can be approached in two related but slightly different ways: in terms of continentality and in terms of aggregate summer warmth.

The climate of the interior part of the region is more continental than that of the coast. This is reflected in Maxwell's (1981) placement of his border between the Nares Strait and northern Baffin Bay climatic subregions on the Johan Peninsula. The increases of mean temperature and mean daily temperature range over the 40 km between Cape Herschel and Alexandra Fiord are similar to those found over similar distances from the coast in Alaska (Haugen and Brown 1980).

Böcher (1954) classified the plants of southwest Greenland in terms of continentality. None of his oceanic species occurs in our area, but many of his continental ecogeographic and climatic indicator species do, as do many of the species which he found were not restricted to either oceanic or continental regions. Grouping our stations into coastal, intermediate and interior regions, and expressing the number of continental species as a fraction of the total species for each region, we found a general increase in the continentality of the flora proceding westward from the coast (Table 1). The Baird Inlet stations and Irene Bay have a high proportion of continental species, which is not altogether unexpected since Baird Inlet was covered with ice to a distance of 30 km to the east of the fiord

TABLE 1. Distribution of continental species in the Hayes Sound flora.

Region	Total Species	Continental Species	
Coastal Region (CH, CR, PI, NPI)	72	30	(42%)
Intermediate Region (AF, AFW, BP, KP)	91	42	(46%)
Interior Region (BF, FB, SP)	53	26	(49%)
Irene Bay (IB)	28	16	(57%)
Baird Inlet (BI, EG)	20	13	(65%)

head when it was visited in late July, and since Irene Bay is situated in the most continental part of the island. However, because both areas were visited only briefly, they may be undercollected for more common species.

Since the Hayes Sound area is very continental by comparison with southwest Greenland, it is not surprising that Böcher's classification does not strictly apply there. Two of his continental ecogeographic species, *Ranunculus sulphureus* and *Saxifraga flagellaris* were found, by us, only on the coast. But several of his continental species, including *Calamagrostis purpurascens, Pedicularis lanata, Erigeron compositus, Lesquerella arctica, Potentilla nivea*, and *Pedicularis capitata*, appear, by their distribution in our area, to be restricted, even in the high Arctic, to areas of relatively continental climate. Following the same criteria, *Epilobium arcticum* and *Pedicularis sudetica*, which do not occur in southwest Greenland, could be placed in the same category. *Carex maritima*, which Böcher describes as a continental littoral species, was not found in the coastal region.

Seven of our species were described by Brassard and Beschel (1968) as more frequent in oceanic parts of the high Arctic. Of these, *Cerastium regelii* has been found only on the coast; *Phippsia algida, Pleuropogon sabinei*, and *Potentilla hyparctica* were found only in coastal and intermediate regions, while *Silene acaulis* and *Pedicularis hirsuta* ranged from the coast to the interior and *Silene involucrata* tended towards the interior.

A large component of a continental climate is temperature. Young (1971) divided the Arctic into four floristic zones based on a correlation of the northern distributional limits of large groups of species with isopleths of aggregate summer warmth. While he places our region in his third zone, a = 12-20, values of a calculated from the available weather data put the region in his second zone, a = 6-12, with Cape Herschel (a = 5.4 in 1973, a = estimated 6.3 in 1979) bordering on the first zone and Alexandra Fiord (a = estimated 11.9 in 1979) and Bache Peninsula (a = 11.0 in 1930-33) bordering on the third zone.

Plants with limits in Young's third zone found at Alexandra Fiord but not at Cape Herschel include *Dryopteris fragrans, Kobresia simpliciuscula, Carex scirpoidea, C. capillaris, C. bigelowii, Draba glabella, D. cinerea, Empetrum nigrum*, and *Pyrola grandiflora*.

Plants with northern limits in Young's second zone which were found at Alexandra Fiord but not at Cape Herschel include *Lycopodium selago, Hierachloe alpina, Carex rupestris, Kobresia myosuroides, Silene involucrata, Saxifraga foliolosa* and *Pedicularis capitata*.

Since the late 1800's various portions of Greenland and the Canadian Arctic Archipelago have been proposed as botanical refugia during the last glaciation (cf. Böcher 1951a; Löve 1962; Savile 1961; Brassard 1971). Detailed discussion of this topic is beyond the scope of this paper. Simmons (1913), however, did propose that the Hayes Sound Region harboured plant life during the last glacial maximum and this matter will be addressed here.

Simmons based his conclusion on the scattered distribution of species on Ellesmere Island and the absence of 29 species of plants for several degrees of latitude to the south. Of these, 17 are now known to be more widespread on Ellesmere and have been found on Devon Island or other intervening areas (Polunin 1940; Barrett and Teeri 1973; Bliss 1977) and can no longer be considered disjunct on Ellesmere Island. In our area this group is represented by *Arnica alpina, Hierchloe alpina, Dupontia fisheri, Kobresia simpliciuscula, Carex ursina, Equisetum variegatum, Ranunculus pygmaeus, Sagina intermedia, Empetrum nigrum* and *Pedicularis arctica. Taraxacum phymatocarpum* is not isolated on the south coast of Ellesmere Island, and had Simmons not acceded to the arbitrary redeterminations of Dahlstedt, he would not have considered it as such.

Of the remaining twelve species, six occur in our area. These include *Arenaria humifusa, Dryopteris fragrans*, and *Carex glacialis*. All of these are widespread on the west coast of Greenland, with centres of occurrence in continental West Greenland (Böcher et al. 1968). Their occurrence in the Hayes Sound Region is easily interpreted as an extension of the Greenlandic range. *Arabis arenicola, Pyrola grandiflora* and *Erigeron compositus* are somewhat more problematic and are dealt with below.

Of the species we found new to the flora of the Hayes Sound Region, *Festuca baffinensis, Trisetum spicatum, Carex scirpoidea, Draba glabella, Saxifraga hirculus* var. *propinqua, Potentilla pulchella, Potentilla vahliana, Pedicularis lanata*, and *Pedicula-*

ris sudetica are widespread in the Arctic Archipelago, and probably migrated into our area from the west. *Carex bigelowii* extends to our area from either West Greenland or Baffin Island.

Nine species which occur in the Hayes Sound area could be considered as truly disjunct in the Queen Elizabeth Islands and/or northwest Greenland (NWn of Böcher et al. 1968). These are *Carex amblyorhyncha, C. capillaris, Potentilla nivea* ssp. *chamissonis, Epilobium arcticum, Draba cinerea, Arabis arenicola, Pyrola grandiflora, Halimolobos mollis*, and *Erigeron compositus. Carex capillaris, Draba cinerea*, and *Epilobium arcticum* are listed by Young (1971) as being limited to his second most southerly floristic zone (Zone 3). *Carex amblyorhyncha, Arabis arenicola, Pyrola grandiflora*, and *Halimolobos mollis* are also found here at the northernmost end of their ranges. It would seem more likely that these species have migrated northward during a postglacial warm period (cf. Koerner and Fisher 1981) and remain as relict at the present time, than that they survived the last glaciation at Hayes Sound.

Böcher (1951a), observing the weediness of *Halimolobos* in western Greenland and its association with native hunting camps there, has reasoned that the species may be considered a good candidate for postglacial migration with the Inuit.

The two species which show sizable disjunctions between the high and low Arctic both have the capacity for long distance dispersal. The seed of *Erigeron compositus* is well adapted to wind transport and *Potentilla nivea* ssp. *chamissonis* belongs to a genus in which the tap root is commonly collected by western Arctic Inuit for medicinal purposes (Young and Hall 1969).

With 117 species, the flora of the Hayes Sound region is moderately rich. Counting all the infraspecies of *Stellaria longipes*, Brassard and Beschel (1968) reported 143 species from northern Ellesmere Island. Using the same taxonomy, Muc and Bliss (1977) revised the number of species at Truelove Lowland to 93, and of Devon Island to 117. The greatest floristic diversity in the Hayes Sound Region is found in the vicinity of Alexandra Fiord. While it is possible that some plant species may have survived the last glaciation on nunataks in that portion of the region, the diversity at Alexandra Fiord is more than adequately accounted for by the present-day climatic ecotone found there, with minor contributions from saline and granitic substrates.

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Seasonal Feeding of Carp, *Cyprinus carpio*, in the Bay of Quinte Watershed, Ontario

PERCE M. POWLES,[1] HUGH R. MACCRIMMON,[2] and DONALD A. MACRAE[3]

[1]Department of Biology, Trent University, Peterborough, Ontario K9J 7B8
[2]Department of Zoology, University of Guelph, Guelph, Ontario N1G 2W1
[3]80 Jeffcoat Drive, Toronto, Ontario

Powles, Perce M., Hugh R. MacCrimmon, and Donald A. Macrae. 1983. Seasonal feeding of Carp, *Cyprinus carpio*, in the Bay of Quinte watershed, Ontario. Canadian Field-Naturalist. 97(3): 293–298.

Observations from three areas and three seasons in 1977-78 suggest that Carp resident in the waters of the Bay of Quinte watershed are omnivorous, but primarily ingest invertebrate organisms. Feeding is curtailed but does not cease during the autumn and winter months. Plant materials make up a small part of digestive tract contents in the fall, changing to seeds in the winter. The presence of considerable debris during summer and fall suggests an active scouring of the substrate during feeding. A low incidence of plant materials in the digestive tract contents at any time of the year indicates a low nutritional dependence on aquatic plants. This suggests that, at present population densities, Carp are not a threat (in terms of direct ingestion) to indigenous aquatic plants though they may still act the role of a control species for many native macrophytes.

Key Words: Carp, *Cyprinus carpio*, feeding, macrophytes, benthos, invertebrates, seasonal, polyphagous, Wild Rice

Carp, *Cyprinus carpio*, became naturalized in the Bay of Quinte watershed early in the present century likely as a result of a combination of easterly movements of the species through the Trent Canal system from Lake Simcoe, and invasions from plantings made in New York State where Carp had been introduced into the Lake Ontario watershed as early as 1890 (Smith 1892). Presence of the Carp was first reported from the Bay of Quinte in 1907 and from most of the Kawartha Lakes by 1915 (McCrimmon 1968; MacCrimmon and Skobe 1970).

There is a longstanding concept, and some evidence, that the feeding habits of alien Carp may be detrimental to pristine aquatic ecosystems, especially indigenous vegetation and dependent fish and wildlife species (Cahn 1919; Gerking 1950). Early Canadian evidence of their deleterious effects on aquatic resources is limited historically to a relationship observed between Carp overabundance and the destruction of rooted aquatics, in particular, Wild Rice (*Zizania aquatica*), Wild Celery (*Valisneria americana*), and Water Milfoil (*Myriophyllum excalbens*), in marsh habitats in the lower Great Lakes basin (McCrimmon 1968; MacCrimmon and Skobe 1970). Other negative relationships between the Carp and the environment are speculative and, in fact, the presence of this species may prove to be beneficial to eutrophifying waters (Uhler 1944; McCrimmon 1968; and others).

Despite concern over potential negative effects of Carp populations on the aquatic resources of waters such as those in the Bay of Quinte watershed, no comprehensive investigation of the feeding and diet of the species has been undertaken in Canadian waters. This paper, therefore, records just such information on the Carp by reporting on the gastrointestinal contents of the species taken from three Bay of Quinte watershed locations over a 12-month period.

Materials and Methods

Carp were collected in the Bay of Quinte watershed from the Indian River, Bay of Quinte itself, and Sturgeon Lake (Figure 1). A detailed description of the watershed is provided by Johnson and Owen (1971).

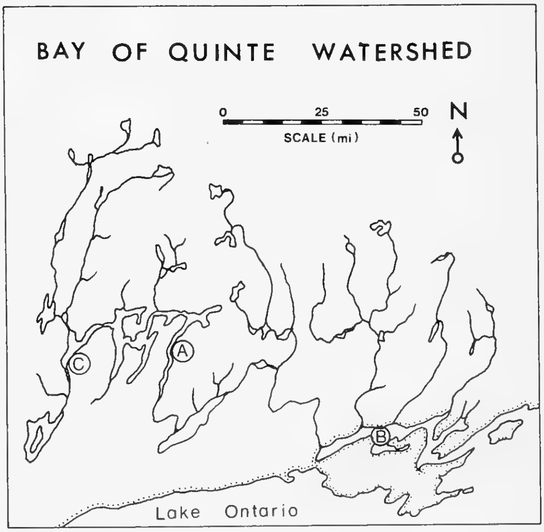

FIGURE 1. Bay of Quinte Watershed showing the Kawartha Lakes District and sampling areas: A, Indian River; B, Bay of Quinte; C, Sturgeon Lake.

Collections from the Indian River were made during the spring and summer of 1977 by seine and fyke net. The Carp were transported to the Trent University laboratory for routine examination. Fish were sorted into two size groups and the entire gastrointestinal tract preserved in 10% formalin for later study. Samples also were taken from Carp caught commercially by gill nets during the fall of 1977 from the Bay of Quinte, and during the winter from Sturgeon Lake, in 1978.

The volumes of digestive tract contents up to 10 ml were measured in graduated cylinders to the nearest 0.1 ml. If the total volume was greater than 10 ml, a mixed 10% subsample was taken from larger samples. Food items were recorded by frequency of occurrence and relative volume (Ricker 1968). Because of the macerated nature of much of the material in the digestive tracts of most fish, some animal life was classified only to order or group, such as plants, (green fragments and seeds), debris (sediments and dead plant material), or unidentified invertebrates. Statistical differences between- and within-group were examined using a "student t-test" (Steel and Torrie 1960).

Results

Indian River Carp specimens collected during the spring and summer months contained food in 92% of the digestive tracts with a mean volume of 12.9 ml/kg body weight (Table 1). Separation of the fish into two size groups showed a higher percentage of animal organisms (91%) in the diet of the younger fish. The dominant invertebrates in relative importance (Table 2) in both size groups were Diptera. Plant remains occurred in 39% of all digestive tracts of the smaller Carp (although only 2% by volume) and included *Ceratophyllum demersum* (Coontail), *Zizania aquatica* (Wild Rice), *Valisneria americana* (Wild Celery), *Elodea canadensis* [= *Anacharis canadensis*] (Waterweed), *Najas flecilis*, (Bushy Pondweed), *Potamogeton crispus* (Curly Pondweed), *Potamogeton pectinatus* (Sago Pondweed) and *Potamogeton richardsonii* (Redhead Grass). Seeds from *Z. aquatica, N. flexilis, P. crispus*, and *P. pectinatus* were found in 25% of the stomachs. The above plant species occurred in the digestive tracts of the larger Carp with the addition of *Nymphaea odorata* (White Waterlily) and *Myriophyllum excalbens* (Water Milfoil). Seeds of *Z. aquatica, N. flexilis, P. crispus* and *P. pectinatus* occurred in the stomachs of 25% of the smaller and 27% of the larger Carp.

The spring and summer diet of Indian River Carp was predominantly animal material (91 and 82% by volume, Table 2). Debris was the second most important food category. Statistical analysis (P = 0.05) revealed no significant difference in food item prefer-

TABLE 1. Vital statistics and contents of digestive tracts of Carp taken from three waters in the Bay of Quinte Watershed, Ontario, 1977 and winter of 1978.

Location	Number of Specimens	Age Range (Years)	Length Range (mm)	Weight Range (g)	Volumetric Diet Composition			Tracts with food (%)	Mean Volume (ml/kg body weight)
					Animal	Plant	Debris (%)		
Spring/Summer									
Indian River	56	1 to 3	135-256	40-700	91	2	7	92	12.9
Indian River	48	4 to 9	257-377	726-4210	82	8	10		
Autum									
Bay of Quinte	128	8 to 16	600-860	3985-9024	74	8	18	86	5.6
Winter									
Sturgeon Lake	120	8 to 17	625-910	3900-9325	97	2	1	74	1.4

ence by prey group with sex or size at this location.

Adult Bay of Quinte Carp specimens collected during the autumn months contained food in 86% of the digestive tracts with a mean volume of 5.6 ml/kg fish (Table 1). Diptera dominated the invertebrate forms (Table 2) with their larvae and pupae making up 38% by volumetric proportion. Debris was the second highest level of relative importance at 18% by volume. The plant component was only 7% by volume (Table 2), principally green fragments and consisting of the same species identified in the Indian River samples. The autumn diet of the Bay of Quinte Carp was dominated by animal material with debris and plant items making up 18 and 8% respectively (Table 1). There were no significant differences between the presence of major food groups and the sex or two size categories.

Mature Sturgeon Lake Carp specimens collected by large mesh (over 18 cm) gill nets during the winter months contained food in 74% of the digestive tracts with a mean volume of 1.4 ml/kg body weight (Table 1). Diptera made up 43% and Cladocera 29% of their diet by volume (Table 2). The plant component, which occurred in 32% of the digestive tracts, made up only two percent of the diet by volume and consisted almost entirely of seeds of *Zizania aquatica, Najas flexilis, Potamogeton crispus*, and *Potamogeton pectinatus*. The winter diet of Sturgeon Lake Carp was found to consist almost entirely of animal items (98% by volume, Table 1). There was no significant difference between food items ingested and either size or sex (t-test, P = 0.01).

Discussion

Analysis of the Carp digestive tract contents between sites revealed no significant difference (P = 0.05) between categories or volumes of ingested groups. Thus comparison of the data by water body or season was simplified. This finding was rather surprising, since some authors have clearly related Carp size to food preference (Bailey and Harrison 1945; Alikunhi 1958). It is possible that clear food/fish size relationships were inconsistent because sampling sites were different over the seasons. It was necessary, however, to use Carp specimens when available from several waters, to round out data in the annual feeding cycle. From this study there is no evidence that available food items varied appreciably within the three waters that were essentially warmwater and eutrophic (Johnson and Owen 1971; R.W. Lewies 1976. The fisheries of the Kawartha Lakes. *In:* Kawartha Lakes Water Management Study/Water Quality Assessment (1972-1976). Ontario Ministry of the Environment and Ministry of Natural Resources, MS pp. 83-106), but future studies should focus on one site

TABLE 2. Incidence of occurrence of mean volumes of materials in digestive tracts of Carp from the Bay of Quinte Watershed, by area and principal food grouping.

Food Category	Indian River Spring/Summer, 1977				Sturgeon Lake Autumn/Winter, 1978		Bay of Quinte Autumn, 1977	
	Small Fish 256 mm		Large Fish 257 mm		Large Fish 600 mm		Large Fish 625 mm	
	% Occurrence	% Volume	% Occurrence	% Volume	% Occurrence	% Volume	% Occurrence	% Volume
Cladocera	63	26	69	7	43	29	77	7
Copepoda	63	20	65	4	43	12.5	66	4
Trichoptera	41	4	69	12.5	0	0	73	9.5
Diptera	86	28	81	32.5	49	43	79	38
Mollusca	32	1	72	10.5	23	6.5	71	8.5
Other Invertebrates	24	11	25	15	0	5.5	30	8
Plant Material	39	2	71	8	32*	2*	84	8
Debris	88	7	81	10	27	1	67	18
Number of Stomachs	56		48		120		128	

*Seeds only

over a season, to confirm our preliminary observations.

The omnivorous nature of the digestive tracts' contents is typical of Carp generally (McCrimmon 1968; Scott and Crossman 1973; McAllister and Coad 1974), and suggests that most littoral plant items are likely to be ingested either by choice or incidentally. The presence of substantial amounts of debris (2 to 8% by volume) in fish from all waters confirms that considerable sucking and digging activity by the Carp may occur while feeding (Vass 1957; Moen 1953). However, the items ingested by each Carp population were principally invertebrates (74 to 97% by volume) although a review of the literature (Table 3) shows that the relative amount of animal and plant materials in Carp from various waters is extremely variable (19 to 98% by volume).

Only during the winter period of ice cover, when macrophyte production would be minimal, did plant material not make up an appreciable percentage (7 to 18%) of the volume of ingested items by the Carp.

Seeds were found in 32% of the Carp in winter, and would represent high caloric-value food. Another noteworthy observation was that Carp did, in fact, feed under the ice in winter. This finding is new, and has not been reported for the Carp in European waters. Opinions differ on the dietary importance of vegetable matter, and there is some question whether feeding on aquatic plants if obligatory, as asserted by Gaevskaya (1969). While some authors (Cole 1905; Tracey 1910) reported direct grazing, other authors (Eder and Carlson 1977) concluded that the presence of plant materials in the digestive tract are a consequence of intensive searching for invertebrates. Others (Summerfelt et al. 1971) argue that there may be no nutritional reward because of the inability of the species to digest cellulose. On the other hand, Carp are known to feed strictly on vegetation in rice fields (Gaevskaya 1966); and Gunn et al. (1976) have clearly demonstrated that Bullhead (*Ictalurus nebulosus*) can assimilate algae. If we add to this the findings of Kevern (1966), who showed that yearling carp ingest and assimilate both detritus and algae, we must also support the argument on the side of herbivory, with the addition of seeds to the winter diet.

With more eutrophic conditions in recent years in the Quinte region, both Carp and plant production have increased noticeably (J. Christie, personal communication). One impact on aquatic vegetation would seem to be uprooting of macrophytes by scouring activity, and there is no doubt (McCrimmon 1968) that high Carp populations can cause marked ecological change by uprooting vast areas of more susceptible rooted aquatics, especially Wild Rice, Wild Celery, and Water Milfoil. Accompanying such activity, the turbidity may reduce photosynthesis. However, population levels of Carp in the Bay of Quinte drainage would seem to be substantially below levels which cause vegetative devastation, perhaps because a significant commercial fishery is maintained, thus keeping the Carp populations within reasonable size.

To maintain primarily an animal diet, as judged by volume (which may or may not be a legitimate method), the Bay of Quinte Carp ingested a wide variety of invertebrate organisms, with Diptera, Cladocera, Trichoptera and Copepoda the dominant categories in Carp from the three sites (Table 2). The considerable variations in dominant invertebrate organisms ingested by Carp (Moen 1953; Nakamura 1955; Sigler 1958; Rehder 1959; Walberg and Nelson

TABLE 3. Food of Carp as reported by various authors, expressed in % of total volume of digestive tract contents, showing the relative importance of plant and animal contingents.

Reference	Region/Habitat	Size	% Animal	% Plant
Birznek (1962) *in* Gaevskaya 1966	Russian Rice Fields	All	Mainly Plants and seeds	
Ewers and Boesel 1935	Buckeye Lake, Ohio	Young	88	12
Egereva (1958) *in* Gaevskaya 1966	Volga River	All	22	78
Harrison 1950	Iowa Lakes	Adult	63	32
Moen 1953	Iowa Lakes	Adult	75	25
Pearse 1918	Wisconsin Lakes	Adult	90	6
Rehder 1959	Des Moines River Iowa	Adult	23	77
Sibley 1929	Lake Erie	Young	62	14
Sigler 1958	Utah Lakes	Adult	23	77
Struthers 1929	Erie-Niagara System	Adult	44	56
Struthers 1930	St. Lawrence Watershed, New York	Adult	50	50
Present Study	Bay of Quinte Watershed	Young	91	8
		Adult	74-98	1-8

1966; Summerfelt et al. 1970; Eder and Carlson 1977) would seem to be explained largely by the local abundance and relative seasonal availability of aquatic invertebrates. A greater prevalence of chironomids in Bay of Quinte Carp than occurred in the two Kawartha waters, for example, may be related to the high abundance of such benthic organisms in the Quinte region (Johnson and Brinkhurst 1971). On the other hand, a high chironomid component could reflect a seasonal or site-specific bias.

While fish eggs, including those of the Carp themselves, have been recorded as infrequent constituents of Carp stomachs elsewhere (Cole 1905; Leach 1919), predations by Quinte Carp on fish eggs or fish was also of negligible consequence in this study. Conversely, Carp are in permanent co-existence with various piscivorous fishes, including esocid and centrarchid species in the Bay of Quinte watershed (MacKay 1963) and juvenile Carp are known to contribute to the diet of these species (McCrimmon 1968). Carp may, therefore, be an amenity to local sport fisheries at this time.

Seasonal variability in feeding activity, or intensity of feeding (Table 1), is apparent from mean volumes of digestive tract contents in the Carp stomachs. The most active feeding seems to occur in the spring and summer months (12.9 ml/kg fish body weight) when the water is warmest, and the least intensive during the cold winter months (1.4 ml/kg fish body weight), when metabolic rates are the highest and lowest, respectively. Similarly, the numbers of Carp containing food are greatest in the spring and summer, and least in the winter. Also, the decreased abundance of debris and plant materials in their diet during the winter suggests a lesser foraging among vegetation. Macrophyte production at the time of sampling under a thick ice-cover, would have been at its lowest annual level.

There is no evidence from the present study that Carp in the Bay of Quinte watershed, at present population levels, are deleterious to either indigenous aquatic vegetation or preferred fish species. Any substantial increase in the Carp populations in these waters may, however, lead up to possibly severe environmental impact, such as has occurred historically in other Canadian waters when Carp become too numerous (McCrimmon 1968).

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Characteristics of Gray Wolf, *Canis lupus*, Den and Rendezvous Sites in Southcentral Alaska

WARREN B. BALLARD and JAMES R. DAU

Alaska Department of Fish and Game, P.O. Box 47, Glennallen, Alaska 99588

Ballard, Warren B., and James R. Dau. 1983. Characteristics of Gray Wolf, *Canis lupus*, den and rendezvous sites in southcentral Alaska. Canadian Field-Naturalist 97(3): 299–302.

Physiography, internal structure, vegetation and spatial relationships of Gray Wolf (*Canis lupus*) den and rendezvous sites in southcentral Alaska were studied from 1976 to 1981. Eighteen den and six rendezvous sites had an average of 4.5 holes per site. No significant differences existed between the average number of holes between den and rendezvous sites. Mean dimensions of tunnel entrances and chambers are reported. No correlation existed between numbers of wolves which had used a site and numbers of holes. Den and rendezvous sites were usually located on knolls or hillsides with sandy, frost-free soil and mixed, semi-open stands of spruce (*Picea* spp.), Quaking Aspen (*Populus tremuloides*), and willow (*Salix* spp.). Wolves generally selected sites with south and/or east exposures. Mean elevation for all sites was 777 m while mean distance to water was 257 m. Average distance between contiguous, concurrent den sites was 45.3 km.

Key Words: *Canis lupus*, Gray Wolf, den site, rendezvous site.

Human encroachment and the development of natural resources often have deleterious effects on wildlife. Minimizing these effects requires a sound understanding of a species' ecological requirements. While studying predator-prey relationships in southcentral Alaska, we investigated the denning ecology of Gray Wolves. This paper describes the external and internal characteristics of wolf den and rendezvous sites examined, 1976 to 1981.

Materials and Methods

Den and rendezvous sites were located from fixed-wing aircraft while tracking radio-collared wolves from 1976 to 1981 in the Nelchina and upper Susitna River Basins of southcentral Alaska. The study area has been described elsewhere (Rausch 1967; Skoog 1968; Bishop and Rausch 1974; Taylor and Ballard 1979; Ballard et al. 1981, 1982). The location of each site was recorded on topographic maps (United States Geological Survey, scale 1:63 360). Ground examinations occurred after wolves had vacated the sites, usually during August or September. Transportation to sites was usually by float-equipped fixed-wing aircraft.

Den sites were distinguished from rendezvous sites by their temporal pattern of use and the presence and size of pups. Dimensions of tunnel structures were determined by entering tunnels with a flashlight and crawling as far as possible. Likewise, the disturbance to sites was minimal as no tunnels were excavated. All measurements were taken with steel measuring tapes calibrated in centimeters. Distances to water were estimated during ground and aerial observations. Distances between concurrent main den sites for contiguous packs were determined by plotting den locations on topographic maps (U.S.G.S., scale 1:250 000) and measuring straight-line distances. Contiguous packs were identified by mapping home range territories from visual observations using the minimum home range method (Mohr 1947). When a pack simultaneously reared two litters at different den sites, the den used by the established alpha female was denoted the main den and this was used for distance computations.

Percent cover of over/understory vegetation was subjectively estimated during ground observations. The nomenclature of vascular plants follows Hulten (1968). Soil types were classified by particle texture and color, and elevation was determined from topographic maps (U.S.G.S., scale 1:63 360), while the aspect of holes was determined with a compass.

External openings of tunnels ("holes") were stratified into two categories based upon size. The size index of each opening was computed using height and width measurements as if each hole was rectangular. There was a discontinuity in the area indices of holes around 1290 cm^2. Holes with an area index greater than this were considered large. The terms "large" and "small" were used to describe each category of holes in lieu of "adult" and "pup" to preclude any erroneous inference, that certain age classes of wolves used holes of a certain size. This method does not exclude Red Fox (*Vulpes vulpes*) holes apparently unmodified by wolves at den or rendezvous sites that appeared to have been used by pups. However, fox-sized holes at sites that did not obviously show any indication of use by wolves were not included in these analyses. Shallow holes less than 1 m deep were also excluded. Statistical comparisons were either by F-test, *t*-test, linear regression, or Chi-square (Johnson 1980).

Results

Den and rendezvous site use by wolves were found to be fairly traditional. Of the 23 sites examined, at least six have been used three seasons since 1975; six have been used twice. The average elevation for 22 sites was 777 m ± 110 m ranging from 610-1097 m. Elevation of the study area ranged from 610 - 1829 m.

Seventeen den sites contained an average of 2.5 ± 1.2 large holes and 2.1 ± 1.8 small holes. Six rendezvous sites contained an average of 2.5 ± 1.0 large holes and 2.8 ± 2.4 small holes. There was no significant difference ($t = -0.74$, pooled data, $df = 21$, $P > 0.05$) in the total number of holes between den and rendezvous sites. No significant correlation was found between the numbers of pup or adult wolves and the numbers of large or small holes per year of use ($r = -0.17$ and -0.35, respectively, $P > 0.05$). Mean height and width of 50 large holes was 42 ± 9 cm by 51 ± 13 cm, while 37 small holes averaged 23 ± 6 cm by 28 ± 7 cm.

Tunnels usually descended at a steep (20-45°) slope for approximately 1 m and then either ascended at a gentle ($< 10°$) slope or were level. A detailed analysis of tunnel lengths is not included in this discussion because tunnels often became too small to allow observers to reach or estimate their endpoints; however, tunnel lengths generally ranged from 1.5-5.5+ m. Small tunnels, 23 - 30 cm in diameter, often radiated from chambers. These tunnels appeared too small for use by adult wolves and could represent residual holes of foxes or be the excavations of wolf pups. Except for the area immediately adjacent to hole entrances, all tunnels were clear of vegetative debris and scats; none were observed lined with fur as described by Haber (1968).

All den and rendezvous sites contained at least 1 chamber. Mean dimensions for 18 chambers were 45 ± 14 cm high by 120 ± 40 cm wide by 102 ± 31 cm deep. Three den sites and one rendezvous site contained more than one chamber; however, not all tunnels or tunnel complexes possessed a chamber. One tunnel complex which contained a large chamber also contained two small chambers with dimensions of approximately 48 by 46 by 61 cm. Some chamber floors consisted of hard-packed sand that was unlike the powdery sand found on floors of other parts of the tunnels. Since the attendant female and pups probably spent most of their time in the chamber, this was probably an incidental result. The distances from tunnel openings to chambers averaged roughly 2 to 3 m.

Generally, holes of both den and rendezvous sites were oriented in a southerly and/or easterly direction ($X^2 = 25.0$, $n = 100$, $P < 0.01$). The average distance to water for den and rendezvous sites was 257 ± 263 m ($n = 16$), and there was no significant difference ($t = 0.75$, pooled data, $P > 0.05$) in mean distance to water between den and rendezvous sites. This distance was exaggerated because ephemeral water sources present during spring and early summer were dry by August or September and could not be measured. All sites were located in stable, sandy, frost-free soils which, in some cases, contained varying quantities of clay and gravel.

Most den and rendezvous sites were located on elevated knolls with homogenous or mixed stands of spruce (*Picea mariana* and *P. glauca*), Quaking Aspen and willow with occasional Paper Birch (*Betula papyrifera*). Tree canopies were semi-open or interspersed with small glades providing places for sunning and vantage points. Rose (*Rosa acicularis*), decumbent willow (*Salix* spp.), Dwarf and Shrub Birch (*Betula nana* and *B. glandulosa*), grasses (*Elymus innovatus*, *Poa* spp., *Calamagrostis* spp.), Lowbush Cranberry (*Vaccinium vitis-ideae*), Labrador Tea (*Ledum palustre*), and Fireweed (*Epilobium angustifolium*) commonly occurred in the undercover.

Den sites were usually located roughly within the center of the observed pack territories but a few sites were located relatively close to territorial boundaries (Ballard et al. 1982). The mean distance between 19 pairs of concurrent natal dens of contiguous packs was 45 ± 14 km; distances ranged from 27 to 67 km. Two wolf packs simultaneously raised two litters of pups at separate den sites. Distances between main and secondary dens within a pack were approximately 8 and 18 km, much less than the distance separating unrelated packs. There was no significant difference ($F = 0.14$, $P > 0.05$) in mean distance separating contiguous den sites among years.

Discussion

We did not observe the typical characteristics of den and rendezvous sites such as hollow logs, rock caves or dug-out Beaver (*Castor canadensis*) lodges described in other regions (Joslin 1966; Mech 1970; Peterson 1974, 1977; Allen 1979). Trees in this region usually do not attain a diameter adequate to house wolves. However, Beaver lodges were numerous and rock caves were also available in the study area. We did not observe pit dens which have been described for wolves from the Brooks Range of Alaska (Stephenson 1974). Most den and rendezvous sites in this area consisted of burrows dug either in elevated knolls or on the sides of hills. Holes were frequently located beneath spruce or aspen trees.

Wolves often enlarge the tunnels of foxes and other small mammals (Murie 1944; Mech 1970; Stephenson

1974; Haber 1977). The presence of Porcupine (*Erethizon dorsatum*) scats and quills suggests this species also uses tunnels while wolves are absent.

Although we made no effort to quantify the abundance of potential wolf den sites, our casual observations suggest that such sites are numerous in southcentral Alaska. Therefore, we do not envision any shortage in wolf den sites due to human encroachment in the immediate future so long as Red Fox densities remain similar.

Several den and rendezvous sites had beds located within 200 m of the main holes. These beds, roughly 60 cm in diameter, were located within sandy, litter-free areas that were 1 to 3 m in diameter. Four of nine beds overlooked tunnel entrances. Five others were located on ridges out of sight of the holes and appeared to have been selected for their view and exposure to direct sunlight. Although one bed was beneath a large White Spruce, other beds did not indicate selection for areas beneath evergreens as reported by Joslin (1966).

The low correlation between the number of holes and the number of wolves was not surprising. Mech (1970) reported that alpha females do most of the digging at den sites. Therefore, the number of holes used at a den site may be more attributable to the number of Red Fox holes present when the site was discovered by wolves than a function of pack size. Attendant yearlings and pups (6 - 8 weeks old) sometimes enlarge existing holes and may dig new holes for play (C. Gardner and J. Westlund, personal communication). Since wolves traditionally re-used den and rendezvous sites, on two occasions interchangeably, hole size and the number of holes could be influenced by the number of years a site was used. Soil density, rocks and root development undoubtedly affect tunneling by wolves as well. Although pups may account for most of the digging at rendezvous sites (Peterson 1974), these other factors apparently overwhelm any correlation between the number of pups and holes at rendezvous sites ($r = -0.42$, $n = 6$).

Mean dimensions reported herein for large holes fall within the 35 - 63 cm range reported by Mech (1970) for diameter of tunnel openings. Mean dimensions of small holes were slightly less, however. Mean dimensions for chamber size were also slightly less than those reported elsewhere (Criddle 1947; Joslin 1966; Stephenson 1974; Haber 1977), but this could be due to differences in the methods of measurement. The number of published, quantitative descriptions of chamber size is inadequate for meaningful comparisons.

Haber (1968) provides the only description of a "nest" chamber lined with hair. Hair shed by adult wolves can adhere to the sides of tunnel structures but probably does not account for Haber's observations. Our observations for the earliest date of denning, 13 April (Ballard et al. 1981), and dates observed for vernal molt (mid-March through April for captive wolves maintained in outside facilities at Fairbanks, Alaska: D. Hartbauer, personal communication) indicate little overlap between periods of denning and shedding.

The average distance of 45 km between contiguous natal dens is comparable with the 40 km computed by Stephenson and Johnson (1973) for the northcentral Brooks Range. Knowledge concerning the average distance between natal dens in conjunction with knowledge of the types of sites used by wolves could allow managers to arrive at a crude approximation of number of denning wolf packs in an area. Also, searches of potential den site areas could aid in locating denning wolves for study, as occurred during this project in 1978.

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*Available from Alaska Department Fish and Game, P.O. Box 3-2000, Juneau, Alaska 99802

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Denning and Foraging Habits of Red Foxes, *Vulpes vulpes*, and Their Interaction with Coyotes, *Canis latrans*, in Central Alberta, 1972-1981

DICK DEKKER

3819-112A Street, Edmonton, Alberta T6J 1K4

Dekker, Dick. 1983. Denning and foraging habits of Red Foxes, *Vulpes vulpes*, and their interaction with Coyotes, *Canis latrans*, in Central Alberta, 1972-1981. Canadian Field-Naturalist 97(3): 303–306.

Red Fox (*Vulpes vulpes*) dens near Edmonton, Alberta, were often dug under barns and uninhabited farm buildings. Ten litters of pups numbered from 3 to 7, and averaged 5. Two adults brought food to each litter, but at one den there were three foraging adults. Active play between two adults and pups was seen at one site. A dead pup was carried away from the den by an adult. A male fox led three pups away to another den during mid-day, while one or two pups remained at the first site where they were later seen with the vixen. At one den all prey seen brought to the young were small rodents. Hunting methods of adult foxes catching voles are described for summer and winter. Other prey was seldom taken. Coyotes (*Canis latrans*) chased foxes on nine occasions. Interspecific strife with Coyotes is believed to be the reason foxes occur close to human habitation in central Alberta.

Key Words: Red Fox, *Vulpes vulpes*, Alberta, foraging, denning, interaction with Coyotes, *Canis latrans*.

The Red Fox's (*Vulpes vulpes*) distribution in Alberta covers all but the treeless prairies of the south (Soper 1964). Banfield (1974) considered the species very rare on the southern plains. I reported Red Foxes virtually absent in central Alberta until the late 1960's when it became locally common in agricultural regions south and east of Edmonton (Dekker 1973). This paper gives information on den sites, litter sizes, parental care, foraging habits and interactions with Coyotes (*Canis latrans*).

Study Area and Methods

From 1972 to 1981, I used three study areas of about 7 km^2 each, but local extirpation of foxes forced me to abandon two areas in 1975. The first area was situated 6 km east of the town of Tofield; the second within the eastern outskirts of the city of Edmonton; and the third 4 km west of Leduc. Areas 1 and 2 each included one occupied fox den until 1974; the third area contained two dens with pups in 1975, but only one thereafter.

All three areas are dominated by gently sloping agricultural fields, intersected by country roads on a 1-mile grid pattern. The Edmonton and Leduc areas contain a narrow creek ravine with mixed woods, mainly Trembling Aspen (*Populus tremuloides*) and willow (*Salix* spp.). The Tofield study area straddles the provincial Highway No. 14 and the C.N.R. tracks, and it contains several wet depressions with marshy vegetation. In general each quarter section of land (64 ha) has a cluster of farm buildings, usually flanked by a windbreak of White Spruce (*Picea glauca*) or a mixed woodlot.

To study the foxes' foraging habits during winter and to locate denning sites, I followed fox tracks in snow on a total of 124 days (466 h). Dens were checked for signs of use in early June. Several occupied dens were reported to me by local residents. I observed occupied sites for varying lengths of time on 70 days in June for a total of 215 h, usually between 0600 and 1000 or between 1900 and 2200. Most watching was done from a car parked on a country road 100-500 m from the den, and I used 10× binoculars and a 20× telescope. I did not seek data on specific subjects, and neither watched systematically nor did any experimentation. Observations that seemed noteworthy were written down upon arriving home.

Results and Discussion

Pelage Variation

All Red Foxes observed during this study were of the red phase. None resembled the so-called cross and silver phases, which together can constitute 22-61% of Canadian populations (Banfield 1974). The foxes under study probably belonged to the subspecies *V. v. regalis*, the Northern Great Plains Red Fox, the largest and palest of the western Red Foxes (Soper 1964). Toward late spring, some foxes had patches of bleached pale-yellow winter fur on their backs and necks, contrasting with the brown summer fur of the flanks and legs. There was a noticeable variation in the extent of black on lower legs, and of white on the tip of the tail. Six of the pups had one or two white front feet or white toes.

At those den sites where I had a good view of both adults together, I noted a difference in size of the two foxes. I assumed that the larger animal was the male, and the smaller the female or vixen. In June, the male appeared to be relatively thicker-furred with a longer and fuller tail. His pelage was generally paler, probably because he spent more time above ground than the vixen.

Dens

During winter, I frequently flushed foxes from their daytime resting places in the open or in a woodlot. However, some foxes apparently spent the day or part thereof underground in dens or borrows, in dry beaverlodges, or under man-made structures such as barns, haystacks, uninhabited farm houses, or grain elevators.

In the Leduc study area, all of six fox families denned under isolated field barns or deserted farm houses. In the Edmonton area, two litters alternately used two dens under buildings and one ground den. In the Tofield area, two fox families used three ground dens in knolls on grain fields or pasture land. Farmers often ploughed or cultivated over ground dens, even if they were occupied. Inhabited dens were re-opened by the foxes. Ground dens had three to six entrances. Dens under buildings had access holes on two or more sides of the structure.

I did not visit the study areas during April and May. The first date I located occupied dens was 1 June. The last date I observed adults with pups at a den was 24 June. During the three weeks or so of my observations, six fox families changed den sites once and one family moved twice. On 19 June 1981, I saw a departure, which was probably prompted by my only attempt to photograph the foxes. My car had been parked about 60 m from the den during the morning. At midday, an hour or so after I had left the field and was watching from the road, the larger of the pair of foxes, probably the male, approached the denning barn and left shortly with three pups, trotting over the fields in a single file. One pup, which happened to be on a side of the barn where it could not have seen the departure of its siblings, stayed behind. Presently it was joined by the vixen, which habitually spent the day under the barn. Next morning, she was there with two pups, but the site was deserted the following day. The foxes had moved to a barn on a farm yard, 0.7 km away.

Pups and parental care

The number of pups in 10 litters that I observed in June averaged 5 and ranged from 3 to 7. Banfield (1974) gives average litter sizes as 5.1. In 1976, I reported a mortality rate of 46% for seven litters during their first three months of life in Central Alberta (Dekker 1976). As main causes of death I listed shooting, traffic and dogs. Direct persecution by humans was probably the reason foxes disappeared from two of my study areas in 1974.

On 21 June 1974, at 0630, I observed a pair of foxes transport a dead pup away from the den. The smaller of the pair, probably the vixen, twice lifted the carcass in her mouth but dropped it again. She left and presently returned with the male, who carried the dead pup 220 m while the vixen followed. Twice the male put the carcass down briefly and finally abandoned it 150 m from the spot where I was sitting on the edge of a woodlot. The carcass was autopsied by J. D. Henry. Cause of death was gun shot wounds. The dead pup's weight was 2.7 kg.

By the middle of June, the pups may spend time above ground at any hour of the day, especially in early morning and in the evening when they are most active and involve each other in play. At two dens I saw the vixen join in play with the pups by pushing and pursuing them. At another den both adult foxes played with the pups. The male was the most active. He began by "bowling over" a pup, and then he ran around the denning barn repeatedly at great speed, ambushing the pursuing pups around the corner and knocking them over. On one occasion, the vixen joined in the chase, but on others she sat on her haunches near the barn. The male jumped over her during his race around the barn and repeated his leap over the sitting vixen three times. Playful interactions between vixen and pups have been described by other field observers (e.g., Tembrock 1958; Allison 1971) but, to my knowledge, active play involving both adults and pups has not been reported before.

At all occupied dens I saw two different adult foxes bring food to the pups, but at one den there were three adults, probably one male and two vixens, which I saw together on several occasions. One vixen could be distinguished by a thin tail. This fox remained somewhat distant from the other two, which frequently "nose-touched" each other but did not exchange such greetings with the thin-tailed animal. All three foxes brought food to the six pups, which appeared to be of the same size and age. Dens with two vixens and two litters of pups of different sizes and age were reported by Sheldon (1950) from New York State, and by Niewold (1976) from the Netherlands. Murie (1961) saw three adults at a den in Alaska. In experimental fox groups, studied in enclosures, Macdonald (1979) observed two non-breeding vixens bring food to the pups of the breeding vixen within their group, but he saw only circumstantial evidence that barren vixens did so in similar groups of wild foxes in Britain.

Food and hunting habits

I was usually unable to identify prey items brought to the pups by the adult foxes because of the distance from which I was watching. However, at one Edmonton area den I had exceptional opportunities for close observation. All of 18 food deliveries consisted of small rodents, probably Meadow Voles (*Microtus pennsylvanicus*) which abounded in surrounding fields. Twelve loads contained 3-7 rodents each. On 20 June 1974, from 0630 to 0800, the foxes delivered five loads, totalling about 24 voles. There appeared to be an ample supply of food. At times, the vixen collected the carcasses of rodents scattered about the den area, and carried them inside the den under the barn. Scavenging birds such as Magpies (*Pica pica*) regularly took dead rodents from the immediate vicinity of the den.

I frequently observed adult foxes hunting and saw about 200 prey caught. A few of these were Pocket Gophers (*Thomomys talpoides*) and frogs, but the vast majority were voles and mice. During June of 1974, the three foxes at the Edmonton area den captured voles with apparent ease on a fallow field, where I observed them on 15 dates. On 20 June, I saw the male fox capture 14 rodents in 25 minutes. He ate four, cached five, and carried three to the den, while he added two along the way.

The hunting technique used by foxed to capture small rodents is the pounce, as reported by many observers (e.g. Smith 1944). Henry (1976, 1980), who described the Red Fox's hunting methods in detail, measured a lunge on level ground at 4.5 m and a downhill one at 7.5 m. On a fallow field in the Edmonton area, foxes seldom pounced and caught most prey with a quick stabbing thrust of the front feet, while the animal's hind legs remained on the ground. If the fox failed to pin the prey down under its feet, it began to dig with quickly alternating front feet. Several times, while I was watching through the scope, I saw a vole emerge from the soil and run. The fox seized it in its mouth in the next instant. The foxes killed voles with a few chewing bites, and then either ate the prey, cached it, or carried it to the den. In the evening and early morning, I frequently saw a resting fox rise and begin hunting. It ate the first 2-6 voles it caught, and then dropped several more onto the ground. Eventually, after 3-6 voles had been left on the field, the fox collected the carcasses and headed towards the den. Sometimes, it deposited its prey load and hunted additional prey, or dug up a cache. Newly acquired voles were either added to the load, or cached. Several times, a Magpie followed a hunting fox, but the bird was chased away by the fox if it had left prey on the ground.

During winter, I frequently observed foxes foraging on snow-covered fields or grassland. They hunted small rodents by stalking. After a pause to pinpoint the prey, either by smell or hearing, or both, the fox pounced and attempted to trap it under its feet. In shallow loose snow, these pounces covered distances of up to 4 m. On thick and crusted snow, the foxes often walked slowly to and fro, head low as if smelling or listening, and pounced straight up and down, landing front feet first in an attempt at breaking the crust. If successful, they often dug extensively. Probably some foxes pounced in this vertical manner to try and collapse snow tunnels used by rodents. The fox secured such prey by digging and thrusting its snout into the snow. However, their slow search and vertical pounce method apparently is most often used to uncover cached food items and rodent nests with young. Some Foxes lunging in this vertical way left craters of up to 0.6 m deep, reaching down to the soil. At the bottom of these craters or on the snow nearby, I found torn grass-made nests, probably of voles. In several instances, I observed foxes chew on small prey items that I believed to be baby voles. It is possible that foxes locate vole nests with young by sound. On 30 November 1970, shrill squeaks guided me to a nest with six baby voles under thick matted vegetation.

On 15 February 1974, I found where a fox had dug numerous craters in 30-80 cm of wind-packed snow covering unharvested swathed grain. Pheasant (*Phasianus colchicus*) tracks led from one crater to the next. Apparently the bird had been feeding on grain exposed by the digging fox.

Foxes caught some prey opportunistically. Tracks revealed that a fox had jumped out of its bed to seize a vole running on top of the snow. It was cached nearby. Such passive methods of hunting may be a deliberate tactic. I often found fox beds on the edge of ditches crossed by numerous tracks of small rodents, or in between the burrow mounds of Ground Squirrels (*Spermophilus richardsonii*) after they had emerged from hibernation in late winter or early spring.

During winter, I seldom found evidence that the foxes hunted prey other than mice and voles. On two occasions, a fox had stalked a covey of Gray Partridges (*Perdix perdix*). One covey, huddled together in a communal bed, had escaped. The other covey, which had been feeding or sleeping in tunnels under crusted snow, had one bird captured, partly eaten and cached. Snowshoe Hares (*Lepus americanus*), occurring in several woodlots in all study areas, were seldom hunted. When snow cover was thick and soft in the woods, the foxes did not enter. Tracks indicated that one hare had been chased unsuccessfully for about 400 m on an open field. A Red Squirrel (*Tamiasciurus hudsonicus*), travelling over open fields from one woodlot to another, had been intercepted by a fox, which I saw carrying and caching the prey.

During June of 1975, I frequently observed foxes hunt in a pasture where Pocket Gopher mounds were numerous. The foxes stalked slowly, apparently sensing the gopher's underground movements, and caught them in a swift dash. They also seized small prey items which I believed to be frogs. I rarely observed the foxes stalk and rush birds, although feathers of several species of ducks and small passerines were much in evidence around den sites.

On 18 and 19 June 1975, I observed two foxes scavenge from a recently dead carcass of a domestic calf. Large chunks of meat and internal organs were carried to the den, about 0.5 km away. The calf had also been fed upon by one or more Coyotes and domestic dogs, which probably opened the carcass.

Interaction with Coyotes

On 18 June 1975, I saw a Coyote crouch and wait for an approaching fox which dodged the Coyote's rush and escaped. On eight occasions, I observed foxes follow and bark at Coyotes that were within 0.8 km from a fox den with pups. The Coyotes repeatedly chased the foxes, which dodged and fled until the Coyote gave up. Murie (1961) saw foxes follow and bark at Wolves (*Canis lupus*) near fox dens in Alaska. On 16 June 1974, I saw a fox approach and bark at two Coyotes, each of which briefly chased the fox. Eventually, the Coyotes entered a woodlot in which the young foxes were hidden. As the fox came near, one Coyote rushed out of the trees and chased the fox along the woodlot, until the second Coyote emerged and took over. Eventually, this Coyote gave up too, but the fox didn't return. The total distance of the chase was about 1 km. On 21 June 1977, I was observing four fox pups sleeping near a field den, when suddenly a Coyote ran towards them. Some distance away, the vixen barked a warning and the pups bolted into the den in the nick of time.

Coyotes may be a serious danger to Red Foxes, especially the young, and foxes avoid Coyotes by spatial segregation. In central Alberta, Red Foxes occur mainly near human habitation and roads. I have found them denning in the immediate vicinity of farms with large dogs, which appeared to keep Coyotes away. Rural residents of the Tofield region told me of three cases where foxes hid their pups under buildings on their yard. Conversely, I have never seen foxes and only once found their tracks on the more remote pasture lands around Beaverhill Lake near Tofield where I have spent about 70 days each year since 1972 and where I saw one or more Coyotes on 120 days.

Red Foxes have only quite recently established themselves on the farmlands of central Alberta (Dekker 1973), perhaps by taking advantage of a depressed Coyote population decimated during the late 1960's by snowmobile hunters. Foxes will probably continue to exist on the Alberta farmlands, but only locally in areas where Coyotes are scarce or absent.

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Dynamics of the Winter Distribution of Rosy Finches, *Leucosticte arctoa*, in Montana

PAUL HENDRICKS[1] and JON E. SWENSON[2]

[1]Department of Zoology, University of Montana, Missoula, Montana 59812
[2]Montana Department of Fish, Wildlife and Parks, 1001 Ridgeway Drive, Livingston, Montana 59047

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During the winter of 1977-78 Rosy Finches (*Leucosticte arctoa* ssp.) were reported across the eastern prairies of Montana, whereas in 1978-79 they were limited to grasslands adjacent to the western mountains. Winter snowfall and days of snow cover on the prairies were similar during both winters. January — July precipitation in 1977 was 23% below normal, whereas it was 50% above normal in 1978. Variability in the winter distribution of Rosy Finches appeared to be a function of early spring and summer precipitation on the prairies (more rain produced more seeds and taller plants) and snow depth relative to plant height (which affected food availability). When food was scarce the finches moved farther onto the prairies.

Key Words: Rosy Finch, *Leucosticte arctoa* ssp. winter distribution, Montana.

Rosy Finches (*Leucosticte arctoa tephrocotis* and *L. arctoa atrata*) breed in alpine areas of western North America, and overwinter primarily on lowland grasslands (Bent 1968). On the wintering areas these finches forage predominantly on seeds of grasses, mustards, Russian thistle (*Salsola kali*), composites, etc. (Cameron 1907, Bent 1968). During the winters of 1977-78 and 1978-79 we noted differences in Rosy Finch distribution in Montana. In this paper we correlate these differences with food availability and climatic conditions.

Methods

Distributional records were obtained from Christmas Bird Counts, published observations in American Birds, a two-year wildlife inventory on an area in extreme eastern Montana (W. Matthews, Bureau of Land Management, personal communication), and field observations in December through March during 1977-78 and 1978-79. The field observations were made opportunistically, but the same general areas were covered each winter. Climatological data were compared for Billings, Glasgow, Great Falls, Lewistown, and Miles City in central and eastern Montana. Estimates of yields of dryland cereals, dryland hay, and livestock numbers were obtained from the Montana Department of Agriculture (1978, 1980).

Results and Discussion

During the winter of 1977-78 Rosy Finches were observed throughout most of Montana east of the Continental Divide, based on all sources of data (Table 1, Figure 1). In contrast, during the winter of 1978-79 Rosy Finches were not reported ranging onto the eastern prairies, but were restricted to grasslands near the western mountains (Table 1, Figure 2). The findings of Turner and Taylor (1980) were consistent with our observations. Of the seven observations they reported of Rosy Finches east of their normal winter range in the Northern Great Plains during these two winters, six occurred in 1977-78 and only one in 1978-79. Turner and Taylor (1980) reported two sightings from the 1978-79 winter, but one of these, in Bismark, North Dakota, was actually observed during the 1977-78 winter (Johnson and Randall 1980). A similar distributional variation may have been noted by Cameron (1907: 403), who reported an absence of Rosy Finches in eastern Montana during the winter of 1905-06 "in great contrast to previous years".

The observed difference in winter distribution of Rosy Finches may be related to a difference in food availability during the two winters. Total snowfall and days of snow cover were similar during both winters (157.2 cm snowfall and 120.8 days with $\geqslant$ 2.5 cm snow cover in 1977-78, compared with 147.9 cm and 136.6 days in 1978-79). Although seed production data on wild food crops utilized by wintering Rosy Finches were not available, a positive correlation between summer precipitation and grass seed production has been reported (Ellison and Woolfolk 1937, Brown et al. 1979). Climatological data show that precipitation during January through July 1977 (i.e. preceding and during the 1977 growing season) was 23% below normal ($\bar{x}$ = 191.5 mm for the five weather stations). During the same period in 1978, precipitation was 50% above normal ($\bar{x}$ = 372.1 mm). Yields of dryland cereal crops responded accordingly, with less seed production during the drought year of 1977 (25.4 bushels/acre for wheat and barley) than the wet year of 1978 (32.8 bushels/acre), a difference of 29.1%

TABLE 1. Numbers of Rosy Finches Reported on Christmas Bird Counts in Montana, 1977-78 and 1978-79.

Region[a] and Count Location	1977-78		1978-79	
	L. a. tephrocotis	*L. a. atrata*	*L. a. tephrocotis*	*L. a. atrata*
Western				
Big Fork (BF)[b]	0	0	0	0
Bozeman (BZ)	0	0	0	0
Ennis (E)	417	0	1	0
Glacier Park (G)	0	0	0	0
Missoula (M)	26	0	0	0
Ninepipe (N)	NC[c]	NC	0	0
Stevensville (S)	0	0	NC	NC
Troy (T)	0	0	0	0
Whitehall (W)	0	0	NC	NC
Central				
Billings (B)	202	0	0	0
Chester (C)	301	0	75	0
Helena (H)	0	75	12	0
Highwood (HW)	0	0	0	0
Lewistown (L)	129	0	0	0
Park County (P)	22	1	250	103
Townsend (TN)	NC	NC	0	0
Yellowstone Park (Y)	9	20	150	40
Eastern				
Fort Peck (F)	0	0	0	0
Miles City (MC)	0	0	0	0

[a] Regions as defined by Montana Department of Agriculture (1978) and shown in Figures 1 and 2.
[b] Locations shown on Figures 1 and 2.
[c] No count.

(Montana Department of Agriculture 1978, 1980). Stem height data were also unavailable, but our impression was that prairie grasses were much taller in 1978 than in 1977. Long-time area ranchers also reported that the growth of prairie grasses was exceptional in 1978. Ellison and Woolfolk (1937) noted marked differences in plant height in southeastern Montana related to dramatic variations in summer precipitation, and Newbauer et al. (1980) have shown a positive correlation between forage yield and growing season precipitation. Yields of dryland hay (mostly native grasses) increased 16.9% from 1977 (1.31 tons/acre) to 1978 (1.49 tons/acre), perhaps indicating a change in stem height. In addition, the 10.5% decrease in cattle numbers from 1977 (2,318,000) to 1978 (2,074,000) in central and eastern Montana resulted in reduced grazing pressure when seed and forage production were higher. Therefore, more food was probably available to Rosy Finches during the winter of 1978-79 than in 1977-78, even though snow cover was similar for the two winters.

Based on observations of population fluctuations at a roost in Utah, King and Wales (1964) concluded that snow cover, which impedes feeding by Rosy Finches, was more significant than ambient temperature in limiting winter flock distribution and in causing temporary displacements of populations. We agree that snow cover is probably important in affecting food availability and thereby in influencing winter distributions of ground foraging granivores. However, Dunning and Brown (1982) showed that density of wintering sparrows in southeastern Arizona can be correlated with summer precipitation (reflected in the resulting seed crop size). Bock and Lepthien (1976) suggested that seed crop size is the primary factor behind "eruptive" southward migrations of boreal seed-eating birds. The winter-to-winter variations in Rosy Finch distributions observed during this study may be analogous in some aspects to the pattern of winter movements found in granivorous species which exhibit eruptive invasions, in that these movements are a response to local shortages of winter food resources. When food availability was more restricted the finches moved farther onto the prairies. Food availability is determined by seed production and stem height from the growing season prior to winter, and by snow cover during winter. The *combined* effects of these variables probably are important in regulating Rosy Finch winter distribution in Montana.

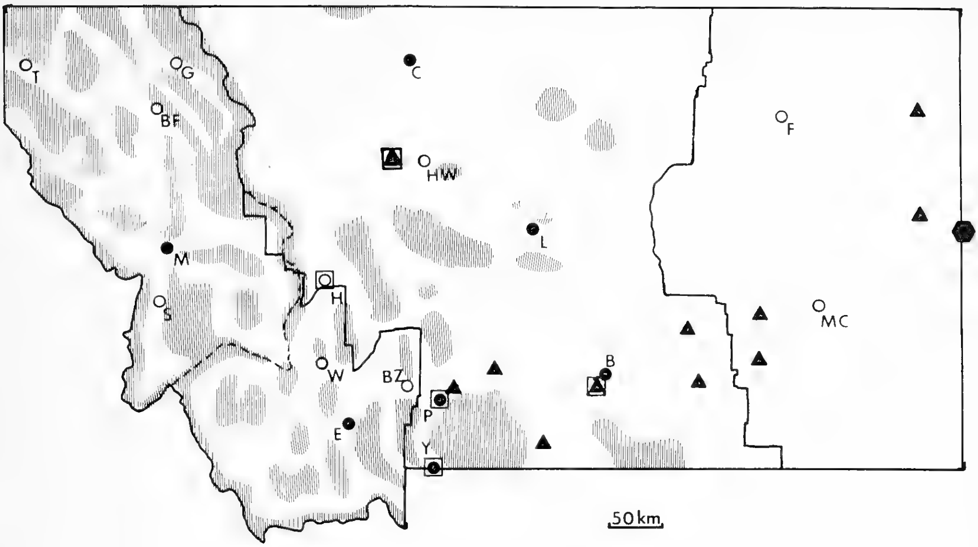

FIGURE 1. Winter Rosy Finch distribution in Montana, 1977-78. (Circles and letters refer to Audubon Christmas Counts, see Table 1, the hexagon to a two-year study by Matthews (personal communication), and triangles to field observations. Open circles and hexagon indicate no Rosy Finches were sighted; filled circles, hexagon and triangles indicate the presence of Gray-crowned Rosy Finches (*Leucosticte arctoa tephrocotis*); boxed open circles indicate the presence of Black Rosy Finches (*L. a. atrata*); boxed filled circles and triangles indicate the presence of both subspecies. Shaded areas indicate mountains. The state is divided into western, central, and eastern Montana, corresponding with the regions used by the Montana Dept. of Agriculture. The dashed line is the Continental Divide.)

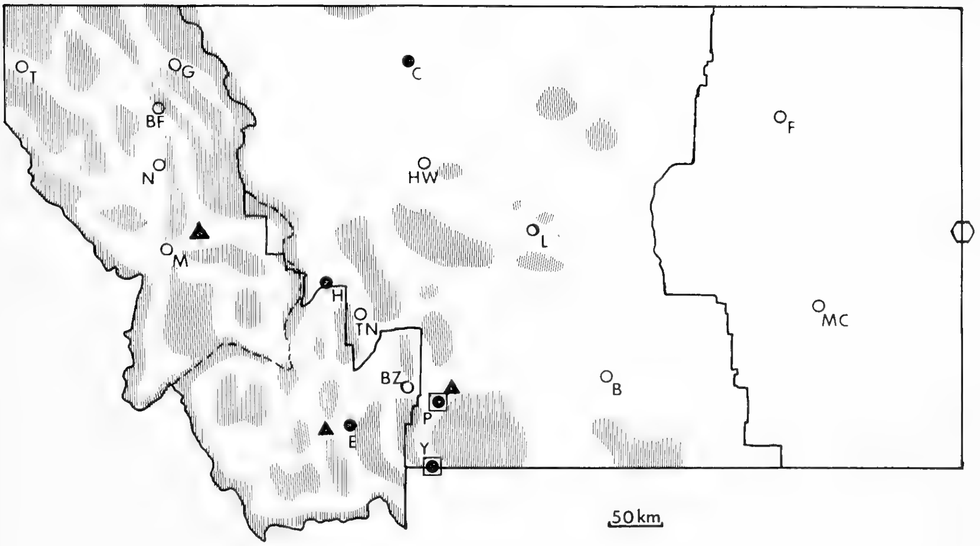

FIGURE 2. Winter Rosy Finch distribution in Montana, 1978-79. (See Figure 1 for explanation of symbols.)

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Variation in Red Fox, *Vulpes vulpes*, Summer Diets in Northwest British Columbia and Southwest Yukon

DONALD M. JONES and JOHN B. THEBERGE

Department of Biology, University of Waterloo, Waterloo, Ontario N2L 3G1

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Diets of Red Fox (*Vulpes vulpes*) were examined in alpine, subalpine, and boreal forest habitats on and near the Chilkat Pass, British Columbia. Above the boreal forest habitat Arctic Ground Squirrel (*Spermophilus parryii*) and voles and mice predominated, especially in whelp scats from dens, but also in adult scats collected elsewhere. Non-den scats contained significantly fewer ground squirrel and more voles and mice remains. Scats at subalpine dens were significantly different from those at alpine dens, the latter containing fewer ground squirrel items. Scats collected from the boreal forest zone were dominated by Snowshoe Hare (*Lepus americanus*), and a greater diversity of species. Significant difference in results were found using "equal weight" and "random sampling" methods of analysis. These data show the considerable dietary plasticity and opportunism of Red Fox predation in this heterogeneous northern environment.

Key Words: Canidae, Red Fox, *Vulpes vulpes*, food habits, predation, scat analysis.

Dietary studies of the Red Fox (*Vulpes vulpes*) in North America indicate that their major prey is small rodents (eg. *Microtus* spp.) and lagomorphs (eg. *Sylvilagus* spp.) (Errington 1935; Scott 1943; Scott and Klimstra 1955; Stanley 1963; Pils and Martin 1978).

Although the range of the Red Fox extends to the Canadian Arctic Archipelago [70° N] (Banfield 1974), no dietary studies have been conducted north of 55° N except those of Murie (1944). The prey in northern environments is characterized by wide spacial, seasonal, and annual differences in abundance.

In this paper, we compare the diets of the Red Fox in boreal forest, subalpine, and alpine habitats of northwest British Columbia, and southwest Yukon Territory. We also compare two different methods of scat analysis: the traditional "equal weight" method, used by the authors mentioned above, and the "random selection" method, used less frequently but with increasing commonness in canid food habits studies (Wyman et al. 1975; Johnson and Hansen 1977a, 1977b; Green and Flinders 1981).

Study Area

The study area was divided into the Haines Road and Alaska Highway sections. The Haines Road Section was the intensive study area, located along the Haines Road from km 91 to km 144 (Figure 1), in the Chilkat Pass. It is above tree-line in the St. Elias Mountains, at elevations exceeding 900 m. The Alaska Highway Section is located along the Alaska Highway from Haines Junction, km 1622, northward to km 1823, and is within the Shakwak Trench where the lowest elevation is approximately 600 m.

Three general vegetation zones occur in the study area. The boreal forest zone, with White Spruce

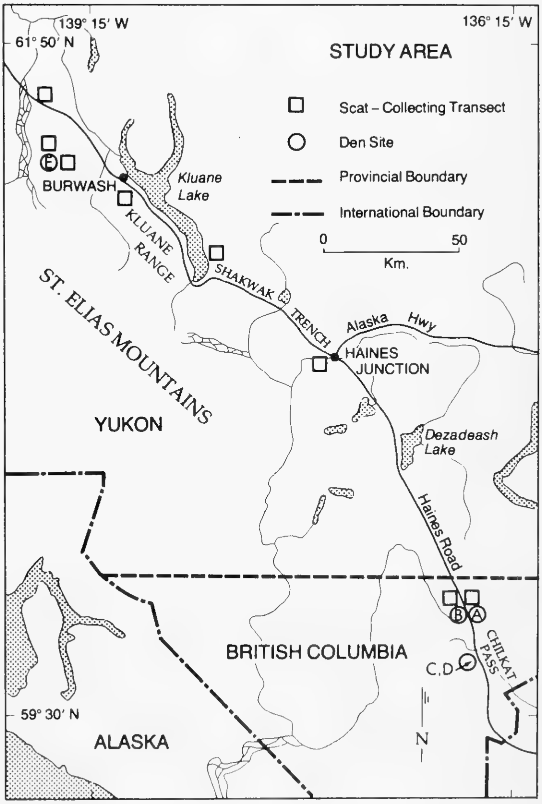

FIGURE 1. Location of the study area showing five den sites and eight scat-collecting transects. The elevations of the den sites are as follows: den A 914 m; den B 914 m; den C 1005 m; den D 945 m; den E 1219 m.

(*Picea glauca*) predominant (Rowe 1972). Stands of Trembling Aspen (*Populus tremuloides*) and Balsam Poplar (*Populus balsamifera*) occur as the result of fire disturbance and extend to approximately 900 m. Dense, subalpine shrub vegetation occurs between approximately 900 and 1000 m, characterized by Dwarf Birch (*Betula glandulosa*) and willow (*Salix* spp.) 1.0-1.5 m high. Scattered pockets of White Spruce occur infrequently. Higher elevations support alpine tundra lichens (predominantly *Cladonia alpestris*), Crowberry (*Empetrum nigrum*), prostrate willows, dwarf birch and ericaceous shrubs.

Repeated glaciation has resulted in a variety of surficial deposits and soils in both sections (Oswald and Genyk 1977). The mean May-September and January temperatures are 9° C and -21° C respectively (data from Haines Junction, Oswald and Senyk 1977).

Methods

Scats were collected from May to September 1978 every two weeks at five fox dens (two in the subalpine and three in the alpine) and along eight transects that were established on infrequently used roads and clearings along an abandoned pipeline (Figure 1). Except for one alpine den, all scats from the Alaska Highway Section were collected below the tree-line. To avoid confusion with Coyote (*Canis latrans*) and Wolf (*Canis lupus*) scats, only scats collected at fox dens or having a maximum diameter less than 19 mm were considered to be fox (Jones 1980). Known fox scats collected at dens ranged up to 23 mm, so choosing 19 mm as a maximum diameter reduced possibilities of overlap with coyote scats. The degree of weathering and the date of the previous collection on the transect were used to identify "summer" scats– mid-April to the end of September, which was the active season of the Arctic Ground Squirrel (*Spermophilus parryii*).

Each scat was sterilized, washed and dried. For the "random selection" method of compilation, four subsamples (usually hair) were randomly selected for identification from each scat. After these four subsamples were identified every different food item in each scat was identified (similar to traditional methodology) in order that we could compare our "random selection" compilation method with the traditional "equal weight" compilation method.

Hairs were identified by comparison with a reference collection of photomicrographs using the hair impression technique (Williamson 1951). Mice and voles were grouped. Non-hair items (bones, seeds) were identified by comparison with a reference collection.

Data for both the random selection and equal weight compilation methods are expressed as percent frequence of occurrence per item, based on the total number of food items. Two-way contingency tables were used to test the null hypothesis that there was no difference between a given pair of diets at the 5% level of significance. Statistical tests were performed only on data pairs consisting of 10 or more scat samples. Contingency tables included only pairs of food items for which one or both items in the pair had a greater than 5% frequency of occurrence.

Results

There were highly significant differences ($p < 0.001$) between the diet compiled by the random selection method and the diet compiled by the "equal weight" method (Table 1). The percent composition of avian, plant and miscellaneous items in the diet was greater with the "equal weight" method while the percent of 12 of 14 mammalian food items was less than the respective percentages compiled by the "random selection" method. For reasons to be explained in the Discussion, the remaining results were compiled by the random selection method.

The main prey in den site scats were Arctic Ground Squirrels, voles, and mice. Collectively, they accounted for 84 and 79% of the identified items at subalpine and alpine dens respectively (Table 1). Scats collected at dens were assumed to be from whelps, because adults rarely defecate at dens (Scott 1943; Jones 1980). All other mammalian prey items, combined, contributed less than 5% of the food items at den sites. Fox fur in scats was not considered a food item residue. Vegetation, found in all three alpine den site scats, contributed 6.7%, whether deliberately or accidentally ingested, and avian prey contributed less than 3%.

Summer diets based on the subalpine den site scats, collectively, were significantly different from alpine den site scats ($p < 0.001$) (Table 1). Scats collected at subalpine dens contained voles and mice less often, and ground squirrel remains more frequently, than did scats collected at alpine dens. Significant differences in diets were also found among every pair of individual den sites between and within habitat types, due primarily to the relative contributions of Arctic Ground Squirrels and small mammals (Jones 1980).

Significant differences ($p < 0.001$) in summer diet were found between den and summer, non-den locations above the tree-line on the intensive study area on the Haines Road (Table 1). Scats collected away from dens were assumed to be adult droppings. The diet at summer, non-den locations was dominated by small mammals (30%), vegetation (23%), ground squirrels (22%), and Beaver (*Castor canadensis*) (18%). In contrast, ground squirrels and small mammals made up 57% and 21%, respectively, of the diet at the dens.

TABLE 1. Differences in Red Fox diets between the random selection compilation method and the equal weight compilation method among various habitats, and den versus non-den sites in northwestern British Columbia and southwest Yukon.[a]

				Non-den location					
	Den Site			Above tree-line		Below tree-line		Total Random Select Method	Total Equal Weight Method
Food item	Subalpine (176)[b]	Alpine (1056)	Total[c] (1028)	Summer (60)	Total (244)	Summer (140)	Total (612)	(856)	(542)
Mammals									
Voles and Mice	19.3[d]	31.4	20.5	30.0	39.8	20.0	19.9	25.6	15.1
Arctic Ground Squirrel	64.2	47.4	57.1	21.7	35.3	32.1	17.5	22.6	13.8
Snowshoe Hare	—	0.8	0.5	—	2.9	35.9	39.5	29.1	13.3
Muskrat	2.3	0.5	0.9	—	3.3	2.9	3.4	3.4	1.7
Red Fox	2.3	6.8	7.0	—	—	—	1.1	0.9	0.4
Porcupine	—	0.4	—	—	—	—	1.5	1.1	1.1
Shrew	1.1	0.8	1.0	6.7	4.1	—	—	1.2	0.7
Dall Sheep or Mountain Goat	—	0.2	0.2	—	—	—	2.0	1.4	0.6
Unknown ungulate	—	0.6	—	—	—	—	0.3	0.2	0.2
Unknown mammal	—	0.5	0.5	—	—	5.0	2.3	1.6	0.9
Moose	—	—	—	—	1.2	1.4	4.7	3.7	2.6
Beaver	—	—	—	18.3	4.5	2.9	1.3	2.2	0.9
Red Squirrel	—	—	—	—	—	—	2.6	1.9	0.7
Black Bear	—	—	—	—	—	—	0.7	0.5	0.2
Birds									
Ptarmigan	—	0.4	0.3	—	—	—	—	—	1.5
Unknown avian	0.4	2.1	2.5	—	1.6	—	—	—	3.1
Unknown Tetraonidae	—	—	—	—	—	—	0.5	0.4	0.6
Unknown Anseriformes	—	—	—	—	—	—	—	—	0.2
Plants									
General vegetation	—	6.7	6.8	23.3	7.4	—	2.6	4.0	27.5
Empetrum nigrum seeds	1.1	0.5	0.7	—	—	—	—	—	4.1
Vaccinium spp. seeds	1.1	—	0.2	—	—	—	—	—	—
Unknown seeds	1.1	0.1	0.3	—	—	—	—	—	4.2
Arctostaphylos uva-ursi seeds	—	—	—	—	—	—	—	—	3.5
Eleagnus commutata	—	—	—	—	—	—	—	—	0.6
Miscellaneous	3.4	0.9	1.6	—	—	—	—	—	2.6

[a] Differences in diets between the "random selection" compilation method and the "equal weight" compilation method, in summer, and between non-den locations above and below tree line were each tested by 2-way contingency tables and are significant $p < 0.001$).

[b] Total number of food items.

[c] The total excludes one alpine den location outside the intensive study area on the Haines Road, to facilitate comparison with scats collected at non-den locations above tree line (data column 4) which represented the same general area.

[d] Percent frequency of occurrence based on total number of food items.

Throughout the year, the diet of adult foxes at non-den locations below the tree-line in the boreal forest was significantly different ($p < 0.001$) from the diet of foxes residing above the tree-line (Table 1). Snowshoe Hare (*Lepus americanus*) was the most common, year-round item in the scats collected in the boreal forest, comprising 36-40% of the food items. In contrast, hares accounted for only 3% of the total diet above the tree-line. The above tree-line scats contained twice as many voles, mice, and ground squirrels as did the scats collected from the boreal forest habitats.

Discussion

The striking contrast between data compiled by the "random selection" and "equal weight" methods is worthy of note. The traditional "equal weight" method overemphasizes the importance of fringe dietary items such as general vegetation. We question the ecological validity of this method where hypothetically two food items representing 0.1% and 99.9% of identifiable items in a scat are treated equally. Data in Table 1, last column, allow comparison with other studies, but for the reason advanced, the following discussion is based upon the random selection method.

Dietary data show the habitat-specific, opportunistic nature of Red Fox predation in this heterogeneous, mountain environment. While fox whelps during the denning season on the subalpine and alpine tundra are largely dependent on Arctic Ground Squirrels and small mammals, significant differences in vulpine diet among all den sites were caused by variation in the relative contribution of these prey. The percentage of ground squirrels exceeded that of small mammals in the diets at three of the four dens that were located less than 200 m from the Haines Road. Here, ground squirrels appeared to be very abundant, possibly due to soil disturbance associated with the construction of both the Haines Road and the pipeline (now abandoned).

Significant differences in summer diet were found between whelp and adult scats collected above the tree-line in the Haines Road Section of the study area. Adults used more small mammals and fewer ground squirrels than did the whelps. These differences in diets suggest an efficient, parental strategy to bring fewer, relatively large items back to the den to feed their young, as suggested by Murie (1944) in Mount McKinley National Park, Alaska.

In contrast to the diet of the tundra-dwelling fox, the vulpine diet of the boreal forest habitats was, like the prey-base, more diversified, and included Snowshoe Hares, as a major prey item, as well as five other minor food items not found in scats collected above the tree-line. This diet approximates the diverse vulpine diets reported for rural agricultural habitats south of 55° N (Errington 1935; Scott 1943; Scott and Klimstra 1955; Stanley 1963; Pils and Martin 1978).

The dietary plasticity described in this paper is evidence of the opportunistic character of Red Fox predation, which has enabled the species to live in a heterogeneous, northern environment.

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Ospreys, *Pandion haliaetus*, Relocate Nests from Power Poles to Substitute Sites

PETER J. AUSTIN-SMITH[1] and GLEN RHODENIZER[2]

[1]Nova Scotia Department of Lands and Forests, Kentville, Nova Scotia B4N 3X3
[2]Nova Scotia Department of Lands and Forests, Bridgewater, Nova Scotia B4V 1V8

Austin-Smith, Peter J., and Glen Rhodenizer. 1983. Ospreys, *Pandion haliaetus*, relocate nests from power poles to substitute sites. Canadian Field-Naturalist 97(3): 315-319.

Eight substitute Osprey (*Pandion haliaetus*) nest platforms were raised in autumn 1979 next to eight nest sites on power poles in Lunenburg County, Nova Scotia. Six platforms were occupied in 1980 and 1981 and five in 1982 by Ospreys, which produced a total of 27 young. Nest success at the platform sites was not significantly different from that at natural sites. Osprey use of nest sites possibly is related to visibility of neighbouring nests as well as of foraging waters.

Key Words: Osprey, *Pandion haliaetus*, nest relocation, Nova Scotia.

Electric power poles and towers are used frequently as nest supports by Ospreys (*Pandion haliaetus*) throughout much of their North American range. Reports of such nest sites have come from several states (Dunstan 1968; Melquist and Johnson 1975; Reese 1977; Henny et al. 1978) as well as from every Canadian province except Quebec and Saskatchewan (Stocek 1981).

In Nova Scotia, as many as 40 pairs of Osprey have been reported nesting on power line support structures (Stocek 1981). The birds nest most commonly on the double wooden crossarms from which the power lines are suspended, and less so on crossbraces between double T poles and on the top most horizontal bracing of steel power line towers. Power line maintenance personnel are concerned about the potential hazards caused by the presence of these nests.

Recently, Olendorff et al. (1981), in a comprehensive review of the problems caused by Ospreys and other raptors on power lines, listed various measures for alleviating such problems. These measures include placing alternate nesting platforms for Ospreys on poles along the right-of-way or relocating nests to nearby trees. Also, triangles of wood or other materials are placed on the top of power line poles to prevent the birds from rebuilding on them. Another apparently successful approach to the problem is to install nesting platforms at safe locations on existing or new power lines.

This paper presents the results of a project to encourage Ospreys to relocate from power line pole nests to platforms situated on a power line right-of-way. The objectives were to: (1) monitor the use of alternate nest platforms by Ospreys nesting on power line poles; (2) compare platform nest success with that at natural nest sites and at previous power line nests.

Study Area

A group of eight pairs of Ospreys nesting on the Indian Path power line in Lunenburg County was chosen for the nest relocation project (Figure 1). This 69 kV line extends from Lunenburg to the Riverport substation over gently rolling terrain. The forests in the area were burned and cut, with the last extensive harvest operation completed in 1972. They consist of immature even-aged spruce and fir (*Picea-Abies*) with numerous short snags but few older and taller trees except scattered White Pines (*Pinus strobus*). The shallow waters of Upper and Lower South Coves and the Lower LeHave River, including Parks Brook inlet, provide foraging areas for Ospreys.

The power line was constructed in late 1970, and according to local residents the first Osprey nest appeared the following spring at site 4 (Figure 1). Table 1 shows nest site development and annual occupancy on the power poles from 1971 through 1979.

Materials and Methods

Eight nest platforms were constructed by cutting off the flat ends of discarded wooden cable spools. The platforms, each 100 cm in diameter, were placed on 12.2 m poles so that the pole top protruded through the platform centre. Each platform was fastened securely to a pole using two pieces of lumber bolted to the pole and to the underside of the platform. Several nails were driven part way into each platform top to provide additional nest anchoring points. All wood was treated chemically to retard rot.

Nest platforms were raised at the edge of the right-of-way close to power line nest sites in mid-November 1979, and the old nests were removed from the power poles. Materials from destroyed nests were arranged on the platforms to simulate crude nests (Postupalsky and Stackpole 1974).

TABLE 1. Nest site development and annual occupancy on the Indian Path power line previous to relocation project.[1]

	Nest site							
Year	1	2	3	4	5	6	7	8
1971				X				
1972		X		X				
1973		X		X				
1974		X	X	X				
1975		X	X	X				
1976	X	X	X	X				
1977	X	X	X	X		X		
1978	X	X	X	X	X	X	X	
1979	X	X	X	X	X	X	X	X

[1] 1971-72 data based on reports from local residents.

Periodic ground observations to monitor Osprey activity were conducted at the power line and platform sites beginning 1 April and ending in late September each year. Helicopter surveys were made on 6 May and 2 July 1980, on 13 July 1981 and 17 May 1982. In 1978, aerial surveys of the power line nests had been conducted on 12 May and 19 July. Eggs and nestlings were recorded in power line and platform nests and also in tree nests on the mainland and islands in Mahone Bay, Lunenburg County.

Results and Discussion

Platform nest use

In 1980, Ospreys were observed first in the Indian Path area on 4 April. By 2 May six platform nests were occupied, one power line nest at site 4 was active, and site 6 was unoccupied. An aerial survey confirmed these observations and indicated the birds were incubating eggs. A final aerial survey recorded ten young Ospreys in the Indian Path platform nests. In late August, one pair of Ospreys built a rudimentary nest on a power pole east of site 3, hereafter recorded as 3A. By 20 September, all Ospreys were gone from the Indian Path area.

In 1981, the first Ospreys were observed in the Indian Path area on 4 April. On 14 May, nest platforms at sites 1, 2, 3, 5 and 7 were occupied and there were two occupied power pole nests, 3A and 4. At site 8, where five Ospreys had been recorded on 13 April, there were no birds after 26 May. An aerial survey later recorded ten young birds in platform nests, two young in the power line nest at site 4 and two eggs at site 3A. All Ospreys had left the Indian Path area by 22 September.

In 1982 Ospreys again appeared in early April and on 17 May there were five occupied nest platforms, two occupied power pole sites, and nesting material on power poles between sites 3A and 4. Ground observations determined that 12 young birds were fledged from the nests (Table 2). A pair of Ospreys constructed a partial nest on a power pole between sites 6 and 7. Ospreys were last observed in the power line area on 26 September.

Reproductive Success

The mean clutch size of 38 natural (tree) nests for 1978 and 1982 was 2.55 ± 0.72, and of 70 eggs counted in 28 nests surveyed later for young, 74% hatched. Clutch size distribution was 2 nests with 1 egg, 16 with

TABLE 2. Reproductive success of Ospreys at natural nest sites and on Indian Path power poles and platforms.[1]

Year		Occupied nests	Productive nests	No. young	Young/occupied nest
1978	Natural sites	34	25	51	1.50
	Power poles	6	5	9	1.50
1980	Natural sites	19	13	26	1.37
	Power poles	1	0	0	0
	Platforms	6	5	10	1.67
1981	Natural sites	20	14	33	1.65
	Power poles	2	1	2	1.00
	Platforms	6	5	10	1.67
1982	Natural sites	4	4	10	2.50
	Power poles	2	2	5	2.50
	Platforms	5	4	7	1.40
Total 1978, 1980-82	Natural sites	77	56	120	1.56 (1.12[2])
	Power poles	11	8	16	1.45 (1.13)
	Platforms	17	14	27	1.59 (0.87)

[1] Nest terminology is as follows: Occupied — nest attended by one or more birds
Productive — nest with well-developed nestlings

[2] Standard deviation

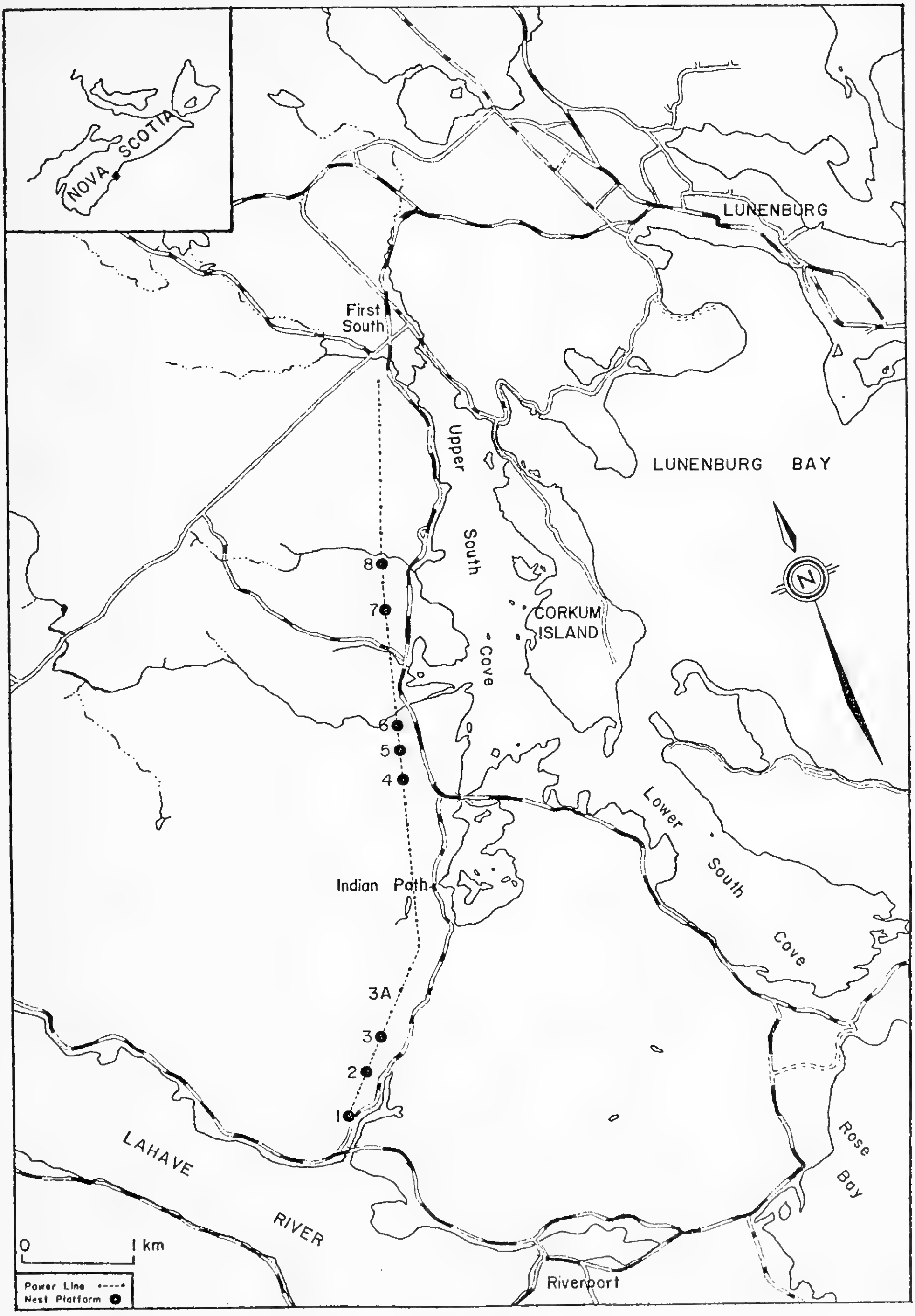

FIGURE 1. Locations of Osprey nest sites on the Indian Path power line, Lunenburg County.

two eggs, 17 with three eggs and 3 with four eggs. Complete egg counts were unavailable in 1980 and 1981. Breeding success rates of Ospreys at natural sites and on man-made structures in Lunenburg County are compared in Table 2. Reproductive success is measured as young per occupied nest (Postupalsky 1974). The four-year average productivity at natural sites and on the platforms was 1.56 and 1.59 young respectively. Power pole nests produced 1.45 young over the same period. There were no significant differences in reproductive success between the natural, power pole or platform nest sites ($X^2 = 0.178$, $p > 0.05$). These recruitment rates are above the 0.95 to 1.30 range required to maintain a stable Osprey population (Henny and Wight 1969). Prevost et al. (1978) calculated an average productivity for a two-year period of 1.22 and 1.08 young on power poles and at natural nest sites, respectively, in Antigonish County, Nova Scotia.

Nest site characteristics

Ospreys occupied nests on six of the eight substitute platforms in 1980 and 1981 and on five in 1982. This degree of acceptance was not expected because four occupied nest platforms were at lower elevations than the previous power pole nests. All of those four nests produced young birds. Table 3 presents the characteristics of platform and power pole nests in relation to occupancy by Ospreys.

As the power line poles were not modified to prevent the birds from rebuilding on them (in 1980 only one pair renested on a pole, at site 4), the occupation of the lower nest sites suggested that Ospreys were attracted to the nesting material. Nest height, however, often is an important factor in nest site location. Although Ospreys nest on elevated structures which normally provide good visibility and protection from terrestrial predators, it is height relative to the surrounding terrain which seems most important. In some areas, Ospreys will nest on low man-made structures (hunting blinds, channel markers) over water (Reese 1977).

Newton (1979), discussing raptor nest dispersion patterns, noted that where foraging grounds are widespread, Ospreys nest in loose colonies. This nesting pattern enhances detection of unpredictable and patchy foods, giving rise to communal feeding areas. Earlier Prevost et al. (1978) referred to social foraging by Ospreys and suggested that nesting in colonies may augment this behaviour. According to Bayer (1982), colonial nesting birds learn of food sources by cueing to flight behaviours of colony members (social facilitation). Our observations of groups of six and seven Ospreys fishing over sections of Upper South Cove and two freshwater lakes may support the communal feeding concept. Hovering and other flight behaviours of Ospreys when they detect prey takes place well above the water surface. On occasion, such activities might be visible to birds at nest sites. For birds in the Indian Path colony, views of flight paths to and from nests and views over the foraging grounds may be as important as direct views of the water surface. It is tempting to suggest that the crude nests, combined with unimpeded views of adjacent nests and views in the direction of the primary foraging waters, stimulated Osprey reproductive behaviour at the four lower sites.

The platform at site 4 remained unoccupied both years by Ospreys, which renested on the adjacent but higher power line pole. This high nest site was the first to be established on the line and has been occupied by Ospreys each year. It apparently provides optimum nesting conditions. The situation at site 6 is unclear

TABLE 3. Characteristics and status of Osprey platform (P) and power line (L) nest sites, Lunenburg County, Nova Scotia.

Nest site	Power pole height (m)	Nest platform height (m)	Visible[1] water (degrees)	Obstructions to horizontal[1] visibility within		Nearest foraging waters (m)	Occupied nest location		
				15.2 m	30.5 m		1980	1981	1982
1	10.4	10.4	158	0	0	98	P	P	P
2	15.8	10.7	22	0	0	152	P	P	P
3	15.8	11.0	55	0	0	400	P	P	P
3a[2]	15.2	no platform	?	0	0	550	—	L	L
4	16.8	10.7	48	0	0	396	L	L	L
5	15.8	11.0	16	0	0	550	P	P	P
6	15.8	10.7	16	X	X	550	—	—	—
7	11.0	11.0	159	0	0	400	P	P	P
8	12.8	11.0	92	0	X	350	P	P	—

[1] As viewed from platform nest rim

[2] Nesting material on power line pole in late August 1980

because Ospreys nested on the power line pole in 1979 yet the site remained unoccupied in succeeding years of this study. Site features are similar to those at occupied site 5 (Table 3) except for a stand of tall conifers within 8 m of the platform which blocks a portion of the horizon in the direction of Upper South Cove when viewed from the platform. The trees also top the power line pole by almost 3 m but are about 16 m from the poles. The platform at site 8, situated 30 m from deciduous trees which thinly obscure a view of the horizon to the Upper South Cove side of the power line corridor, was occupied in 1980 after gravel removal operations ceased nearby. Although five birds were noted there early in the 1981 breeding season, none were present after mid-June that year nor throughout the 1982 breeding season.

In summary, substitute nest platforms were effective in reducing the number of Ospreys occupying power pole nests while maintaining the productivity and size of the local breeding population of these birds. Continued use of the Indian Path platforms may depend upon the presence of platform nest materials each spring, adequate visibility over the forest canopy to the foraging waters, and no substantial increase in human disturbance.

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Notes

Distribution and Ectoparasites of Little Brown Bats, *Myotis lucifugus*, on Prince Edward Island

GWILYM S. JONES[1] and HOWARD H. THOMAS[1,2]

[1]Department of Biology, Northeastern University, Boston, Massachusetts 02115
[2]Present Address: Department of Biology, Fitchburg State College, Fitchburg, Massachusetts 01420

Jones, Gwilym S., and Howard H. Thomas. 1983. Distribution and ectoparasites of Little Brown Bats, *Myotis lucifugus*, on Prince Edward Island. Canadian Field-Naturalist 97(3): 320–321.

Little Brown Bats (*Myotis lucifugus*) have been collected at four localities on Prince Edward Island. The following ectoparasites were collected from Cherry Valley: *Pygmephorus mahunkai, Spinturnix americanus, Macronyssus crosbyi*, and *Myodopsylla insignis*. The specimen of *Pygmephorus mahunkai* constitutes the first record of a pygmephorid mite from a bat; the other species are provincial records.

Key Words: Little Brown Bat, *Myotis lucifugus*, Prince Edward Island, ectoparasites, mites, flea, new records.

Although seven species of bats occur in New Brunswick and five in Nova Scotia, only the Little Brown Bat (*Myotis lucifugus*) has been reported from Prince Edward Island. Three were collected at Mt. Hebert, Queen's County and were deposited in the U. S. National Museum of Natural History (Cameron 1952). Five, previously unreported, fluid preserved specimens were collected on 15 June 1938 at Ellerslie, Prince County and were deposited in the Royal Ontario Museum. Another unreported series of 22 Little Brown Bats was collected on 19 June 1958 in the attic of Green Gables House, Cavendish, Queens County; they are on deposit in the Acadia University Museum. Finally, eleven specimens were collected in an attic in Cherry Valley, Queen's County on 12 August 1980; they are preserved as skins, skulls, and skeletons in the Northeastern University Vertebrate Collection.

Ectoparasites were collected from the Cherry Valley bats by searching through the fur under a dissecting microscope and then washing each specimen with detergent, filtering the solution through a Buchner funnel and recovering the ectoparasites from the filter paper. Two of the seven males and all four females harbored at least one ectoparasite.

Four species of ectoparasites were found — the mites *Spinturnix americanus* (n = 1), *Macronyssus crosbyi* (n = 3, ex. 2 bats), *Pygmephorus mahunkai* (n = 1), and the flea *Myodopsylla insignis* (n = 12, ex. 6 bats). Representative specimens are preserved in the Northeastern University collection. The mites were found only on female bats. Both *Spinturnix americanus* and *Macronyssus crosbyi* have been previously reported from the Little Brown Bat and both infest a wide variety of bat species (Whitaker and Wilson 1974). *Macronyssus crosbyi* has been reported from *Myotis* sp. in Nova Scotia (Wright 1979), but this is the first record of *Spinturnix americanus* in southeastern Canada. The specimen of *Pygmephorus mahunkai* is the first record of a pygmephorid mite from any bat species (Smiley and Whitaker 1979); *P. mahunkai* has previously been recorded from *Scalopus aquaticus* and *Rattus norvegicus* from Indiana (Smiley and Whitaker 1979) and *Zapus hudsonius* and *Napaeozapus insignis* from Prince Edward Island (Jones and Thomas 1982). Little is known about host distribution of phoretimorphic pygmephorids. All parasitized bats harbored at least one flea (range 1-4). *Myodopsylla insignis* is a frequent ectoparasite of *Myotis lucifugus* (e.g. Whitaker 1973). *Spinturnix americanus, Macronyssus crosbyi*, and *Myodopsylla insignis* are new provincial records.

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Heterospecific Vocal Mimicry by Six Oscines

DOUGLAS B. MCNAIR[1] and RICHARD A. FORSTER[2]

[1]Department of Zoology, Clemson University, Clemson, South Carolina 29631
[2]Natural History Department, Massachusetts Audubon Society, Lincoln, Massachusetts 01773

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Heterospecific vocal mimicry in nature, especially by vireos, is described.

Key Words: Blue Jay, *Cyanocitta cristata*, vireos, *Vireo* spp., Rose-breasted Grosbeak, *Pheucticus ludovicianus*, vocal mimicry.

Heterospecific vocal mimicry in nature may occur in many avian species (Armstrong 1973). We present evidence of vocal mimicry in nature for several avian species, especially vireos, for which we believe such mimicry is under-recorded, overlooked, or rare. Terres' (1980) descriptions of primary song, calls, or other vocal sounds are used. Our combined field experience is about 40 years, and we believe our aural knowledge of bird sound is adequate to judge that the examples recorded are true mimicry and not normal variation of songs or single notes.

The Blue Jay, *Cyanocitta cristata*, may readily imitate other sounds, both avian and non-avian (Bent 1946). Blue Jays are renowned for mimicry of the call of the Red-shouldered Hawk, *Buteo lineatus*. The latter species has been extirpated from many former breeding sites in eastern Massachusetts during the last 15-20 years and mimicry of their 'kee-yoo, kee-yoo' call has often been replaced by mimicry of the Broad-winged Hawk, *B. platypterus*, call 'pweeee'; the latter breed at many sites in eastern Massachusetts. Jays still frequently imitate Red-shoulders at Boxford, Massachusetts, where the latter still nest. The same Blue Jay may imitate calls of both hawks; on 30 October 1976 in Wellesley, Massachusetts, a lone Blue Jay perched on top of a pine, scanned the sky for 10 sec, then uttered a high pitched imitation of a Red-shoulder, followed 5 sec later by a high-pitched call of a Broad-wing. Blue Jays may also imitate the 'kree-e-e-e' call of the Red-tailed Hawk, *B. jamaicensis*, though they do so less frequently. Imitations of the Cooper's Hawk, *Accipiter cooperii*, call 'cuck-cuck-cuck' in the southeast United States have been heard about 20 times. Our observations are similar to those of Norris (1957). Mimicry of all four hawks has been heard at all seasons, whether or not the hawk imitated may have been present.

Most North American vireos seldom mimic other avian sounds, though White-eyed Vireo, *Vireo griseus*, mimicry may be more frequent than recorded. We have many records, from at least 30 individuals, of vocal mimicry for this species from April through August in southern New England and southern United States. Examples are the 'scrip' note of Red-cockaded Woodpecker, *Picoides borealis*, and the 'chuck' note of Gray Catbird, *Dumetella carolinensis*, and songs of Bobwhite, *Colinus virginianus*, Yellow-billed Cuckoo, *Coccyzus americanus*, and Carolina Wren, *Thryothorus ludovicianus*. Usually only parts of a song were mimicked, rarely the complete song.

Most imitated sounds were interspersed with the primary song of the White-eyed Vireo, though some mimicked sounds were given alone. White-eyed Vireo vocal imitations in southwest Virginia were predominantly non-territorial sounds (Adkisson and Conner 1978).

A Yellow-throated Vireo, *V. flavifrons*, singing on territory for at least a week in deciduous canopy at Acoaxet, Massachusetts, had snatches of the primary song of the White-eyed Vireo interspersed in its primary song.

A Solitary Vireo, *V. solitarius*, in spruce woods on 10 August 1977 in Windsor, Massachusetts mimicked the 'pse-ek' call of the Yellow-bellied Flycatcher *Empidonax flaviventris* for 15 min.

We have heard Red-eyed Vireos, *V. olivaceus*, mimicking the 'que-bec' and 'hick-three-beers' calls of the Least, *E. minimus*, and Olive-sided, *Nuttallornis borealis*, flycatchers in New England and Canada. Red-eyed Vireos incorporate these songs into their own primary song and this mimicry is fairly frequent. A red-eyed Vireo was also heard mimicking a Yellow-bellied Flycatcher call in a deciduous and evergreen grove 24 km north of Winnipeg, Manitoba.

Finally, an adult Rose-breasted Grosbeak, *Pheucticus ludovicianus*, heard and seen singing for 15 min in deciduous-coniferous forest on 27 June 1977 at Savoy, Massachusetts, mimicked the songs of several species. Interspersed, at about 10 sec intervals in its primary song, were imitations of Red-eyed Vireo primary song and its 'tschay' alarm note. Gray Catbird 'mew' call and a scold note, two variations of Northern Cardinal, *Cardinalis cardinalis*, primary song, and Rufous-sided Towhee, *Pipilo erythrophthalmus*, 'teeeeeeee' song and 'che-wink' call. All imitated species were locally common to abundant.

We believe mimicry in nature by the Blue Jay, White-eyed Vireo, and possibly Red-eyed Vireo, has been often overlooked. Mimicry in nature for the other species is probably quite rare, though the proclivity of mimicry by vireos suggests it too may be overlooked. Mimicry has been reported before for all of these species (Bent 1950, 1968; Benton 1952; Borror 1961; James 1976). The majority of mimicking species mentioned in this note used elements of primary song or other avian vocalizations in their own primary song or advertising calls.

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Photoperiod as an Environmental Cue for Hibernation in Juvenile Richardson's Ground Squirrels, *Spermophilus richardsoni*

TERESA M. DOLMAN

Department of Biological Sciences, the University of Lethbridge, Lethbridge, Alberta T1K 3M4

Dolman, Teresa M. 1983. Photoperiod as an environmental cue for hibernation in juvenile Richardson's Ground Squirrels, *Spermophilus richardsoni*. Canadian Field-Naturalist 97(3): 323–325.

Richardson's Ground Squirrels raised in the laboratory under a simulated natural photoperiod entered their first period of torpor more readily than did squirrels raised under a constant photoperiod of LD 12:12. There were no significant differences in body weights between the two groups of animals. Although squirrels of the natural photoperiod tended to be fatter than those of the LD 12:12, the differences were not significant.

Key Words: Richardson's Ground Squirrel, *Spermophilus richardsoni*, hibernation, photoperiod.

Species of hibernating mammals vary in their dependence on environmental cues, such as temperature or photoperiod, to prepare for and enter the hibernation state (Mrosovsky 1978). For Richardson's Ground Squirrel (*Spermophilus richardsoni*) the role which photoperiod plays is unclear. Harding (1980) found that reduction of metabolic rate, food consumption and activity, cessation of growth, moulting, building of deep nests and docility all occurred prior to photoperiod or temperature manipulations; she thus concluded that photoperiod is relatively unimportant. Scott and Fisher (1970) found that annual rhythms of hibernation persisted under constant photoperiod of LD 12:12 at 0°, 6° or 18° C, whereas no hibernation was observed in squirrels maintained under LD 12:12 at 0° C (Pengelley and Fisher 1961) or under LD 12:12 at 15° C or room temperature (Hudson and Deavers 1976). Demeneix and Henderson (1978) reported that 75% of their squirrels entered hibernation when exposed to a decreasing photoperiod, light intensity and temperature regime (final conditions: LD 2:22, 0.2-1 lux, 6° C), and Abbotts and Wang (1980) induced hibernation by holding squirrels in total darkness at 5° C. Although these studies imply that photoperiod *per se* is not an important cue for entry into hibernation, they all used field-caught squirrels, which may have been entrained to the natural photoperiod before their exposure to artificial photoperiods. This study reports on an experiment designed to determine if photoperiod has an effect on the tendency of laboratory-born, young of the year Richardson's Ground Squirrels to prepare for their first hibernation, as assessed by fat status (the long period of winter dormancy of many hibernators is fueled only by their "on-board" fat stores) and to enter their first hibernation state or torpor, as assessed by actual drop in body temperatures.

Methods

In mid April 1981 four pregnant Richardson's Ground Squirrels were trapped in the vicinity of Red Deer, Alberta and transferred to the animal holding facilities of the Department of Biological Sciences, University of Lethbridge at Lethbridge, Alberta. Each female and her subsequent litter were housed in a large plastic cage (40 × 50 × 20 cm) and provided with nesting material, water and food *ad libitum*. Within three days of birth each litter was culled to five pups in order to minimize possible effects produced by differential growth rates of litters of different sizes. Before the pups' eyes opened, two litters were transferred to a room with constant photoperiod of LD 12:12. The other two litters were exposed to a photoperiod reset about every two weeks to approximate the natural photoperiod of Lethbridge; it began with LD 15:9 in May, lengthened to 16:8 in June and shortened to 13:11 in September. Both rooms were maintained at 20 ± 5° C. At six to seven weeks of age (in early to mid June) all animals were transferred to individual hanging wire mesh cages (18 × 24 × 18 cm).

During the second week of September 1981 all squirrels were placed individually in plastic cages with sawdust, cotton and paper towels for nesting material, but no food or water. The cages were then placed in an environmental chamber set at 4 ± 2° C, in darkness, for 24 h. On their removal next day, it was noted which squirrels appeared torpid and their rectal temperatures were measured. All animals were returned to their hanging cages, at 20° C. One week later all were sacrificed and weighed (minus stomach contents) to the nearest g. The paired abdominal white fat deposits and the paired axillary brown fat deposits were dissected out and weighed to the nearest mg. The weight of single fat deposits is a reliable indicator of general body fatness (Morton and Tung 1971). Brown fat deposits represent a special class of adipose tissue used to generate heat when a hibernator returns to normal body temperature from a period of torpor (Joel 1965).

Results

All animals during their 24 h exposure to low temperature constructed substantial nests of shredded paper mixed with cotton. The animals which had not gone into torpor were immediately active and vocal when removed from their cages. The others remained immobile, were in a hibernating posture (see figures in Pengelley and Fisher 1961), and had low respiration rates. Only one individual, a male, of the LD 12:12 photoperiod group became torpid (body temperature = 16° C), while six squirrels of the natural photoperiod group did so (3 males, with mean ± S.D. body temperature of 8.2 ± 1.4° C and 3 females, with mean body temperature of 9.7 ± 1.0° C). These squirrels shortly began shivering when transferred to 20° C and aroused from their torpor. Table 1 indicates that fat deposit weights and body weights were higher in the natural photoperiod animals than those of LD 12:12, but the differences were not significant ($p > 0.05$). The LD 12:12 male that became torpid was not significantly heavier, nor did he have significantly more white or brown fat than the other males of his group. Likewise the males and females of the natural photoperiod group that became torpid were not significantly heavier, nor did they have significantly more white or brown fat than the other males and females, respectively, of that group.

Discussion

Despite the relatively small sample sizes in this experiment, it does appear that Richardson's Ground Squirrels raised under a simulated natural photoperiod are more prone to enter hibernation than those raised under non-varying photoperiod. Wang's (1978) laboratory and field studies of animals with implanted transmitters for monitoring body temperature have shown that with maximum rates of body cooling, 19 to 26 h are required for an animal to drop its body temperature from a normal 37° C to 9° C (the body temperature reached by animals in this study under natural photoperiod). At maximum, then, five hours elapsed between the time the animals were first placed in the cold and the onset of torpor, and some of this time was spent in first constructing nests. These animals therefore were predisposed to enter torpor, and required only the stimulus of cold temperature and/or food withdrawal to make them do so. This does not imply that the LD 12:12 squirrels were incapable of hibernating. In fact, one of them had entered torpor and perhaps more would have if allowed more time. They were simply not "as prepared" or "as inclined" to do so as the natural photoperiod animals were.

TABLE 1. Influence of photoperiod on weights of white and brown fat deposits in young squirrels. Variability expressed as ± one standard deviation of the means. Body weights at termination of experiment.

Photoperiod	Numbers Sex	Mean Body Wt. (g)	Mean Wt. of White Fat Deposit (mg/g body weight)	Mean Wt. of Brown Fat Deposit (mg/g body weight)
LD 12:12	5 males	407 ± 74	86.0 ± 29.8	7.1 ± 1.2
	5 females	350 ± 52	104.8 ± 33.4	7.0 ± 1.8
Natural	5 males	424 ± 76	106.7 ± 17.6	7.9 ± 1.1
	5 females	353 ± 23	131.6 ± 19.8	7.5 ± 0.8

One obvious way in which many squirrels prepare for hibernation is to accumulate body fat. If fat deposition in Golden-mantled Squirrels is prevented, hibernation is delayed (Phillips 1979). Phillips (1980) also suggested that photoperiod may indirectly influence the date of onset of the initial hibernation period by controlling fat storage, and he found that laboratory-born *Citellus lateralis* raised under LD 6:18 acquired more body lipid than those raised under LD 18:6. However, there was no significant difference in fat status of the two photoperiod groups in my experiment and thus fat status as such may not account for the proclivity of the natural photoperiod group to enter torpor.

One must be cautious in applying the results of this experiment to animals in the wild. Laboratory raised squirrels are generally better fed and consequently heavier than wild squirrels (Harding and Rauch 1981) and a photoperiod effect on fattening might show up only under natural conditions. As well, wild squirrels are not out of their burrows from dawn to dusk and therefore the effective photoperiod may be considerably different from the natural photoperiod by virtue of the animals' own activity patterns. This experiment suggests that young squirrels are capable of using an environmental cue, photoperiod, to time or to trigger entrance into hibernation, but it does not reveal the importance of photoperiod relative to other possible environmental cues, nor does it indicate which aspect of the photoperiod is important (the increasing daylength component, the decreasing daylength component, both, or change itself, regardless of direction). The answers to these and many other questions must await further laboratory experiments and field observations.

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A Survey and Census of the Endangered Furbish Lousewort, *Pedicularis furbishiae*, in New Brunswick

ROBIN T. DAY

Department of Biology, University of Ottawa, Ottawa, Ontario K1N 6N5

Day, Robin T. 1983. A survey and census of the endangered Furbish Lousewort, *Pedicularis furbishiae*, in New Brunswick. Canadian Field-Naturalist 97(3): 325–327.

Known Canadian locations of the endangered plant Furbish Lousewort (*Pedicularis furbishiae*) were explored and a census indicated there were 546+ Canadian plants contributing to a world total of approximately 5546. This is about 146 more Canadian plants than previously reported. Plants were most common on moist, disturbed, morning-shaded riverbank habitat. Insects associated with this plant were identified and both American and Canadian sites were mapped.

Key Words: *Pedicularis furbishiae*, Furbish Lousewort, census, habitat, endangered species, New Brunswick.

Furbish Lousewort, *Pedicularis furbishiae* S. Wats., occurs predominantly on moist, disturbed banks of the St. John River through its northern drainage of the State of Maine and Province of New Brunswick. This species is a perennial herb that produces 3-6 leaves by the first week in June. Leaves are often tinged with an anthocyanin-red at this time. Racemes are produced on most large plants in early June and these begin to flower around 10 July. Seed is dispersed by wind or water during autumn and winter and some seed may be retained in the capsules late into the following summer in sites undisturbed by river flood. In the early growth stages Furbish Louseworts must make haustorial root contact with a host plant or die (Macior 1980). By carefully unearthing mature plants Macior (1978) found no root contact with surrounding plants. The obligatory parasitism must therefore be considered a temporary juvenile characteristic.

I have observed that if the microclimate remains favourable and there are no major disturbances for three or more years, flowering stalks usually will be produced. If, however, there is too much shade the plants remain in a vegetative state.

Habitat Description and 1981 Census

During the summer of 1981 a survey and census of Canadian Furbish Lousewort populations was completed. (Day, R. T. 1981. New Brunswick Ecological Reserves 1981 Field Work and Plant Collecting. Internal Report, Department of Natural Resources, Lands Branch, Ecological Reserves Program. Centennial Building, Fredericton, New Brunswick. 18 pp). The location of populations is given in Figures 1 and 2.

Site 1 was discovered by Mr. H. Hinds in 1977 near a railway embankment (46°44′N, 67°43′W), at the confluence of the Saint John and Aroostook Rivers. This habitat was atypical for this species. Here the plants were found along 25 meters of a steep bank beside a railway track. Brush cutting by a railway crew was evident from the remaining tree stumps. The removal of shrub and tree growth seemed to benefit the herbaceous layer by reducing deep shade. My 1981 census gave a total of 80 plants (all age classes included). Stirrett (1980) reported "about 33 plants" from a 1978 count.

Site 2 is along the east bank of the Saint John River immediately south of the Little River delta (46°52′N, 67°41′W), near North Tilley. Here the Furbish Louseworts occur in a narrow linear zone along the Saint John riverbank. The plants are found only along the upper riverbank between the edge of the stable forested slope and the lower riverbank where seasonal flooding and ice-push cause disturbance to soil and plants. Plants usually grow in river-deposited calcareous silt. Stirrett and Tribe found "about 70+ plants of *Pedicularis furbishiae* scattered along 0.8 miles of riverbank" (Stirrett, G.M. 1977. Report on Investigations of the Flora of Northern Maine and Northern New Brunswick with Particular Reference to *Pedicularis furbishiae* and other Rare Plants. Report on Contract No. DACW 33-77-M-0885. U.S. Department Army, Corps of Engineers. Waltham, Massachusetts. 61 pp.). In 1979 a total of "115 or 69 mature flowering plants and about 46 young plants" were counted (Stirrett 1980). Prolonged searching during my 1981 census led to the discovery of 212 plants along 1.5 km of the riverbank south of the Little River delta.

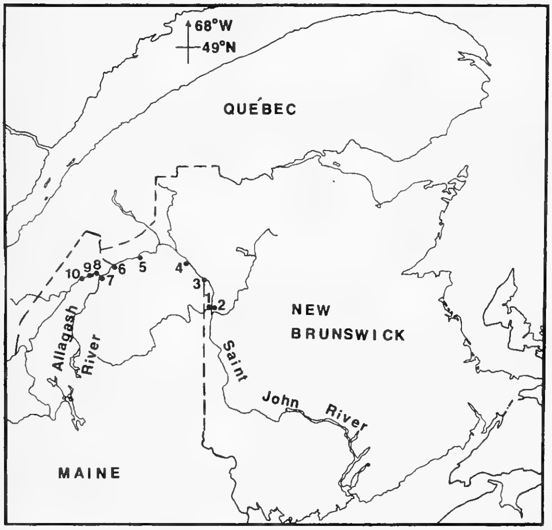

FIGURE 1. Distribution of *Pedicularis furbishiae*. Sites 1 to 3 in Canada (Day 1981), 3 to 10 in the United States (Dyer 1981): 1 = confluence of Saint John and Aroostook Rivers, 2 = near confluence of Saint John and Little River, 3 = spans the Maine - New Brunswick border near Hamlin and Grand Falls, 4 = Van Buren, 5 = Fort Kent, 6 = St. Francis, 7 = Allagash, 8 to 10 = Townships T14R13, T15R13 and T16R12 on the Saint John River.

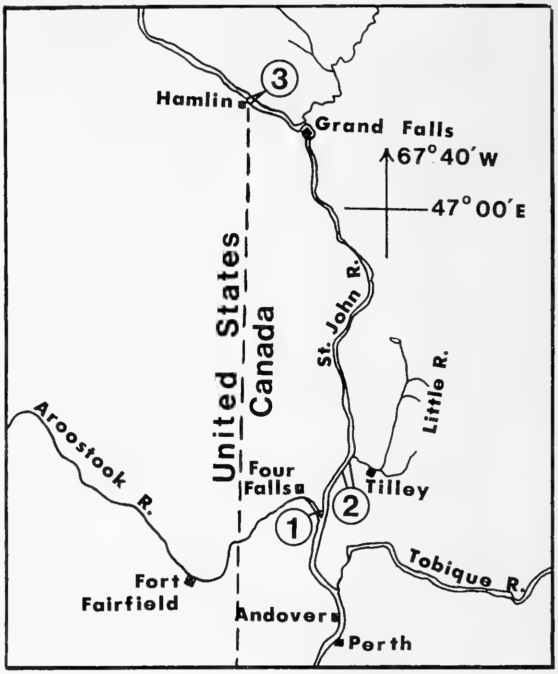

FIGURE 2. Locations of Furbish Lousewort within New Brunswick, Canada: an enlargement of part of Figure 1, showing sites 1, 2, and 3.

Site 3 is at the Maine-New Brunswick border (47° 04′N, 67°47′W), at the base of a very steep slope. Plants were usually growing within one meter of the water's edge on nearly vertical carpets of moist Feather Moss, *Pleurozium schereberi*, at the base of the stable forested slope. My 1981 census produced a total of 102 plants. In 1977, Stirrett and Tribe made a more extensive survey of this site along 1.2 miles of the riverbank and they found "about 254+ plants": 154 flowering plants and 100 young non-flowering plants. (Stirrett 1977, 1980). There has been little disturbance to these populations since 1977, and therefore 254+ plants is probably the best estimate of current numbers.

All three sites were at the base of fairly steep slopes where seepage water kept the soil near saturation. Many of the plants of Site 3 rooted in moss, however, exhibited moisture stress on 17 July as indicated by their flaccid leaves. The three sites were shaded by the trees and steep banks until approximately 1130-1200 h.

In 1980, a survey of U.S. populations was completed by Richard Dyer in which only flowering stems were counted. From approximately 2055 flowering plants counted (R. W. Dyer, personal communication) he makes a rough total population estimate of 5000 American plants (Dyer 1981). This estimate assumes a 1:1 relationship between flowering and non-flowering plants, and an additional 20 percent factor for colonies that may not have been observed.

My 1981 census has increased the Canadian total by 146 plants from approximately 402 (Stirrett 1980) to 546+. The Furbish Lousewort 1981 total world population is therefore (254+) + (80) + (212) = 546+ Canadian plants and approximately 5000 American plants = 5 546+.

The results of the 1982 New Brunswick census were: site 1 = 125, site 2 = 213, site 3 = 117, a total of 455 plants (Don Brown, personal communication, 4 August 1982. Wildlife, Department of Natural Resources, New Brunswick). There appears to be a considerable increase in numbers at the railway embankment Site 1, from 80 in 1981 to 125 in 1982.

Site Disturbance

Because of the water seepage and steepness of the banks at Sites 2 and 3, the soil with its vegetation cover periodically slips downslope onto an unstable part of the riverbank where the plants are destroyed by flood and wave action. On more stable rocky and sunnier parts of the riverbank competing vegetation grows more vigorously over time, thus, the Furbish Louseworts are suppressed by the heavy shade that develops. Site 1 is temporarily maintained as a good Furbish Lousewort habitat because of brush cutting by railway crews. On this seepage slope, soil slippage was not evident.

In summary, the Furbish Lousewort usually inhabits unstable, morning-shaded, seepage slopes where the competitive effects of associated plants are reduced. Because of the unstable nature of the sites (river erosion, steep slipping banks) new Furbish Lousewort habitat is being created while old patches are being destroyed. Thus the Furbish Lousewort is a typical "fugitive species" (Grime 1979) occupying temporary habitats which are periodically destroyed.

At Site 2 a Groundhog (*Marmota monax* (L.)) had clipped a number of Furbish Lousewort flower stalks from several plants. The following herbivorous insects were present at all sites: two species of Spittlebug (Cercopidae), *Aphrophora gelida* (Wlk.) and nymphs, probably *Neophilaenus lineatus* (L.), were often observed to stunt and deform the flowering stems (see Macior 1978) and lepidopterous larvae fed on the leaves. These larvae died in rearing trials because they had been parasitized by Ichneumon Wasps (*Macrocentrus* sp.). Forest Tent Caterpillars (*Malacosoma disstria* Hbn.) were frequently collected on Furbish Louseworts during their population boom in the summer of 1981 but were never observed to cause damage to the leaves.

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Nodding Thistle, *Carduus nutans*: an Addition to the Vascular Flora of Alberta

BERYL HALLWORTH[1] and MICHAEL MYCHAJLUK[2]

[1]Herbarium, Department of Biology, University of Calgary, Calgary, Alberta T2N 1N4
[2]2616 11th Avenue S.E., Calgary, Alberta T2A 0E3

Hallworth, Beryl, and Michael Mychajluk. 1983. Nodding Thistle, *Carduus nutans:* an addition to the vascular flora of Alberta. Canadian Field-Naturalist 97(3): 328.

The first record of the Nodding Thistle, *Carduus nutans*, in the province of Alberta is reported from the Calgary area. It is readily distinguished from true Thistles, *Cirsium* spp., and its dispersal and habitat characteristics may facilitate its spread in Alberta.

Key Words: Nodding Thistle, *Carduus nutans*, Alberta, habitat, characteristics.

The Nodding Thistle, *Carduus nutans* L. is a Eurasian immigrant to Canada that is a serious weed of waste places, pastures and cultivated fields. Prior to this report it was known "in every province except Prince Edward Island and Alberta" (Mulligan 1976); it is here reported from Alberta.

In February 1976 it was collected by Beryl Hallworth and Desmond Allen, north of Calgary, near Beddington (now included in the city); in July of the same year a large stand was located by Cathy Osborne northwest of Calgary; Michael Mychajluk later located it in two places in the southeastern part of the city, and in 1981 it was found by Dr. L. V. Hills to be growing one-quarter mile west of Calgary. Specimens of these plants have been deposited at ALTA, CAN, and UAC.

The specimen in CAN has broad heads (ca. 5 cm broad heads), distinctly reflexed outer involucral bracts, and glabrous leaves, which place it in subspecies *leiophyllus* (Petrovic) Stoj. & Stef., as treated by Moore and Frankton (1974).

The Nodding Thistle, also called the Musk Thistle, flowers from July to September. It is a striking plant, standing 3-25 dm tall, and bearing many large reddish-purple, thistle-like heads (2.5-5 cm broad). The heads are borne on long, erect peduncles that nod at the ends. Only tubular disk-florets are present, surrounded by large, broad involucral bracts, each terminated by a spine. These bracts occur in several series and the outer bracts are reflexed. The spiny thistle-like leaves are up to 40 cm long, and clasp spiny stems. The fruit is a cypsela, (an inferior achene), with a white "parachute" composed of simple pappus hairs. The pappus is an effective aid to wind dispersal.

Carduus nutans may be distinguished from the true thistles, *Cirsium* spp., by the reflexed involucral bracts, long peduncles, and simple, not feathery, pappus hairs.

The habitat of this plant is "dry sandy and clay soils in grasslands, roadside, pastures, margins of cultivated fields, and waste lands" (Moore and Frankton 1974). It "often forms very dense stands on rocky, hilly soil where there is little competition" (Frankton and Mulligan 1971).

B. Hallworth and D. Allen found the Nodding Thistle specimens associated with gravel pits. L. Hills found them in a similar habitat. The plants found by C. Osborne were in a roadside ditch, in disturbed sandy prairie soil, while those found by M. Mychajluk were growing in rocky soil. These habitats conform to that given by Frankton and Mulligan.

It is probable that, because of its efficient mode of dispersal and its ability to occupy habitats that may be unsuitable for other species, it will soon be found all across southern Alberta.

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Ambivalence of the Concealing Pose of Owls

S. BONDRUP-NIELSEN

Department of Zoology, University of Alberta, Edmonton, Alberta T6G 2E9

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It is argued that the "concealing pose" of owls is ambivalent and that applying this functional name is inappropriate. Rather, Ligon's (1968: 63) term "erect posture" should be used with modifications.

Key Words: concealing, owls, behaviour.

Hiding, protective (Bent 1938), erect (Ligon 1968) and concealing (Catling 1972) poses, all suggested to have a concealing function, have been attributed to various species of owls: e.g. Screech Owl (*Otus asio*), Long-eared Owl (*Asio otus*) (Bent 1938), Elf Owl (*Micrathene whitneyi*) (Ligon 1968), Great Gray Owl (*Strix nebulosa*) (Höglund and Lansgren 1968), Saw-whet (*Aegolius acadicus*) and Boreal Owls (*Aegolius funereus*) (Catling 1972). All poses are similar, but there are some important differences among them that suggest to me that all cannot serve the same function.

Bent (1938: 255), quoting Durfee, described the hiding pose of two Screech Owls as follows: "The attitude was long drawn out, . . . the wings and feathers held as close to the body as possible . . . (giving) the appearance of two long stubs, the top of the head being nearly square across. The eyes were slanted slits, and while the head was directly toward me, the body was swung sideways so as to keep the wing in front as a shield: in other words, they were looking over their shoulder'" As Durfee walked around the owls, one suddenly swung halfway around so that it was looking over the other shoulder. Bent (1938: 256) further quoted Shelley's description for the same species: "As we came into sight, very slowly the bird attained the protective pose of a dead stub. . . . the eyes half closed.". On the other hand, Catling (1972) described what he called the concealing pose of Saw-whet and Boreal Owls, both of which stood erect on their legs, with the plumage of the breast and upper back appressed, and thus had a narrow oblong appearance. The wing nearest the intruder was directed toward him and raised to the level of the bill. The frontal crown feathers immediately above each eye were raised while those in the center of the crown remained flattened. The feathers between and somewhat above the eyes were fanned out, which resulted in expansion of the white areas between the eyes. The eyes were fully open. What Catling (1972) failed to mention is that the above pose is adopted abruptly rather than slowly (personal observation). In fact, the abrupt movement made by Saw-whet Owls as they assumed the "concealing pose" often led me to detect otherwise well-concealed individuals in their roost. The sudden flash of fully open eyes with white between them was revealing rather than concealing.

The Elf Owl has an erect posture, which has been described as concealing (Ligon 1968), and which is similar to the concealing posture of the Saw-whet Owl. Again the eyes are fully open and there is conspicuous erection of the white feather patches, one above the eyes and one below the facial discs. Brewster (1883:28), who was quoting Stephens, wrote of the Elf Owl: "I could just see its eyes over the wing, and had it kept them shut I might have overlooked it, as they first attracted my attention.".

Putman (1958) described the concealing pose of a Screech Owl in the presence of House Sparrows (*Passer domesticus*). The owl adopted the pose abruptly, but otherwise its pose appeared identical to that of the Screech Owl described by Bent (1938). Putman could not see whether the eyes were open or closed. Indeed, if owl eyes are releasers for mobbing by passerines (Curio 1975), it would be surprising if the owl's eyes were open.

In the Long-eared (Bent 1938) and Great Gray Owls (Höglund and Lansgren 1968), the eyes are fully open during the so-called "concealing pose." Long-eared Owls will even close and open their eyes abruptly several times in succession during the pose (Kay McKeever, personal communication).

Common features of all these poses are 1) upright posture, 2) the wing nearest the intruder is raised to the bill, 3) appression of the body plumage, and 4) expansion of the lateral crown feathers. However, three features of the pose do not support the hypothesis that the function of the pose is to conceal the owl: open eyes, increased exposure of white feathers around the eyes, and the abrupt manner in which the pose is adopted.

For an animal to achieve concealment, it should avoid abrupt movement, because predators are generally extremely alert to movement (Alcock 1975). Although Catling (1972) maintained that the white on the wing and between the eyes of the Saw-whet Owl served as disruptive camouflage, cases of disruptive camouflage usually involve bold lines and patches that alter the outline of an animal (Alcock 1975). In most vertebrates, eyes are conspicuous and are important signalling devices. Eye spots are used by many animals, especially Lepidoptera and some Amphibians, to divert attack by predators to less vital areas, or to surprise predators (Alcock 1975). Many animals also make their eyes less obvious by having various markings through the eye, e.g. tropical reef fishes.

The posture of the Screech Owl, which is adopted slowly and in which the eyes are mere slits, does unquestionably conceal the bird. However, this was not achieved by the other owl species described, especially the Saw-whet and Elf Owls in which the pose was adopted abruptly, with fully open eyes and a flash of white feathers catching the attention of at least human intruders.

It appears, therefore, that two different postures are involved in the so-called "concealing pose" of owls, and to give them the same or similar functional names is premature. Until this posture is more thoroughly studied, I believe it is more appropriate to name the poses by descriptive terms; I propose, therefore, that Ligon's (1968: 63) term "erect posture" be used with the addition of "abrupt" and "gradual" to distinguish between the posture that is adopted abruptly with open eyes and white markings and the posture adopted slowly with eyes reduced to mere slits.

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Interspecific Food Piracy of Rough-legged Hawk, *Buteo lagopus*, on Red-tailed Hawk, *B. jamaicensis*, and Scavenging by Rough-legged Hawk

GEOFFREY G. HOGAN

Department of Biology, University of Prince Edward Island, Charlottetown, Prince Edward Island C1A 4P3

Hogan, Geoffrey G. 1983. Interspecific food piracy of Rough-legged Hawk, *Buteo lagopus*, on Red-tailed Hawk, *B. jamaicensis*, and scavenging by Rough-legged Hawk. Canadian Field-Naturalist 97(3): 330–331.

A Rough-legged Hawk, *Buteo lagopus*, attacked a Red-tailed Hawk, *B. jamaicensis*, feeding upon a Common Crow, *Corvus brachyrynchos*, and usurped the prey. Twenty minutes later a second Rough-legged Hawk scavenged the remains. A heavy snow crust may have caused a reduction in the availability of normal prey items for these raptors, thus prompting other means of obtaining food.

Key Words: Red-tailed Hawk, *Buteo jamaicensis*, Rough-legged Hawk, *B. lagopus*, food piracy, scavenging, Prince Edward Island.

Red-tailed Hawks, *Buteo jamaicensis*, and Rough-legged Hawks, *B. lagopus*, rely heavily upon small mammals, especially Meadow Voles, *Microtus pennsylvanicus*, as winter prey, yet reduce competition on their sympatric winter range through differences in habitat utilization (Schnell 1968; Baker and Brooks 1981). These workers did not mention direct confrontations between the two species. Bildstein (1979), however, recorded wintering Red-tailed Hawks and Northern Harriers, *Circus cyaneus*, as victims of piracy in 20% of encounters (103 interspecific) among four raptor species studied in south-central Ohio but did not say what species was the aggressor. Red-tailed Hawks are known to be occasional scavengers (Tufts 1973) although this behavior appears to be less common among Rough-legged Hawks (Smith 1975). Severe winter weather may disrupt normal feeding methods and Klein and Mason (1981) reported that several raptors, including Rough-legs, shifted from food territories to patrolling highways for dead or living prey after a storm.

At 11:55 on 6 February 1982, several colleagues and I observed an adult Red-tailed Hawk feeding upon a Common Crow, *Corvus brachyrhynchos*, carcass on the edge of the frozen North River, Prince Edward Island (46°17′N, 63°10′W). After about 5 min a Rough-legged Hawk (dark phase) flew in and attacked the Red-tail. The two birds fought vigorously on the ice for 10-15 sec, with talons outstretched and wings spread, after which the Red-tailed Hawk retreated and the Rough-legged Hawk usurped the prey. Over the next 5 min, the Red-tailed Hawk remained 3-4 m away on the ice nearby while the Rough-legged Hawk mantled the prey but did not feed. At 12:15 the Red-tail flew 15-18 m to a White Spruce, *Picea glauca*, whence it watched the Rough-leg. The latter then commenced plucking and feeding upon the crow until 12:30, when it flew off suddenly, carrying part of the crow in its talons. At this time a second Rough-legged Hawk (light phase) flew in and began feeding upon the portion remaining. Almost immediately the Red-tailed Hawk flew off, alternately soaring and flapping over adjacent fields. The second Rough-leg fed until 12:55, during which time several crows investigated but did not harass the hawk. One crow on the ice approached within 2-3 m of the hawk and fed briefly on the remains when the hawk flew away. During the observation period viewing conditions were good despite a southwest wind that carried blowing snow and, later, freezing rain. The air temperature was around –5°C.

Upon investigation we found only the outer right wing and scattered feathers, but no blood on the freshly fallen snow. As we did not see the Red-tailed Hawk capture the crow, we do not know whether the hawk had killed it or was scavenging. Rough-legged and Red-tailed Hawks are the only buteos found on Prince Edward Island during the winter, and Rough-legs are generally more numerous. Small woodlots interspersed with farmland over much of the island provide suitable winter habitat for both species.

The weather for the week previous to 6 February 1982 alternated between mild and freezing temperatures, thus creating a hard crust over the otherwise deep snow. Klein and Mason (1981) suggested that behavioral changes in hunting techniques by raptors following severe winter weather are examples of adaptability. The unusual behavior reported here also suggests that the formation of a hard snow crust prompted alternative feeding methods.

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Ivory Gulls, *Pagophila eburnea*, Nesting on the Brodeur Peninsula, Baffin Island, N.W.T.

AUSTIN REED and PIERRE DUPUIS

Canadian Wildlife Service, 1141 Route de l'Eglise, P. O. Box 10100, Ste-Foy, Québec G1V 4H5

Reed, Austin, and Pierre Dupuis. 1983. Ivory Gulls, *Pagophila eburnea*, nesting on the Brodeur Peninsula, Baffin Island, N.W.T. Canadian Field-Naturalist 97(3): 332.

Two small colonies of Ivory Gulls, *Pagophila eburnea*, were found on the northwest portion of the Brodeur Peninsula, Baffin Island, in August 1981. This is the first confirmed observation of nesting on the Brodeur Peninsula, an area long believed to harbour breeding Ivory Gulls.

Key Words: Ivory Gull, *Pagophila eburnea*, breeding, distribution, Baffin Island.

The present knowledge of breeding distribution of the Ivory Gull has been summarized by Blomqvist and Elander (1981). Based on confirmed records, the Canadian breeding range included Prince Patrick Island and the Polynia Islands (Sites abandoned since their discovery by McClintock in the 1800's: MacDonald and Macpherson 1962; MacDonald 1976), a floating ice island off Amund Ringnes Island (probably also abandoned: MacDonald 1976), reefs off Meighen Island (MacDonald 1976), Seymour Island (MacDonald 1976) and on eastern Ellesmere Island (Frisch and Morgan 1979; Witts and Morrison 1980). The Brodeur Peninsula on Baffin Island had often been identified as a probable breeding location (MacDonald and Macpherson 1962; Renaud et al. 1979), but confirmation was lacking until now.

On 8 August 1980, while flying across the interior of the Brodeur Peninsula from Nanisivik to Resolute Bay in a fixed-wing aircraft, we saw two groups of small, whitish gulls rise from the ground and circle in a manner typical of gulls disturbed from a breeding colony. The altitude and speed of the aircraft prevented us from confirming our suspicion that they were breeding Ivory Gulls.

On 10 and 11 August 1981, we crossed the same peninsula by helicopter, during goose surveys. Two groups of gulls were located on 11 August in similar habitat to those seen the previous year. On approaching with the helicopter we confidently identified the adult birds as Ivory Gulls (30 at one site, 18 at the other) and confirmed their breeding status by observing several flightless young about ½ to ¾ grown. We immediately retreated from the colonies without landing in order to minimize disturbance.

The colonies were on the interior plateau about 15 km inland from Prince Regent Inlet and near 73° N (a detailed description of their location is on file with the Canadian Wildlife Service). Both colonies, like the suspected ones of the previous year, were on gently sloping mounds or ridges. The sites were characterized by greyish boulders contrasting with the surrounding terrain, which was more smoothly textured and of a beige colour.

Other Ivory Gulls were observed in the area during the same period in 1981, either as singles or small groups flying over the peninsula (total 61 birds) or as feeding groups on coastal waters (6 birds near Arctic Bay and 52 on Prince Regent Inlet). Our observations, confirming those of past generations of local Inuit, suggest other small colonies scattered over the Brodeur Peninsula. A complete inventory would require an intensive aerial search.

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Long Distance Movement by Gray Wolves, *Canis lupus*

WARREN B. BALLARD[1], RICK FARNELL[2], and ROBERT O. STEPHENSON[3]

[1]Alaska Department of Fish and Game, P.O. Box 47, Glennallen, Alaska 99588
[2]Yukon Game Branch, P.O. Box 2703, Whitehorse, Yukon Territory Y1A 2C6
[3]Alaska Department of Fish and Game, 1300 College Road, Fairbanks, Alaska 99701

Ballard, Warren B., Rick Farnell, and Robert O. Stephenson. 1983. Long distance movement by Gray Wolves, *Canis lupus*. Canadian Field-Naturalist 97(3): 333.

Between 10 April 1978 and 10 January 1979 at least two and probably four Gray Wolves (*Canis lupus*) from the same pack moved 732km from the Nelchina Basin of southcentral Alaska to the Brooks Mountain Range of northeastern Alaska.

Key Words: *Canis lupus*, Coleen River, Nelchina Basin, movements, dispersal.

The longest movement of a Gray Wolf (*Canis lupus*) reported in the literature is 670 km (Van Camp and Gluckie 1979). Recently, however, the record movement for a single Wolf was extended to 917 km (S. Fritts, personal communication). This report documents a minimum movement of 732 km by at least two and probably four Gray Wolves from the same pack.

On 10 February 1978, a 42-kg male Gray Wolf, judged by tooth wear to be a least two years old, was captured (Ballard et al. 1982) and radio-collared for movements studies in the vicinity of St. Anne's Creek (61°47′N, 146°0′W) in southcentral Alaska (Ballard et al. 1981). The marked wolf was observed with the pack on six occasions during 10 February — 10 April 1978. On 7 and 10 April 1978, two additional wolves in the pack were radio-collared. After 10 April contact was lost with the male captured on 10 February and with a young adult male captured on 10 April. During subsequent observations of the pack only eight of the original 12 wolves were present. Harvest records did not indicate any of the wolves had been killed by hunters or trappers.

The wolf captured on 10 April was known to have dispersed at least as far as Tanada Lake by August 1978, 142 km northeast of its capture location. Contact was lost after this observation until 10 January 1979 when biologists heard two radio signals with frequencies and pulse rates identical to those of the two missing radio-collared St. Anne's wolves in the Brooks Mountain Range of northeastern Alaska (67° 41′N, 143°03′W). On 2 March 1979, the radio-collared adult was observed with three Gray Wolves which probably included the radio-collared yearling about 64 km north of the 10 January location. The wolves were last observed there on 28 March 1979. Other researchers in the region were not missing radio-collared wolves with either of the two identified frequencies. Therefore, we believe the wolves originated from the Nelchina Basin in southcentral Alaska, a minimum straight-line movement of 732 km. Since wolves commonly travel along waterways and through river valleys, the movement undoubtedly was considerably greater than 732 km. Because both radio-collared wolves disappeared from the St. Anne's area at the same time the pack's numbers declined by 4, and since four wolves were observed, all 4 may have been from the Nelchina Basin.

The cause of this long movement by at least two and probably four wolves is unknown but may have been related to the low availability of prey in the St. Anne's area (Ballard et al. 1981). Other radio-collared wolves in this study area have dispersed either singly or in pairs from 22 to 193 km, often into vacant habitat. The observations reported here are a record dispersal for a group of wolves and are significant because they illustrate the ability of wolves to traverse long distances and repopulate areas with suitable habitat and prey.

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*Available from Alaska Dept. Fish and Game, P.O. Box 3-2000, Juneau, Alaska 99802

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Reduction of the Pelvic Skeleton in the Threespine Stickleback, *Gasterosteus aculeatus*, in Two Lakes of Québec

THOMAS A. EDGE and BRIAN W. COAD

Ichthyology Section, National Museum of Natural Sciences, Ottawa, Ontario K1A 0M8

Edge, Thomas A., and Brian W. Coad. 1983. Reduction of the pelvic skeleton in the Threespine Stickleback, *Gasterosteus aculeatus*, in two lakes of Québec. Canadian Field-Naturalist 97(3): 334–336.

Populations of *Gasterosteus aculeatus* having reduced pelvic skeletons are reported for the first time in Eastern Canada from the Saint John River drainage in Québec. Examination of 120 specimens from 12 collections revealed pelvic skeletal variation from total absence to a full complement of incompletely developed pelvic elements. Bilateral asymmetry in pelvic structure was common. Brook Trout, *Salvelinus fontinalis*, were recorded from both lakes and were known to eat *G. aculeatus*.

Key Words: Threespine Stickleback, *Gasterosteus aculeatus*, pelvic skeleton, Eastern Canada.

The Threespine Stickleback, *Gasterosteus aculeatus*, shows considerable morphological and meristic variation throughout its circumboreal distribution. Populations of *G. aculeatus* having reduced pelvic skeletons are known from the Queen Charlotte Islands, B.C. (Moodie and Reimchen 1973), Texada Island, B.C. (Bell 1974; Larson 1976) and the Outer Hebrides, Scotland (Campbell 1979). Similar pelvic reductions are known for other stickleback species, *Pungitius pungitius* (Nelson 1971a; Coad 1973), *Culaea inconstans* (Nelson 1969) and from Pliocene fossil records of *Gasterosteus doryssus* (Bell 1974).

The purpose of this study is to report, for the first time in Eastern Canada, the presence of two populations of *G. aculeatus* with reduced pelvic skeletons. Lake surveys were conducted by le Ministère du Loisir, de la Chasse et de la Pêche in Temiscouata County, Québec during the summers of 1980 and 1981. Surveys of Lac Croche (47°47′50″N, 68°47′18″W) at 259 m altitude and Lac Rond (47°44′42″N, 68°44′01″W) at 229 m altitude within the Saint John River drainage produced 12 collections with 120 specimens of *Gasterosteus aculeatus*, all with reduced pelvic skeletons. The morphological variation and frequency of pelvic skeletal reduction exhibited are shown in Figure 1 and Table 1 respectively. Pelvic skeletal elements were described according to Nelson (1971b) and the figure was drawn from six specimens stained in alizarin.

None of the fish examined had a completely developed pelvic skeleton and bilateral asymmetry in pelvic structure was found in 58% of the fish examined. All specimens had a normal complement of three dorsal spines and lateral plate development was consonant with that reported elsewhere for freshwater populations (Hagen and Moodie 1982). In specimens longer than 34 mm both the completely-plated morph and the partially-plated morph were found, with the latter predominating (> 90%). Keel development in the partially-plated morph was very weak. Counts of lateral plates for specimens longer than 34 mm were 10-21 (mean 13.8, standard deviation 2.5) for the partially-plated morph based on 31 specimens. Dorsal spine length in standard length for 30 specimens of the partially-plated morph was 10.8-15.3 (mean 13.2, standard deviation 1.2).

Limnological data available from surveys showed Lac Rond to have a maximum depth of 25 m, a surface area of 150.3 ha, and a conductivity of 100 umhos. Lac Croche has a maximum depth of 15 m, a surface area of 80.4 ha, a conductivity of 80 umhos, and a pH of 7. All sticklebacks were caught in depths of less than 1 m by electro-fishing or by seining over rocks, gravel and sand, or among vegetation and dead trees. *Salvelinus fontinalis* has been recorded from both lakes since 1973 but evidence of its presence or absence previous to this date is lacking (C. Banville, personal communication, 1981). The cyprinid *Pimephales promelas* has been recorded from Lac Rond but not Lac Croche. Stomach content analysis of *S. fontinalis* from Lac Croche revealed the presence of *G. aculeatus* in 25 of 75 trout examined.

The co-existence of *S. fontinalis* with *G. aculeatus* having pelvic reductions in Lac Croche and Lac Rond shows that no simple correlation of pelvic skeletal reduction with the absence of predatory fish exists, as is also emphasized by Reimchen (1980) and indicated in Campbell (1979). *G. aculeatus* populations with reduced pelvic skeletons reported by Reimchen (1980; 1982 ms: "Status report on endemic stickleback (*Gasterosteus aculeatus*) on the Queen Charlotte Islands, British Columbia", submitted to the Committee on the Status of Endangered Wildlife in Canada, 14 pp., 4 figs.) in the Queen Charlotte Islands were from small, shallow, bog lakes with a low pH in contrast to the lakes reported here. Environmental factors may have

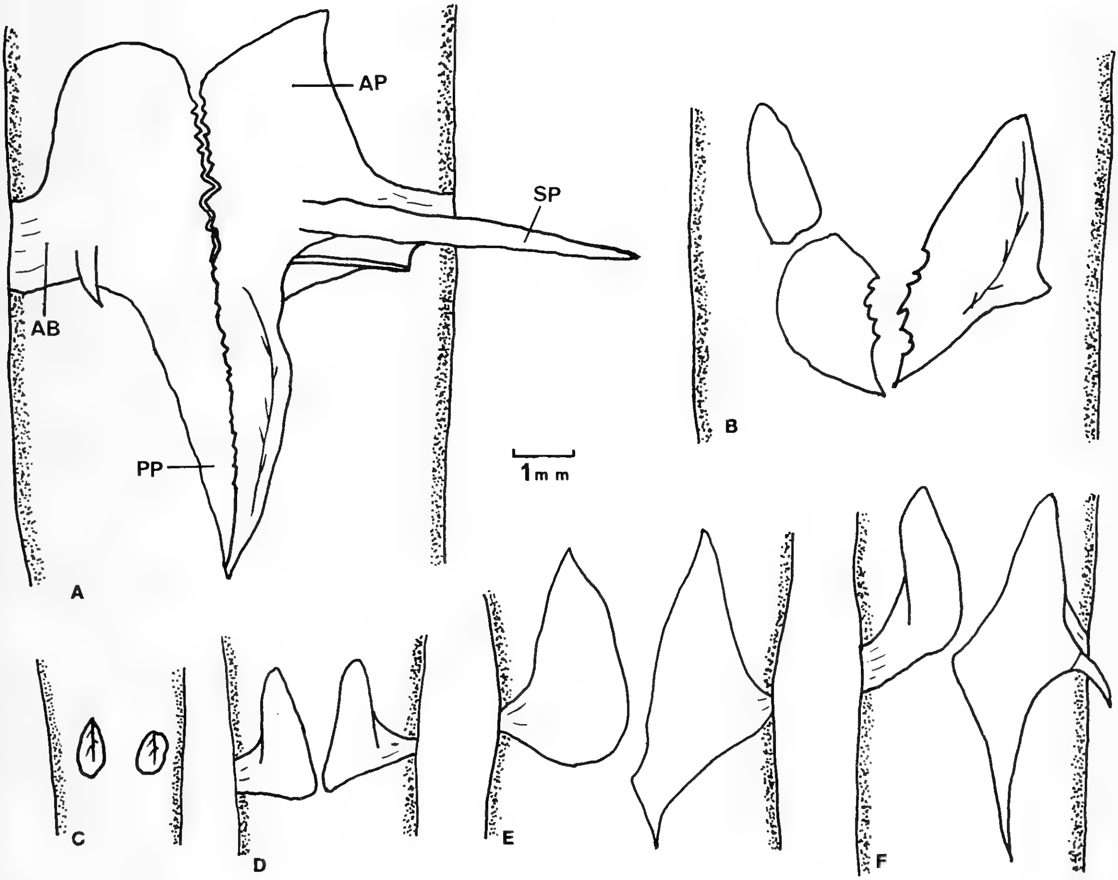

FIGURE 1. Ventral view of pelvic skeletons of *Gasterosteus aculeatus* showing morphological variation. The standard lengths for specimens are: A = 53.3 mm, B = 41.6 mm, C = 21.2 mm, D = 24.8 mm, E = 43.5 mm and F = 31.4 mm. AB = ascending branch, AP = anterior process, PP = posterior proces, and SP = spine.

TABLE I. Reduction of the pelvic skeleton in *Gasterosteus aculeatus* from two lakes in Québec. SL = standard length, AP = anterior process fragments present, AB = ascending branch present on one or both sides, PP = posterior process present, 1S = one spine present, incompletely developed, 2S = two spines present, incompletely developed.

Catalogue number	n	mm SL	Absent	AP	AP + AB	AP + AB + PP	AP + AB + PP + 1SP	AP + AB + PP + 2SP
Lac Rond								
NMC81-1207	13	20.2-46.9	—	8	5	—	—	—
NMC81-1208	29	25.5-46.3	—	11	14	3	1	—
NMC81-1209	7	21.1-37.8	—	1	5	—	1	—
NMC81-1210	14	27.4-37.5	—	3	9	1	1	—
NMC81-1211	15	21.4-48.9	—	4	8	3	—	—
NMC80-1050	4	45.8-73.9	1	—	3	—	—	—
Sub-total	82	20.2-73.9	1	27	44	7	3	—
Lac Croche								
NMC81-1212	10	23.0-28.5	—	1	7	1	1	—
NMC81-1213	12	23.0-28.3	—	2	7	3	—	—
NMC81-1214	9	21.3-31.8	—	2	6	1	—	—
NMC81-1215	3	45.2-52.4	—	—	2	1	—	—
NMC81-1216	2	55.1-58.7	—	—	1	—	—	1
NMC80-1049	2	25.9-27.4	—	—	2	—	—	—
Sub-total	38	21.3-58.7	—	5	25	6	1	1
Total	120	20.2-73.9	1	32	69	13	4	1

led to selective advantages for individuals with reduced pelvic skeletons in Lac Croche and Lac Rond. The available data do not permit proper elucidation of selective pressures operating within these two lakes.

Acknowledgments

We would like to thank Jean-Pierre LeBel, Charles Banville and le Service d'aménagement et d'exploitation de la faune at Rimouski, Québec for collecting specimens and providing survey data. Dr. D. E. McAllister, National Museum of Natural Sciences, Ottawa kindly commented on the manuscript.

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Received 14 July 1982
Accepted 4 January 1983

Report of Council to the 104th Annual Business Meeting of The Ottawa Field-Naturalists' Club
11 January 1983

Minutes of the 103rd Annual Business Meeting of The Ottawa Field-Naturalists' Club 12 January 1982

Auditorium, Victoria Building, National Museum of Natural Sciences, Metcalfe and McLeod Streets, Ottawa — 2000 h.

Chairman: Dr. R. Taylor, President, The Ottawa Field-Naturalists Club.

Attendance: About 75 people were in attendance.

1. *Minutes of the Previous Meeting:*

E. F. Pope, Recording Secretary, read the minutes of the 102nd Annual Business Meeting. It was moved by S. Gawn, (2nd D. Laubitz) that the minutes be approved.

(*Motion Carried*)

2. *Business Arising from the Minutes:*

(a) Regarding the comment on Club assets, R. Taylor said that the search for a permanent office for The Ottawa Field-Naturalists' Club was continuing and that C. Gilliatt, Chairman of a committee investigating the establishment of a Club scholarship, was expected to report in 1982.

(b) The raccoon dogs are still in Ontario. Unfortunately the Ontario Government refused to share the cost of destroying the animals with the Federal Government.

(c) The meeting acknowledged the presence of Honorary Member, George McGee, who has completely recovered from the bout of illness reported at the last Annual Meeting.

(d) Seven study groups have now been established.

3. *Finance:*

(a) M. Brigham gave a brief summary of the financial report. The operating statements show that revenues from *The Canadian Field-Naturalist* balanced expenses but that the Ottawa Field-Naturalists' Club account lost money, the combined figures amounting to a deficit of about $1,000 for the fiscal year ending September 30, 1981. The balance sheet indicates that the Club is in sound financial condition.

(b) P. Narraway asked if the increase in fees would be enough to cover the increase in postal rates. The Council thought it would.

(c) It was moved by W. Cody (2nd P. Hall) that the financial report be approved.

(*Motion Carried*)

4. *Report of Council:*

R. Taylor and D. Brunton read the Report of Council. It was moved by E. Todd (2nd D. Laubitz) that the report be accepted with the following amendments:

- the bird records from A. G. Kingston were from 1890 to 1910
- the National Museum Library is on Walkley Road

(*Motion Carried*)

5. *Motion to Amend the Constitution*

It was moved by D. Brunton (2nd P. Catling) that the Ottawa Field-Naturalists' Club following amendment be made to the constitution of The Ottawa Field-Naturalists' Club, due notice having been given in Vol. 95, No. 3 of *The Canadian Field Naturalist*. D. Brunton read the amended clauses which were discussed and voted upon in order.

(a) Article 8. Officers. The officers of the Club shall be a President, a First Vice-President, a Second Vice-President, a Recording Secretary, a Corresponding Secretary, and a Treasurer. The effect was to add a vice-president.

(*Motion Carried*)

(b) Article 10. Standing Committees. Six standing committees, each consisting of at least six members, shall be appointed by the Council, namely: an Executive Committee, a Publications Committee, an Excursions and Lectures Committee, a Finance Committee, a Conservation Committee, and a Membership Committee. The Chairman of each other standing committee shall be chosen from among the members of Council.

Both Vice-Presidents and the Recording Secretary shall be members of the Executive Committee. The membership of each standing committee shall contain at least one of the Vice-Presidents. The treasurer and the Business Manager of *The Canadian Field-Naturalist* shall be members of the Finance Committee. The editor of *The Canadian Field-Naturalist* and the Business Manager of *The Canadian Field-Naturalist* shall be members of the Publication Committee. The Chairmen of the Excursions and Lectures Committee, the Conservation Committee and the Membership Committee shall have power to add to their committees.

The effect was to increase the number of standing committees from 4 to 6 and to increase the minimum membership of each standing committee from 5 to 6. The committees added were Executive and Conservation.

It was moved by P. Narraway (2nd C. Gruchy) that the motion be amended to include the Awards Committee. (The amendment *carried* by a vote of 26 to 1). The motion as amended was then voted.

(*Motion Carried*)

(c) Article 17. Duties of the Vice-Presidents. In the absence of the President, or at his request, either the First or Second Vice-President shall act in his stead. Both Vice-Presidents shall be members of the Executive Committee. The membership of each standing committee shall contain at least one of the Vice-Presidents. The effect of the change was to outline the duties of both Vice-Presidents.

In response to a question the Chairman said that the Vice-Presidents would be equal in status and that duties would be distributed according to interest and availability.

(*Motion Carried*)

(d) Article 18. Duties of the Recording Secretary. The Recording Secretary shall keep minutes of the proceedings of the Council, the Annual Business Meeting, and Special Business Meetings. He shall give previous notice to each member of the Council of its meeting and to the general membership of the Annual Business and Special Business Meetings. He shall be the custodian of the Constitution and the By-laws and of the records of the Club. He shall be the compiler of the Annual Report of the Council and shall make it available to the general membership at the Annual Business Meeting. He shall receive and deal with proposed motions to amend the Constitution pursuant to Article 23. The Recording Secretary shall be a member of the Executive Committee. The effect of the change was to include the Recording Secretary in the Executive Committee.

(*Motion Carried*)

6. *Nominations*:

D. Laubitz, Chairman of the Nominations Committee, presented the following slate for the 1982 Council. Each nominee was introduced.

President — D. F. Brunton
Vice-President — P. M. Catling
Vice-President — C. G. Gruchy
Recording Secretary — E. F. Pope
Corresponding Secretary — W. K. Gummer
Treasurer — P. M. Ward
Past President — R. Taylor
Council Members:

R. E. Bedford
D. Cameron
B. Campbell
W. J. Cody
F. R. Cook
S. Darbyshire
E. Dickson
S. Gawn
G. M. Hamre
J. A. Jackson
S. Jackson
D. Laubitz
C. R. Leavens
B. M. Marwood
J. K. Strang
K. Taylor
P. S. Walker

It was moved by D. Laubitz (2nd S. Darbyshire) that the slate of nominations be approved.

(*Motion Carried*)

7. *Nomination of Auditor*:

W. Cody moved (2nd J. Gates) that F. M. Brigham be appointed to audit the accounts of The Ottawa Field-Naturalists' Club for the 1981/82 fiscal year.

(*Motion Carried*)

8. *New Business:*

(a) R. Taylor thanked the outgoing Council members and reflected upon the members of Council he had worked with during his term of office. It had been hard work but interesting and rewarding.

D. Laubitz moved a vote of thanks to the outgoing President for his contribution to The Ottawa Field-Naturalists' Club. The motion was seconded by P. Hall and carried with a warm round of applause.

(b) A member suggested from the floor that the reading of Committee reports might be discontinued in future Annual Business meetings since they were printed and available at the beginning of the meeting. She thought this might improve the meeting. In the discussion that followed it was acknowledged that the reading of the reports was dull but important. Some thought that were they not read, members might never take the time to read them. Others thought there might be a legal requirement under the Act by which the Club was incorporated. An alternative suggested was for each Committee Chairman to read his own report. The Council was asked to consider the matter. To guide the Council an expression of opinion was requested. Almost all of those present supported reading the Committee reports.

(c) The new President remarked that the Club has had 56 presidents since its founding and he ranked Roger Taylor with the best of them. The contribution of H. L. Dickson, whose employment has taken him to Alberta, was also given special recognition. The new President thought that an important function of the presidency was to ensure the continuity of the traditions of the Club. In this regard, he thought that James Fletcher, a founder of the Club and president in 1882, would have been proud of us. The challenge for the Club in the 1980s was given in the following quote from Mr. Fletcher's inaugural address: "It is the duty of everyone who takes a true interest in the welfare of his country to strive in every way possible to help the cause of science, and to ensure that no benefits be lost." The President went on to say "Let us all serve our community by becoming the best naturalists we know how to be and by sharing this knowledge."

9. *Adjournment*

It was moved by K. Taylor (2nd E. Dickson) that the meeting adjourn.

(*Motion Carried*)
2130 hours 10.

Following the business meeting a National Film Board film, Images of the Wild, describing the art of Robert Bateman, was run. After the film the meeting moved to Activity Room 3 for refreshments.

E. F. POPE,
Recording Secretary.

Financial Report of the Ottawa Field Naturalists' Club for Fiscal Year 1981-1982

Auditor's Report

To: Members of The Ottawa Field-Naturalists' Club

I have examined the balance sheet of The Ottawa Field- Naturalists' Club as at September 30, 1982, and the related Income Statements for the year then ended. My examination included a general review of the accounting procedures and such tests of the records and supporting vouchers as considered necessary under the circumstances.

In my opinion, these financial statements present fairly the financial position of the organization as at September 30, 1982, and the results of its operations for the year then ended in accordance with generally accepted accounting principles.

January 4, 1982 (Signed) F. Montgomery Brigham

The Ottawa Field Naturalists' Club

Balance Sheet as of September 30, 1982

Assets

Current		
Cash and Term Deposits	$ 67,229	
Accounts Receivable	12,279	
Accrued Interest	1,883	
Prepaid Expenses	905	
		$ 82,296
Fixed-at-cost		
Equipment	1,152	
Less: Accumulated Depreciation	718	434
Total Assets		$ 82,730

Liabilities and Surplus

Current Liabilities			
Accounts Payable		$ 19,935	
Deferred Income		8,197	$ 28,132
Memorial Funds			
Baldwin		198	
Father Banim		50	248
Other Funds			
Seedathon			204
Surplus			
Balance October 1, 1981		52,607	
Expenditure over Income for Year			
The Ottawa Field Naturalists' Club	$ 335		
The Canadian Field Naturalist	19		
	354		
Less: Net Income — Centennial Projects	1,185	1,539	
Balance September 30, 1982			54,146
Total liabilities and surplus			$ 82,730

The Ottawa Field-Naturalists' Club: Statement of Income and Expenditure

for the year ended September 30, 1982

Income			
Apportionment of Membership Fees			
Annual	$ 9,129		
Life	120	$ 9,249	
Trail & Landscape —			
Subscriptions	295		
Back Numbers	127	422	
Shrike Subscriptions		929	
Donations		1,174	
Interest		2,104	
			$ 13,878
Expenditure			
Trail & Landscape			
Publishing	5,074		
Circulation	245		
Editing and Office	203		
Honoraria	520	6,042	
Shrike Publishing and Data Entry		1,232	
Committee Activities — Net			
Excursions and Lectures	465		
Membership	1,019		
Macoun Club	282		
Conservation	104		
Bird Records			
Bird Feeders	94		
Publications	24	1,988	
Affiliation Fees	215		
Baldwin Scholarship	150		
Special Activities	33		
Council Expenses	191		
Office Assistant	351		
Office Supplies and Expenses	1,511		
Computer Charges	1,412		
Miscellaneous	412	4,281	13,543
Excess of Income Over Expenditure			$ 355

The Canadian Field-Naturalist: Statement of Income and Expenditure

for the year ended September 30, 1982

Income			
Apportionment of Membership Fees			
Annual	$ 6,026		
Life	80	$ 6,106	
Subscriptions		16,673	
Publication			
Reprints	5,644		
Plates and Tab Settings	2,517		
Extra Pages	8,698		
Back Numbers	1,994	18,853	
Other			
Interest	7,847		
Exchange	1,675	9,522	$ 51,154
Expenditure			
Publishing	36,303		
Reprints	4,734	41,037	
Circulation		3,916	
Editing and Expenses		502	
Office Assistant		2,340	
Postage		1,623	
Office Supplies		199	
Honoraria		1,518	51,135
Excess of Income Over Expenditures			$ 19

The Ottawa Field-Naturalists' Club:

Statement of Centennial Project Revenue and Expenditure

for the year ended September 30, 1982

	1979-81		1982	
Recording — Song of the Seasons				
Revenue	$12,070		$1,878	
Expenditure	9,068	$3,002	1,529	$ 348
Club Pin				
Revenue	229		30	
Expenditure	1,188	(959)	—	31
Bird Record Cards				
Revenue	196		96	
Expenditure	405	(209)	—	96
Hasti Notes				
Revenue	95		11	
Expenditure	89	6	—	11
Macoun Autobiography Reprint				
Revenue	7,587		510	
Expenditure	10,728	(3,141)	27	483
CFN Index				
Revenue	1,257		162	
Expenditure	10,534	(9,277)	—	162
Club T-Shirts				
Revenue	302		53	
Expenditure	185	117	—	54
Orchids in the Ottawa District		(3,562)		—
Publication of Conference Papers in *The Canadian Field-Naturalist*		(1,700)		—
Projects completed in prior periods		(1,761)		—
Revenue over (under) expenditure		($17,484)		$1,185

Report by Council to The Ottawa Field-Naturalists' Club 1982

This report is made up primarily of reports by Committees of Council. The council has had an active year as will be evident from the following reports.

Awards Committee

1982 was the first full year of regular operation for the Awards Committee. During the early part of the year the Committee was involved in the consideration of nominations for the new internal awards and for Honorary Memberships. Both the Committee and the Council found it a difficult process to select one winner from so many deserving members. The following people were presented with awards at the soirée in April:

Honorary Membership — T. H. Manning
Member of the Year — J. M. Reddoch
Conservation Award — A. W. Dugal
Service Award — E. M. Dickson
Anne Hanes Natural History Award
— P. Hall
— D. Lafontaine
— R. Layberry

A report on the award winners was written for *Trail & Landscape* and appeared with the report on the soirée in issue No. 4. A similar report has been submitted to the editor of *The Canadian Field Naturalist*.

Certificates documenting the presentations in each of the five award categories were designed. The design of the Great Horned Owl done by Brenda Carter, used on the membership cards, was used for a background design. Bill Knight expertly printed a supply of these certificates for all categories. Names and dates were added to the certificates presented this year in the beautiful calligraphic hand of Ann Gruchy. As well as arranging presentation of certificates to winners at the soirée, this year the Committee has also arranged to have certificates sent to past winners of an Honorary Membership.

A number of operational and procedural problems were identified in the first year of normal activity. In the later part of the year many of these problems were discussed and a report on some aspects of procedural policy was submitted to the Council for consideration in January 1983.

(S. Darbyshire)

Birds Committee

The Birds Committee, which is responsible for all bird-related activity within the Club, had another busy and successful year in 1982.

In addition to the popular Christmas Bird Count, Spring and Fall counts were held as well this year. Thanks to the efforts of Bernie Ladouceur, our perennial compiler, there were over 150 participants in this year's Christmas Bird Count, placing us among the top counts in this category.

The second annual Seedathon took place in September and again proved to be a great success. With the backing of a good number of sponsors, the team of Dan Brunton, Bernie Ladouceur and Roger Taylor went all out and managed to find over 100 species of birds on their big day. The money raised will be used to purchase bird seed for the feeders operated by The Ottawa Field-Naturalists' Club or if there is money left over, to fund other Club bird activities.

Three Winter bird feeders were maintained by the Club in 1982: Moodie Drive (Jack Pine Trail), Davidson Road and Pink Road. Mr. & Mrs. Roy Millen, Mr. George McGee, Mr. Bill Miller & The Hull Ornithological Club all assisted in maintaining these feeders. Thanks to last year's Seedathon donations, in the Spring the Club was able to purchase at a sale price, 3000 lbs of feed for the 1982-83 season. The possibility of establishing a new feeder in the Rockcliffe area is being explored.

This year's Owl Census, conducted in early Spring, suffered from a lack of clear, windless nights - the best conditions for hearing owls. A new approach of censusing along prearranged routes, tried for the first time this year could not be properly evaluated. In spite of the problems, over 200 owls of seven species were recorded.

The Bird Records Subcommittee evaluated approximately 30 rare bird reports in 1982. Reports submitted included an outstanding Gray Kingbird, a first record for the area.

The Ontario Breeding Bird Atlas program, coordinated locally by Bruce Di Labio, continues to go well. Over 40 percent of the 10 km squares assigned to the Ottawa region have already been covered in the project, which is slated to run to 1985. To date, nesting has been confirmed for over 100 species in our area.

The Birds Committee was successful in reaching formal agreement with the Regional Municipality of Ottawa-Carleton on access to its property. We are grateful to Works Commissioner, Mr. F. E. Ayers, for granting Club members permission to enter the Nepean dump and the Green's Creek sewage treatment area for the purpose of observing birds. Members may be required to present their membership cards in order to gain access to these sites.

A Bird Hot-Line (a dial-up recorded message giving local bird news and latest sightings) has temporarily been shelved. Due to the unexpected turnover in volunteers to look after such a machine and the installation costs for changing the telephone line, it was felt that the project must await a permanent office for The Ottawa Field-Naturalists' Club.

I wish to thank all members and subcommittees for their efforts in making 1982 an interesting and successful year of birding activity for the Club.

(T. Hanrahan)

Centennial Steering Committee

The Centennial Steering Committee tabled its final report to the Council of The Ottawa Field-Naturalists' Club at the meeting of October 4, 1982. The report was circulated to the Council members, and was discussed and accepted at the meeting of December 13. The report outlines the history of the Committee; briefly discusses every project suggested, whether or not the project came to fruition; and makes a series of recommendations. The background material from all projects was presented to the President for deposition in the Public Archives of Canada. Hue MacKenzie was chairman of this Committee from its inception to its dissolution, and to him must go much of the credit for the success of the centennial celebrations. Those who served on the Committee were: Gerry Audcent, Diane McClymont, Roger Taylor, Diana Laubitz, Jo Ann (Murray) MacKenzie, and Jane Diceman Proulx.

(D. Laubitz)

Conservation Committee

In 1982 the Committee continued its heavy involvement in not only local issues but also issues of provincial and national significance.

National Issues

— The Raccoon Dog question appears to be settled satisfactorily. The Canadian Wildlife Service has negotiated a settlement with Supi Farms whereby all existing raccoon dogs at Madoc will be pelted in December and replaced by a native fur-bearing species. The Committee wishes to thank all those who provided information or otherwise assisted in the satisfactory solution of this problem.

— The Committee has been receiving Environmental Impact Statements and other information relating to oil drilling activities in the Beaufort Sea. The program will continue to be maintained.

— A brief on the planning program in Wood Buffalo National Park was prepared and sent to the Park authorities as well as appropriate naturalists' groups.

— A letter has been sent out concerning the proposed new Bruce Peninsula National Park.

— The Committee has expressed its concerns about the probability that the 1988 Winter Olympic Games site will be moved from Sparrowhawk Mountain to Lake Louise within Banff National Park. No assurance that this will be done has been received from the Ministry of Environment. The Committee has alerted naturalists' groups in Alberta.

— A letter in support of the Friends of the Stikine has been sent out. This group is opposing the construction of a dam on the Stikine River in British Columbia.

Provincial Issues

— Dr. Isabel Bayly, on behalf of Carleton University and The Ottawa Field-Naturalists' Club, organized a wetlands conference in January and prepared a brief on Ontario wetlands policy.

— New Parks for Ontario: The Committee has given complete support to the efforts of the Federation of Ontario Naturalists and allied organizations to call for implementation of the proposals in the Monzon Report, tabled by the Minister of Natural Resources last Spring. Several briefs were prepared and Club members were urged to show their support by writing letters, attending open houses and also attending a public meeting in December organized by the Minister, where two Club briefs were presented.

— Alfred Bog is being threatened by a zoning change from conservation to agricultural land. The Club is actively supporting the Vankleek Hill Nature Society in its opposition via the Ontario Municipal Board to this zoning change. The Nature Reserves Committee of the Federation of Ontario Naturalists has been informed about the bog and it has been suggested to the Federation of Ontario Naturalists that a plan of action to acquire a major portion of the bog should be drawn up. It is hoped that the Nature Conservancy will get involved.

— A letter opposing peat cutting in Westmeath Bog has been sent out.

— Letters have also been sent out opposing the blanketing of entire areas with insecticide spray as a means of controlling the Gypsy Moth.

Local Issues

— Various members of the Committee met with the Deputy Minister of Natural Resources, W. T. Foster, last spring, and communicated to him several local and provincial concerns.

- The Ontario Municipal Board hearing on amendments 12 and 24 to the Official Plan of the Regional Municipality of Ottawa-Carleton took place in June. The ruling handed down contained no reference to evidence presented and concerned itself mainly with compensation to landowners where land is zoned for conservation. The opposition by The Ottawa Field Naturalists' Club to amendment 24 was ignored and it seems that Campeau Corporation is free to develop the South March Highlands.
- Despite Club opposition the City of Ottawa has approved a plan to sell Screech Owl Woods at Billings Bridge to a developer. It may be possible, however, to revive this issue.
- Again despite opposition from the Club and environmentalists the Regional Municipality of Ottawa-Carleton will go ahead with a plan to dump new-fallen snow (less than 48 hours old) into the Ottawa River from Chaudière Island.
- Ontario Hydro plans to install new transmission lines from Kingston to Ottawa to Cornwall. Possible corridors are being explored with various interest groups. Two Committee members, Joyce Reddoch and Vivian Brownell, are representing Club concerns.
- The Committee has pointed out that the site of the proposed Laboratory Waste Transfer Station in Nepean is environmentally unsound. The Department of Public Works is still considering the matter.
- The Committee has called for a complete revision of the recently released Torbolton Forest 20-year management plan. A response from the Club will soon be forthcoming.
- The Committee has provided input into the planning process for a route for highway 416.
- Committee member Steve Darbyshire is the Club representative on the Marlborough Forest Advisory Committee and has communicated their management plans to the Committee.

(R. Taylor)

Education & Publicity Committee

On behalf of the Club, the Committee produced and mounted displays at the following events:

(a) The Annual Meeting and Conference of the Federation of Ontario Naturalists at Kingston, Ontario.
(b) The Wetlands Conference at Carleton University.
(c) The Club's Annual Soirée.
(d) The Duck Club Wildlife Art Show.

Arrangements were made for leaders for outings by senior citizen groups, junior and high school students, Boy Scouts and a visit by members of the Catharine Traill Naturalists' Club and the Montreal Zoological Society.

Again this year The Ottawa Field-Naturalists' Club, coordinated by the Education and Publicity Committee, awarded cash prizes and subscriptions to *Trail & Landscape* to deserving exhibitors in the "Life Sciences" category at the Ottawa Regional Science Fair. For 1982 the winners were: Dawna Duff (Tree Rings and Precipitation), Chris McArton (Whales), Matt Laird and Mike Kenney (Acid Rain: Effects on the Environment). The judges for this event were K. Taylor, S. Gawn and E. Munroe.

Club publications, badges, recordings, etc. were sold by Committee Members (and others) with the proceeds going into the general revenue fund of the Club.

P. Walker resigned as chairman on November 4, 1982, and was replaced by K. Taylor.

(P. Walker)

Excursions and Lectures Committee

The Committee organized 44 excursions including 12 general interest, 9 birds, 5 botany, 1 mushrooms, 1 landscape interpretation, 1 geology, 1 lichens, 1 amphibians and 1 butterflies, as well as 2 special evening events, 4 special bird walks for beginners at 7:30 a.m. in May and 5 general interest evening strolls in May and June. General interest outings have increased in popularity and the relatively large number of these in the program reflects this. Other than an interest in more tree identification and butterfly outings the membership seemed to be well satisfied with the program. The major outings included two trips to Presqu'ile featuring bird migration, a general interest trip to Chaffey's Locks on 8 May, a trip to Nairne Island featuring waterfowl on 14 November and a trip to view the whales and snow geese in the Gulf of St. Lawrence.

As usual there were nine monthly meetings as well as the business meeting. Titles of evening presentations included "Canada's Northernmost Park", "Springtime in the Valley", "Moose, rocks and other wildlife", "Wildlife in the western Himalayas", "Wetland Management and Protection", "Member's Night", the "Excursion by The Ottawa Field-Naturalists' Club to Trinidad and Tobago", "The Ways of the Whiskey-Jack" and "All about Lichens". The attendance at these monthly meetings averaged over 100. The Annual Soirée was a great success. (See article by Peter Hall in *Trail & Landscape*, 16(4): 182-184).

Other excursions have been, or will be, described in

Trail & Landscape; e.g., V. B. Ladouceur and B. M. Di Labio regarding the spring and autumn trips to Presqu'ile, 16(4): 221, 16(5): 225-264 and T. Bedford regarding the trees in winter field trips, 16(3): 136-143.

The Committee extends thanks to all speakers and leaders. The National Museum of Natural Sciences continued to provide a meeting place and other facilities for our monthly meetings and the Museum's dinobus was a very important part of our excursion program. This support from the museum is very much appreciated.

(P. Catling)

Federation of Ontario Naturalists' Conference Committee

At the September 25th meeting of the Board of Directors for the Federation of Ontario Naturalists it was revealed that no site had yet been found for the 1983 Annual Conference. At the October 4th meeting of The Ottawa Field-Naturalists' Club Council, R. Taylor put forward a proposal that the Club host the Conference and hold it at Carleton University on June 3-5, 1983. The proposal was enthusiastically received by the Council and the Club offer to the Federation of Ontario Naturalists was given a similarly enthusiastic reception. Subsequently, Mike Singleton, General Manager of the Federation of Ontario Naturalists inspected the facilities at Carleton University and met with Club representatives to discuss the modus operandi and set up deadlines. A committee of about 12 people was formally approved by Council on 8 November. The following subcommittees have been set up (chairmen in brackets): Program (D. Brunton), Registration (B. Martin), Photo Section (R. Hamaguchi), Exhibits (E. Evans), Exhibit by The Ottawa Field Naturalists' Club (P. Hall). To date an ad for the Winter issue of *Seasons* magazine has been prepared as has the Photo Sector application form which was mailed with that same issue of *Seasons*. The Committee appears to be on schedule for the next deadlines of January 18 (small ads for Spring issue of *Seasons*) and March 10 (registration and program brochure). A tentative program has been approved by the Committee featuring the Ottawa Valley and speakers and excursion leaders are being sought. Robert Bateman is confirmed as the Banquet speaker. A budget has been prepared and is now awaiting approval by the Federation of Ontario Naturalists.

(R. Taylor)

Finance Committee

The Committee held no formal meetings during the year.

Budgets were prepared for the 1982/83 fiscal year for both The Ottawa Field-Naturalists' Club and *The Canadian Field Naturalist*. These budgets were presented to the Council in a statement showing comparisons with estimted expenditures for 1981/82 and actual expenditures for 1980/81.

Both the Club and *The Canadian Field Naturalist* accounts are healthy.

(C. Gruchy)

Macoun Field Club Committee

During the 1981-82 season the Macoun Field Club faced a number of problems that threatened to incapacitate some or all of its activities. This September, with the beginning of the 1982-83 season, several of these problems were resolved and the Club is running more smoothly now. Not the least of its problems was the publication of the *Little Bear*. Material dating back to 1979 was published as Volume 37 and was distributed to the members in September. This season we are trying a newsletter approach to the *Little Bear*. Every two months we collect the submitted material from Club members and combine it with a schedule for the next two months and any news, comments, or correspondence. The material is edited and put together by a senior member, Sonja McKay, and a helpful parent, Louise Manga. The *Little Bear* newsletter is reproduced on a high quality photocopier with the kind permission of Louise LeClaire, Interpretation and Extension Division, National Museum of Natural Sciences. The production schedule has meant that members can see their work quickly and their response has been very positive. It has also allowed production to be spread out over the year rather than being concentrated in May. Two issues of Volume 38 have been published and the third is in production.

As of September 1982 the coordinators for the Juniors and Intermediates are Sharon Gowan, Sharon Smith, and Julia Murphy. As was indicated by the comments of the Macouners at the 1982 soirée, these women are doing an excellent job that is obviously appreciated by the youngsters. Vic Solman has agreed to help with the seniors this year. He has become a familiar figure at meetings and field trips which he misses only when he is out of town. At the 22 October meeting he gave a very lively talk on bird migration. Arnet Sheppard is still helping to a limited extent but has been unable to attend many meetings. Andrew MacFarlane has been busy with other commitments this year although he very kindly found time to take the senior group on a week-end camping trip in mid-November to the Chaffey's Locks area.

This year Jo Ann MacKenzie donated a beautiful pair of 7 × 50 binoculars to the Club. These have been very well received and put to extensive use already.

Daniel Campbell was last year's winner of the W. K. W. Baldwin Award.

Membership for 1982-83 season:
Seniors — 17
Intermediates — 26
Juniors — 32

(S. Darbyshire)

Membership Committee

The total membership of the Club has remained at much the same level as in 1981. A drop of 30 non-local members was offset by an increase of 53 local members. New members joining the Club in 1982 were 192, an increase of approximately 30 over 1981. The total membership in the Club as of December 1982 is 1246, an increase of 23 over the 1981 total of 1223. Family memberships total 295. Based on an average of two members per family we therefore estimate the total membership served by the Club at 1541.

The table shows the membership distribution. The figures in brackets contain 1981 totals.

T. H. Manning, a distinguished member of the Club since 1941 was elected Honorary Member in 1982.

The Club has recently been saddened by the loss of Honorary Members J. D. Soper and R. W. Tufts, both of whom were long time Members.

The 1981 Volunteer List was updated by the addition of 44 new volunteers. These lists are circulated to all Committees of the Club. The volunteers have a broad diversity of knowledge and experience which can be of significant benefit to the Club.

Due to increased postal costs, 1983 membership cards have been mailed with the 1983 membership renewal forms, thereby reducing expenses by approximately $350.00.

The Membership Committee has assumed responsibility for the registration process for the 1983 Conference of the Federation of Ontario Naturalists. Barbara Martin is coordinating this part of the Conference, ably assisted by Ellaine Dickson.

I would like to thank all members of the Committee for their assistance; Roger Taylor, whom I replaced as Chairman in mid term, Ellaine Dickson, Barbara Campbell, Fran Goodspeed, Luella Howden, Vi Humphreys, Barbara Martin, Aileen Mason and Peter Walker. As in the past, Patricia Narraway has continued to oversee our computer programs.

(K. Strang)

Publications Committee

The Chief responsibility of the Publications Committee is to oversee and to advise the Council on all matters relating to the Club's publications.

In 1982 four issues of *The Canadian Field-Naturalist* were published, comprising Volume 95, issue 4, and Volume 96, issues 1, 2, and 3. These were the first issues to appear under the "new" editorship of Francis Cook. Some delay in publication had been occasioned by the transfer of the editorship. These four issues included a total of 496 pages, 40 articles, 36 notes, 78 book reviews and a listing of more than 400 new titles. Amongst the articles was the third in the series on the Biological Flora of Canada. Two associate editors resigned — Dr. David Scott and Dr. Charles Krebs. The Committee thanks these gentlemen for the valuable services they rendered during their tenure. Two new associate editors have accepted appointment — Dr. D. McAllister and Dr. C. Van Zyll de Jong. No financial assistance from fund-granting organizations was required for 1982 or was requested for 1983.

Volume 16 of *Trail & Landscape* with five issues and a total of 264 pages was published. The highlight of Volume 16 was the appearance in issue 1 of the article "Butterflies of the Ottawa District" by Ross Layberry, Don Lafontaine, and Peter Hall for which the authors, jointly, became the first recipients of the Anne Hanes Award for Natural History. The extremely competent editorial staff remained unchanged during 1982. An index to the first 15 volumes of *Trail & Landscape* is being compiled.

Six issues of *The Shrike* appeared in 1982 — Volume 6, issues 5, 6 and Volume 7, issues 1-4. The reporting of bird sightings in the form of graphical and tabular computer printouts, in addition to a written commentary, was continued. With this system a

Ottawa Field-Naturalists' Club 1982 Membership

	Canada		Foreign		
Type	Local	Other	USA	Other	Totals
Individual	476 (439)	323 (340)	80 (86)	5 (5)	884 (870)
Family	264 (247)	29 (33)	2 (3)	0 (1)	295 (284)
Sustaining	15 (14)	2 (3)	0 (0)	1 (1)	18 (18)
Life	13 (15)	16 (15)	3 (3)	1 (2)	33 (35)
Honorary	10 (10)	5 (5)	1 (1)	0 (0)	16 (16)
	778 (725)	375 (396)	86 (93)	7 (9)	1246 (1223)

significant and important data base for bird records in the Ottawa District is gradually being compiled. With the final issue of the year, Tom Hanrahan has replaced Roger Taylor as editor. We thank Roger for his work as editor.

No Special Publications were produced in 1982. Sales of numbers 1 and 2 are continuing, albeit slowly. Preparation of the book on Orchids in the Ottawa District by Allan and Joyce Reddoch, which may appear as a Special Publication, is continuing.

The Publications Committee spent considerable time in reviewing and revising the text of The Ottawa Field-Naturalists' Club's Publications Policy. The many resulting recommendations have recently been reviewed by the Council and a final draft will soon be prepared for publication.

The Publications Committee thanks the editorial and production staffs of all three journals for their continued excellent work.

(R. E. Bedford)

Natural History Study Groups

Four of the study groups (botany, butterflies, photography and sound recording) made excellent exhibits for the soirée in April and it is hoped that this involvement will continue.

The Bird Study Group had several meetings in 1982 and has a number of projects including restricted area bird studies, a waterfowl survey and a winter bird-feeder survey. Approximately 35 come to the regular meetings.

In 1982 the Botany Study Group, organized two tree identification outings, both of which were a great success. A fern identification walk was also organized for the Club. The group had several evening planning meetings. Both of these and the outings were attended by 10-30 people.

The Butterfly Study Group had two spring meetings and a summer field trip. Projects include updating the "Butterflies of the Ottawa District" and a continuing study of larval stages. For 1983 the first butterfly count in Eastern Canada is being planned. There are already 30 in the United States.

The Sound Recording Study Group was very active in 1982 with several meetings and field trips. The Art Study Group was active in the early part of the year but became inactive when the single individual doing the work was unable to carry on. Two study groups were essentially inactive, Photography and Insects.

It has been found that although many people are interested in study groups from the point of view of learning and entertainment, there are few who want to accept the organizational responsibility. It is hoped that the Photography, Insect and perhaps a Mushroom Study Group will find interested persons to take a leadership role.

Although members have expressed interest in invertebrate, fossil geology, ichthyology, interpretation and mammal study groups, the number of people in all cases is too small to form a group as yet.

JOSEPH DEWEY SOPER, 1893-1982

One of Canada's great modern-day explorers and naturalists, J. Dewey Soper, died on 2 November 1982, after repeated periods of illness. He is survived by his wife, Carolyn, a son, Roland and a daughter, Mary Lou.

During his long career Dr. Soper made numerous significant contributions in the field of natural history in Canada and firmly established a reputation as an explorer, naturalist and writer.

Dewey was born on 5 May 1893 near Guelph, Ontario. As did many of his contemporaries who went on to distinguish themselves in nature study and wildlife management, he started as a farm boy with an interest in nature. With money made from trapping, he purchased bird books and binoculars so that he could further his studies. Discouraged by his parents from becoming a professional trapper, he became a journeyman carpenter like his father, a skill which was to serve him in good stead later when establishing outposts in Canada's eastern Arctic. However, his love of nature could not be submerged, and by the time he was 21 years old he had resolved to make nature his profession. He was influenced at that time by W. B. Saunders of London, Ontario, and Rudolph Anderson and Percy Taverner of the National Museum of Canada in Ottawa.

During the winters of 1921, 1922 and 1923 he attended the University of Alberta in Edmonton, where he studied zoology under Dr. William Rowan. In the summer of 1923, Rudolph Anderson arranged for his engagement as naturalist on the patrol vessel *Arctic* under the famous Captain Bernier. He departed in July from Quebec City and returned in October after visiting Greenland, Devon Island and Baffin Island. Having demonstrated his competence on that venture, he was rehired by the National Museum to conduct a two-year Baffin Island Expedition with headquarters at Pangnirtung. He arrived there in July 1924 and spent the first winter travelling westward to Nettilling Lake, where a headquarters camp was established and the lake and its environs were explored. The following winter he continued explorations in the same area and, after a return to Pangnirtung, undertook a long sledge journey to Cape Dorset, exploring and collecting museum specimens enroute. Visiting his family in Alberta after his return he met Carolyn K. Freeman, a young nurse, whom he married the following spring. That winter he wrote the manuscript for the faunal investigation of southern Baffin Island that appeared in print as a National Museum bulletin in 1928.

The summer of 1927 was spent conducting a mammal survey along the Canada-USA boundary from the Rocky Mountains to Turtle Mountain in Manitoba. He returned to Alberta in time for the birth of his son, Roland, in December.

Because the National Museum was unable to provide him with permanent employment, he accepted an offer from the NWT and Yukon Branch to conduct further investigations on Baffin Island, with a special assignment of discovering the nesting grounds of the blue goose. Leaving his family behind, he once again

Dr. J. Dewey Soper, dressed for wilderness exploration, at Pangnirtung, Baffin Island, during the winter of 1924-25.

Dr. J. Dewey Soper upon return to Cape Doset after surveys run to Nuwata across the interior of Fox Peninsula and from there east to Ungmaluktuk Lake and south to Gordon Bay during March 1929. University of Alberta Archives photo 79–21–34: 1579.

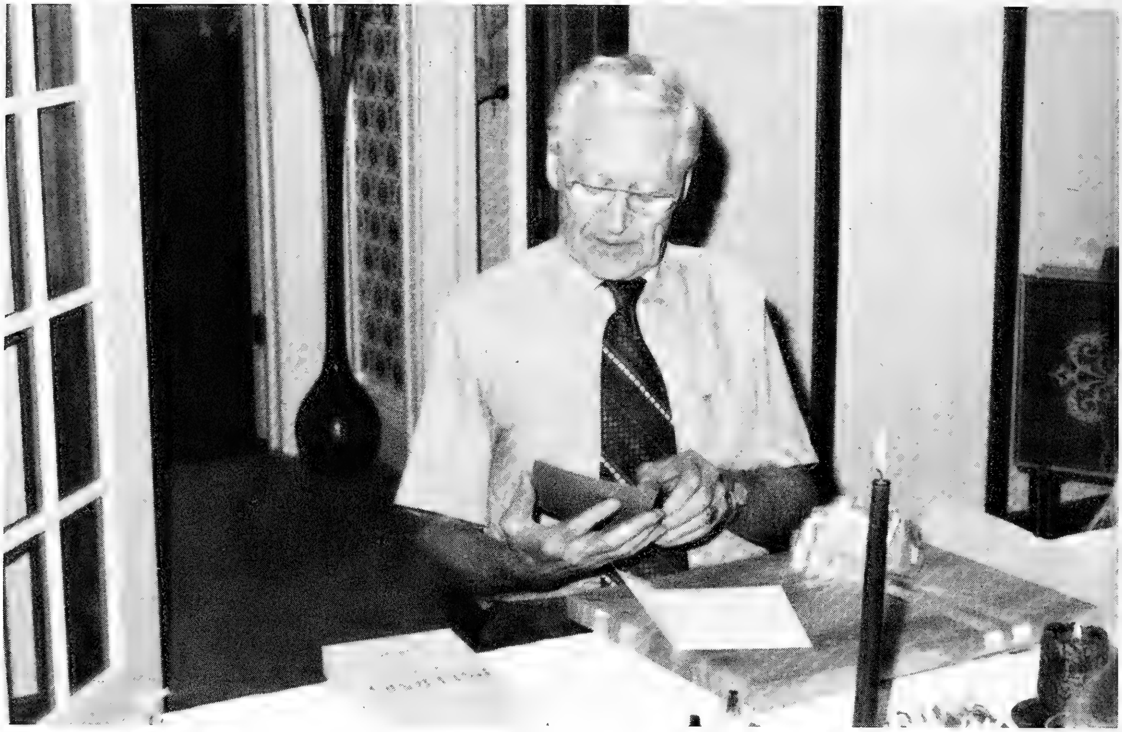
sailed to the Arctic, spending the winter of 1928-29 in the exploration of the coast of Foxe Basin as far north as Bowman Bay and Hantzsch River. Following advice provided by the Eskimo, he returned to Bowman Bay the following summer and confirmed that area as a major nesting ground for the blue goose.

In the summer of 1930 he brought his wife and infant son to Lake Harbour on Baffin Island where he and his Eskimo helpers built a proper home for them. From 1930 to 1932 the family lived in Lake Harbour while Dewey conducted zoological and botanical investigations and did topographical surveys. A self-taught surveyor, he established surprisingly accurate map points and made meticulous sketches of the coastline of southern Baffin Island and its hinterland.

Recalled to southern Canada in 1931, he was assigned to conduct a two-year wildlife study of the Wood Buffalo Park, with special reference to the herds of Bison found there. A monograph about the Bison and several papers about the physical geography and the wildlife of the park were later published.

A daughter, Mary Lou, was added to the family in 1934. Dewey, accepting the necessity for a more ordered life, was appointed as the Chief Federal Wildlife Officer for the Prairie Provinces in July 1934, one of four such officers in Canada at that time. His headquarters were in Winnipeg, and he spent the next 14 years there fostering the protection and conservation of migratory birds, never forgetting, however, his interest in the other fauna and flora of the province. Later he published a paper on the mammals of Manitoba.

The Canadian Wildlife Service was established in



Dr. J. Dewey Soper on his 81st birthday, 5 May 1974.

1947, and in the expansion of staff that followed, Dewey was transferred in 1948 to Edmonton as the Chief Federal Migratory Birds officer for Alberta, Yukon and the Northwest Territories. During the summer of 1949 he travelled extensively in the western Arctic and the following summer went to the Yukon. In 1951 he retraced part of his route in the Northwest Territories in aid of establishing areas of sanctuary for migratory birds.

In 1952 Dewey retired from CWS after 29 years in the service of the wildlife of Canada. The rest of his life was spent in Alberta.

Retirement, however, did not slow his activity. He continued in summer to collect birds and mammals for the zoology museum of the University of Alberta and for the National Museum of Canada. His book, *The Mammals of Alberta,* appeared in 1964, and mammal lists of Jasper and Waterton Lakes parks were published subsequently. Finally in 1978 he donated his journals and field reports to the University of Alberta and his books and Arctic photos to the Boreal Institute.

There are many things to remind Canadians of the accomplishments of J. Dewey Soper. Maps of Baffin Island show the Soper Highlands, Soper Lake, Soper River and Dewey Soper Migratory Bird Sanctuary at Bowman Bay. The taxonomic literature lists three mammals (Vagrant Shrew, *Sorex vagrans soperi* Anderson and Rand, 1945; Heather Vole, *Phenacomys intermedius soperi* Anderson, 1942; Ringed Seal, *Phoca hispida soperi* Anderson, 1943) and one beetle (*Pterostichus (Cryobius) soperi* Ball, 1966) named in his honor from among his lifetime collection of over 10 000 specimens of mammals, birds, insects and plants. The more extensive scientific and popular literature contains two books and about 90 articles that he published. His interest, however, ranged far beyond scientific publications. His concern for informing the public about natural history was demonstrated by his 30 newspaper articles in the *Montreal Family Herald and Weekly Star, Guelph Evening Mercury, Edmonton Journal, Ottawa Citizen, The Albertan,* and others.

Dr. Soper was also an accomplished artist. Many of his sketches were published in his books and papers. Watercolours from his travels in the Arctic were published in L.H. Neatby's translation of B.A. Hantzsch's *My Life Among the Eskimos* (Institute of Northern Studies, University of Saskatchewan, Saskatoon, 1977).

Dr. Soper received a number of awards. The Natural History Society of Manitoba presented him with its Bronze Medal for his 1941 monograph on the northern Bison. The University of Alberta awarded him an honorary Doctorate in 1960, and in 1972 the Premier of Alberta gave him an Achievement Certificate on behalf of the Province of Alberta. The NWT Commissioner in 1978 presented him with a certificate and plaque for his significant contributions to science and exploration, and the Canadian Nature Federation gave him the Pimlott Conservation Award in 1980.

Dewey Soper was a modest man with boundless energy and enthusiasm for nature in all its forms. Meticulous in his field studies and literate in his reporting, he has left a legacy for other Canadians that will be difficult to emulate. He will be missed by all those whom he inspired and befriended.

W. E. STEVENS and GEORGE W. SCOTTER

Canadian Wildlife Service, 9442-108 Street, Edmonton, Alberta T5K 2J5

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GEORGE W. SCOTTER

Canadian Wildlife Service, 1000, 9942-108 Street,
Edmonton, Alberta T5K 2J5

Book Reviews

ZOOLOGY

The Emergence of Ornithology as a Scientific Discipline: 1760-1850

By Paul Lawrence Farber. 1982. D. Reidel Publishing Company. Boston. xxi + 191 pp., illus. U.S. $39.50.

Paul Farber's book on the emergence of ornithology in Europe traces the developing knowledge of birds as a subject of serious study from the mid-18th to the mid-19th century. The author indicates clearly the major change from the restricted study of private natural history collections, consisting mostly of objects of curiosity or the results of collecting mania of wealthy individuals, to natural history museums with extensive study collections where scientific investigations could be pursued. During the same period improved printing techniques and the development of natural history illustrations produced an increasing number of bird books of popular appeal. Scholarly works, aimed at other specialized natural historians, also proliferated.

Farber discusses in some detail the colonial expansion of several European nations which, in addition to voyages of scientific explorations, enabled naturalists to acquire large numbers of plant and animal specimens. The organization and classification of birds occupied most, but not all ornithologists of the early 19th century. Naturalists of that period were striving to uncover the existing order in nature. With the influx of an unprecedented number of natural history specimens from "exotic" places (such as Africa, South America, Australia) cataloguing had to be carried out along specialized lines. According to Farber the increased amount of empirical data available during the first few decades of the 19th century prompted specialization along taxonomic lines and speeded up the transformation of natural history into specialized disciplines. Ornithology was merely one of these specializations.

Farber overemphasizes the importance of the large data base and the impetus this had on the emergence of ornithology. As he sees it the central event in ornithology during the 1800-20 period was the focus on classification. While it it evident to readers of the book that naturalist-ornithologists in Europe took advantage of the availability of a large number of new bird specimens, other aspects of ornithology also had their practitioners. This was particularly true in Germany and in England where ornithological studies of local and regional nature flourished. These, and what the author terms other "minor" traditions, such as the study of anatomy, morphology, migration, life history, are not adequately developed in the book. While Farber mentions some of the active practitioners of these minor traditions, such as Nitzsch in anatomy and Verreaux and La Fresnaye in life history, it is obvious that he does not consider them as important as taxonomists from Brisson to Bonaparte. This slant gives an unbalanced treatment to the development of ornithology in Europe.

In his chapter on the "Emergence of a Discipline" the author discusses some of the results of the upsurge of ornithological activity in the early 19th century. At that time there were over thirty natural history societies which had mémoirs, proceedings and transactions where ornithologists could publish their findings. There were also some general natural history journals. Attempts at establishing exclusive ornithological journals in Germany are not even mentioned. Again Farber stresses that the central questions of ornithology emanated from classification, but also quotes a work by British naturalist-zoologist Hugh Strickland (1845) which considered ornithological developments in Europe on a much broader base, including such areas as fossil birds, regional avifaunas, anatomy and morphology. Unfortunately Farber does not consider any research questions emanating from these aspects of ornithology. He uses ornithology as a case study in the transformation of natural history to a number of modern scientific disciplines. It is debatable however, whether in 1850 ornithology can be regarded as a discipline. It was certainly a well defined specialization within natural history. It had a growing number of practitioners and some clear goals and methods. It would have been enlightening to know what facilities were available for practising ornithologists of that period to pass on their knowledge and expertise to younger people. Was there a custom of apprenticeship? How many of the ornithologists had medical training? Were they self-educated specialists? Some statistical comparison with other branches of natural history would also have been helpful in evaluating this process of development.

Its shortcomings notwithstanding, this is an informative, well written book. It will be enjoyed by general naturalists, specialists and historians. The unfortunately high price of the book may deter otherwise interested Canadians from buying their own copy.

MARIANNE GOSZTONYI AINLEY

History and Philosophy of Science Program, McGill University, Montreal, Quebec H3A 1B1

A Field Guide to the Birds of East Africa

By J. G. Williams and N. Arlott. 1980. Collins, London, England. 415 pp., illus. $44.95.

Darwin spoke of his "unornithological eyes." By that standard I must be called bird-blind. Nevertheless, I have been able to make enjoyable progress with a new fauna with the help of this recently-updated field guide. It lacks range maps, but is otherwise in standard "old-style" format. Over 600 species (usually adult males only) are given small but attractive illustrations in forty-eight colour plates clustered at the centre of the book. However, because there are so many species to cover, almost as many again receive no illustration at all but only a bare mention under "allied species." The notes are perceptive and often very helpful in the field, but again, tend to cover only the more common residents. A separate guide to Palearctic birds (for migrants), and perhaps another for tropical sea birds would be useful complements. My copy has so far proved resistant to the rigours of life in a tropical backpack. The book should be considered essential equipment for any naturalists' safari to east Africa (in a broad sense: Zimbabwe and Mozambique to Ethiopia, but not Madagascar). Armchair birders might also enjoy it, if they are not put off by the price, although this is no substitute for seeing a Carmine Bee-Eater on the wing.

JOHN MIDDLETON

Department of Botany, University of Dar es Salaam, P.O. Box 35060, Dar es Salaam, Tanzania

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Ecology and Biology of the Pacific Walrus, *Odobenus rosmarus divergens* Illiger

By Francis H. Fay. 1982. United States Department of the Interior, Fish and Wildlife Service, Washington, D.C. North American Fauna, Number 74. vi + 279 pp.

In 1952, when Bud Fay began field work for his landmark study of the Pacific walrus, it was widely feared that this animal was "on the road to extinction." Since that time, however, owing largely to protective measures implemented by both the United States and the Soviet Union, the population has made an impressive recovery. In his monograph, Fay concludes: "The Pacific walrus population at present seems to be very large, very productive, and very secure under the current harvest system." This is good news.

The main cause for concern, according to Fay, is that the future of the Pacific walrus continues to hinge on cooperative, or at least complementary, management by the United States and the Soviet Union. In their annual migration between the Bering Sea and the Chukchi Sea, the walruses "transcend international boundaries." Thus, not only must both superpowers agree to limit harvests to sustainable levels, but if the idea of ecosystem management is ever to be approached, it will require that they actively promote and support large-scale research projects involving scientists from the two countries. One of the many strengths of Fay's treatise, and indeed his career, is that he consistently strives to integrate, compare, and evaluate the work of Soviet colleagues with his own and that of other Western researchers. In a bibliography comprised of some 350 titles, there are at least 67 written by Soviet authors and published in the Soviet Union.

Considering the vast number of walruses killed over the years for sport, profit, and subsistence, surprisingly little is known about their basic natural history. There has been much speculation about the function of the walrus' tusks. They are not, as is so often alleged, used principally for digging up clams and other prey from bottom sediments. In fact, Fay marshals a convincing argument against any major role of the tusks in food procurement: "The characteristics of the skin on the face, the abraded surfaces of the vibrissae, and the abrasion of the tusks all indicated to me that digging, if done at all, is accomplished by 'rooting' with the upper edge of the snout, rather than with the tusks." Direct observations by Fay and others (e.g. E. H. Miller. 1975. Walrus ethology. Part I. The social role of tusks and applications of multidimensional scaling. Canadian Journal of Zoology 53: 590-613) have demonstrated that the tusks play an important role in establishing and maintaining dominance relationships within walrus herds.

Then how *do* these animals feed? According to Fay, the walrus probably roots along the sea floor, feeling for mollusks and other invertebrate prey with its muscular rostral pad and mobile mystacial vibrissae. He likens the efficiency of these organs in "sorting, selecting, and manipulating materials" to that of a pair of human hands. Normally, only the feet and siphons of bivalve mollusks are consumed. Once found and selected, a clam is grasped firmly with the lips while a powerful "vacuum pump" formed inside the walrus' mouth enables it to suck, not bite or tear, the desired fleshy parts away from the shell. "Although many of the details of the actual search and ingestion process will remain obscure until the animals can be closely observed under natural conditions, the important factors now appear to be the strong, sensitive snout and oral suction, rather than the eyes, tusks, and crushing teeth."

The book is tightly written and sensibly organized, qualities reflecting not only a competent author but the kind of first-rate editing that is to be expected from this prestigious monograph series. Fay is scrupulous about defining terminology: two entire subsections are devoted to definitions — one for dentition and one for reproduction. Methodology is explained in detail. Well-tested hypotheses are clearly differentiated from well-conceived but as yet untested opinions. Fay not only draws on a wealth of first-hand experience with his subjects — living and dead, in the field and in captivity — but he frequently incorporates the observations and views of other investigators. For example, in an excellent month-by-month summary of the Pacific walrus' distribution and migration, he cites over 45 published titles, 56 "personal communications" from 24 different individuals, and his own and Karl Kenyon's "unpublished data." No effort has been spared in providing graphic support for the text. The 138 figures, slightly more than half of which are photographs, are carefully chosen and, for the most part, clearly reproduced.

Fay's Ph.D. thesis — *The Pacific Walrus: Spatial Ecology, Life History, and Population* — was completed at the University of British Columbia in 1955. It took another 27 years for this polished, comprehensive description of the species to emerge, but it was well worth the wait. As a case-study of a species' morphology, functional anatomy, life history, and ecology, Fay's walrus monograph will serve a useful purpose in college classrooms and seminars. It is and will long remain an essential reference for professionals concerned with the management of Arctic marine mammals.

RANDALL R. REEVES

Box 99, Como, Quebec J0P 1A0

Handbuch der Vögel Mitteleuropas: Volume 9, Columbiformes -Piciformes

By Glutz von Blotzheim, Urs N., and Kurt M. Bauer. 1980. Hard cover binding. Akademische Verlagsgesellschaft, Wiesbaden, West Germany. 1148 pp., illus. 208 DM.

This is the ninth volume of the high quality handbook series on the birds of central Europe. This volume deals with the Columbiformes, Cuculiformes, Strigiformes, Caprimulgiformes, Apodiformes, Coraciiformes, and Piciformes of Europe, of which 42 species are treated. The 37 nesting species have been given a particularly extensive coverage. The overall quality of the previous 8 volumes has been retained here and the thickness of the book exceeds much that of all the others which makes one fear for the binding if used much as it well deserves it. The line drawings by F. Weick are of very good quality and very accurate. Each order, family and genus is briefly introduced with taxonomic or nomenclatural considerations. Keys to genera and species are provided where applicable and the following coverage is given for each species: range of the species (Verbreitung der Art), subspecific treatment (Rassengliederung), field marks (Feldkennzeichen), description (Beschreibung), molt (Mauser), song (Stimme), nesting (Brutgebiet), distribution in central Europe (Verbreitung in Mitteleuropa), migration (Wunderungen), habitat (Biotope), breeding (Fortpflanzung), food (Nahrung), and references (Literatur). Numerous sonagrams are used throughout the text. A bibliography of food habits is given and should be useful particularly to those interested in owls.

The taxonomy is up-to-date although one may not always agree with the classification used, particularly in this case with the inclusion of the genus *Dendrocopos* in *Picoides,* for no valid reason. The literature coverage appears to be as complete as it could be in an extensive treatise of this quality and numerous checks have revealed that only one reference cited in the text is missing from the list of references. The parts dealing with identification and behavior are extensive in their coverage and yet concise.

In spite of its high price, this volume (and the whole series) is well worth the cost and I strongly recommend the series to those who need to obtain a great deal of information about Palearctic species breeding in central Europe without having to do an extensive literature survey. Again the authors and their associates are to be congratulated for their excellent work.

HENRI OUELLET

National Museum of Natural Sciences, National Museums of Canada, Ottawa, Ontario K1A 0M8

Annotated Checklist of the Birds of Arizona.

By Gale Monson and Allan R. Phillips. 1981. Second edition. University of Arizona Press, Tucson. 240 pp. U.S. $5.95

This inexpensive, pocket-sized book should be of interest to Canadians because it serves in many respects as a model for other states and provinces and because it is ideal for use during birding visits to Arizona, one of the most popular states for birders. Here C. Hart Merriam first recognized and named his Life Zones nearly a century ago and here one can travel the same day from 43 m above sea level to 3862 m at the highest mountain peak, passing successively through the Lower Sonoran, Upper Sonoran, Transition, Canadian, Hudsonian and Arctic-Alpine life zones. One meets new bird species in each zone, equivalent to travelling thousands of kilometers to the north. Arizona is equally a meeting place for eastern and western species– where else can you find all three North American species of bluebird nesting?

This list updates *The Birds of Arizona* by the same authors (and Joe Marshall) and the first edition of their companion checklist, both published in 1964. Gale Monson's contribution is a careful, succinct compilation of new records, which tell of changing patterns of bird distribution and abundance and also reflect the great increase in birding activity in the past 20 years. Fifty-five new species have been added, bringing the total of fully accepted species to 477, in addition to 32 hypothetical species. Allan Phillips tells us why stringent criteria are necessary before a new species can be added to a state list; amateurs and scientists alike should read his explanation of the value of specimens as a source of reverifiable data.

Phillips differs from the American Ornithologists Union in his treatment of some taxonomic matters; for example he considers the Nashville, Virginia and Colima Warblers as one super-species, but splits the western or "Patterned" Towhee as a species separate from the Rufous-sided Towhee. Phillips places heavy emphasis on subspecific determination of specimens, and an appendix serves as a slightly unconventional place to summarize Phillips' life-long sorting-out of the many races of Red Crossbills, including the description of two new subspecies.

There are seven pages of helpful maps, but space precludes a bibliography; for several species breeding status is only inferred from terms that lack the clarity and precision that characterizes the rest of this book. An index provides quick access to any species. No typographical errors were detected. This is an excellent buy for anyone interested in bird distribution.

C. STUART HOUSTON

863 University Drive, Saskatoon, Saskatchewan S7N 0J8

Birds of Oak Hammock Marsh Wildlife Management Area

By Kenneth A. Gardner. 1981. Manitoba Museum of Man and Nature, Winnipeg. 172 pp., illus. $10.50

On the prairies where "improved" in agricultural parlance means "brought under cultivation," and where wildlife habitat continues to be lost at a frightening rate, it is rare to have a wetlands area restored, and even less common to have good studies of bird life before and after the restoration. Although A. G. Lawrence, in his weekly "Chickadee Notes" in the *Winnipeg Free Press,* in 1923 recommended preservation of what is now known as Oak Hammock Marsh, government planning did not begin until 1967. Construction began in 1972, with funding by the Manitoba Department of Mines, Resources and Environmental Management, by the federal Fund for Rural Economic Development, and by Ducks Unlimited. Fourteen miles of dykes were built, restoring 3500 acres of marsh containing numerous artificial islands, with the ability to control water levels separately in each of three cells. There are also 5000 acres of upland habitat.

Fortunately, Ken Gardner of nearby Stonewall had personal records for the area dating back to 1947, and his brother Irvine's dated back to 1935. An interested farmer, D.T. Mollard, with a bird-feeding station, lived within the area. Since restoration of the marsh, only 15 miles from the northern edge of Winnipeg, it has been an attraction for an increasing number of birders. Ken Gardner, editor of the "Wild Wings" column in the *Winnipeg Tribune* for 20 years, has done a fine job in amalgamating all available records since 1935, and has contributed his own comparative counts of bird numbers before and after restoration. Gardner's dedication is to the memory of Al Pakulak and Claude Holmstrom, who died in 1973 while carrying out a waterfowl census of the area by helicopter.

Gardner has provided much more than the title implies, for he presents an up-to-date compendium of rare species records for all of Manitoba. The book is sumptuously illustrated with 12 pages of colour photographs, averaging four to a page by Andy Lindsay, Robert R. Taylor, Barry N. Verbiwski, Harold Hosford and others, together with three attractive maps and six black-and-white photographs.

Not surprisingly, wetland birds are now present in greater diversity and numbers, while the Sedge Wren and upland species such as the Sprague's Pipit and some sparrows have decreased. Pintails are remarkably common, constituting 73% of duck broods before restoration and 57% of duck nests found in May and June after restoration. Piping Plovers, perhaps in response to high water levels on Lake Winnipeg that year, had four nests on gravel roads and parking lots in 1974 and one nest there in 1975.

There is inconsistency in the handling of species whose breeding range begins in mixed forest not many miles to the east and north of Oak Hammock. It is misleading to say that the Goshawk and Swainson's Thrush are "within the breeding range" and to omit any statement for the Ruby-crowned Kinglet; I prefer the statement "on the periphery of the southern Manitoba breeding range" as given for the Brown Creeper and Winter Wren. The historical status of some species including Sandhill and Whooping Cranes and the Passenger Pigeon is adequately presented, but available information on the increase with early settlement of such species as the Greater Prairie Chicken, Mourning Dove, Western Kingbird, Barn Swallow and the later spread of the Mountain Bluebird in southern Manitoba is not cited. The attractive maps fail to show the location of the interpretive center, the three parking lots and the observation hummocks. "Grant's Lake," stressed in the text as a former goose staging area, is not shown on any map. One "nonsense sentence" under Sprague's Pipit and a few typographical errors slipped by the proof-readers.

In summary, this handsome, well-planned and well-written account is highly recommended. It proves that regional bird lists are still useful.

C. STUART HOUSTON

863 University Drive, Saskatoon, Saskatchewan S7N 0J8

BOTANY

Trees and Shrubs of the Dominion Arboretum

By A. R. Buckley. 1980. Publication 1697, Agriculture Canada, Ottawa. xii + 237 pp., illus. $19.95 in Canada, $23.95 elsewhere.

This book, according to the introduction, "is intended as a guide for homeowners, gardeners, and nurserymen." Based on observations at the Dominion Arboretum in Ottawa, in some cases from records dating back to the nineteenth century, it provides horticulturally oriented descriptions, evaluations, and performance records for over 2000 taxa of woody plants (including many cultivars). Emphasis in evaluations is on effect in the landscape and on hardiness, with comments on other aspects, such as susceptibility to disease, included where appropriate. Such records, of course, will be useful for selecting ornamental trees and shrubs in much of Canada.

The taxa listed include both angiosperms and gymnosperms, ranging from marginally woody species to large trees. Many are decidedly uncommon in cultivation. Some of these, nevertheless, have performed well in Ottawa and have shown excellent ornamental properties; this book should contribute to greater appreciation and use of these taxa. Naturalists will be pleased to see many native species included, although they are greatly outnumbered by exotics and cultigens.

High standards of scholarship are evident throughout this work. Taxa are listed only if the identity of the plants has been confirmed and they are represented by specimens in the herbarium of the Biosystematics Research Institute. Nomenclature is based on modern, reliable references, and the orthography of the scientific names conforms well to the codes of nomenclature for botany and for cultivated plants.

All persons involved in the production of this book have done their work well. The text is attractively printed on high-quality paper, and the proofreading has been thorough. The illustrations, all photographs, are numerous and well chosen. There are close-ups and illustrations of habit, taken at different seasons of the year, according to the horticulturally important characters of the respective taxa. The 216 colour illustrations are especially excellent. All are sharp, with true colours.

In summary, this is a very well executed work, containing a great deal of information on hardy woody ornamentals, and should be a standard reference for Canadian horticulturists. It is, therefore, a good buy at $19.95.

JAMES S. PRINGLE

Royal Botanical Gardens, Box 399, Hamilton, Ontario L8N 3H8

Ferns and Allied Plants: with Special Reference to Tropical America

By Rolla M. Tryon and Alice F. Tryon. 1982. Springer Verlag, New York, Heidelberg, Berlin. xii + 857 pp.,illus. U.S. $148.00.

This splendid volume brings together a wealth of information on morphology, systematics, ecology, geography, spore morphology (SEM), cytology, phytochemistry, experimental biology and the relevant literature for 29 families and 127 genera of the pteridophytes in the New World. The book is greatly enhanced by superb photographs of selected species in their native habitat and large numbers of photographs of the surface of spores using scanning electron microscopy. The book is exceptional in its quality of illustration and organization. The families and genera are numbered and these are keyed to the illustrations, so one can easily move about in the book without constant recourse to the index.

The authors have been very "even-handed" for each of the 127 genera. It must have been tempting when considering some of the larger genera, e.g. *Asplenium*, *Dryopteris*, *Lycopodium*, etc. to greatly expand sections at the expense of some of the smaller and rarer genera, many of which have received little study or publicity. This would have lead to a multi-volume treatise which would have been less compact and concise.

Many Canadian readers will consider *wrongly* that tropical pteridophytes are irrelevant to their interests. But as the authors point out, of the 3250 species in America (9000 in the world), 3000 occur in the tropics. There are only 8 small genera without representation in the tropics. Accordingly, any serious student of this group will find most of the diversity and most of the material in the tropics. Viewed this way our Canadian species are outliers, and their ancestors and evolution can be understood only if we look at the whole array of variation. In fact, Canadians will find much information in this book about plants that grow in Canada. The reader will feel at home with genera such as *Cystopteris*, *Dryopteris*, *Polystichum*, as well as *Lycopodium*, *Selaginella*, *Isoetes* and *Equisetum*. Many of our species are mentioned as well.

Today, when segregate genera and segregate species are appearing daily, it is refreshing to see a treatment that attempts to classify the ferns by grouping those that have many similarities in common, rather than emphasizing differences. At the same time, it is sobering if one thinks that one can recognize an *Asplenium* at a glance, to see the amazing variation in the architecture of the blade for different species (p. 639). This diversity is apparent and well illustrated for many other genera, e.g. *Notholaena*, *Adiantum*, *Grammitis*, *Lindsaea*, and is a striking characteristic of most large genera. This is a snare to the uninitiated!

I find the book most worthwhile and useful when one is able to go directly to the genus in question. One would have problems with an unknown plant. The keys to the families (pp. 22-24) I found very difficult (try Polypodiaceae, p. 23 under (j)); and the early material (pp. 1-24) goes by very quickly. There are no easy routes or short-cuts to the genera.

Scholars will find the book a goldmine for references in all the areas mentioned at the beginning of this review. In this sense the book is like a giant encyclopedia. The book is, however, more than a compilation of published works. It is a synthesis of the ideas concerning classification, and therefore the evolution of these plants. Since the authors know these ferns, having examined the world-wide collections and studied many genera in detail, e.g. Tree Ferns, *Pellaea*, *Doryopteris*, *Pteridium*; it is extremely worthwhile to have a record of their conclusions about affinities on the one hand, or even of their uncertainties about the position of many of the genera and some of the species, on the other hand. It is also apparent that much remains to be done. The authors have not left us with simplistic solutions! Problems abound in all the genera and the surface has only been scratched. For example, only 20% of the pteridophytes have been examined cytologically.

To many, a Pteridologist is already a specialist. At the same time, to fully understand any of the 127 genera in this book will be a large task given the diverse tools of modern biosystematics. The Tryons have made a fine start, and have shown us the right directions to proceed.

Many will find the price inhibiting, although when one sees all the illustrations, the references, and reads the factual, concise text, there is no question that one is getting full value. I hope this book will become available in libraries, especially for students and those who wish to broaden their horizons concerning this marvelously diverse group of plants.

DONALD M. BRITTON

Department of Botany and Genetics, University of Guelph,
Guelph, Ontario N1G 2W1

ENVIRONMENT

Man and Wildlife in a Shared Environment

Edited by Roy Vontobel. 1982. Canadian Wildlife Service, Ottawa. 55 pp., illus. Free, one per request.

The Canadian Wildlife Service is the principal wildlife agency in Canada doing wildlife research and management. The book reviewed here is a handsome statement from that Service about its more important programs, projects, and philosophies. It is a thin, magazine-type book of some 55 pages heavily illustrated with 84 photographs and maps, most in full colour. The photographs, all good to excellent with many quite spectacular, are a visual feast with unusually informative captions. These alone would more than justify the publication. The text is an organized collection of short, lucid accounts of wildlife problems, studies, and values currently of importance.

True to the tradition of North American wildlife agencies in government, this book contains a strong emphasis on large mammals and birds. In this respect the photographs are less biased than the text, showing a reptile, an insect and many small birds. Criticism is not intended here; simply noting a fact of wildlife priorities in Canadian governments. Since its formation the Canadian Wildlife Service has in fact been the national leader in both the breadth and depth of its wildlife interests and priorities, but provincial biases still must influence its priorities.

This book deserves high marks as a popular and attractive interpretation of the Service's activities and concerns. Not that it is perfect; no publication can please everyone. Some accounts of research and habitat issues indicate sources of additional information, for which full marks cannot be given since others give no hint at all where the newly interested can learn more. A few general references at the back may help, but there is some evidence here of not thinking through the purpose of the book, a not uncommon oversight. This book will "hook" the "converts," but they are not often shown how to pleasantly feed their new appetite.

Small oversights aside, you can sit down with this small book for a quick and enjoyable update on much of the nation's wildlife research. The Canadian Wildlife Service is still there, is still getting things done, and still needs much more support from the Canadian people. This book should help to find some.

Copies are free, one to a customer while they last.

YORKE EDWARDS

British Columbia Provincial Museum, Victoria, British Columbia V8V 1X4

Microcosms in Ecological Research

Edited by John P. Giesy, Jr. 1980. United States Department of Energy Symposium Series #52. National Technical Information Service, Springfield, Virginia. 1112 pp., U.S. $54.

This substantial volume consists of fifty papers given at a symposium held in Georgia in November 1978. The apparent topic is use of microcosms in the study and regulation of pesticides, but in fact the discussion ranges widely over many aspects of ecological theory and practice. The editor has used a very light hand, and there are many paragraphs, pages, and at least a few whole papers that would have been better omitted. Nevertheless, in spite of some shallow rationalization and unconvincing philosophies, there is much of interest.

There is only vague agreement over what should be called a microcosm. Examples discussed range from the stark elegance of small flame-sealed flasks to complex ecosystems of whole lakes. Most involve living organisms of several species, more than a single trophic level, and some restrictions on exchange of material and energy with the external environment, although exceptions can be found to all of these. Replicability and repeatability are highly valued, for these are the keys to using any microcosm as a standard tool. The ability to be self-sustaining is also mentioned longingly by several authors but I was impressed by how little fuss was made over this point. There are a few holdouts for stable, unchanging equilibria, but most accept that the reference against which treatments are to be compared may be not a point but an ever-changing trajectory in a multidimensional space. Ecology does progress!

There is an invigorating tension running through the book, and through much of ecology, concerning the "complexity" of nature and the "simplicity" of models — what they are and how todeal with them. Most ecologists are willing to complain (or, more honestly, to boast) that ecological systems are very complex. One school goes on to argue that models must, for practicality, be simplified versions of the real world, but that this simplicity is a curse, tolerable only because the science is immature. Use of simple models is a sign of weakness. Another line of thought (the right one I think) is to say that models may or may not be simpler than complex reality, but that in either case the simplicity and complexity are largely irrelevant. Complex systems do not require complex questions in order to be understood.

A good example of the first attitude is provided by the Channels Microcosm at Savannah River in Georgia. This permanent facility consists of six concrete channels each 90 m long. Water is pumped from a special well and is adjusted to have a known concentration of all nutrients. An experiment described here, on the effects of cadmium, used almost forty tonnes of disposible materials, and many thousands of individually counted and specified organisms, from plants to fish, as well as 14 000 L of treated water per day for over a year. A large staff was also necessary, both at the facility and in the laboratory. Despite the massive investment of money and effort, the experiment was, by general agreement, a failure. The system was too complex — the staff could make only a fraction of the potentially useful measurements. At the same time, the system was too simple — it left out many aspects of real streams, so they were unwilling to extrapolate even those measurements they did make. In retrospect, the failure was predictable. They did not study an ecosystem, but rather plants, and snails, and crayfish, and so on, which is not the same thing. The morals are that nature does not yield to brute force, and that, as we have always known, an ecosystem is no trivial function of its parts (although it is undoubtedly *some* function of its parts).

A good contrast is provided by another set of large artificial channels, at Browns Ferry nuclear station in Alabama. This facility is even bigger, with twelve channels each 112 m long. However in this case water and some organisms are diverted directly from the adjacent river. Conditions are thus ever-changing and largely unknown. The operators asked a simple question: what happens to the system if its temperature is raised by waste heat from the nuclear plant? In complete contrast to the first example, they obtained clear, repeatable answers in terms of export of biomass, dominance of consumers, and so on. What's more, the answers could be extrapolated directly to form a sound basis for management decisions.

Most of the microcosms discussed are not so elaborate. One that impressed me takes up less than a metre in any direction. Corn or another crop is planted in a standard soil in a glass carboy, and is treated with ^{14}C-labelled pesticide at recommended doses. As the plants grow, earthworms, slugs, pillbugs, and caterpillars are added. After two weeks a single vole is added and eats almost everything, plants and animals. It is removed, and the soil is gently flooded. Algae, snails, *Daphnia*, and finally fish are added and left a few days. Each experiment lasts less than a month, but in that time the pesticide is exposed to almost every ecological transformation imaginable. This biological model certainly does not copy the real world, but it works, and yields interpretable data on the comparative behaviour of many different chemicals.

Other contributions cover a wide range of considerations in the use of microcosms, from the practice of keeping walls free of slime (use a brush) to the theory of maintaining formal homeostasis in the absence of negative feedback (use congeneric homotaxis). I was disappointed to see little reference to the large literature on mathematical models. The propensity of even crude equations to exhibit chaotic behaviour, for example, would seem to be relevant. On the other hand I was stimulated by a number of useful discussions on the properties of ecosystems and how to measure them.

The book would be better at half the length, but critical readers with a serious interest in the theory of ecosystems are likely to find something of interest.

JOHN MIDDLETON

Department of Botany, University of Dar es Salaam, Box 35060, Dar es Salaam, Tanzania

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Mining, Land Use, and the Environment, 1: A Canadian Overview

By I. B. Marshall. 1982. Land Use in Canada Series No. 22. Lands Directorate, Environment Canada. Ottawa. 280 pp., illus. Free.

Environmental organizations frequently accuse the Canadian mining industry of degrading the environment through significant changes in land use patterns. In this book, Environment Canada's Lands Directorate addresses this issue by providing a national overview of the industry's land use activities and their environmental impacts. Marshall hopes that by fostering understanding about how and why mining is just one of many competing users of Canada's land, better discussions on resource management will be possible.

The most obvious accomplishment of this book is its vivid presentation of the tremendous area of Canadian land affected by the various sectors of the multi-billion dollar mining industry. For instance, some 284 000 hectares, an area about half the size of Prince Edward Island, are currently "disturbed, utilized and alienated" by Canadian mining activities. In 1979, the industry held the rights to 39.2 million hectares for mineral development and another 66 million hectares for on-shore petroleum development. Furthermore, the mining industry anticipates that, because of an increased future demand for Canadian mineral resources, even more land will be required for future mining activities with a consequent increase in land use conflicts.

This book also presents timely information on several other aspects of mining that are of special concern to environmentalists, particularly the "shadow effect" which refers to the impacts of mines and mining activities that extend beyond the immediate mine area. These are usually transported by atmospheric, lithographic, and aquatic processes. Several sobering case studies of this potentially disastrous effect are presented as well as brief descriptions of the effects attributed to sulphide emissions from smelting operations in the Sudbury and Wawa regions of Ontario. The Canadian mining industry is also portrayed as having a very poor record in the reclamation of mining lands. One of the major problems with reclamation is that the industry doesn't want to take responsibility for so-called "orphan lands," those that were disturbed prior to current regulatory requirements. Apparently, significant proportions of this derelict land may never be reclaimed because the cost frequently exceeds the perceived benefits. We can only hope that stiffer regulations and improved technology will soon eliminate this type of environmental irresponsibility.

Luckily, this book does not presume that the reader has any particular technical knowledge of the mining industry. To this end, Marshall has included a general review of the nature, distribution, and recent production records of the Canadian mining industry, a description of the most sought-after minerals, and the typical pre-production, production, and post-production stages in a mine's lifetime. An additional plus is a wealth of information on other Canadian land use patterns, including park systems, wildlife lands, native land claims and IBP sites. All of this valuable information make this book a very valuable and usable asset in any environmentalist's or geographer's library. Unfortunately the book's poor binding probably won't enable it to stand up to the amount of use that its contents would warrant. Besides the technical information, this volume also provides the reader with some marvelous insights into the approaches of the mining industry to its environmental problems. For instance, the industry feels that the agriculture and forestry industries should share much of the responsibility for deteriorating land quality in Canada. Mining concerns admit that environmental groups have traditionally been the strongest opponents to mine development but they are confident that some potential conflict situations in the future can be avoided. Finally, the tone and content of this enlightening book would seem to suggest that the poor environmental record of which the Canadian mining industry is often accused and about which it seems so sensitive is not entirely undeserved.

MICHAEL M. J. MORRIS

5162 Montclair Avenue, Montréal, Québec H4V 2K8

MISCELLANEOUS

Sampling Design and Statistical Methods for Environmental Biologists

By R. H. Grenne 1982. Wiley and Sons, New York. 257 pp. U.S. $41.00

As an environmental biologist currently engaged in the study of statistics and its applications to environmental scientific endeavor, it was with particular zeal that I read this book. To my knowledge, within the great body of statistical literature, there has been no previous attempt to provide a treatise on this rather specific topic. Because of its novelty, this book cannot help but be notable.

In practice however, the text is not altogether successful. As an example, a viewpoint held by the author is that the statistics of statisticians (referred to as "classical statistical analysis"), is an extremely rigid structure of a solely mathematical nature. There are two problems with this view. First, it is dangerous because it fosters the so-called technological gap between statisticians and biologists. Logically, this distance should be reduced to realize the eventual end goal of both disciplines; proper design and analysis of environmental experiments. Second, it is contradictory, for to follow the progression of ideas presented in the text, an understanding of "classical statistical analysis" is thought to be a necessary pre-requisite.

By far the best part of the book is the excellent discussion of the required principles for sampling design in environmental biology. This section (Chapter 2) is required reading for it presents a logical, stepwise description of the requirements of environmental sampling. If implemented at an early stage in the research project, this information will be invaluable when the eventual data analysis begins. It is unfortunate that the remainder of the book contains a somewhat limited selection of statistical methods. If the reader is seeking a comprehensive statistical guide as is proclaimed on the book jacket, he/she may not be completely satisfied.

For those who are about to embark on an environmental research project, do read the second chapter of this book, and do seek the advice of a statistician.

ALAN J. KENNEDY

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NEW TITLES

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Advances in the study of mammalian behaviour. 1983. Edited by John F. Eisenberg and Devra G. Kleiman. Special Publication No. 7. American Society of Mammalogists, c/o The Vertebrate Museum, Shippensburg State College, Shippensburg, Pennsylvania. 753 pp. U.S. $45.

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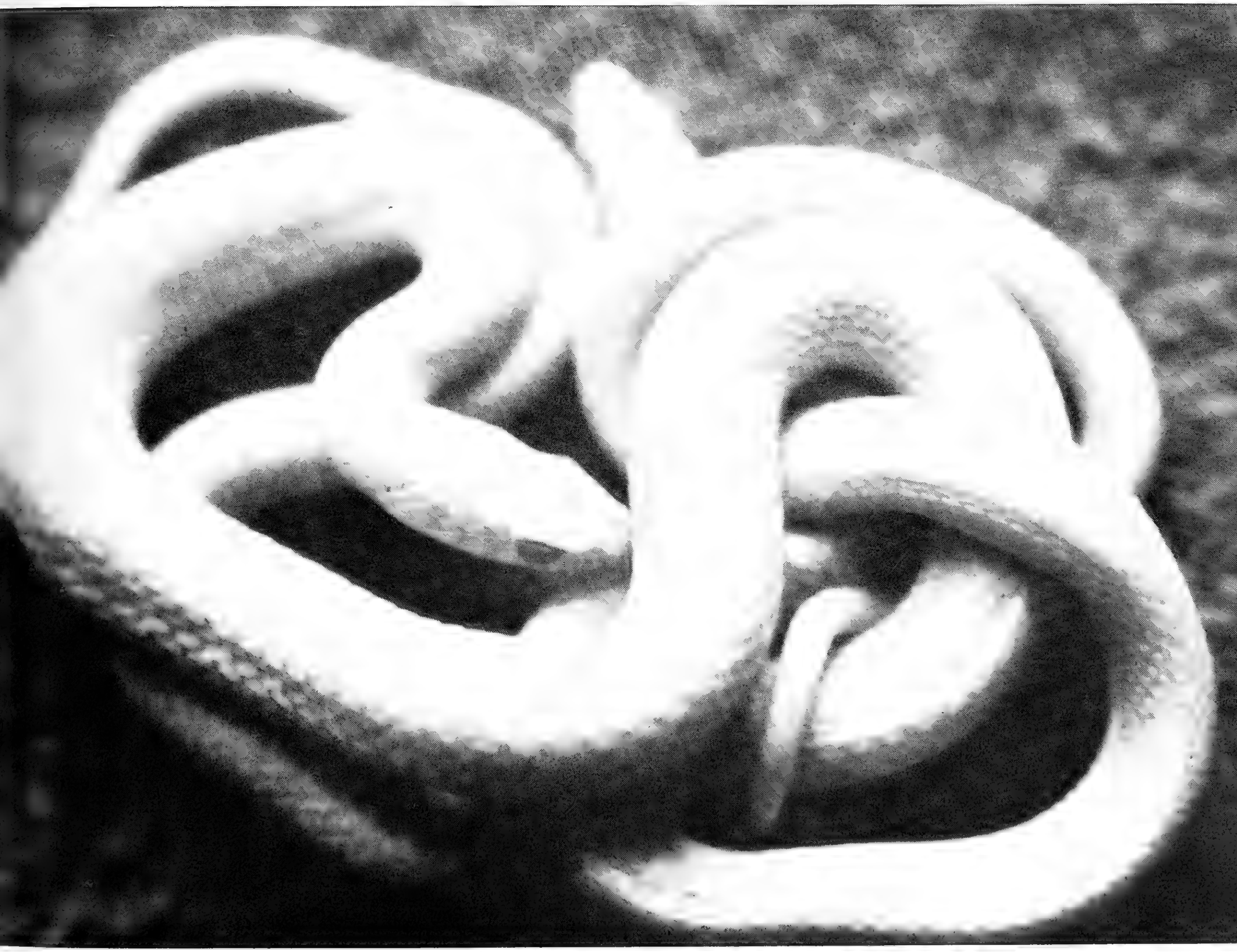

Volume 97, Number 4

October-December 1983

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Cover: Albino Eastern Garter Snakes, *Thamnophis sirtalis sirtalis*, from Moira Lake, Hastings County, Ontario. Photograph courtesy Wayne F. Weller. See note by Weller p. 456.

The Canadian Field-Naturalist

Volume 97, Number 4 October-December 1983

Densities of Breeding Birds at Polar Bear Pass, Bathurst Island, Northwest Territories

HAROLD F. MAYFIELD

9235 River Road, Waterville, Ohio 43566

Mayfield, Harold F. 1983. Densities of breeding birds at Polar Bear Pass, Bathurst Island, Northwest Territories. Canadian Field-Naturalist 97(4): 371–376.

Polar Bear Pass is an "oasis" in the polar desert of the Canadian high arctic. One km^2 of sedge-moss meadow censused in four consecutive years held a mean nesting density of 12 pairs/km^2, and an adjacent dry upland tract held a density of 4 pairs/km^2. Eight species nested on the wet meadow, two other species resided there but did not nest, and 11 species nesting in the vicinity visited regularly to feed. Seven species nested on the upland tract, feeding mostly away from it on the better-vegetated lowlands. These nesting densities were higher than those reported for a few locations farther north, but only 1/10 the densities found at some arctic sites farther south.

Key Words: arctic, Bathurst Island, bird census, bird population, habitat.

Polar Bear Pass on Bathurst Island, N.W.T., (75° 44′N, 98°25′W) is an "oasis" in a region of polar desert, and it plays an important role in sustaining bird and mammal populations on this island, including the Muskox (*Ovibos moschatus*) and Peary Caribou (*Rangifer tarandus pearyi*). For these reasons it is now being evaluated for preservation and management as a Canadian Ecological Site (Interdepartmental Working Group on International Biological Programme (IBP) Ecological Sites, unpublished report, 1981)*. The value of this site is enhanced by more than a decade of biological study providing information not available for many high arctic locations. This article presents bird census data, and compares them with results from other arctic studies.

Study Area

Polar Bear Pass lies across the narrow waist of Bathurst Island between Goodsir Inlet to the east and Bracebridge Inlet to the west. The floor of the valley is about 2-4 km wide, generally less than 25 m above sea level, and bordered on north and south by rounded hills that characterize most of this island. The hills in the first tier usually rise less than 50 m but gradually become higher in the interior, sometimes reaching 200-300 m. The region has suffered relatively little human disturbance. There are no year-round human inhabitants on the island (19 700 km^2), and only occasional visits by Inuit hunters. The National Museum of Natural Sciences established the High Arctic Research Station at Polar Bear Pass in 1968. During 1968-1980 this has been the site of active ecological studies by many scientists for three to four months each year, and since 1980 has continued to serve as a base staging area for arctic research elsewhere (see MacDonald 1981: 183-185 for summary of station activities).

The valley benefits from an abundance of fresh water, nutrient-rich surficial deposits, and an accelerated thaw as compared to much of the surrounding region. The earliest melt on the wet flats occurs where windblown dust has gathered on the snow in the lee of the surrounding hills. The site is larger and richer than similar wet meadow communities elsewhere on Bathurst Island, or on Cornwallis, eastern Melville, or the Sverdrup group to the north, including Axel Heiberg and Ellef Ringnes Islands (Interdepartmental Working Group in IBP Ecological Sites, unpublished report, 1981; and Nettleship and Smith 1975: 17). In addition, this is a region where a combination of present conditions and climatic history has produced a flora that is less varied than that found at similar or higher latitudes on Devon Island, Ellesmere Island, and Greenland (Figure 1) (Savile 1961a; Beschel 1969).

Here I selected two quite different habitats for breeding bird censuses: lowland sedge-moss meadow

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*Approved 30 July 1982 as the first National Wildlife Area in the North.

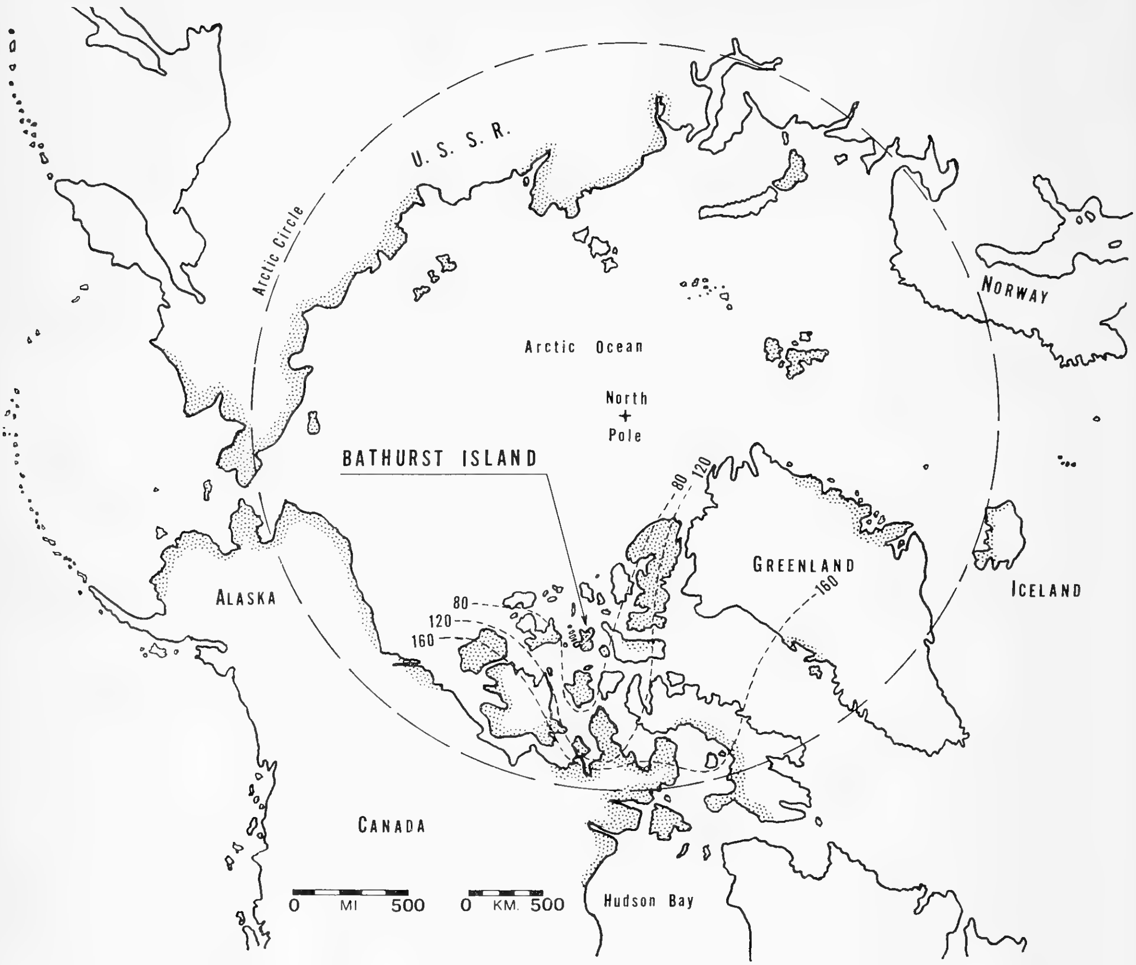

FIGURE 1. The Arctic. Dotted lines in the Canadian Arctic Archipelago show the "barren wedge" in flora, outlining the northern limits of zones supporting 160, 120, and 80 species of vascular plant. Stippling shows the breeding range of the Red Phalarope, mainly from Godfrey (1966: 167) and Dement'ev et al. (1969: 289, 290).

and upland saxifrage semi-desert, separated by a fairly sharp boundary at the foot of the hills. The most abundant sedge in the wet meadow was *Carex stans*, but several species of grass were common also, especially *Arctagrostis latifolia*. Much of the ground was bare even in the best vegetated areas, and leaves from the previous year often curled over at a height of about 8 cm as though mowed. Within the lowland census tract 20 shallow ponds, occupying about 1/10 of the surface, persisted through the summer. These ranged in diameter from 10 to 150 m. In addition, the southwest corner of the tract bordered on Hunting Camp Lake, the largest body of fresh water in the vicinity, 3 x 1.5 km in extent but only 1½ m deep. All of the ponds and streams froze solidly in winter and were devoid of fish.

In contrast with the relatively well-vegetated lowlands, the dry slopes of the upland tract were marked sparsely with low-growing plants such as lichens and purple saxifrage (*Saxifraga oppositifolia*), with occasional more productive spots where temporary seepages occurred.

The meadows usually remained covered with snow until late June except in a few favored places of early melt, but if thawing was delayed until July the result was a "nonbreeding year" when nesting for some species was severely reduced or eliminated. In the seven years 1970-1976, only 1972 was such a year.

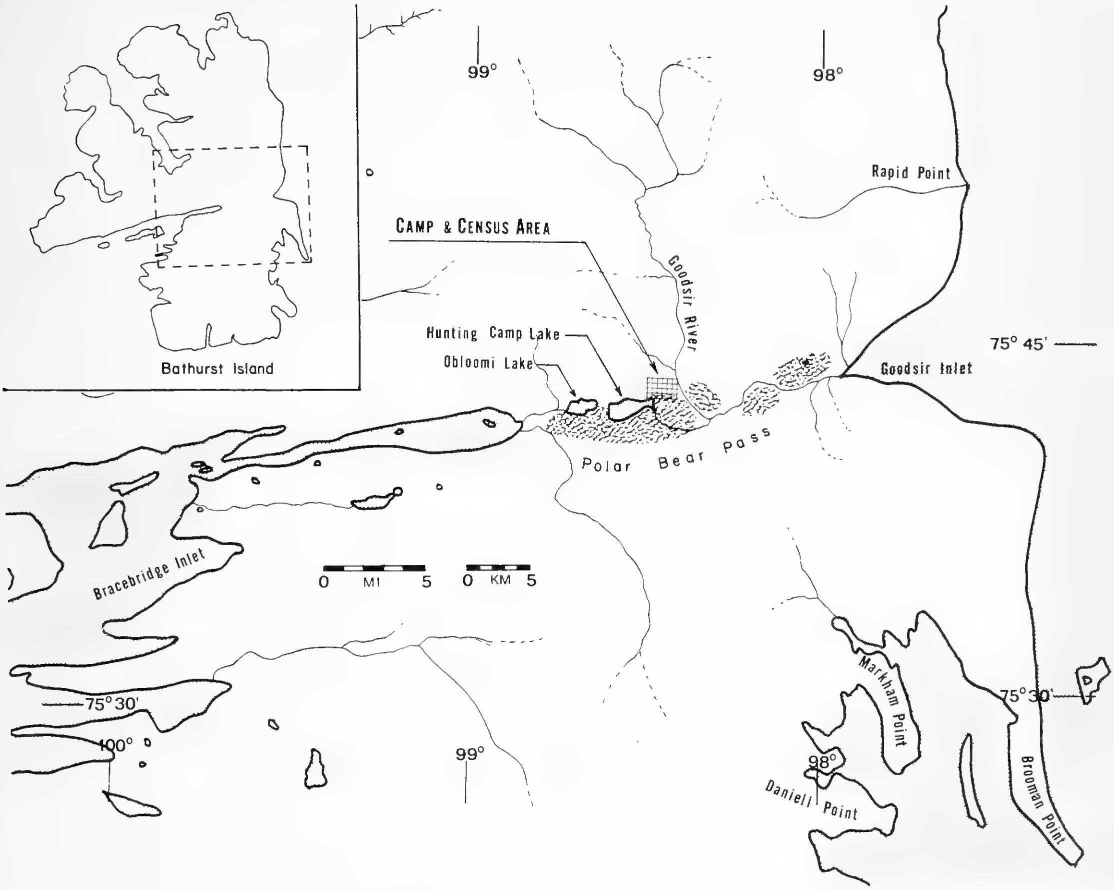

FIGURE 2. Central Bathurst Island. Stippling shows the major areas of sedge-moss wetlands. Inset shows the portion of Bathurst Island covered by this map.

The mean temperature for July, the warmest month, was about +4.0C (39° to 40° F), and few days reached +10° C (50° F). In most summers the sea ice does not break up around the island. The rigor of the climate is attested by the absence of mosquitoes in spite of an abundance of shallow water.

Methods

I staked a rectangle 2 x ½ km (1 km^2) on the valley floor and adjacent to it a larger rectangle 2 x 1 km (2 km^2) of dry uplands (Figure 3). Each of these tracts was relatively homogeneous and representative of its type. Throughout each nesting season I spent a portion of each day in both tracts, and other biologists of our party also noted all birds seen and nests found. Since the terrain was open and the bird populations small, we believe very few birds or nests eluded us. I spent about 250 hours on the lowland tract each nesting season and about 100 hours on the upland tract, and my associates visited both tracts daily for varying amounts of time. My own efforts covered the nesting seasons of 1970, 1971, and 1973. Information on 1972 and later years was supplied by others.

To appraise the nesting population, I considered a mated pair as a unit, and counted each nest as a pair. In the phalarope I counted each male with a nest as a resident pair even though I suspected a few instances of polyandry and perhaps offsetting numbers of unmated females. In a few cases breeding was inferred from behavior although nests were not found.

Results and Discussion

The wet meadow census tract had nests of eight species of birds in four years, but no more than five species in any one year (Table 1). The mean density was 11.75 pairs/km^2, but ranged from 3 to 18 pairs/km^2 in different years. The variability from year to year was most marked in the Red Phalarope (*Pha-*

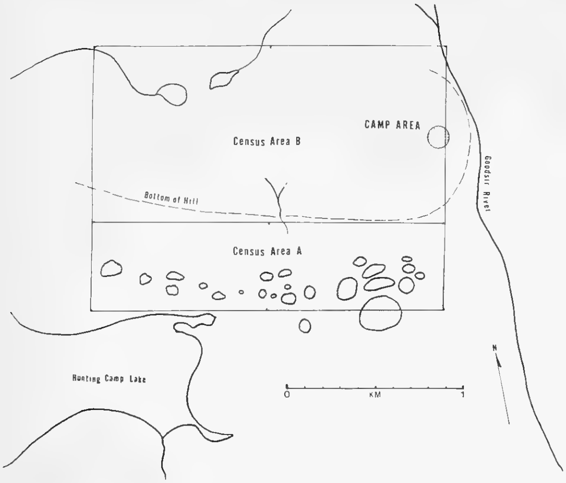

FIGURE 3. Census area. Tract A (1 km²) consisting mainly of sedge-moss lowlands, and tract B (2 km²) consisting mainly of dry uplands.

laropus fulicaria), mean 7 pairs/km², range 0 to 14 pairs/km².

In addition to the species known to nest here, two other species remained on the tract each nesting season, but their nests were not discovered: White-rumped Sandpiper (*Calidris fuscicollis*), 4-12 individuals, mean 8, and Purple Sandpiper (*Calidris maritima*), 2 individuals. The White-rumped Sandpipers, conspicuous with wing and vocal displays, were possibly all males. These non-nesting full-time residents raised the population from 12 pairs/km² to 34 individuals/km².

To look narrowly at these census counts gives an incomplete understanding of the importance of the lowland and the diversity of birds using it. Eleven other species nested in the vicinity and depended heavily on the wet meadows for food and for rearing their young. We can only guess how many of these would have been listed in a transect count. These regular users and the approximate number seen here each day in nesting season were as follows: Brant (*Branta bernicla*), 2; Snow Goose (*Chen caerulescens*), 6; Oldsquaw (*Clangula hyemalis*), 6; Rock Ptarmigan (*Lagopus mutus*), 2; Red Knot (*Calidris canutus*), 12; Baird's Sandpiper (*Calidris bairdii*), 4; Glaucous Gull (*Larus hyperboreus*), 6; Thayer's Gull (*Larus thayeri*), 2; Arctic Tern (*Sterna paradisaea*), 2; Snowy Owl (*Nyctea scandiaca*), 1; and Snow Bunting (*Plectrophenax nivalis*), 4; The absence of rocky cliffs and talus slopes on both census tracts explains the absence of the nearly ubiquitous Snow Buntings from the nesting lists. Casual visitors have been omitted. A total of 30 species have nested and 53 species have been recorded at Polar Bear Pass (Anonymous 1981: 6).

At the beginning of summer the ponds of the valley also served as a temporary staging area for larger numbers of Brant, Snow Geese, Oldsquaws, and King Eiders (*Somateria spectabilis*) before they dispersed to nesting sites.

The lowland census tract was a favored part of the valley, and to get a better idea of densities in the valley as a whole I considered the most numerous species, the Red Phalarope, and extended the area 6 km eastward to include 20 km². Here I estimated about 1.6 pairs/km² of this one species. This was less than ¼ the density of the census tract. The phalarope nested only in the wetter, better-vegetated portions (Mayfield 1978).

On the upland census tract (Table 2) seven species of birds nested, with up to six species in any year. The mean density was 4.25 pairs/km². The most abundant nesting species was the Sanderling (*Calidris alba*), 1.5 pairs/ km², range 0 to 2 pairs/km². Although Sanderlings also nested on the valley floor, they placed their nests only in areas of very scanty vegetation. The Black-bellied Plover (*Pluvialis squatarola*) also nested on relatively bare ground but, unlike the Sanderling, always near extensive grassy areas.

Birds nesting on the upland tract benefited from the nearby lowlands, but the reverse was not true. All the birds of the uplands fed partly or entirely on the vegetation or ponds of the wet meadows, and many walked their newly-hatched young to the food and concealment offered there. As the lakes and ponds of the valley floor rose to their highest levels during melt, mats of moss floated to the surface and wind piled heaps of this vegetation on the shores. These masses were rich in invertebrate life, and shorebirds, ducks, jaegers, and Snow Buntings flew long distances to feed on them.

To put these censuses into perspective, we need to remember that the productive meadows make up a very small part of this island, and the dry upland the greater part of it.

Tundra is not all alike, even in the high arctic, as shown by the birds at different locations. Freedman and Svoboda (1982) compared censuses in a number of North American arctic communities and found wide differences in species and density. Generally, more southerly arctic sites yielded higher densities, some of them more than 10 times those of Polar Bear Pass. At the other extreme, the cold and sparsely vegetated land at Isachsen on Ellef Ringnes Island (78°47′N, 103°30′W), 360 km north of Polar Bear Pass, held a density of 1.9 pairs/km², only half that of the uplands near Polar Bear Pass. The species were similar except that the Sanderling was missing at

TABLE 1. Breeding pairs on 1 square kilometer of sedge-moss meadow, Polar Bear Pass, Bathurst Island.

	1970	1971	1972	1973	Mean
King Eider	2	0	1	0	0.75
Black-bellied Plover	2	1	0	2	1.25
Sanderling	0	0	1	1	0.50
*Red Pharlarope	6	14	0	8	7.00
Pomarine Jaeger *(Stercorius pomarinus)*	0	1	0	0	0.25
Parasitic Jaeger *(S. parasiticus)*	1	1	1	1	1.00
Long-tailed Jaeger *(S. longicaudus)*	0	0	0	2	0.50
Lapland Longspur	1	1	0	0	0.50
Pairs	12	18	3	14	11.75
Species	5	5	3	5	4.50

*Male phalarope on nest counted as a pair.
In addition, two species resided on the tract but did not nest, and 11 species nesting in the vicinity visited regularly to feed. See text.

Isachsen (Savile 1961b). However, a census taken at Polar Bear Pass by chance in the "nonbreeding year" of 1972 would have given a density near that of Isachsen.

The relatively dry and sunshiny climate of Lake Hazen on Ellesmere Island (81°41′N, 71°18′W) held 4.8 pairs/km² (Savile and Oliver 1964), a density close to that on the upland portion of Polar Bear Pass, but with some different birds, Ruddy Turnstone (*Arenaria interpres*) and Hoary Redpoll (*Carduelis hornemanni*) breeding regularly. At Alexandra Fjord on Ellesmere Island (78°53′N, 75°55′W) on a 12 km² tract over two seasons 10 species nested at a mean density of 13.2 pairs/km² and also included Hoary Redpolls (Freedman and Svoboda 1982).

Because of the variability from year to year in high arctic nesting activity, I focused attention particularly on localities that, like Polar Bear Pass, have been censused on several consecutive years. An example is Truelove Lowland on Devon Island (75°33′N, 84° 40′W), another polar "oasis" 350 km east of Polar Bear Pass and at about the same latitude. There were significant differences in the bird populations. The most abundant breeding species of the Bathurst wetlands, Red Phalraope, and uplands, Sanderling, were only occasional breeders or visitors at Truelove (Pattie 1977). Further, the Lapland Longspur (*Calcarius lapponicus*) was abundant at Truelove but scarce at Polar Bear Pass. Comparisons of densities at the two localities cannot be exact because of different census methods. At Truelove the counts were based on long walking transects over an area of 43 km². Still, the Truelove mean population densities, about 30 individuals/km² appear to be somewhat less than those of the wetlands of Polar Bear Pass, which had 34 individuals/km², but greater than in the Polar Bear Pass area generally with uplands included.

One of the most thoroughly studied regions in the Canadian high arctic, although not formally censused, is Pond Inlet on northern Baffin Island and the

TABLE 2. Breeding pairs on 2 square kilometers of dry upland, Polar Bear Pass, Bathurst Island.

	1970		1971		1972		1973		Mean	
	no.	pr/km²	no.	pr/km²	no.	pr/km²	no.	pr/km²	no.	pr/km²
Red-throated Loon *(Gavia stellata)*	1	0.50	1	0.50	0	0	0	0	0.50	0.25
Oldsquaw	0	0	1	0.50	1	0.50	1	0.50	0.75	0.375
King Eider	2	1.00	1	0.50	3	1.50	2	1.00	2.00	1.00
Rock Ptarmigan	1	0.50	0	0	0	0	0	0	0.25	0.125
Black-bellied Plover	0	0	1	0.50	0	0	0	0	0.25	0.125
Sanderling	4	2.00	4	2.00	0	0	4	2.00	3.00	1.50
Long-tailed Jaeger	2	1.00	2	1.00	1	0.50	2	1.00	1.75	0.875
Pairs	10	5.00	10	5.00	5	2.50	9	4.50	8.50	4.25
Species	5		6		3		4		4.50	

adjacent portions of southern Bylot Island (73° N, 78° W), which has been visited by ornithologists in 12 years over six decades. Here the vegetation in places was much more luxuriant than anywhere at Polar Bear Pass, and birds were more than twice as abundant (Van Tyne and Drury 1959). Some species common at Polar Bear Pass such as the Red Knot and Sanderling rarely or never nested at Pond Inlet, and several species including the Golden Plover (*Pluvialis dominica*), Horned Lark (*Eremophila alpestris*), and Water Pipit (*Anthus spinoletta*) nested regularly here although absent from Bathurst Island. Notable additions at Pond Inlet were small numbers of Eurasian species, the Ringed Plover (*Charadrius hiaticula*) and Wheatear (*Oenanthe oenanthe*) (Renaud et al. 1981).

Of the arctic censuses available to me, the most similar in methods and duration at high latitudes were conducted on two tracts of coastal plain at Barrow, Alaska (71° 18′N, 156° 42′W). Here intensive censuses were carried out for six consecutive years (Myers et al. 1981). The mean numbers of pairs were 135 and 133/km^2, about 10 times the density of the wetlands of Polar Bear Pass. In these two locations separated by about 1800 km, the species composition was almost totally different, and catastrophic reductions in nesting characterized as "nonbreeding years" do not occur at Barrow (J. P. Myers, in litterature, 1982).

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The Ecology of the Muskrat, *Ondatra zibethicus*, at Luther Marsh, Ontario

GILBERT PROULX and FREDERICK F. GILBERT[1]

Department of Zoology, University of Guelph, Guelph, Ontario N1G 2W1
[1]Present address: Wildlife Biology, Washington State University, Pullman, Washington 99164-4220

Proulx, Gilbert, and Frederick F. Gilbert. 1983. The ecology of the Muskrat, *Ondatra zibethicus*, at Luther Marsh, Ontario. Canadian Field-Naturalist 97(4): 377–390.

The ecology of Muskrat (*Ondatra zibethicus*) populations inhabiting areas of different floristic composition and subjected to seasonal changes in water level was studied at Luther Marsh, Ontario. House building sites consisted of open water areas and heavy emergent vegetation stands, particularly cattail (*Typha* sp.) stands, with > 15 cm water. The average home range had a ratio of vegetation:open water areas of 1:1. With a decline in water level, Muskrats extended their home range significantly ($p < 0.05$) from 484 (± 238.4) m^2 in June-July to 1112 (± 842.7) m^2 in August-September and increased significantly ($p < 0.05$) the average number of houses/family from 1.5 (± 0.7) in early summer to 3.9 (± 1.7) in late summer. Cattail was the most important foodstuff but food habits depended upon the movements of the animals and the diversity of the flora. Adult and juvenile populations usually had an even sex ratio in summer. Most females had two litters with an average of 6.3 embryos/litter. In cattail-rich areas, females produced 1 to 4 more young/litter than females of other habitat types and there were more animals/ha of home range (> 100 animals) than in any other habitat type (< 80 animals). The survival rate of juveniles was estimated at 66.4% in summer and 31.8% in winter. The maximum life span of a Luther Marsh Muskrat would be five years.

Key Words: Muskrat, *Ondatra zibethicus*, Luther Marsh, home range, populations.

Muskrats (*Ondatra zibethicus*) inhabit a wide range of community types but generally prefer lentic water containing vegetation (Perry 1982). The effect of water depth on habitat selection by Muskrat has been noticed by Sather (1958) and Danell (1978) and the direct effect of fluctuating water levels on muskrat populations has been considered greater than the indirect effect through altering the composition of the vegetation habitat (Bellrose and Brown 1941). On the other hand, McDonnell and Gilbert (1981) suggested stability in habitat usage by Muskrats even when water levels declined substantially. An obvious lack of information still exists concerning the relationship between muskrat populations and their environment and the effects of environmental conditions on muskrat reproduction (Errington 1937; Bellrose and Low 1943; Arata 1959) and food habits (Errington 1941) are poorly known.

The present study concerned the ecology of Muskrat populations inhabiting different habitats of a marsh subjected to seasonal changes in water level. The primary objective was to determine and quantify the effects of vegetative composition and water level fluctuations on the selection and utilization of marsh habitat by muskrats. Muskrat population productivity and changes over the year, were also investigated.

Study Area

The Luther Marsh Management Area is located 65 km north of Guelph, Ontario. The reservoir averages about 120 cm in depth with annual water level fluctuations of 50-70 cm. The climate is humid continental with mean maximum and minimum temperatures for July of 23.6° C and 12.1° C, and for January, -5.6° C and -13.5° C, respectively. Mean annual precipitation is 89.8 cm (Heidorn 1975). Marsh areas have predominantly submerged and emergent vegetation including cattail (*Typha* sp.), smartweed (*Polygonum* sp.), pondweeds (*Potamogeton* sp.), sedges (*Carex* sp.) and bulrush (*Scirpus* sp.) (Schiefele 1973). Peat and muck are the two major soil types of the Management Area (Canada Department of Agriculture 1962, 1963).

In 1979, five study areas representative of Luther Marsh habitats were delineated: East Bay (11.2 ha), Western Shore (0.5 ha), Teal Bay (0.8 ha), Creek (0.2 ha), Pond 1 (0.4 ha) and Pond 2 (0.3 ha) (Figure 1). In 1980, a sixth study area, Upper Shore of Teal Bay (0.3 ha), was studied (Figure 1).

Methods

In May 1979 and 1980, the vegetative composition of each study area and the degree of open water areas were determined. When possible, the vegetation of a study area was subdivided into belts, each of which consisted of a distinct cover type (Takos 1947). A transect was randomly located through each study area. Measurements of the width and length of each vegetation belt and its position relative to free water areas were made at 10 m intervals along the transect. All information was transferred onto maps at an original scale of 1:1000. Vegetation and free water areas

FIGURE 1. Luther Marsh showing location of the study areas.

were determined with the aid of a conventional planimeter.

The reservoir water level at the dam and the amount of precipitation were recorded by Grand River Conservation Authority staff. Daily water depths in the total area of each study area, except East Bay, were recorded at 0, 5, 10, and 15 m on each side of the transect in May and early June. In East Bay, water levels were recorded every month at Muskrat houses. In late summer, three transects were established between the shoreline and the back of East Bay and water depths were recorded every 2 m along each transect. These values, along with the reservoir water level at the dam, permitted determination of monthly water level fluctuations and delineation of regions, within the study area, with distinct water depths.

The vegetation was analysed with the aid of permanent 0.5 m × 1.0 m plots placed at random in each of the vegetation belts. In Western Shore and Teal Bay, the number of plots in a belt was proportional to the area covered by that belt. Therefore, 44 plots were inventoried in Western Shore (horsetail belt, 25; cattail belt, 12; sedge belt, 7) and 38 in Teal Bay (cattail belt, 25; spike rush belt, 13). The vegetation of the other habitats was treated as one belt and 25 plots were placed randomly in each habitat. Due to the size of East Bay, 100 quadrats were inventoried. The number of individual shoots of each taxon was counted in each plot. Two inventories were carried out in summer 1979; the first in late May-early June and the second in early July. In 1980, similar inventories were conducted with a third one in August. Considering that some plants grow slower than others and that their representation was low in the May sample, only the July results were used to compare the floristic composition of the habitats. A similarity index between 1979 and 1980 floristic compositions of each habitat was calculated according to the formula

$$S = \frac{2C}{A + B} \times 100$$

where S is the similarity index in percent, A is the number of taxa in sample A, B is the number of taxa in sample B, and C is the number of taxa common to both samples (Odum 1971). For each plot, the relative density of each plant was calculated and habitats were compared to each other by a stepwise discriminant analysis (F-to-enter = 4.0, F-to-remove = 3.9; Klecka 1975). This analysis is a multivariate statistical analysis technique that allows one to describe, differentiate and classify elements characterized by a set of "p" variables. In this analysis, according to the linear combination of "p" variables that best separated and characterized the sample plots of one study area from that of other habitats being compared, a sample plot was classified in its original study area or in another study area to which it was floristically more similar. The variables were the relative densities in a sample plot of: cattail, bulrush, spike rush (*Eleocharis* sp.), bur reed (*Sparganium* sp.), Graminae, horsetail (*Equisetum* sp.), arrowhead (*Sagittaria* sp.) and 'others'. All taxa, except those included in 'others', were used by Muskrats of all study areas in their building and feeding activities. 'Others' included taxa which were found in 1979 or 1980, but not in both years.

A forage ratio was used to relate the quantities of the various taxa found at the feeding platforms to the proportions available in the study area (Takos 1947). A ratio of 1.0 implied that the plant was found on the feeding platforms in frequencies proportional to its occurrence in the habitat. When the ratio was < 1.0, the plant was used less than would be predicted if selection was random. A ratio > 1.0 implied preferential selection of the taxon by Muskrats. Only platforms of recent origin (characterized by fresh remnants) were tabulated. Surveys of feeding platforms lasted approximately one month and were related to the period during which a vegetation analysis was done.

Study areas were surveyed for Muskrat houses during the last week of May 1979 and the second week of May 1980. Thereafter, weekly checks for houses were made during the live-trapping period. Inhabited houses were recognized by fresh signs of Muskrat activities. In 1979, the vegetation surrounding the houses was recorded in late May-early June, as the vegetation inventory was being conducted. In early June 1980, the vegetation surrounding all Muskrat houses was recorded. Each house was located by triangulation and plotted on the habitat map.

Muskrat were trapped with National live traps (17.8 × 17.8 × 50.8 cm; Tomahawk Livetrap Co.) from 25 May to 23 September 1979 and from 16 May to 25 September 1980. Two traps were set in close proximity to each active house, usually at feeding stations, defecation sites or along runways. Those sites permitted optimum sampling (Aldous 1946; Erickson 1963; Vincent 1972). Traps were maintained at each site throughout the trapping season and baited with carrots (Erickson 1963; MacArthur 1978).

Adult muskrats were immobilized with an intramuscular injection of 10 mg Ketamine (Ketaset™-BTI Products Inc.). Animals were sexed by manipulation of the urinary sheath (Sather 1958) and exposure of the penis (Baumgartner and Bellrose 1943). A numbered No. 1 monel tag was put in one ear and a numbered rabbit tag in the other (National Band and Tag Co.). Adults and juveniles were released after their tag number and capture location were recorded.

Because grid trapping is inadequate for the study of Muskrat movements (Proulx 1981), related methods for the determination of the home range size (Sanderson 1966) were rejected. The home range size of a family corresponded to the immediate site of the dwellings of a family plus the surrounding area delineated by the lines interconnecting the outermost capture sites, defecation points, feeding platforms and trails (connected to the water pool of a dwelling). However, since areas used by Muskrats wandering far from their dwelling might have been missed, either because some feeding platforms were not found or Muskrat signs were absent, the home range sizes determined in this study corresponded to minimum areas, intensively used by muskrats.

In order to determine natural mortality, all study areas were free of any trapping pressure during fall 1979 — spring 1980. However, carcasses of muskrats harvested in adjacent areas by a resident trapper were obtained in fall 1978 and 1979. Mean litter size and number of litters per breeding female were estimated from placental scars and used to provide an estimate of summer juvenile mortality. The summer mortality rate, along with live-trapping information, permitted an estimate of fall Muskrat populations, and that, together with knowledge of the breeding stock the following year, permitted an estimate of the winter mortality rate. A life table, based on summer and winter mortality rates, was developed according to Caughley (1977).

Results

Habitat Characteristics

The reservoir water level was approximately 30 cm higher in 1980 than in 1979. The amount of precipitation from 1 May to 30 September was 33.9 cm in 1979 and 53.4 cm in 1980.

Comparison of the floristic composition of the habitats by discriminant analysis indicated significant differences ($p < 0.05$) among marsh habitats. East Bay plots were characterized by high relative densities of cattail (> 46%) and Graminae (> 46%) shoots, Western Shore plots, by their relative density of horsetail shoots (> 28%) and Teal Bay plots, by their relative density of spike rush (> 41%) and arrowhead (> 11%) shoots. None of these plants was characteristic of Creek plots which consisted predominantly of sedge shoots (> 69%). Upper Shore of Teal Bay was similar to Teal Bay in its floristic composition. According to the linear combination of all these variables, > 70% of the plots of each study area remained in their original study area in which they were inventoried. This analysis indicates that each study area had a distinct floristic composition. On a scale of ascending importance of cattails, Western Shore was the lowest, followed by Creek, Teal Bay, Upper Shore of Teal Bay and East Bay. Indices of similarity > 70% indicated that the taxa composition of each habitat did not change markedly from 1979 to 1980 (Table 1), although species which grow better on dry or wet land than in flooded areas were more frequent in 1979.

The difference in vegetation between ponds and marsh habitats is attributed to a lack of emergent aquatic vegetation in the former (Table 1). A Graminae belt surrounded both Ponds 1 and 2 and indices of similarity > 80% indicated that their respective taxa composition did not change from 1979 to 1980.

In East Bay, open water accounted for 18% of total habitat area in June-July 1979, and during the entire summer 1980. In August and September 1979, 15% of the habitat was covered by free water areas. Four water regions were delineated in East Bay (Figure 2a). In 1979, only region IV was covered by more than 15 cm of water from May to September. In 1980, regions II, III, and IV were covered by more than 15 cm of water during most of the summer months. In Western Shore, five water regions were delineated in relation to the vegetation belts (Figure 4a). In 1979, only regions IV and V had > 15 cm of water from May to September. In 1980, all regions had > 15 cm of water during all summer months. In 1979, 56% of Teal Bay was covered by > 15 cm of water from June to September. In 1980, the entire habitat was covered by that much water from June to September. The water conditions of Creek varied with the amount of precipitation but there was > 15 cm of water throughout summers 1979 and 1980. Some shores of the ponds were more affected than others by a drop in water level during summer 1979. In 1980, however, all shores

TABLE 1. Floristic composition of seven Muskrat habitats at Luther Marsh, Ontario, in July 1979 and 1980.

Taxon	Percent of Plots in Each Habitat with Taxa Present																		
	East Bay				Western Shore				Teal Bay				Creek		Upper Shore	Pond 1		Pond 2	
			Horsetail Belt		Cattail Belt		Sedge Belt		Cattail Belt		Spike Rush Belt								
	1979	80	79	80	79	80	79	80	79	80	79	80	79	80	80	79	80	79	80
Epilobium sp.			—				—				–	—	–		–	—	—	12	
Taraxacum sp.	–			—			—				—	—			–	—	20	20	40
Sium suave	3	1	20	12	83	58	43	29	92	60	38	18	24		52		—	32	—
Eleocharis sp.	42	30	44	40	25	67	43	29	68	76	92	92	8	8	13		—	20	
Sagittaria sp.	15	16	52	28	58	50	14	14	84	72	85	81	16	8	13		–		—
Scirpus validus	2	6	40	40	50	67	29	14	44	44	8	8	40	24	39	4	—	12	12
Polygonum sp.	8	—	36	8	50	8	71	43	12	4	23	—	28		–		—		—
Ranunculus sp.	4	—		—	–		—			—	—	—				—	-		—
Sparganium sp.	13	24	16	4	—	—	—	—		8	54	27		–	—	—			—
Mentha sp.	2	1	4	4	8	–	14	29	12	40	—	–	48	60	22	—	8		—
Equisetum fluviatile	7	5	92	96	83	92		—	72	76	4	73	24	40	40	—		—	—
Galium sp.	6	2	—		17	–	57	—	4	12	—	—		–		—		—	—
Solanum sp.	1	2	8	—	8	—		—	4	16	8	—	24	40	65	—		–	—
Graminae	87	87	32	48	67	83	29	57	24	56	38	82	44	68	17	96	100	92	100
Typha sp.	80	86	8	8	92	92	14	1	92	96	—	18	52	52	100	—	—		—
Carex sp.		1	–		17	17	57	57	60	40	38	8	80	72	35	4	4	40	—
Solidago sp.	—	1		—	8	17	71	14	—		—	—	8			40	20	20	40
Fragaria sp.	—	1		—		—		—	—			—			—	—	–	—	4
Lycopus sp.	—		4	—	—			—	—			—		—	—	—	–	—	
Lysimachia sp.	—		—		8	—	—	—	36			—	—	– –	—	—		—	
Plantago sp.		—	—		8	—	14		—	–		—	–	—	—	72	40	–	4
Impatiens sp.	—	—	—		17		57		—	—		—	76	32	22	—	–	—	
Scutellaria sp.	—	—		-	33		43	57	52	—	15	—	–	—	—	—	—	–	
Asclepias sp.	—	—			—	-	29	—	—	—	—	—	—	—	—		—		—
Equisetum arvense	—			—	—	—	71	100	–	—	—	—	—	—	—	16	32	17	76
Veronica sp.	—	–	–	–	—	—		—	4	—	–	—	4	—	—	—	—	–	—
Trifolium sp.	—	-	—	—	—	—	-	—	—	—	—	—	—	–	—	76	36	11	32
Chrysanthemum sp.	—	—	—	—		—		—	–	—	—	–	—	–	—	68	16	12	4
Vicia cracca	—	—	—		—	–	–	—	—	—	—	—	—	—	—	16	12	32	40
Cirsium sp.	—	—	–	—	—	–	—	—	—	–	–	—	—	—	—	8	24	12	28
Daucus carota	—	—	–	—	—	–	—		—	—	—	—	—	—	—	4	36	28	28

were well supplied with water. No information was recorded relative to water levels in Upper Shore of Teal Bay.

Muskrat Installations and Home Ranges

East Bay — In 1979, the vegetation stands surrounding 11 of 24 houses built in spring were carefully recorded. The majority (82%) of houses were surrounded by mixed Reed Canary Grass (*Phalaris arundinacea*)-cattail stands. In 1980, there were only 14 houses active in May and 67% of them were surrounded by the same mixed stands. The frequency of those stands was not significantly different from that observed in the habitat in 1979 ($\chi^2 = 0.297$, $p > 0.05$) and 1980 ($\chi^2 = 0.601$, $p > 0.05$). In 1979, 10 of the 24 installations were used intensively and maintained by Muskrats during June and July. These were the main dwellings where the young-of-the-year were born and weaned. The other 14 houses were used in early summer by bachelors and in July by first litter juveniles investigating the surroundings of their main dwelling. In 1980, 10 of the 14 houses were main dwellings and the four others were used as shelters by adults of some families or first litter juveniles moving around the main dwelling. In July, another main dwelling, a burrow, was found. The average distance between two main dwellings in 1979 was 87.6 (± 51.4) m and was not significantly different from that in 1980 (87.2 ± 39.3 m; $t = 0.023$, $p > 0.05$). In 1979, two of the main dwellings were built in region II, two in region III and six in region IV. Region I was a dry-out in May and no main dwellings were built there. The reachable free water areas covered 19 280 m^2 and 19% of the covered area was in region II, 31% in region III and 50% in region IV (Table 2). The hypothesis that muskrats utilize open water areas in exact proportion to their relative importance in each region of the study area was tested by the chi-square test. No significant difference existed between the observed occurrence of main dwellings in each region and the one expected according to the proportion of free water areas in each region of the study area ($\chi^2 = 0.406$, $p > 0.05$). In 1980, the proportion of main dwellings/region was also similar to the proportion of open water areas in each region ($\chi^2 = 0.119$, $p > 0.05$; Table 2). In early summer of both years, Muskrats were concentrating their activities by their main dwellings (Figure 2a, 3a). The average area of 1979 June-July home ranges (484 ± 238.4 m^2) was not different from that of 1980 (302 ± 202.3 m^2; $t = 1.664$, $p > 0.05$). No home range in early summer 1979 or 1980 had $< 25\%$ of either open water or vegetation and the average home range had a ratio of vegetation:open water areas of 1:1 (Table 3). The average number of houses used by a family in June-July was 1.5(± 0.7) in 1979 and 1.2(± 0.6) in 1980 ($t = 1.867$, $p > 0.05$).

Building activity occurred in late summer 1979 and there were 44 active houses in August-September. The observed occurrence of main dwellings per region was significantly different from the one expected according to the proportion of open water areas in each region of the study area ($\chi^2 = 11.097$, $p < 0.05$; Table 2). Then, animals concentrated their building activity towards the edge of the lake. They were "over-using" region IV, the region where free water areas were surrounded by vegetation stands with > 15 cm of water. Only eight new houses were built in August-September 1980 and a total of 23 installations were used by Muskrats in late summer. The proportion of dwellings in each region was not significantly different from the proportion of open water areas found in each region ($\chi^2 = 0.790$, $p > 0.05$; Table 2). The average distance between the main dwellings and the new houses was 39.6 (± 33.1) m in 1979 and 33.4 (± 19.7) in 1980 ($t = 1.460$, $p > 0.05$). In 1979, the late summer home ranges (Figure 2b) were significantly larger than early summer ones ($t' = 2.268$, $p < 0.05$) and averaged 1112 (± 842.7) m^2. In 1980, the average late summer home range was 470 (± 182.7) m^2 (Figure 3b) and was not significantly larger than that of June-July ($t = 1.664$, $p > 0.05$). It was, however, significantly smaller than August-September 1979 ($t' = 2.361$, $p < 0.05$). There was no summer home range in 1979 or 1980

TABLE 2. Distribution of Muskrat dwellings and relative importance of open water areas (%) in East Bay in summers 1979 and 1980.

	June-July				August-September			
	1979		1980		1979		1980	
Water Regions	Dwellings	Open Water Areas %	Dwellings	Open Water Areas %	Dwellings	Open Water Areas %	Dwellings	Open Water Areas %
I	0	0	1	5	0	0	1	5
II	2	19	2	18	2	8	4	18
III	2	31	3	29	6	35	5	29
IV	6	50	5	48	36	57	13	48

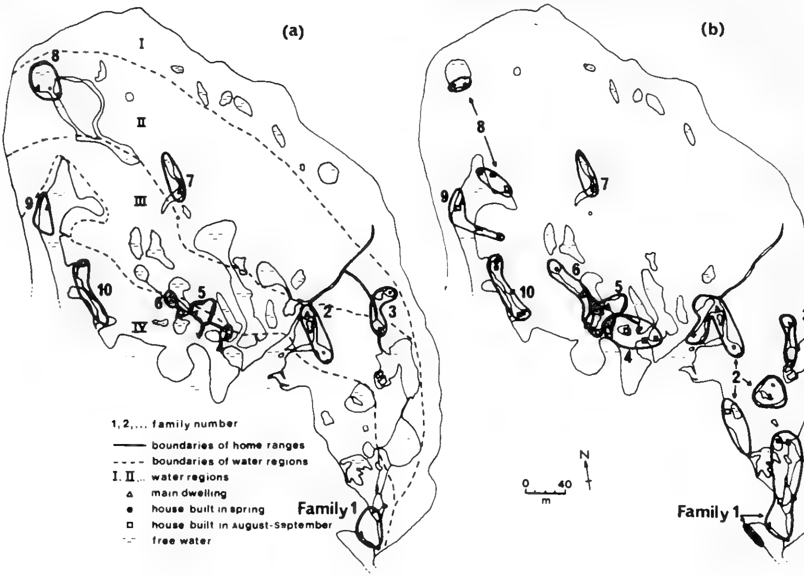

FIGURE 2. Home ranges of families inhabiting East Bay in summer 1979: a) June-July home ranges; b) August-September home ranges.

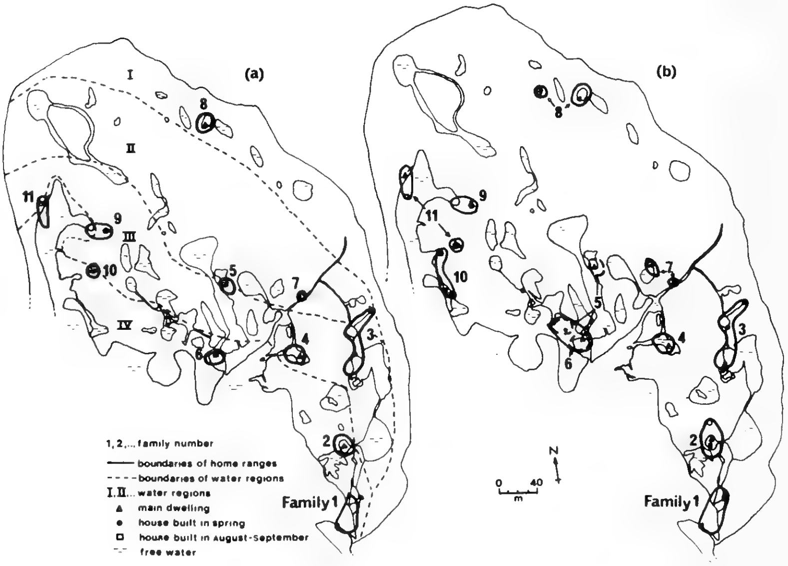

FIGURE 3. Home ranges of families inhabiting East Bay in summer 1980: a) June-July home ranges; b) August-September home ranges.

TABLE 3. Average composition of early and late summer Muskrat home ranges in East Bay in 1979 and 1980.

	June-July				August-September			
	1979		1980		1979		1980	
	Average Area (m²)	S.D.	Average Area (m²)	S.D.	Average Area (m²)	S.D.	Average Area (m²)	S.D.
Vegetation Stands	213.1	121.8	154.3	119.3	599.4	493.3	244.6	113.0
Open Water Areas	270.9	185.0	148.4	104.1	512.9	368.3	225.2	100.0

with $< 25\%$ of either open water or vegetation. In August-September of both years, water covered 50% of the area of the average home range (Table 3). There were 3.9 (± 1.7) houses/family in late summer 1979. This average was significantly higher than in early summer 1979 ($t' = 4.128$, $p < 0.005$). In late summer 1980, there were 2.2 (± 0.7) houses/family. This average was significantly higher than in early summer 1980 ($t = 3.382$, $p < 0.005$) but significantly lower than in late summer 1979 ($t' = 2.943$, $p < 0.005$).

Western Shore — Three of four installations built in spring 1979 were main dwellings: one house in the cattail stands, and two burrows in the horsetail stands. At the end of July, the surroundings of the burrows were dried out and animals relocated in houses built approximately 40 m from shore, in water > 70 cm deep. During summer 1979, two captures occurred in the sedge belt, nine in the cattail belt and 16 in the horsetail belt. The observed occurrence of captures in each vegetation belt was not different from the expected occurrence of captures for each vegetation belt ($\chi^2 = 0.415$, $p > 0.05$) and Muskrat appeared to use the belts at random. The summer home ranges averaged 2283 (± 816) m² (Figure 4b).

In spring 1980, four of five installations were main dwellings: three houses in the cattail belt and one burrow in the horsetail belt. New building occurred in August and a total of nine installations were used by Muskrats: six in the cattail belt and three in the horsetail belt. The number of installations in each vegetation belt was not distributed proportionately to occurrence of vegetation belts ($\chi^2 = 5.577$, $p < 0.05$) which implies that the cattail belt was "over-used." However, no significant difference existed between the observed occurrence of installations in each water region and the one expected according to the proportion of water regions in the study area ($\chi^2 = 1.153$, $p > 0.05$). Two of 17 captures prior to August occurred in the horsetail belt and 15 in the cattail belt. The observed occurrence of captures in each vegetation belt was different from the expected occurrence of captures in each belt and Muskrat captures were not distributed proportionately to occurrence of vegetation belts ($\chi^2 = 30.547$, $p < 0.005$). In August and September, 31 of 46 captures occurred in the cattail belt, 13 in the horsetail belt, and two in the sedge belt. Again, Muskrat captures were not distributed proportionately to occurrence of vegetation belts ($\chi^2 = 34.203$, $p < 0.005$) and Muskrat were concentrating more their activities in the cattail belt than in the others. Trapping results and field observations occurred in the vegetative portion of the habitat and the proportion of free water areas used by muskrats in their movements from one site to another is unknown. However, using an estimate of 50% water and 50% vegetation based on East Bay data, home range averaged 1682 (± 783) m² (Figure 4c).

Teal Bay, Creek and Upper Shore of Teal Bay: In 1979, Teal Bay and Creek were used by only one family which established its house in the cattail stands of the creek. The same house was used in 1980 by one family and another main dwelling was found in Teal Bay, in a clump of willows (*Salix* sp.) at the junction of the cattail and spike rush belts. In Upper Shore of Teal Bay, three main dwellings were found among cattail stands. One of them was found destroyed in July and Muskrats built a new one among cattail and bulrush stands. Captures and feeding platforms were restricted to the immediate site of the houses and the area covered by the movements of the animals was not determined in any of these habitats.

Ponds: In early summer 1979, seven burrows were found in Pond 1 but only two were still active in August. All others were abandoned as soon as their entrances became exposed by the drop in water level. In August, two more burrows were built in the shore of the island. Muskrats were using trails up to 10 m long leading from their burrows to feeding grounds. The home range was estimated at 3900 m². It had 2100 m² (54%) of vegetation stands and 1800 m² (46%) open water.

In 1979, in Pond 2, two burrows, located on the only shore well supplied with water, were used during all summer months. Muskrats were using trails up to 8 m long leading from their burrows to feeding grounds. Their home range was estimated at 3200 m². Vegetation stands covered 1700 m² (53%) and open water, 1500 m² (47%).

In 1980, Ponds 1 and 2 were used by the same family. Burrows that had been used from May to

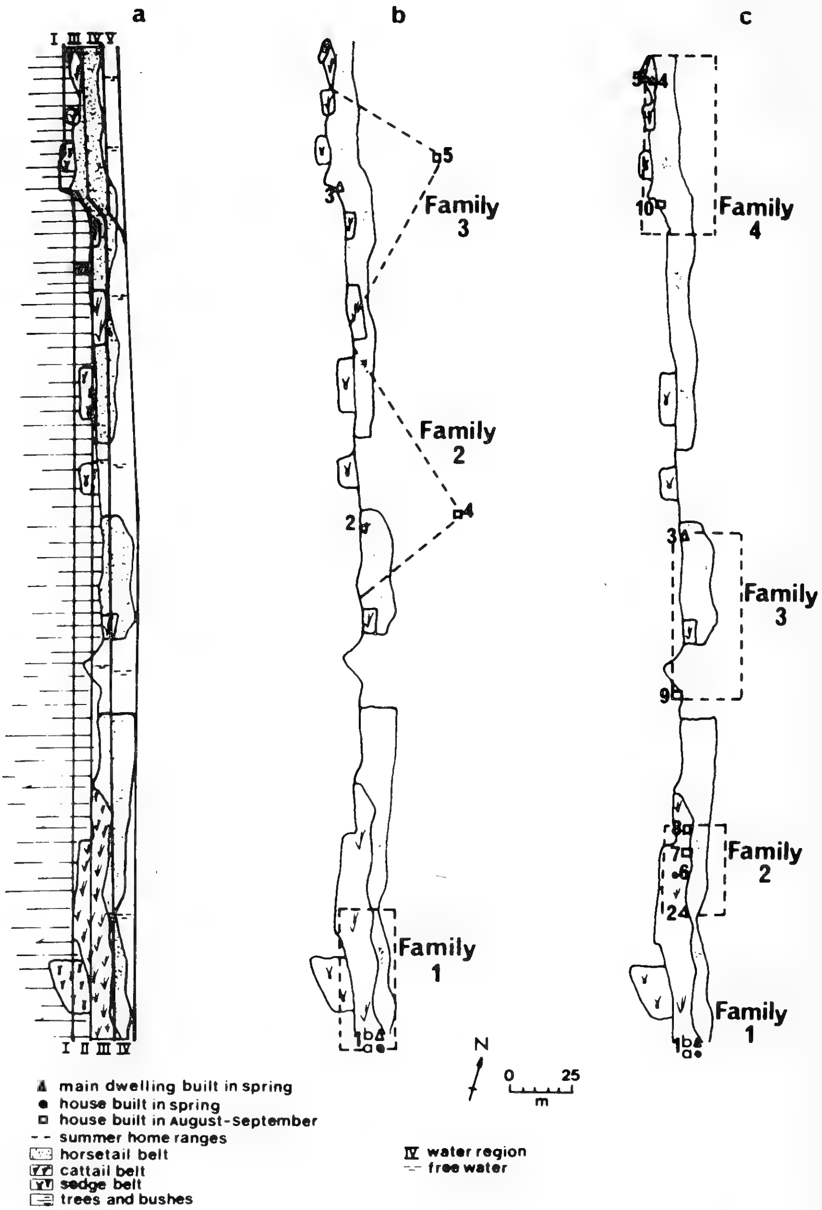

FIGURE 4. Vegetation belts and water regions (a) and location of muskrat installations and home ranges of families inhabiting Western Shore in summers 1979(b) and 1980(c).

September 1979 were used again. The home range was estimated at 7100 m². Vegetation stands covered 3800 m² (54%), and open water, 3300 m² (46%).

Food Habits

Sufficient information to study Muskrat food habits was obtained from East Bay and Western Shore. In East Bay, cattail and Reed Canary Grass (*Graminae*) had the highest frequency indices and were also important Muskrat food items (Table 4). Cattail was always abundant on the feeding platforms but its forage ratio decreased from May to August (Table 4).

In Western Shore, in 1979, all species, except bulrush, were in proportions lower than their availability (Table 4). In 1980, Muskrat food habits were also diversified but the frequency of cattail on feeding platforms at different periods of the year was always very high and the species was used in proportions greater than its availability (Table 4).

Muskrat Populations

In 1979 and 1980, most females in each habitat had two litters. In 1979, the number of first litter juveniles captured per female averaged 5.7(± 2.3) in East Bay (10 families) and 5.0(± 2.0) in Western Shore (three families). No significant difference existed between these two values ($t = 0.473$, $p > 0.05$). It appeared that females which had a second litter in East Bay (six families) produced more young than in Western Shore (three families) and the averaged number of second litter juveniles captured per family was 3.8(± 2.5) and 1.3(± 1.5) respectively ($t = 1.564$, $p > 0.05$). In 1980, an average of 6.6 (± 2.4) first litter young were captured per family in East Bay (11 families), 5.7(± 2.9) in Western Shore (four families) and 5.7 (± 0.6) in Upper Shore of Teal Bay (three families). These values were not significantly ($p > 0.05$) different from each other. The average number of second litter juveniles captured per family in East Bay (eight families) and Western Shore (three families) was 5.4 (± 2.5) and 5.3 (± 4.0) respectively ($t = 0.049$, $p > 0.05$). Few second juveniles were captured in Upper Shore of Teal Bay because of a lack of favorable trap sites in late summer 1980 and the trapping results relative to this age were not considered for that habitat.

Juveniles represented between 66 and 92% of all trapped populations (Table 5). When all muskrat populations of all habitats were grouped together, juveniles comprised 74.4% of the trapped population in 1979 and 85.5% in 1980. The sex ratio of most population segments was even. When all populations were grouped together, adult sex ratios favored males ($\chi^2 = 5.333$, $p < 0.05$) in 1979 but were even in 1980. First litter sex ratios were even in 1979 ($\chi^2 = 2.539$, $p > 0.05$) but departed significantly from a 1:1 ratio in 1980 ($\chi^2 = 6.931$, $p < 0.05$). Second litter juveniles had

TABLE 4. Muskrat food habits in East Bay and Western Shore in 1979 and 1980 (A = % availability in the habitat; 0 = % occurrence on the feeding platforms; FR = forage ratio).

	28 May- 6 June 1979 24 Platforms			25 June 29 July 1979 51 Platforms			28 May- 10 June 1980 32 Platforms			16 June- 22 July 1980 48 Platforms			29 July- 27 August 1980 33 Platforms			12 June- 12 August 1979 14 Platforms			16 May- 16 June 1980 9 Platforms			23 June- 17 July 1980 9 Platforms		
	A	O	FR	A	O	FR	A	O	FR	A	O	FR	A	O	FR	A	O	FR	A	O	FR	A	O	FR
Typha sp.	85	100	1.2	80	74	0.9	61	44	1.5	86	81	1.0	81	64	0.8	32	21	0.7	26	78	3.1	31	33	1.1
Equisetum sp.	9	8	0.9										5	6	1.2	84	28	0.3	88	67	0.8	94	62	0.7
Graminae	78	29	1.4	87	59	0.7	92	69	0.7	87	52	0.6	88	21	0.2	41	14	0.3	63	67	1.1	58	22	0.7
Eleocharis sp.	37	33	0.9	7	23	3.3	7	16	2.2	30	29	1.0	22	27	1.2	68	7	0.1	17	33	1.8	45	22	0.5
Sagittaria sp.				15	2	0.1				16	2	0.1				46	21	0.4						
Sparganium sp.				13	2	0.1							28	21	0.8									
Scirpus sp.				2	2	1.0				6	2	0.4				41	50	1.2	23	11	0.4	43	78	1.8
Carex sp.																			15	11	0.7	13	11	0.8
Polygonum sp.																						13	11	0.8

TABLE 5. Muskrat captures in Luther Marsh study areas in summers 1979 and 1980.

Age and Sex Classes	East Bay		Western Shore		Teal Bay & Creek	Teal Bay	Creek	Upper Shore of Teal Bay	Pond 1		Pond 2
	1979	1980	1979	1980	1979	1980	1980	1980	1979	1980	1979
Adults	36	23	6	6	2	1	1	3	2	2	2
Male	*25	12	4	4	1	—	—	1	1	1	1
Female	11	11	2	2	1	1	1	2	1	1	1
First Litter	57	73	15	22	3	9	3	18	6	9	8
Male	33	*49	*12	7	2	5	2	10	2	7	3
Female	24	24	3	13	1	4	1	6	4	2	5
Unknown	—	—	—	2	—	—	—	2	—	—	—
Second Litter	22	38	4	15	1	3	—	5	—	4	4
Male	12	23	3	9	1	2	—	3	—	2	1
Female	10	15	1	6	—	1	—	2	—	2	3
Third Litter	—	9	—	—	—	—	—	—	—	—	—
Male	—	7	—	—	—	—	—	—	—	—	—
Female	—	2	—	—	—	—	—	—	—	—	—

*Sex ratio significantly different ($P < 0.05$) from 1:1.

an even sex ratio in 1979 ($\chi^2 = 0.322$, $p > 0.05$) and 1980 ($\chi^2 = 2.615$, $p > 0.05$).

Estimates of Population Size and Density

In fall 1978, 15 female adults were autopsied and 186 placental scars were counted (12.4 scars per female). In fall 1979, 424 scars were counted for 33 breeding females (12.8 scars per female). Since most of the females of the studied habitats had two litters, these results indicate that female Muskrats produced an average of 6.3 embryos per litter. This average was applied to the live-trapping results to estimate population size in each habitat. The population of East Bay was the largest, followed by the populations of Western Shore and Upper Shore of Teal Bay, Teal Bay and Creek and Ponds (Table 6).

These population estimates were used in a determination of maximum relative densities which would have occurred if all animals were alive (Table 6). The relative densities were calculated with respect to the habitable portion of the habitats, according to water levels and open water areas. With the exception of Pond 2, there were between 19.3 and 22.4 animals/ha in 1979 and between 18.1 and 22.6 animals/ha in 1980.

Population densities can also be estimated by the areas covered by the home range (Table 6). East Bay populations had markedly more animals/ha of home range (> 100 animals) than in any other populations (< 80 animals).

TABLE 6. Estimates of Muskrat population size and density in Luther Marsh study areas in summers 1979 and 1980.

Study Area	Maximum Population Estimate	Muskrat/ha of Habitat	Muskrat/ha of Home Range
1979			
East Bay	121*(137)	21.2	109
Western Shore	44	19.3	65
Teal Bay + Creek	15	22.4	—
Pond 1	8	20.5	20
Pond 2	15	46.9	47
1980			
East Bay	148	23.5	287
Western Shore	52	22.6	77
Teal Bay	15	18.1	—
Creek	8	—	—
Pond 1	15	21.1	21
Upper Shore of Teal Bay	44	—	—

*Value obtained when one considers that thae adult population was made up of only 10 breeding pairs. The value within brackets includes adult male bachelors.

Yearly Muskrat Population Changes

From spring 1979 to spring 1980, growth rates of 1.1., 1.3, 2.0, and 1.0 were obtained for breeding muskrat populations of East Bay, Western Shore, Teal Bay and Creek, and Pond 1 respectively. The

Muskrat population of Pond 2 was completely exterminated from 1979 to 1980. Considering that all populations had a large number of juveniles in 1979, a considerable reduction of the densities occurred over winter 1979-80.

In fall 1978, 159 carcasses were analysed and there were 8.6 juveniles per female adult. Considering that there were 12.4 placental scars per female, the juvenile mortality rate from birth to the fall trapping season was estimated at 30.6%. In fall 1979, there were 8.1 young and 12.8 placental scars per adult female in a sample of 338 carcasses, which give an estimate of mortality between birth and the fall trapping season of 36.7%. The juvenile mortality over the two summers averaged 33.6%.

The reduction of Muskrat populations over winter was calculated according to the maximal summer population estimates (Table 6), the sex ratio of each population segment and the average summer survival rate of the juveniles. A 10% adult mortality during summer (Errington, personal communication *in* Olsen 1959), an equal mortality for males and females and an immigration rate equalled to the emigration rate were also assumed. In East Bay, the surplus of male adults in summer 1979 consisted of bachelors which left the study area over summer. Thus, only 10 males were considered as part of the summer adult population. Also, the winter natural mortality rate in this habitat was calculated according to a potential of 12 breeding pairs in East Bay in spring 1980 (one female died in early summer from Tyzzer's disease). The winter reduction ranged from 60 to 75% in East Bay, Western Shore, Teal Bay and Creek, and Pond 1 (Table 7). The average was 68.2(± 6.4)%. Reduction of male and female populations averaged 65.3(± 13.1)% and 68.3(± 6.5)% respectively. Male populations were not reduced significantly more than female populations ($t = 0.407$, $p > 0.05$).

Life Table

If the summer mortality rates of adults and juveniles are fixed at constant rates of 10 and 33.6% respectively, and the winter kill is 68.2%, a hypothetical life table can be built for a cohort of 1000 juveniles (Table 8). More than half the animals would die during the fall and winter months following their birth and only 21.1% would be present during the first breeding season. Maximum longevity would be 60 months. A survivorship curve for such a population would be characterized by a high mortality during the summer months of the first year and during each winter season (Figure 5).

TABLE 7. Winter reduction (%) of fall muskrat populations in Luther Marsh study areas in 1979-80.

	% Reduction		
Habitat	Male Population	Female Population	Total Population
East Bay	71.4	71.4	71.4
Western Shore	66.7	80.0	75.0
Teal Bay + Creek	60.0	60.0	60.0
Pond 1	50.0	75.0	66.7

TABLE 8. Hypothetical muskrat life table for a cohort of 1000 juveniles at Luther Marsh.

Age (months) *x*	Survival *lx*	Mortality *dx*	Mortality Rate *qx*	Survival Rate *px*
5	1000	336	0.336	0.664
5	664	453	0.681	0.319
12	211	21	0.099	0.901
17	190	130	0.684	0.316
24	60	6	0.100	0.900
29	54	37	0.685	0.315
36	17	2	0.118	0.882
41	15	11	0.733	0.267
48	5	1	0.200	0.800
53	4	3	0.750	0.250
60	1	—	—	—
65	—	—	—	—

Discussion

Muskrat houses were found in areas affording two essential constituents: 1) heavy building material and 2) enough water to cover house channels and provide Muskrats with access to their house beneath the water's surface. According to water conditions which prevailed in regions where intensive building occurred and those where abandonment of houses was observed, a minimum of 15 cm of water was necessary to accomodate lodge-building Muskrats. This estimate is in agreement with the findings of Bellrose and Brown (1941). Abandonment of houses was observed with a decrease in water level (Coulter 1948; Westworth 1974; Danell 1978). Therefore, water plays the role of a dispersion factor. However, the selection of cattail stands by Muskrats in Western Shore 1980 suggests that, when water levels are > 15 cm deep everywhere within a habitat, vegetation stands become a dispersion factor. Therefore, the suitability of a site for Muskrat building activities depends on the simultaneous presence of heavy emergent vegetation and water. Although previous studies pointed out that muskrats intensively use burrows in summer (Dilworth 1966; Philips 1979), the present study indicates that Muskrats used such structures as an alternative to houses only when heavy emergent vegetation was absent and/or water depths were < 15 cm.

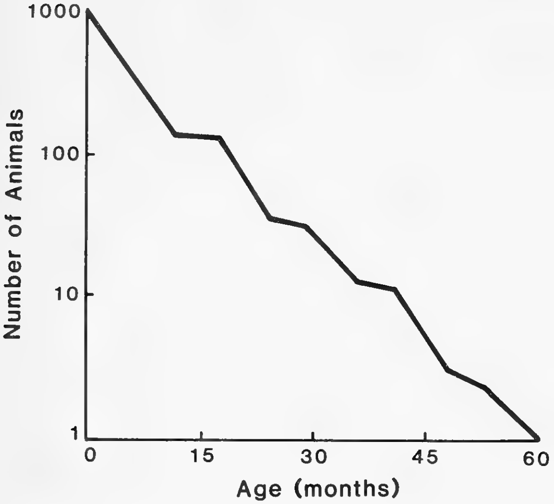

FIGURE 5. Hypothetical survivorship curve of a cohort of 1000 juveniles at Luther Marsh.

Until now, no one has ever quantified the proportions of a home range in water and vegetation stands and thus determined the composition of suitable Muskrat habitat. In this study, the average home range had a ratio of vegetation stands:open water areas of 1:1 and it is suggested that vegetation stands cannot be dissociated from water areas when one considers the composition of a suitable habitat. According to previous studies (Sather 1958; Erickson 1963; Neal 1968), summer home ranges can be enclosed by a circle 45 to 60 m in diameter. In this study, such a circle would have overestimated home range sizes by including areas unused by Muskrats, such as vegetation stands isolated from water areas and thus inaccessible. Furthermore, in this study, late summer home ranges often consisted of disconnected areas, each occupied by some family members concentrating their activities around the installations that they built. The minimum home range sizes determined in this study would appear to be realistic in that they measured areas intensively used by Muskrats and not areas traversed by animals in the re-establishment of their areas of daily activity.

Home range expansions during the summer could be due to juveniles which were forced to leave the breeding lodge before the birth of the next litter (Errington 1961). In this study, home range expansions occurred in late July. At this time of the year, second litter juveniles started to investigate the immediate surroundings of the main dwelling and first litter juveniles re-established themselves in new homes. However, with a decrease in the water level in late summer 1979, several vegetation stands became inaccessible. An expansion of the home ranges could have served to re-establish a balance of water to vegetation and to avoid frictions usually observed in degraded environments (Errington 1951, 1954; Neal 1968).

Muskrat food habits were related to three factors acting simultaneously: 1) diversity of the flora; 2) movements of the animals; and 3) preference of the animals. When possible, muskrats concentrated their activities near their installations. Also, food habits reflected the floristic composition of the surrounding stands. This explains the high occurrence of cattail on the feeding platforms. When the surroundings had a diversified floristic composition, as in Western Shore, there was a larger number of plants with a high percentage of occurrence on feeding platforms. When vegetation and water did not make up, together, the surroundings of Muskrat installations, Muskrat food habits became more diversified. Captures in Western Shore, 1979, showed that feeding activities there occurred far from the installations and animals used the different vegetation stands as they encountered them. Finally, a variation in the forage ratio of the plants, such as cattail, indicated that there was some seasonal preference in plant food. This was also noticed by Butler (1940) and Takos (1947).

In 1979 and 1980, most females had two litters in all study areas. This agrees with other studies carried out in temperate Canada and the adjacent United States, e.g. McCann (1944) in Minnesota, Gashwiler (1950) in northern Maine, Fuller (1951) in the Athabasca-Peace Delta, MacLeod and Bondar (1952) in southern Manitoba and Stewart and Bider (1974) in southern Quebec. Bellrose and Low (1943) and Arata (1959) have suggested that litter size may vary with environmental conditions. At Luther Marsh, environmental conditions might have had an effect on the number of animals born alive or surviving during the few hours or days following their birth. Trapping results indicated that juveniles made up a larger portion of the population in 1980 than in 1979. In Western Shore, although no significant difference was observed between the average number of juveniles captured per family in 1979 and 1980 (because of small sample size), the fact remains that 1980 families produced four more second litter juveniles than the 1979 families. Considering that 1980 families were located in an environment more favorable with respect to vegetation type and water conditions, a higher productivity of juveniles would have been expected as an outcome. Also, the difference between captures of East Bay and Western Shore in 1979, although not found statistically significant, could be meaningful on a long term basis, if the same environmental situation was repeated over many years in each habitat. In 1980, the similarity between captures of juveniles of East Bay, Western Shore, and Upper Shore of Teal Bay appears to have been a result of families of all habitats having been subject to similar environmental conditions.

During summers 1979 and 1980, adult populations usually had an even sex ratio. This was also found by Aldous (1947), Coulter (1948), and Erickson (1963). An even sex ratio and the fact that only one adult male and one adult female were captured per main dwelling supports the idea of a monogamous breeding system (Stevens 1955; Sather 1958; Mathiak 1966). The general trend of the juvenile populations was also towards an even sex ratio. That result agrees with the findings of McDonnell (1979) and with the theory of Fisher (1930) who concluded that, at equilibrium, an optimal organism should allocate half its reproductive effort to progeny of each sex.

Very few publications concern Muskrat densities in summer. An average of 21 animals/ha was obtained in all habitats in 1979 and 1980. This is markedly smaller than the 123 and 55 Muskrats/ha reported by Lynch et al. (1944) and Vincent and Quéré (1972) respectively for more moderate climes, but is similar to 21.7 Muskrats/ha estimated by McDonnell (1979) for Luther Marsh. Previous studies correlated population densities to the type of vegetation present in a habitat (Bellrose and Brown 1941; Errington 1941, 1948; Alexander 1955). A vegetation-Muskrat density relationship becomes apparent when one considers the density of animals/ha of home range. In this respect, there were markedly more animals in East Bay per unit area than in any other habitat. This observation agrees with Smith and Jordan (1976) who associated the largest concentrations of Muskrats/ha with the habitat richest in cattails.

The summer survival rate was very high at Luther Marsh and was greater than the values reported by Baumgartner and Bellrose (1943), McCann (1944), Alexander (1955), Dorney and Rusch (1953) and Olsen (1959). On the other hand, the winter reductions estimated at Luther Marsh were very high, compared to 38 and 44% reported by Errington (1939) and Stewart and Bider (1974) respectively. Relatively low summer population densities could have favored a high summer survival rate of the juveniles and concurrently, allowed too high a concentration for the harsh winter environment at Luther Marsh. Intraspecific strife, starvation and disease might have occurred in animal groups subjected to restricted winter feeding grounds (Errington 1954, 1961).

According to the life table, 99.5% of a cohort of 1000 juveniles would not reach four years of age. Errington (1961) estimated the Muskrat life span to be three to four years but he had no numerical values to substantiate his conclusions. The shape of the survivorship curve implies a constant rate of mortality, independent of age. Although many Muskrats die in their first year of age, the reduction did not produce a concave survivorship curve as hypothesized by Giles (1978). Probably no real population has a constant survival rate throughout its whole life span and the sigmoid curve reported in studies of other rodents (Caughley 1966; Barkalow et al. 1970) might be applicable also to Muskrat populations. Animals in their prime might be more capable of coping with the environmental conditions than are older ones, and the slope of the corresponding portion of the survivorship curve might be less steep in the real world. Data collected in a minimum five-year study would provide a more reliable survivorship curve.

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Some Effects of Winter Shelter Conditions on White-tailed Deer, *Odocoileus virginianus*, Fawns

F. F. GILBERT[1] and M. C. BATEMAN[2]

School of Forest Resources, University of Maine, Orono, Maine 04473
[1]Wildlife Biology, Washington State University, Pullman, Washington 99164-4220
[2]Canadian Wildlife Service, Sackville, New Brunswick E0A 3C0

Gilbert, F. F., and M. C. Bateman. 1983. Some effects of winter shelter conditions on White-tailed Deer, *Odocoileus virginianus*, fawns. Canadian Field-Naturalist 97(4): 391–400.

The behavior of 11 White-tailed Deer (*Odocoileus virginianus*) fawns was observed from December 1970 through March 1971. The animals were maintained in individual pens under cover conditions that were naturally wooded, clear-cut, or clear-cut with an artificial windbreak. Commercial feed was supplied ad libitum and consumption measured weekly. The responses of the animals to winter climatic conditions were monitored. The deer maintained in the clear-cut pens with an artificial windbreak lost a greater percentage of their body weight, had a lower kidney fat index, and ate less relative to body weight than the deer in the other pens. Fewer opportunities for socialization by these deer was considered partially responsible for these results. Solar radiation accounted for about 28 percent of the variation in food consumption. Food intake was maximum at a mean daily ambient temperature of -15°C, minimum at -4°C and decreased below -15°C. Greater feeding and other activity occurred when skies were overcast, when the barometer was falling and when vapor pressure humidity was increasing. The location of bed sites was affected primarily by the location of deer in adjacent pens. Sites that were potentially solar exposed were selected more often on clear than overcast days. The deer in the clear-cut pens maintained trails around the periphery of their enclosures and used those portions of the trails along fences where other deer were present more than those portions where no deer were adjacent. The animals seldom moved off their trail networks when snow thickness exceeded 30 cm. Energy costs of maintenance under these free-ranging conditions were higher than those predicted from laboratory studies by a factor of 2.

Key Words: White-tailed Deer, *Odocoileus virginianus*, winter, shelter, energy requirements.

Winter weather conditions at the northern extremities of the White-tailed Deer's (*Odocoileus virginianus*) range have long been considered a major limiting factor for this species. Low temperatures, high winds and deep snow cover place energy demands on the animal that it partially meets by lowering its basal metabolic rate (Silver et al. 1969).

Previous studies have indicated that shelter from unfavorable weather is a primary reason for use of "yarding" areas during the winter (Cook and Hamilton 1942; Webb 1948; Severinghaus 1953). Verme (1965) found that areas with abundant browse but little shelter were not used as wintering areas. Ozoga (1968) demonstrated that yard areas had smaller fluctuations in temperature and lower wind velocities than other sites, which would mean energy requirements might be lessened in such locations due to more favorable climatic and snow thickness conditions. Robinson (1959) concluded that even in sparse cover deer could find adequate shelter from adverse weather.

Although the general characteristics of deer wintering areas have been described by many authors (e.g. Severinghaus and Cheatum 1956; Gill 1966) and it is accepted that protection from severe weather is an important factor in determining yard location, there have been few studies which show how the lack of cover may affect wintering deer. Tarchinski (1969) attempted to show the effects of temperature and wind velocity on the winter nutritional requirements of White-tailed Deer fawns but found only that variation in coat insulation was an important factor. Robinson (1959) showed that penned deer on a restricted diet bedded in areas with the most favorable microclimate, but Westover (1971) found no difference between the cover conditions at bed sites and those at random points in Michigan deer yards. Hugie (1973), studying a northern Maine deer population, found that the animals completely abandoned a winter shelter area in favor of an active cutting operation nearby in more open cover conditions.

It appears that White-tailed Deer employ a number of behavioral and physiological strategies designed to ameliorate or minimize the effects of severe winter weather conditions. The purpose of this study was to relate differences in the behavior and condition of White-tailed Deer penned under three different cover situations to environmental factors.

Methods

Description of Study Area

The study was conducted at the big game enclosures located in the D. B. Demeritt Forest at Orono, Maine. This area is included in Fobes' (1946) Central and Southwestern Interior Climatic Division. The annual mean snowfall for this division is 193.0 cm and the mean January temperature is between -7.8° and -7.0°C.

One deer was confined in each of eleven 0.10 ha pens that provided 3-4 replicates of each experimental cover condition (Figure 1). The experimental conditions were: (1) natural tree cover (N), (2) absolute clear-cut (A), and (3) clear-cut with vertical wall windbreaks (C). Each pen was gridded into 12 separate areas by red wooden posts. Each deer was designated the letter-number sequence of the pen it occupied.

The A and C pens were cleared of all woody growth the summer of 1969. All edible brush and branches were removed from the N pens to a height of 1.8 m. In order to reduce the shelter effects of trees adjacent to, but outside, the experimental pens, 9 and 15 m wide strips were clear-cut at the east and west ends, respectively, of the A and C pens during the summer of 1970. Although the difference in elevation was small, all pens sloped west.

The overstory density for each area within each pen was measured with a spherical densiometer (Lemmon 1956) in January, 1971. The average value of the overstory density measured when facing north, west, south, and east in the center of each area of each pen was determined. Average N, A, and C values (in %) were 72, 6, and 8, respectively. The total basal surface area in the N pens ranged from 4.01 to 1.34.

In area 9 of each C pen (Figure 1), a vertical-wall windbreak consisting of three sides radiating from a central post was constructed of rough lumber. Each side was 2.4 m long and 2.1 m high.

Description and Treatment of Experimental Animals

Six male and 5 female fawns were used in the study which began during December 1970. Three males (N4, A4, C4) and 3 females (N2, A2, C2) were received 2 October 1970 from the game farm of the Maine Department of Inland Fisheries and Game located at Gray. Two males (N1 and A1) and one female (N3) were part of the Orono deer herd and had been raised by their does in the experimental pens. The other fawns (A3 and C1) were captured on Swan Island Game Management Area at Richmond, Maine, 7 August and 27 August 1970, respectively. Deer N1, A1, C1, N3 and A3, are designated Orono-raised; deer received from the game farm are referred to as game farm-raised. All experimental animals were allowed complete freedom of the 1.2 ha experimental area from the time they were received (or from the first of

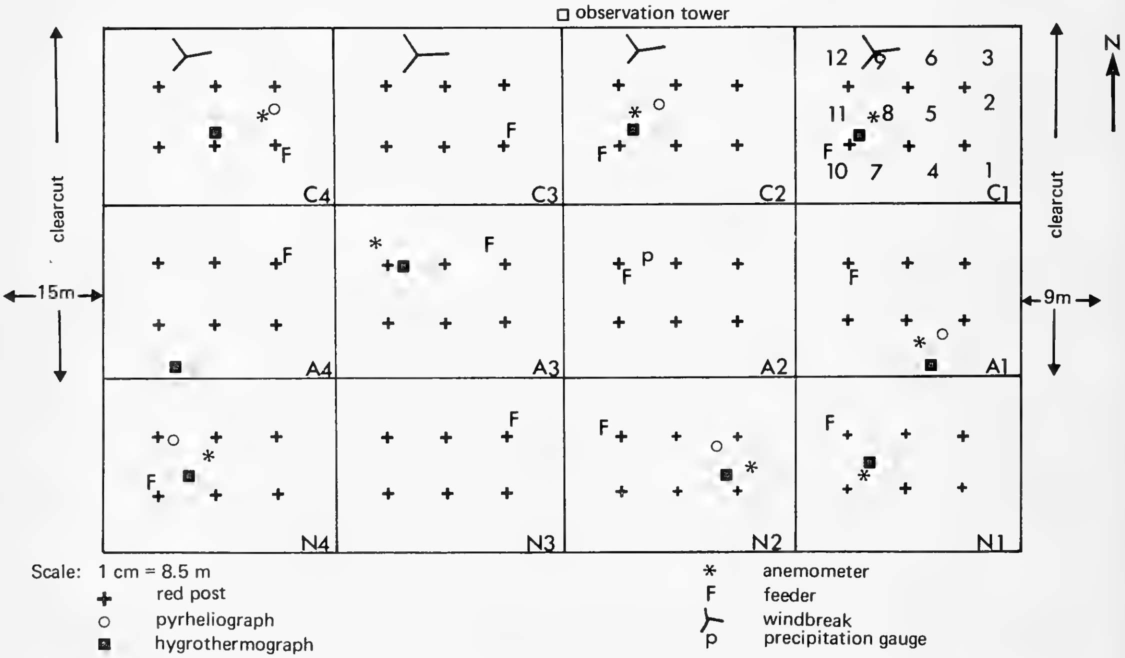

FIGURE 1. The experimental pen lay-out showing positions of wind-breaks, climatological instruments, feeders, grid markers and grid number. The clear cut areas adjacent to the pens are also shown.

September when the Orono does were separated from their fawns) until placed in the experimental pens.

Description of Behavioral Observations

The basic observation period was a 10-min interval during which the behavior of each deer was recorded sequentially on a data sheet. These 10-min intervals were repeated continuously for about 3 h. The location of each deer within its pen and the animal's behavior were noted (Bateman 1972). The behavior of deer in each replicate was recorded as quickly as possible. Generally, 5-6 min separated the observations of the first and last replicates within one 10-min period. The deer were observed during all hours of the day so that the total of the observations gave information on a complete solar day.

Data recorded at the beginning of each 10-min observation period included: the local time of day (E.S.T.), the time before or after sunset (BSS, ASS) or sunrise (BSR, ASR) corrected to local incident time, cloud conditions, wind speed and direction, and precipitation.

Measurement of Feed Consumption

The deer were allowed to eat New Hampshire deer pellets (Thompson et al. 1973) ad libitum from individual feeders. Each feeder was located within 3.0 m of the red marker post nearest a corner of the pen so that the deer had to move away from the fence area to eat. Each week the amount of feed required to fill each feeder to a permanent line was weighed to the nearest 0.2 kg. This was assumed to be the weight of feed eaten by the deer during the previous week. The accuracy of this method was determined by refilling feeders from which various amounts of feed had been previously removed and weighed. From a series of 20 of these trials it was estimated that the weight of feed consumed weekly could be measured with 95 percent confidence within ± 1.6 kg.

Two control feeders which could not be opened by the deer were set up to determine feed loss to small mammals and birds. One control was placed in H4 while the other was moved from A4 to C4 after one month. Although Red Squirrels (*Tamiasciurus hudsonicus*) and small birds were seen leaving both the control and experimental deer feeders, the small amount taken could not be measured by the techniques of this study. No spillage by the deer was observed.

The weekly food consumption was divided by 7 and expressed as kg/day, or, using the average of the December-January and March body weights, expressed as kg/day/100 kg body weight.

Collection of Meteorological Data

Relative humidity, temperature, solar radiation, and barometric pressure were recorded using Casella 931 hygrothermographs, Belfort 53850 pyrheliographs, and a Short and Mason A2868 barograph. The positions of these instruments during the study are shown in Figure 1.

Average daily maximum and minimum temperatures, average daily percent humidity, vapor-pressure humidity, and mean temperature were calculated for each week. The temperature and humidity measured by each instrument were checked periodically with a standard thermometer and Bendix Model 566 psychrometer. The amount of precipitation that fell during each storm was measured in a U.S. Weather Bureau type precipitation gauge at the location shown in Figure 1.

Solar radiation, in langleys per day, was calculated from the average of three measurements of the area under the daily curves on the pyrheliograph charts. Totalizing anemometers (five Belfort 5-349, three Casella w1200/1) (Figure 1), recorded weekly total wind mileage. The average snow thickness of each cover condition was determined from 10 permanent snow stakes installed 15.2 m apart in a line through the center of each cover type. In addition, a meter stick was used to measure the snow accumulation in each area of each pen. These snow thicknesses were measured at approximately the same place each time. Deer sinking depths were determined by measuring the depth of deer tracks when deer moved off the trails, or estimated with a snow compaction gauge (described by Verme, 1968) when deer used trails exclusively. All snow measurements and deer sinking depths were recorded after precipitation (several hours to two days), or at least once every week. Trails and bed sites were mapped when snow thicknesses were measured. If the deer had travelled the same path three or more times, it was marked as a trail. The location of tracks was also mapped.

Weighing and Necropsy Procedures

All deer except C1 were weighed to the nearest 0.4 kg December 18 or 19. C1 was weighed February 2. The animals were killed during the period 30 March -11 April, weighed and autopsied.

A kidney fat index was calculated for each animal, using the method of Anderson and Medin (1965). The wet weights of the kidneys were recorded and the amount of body fat described. Three femur bone marrow samples from each deer were frozen for later determination of the fat content by a modification of the Association of Official Agricultural Chemists' (1965) ether extract method. This analysis was performed on two of the samples from each deer. When there was a large difference between samples from the same deer, a third sample was analysed and the two closest values averaged.

Statistical Analysis of Data

Analyses of variance were run on data grouped to test for significance between cover conditions, between individual deer, between sexes, and, in some cases, between the Orono and game farm-raised animals. Significance, or nonsignificance was determined by the Student-Newman-Keuls' (SNK) test (Steel and Torrie, 1960) at the 5 percent level unless otherwise stated. If the F ratios from analyses of variance were not significant, nonsignificance was assumed and SNK differences were not calculated.

In most cases the December-January data were analysed together because a relatively small number of observations were made in December. All measurements except organ weights were made in English system units and converted to metric units after analysis.

Results

Condition Indices

The C deer lost a greater percentage of their December body weight (9.6 percent) than the A (6.2 percent) or N (6.1 percent) deer even though their December body weights were 3.0 kg lighter than the N deer (Table 1).

The game farm deer lost two percent less weight than the larger Orono-raised deer. A negative r value (-0.36) between weight gain and December body weight of all deer was not significant.

The A and C deer had much lower kidney fat indices (39.6 and 32.7 percent, respectively) than the N deer (53.9 percent). They also averaged lower bone marrow fat percentages (70.4 and 75.6 compared to 86.0 percent).

Females lost more weight on the average than males ($P \leqslant 0.10$) but both kidney fat indices and bone marrow fat percentages were higher in the females. The game farm-raised fawns had a much lower (29.7 percent) kidney fat index than the Orono fawns (58.8 percent), but the bone marrow fat percent was higher in the game farm deer (80.2 vs. 74.1 percent).

The differences in condition indices (kidney fat indices, bone marrow fat percentages, weight gain in pounds, `or weight gain expressed as percent of December body weight) between cover types, sexes, and origins were not significant.

Food Consumption

The differences in average food consumption of deer by cover condition were not significant, but when the food consumption of game farm-raised deer was analysed on an individual deer basis, N and A deer ate significantly more than C deer (Table 2). Food consumption of Orono-raised fawns was not tested separately because of the small sample size.

When data from all deer were analysed, no significant differences in food consumption by deer in the different cover conditions were evident with the exception of the 22 January to 26 March period when N and A deer ate significantly more than C deer.

Orono-raised deer ate significantly less ($P \leqslant 0.01$) per unit body weight than game farm-raised deer. However, the difference in daily food intake was not significant.

The correlation between average weekly feed consimption and weight gain of each deer over the study period approached significance ($r = 0.50$, significant $r = 0.58$). Combined data from all deer showed a significant negative correlation ($P \leqslant 0.01$) between food consumption by deer and total weekly solar radiation in langleys ($r = -0.33$). Food consumption by the N deer was less correlated with total solar radiation ($r = -0.54$) than was food consumption of either the A ($r = -0.62$) or C ($r = -0.71$) deer.

General Activity

Most activity occurred during the hour after sunrise and the hour before sunset in all cover types in all months. Activity peaks occurred more frequently in March (at two to three hour intervals) than in February or January (at three to four hour intervals).

Deer activity during periods of falling snow was not significantly different from activity at all times. Activity increased significantly ($P \leqslant 0.01$) as temperature increased. The percent of observations of deer lying

TABLE 1. Mean December and March body weights of experimental deer.

Deer Group	Body weight (kg) December	March	Weight gain (kg)	Percent change
N	41	38	-2.7	-6.1
A	38	34	-2.3	-6.2
C	38	34	-3.5	-9.6
Male	40	38	-2.3	-4.9
Female	36	33	-3.2	-9.1
Orono	41	37	-3.2	-7.9
Game farm	37	34	-2.3	-5.9

TABLE 2. Average daily weight of feed consumed by deer for each month based on weekly totals (kg/day/100kg).

	Game Farm			Orono				
Date	N	A	C	N	A	C	Farm	Orono
Dec.	4.1	4.0	3.9	3.1	3.6	3.6	4.0	3.5
Jan.	2.7	3.3	3.0	2.4	2.8	2.9	3.1	2.6
Feb.	2.9	2.7	2.7	2.4	2.3	2.3	2.9	2.4
Mar.	3.2	2.7	2.2	2.3	2.1	1.6	2.7	2.0

down decreased from a mean of 95.6 when air temperature was -18° to -34°C to 77.5 when the ambient temperature was -5.6° to -12°C, and to 26.6 when the temperature rose to between -5.6° and 10°C. The difference between activity in the temperature range -12° to -18°C and in the temperature range -5.6° to -12°C was significant.

When the deer's activity at each temperature range was analysed for each cover type separately, activity at the highest temperature range (-5.6° to 10°C) was in each case significantly greater ($P \leqslant 0.01$) than activity at any of the lower temperatures.

Activity of deer was compared in three ranges of humidity expressed as vapor pressure in (mm) of mercury: 1 = 0.000 to 0.050 mm; 2 = 0.051 to 0.200 mm; 3 = 0.201 to 0.300 mm. Activity increased but not always significantly for each range of greater humidity. The percent observations lying in humidity range 1 (57.2) were significantly greater than for humidity range 3 (44.5). These differences were not evident when each cover condition was analysed separately.

Deer activity was greater under overcast than under clear skies, and greater when barometric pressure was falling than when rising or steady (Table 3). Activity when winds were moderate averaged 2.9 percent less than when there was no wind. Differences due to barometric pressure and cloud cover were significant when all cover types were grouped (Table 3).

Feeding Activity

The effect of weather conditions on feeding activity was similar to weather effects on general activity. The average number of deer eating each 10 min was greater under overcast (0.4) than under clear (0.3) skies, and greater when barometric pressure was falling (0.4) than when it was rising (0.3) or steady (0.3). Both of these differences were significant in the open but not in the N pens. The average number of deer eating during each 10 min observation period was the same (0.4) when wind speed was moderate, low or calm.

There was no linear relationship between food consumption by deer and temperature. A third degree polynomial regression using average daily temperature as the independent variable and food consumption as the dependent variable had an R^2 value of 0.48 and the F value was significant ($y = 2.7820 + 0.2340x - 0.0199x^2 + 0.0004x^3$).

A stepwise multiple regression analysis using food consumption as the dependent variable and total weekly solar radiation (langleys) (X1), average daily temperature (°F) (X2), and average daily wind mileage (X3) as independent variables resulted in the equation

$$y = 3.4109 - 0.006X1 + 0.0107X2 - 0.0073X3$$

Although average daily total wind mileage had a higher linear correlation ($r = -0.33$) with food consumption than did average daily temperature ($r = -0.05$), a greater amount of variation in food consumption was due to temperature as indicated by the results of a multiple linear regression. The only significant reduction in variation was due to solar radiation which accounted for approximately 28 percent of the variation in food consumption. Since the R^2 value was only 0.32, the equation was not further refined.

Trail Length

The C deer maintained an average trail length (116

TABLE 3. Inactivity expressed as percent of observations that deer were lying down during selected weather conditions. (Significant differences indicated by lines).

Cover type	Cloud cover		Wind Speeds			Barometric pressure		
	clear	overcast	none	light	moderate	falling	rising	steady
N	65.5	59.3	58.9	56.2	59.3	59.6	62.5	66.3
A	63.4	58.9	57.4	55.4	62.9	54.4	62.3	62.4
C	64.1	53.2**	57.2	53.0	60.0	48.2	58.3	57.7
All	64.0	56.7**	57.8	54.9	60.7	54.1	59.6	61.2

**$P \leqslant 0.01$

m) shorter than A (125 m) or N (132 m) deer. The average total trail length was shorter in pens of Orono-raised deer (119 m) than in pens of game farm deer (131 m). None of these differences were significant.

The length of N3 trails (98 m) averaged significantly less than those of N4 (149 m), N1 (143 m), A2 (140 m) or N2 (137 m).

A simple correlation between trail length and deer sinking depth was significant ($P \leqslant 0.01$) ($r = 0.34$). The deer seldom moved off trails when sinking depth was greater than 30 cm.

Selection of Bed Sites

The most frequently used bed sites were in corners of pens close to bed sites of other deer. Ninety percent of all bed sites were within 4.5 m of bed sites of one or more other deer. All but four (16 percent) of the most frequently used bed sites were within a 4.5 m radius of a pen corner.

Selection of solar-exposed sites by the A and C deer increased from January through March. During January, 67 percent of the daytime changes in bed site selection of these deer was to more solar exposed sites when skies were less than one-half clouded. The February and March percentages were 70 and 80 percent, respectively. The N deer showed fewer changes in bed site preferences due to cloud cover, and a smaller percentage of these changes was to solar exposed sites.

Bed site selection appeared affected by temperature only during December-January. During this period six of the deer selected sites of greater overstory density when temperatures were less than -23.3°C (-10°F). Deer were recorded in some seldom-used bed sites when temperatures were between -5.6° and -17.7°C only when the sites were solar exposed. The selection of a bed site was dependent on location and temperature of the bed site (Table 4).

Some changes in bed site preference were evident during periods of snowfall. Deer A1, C1, C2, and C4 selected bed sites in the open more frequently during precipitation. However N4 was observed lying in the most sheltered area of its pen 37.1 percent of the observations during snowfall compared to 16.4 percent of the observations when there was no precipitation.

Most association with other deer occurred when the animals were lying down. Differences in the amount of association between deer in the three cover conditions were not significant during December-January, or March, but N and C deer were both significantly less "social" than A during February.

The C deer were significantly less "social" than A deer during the ASR quarter of the day during both February (49.2 percent of the observations by no other deer compared to 27.1 percent) and March (38.1 percent compared to 35.5 percent). During the BSS quarter of the day, N deer were observed within 4.5 m of one or more other deer significantly less than A deer in February (54.1 percent compared to 74.4 percent) and in March (57.3 compared to 65.4 percent). The greatest differences in deer association between cover types were recorded in February.

Discussion

Percent bone marrow fat content, kidney fat index, and weight loss (expressed as weight gain) were used as condition indices. Since kidney fat is usually metabolized before bone marrow fat, it was probably the better indicator of deer condition in this study. Since all deer were in relatively good condition, the variation in bone marrow fat percent probably only indicated the naturally occurring variation in fawns.

Robinson (1959) found indications that smaller deer grew more than larger deer during the winter. His

TABLE 4. Frequency of utilization of each bedsite at each relative temperature for each month and the result of Chi-square tests. (Parentheses indicate number of times each bedsite showed each relative temperature).

Month	Relative temperature*	Bedsite area 1	Bedsite area 3	Bedsite area 9
Jan.	1	5(34)	2(5)	5(16)
	2	-(6)	3(23)	6(24)
	3	2(6)	1(18)	3(6)
			$x^2 = 9.39$ sig. $x^2 = 9.49$	
Feb.	1	8(30)	-(4)	8(21)
	2	6(13)	-(16)	7(21)
	3	2(2)	5(25)	1(3)
			$x^2 = 21.12$ sig. x^2 ($p \leqslant 0.01$) $= 13.13$	
Mar.	1	2(8)	-(2)	6(24)
	2	11(15)	2(12)	3(5)
	3	4(7)	1(16)	-(1)
			$x^2 = 10.87$ sig. $x^2 = 9.49$	

*1 = coldest, 3 = warmest

study showed that deer that lost the most weight grew the least during the winter. Skeletal growth was not measured in this study but there are some indications that the smaller deer lost less weight. The game farm-raised deer were smaller, lost less weight and had less body fat reserves, as measured by kidney fat indices, than Orono deer. This perhaps suggests more true growth occurred in the game farm deer. This is also indicated by a lack of significance in correlation between kidney fat indices and weight loss or initial body weights. If all the deer had not grown or had grown the same amount, the amount of body fat present should have been related to the body weight lost. If, however, the smaller deer grew more, and at the same time metabolized more of their fat reserves, there would be little relation between remaining body fat and weight loss. Thompson et al. (1973) suggested tissue energy and nitrogen retention were better indices of growth in fawns than body weight change. However, they too concluded that growth continued during the winter period.

Food Consumption

A significant difference in food consumption relative to body weight between Orono and game farm fawns made it necessary to consider these two groups separately. The study showed that as much food per kg body weight is required to maintain a small fawn as a large one under similar circumstances.

The difference between average food consumption of deer in different cover conditions was more pronounced in the latter part of the winter. This may, in part, have been due to increased solar radiation, since solar radiation caused a large part of the variation in feed consumption. Because the C pens received more solar radiation than N or A, those deer would therefore have been more subject to changes caused by differences in solar energy levels which might explain their lower food consumption rates.

Northern White-tailed Deer voluntarily restrict their food intake with a resulting decrease in body weight during the winter months (McEwen et al. 1957; Silver et al. 1969; Ozoga and Verme 1970). A sudden increase in food consumption during the weeks preceding 11 and 18 December corresponded to an abrupt drop in average daily temperature from 0.3°C to -13.3°C. Since this was the first cold weather of the season, it is quite possible the deer required two weeks to become acclimated to these severe temperatures. Colder average daily temperatures later in the winter did not have a similar effect on food consumption.

Temperature appeared to have a polyphasic effect on food consumption. A low feed intake when average daily temperatures dropped to less than approximately -15°C was probably due to conservation of energy by inactivity. Some homeothermic animals such as deer are known to conserve heat during cold weather by remaining inactive (Moen 1976). Maximum food consumption when daily temperatures averaged from -15° to -12°C may indicate a temperature range where energy requirements are high due to heat loss and relatively uncurtailed activity. A decreasing food consumption when average air temperatures were -12°C to -4°C probably reflected decreased thermoregulatory requirements. Silver et al. (1969) recorded a continuous drop in fasting metabolic rate during the fall until November-December. Food consumption in this study did not reach a stable low until the end of January. Silver (1971) recorded a continuous drop in food consumption during the winter and Ozoga and Verme (1970) found that fawns increased their food consumption at the end of March.

Food consumption per se is not a very precise measure of energy metabolism but by comparing the results to laboratory studies of the maintenance energy requirements for deer fawns (Thompson et al. 1973; Baker et al. 1979), some predictive values for free-ranging animals can be obtained. The fawns in our study ate about the same dry weight of feed/kg body weight as the Colorado Mule Deer (*Odocoileus hemionus*) fawns (Baker et al. 1979), but 40-50% more than the New Hampshire White-tailed Deer fawns fed the same diet as ours (Thompson et al. 1973). Baker et al. (1979) found the winter maintenance requirements for the Mule Deer fawns held outside under ambient conditions to be 158 kcal ME/kg $W^{0.75}$ while Thompson et al. (1973) computed 121 kcal ME/kg $W^{0.75}$ in January and 108 kcal ME/kg $W^{0.75}$ in March. Our comparative data (using ME values for the New Hampshire deer ration reported by Thompson et al. (1973) would be 277 and 225 kcal ME/kg $W^{0.75}$ for January and March, respectively, an increase $>$ 100% over the predicted basal rates. When it is considered that our fawns had ready access to feed ad libitum and thus would have little energy expenditure for foraging it is possible to imagine energy requirements in the wild for White-tailed Deer fawns as much as three times those obtained in the laboratory by Thompson et al. (1973).

Bed Site Selection

The average bed site in a Maine deeryard has been described by Gill (1966) as being about 25 cm deep and about 1-2 m from a 20 cm dbh spruce in a spruce-fir stand with 41 to 70 percent overstory density. Day's (1963) measurements supported these findings. Day (1963), Gill (1966), and Robinson (1959) have presented evidence that suggests deer select bed sites that provide a more moderate microclimate than the surrounding area. However, Westover (1971) has shown that in a northern Michigan yard, areas of bed sites did not differ from randomly selected areas in the yard.

Location of bed sites within the pens appeared to be determined at least partially by the opportunity for association with other deer. Multiple bed sites are common in the wild; Day (1963) reported finding bed sites in groups of one to three and Westover (1971) calculated the average number of bed sites in a group to be three. The importance of such socialization may be greater in fawns than in adults, and is probably emphasized by the confining conditions of a pen study. Even so, the presence of other animals may be more important psychologically to deer survival than is realized.

Despite the difficulties in distinguishing between bed site selections caused by shelter and those caused by social factors, some indications of variation in utilization caused by weather were present. Socialization appeared less important in bed sites during adverse weather (storms, etc.), and during the night. Less grouping during the night might indicate a greater tendency to select bed sites which give shelter from the environment.

The density of trees around a bed site has an important effect on snow thickness, wind speed, and temperature. Snow thickness under pen conditions proved to be relatively unimportant in bed site selection. Day (1963) suggests that deer in the wild maintain fewer bed sites in more sheltered areas when conditions are severe. Under conditions of this study wind speeds decreased with increasing distance into the N pens, increased from west to east, and were often least along the north edge of the C pens. Wind speeds in N pens also appeared affected by density of stems. Wind speed did not have any effect on bed site selection. However, the influence of wind in bed site selection could have been masked by other environmental factors.

Temperature was probably affected by overstory density and stem density as well. The importance of nocturnal radiant energy has been hypothesized for White-tailed Deer by Moen (1968a). The net long wave radiation value is affected by the density of the canopy cover (Lull and Relgner 1967). Moen (1968b) found that the infrared radiation from a tree affected radiometers at ground level to a distance of about one-half the height of the trees. The environment of the clear-cut pens would be affected, at most, one-half way across each pen. The A deer consistently selected bed sites in the radiant environment of the N pen trees. The C deer showed a tendency, at night when radiant energy from the trees would be most valuable, to select bed sites in the open. Under cold windy conditions, deer C1 and C2 often selected more sheltered bed sites. When temperatures were as low as -26°C and winds were light, the C deer preferred the open sites. The A deer also were recorded lying in the open at low temperatures. Similar action has been reported for wild deer by Kramer (1971) in Alberta and Moen (1968c) in western Minnesota. Moen calculated that a 40 kg deer on full feed would reach a negative energy balance when standing under the conditions of his study at approximately 10 km/h wind speed and temperatures of -25°C. Since lying deer conserve heat energy, the A and C deer in this study probably were not experiencing thermal stress.

Trails

Most trails were close to the fences. Trails beside fences with deer on the opposite side were used more frequently than trails on the periphery of the pen complex. This again implies that the presence of other deer may be important in determining behavioral responses.

The N deer maintained a trail through the center of their pens, where snow depth was often less, instead of along the outside edges. Deer in N pens made more tracks off trails than A or C deer, probably because the average sinking depth was less in the N pens. A positive correlation between trail length and deer sinking depth indicates that the track-trail relationship proposed by Severinghaus (1953) may be a good measure of mobility. Under pen conditions increased trail length resulted from confinement to trails. Confinement to trails occurred when deer sinking depth reached about 30 cm. Total snow thickness was 46 to 51 cm at this time. Telfer (1970) concluded a snow thickness of 50 cm caused confinement.

General Activity

The observed greater activity at sunset than at sunrise was similar to that recorded in summer by Tibbs (1967). Since all night observations were made when moonlight was bright enough to allow observations, and Anderson (1959) found nocturnal activity to be greatest on bright nights, the night activity recorded in this study possibly represented a maximum value. Colder temperatures and a less favorable radiant energy environment at night may result in a reduction of nocturnal activity.

Daily activity patterns were similar to those described for unconfined deer by Marchington (1968) and Tibbs (1967).

Inactivity at low temperatures is a well known behavior pattern which conserves heat. Activity of the experimental deer was significantly greater in each of four progressively warmer temperature ranges. Behrend (1966) found activity levels during January and February correlated with maximum daily temperatures. Halloran (1943) reported decreased road counts in Texas during cold weather.

Precipitation caused no evident effects on activity, although deer were observed on several occasions to get up and move about as snow began to fall. Behrend (1966) noticed increased activity before and during the first stages of a storm, but prolonged storms caused inactivity. Allen (1970) also recorded reduced activity during heavy snowfall. Marchington (1968) observed increasing activity prior to a front of bad weather and Anderson (1959), found Columbian Black-tailed Deer (*Odocoileus hemionus columbianus*) to be more active on cloudy and stormy nights in summer. In this study, greater activity when skies were overcast, when barometric pressure was falling, and with increasing humidity vapor pressure indicates greater activity preceding a storm. A relative increase in activity before storms may be an inherent behavior trait rather than a directed movement to shelter. Increased feeding before stormy periods has survival value if inactivity, and consequently less feeding, occurs during storms. No reduction in activity due to snowfall was shown in this study, but it may occur in lengthy storms as previously reported. Under natural conditions more energy would probably be required during and after storms in order to break trails and move greater distances from shelter to feeding areas.

Feeding Activity

The effects of weather on feeding activity were similar to the effects on general activity. However, unlike general activity, the effects of the direction of barometric pressure and of cloud cover were significant for A and C deer tested separately. Possibly the deer in the clear-cut pens were more influenced by changing weather conditions. Since a greater feeding activity when barometric pressure was falling was recorded under clear as well as overcast skies, the effect appears to be a result of falling pressure rather than a combined effect of pressure and cloud cover.

Conclusions

In summary, it was shown that if fawns have access to an adequate food supply, they can withstand severe winter weather even in the absence of shelter. While adequate shelter may reduce the maintenance requirements of deer so that winter survival is more likely, in this study shelter did not cause a reduction in the amount of food consumed. This indicates that increasing attention should be given to the quality of food available on winter range in relation to over winter carrying potential and to physical condition of fawns in the autumn prior to the demands of winter (Verme and Ozoga 1980). Energy requirements for maintenance of free-ranging deer during winter may be 2-3X above basal metabolic values determined from laboratory studies.

Temperature and solar radiation have value as predictors of winter energy requirements of deer on northern ranges. Although food consumption is reduced in cold weather, the energy drain may be sufficient to necessitate ingestion of more food once temperatures moderate.

The presence of other deer may prove very important for the winter survival of White-tailed Deer fawns. Although other deer may be an advantage for fawns for purely mechanical reasons (e.g. breaking trail), the effects on behavior and physiology may also be important.

Acknowledgment

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Breeding Ecology of the Horned Grebe, *Podiceps auritus*, in Southwestern Manitoba

ROBERT S. FERGUSON[1] and SPENCER G. SEALY

Department of Zoology, University of Manitoba, Winnipeg, Manitoba R3T 2N2
[1]Present address: Wildlife Management Division, Department of Renewable Resources, Government of the Northwest Territories, Yellowknife, N.W.T. X1A 2L9

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Nesting Horned Grebes, *Podiceps auritus*, studied in 1974 and 1975 in pothole marsh habitats near Minnedosa, Manitoba, selected permanent, open ponds with peripheral stands of emergent vegetation. This reflected their dependence on open water feeding areas and emergent nesting cover, and possibly alleviated competition with Pied-billed Grebes, *Podilymbus podiceps*. Annual variation in initiation of first clutches was related to spring weather conditions. Clutch size varied from 3 to 8 eggs and declined significantly as the nesting season progressed. Nest losses were high, with predators accounting for at least 54% of the total egg loss. Following nesting failure, pairs made up to three renesting attempts. Asynchronous hatching resulted in considerable age and size differences between first and last hatched chicks of a brood. Brood division, parental aggression, and selective feeding of smaller chicks appeared to be adaptations for reducing the competitive disparities among chicks that resulted from asynchronous hatching. The reproductive biology of Horned Grebes in southwestern Manitoba suggests ecological parallels with grebes of the genera *Rollandia* and *Tachybaptus* which are also adapted to nesting in unstable marsh habitats.

Key Words: Horned Grebes, *Podiceps auritus*, breeding ecology, pothole marshes, Manitoba.

Grebes and other waterbirds nesting in pothole marshes of the Canadian prairies and parklands are subjected to rapidly changing environmental conditions. The availability and quality of nesting cover in the form of emergent vegetation vary widely from year to year in response to fluctuating water levels (Weller and Spatcher 1965; Kiel et al. 1972). As a result of their anatomical and behavioural adaptations to aquatic habitats, grebes appear less tolerant of environmental change than relatively non-specialized species. Some marsh-nesting icterids, for example, exploit alternative habitats when marshes are unfavourable for nesting (Robertson 1972; Voigts 1973). Despite its specific nesting requirements, the Horned Grebe (*Podiceps auritus*) is a prominent species in the avian community of pothole marshes in southwestern Manitoba. In 1974 we initiated a breeding study of the Horned Grebe near Minnedosa, Manitoba, in order to determine its ecological adaptations for nesting in unstable marsh habitats.

A holarctic species, the Horned Grebe breeds throughout much of northern Europe, northern Asia, and northwestern North America (Fjeldså 1973a). No detailed nesting studies of any North American populations (*P. a. cornutus*) have been published. The reports of Bent (1919), Dubois (1919), Munro (1941), and Palmer (1962) were based on casual observations of a few nesting pairs from widely scattered localities and were generally incomplete. Storer (1969) described and analyzed the behavioural repertoire prior to egg-laying, and Faaborg (1976) and Sugden (1977) studied aspects of habitat selection in North Dakota and Saskatchewan, respectively. The breeding habits of *P. a. auritus* and *P. a. arcticus* are better known (Clase et al. 1960; Onno 1960; Hogstrom 1970; Fjeldså 1973b, c, d).

Study Area and Methods

Horned Grebes were studied in an area of pothole marshes (75 km^2) south of Minnedosa, Manitoba (50° 15′N; 99° 50′W). That area lies within the aspen parkland and has been described in detail in numerous papers. Descriptions of topography, hydrology, soils, vegetation, and climate of the Minnedosa pothole district are provided by Ehrlich et al. (1957), Bird (1961), Kiel et al. (1972), and Adams and Gentle (1978). Pothole marshes were classified into four types on the basis of water permanency and the distribution of wetland vegetation according to Millar's (1976) classification. The four wetland types are Wet Meadow, Shallow Marsh, Emergent Deep Marsh, and Open Water Marsh.

Field studies were conducted from 27 April through 27 August 1974, and from 17 April through 30 September 1975. Each nest found was visited at least once every three days. Eggs were measured (width and length) to nearest 0.1 mm, and numbered inconspicuously with a waterproof marker in the order of laying. Behavioural aspects of territoriality, incubation, parental care, and chick development were studied from a blind or parked car. During incubation, adult birds were captured with a gill net set in the water between the nest site and open water (Ferguson 1980). Forty-three adults and seven young were captured, sexed (adults only), measured, and banded. In May and June, adults were sexed on the basis of sexual differences in onset of the prebasic molt, length of the nuptial plumes, and colouration of the neck and flanks (see Storer 1969; Fjeldså 1973a, d). In 1975, 12 females and 9 males were individually colour-marked with feather dye appled to the yellow head plumes and white secondaries. The head marking lasted until the plumes were shed during the prebasic molt, usually in early July.

Pothole sizes were determined by planimetry from aerial photographs supplied by the National Air Photo Library, Department of Energy, Mines and Resources, Ottawa. Meteorological data for Minnedosa were obtained from the Atmospheric Environment Service, Winnipeg. Means are expressed as ± 1 standard deviation.

Results

Territorial Establishment and Pothole Selection

Horned Grebes were first observed on the study area on 29 April 1974 and 30 April 1975; the peak influx occurred during the first week of May. Establishment of territories commenced as early as 7 May and continued throughout the month of May. Nesting Horned Grebe pairs showed a distinct preference for Open Water Marshes (Table 1). Potholes used for nesting varied in size from 0.1 to 8.4 ha (mean 1.2 ± 1.3 ha; n = 65). Only three potholes supported more than one nesting pair of Horned Grebes. Two potholes of 1.1 ha each supported two pairs and one of 2.6 ha supported four pairs. Each pair defended a Type A territory (Nice 1943) which consisted of an area of open water and associated shoreline. In the absence of conspecifics, a nesting pair used all areas of a pothole for feeding and brood-rearing.

Nest-Site Selection

All nests located on the study area were anchored to emergent vegetation (Table 2). Nests built before 25 May were usually anchored to residual vegetation from the previous growing season. Unless flattened in winter by snow, residual vegetation such as bulrush and cattail provided sufficient nesting cover early in the season before new growth had appeared above the water surface. Water depth, measured at 119 nests at the time of clutch initiation, averaged 39.2 ± 11.7 cm. Only 2 nests were located in water < 20 cm deep. A minimum water depth of 20 cm seems necessary to allow the grebes easy underwater access to and from a nest site. Nests located in shallower water may become stranded on dry land as water levels in many potholes fell by as much as 15 to 20 cm during a month of hot, dry weather.

Egg-Laying

Eggs were laid over a period of 53 days in 1974 (22 May to 13 July) and 57 days in 1975 (17 May to 12 July). Initiation of laying of first clutches (n = 70) ranged from 17 May to 11 June (Figure 1). In 1974 (n = 34) and 1975 (n = 36), 50% of first clutches had been initiated by 1 June and 25 May, respectively. Within a clutch, the interval between laying of consecutive eggs varied from 1 to 3 days, but 3-day intervals were relatively uncommon. Total egg-laying periods for the three most frequent clutch sizes were 7-8 days for clutches of five eggs, 8-9 days for clutches of six, and 9-11 days for clutches of seven.

Following nesting failure, most pairs renested at least once. Of 40 pairs whose first nests were destroyed, 68% renested on the same territory. Although many birds were not individually marked, we are confident that these renests involved the same pairs. The promptness with which lost clutches were replaced and the distribution of nesting pairs (one per pond) support this assumption. Only 6% of 73 renests were located on previously unsuccessful sites. After

TABLE 1. Differential habitat selection by nesting Horned Grebes.

Pothole Type	Relative Availability of Pothole Types (%)	Potholes Used by Nesting Horned Grebes: Expected Frequency	Observed Frequency
Shallow Marsh	17	11	1
Emergent Deep Marsh	23	15	6
Open Water Marsh	60	39	58
Totals	100	65	65

$x^2 = 23.7$; $p < 0.005$.

Note: Relative availability of pothole types was determined by classifying all wetlands within a central area (8.4 km²) of the study block. Wet Meadow wetlands were excluded from the analysis owing to their ephemeral water supply and unsuitability as nesting habitat for grebes.

TABLE 2. Frequency distribution of Horned Grebe nests according to the dominant species of emergent cover.

Species	Number of Nests (%)
Whitetop (*Scolochloa festucacea*)	41 (32)
Bulrushes (*Scirpus* spp.)	39 (30)
Cattails (*Typha* spp.)	29 (22)
Water Parsnip (*Sium suave*)	8 (6)
Goosefoots (*Chenopodium* spp.)	3 (2)
Willows (*Salix* spp.)	2 (2)
Sedges (*Carex* spp.)	1 (1)
Water Crowfoots (*Ranunculus* spp.)	1 (1)
Unidentified	5 (4)
Total	129 (100)

repeated failures, six pairs renested twice and another six pairs renested three times, all within their original territories. Elapsed time between nesting failure and clutch initiation varied from < 2 to 9 days. When nesting failure occurred during laying, 22 of 28 replacement clutches were initiated within four days. For nests that failed after laying was completed, replacement clutches were rarely initiated within four days (1 of 8 nests). Egg-laying in the remaining seven nests began 5-9 days following nesting failure.

Two pairs laid a second clutch after their first clutch had hatched (Figure 1). In 1974, a pair initiated a second clutch 10 days after the last egg of the previous clutch had hatched. The same nesting platform was used for the second clutch. In 1975, a pair initiated a second clutch 16 days after the previous clutch had hatched. That pair, in which the female was individually marked, built a new nesting platform 3.5 m from the first nest. Chicks from the first broods were still being attended by their parents when the second clutches were initiated.

Mean dimensions of 591 eggs were 44.3 mm (range = 39.0-48.4) × 30.2 mm (range = 27.8-33.0). Clutches varied from 3 to 8 eggs (mean 5.9 ± 1.2 eggs; $n = 79$). Clutches of 5, 6, and 7 eggs were most common, comprising 81% of all nests examined. Variation in clutch size in relation to date of laying is shown in Figure 2. The regression lines did not differ significantly between years ($F = 0.14$; 1, 75df; NS; $F = 2.20$; 1, 76df; NS), thus the data were pooled. A significant correlation ($r = -0.70$) between clutch size and laying date was obtained ($t = 8.60$; $P < 0.001$).

Incubation

Incubation began as soon as the first egg of a clutch was laid. The incubation period for 17 marked eggs

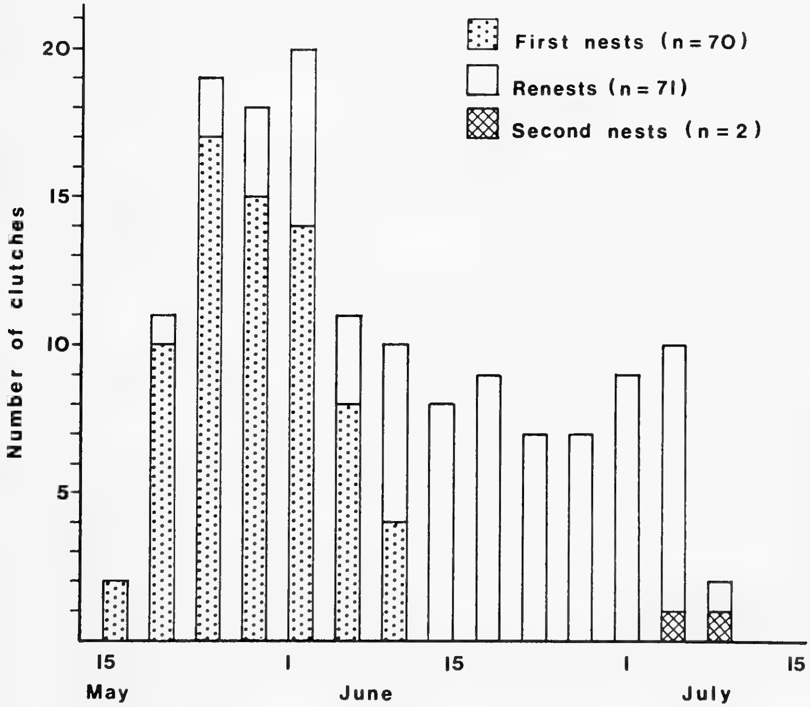

FIGURE 1. Seasonal pattern of egg-laying as revealed by dates of laying of the first egg in each clutch. (Each bar represents a 4-day interval.)

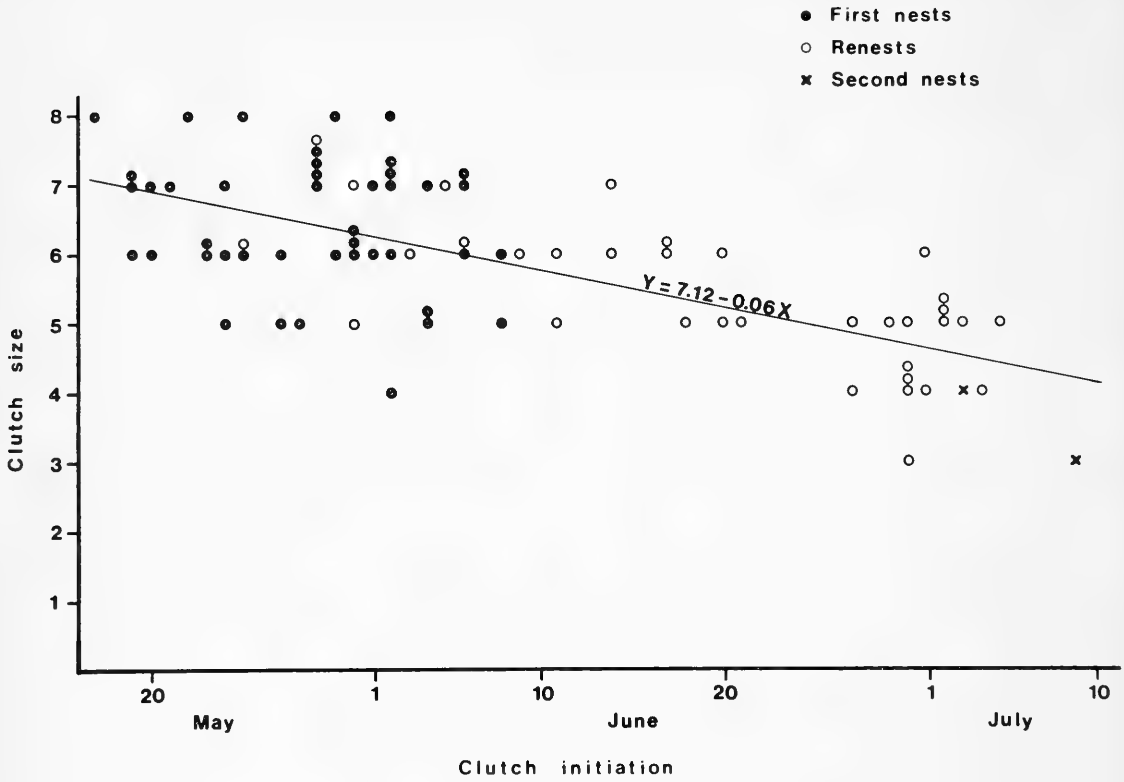

FIGURE 2. Variation in clutch size in relation to date of laying.

from 10 clutches was 23-24 days, but in 2 nests hatching did not begin until the first eggs had been incubated for 28 and 34 days. Attentive periods of males and females from 8 pairs ranged from 17 to 102 min (mean 45.3 ± 20.2 min; n = 33). During egg-laying incubation was shared almost equally (55% by females, 45% by males), but after egg-laying females spent considerably more time on the nest (63%) than did males (37%).

Hatching

During both years, first eggs in 47 nests hatched between 10 June and 2 August (Figure 3). Clutches hatching after 5 July were either replacement or second clutches. Generally, the interval between hatching of consecutive eggs reflected the laying interval; most chicks hatched at 1-2 day intervals. Hatching periods for the three most frequent clutches were 7-8 days for clutches of five eggs, 8-9 days for clutches of six, and 9-10 days for clutches of seven.

Hatching success was low in both years (30.3% of 637 eggs). Predators destroyed 38% of eggs laid, waves generated by high winds washed out 12%, and adults deserted 2%. Eggs that disappeared from nests (18%) were not attributed to a specific cause, but predators were likely responsible for most of those losses as well. The appearance of eggshell remains (see Rearden 1951) indicated that Raccoons (*Procyon lotor*) were responsible for most of the predation. Most destroyed eggs were characterized by an opening in the large end of the shell which suggested that the end had been bitten off. The Raccoon's activity as a predator on over-water nests in the Minnedosa district is well documented (Kiel et al. 1972; Cowan 1973). Canvasbacks (*Aythya valisineria*) nesting on the study area in 1974 and 1975 also suffered high egg losses to Raccoons (J. Serie, personal communication). Potential avian predators of eggs included American Crow (*Corvus brachyrhynchos*), Black-billed Magpie (*Pica pica*) and American Coot (*Fulica americana*) (see Burger 1973).

Chick Development and Parental Care

Shortly after hatching, chicks climbed onto the incubating parent's back where they were brooded among the feathers between the adult's slightly raised wings. During their first three days, chicks were brooded almost constantly although they spent brief periods in the water to drink, defecate, or regurgitate a

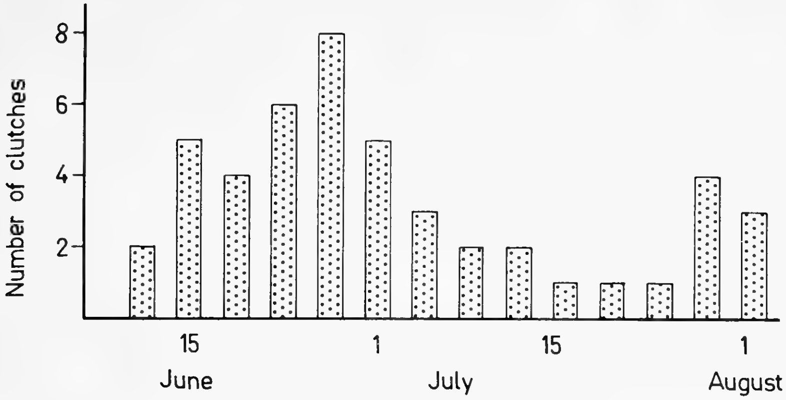

FIGURE 3. Distribution of hatching of first eggs in Horned Grebe clutches. (Each bar represents a 4-day interval.)

pellet. Pellet-casting was observed six times by young ranging in age from 3 days to 7 weeks. Chicks readily swallowed feathers offered by adults within 24 hours after hatching, an indication of the important role of feathers in the grebes' digestive tract (Storer 1969). At 4-5 days of age chicks spent longer periods in the water, and by 8-9 days they no longer were brooded during the day. This corresponds to the age at which preening and waterproofing had developed in a captive chick (McAllister 1963). At 12-13 days, chicks began to capture their own prey. At 19-21 days, most chicks were independent of parental care although the younger brood members frequently were fed until they were 21-24 days old.

Seventy-five percent of 51 known-aged young fledged between 45 and 50 days of age. The youngest chicks observed in sustained flight above the water were 41-42 days old. In at least 11 of 16 broods, the older chicks departed from their natal pond before the younger siblings. In 1974 and 1975, fledging dates ranged from 1 August to 15 September. From an average brood size of 4.3 chicks at hatching (n = 38 broods), 64% survived to fledging. Chick mortality was greatest in the first few days after hatching; only 72% survived the first 10 days. None of the 3 chicks that hatched from second clutches survived to fledging. Causes of post-hatching mortality were generally unknown because few dead chicks were found. Chick survival to fledging was independent of initial brood size (Table 3).

Participation of adults in parental care was influenced by brood size. In six of eight families with < 4 chicks, one parent abandoned the territory within the week following the brooding period, leaving its mate to care for their young. In four families where the adults were individually marked, the female remained with the young in two cases, the male in the other two cases. In six of seven families with four or more chicks, the young were divided between the parents. Brood division also occurred in one family of three chicks and one family of two chicks. Brood division is similar to that described for the Great Crested Grebe, *Podiceps cristatus* (Simmons 1974). On the basis of size differences among chicks, they did not appear to be divided between the parents according to age. Brood division did not always involve the entire brood. In families of five or more young, the age difference between first and last hatched chicks was often as great as 8 or 9 days and the oldest one or two chicks were nearly independent when the brooding period

TABLE 3. Chick Survival to fledging in relation to initial brood size.

Initial Brood Size	Number of Broods	Number of Young Fledged/Hatched*	Proportion Surviving to Fledging
2-3	6	10/14	0.71
4-5	17	48/78	0.62
6-7	10	44/63	0.70
Totals	33	102/155	0.66**

*$\chi^2 = 0.44$; $p>0.05$.
**Proportion for all broods combined.

ended. In those families, the younger chicks were divided between the parents, while the older chicks foraged alone or with other independent siblings.

During the brooding period, older chicks had a competitive advantage over their younger siblings because of their larger size and greater mobility. Chicks that were being warmed on a parent's back simply waited for the second parent to provide them with food. Older chicks that did not require brooding developed a conspicuous begging display and usually rushed toward the feeding parent. That display was similar to one described for the Great Crested Grebe (Simmons 1968) and involved loud begging calls and splashing movements of the feet and legs. On many occasions, a parent refused to feed an older brood member that was exhibiting high-intensity begging displays but offered the food item to a younger, brooded chick. When older chicks (16-18 days of age) approached their parents for food, they were frequently chased away in a threatening manner. Such aggression was most pronounced when a parent was attempting to feed a smaller chick. Parental aggression was observed only when a family, or family unit in the case of divided broods, comprised two or more chicks.

Discussion

Pothole marshes in the aspen parkland are highly productive (Barica 1974; Driver and Peden 1977) and perhaps support the highest breeding densities of the Horned Grebe in North America (Sugden 1977). At Minnedosa, nesting pairs showed a distinct preference for permanent, open ponds with peripheral stands of emergent vegetation. Selection of that habitat reflects the grebes' specialized foraging techniques and their dependence on open water feeding areas (Wetmore 1924). Only Emergent Deep Marshes and Open Water Marshes retain water long enough to permit a pair of Horned Grebes to rear a brood to fledging. Emergent Deep Marshes, with good interspersion of open water and emergent vegetation, offer a wide choice of protected nesting sites, but competition with Pied-billed Grebes (*Podilymbus podiceps*) may restrict the Horned Grebe's use of that habitat type. Only three of 65 marshes that supported nesting Horned Grebes were used by Pied-billed Grebes. Similar nesting distributions were obtained for Pied-billed Grebes in Minnedosa (Sealy 1978) and for Horned and Pied-billed Grebes on small ponds in North Dakota (Faaborg 1976). Faaborg (1976) noted that Pied-billed Grebes selected more heavily vegetated ponds than Horned Grebes, and suggested that segregation by habitat allowed those ecologically similar species to co-exist in the glaciated prairie region of North America.

Horned Grebes depended on emergent vegetation for protection and support of over-water nesting platforms. A nest site also must meet the minimum depth requirement of 20 cm. During dry years when receding water levels reduce the availability of emergent nesting cover, grebes select exposed sites far from shoreline vegetation and nest losses to wave action may be high (see also Glover 1953; Nuechterlein 1975; Faaborg 1976). Water levels at Minnedosa were high in 1974 and 1975, and peripheral stands of tall emergents provided an abundance of nesting sites well protected from wind and waves; Horned Grebes sustained low egg losses to wave action. An important determinant of nesting success is the water level through its controlling influence on the distribution of emergent vegetation. Even in years when habitat conditions are good, egg losses to predators can be high.

In unpredictable habitats where the probability of producing young is uncertain, species which maximize their reproductive potential are favoured (Cody 1971). At Minnedosa, Horned Grebes appeared to nest as early as weather conditions permitted. Earlier clutch initiation in 1975 than in 1974 was attributed to weather differences during the pre-laying period (1-20 May). Precipitation (5.5 cm, in the form of rain and snow) fell on 15 days during that period in 1974, but on only 6 days in 1975 (1.3 cm, rain only). Mean maximum daily temperatures during the same period were 8.9° C and 16.8° C in 1974 and 1975, respectively. Pairs that nest early potentially have more time for the laying of replacement clutches. After repeated failures, some pairs made as many as four nesting attempts. Within wide limits, any increase in the number of nesting attempts by a pair augments its chances of producing young. In North Dakota, the first territorial pair of Horned Grebes to occupy a large pond with a limited number of nesting sites usually selected the most sheltered site and nested successfully, whereas late-arriving pairs were forced to select more exposed sites and sustained higher nest losses to wind and wave action (Faaborg 1976). We were unable to test this hypothesis at Minnedosa because so few ponds supported more than one nesting pair. Two or more nesting pairs occurred only on ponds of area $>$ 1 ha, as found also by Fjeldså (1973c) for pairs nesting on eutrophic ponds in Iceland.

A third advantage of early nesting is that early clutches are potentially more productive than later ones. Clutch size decreased as the nesting season progressed and was much reduced after 15 June. The reproductive potential is also enhanced by brood division and parental aggression. Many aspects of parental care appear to be adaptations for reducing the competitive disparities among chicks that result from asynchronous hatching. During the brooding period, parents ensured that older chicks did not receive all the food by selectively feeding the younger chicks. When the older chicks were nearly self-sufficient, parents directed their attention to the younger brood members and fed them until they were fully independent. That prolonged period of parental care for younger chicks may compensate for any competitive disadvantages that they experienced earlier in the brood-rearing period. Indirect evidence that competitive disparities were effectively reduced was provided by examining chick survival in relation to initial brood size. Age differences and presumably competitive differences among chicks are more pronounced as brood size increases. At Minnedosa, chick survival to fledging was independent of initial brood size. The family structure of Minnedosa Horned Grebes suggests ecological parallels with grebes of the genera *Rollandia* and *Tachybaptus* which are adapted to nesting in temporarily flooded habitats by raising as many young as possible in a brief period (J. Fjeldså, personal communication). Climatic variability, fluctuating water levels, and frequent short-term changes in the availability of emergent nesting cover attest to the unpredictable nature of prairie pothole marshes as breeding habitats for aquatic birds (Eisenlohr 1969; Kiel et al. 1972). In contrast, Icelandic Horned Grebes are adapted to using more predictable permanent waters such as Lake Myvatn, and appear to maintain an optimal population level by moderate reproductive efforts through density-dependent mechanisms (Fjeldsa 1973c).

Acknowledgments

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Variability in Size and Age at Sexual Maturity of Witch Flounder, *Glyptocephalus cynoglossus*, in the Canadian Maritimes Region of the Northwest Atlantic Ocean

TERRY D. BEACHAM

Department of Fisheries and Oceans, Fisheries Research Branch, Pacific Biological Station, Nanaimo, British Columbia V9R 5K6

Beacham, Terry D. 1983. Variability in size and age at sexual maturity of Witch Flounder, *Glyptocephalus cynoglossus*, in the Canadian Maritimes region of the northwest Atlantic Ocean. Canadian Field-Naturalist 97(4): 409–422.

The variability in length and age at which 50% of individuals were mature was investigated for Witch Flounder *(Glyptocephalus cynoglossus)* in the Northwest Atlantic Ocean from 1959 to 1979. Median length and age at maturity generally declined through time, and males matured at smaller sizes and younger ages than did females. During 1975-1979, median length at maturity for males ranged from 29.2 cm (NAFO Division 4W) to 33.0 cm (Division 4T), while median age at maturity ranged from 5.1 yr (Division 4X) to 9.2 yr (Subdivision 4Vn). Median length (and age) at maturity for females ranged from 33.0 cm (8.8 yr) in Subdivision 4Vn to 34.3 cm (7.2 yr) in Division 4X. Witch Flounder in warmer waters matured at younger ages than did those in colder waters. Biological and fishery mechanisms causing these changes are examined.

Key Words: age, length, maturity, Northwest Atlantic, Witch Flounder, *Glyptocephalus cynoglossus*.

Canadian groundfish surveys have indicated that Witch Flounder (*Glyptocephalus cynoglossus*) is widely distributed in Northwest Atlantic Fisheries Organization (NAFO) Subarea 4 (Figure 1) (Scott 1976). Witch Flounder is more abundant along the edge of the Laurentian Channel in Subdivision 4Vn, between Banquereau and Sable Island Banks, and in deeper areas of the Bay of Fundy than in other areas of NAFO Subarea 4 (Halliday 1973). Limited seasonal movements of witch may occur between the southern Gulf of St. Lawrence and the Scotian Shelf (Powles and Kohler 1970). Catches of Witch Flounder in the commercial fishery have been largest in Division 4V and 4W, the fishery mainly conducted by otter trawlers. Spawning occurs from late spring to summer (Leim and Scott 1966), and thus summer groundfish surveys would be timed appropriately in order to assess the reproductive state of an individual.

Vertebrate population dynamics are determined by the combined effects of reproduction, growth, dispersal, and mortality. The age at which individuals attain sexual maturity has a large impact upon the potential for population growth rates (Cole 1954; Stearns 1976). Growth rates of individuals and reproductive potential of a population are linked by the size and age at which individuals attain sexual maturity, and therefore these parameters are of importance in an investigation of population dynamics. Long term population monitoring of Witch Flounder in several areas of NAFO Subarea 4 presented an opportunity for an investigation of variability in median size and age at sexual maturity of Witch Flounder among areas. The major purpose of this paper is to present historical changes in median size and age at maturity and to attempt to account for biological variability among witch in different areas.

Materials and Methods

The data analyzed in the present paper were derived from Canadian groundfish surveys of the M/V HARENGUS, E. E. PRINCE, and A. T. CAMERON from 1959-1979. Annual values for median (50% mature point) length and age at maturity were calculated where possible. Groundfish surveys were usually conducted in September of each year in the southern Gulf of St. Lawrence (Division 4T). Witch Flounder in the other areas surveyed were sampled during July surveys of the A. T. CAMERON. All autumn surveys in a particular time interval were grouped for the analysis, as were all summer surveys on the Scotian Shelf. Maturity ogives, which are percentage mature in size or age class versus size or age, were also calculated if possible for four periods: 1959-1964, 1965-1969, 1970-1974, and 1975-1979. Details of the surveys, including vessels and gear used and areas surveyed, were outlined by Halliday and Koeller (1981). During the surveys, total length of Witch Flounder was recorded to the nearest cm. The stages of maturity outlined by Powles (1965) for American Plaice (*Hippoglossoides platessoides*) were used in assessing maturity of Witch Flounder. Witch Flounder were aged by otoliths according to the method used for Cod (*Gadus morhua*) by Kohler (1964). The validity of using otoliths for age determination in Witch Flounder was established by Powles and Kennedy (1967).

The transition from the immature to the mature condition in fish usually occurs over a range of length

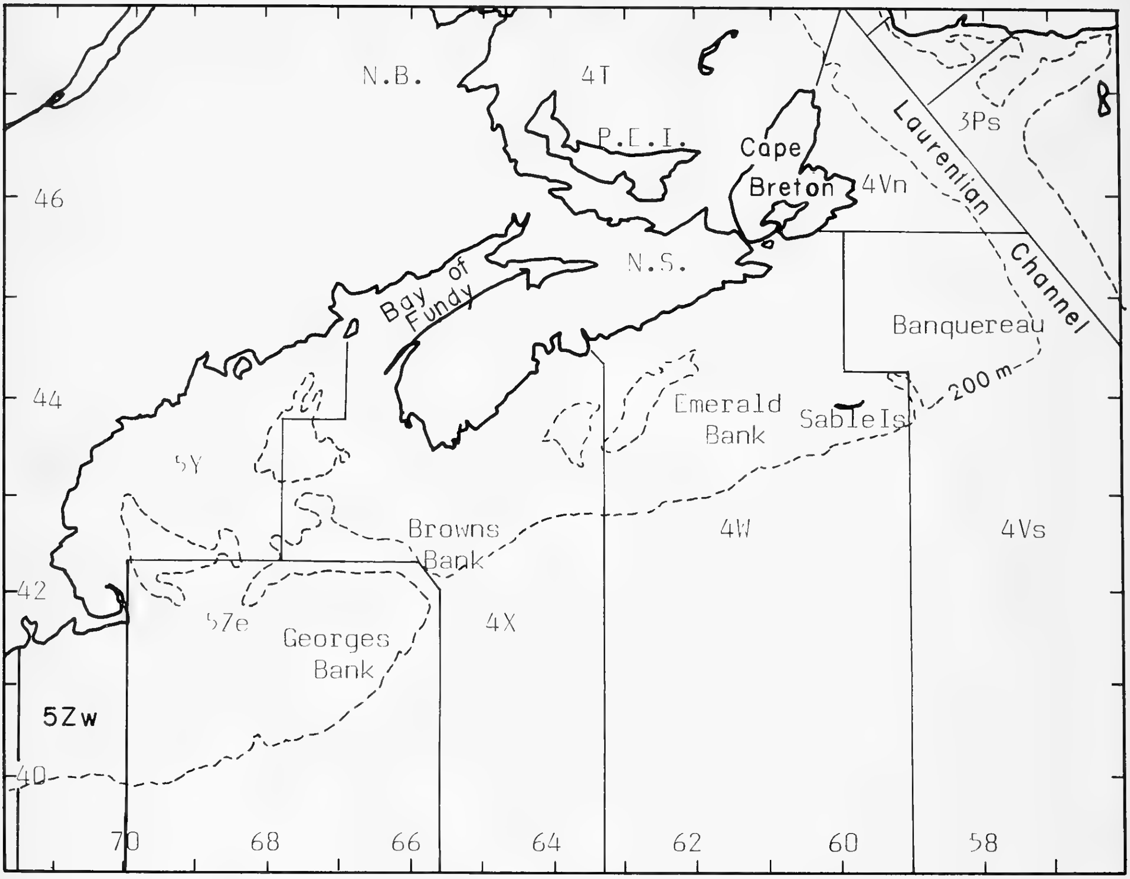

FIGURE 1. Northwest Atlantic Fisheries Organization Divisions in Subarea 4.

and age in the form of a sigmoid curve. The median length at sexual maturity was calculated by probit analysis (Leslie et al. 1945) from the percentage of mature individuals (gonads in ripening, ripe, spawning, spent, and recovering condition) in 2-cm length intervals. Median age at maturity was calculated by probit analysis by grouping the data in 1-yr intervals.

Results

Division 4T

There were not sufficient data to compute annual variability in median size and age at sexual maturity, so multi-year groupings were used. Maturity ogives based on length indicated that median length at maturity for male Witch Flounder was relatively constant during 1959-1979 at 33 to 34 cm (Figure 2). However, median length at maturity for females did decline from 42 cm during 1959-1964 to 33 cm during 1975-1979 ($t = 8.83$, $P < 0.01$). During 1959-1964, 70% of females 45 cm in length were mature, but during 1975-1979, 100% of 45-cm females were mature. Maturity ogives based on age indicated that median age at maturity for males was relatively constant at 8.0 yr, but median age for females declined from 12.6 yr during 1959-1964 to 8.8 yr during 1975-1979 ($t = 3.55$, $P < 0.05$) (Table 1).

Subdivision 4Vn

As was the case for witch in Division 4T, annual variability in median size and age at maturity could not be investigated. However, median length at maturity for males declined from 37 cm during 1959-1964 to 33 cm during 1975-1979 ($t = 3.30$, $P < 0.05$) (Figure 3). Median length at maturity for females declined from 44 to 33 cm during the same period ($t = 5.11$, $P < 0.05$). A larger percentage of witch was mature at smaller sizes, with no females 35 cm in length mature during 1959-1964, but with over 60% of 35 cm females mature during 1975-1979 (Figure 3).

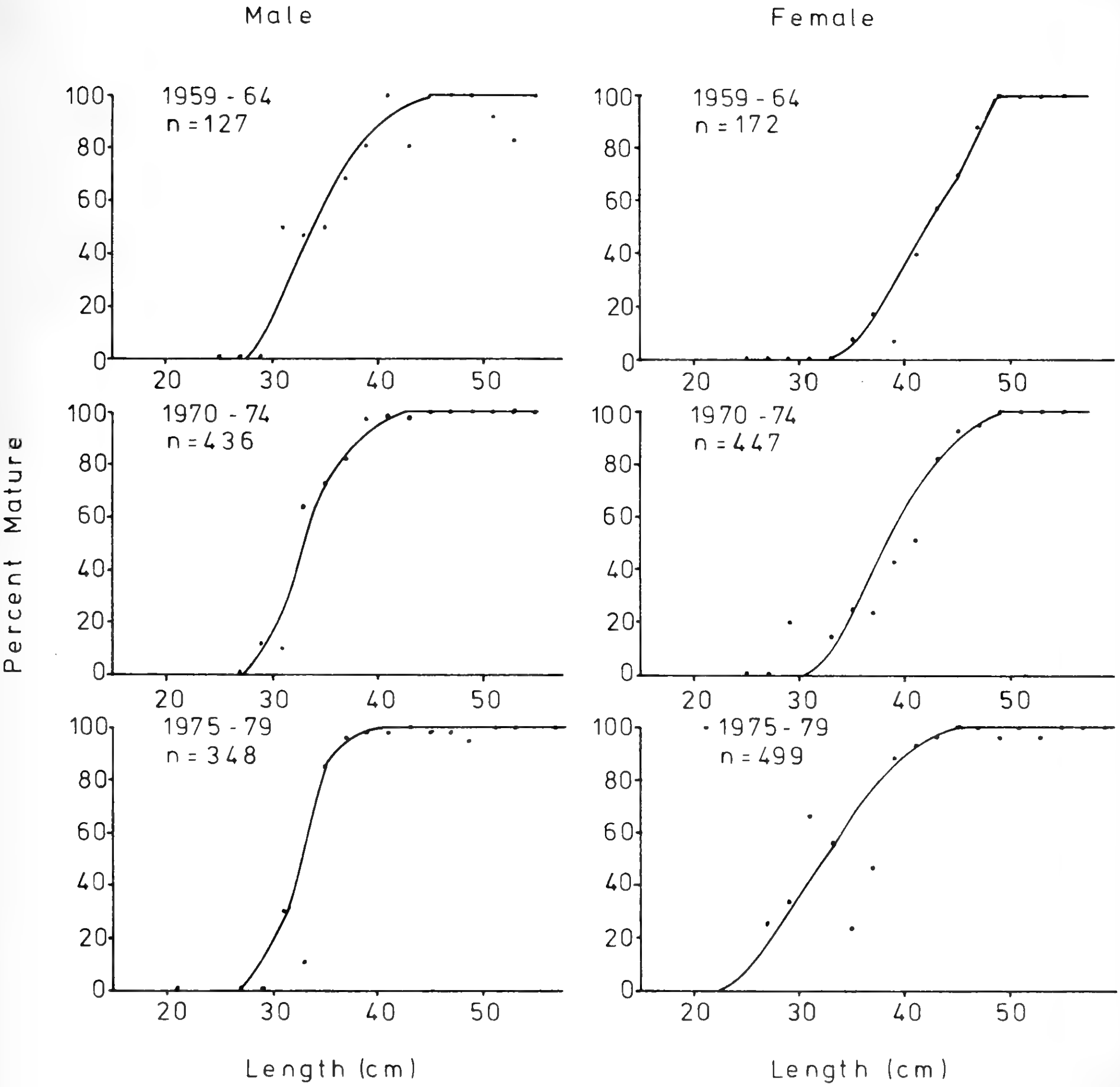

FIGURE 2. Maturity ogives of Witch Flounder derived from Canadian groundfish surveys in Division 4T, 1959-79.

TABLE 1. Percentages of sexually mature Witch Flounder by age and sex caught during Canadian groundfish surveys in the southern Gulf of St. Lawrence, 1959-1979. Sample sizes in parenthesis after individual ages and 95% confidence limits after A_{50} (yr).

Age (yr.)	1959-1964	1970-1974	1975-1979
		Male	
6	0.0(4)	—(0)	0.0(1)
7	40.0(10)	100.0(1)	50(2)
8	50.0(12)	100.0(1)	66.7(3)
9	77.8(9)	100.0(4)	80.0(5)
10	83.3(12)	85.7(7)	64.7(17)
11	50.0(4)	100.0(4)	88.5(26)
12	50.0(2)	100.0(11)	100.0(19)
13	100.0(2)	100.0(2)	96.3(27)
14	100.0(1)	100.0(10)	100.0(30)
A_{50}	7.97(6.94-9.14)	—	8.04(6.75-9.58)
		Female	
6	0.0(2)	— (0)	40.0 (5)
7	6.3(16)	0.0(2)	33.3(3)
8	6.3(16)	0.0(4)	25.0(4)
9	21.4(14)	33.3(9)	57.1(7)
10	26.7(15)	0.0(7)	16.7(6)
11	30.0(10)	42.9(7)	75.0(16)
12	0.0(2)	36.4(11)	73.9(23)
13	66.7(6)	42.9(7)	100.0(25)
14	100.0(1)	100.0(4)	92.9(28)
15	100.0(4)	100.0(8)	89.2(37)
16	100.0(3)	100.0(3)	100.0(40)
A_{50}	12.64(10.20-15.68)	—	8.77(7.43-10.36)

Maturity ogives based on age indicated a non-significant increase in median age at maturity for males from 7.8 yr during 1959-1964 to 9.2 yr during 1975-1979 ($t = 1.53$, $P > 0.05$), although less than 10 fish per age were sampled during 1975-1979 (Table 2). Median age at maturity for females declined from 10.5 yr during 1959-1964 to 8.8 yr during 1975-1979, although the decrease was not significant ($t = 0.91$, $P > 0.05$).

Subdivision 4Vs

Annual variability in median size at maturity was investigated for witch in Subdivision 4Vs. Median length at maturity generally declined during 1964-1978, with males maturing at smaller lengths than females (Figure 4). With data grouped multi-annually, maturity ogives based on length indicated that median size at maturity declined from 36 to 31 cm for males ($t = 3.77$, $P < 0.05$) and 43 to 34 cm for females ($t = 15.53$, $P < 0.01$) during 1959-1964 to 1975-1979 (Figure 5). As with witch in Division 4T and Subdivision 4Vn, smaller witch became mature through time as the 0% and 100% mature points shifted towards smaller fish. For males ages 4-7 and females ages 4-8, there was a general increase in percentage mature at age with time (Table 3). Median age at maturity also declined during 1959-1979, but more rapidly than median length at maturity. Median age at maturity for males declined from 6.9 yr during 1959-64 to 6.1 yr during 1975-1979 ($t = 1.40$, $P > 0.005$), while median age for females declined from 9.2 to 7.6 yr during the same interval ($t = 3.63$, $P < 0.05$).

Division 4W

Trends in median size and age at maturity for witch in Division 4W were similar to those of witch in the other areas investigated. There was an increasing percentage mature at shorter lengths through time, so that maturity ogives shifted towards smaller fish (Figure 6). Median length at maturity for males declined from 36 cm during 1959-1964 to 29 cm during 1975-1979 ($t = 12.72$, $P < 0.01$), while those for females declined from 42 to 33 cm, respectively ($t = 3.85$, $P < 0.05$). Median ages at maturity for males also declined from 7.7 yr during 1959-1964 to 5.8 yr during 1975-1979 ($t = 4.81$, $P < 0.05$), while those for females declined from 9.2 to 7.1 yr, respectively ($t = 6.13$, $P < 0.05$) (Table 4). The proportion of

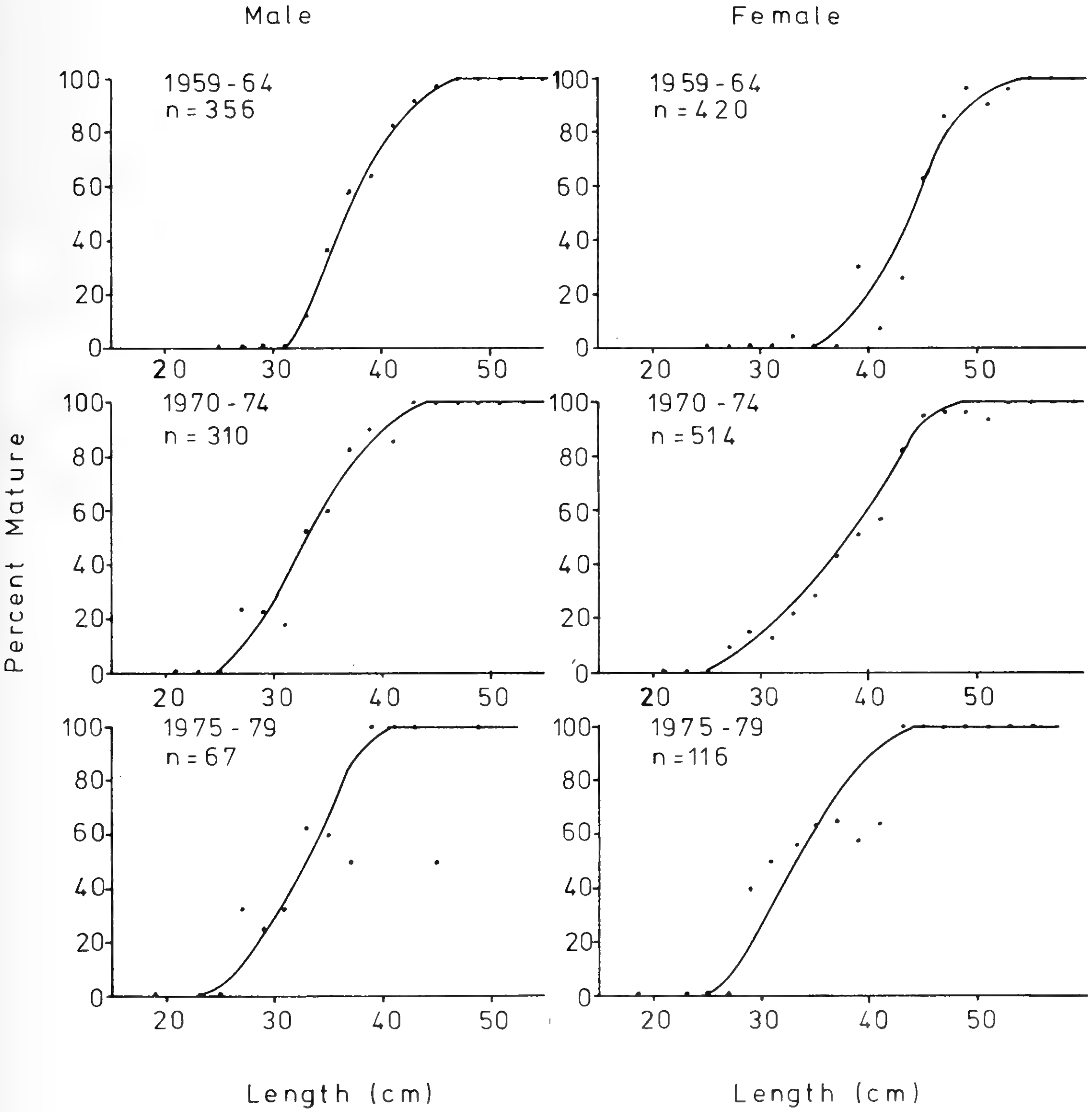

FIGURE 3. Maturity ogives of Witch Flounder derived from Canadian groundfish surveys in Subdivision 4Vn, 1959-79.

TABLE 2. Percentages of sexually mature Witch Flounder by age and sex caught during Canadian groundfish surveys in Subdivision 4Vn, 1959-1979. Sample sizes are in parenthesis after individual ages and 95% confidence limits after A_{50} (yr).

Age (yr.)	1959-1964	1970-1974	1975-1979
		Male	
5	0.0(1)	0.0(4)	0.0(5)
6	50.0(2)	0.0(3)	0.0(0)
7	50.0(16)	36.4(11)	50.0(6)
8	40.5(42)	33.3(12)	40.0(5)
9	70.7(58)	64.0(25)	12.5(8)
10	81.0(63)	54.2(24)	75.0(8)
11	87.5(32)	94.1(17)	75.0(8)
12	97.4(39)	75.0(12)	60.0(5)
13	93.1(29)	75.0(4)	66.7(3)
14	100.0(13)	100.0(4)	100.0(4)
A_{50}	7.83(7.29-8.40)	8.56(7.76-9.45)	9.21(7.93-10.69)
		Female	
5	0.0(3)	—(0)	0.0(0)
6	20.0(5)	50.0(2)	66.7(3)
7	6.7(15)	44.4(9)	0.0(1)
8	14.3(42)	41.2(17)	25.0(8)
9	20.8(53)	42.9(14)	33.3(6)
10	40.0(65)	60.0(25)	66.7(18)
11	65.7(35)	42.3(26)	57.1(7)
12	75.0(28)	47.1(17)	90.0(10)
13	85.7(35)	71.4(14)	44.4(9)
14	92.3(26)	86.7(15)	66.7(9)
15	86.4(22)	90.0(10)	100.0(6)
16	100.0(16)	100.0(6)	100.0(3)
17	93.3(15)	100.0(1)	100.0(4)
18	100.0(5)	100.0(1)	100.0(1)
A_{50}	10.45(10.05-10.85)	9.46(8.04-11.11)	8.80(6.23-12.43)

individuals mature at each age generally increased through time for males ages 4-8 and for females ages 5-9, and thus median age at maturity declined.

Division 4X

Maturity ogives based on length indicated that there was a decline in median size at maturity for witch in Division 4X, as in the other areas. Median length at maturity for males declined from 34 cm from 1959-1964 to 30 cm during 1975-1979 ($t = 2.01$, $P < 0.05$), while those for females declined from 44 to 34 cm, respectively ($t = 4.21$, $P < 0.05$) (Figure 7). During 1959-1964, 60% of females 45 cm in length were mature, but during 1975-1979, 100% of 45-cm females were mature. The number of fish sampled at each age was generally small during 1959-1964 and 1975-1979 (Table 5), but median age at maturity for males declined from 7.7 yr during 1959-1964 to 5.1 yr during 1975-1979 ($t = 3.01$, $P < 0.05$). Median age at maturity for females declined from 10.2 to 7.2 yr during the same period ($t = 4.01$, $P < 0.05$).

Comparisons among areas

Several consistent trends were apparent when all areas were considered in the multi-year grouping of the groundfish surveys. Median lengths at sexual maturity generally declined through time (Table 6), as did median age at maturity. Males matured at younger ages and smaller sizes than did females. Median lengths at maturity were relatively constant among areas within an interval. Witch Flounder in the more northerly areas (Division 4T and Subdivision 4Vn) had older median ages at maturity than did those on the southern Scotian Shelf (Divisions 4W and 4X). Bottom water temperatures derived from all sets on the July groundfish surveys on the Scotian Shelf during 1975-1979 were 3.80°C in Subdivision 4Vn, 3.99°C in Subdivision 4Vs, 6.48°C in Division 4W, and 7.19°C in Division 4X. There was a trend for higher median age at maturity for Witch Flounder caught in colder waters. Growth rates of Witch Flounder have been correlated positively with water temperature (Beacham 1982), so there was a trend for Witch Flounder that had slower growth rates to mature at older ages, but at similar lengths, than did faster-growing witch.

Discussion

Little research has been conducted on variability in size and age at maturity of Witch Flounder in the Northwest Atlantic. Bowering (1976) reported that

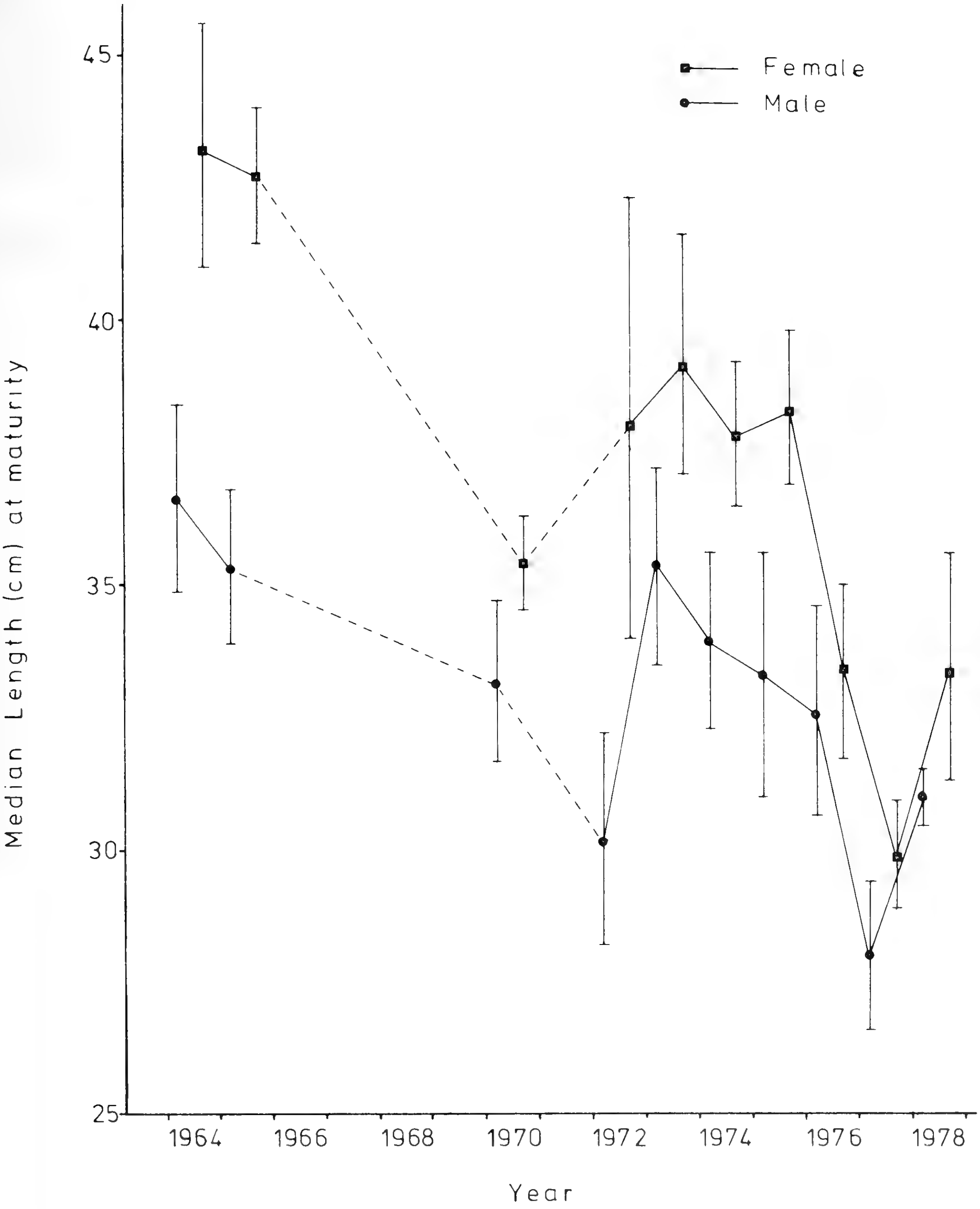

FIGURE 4. Median length at sexual maturity for Witch Flounder caught in Canadian groundfish surveys in Subdivision 4Vs, 1964-78. Vertical bars indicate 95% confidence limits.

TABLE 3. Percentages of sexually mature Witch Flounder by age and sex caught during Canadian groundfish surveys in Subdivision 4Vs, 1959-1979. Sample sizes are in parenthesis after individual ages and 95% confidence limits after A_{50} (yr).

Age (yr.)	1959-1964	1965-1969	1970-1974	1975-1979
		Male		
4	0.0(2)	0.0(6)	0.0(12)	4.2(24)
5	0.0(3)	0.0(1)	50.0(10)	38.2(34)
6	—(0)	22.2(9)	43.8(16)	59.1(22)
7	—(0)	43.8(16)	50.0(22)	62.5(8)
8	66.7(21)	66.7(9)	66.7(36)	66.7(12)
9	88.9(18)	69.6(23)	88.9(18)	66.7(15)
10	85.7(14)	79.5(39)	82.4(17)	80.0(20)
11	83.3(6)	100.0(25)	100.0(2)	100.0(13)
12	83.3(6)	100.0(12)	100.0(7)	71.4(7)
13	100.0(1)	100.0(4)	100.0(3)	100.0(7)
A_{50}	6.87(5.56-8.48)	7.50(6.85-8.22)	6.53(5.92-7.20)	6.07(5.34-6.91)
		Female		
4	0.0(5)	0.0(4)	0.0(2)	0.0(26)
5	0.0(1)	0.0(4)	8.3(12)	15.2(33)
6	0.0(2)	9.1(11)	50.0(4)	68.2(22)
7	0.0(5)	0.0(7)	30.0(20)	54.6(11)
8	0.0(5)	16.7(12)	18.4(38)	30.0(10)
9	72.7(11)	23.1(13)	42.9(28)	64.3(14)
10	66.7(21)	35.3(17)	72.2(18)	42.9(14)
11	55.6(9)	72.4(29)	100.0(9)	80.0(20)
12	100.0(12)	92.0(50)	90.0(20)	94.1(17)
13	100.0(8)	96.8(31)	100.0(10)	87.5(8)
14	100.0(6)	95.8(24)	100.0(6)	100.0(7)
15	100.0(4)	100.0(8)	100.0(6)	100.0(6)
A_{50}	9.16(8.39-9.98)	9.76(9.27-10.28)	8.88(8.29-9.51)	7.55(6.80-8.39)

for Witch Flounder caught between 1958-1974, median age at maturity for males ranged between 4.2 yr in Divisions 2J-3KL (Southern Labrador and Northeast Newfoundland Shelf) to 6.2 yr in the northern Gulf of St. Lawrence (Division 4RS). Age at 50% maturity for females ranged from 8.4 yr on the Grand Bank (Division 3NO) to 10.2 yr on St. Pierre Bank (Subdivision 3Ps). Length at 50% maturity for males ranged from 25-30 cm, while that for females ranged from 40-50 cm. Bowering (1976) concluded that faster-growing witch matured at an earlier age, but all matured at approximately the same size, and the results of the present study support that conclusion. Powles and Kohler (1970) reported that for Witch Flounder caught on the Scotian Shelf in 1965, median length at maturity was 37 cm for males and 44 cm for females, with median ages of 7 and 10 yr, respectively, similar to the results in the present study.

For Witch Flounder in most of the areas investigated in the present study, median length and age at sexual maturity generally declined through time. To the extent that size and age at maturity has a genetic component (Alm 1959), there has been selection for fish that mature at smaller sizes and younger ages. Witch Flounder have been exploited commercially for many years, and selection would favour those genotypes that reproduce at lengths not fully recruited to the commercial fishery, whereas a genotype that matures at a larger size might be removed before spawning. This mechanism would account for the decreasing abundance of larger, immature fish through time.

In a study of variability in median size and age at sexual maturity for Haddock (*Melanogrammus aeglefinus*), Templeman and Bishop (1979) attributed a decline in median length at maturity to decreasing growth rates, and a decline in median age at maturity to increasing growth rates. However, Templeman et al. (1978) reported that median age at maturity of Grand Bank Haddock declined during 1953-1956 as successful year-classes appeared and the growth rate decreased. Thus median age at maturity declined in periods of increasing and decreasing growth rates, and trends through time may not be simply related to changes in growth rates. In North Sea Sole (*Solea solea*), de Veen (1976) reported that median length at maturity increased while median age at maturity remained relatively constant during a 10-year period,

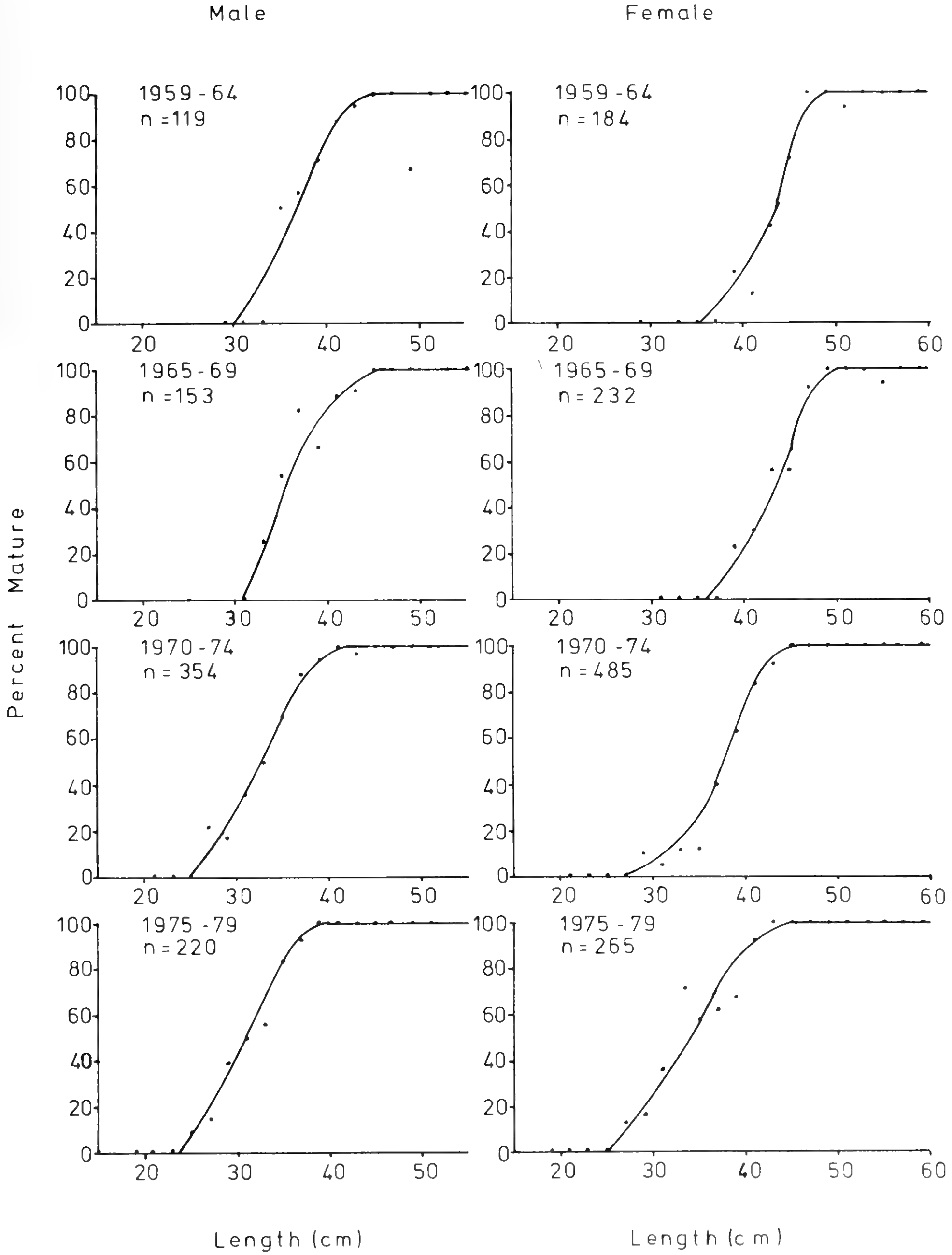

FIGURE 5. Maturity ogives for Witch Flounder caught in Canadian groundfish surveys in Subdivision 4Vs, 1959-79.

TABLE 4. Percentages of sexually mature Witch Flounder by age and sex caught during Canadian groundfish surveys in Division 4W, 1959-1979. Sample sizes are in parenthesis after individual ages and 95% confidence limits after A_{50} (yr).

Age (yr.)	1959-1964	1965-1969	1970-1974	1975-1979
		Male		
3	0.0(3)	0.0(1)	0.0(3)	0.0(6)
4	0.0(8)	0.0(16)	0.0(7)	20.0(5)
5	10.0(10)	12.9(31)	33.3(3)	8.3(12)
6	28.1(32)	10.5(19)	25.0(4)	72.7(22)
7	26.3(57)	54.6(22)	83.3(12)	81.3(16)
8	50.8(61)	72.0(25)	82.4(17)	84.6(13)
9	78.8(33)	92.9(28)	100.0(20)	82.4(17)
10	93.3(15)	82.6(23)	100.0(18)	79.0(19)
11	100.0(9)	100.0(14)	100.0(4)	94.7(19)
12	100.0(4)	100.0(8)	100.0(9)	100.0(14)
A_{50}	7.68(7.33-8.04)	7.01(6.61-7.43)	6.16(5.52-6.86)	5.75(5.09-6.50)
		Female		
5	0.0(17)	0.0(25)	0.0(2)	0.0(7)
6	4.3(47)	5.0(20)	25.0(4)	33.3(12)
7	9.2(65)	0.0(24)	33.3(6)	40.0(5)
8	16.5(85)	5.6(18)	38.5(13)	45.5(11)
9	56.0(75)	13.8(29)	69.2(13)	100.0(6)
10	65.2(46)	48.2(27)	70.0(10)	88.2(17)
11	80.7(31)	68.8(32)	100.0(16)	93.3(15)
12	100.0(21)	87.0(23)	93.8(16)	95.2(21)
13	94.1(17)	100.0(13)	100.0(14)	100.0(19)
14	100.0(5)	100.0(8)	90.0(10)	100.0(13)
A_{50}	9.17(8.88-9.48)	10.24(9.89-10.59)	8.16(7.34-9.06)	7.12(6.42-7.90)

with the increase in length at maturity being accounted for by an increase in growth rates.

Many groundfish stocks in the Northwest Atlantic endured high rates of exploitation in the 1960s and early 1970s, and consequently declined in stock biomass. If growth rates of Witch Flounder are inversely correlated with stock biomass, then an increase in growth rate could account for a decline in age at maturity, but it is difficult to account for a decline in size at maturity. Catch quotas were introduced in the mid-1970s and thus stock biomass may increase in the future. Further research is necessary in order to distinguish between selection for early maturing individuals producing a decline in size and thus age at maturity or changes in environmental parameters such as stock biomass or temperature accounting for the decline in size and age at maturity. If changes in size and age at maturity are largely dependent upon stock biomass, then these parameters should increase if stock biomass increases under a management regime of reduced exploitation.

During 1975-1977, median age at sexual maturity varied from 8 to 9 years for males and 9 years for females in the northern Division 4T and Subdivision 4Vn populations to 5 years for males and 7 years for females in the southern Division 4X population. Mean growth rates in the populations generally declined after most of the individuals became sexually mature (Beacham 1982).

The present study indicated that Witch Flounder inhabiting regions of warmer water temperatures matured at younger ages than did witch in regions of colder water temperatures. This general trend was noted by Gunter (1950) who stated that fish inhabiting regions of higher water temperature grew faster initially, attained sexual maturity earlier, and were of smaller final size than the same species in regions of lower water temperature. However, Fleming (1960) found that Cod in the Labrador region of Newfoundland attained sexual maturity at younger ages, but grew more slowly than Cod in stocks further south. Fleming attributed this result to Cod in poorer environments maturing earlier than those in more favourable environments. The results of the present study indicate that individuals with higher growth rates attained sexual maturity earlier than those with slower growth rates. Alm (1959) noted that fish with a high growth rate attained sexual maturity at an earlier age than did slower-growing fish, and the results of the present study on regional variability in age at maturity support that conclusion.

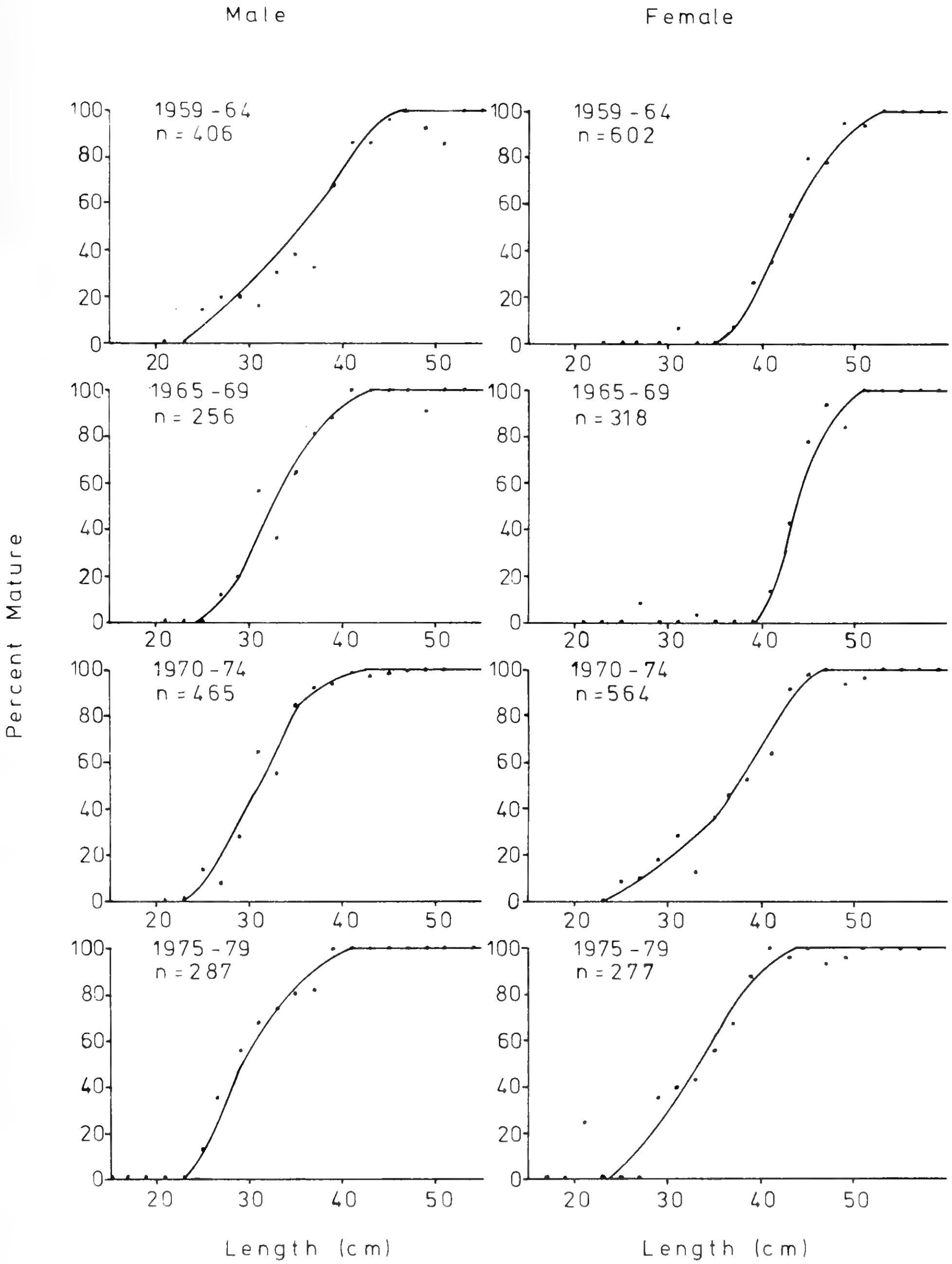

FIGURE 6. Maturity ogives for Witch Flounder caught in Canadian groundfish surveys in Division 4W, 1959-79.

TABLE 5. Percentages of sexually mature Witch Flounder by age and sex caught during Canadian groundfish surveys in Division 4X, 1959-1979. Sample sizes are in parenthesis for individual ages and 95% confidence limits after A_{50} (yr).

Age (yr.)	1959-1964	1970-1974	1975-1979
	Male		
3	—(0)	0.0(3)	—
4	0.0(1)	33.3(3)	100.0(1)
5	—(0)	0.0(4)	33.3(9)
6	0.0(4)	100.0(2)	66.7(12)
7	0.0(3)	45.5(11)	88.9(9)
8	71.4(7)	80.0(15)	83.3(6)
9	71.4(7)	94.4(18)	83.3(6)
10	87.5(16)	85.7(14)	100.0(10)
11	100.0(4)	91.7(12)	91.7(12)
12	85.7(7)	100.0(3)	100.0(8)
13	100.0(1)	80.0(5)	100.0(15)
A_{50}	7.74(6.51-9.20)	5.96(4.63-7.67)	5.09(4.05-6.39)
	Female		
4	0.0(0)	0.0(1)	0.0(2)
5	—(0)	0.0(4)	20.0(5)
6	0.0(7)	0.0(6)	25.0(4)
7	0.0(5)	20.0(10)	25.0(8)
8	14.3(7)	27.8(18)	71.4(7)
9	22.2(9)	60.0(20)	77.8(9)
10	33.3(9)	87.1(31)	100.0(6)
11	62.5(8)	85.7(14)	100.0(9)
12	90.0(10)	100.0(22)	92.9(14)
13	100.0(5)	100.0(19)	94.4(18)
14	100.0(1)	92.3(13)	100.0(14)
A_{50}	10.18(9.54-10.86)	8.52(8.03-9.03)	7.21(6.41-8.10)

TABLE 6. Median length at sexual maturity and 95% confidence limits of Witch Flounder in Divisions 4T, 4V, 4W, and 4X determined from Canadian groundfish surveys from 1959-1964, 1965-1969, 1970-1974, and 1975-1979.

	Males			
Division	1959-1964	1965-1969	1970-1974	1975-1979
4T	34.22 (32.66-35.85)	—	32.97 (32.04-33.92)	32.95 (31.62-34.34)
4Vn	36.92 (36.00-37.86)	—	33.14 (32.28-34.03)	32.88 (30.58-35.36)
4Vs	36.40 (34.58-38.32)	35.32 (33.92-36.78)	32.42 (31.66-33.19)	30.77 (29.77-31.81)
4W	35.71 (34.76-36.68)	32.45 (31.35-33.60)	30.96 (29.89-32.07)	29.20 (27.82-30.65)
4X	33.76 (31.37-36.32)	—	33.00 (31.30-34.79)	30.13 (27.90-32.54)

	Females			
Division	1959-1964	1965-1969	1970-1974	1975-1979
4T	42.45 (40.92-44.03)	—	39.26 (38.50-40.03)	33.36 (31.39-35.45)
4Vn	43.90 (43.09-44.73)	—	37.69 (36.75-38.66)	32.96 (28.50-38.13)
4Vs	43.37 (42.16-44.55)	42.76 (41.56-44.00)	37.64 (36.88-38.42)	33.54 (32.28-34.86)
4W	42.37 (41.69-43.06)	43.56 (42.75-44.37)	36.44 (35.52-37.88)	33.10 (31.51-34.77)
4X	43.92 (40.63-47.46)	—	39.41 (38.04-40.83)	34.29 (32.51-36.17)

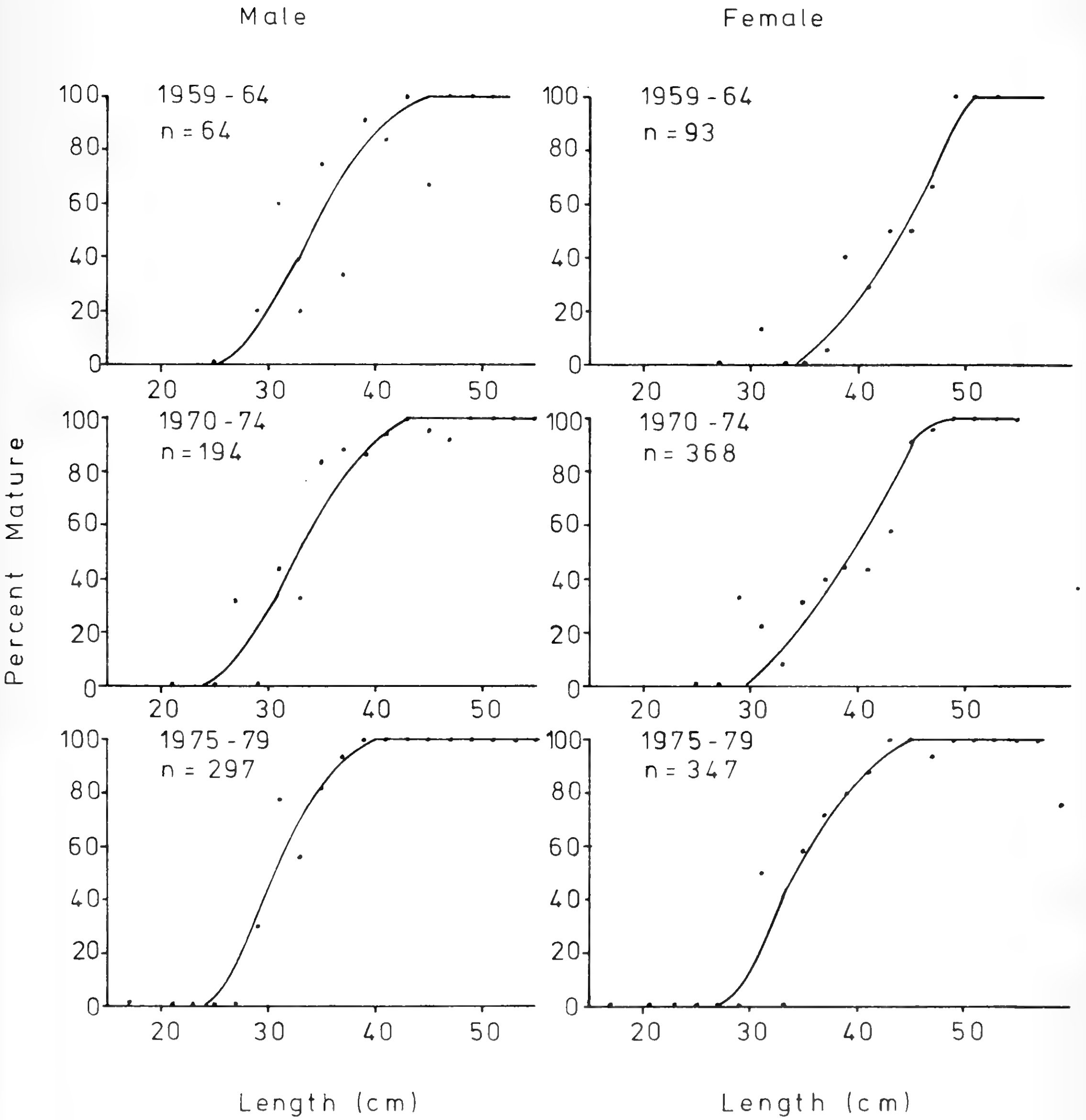

FIGURE 7. Maturity ogives for Witch Flounder caught in Canadian groundfish surveys in Division 4X, 1959-79.

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Food Habits of Young Anadromous Alewives, *Alosa pseudoharengus*, in Lake Ainslie, Nova Scotia

ROBERT S. GREGORY, GAIL S. BROWN, and GRAHAM R. DABORN

Department of Biology, Acadia University, Wolfville, Nova Scotia B0P 1X0

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Gut contents of 60 larval and 170 juvenile *Alosa pseudoharengus*, in Lake Ainslie, Nova Scotia, collected in 1979, were examined concurrently with zooplankton samples. Until August, the larvae fed primarily on the dominant zooplankters *Bosmina* spp., *Daphnia retrocurva* and *Diaptomus minutus*. In August, however, the young Alewives switched to feeding on adult Diptera and Ephemeroptera when zooplankton abundance was low. A substantial drop in average gut biomass was noted at this time. The contribution of these two orders of insects to the dry weight biomass of the gut was as high as 82.6% on 23 August.

Key Words: *Alosa pseudoharengus*, anadromous population, zooplankton, Margaree River system, opportunistic feeding.

The feeding habits of landlocked Alewives (*Alosa pseudoharengus*) and Blueback Herring (*A. aestivalis*) have been well studied. In general they are considered to be largely or solely planktivorous in habit, and through size-selective feeding, to exert major influence on the specific composition of the zooplankton (e.g. Brooks and Dodson 1965; Brooks 1968; Hutchinson 1971; Wells 1970; Warshaw 1972; Vigerstad and Cobb 1978). Some studies have shown, however, that Alewives become more omnivorous with increasing size (Norden 1968; Morsell and Norden 1968; Watt and Duerden 1974; Kohler and Ney 1980).

In contrast, relatively little is known about the feeding habits of anadromous Alewives, or of their impact on lake communities during their limited freshwater phases. Less is understood about the effects of feeding by young-of-the-year of these populations. Vigerstad and Cobb (1978) interpreted changes in zooplankton composition of a small New England reservoir as resulting from anadromous Alewife predation. Adult anadromous Alewives generally return to the estuary or the sea during mid or late summer, and juveniles follow in late summer or fall. The impact is thus seasonally highly variable.

B. Jessop (personal communication) has estimated that 3×10^6 adult Alewives successfully evaded the approximately 50 commercial fishing operations on the Margaree River and entered Lake Ainslie in May and June, 1979. This study was conducted to examine the food habits of larval and juvenile Alewives in Lake Ainslie in relation to seasonal changes in zooplankton density and composition.

Study Area

Lake Ainslie is a large shallow freshwater lake in Cape Breton Island, Nova Scotia, Canada (46°08′N, 61°11′W). The lake is 19 km long and 7 km wide, with a total surface area of 57.4 sq km. Mean depth is 5.75 m, reaching a maximum depth of 18 m. Lake Ainslie is drained by the Southwest Margaree River, which flows north-westerly to the Gulf of St. Lawrence.

The shore line consists of gravel to boulder sized stones interspersed with the occasional sand beach. The lake bottom is mostly sand, silt, or a sand-silt mixture. The lake's sparse macrophytic vegetation is found mostly in the northwestern portion of the lake and consists mainly of bulrushes (*Scirpus* sp.) cattail (*Typha* sp.) and water lilies (*Nuphar* sp. and *Nymphaea* sp).

The lake is oligotrophic: oxygen levels in the water column normally exceed 90% saturation and the lake remains unstratified during the summer because of wind mixing. Other fish occurring in the lake include the American Smelt (*Osmerus mordax*), White Perch (*Morone americana*), Brook Trout (*Salvelinus fontinalis*), Atlantic Salmon (*Salmo salar*), White Sucker (*Catostomus commersoni*), Killifish (*Fundulus diaphanus*), American Eel (*Anguilla rostrata*), Threespined Stickleback (*Gasterosteus aculeatus*), Ninespined Stickleback (*Pungitius pungitius*) and Creek Chub (*Semotilus atromaculatus*).

Methods

Samples of larval fish were obtained between 20 May 20 and 28 July 1979 using a 1050 μm, 0.5 m diameter plankton net. Juveniles were collected between 12 June and 23 August with a 15.2 × 2.4 m beach seine, the bag of which consisted of 2.4 meters square of 0.6 cm delta nylon knotless mesh. Fish from 13 stations were used for gut analysis; specimens were immediately preserved in 95% ethanol. Vertical zooplankton hauls of the full water column were taken concurrently in close proximity to these sites using a No. 20 Wisconsin net.

Lengths of larvae (L) were measured to ± 0.01 mm by eyepiece micrometer in an Olympus microscope, and juveniles to the nearest 0.05 mm using Vis calipers. Juveniles were designated as those specimens of 19.1 mm L or greater (Jones et al. 1978).

Sixty larvae and 170 juveniles were examined. Specimens were selected to represent sample sites, dates, and sizes as completely as possible. Larval fish were cleared with 3% KOH and glycerine to make gut material visible through the digestive tract, which is relatively undifferentiated until 20 mm L. Total gut analysis was necessary up to 23.0 mm FL, after which only stomach contents were analyzed.

Dry weight biomass of the gut contents was estimated from mean dry weight of the predominant food organisms. These were vacuum dried for 24 hours in a Fisher Isotemp vacuum oven at 70° C. Dry weight was determined with a Cahn electrobalance. Six groups were determined for each food organism, when possible, the number of organisms per group varying with their availability. Cladocerans and copepods were obtained from the plankton samples. Dipteran and ephemeropteran insects, ostracods, and amphipods were obtained from juvenile stomachs; in order to avoid discrepancies in mass due to digestion, these organisms were only taken from the anteriormost portion of the stomach. Only intact specimens were used. The dry weight of rotifers was not estimated. We could not find intact specimens, and their size rendered them relatively insignificant to the diet.

Results

Changes in abundance and species composition of zooplankton (Figure 1) exhibited distinct seasonal trends. Total abundance reached a peak in June, declined in July and remained very low in August. By the end of September, there was a substantial increase in zooplankton.

The major species of zooplankton were *Diaptomus minutus, Cyclops* sp., *Daphnia retrocurva, Bosmina* spp., *Asplanchna priodonta, Keratella cochlearis,* and *Polyarthra vulgaris. Diaptomus, Daphnia,* and *Bosmina* were dominant during the spring maximum, whereas *Cyclops* was most numerous in early July and late September. During August, when zooplankton density was low, the predatory rotifer *Asplanchna priodonta* was the most abundant organism. By the end of September, *Bosmina* and *Cyclops* were dominant at all stations. The species assemblage and changes in seasonal abundance are considered fairly typical of temperate lakes.

All sampling stations exhibited similar trends in changes of abundance of zooplankton except for Loch Ban, which was identified as the major area of spawning, hatching, and early development for Alewives. We presume that the low springtime abundance of zooplankton in Loch Ban is the result of feeding pressure exerted by Alewife larvae.

The cladocerans *Bosmina* spp. and *Daphnia retrocurva* and the copepod *Diaptomus minutus* were the primary food items of young Alewives until early August (Figure 2). The three species represent by far the largest proportion of the zooplankton in the water column (Figure 1). Except for 23 May, rotifers were present in the diet from 20 May to 27 June in reasonable numbers. Calculations of feeding indices (Berg 1979) suggest that rotifers and copepod nauplii are strongly selected at lower lengths of larvae and juveniles, but negatively selected by larger fish. During August, when rotifers represented the largest proportion of the plankton, they were not consumed.

The weight of food in the gut showed a significant drop early in August (Figure 3) followed by a sharp rise at the end of the month. The decline in the amount of food in the gut was apparent on three successive days.

Our data clearly indicate that anadromous alewives are opportunistic feeders, rather than determined planktivores. With increase in body size during development the variety of food types increases, generally in accordance with availability. Organisms utilized included both planktonic and benthic species, and the presence of adult insects indicates a propensity for surface feeding also.

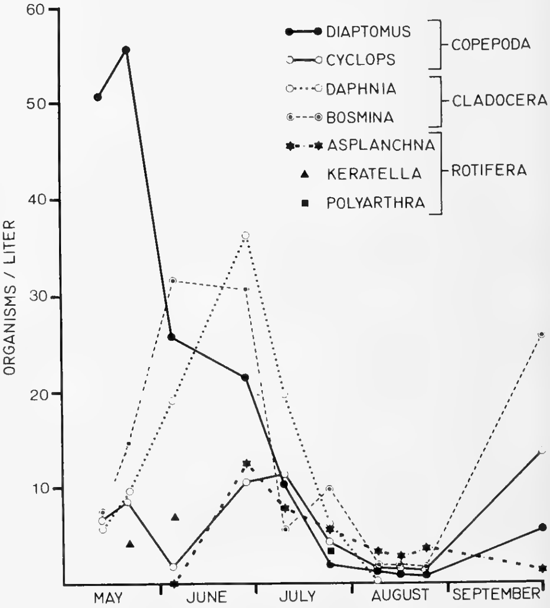

FIGURE 1. Changes in mean abundance of zooplankton at 13 stations in Lake Ainslie, Nova Scotia, 1979.

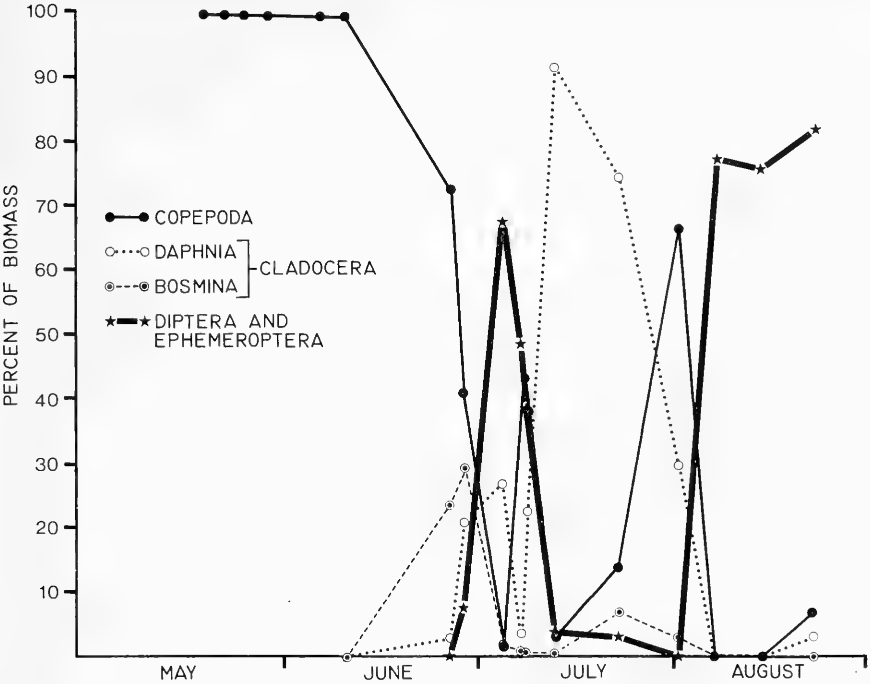

FIGURE 2. Changes in weight percent of food ingested by young-of-the-year Alewives (*Alosa pseudoharengus*) in Lake Ainslie, 1979.

Discussion

Brooks and Dodson's (1965) theory that the Alewife is an obligate planktivore selecting larger prey sizes as length increases, was generally true until August. At this time, large numbers of adult chironomids and mayflies were incorporated into the diet. The period of heavy reliance on insects corresponds with the period of lowest zooplankton density. Similarly, Pritchard (1929), Odell (1934), Norden (1968), Hutchinson (1971), Watt and Duerden (1974), and Kohler and Ney (1980) supply data suggesting that young Alewives become more omnivorous with increasing size. Larvae in May were taking 1 or 2 food types whereas juveniles in August were taking 14 to 18.

Brooks and Dodson (1965) have suggested selective predation as a cause of cyclomorphosis, the cyclical seasonal change in shape exhibited by some *Daphnia* populations; *Daphnia retrocurva* inhabiting lakes with landlocked populations of Alewives is often strongly cyclomorphic. Despite intense predation on *Daphnia retrocurva* by young Lake Ainslie Alewives until August (when it disappeared from plankton samples), it underwent neither changes in body size or form.

The low zooplankton densities exhibited during August would undoubtedly have an effect on a planktivorous fish. It has been suggested that low food resources could be a cause of downstream migration of Alewive juveniles (Richkus 1975; Vigerstad and Cobb 1978). We have no evidence of early August migration from Lake Ainslie in 1979, although there seems to have been a general movement of juveniles toward the outlet of the lake at this time (O'Neill 1980). Low plankton densities during August may normally cause downstream migrations, but the switch in feeding behaviour from planktonic to surface feeding on insects, could have enabled some juveniles to remain in the lake. Although the extensive changes in weight of gut contents are not entirely explained, they may demonstrate that drastic switches in feeding behaviour can be accomplished after a period of adjustment.

The Alewife is clearly capable of drastically altering zooplankton densities, and perhaps species composition. In Lake Ainslie, a lake of apparently modest productivity, the production of an estimated 3×10^{11} young Alewives from an escapement of 3×10^{6} adults into the lake, is of major significance. Much more needs to be learned regarding the impact of anadromous species like the Alewife on the trophic structure of lakes used for spawning.

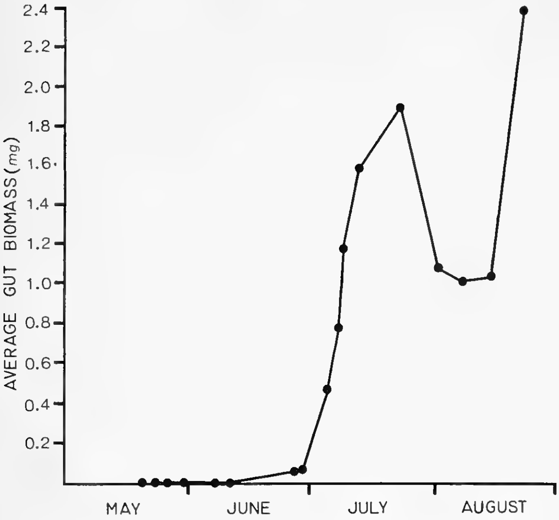

FIGURE 3. Changes in total food ingested by young-of-the-year Alewives (*Alosa pseudoharengus*) in Lake Ainslie, 1979.

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Coastwide Distribution and Ocean Migration Patterns of Stream- and Ocean-Type Chinook Salmon, *Oncorhynchus tshawytscha*

M. C. HEALEY

Department of Fisheries and Oceans, Fisheries Research Branch, Pacific Biological Station, Nanaimo, British Columbia V9R 5K6

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Chinook Salmon, *Oncorhynchus tshawytscha*, hich spend a year or more in fresh water before migrating to sea (stream-type) have been considered to be an environmentally produced variant of those migrating to sea in their first year of life (ocean-type). The available evidence, however, shows that these two life-history types differ in the coastal distribution of their spawning populations, in their ocean distribution as immatures, and in the seasonal timing of their spawning migrations. These differences in distribution and behaviour cannot be accounted for by the fresh-water environmental conditions that might influence fresh-water residence. Rather, it appears that stream- and ocean-type Chinook Salmon are distinct races.

Key Words: Chinook Salmon, *Oncorhynchus tshawytscha*, racial identification, coastal and ocean distribution, migration.

Gilbert (1913) showed that Chinook Salmon (*Oncorhynchus tshawytscha*) may migrate seaward during the spring and summer of their first year of life, or after one or two years in fresh water. He termed those chinook which migrated to sea during their first year sea (ocean-) type and those which reared for one or two years in fresh water stream-type. Rich (1925) noted that in the spawning run of Chinook Salmon to the Columbia River, which extends throughout the spring, summer and autumn, stream-type chinook predominated early in the run and ocean-type chinook late in the run. Rich (1925) also noted that the most upstream spawning populations in the Columbia tended to be dominated by stream-type fish. These same features distinguish stream- and ocean-type chinook in the Fraser River (Ball and Godfrey 1968a; P. F. Starr, C. L. Cross, and F. J. Fraser. 1981. Chinook and coho of the Fraser River: summary 1951-1978. Canada Fisheries and Marine Service, unpublished ms. 152 pp.), the Nanaimo River (Healey, unpublished data), and probably other rivers having both life history types. On the basis of samples from Monterey Bay, the Columbia River, the Strait of Georgia, and the Yukon River, Rich (1925) observed that the proportion of stream-type chinook in spawning runs was positively correlated with both latitude and altitude of the spawning beds. Rich (1925) concluded that the tendency to remain a year in fresh water was determined by the harshness of the fresh water rearing environment, with more chinook remaining a year in fresh water in harsher environments.

Considerable additional information now exists on the occurrence of stream- and ocean-type chinook in spawning rivers along the coast of North America, and on the distribution of the two types at sea. These data suggest that, rather than phenotypic variants determined by environmental conditions, stream- and ocean-type chinook may be separate races. This paper presents the evidence in support of this alternate hypothesis.

The Coastwide Distribution of Spawning Stream- and Ocean-type Chinook

To describe the coastwide occurrence of spawning stream- and ocean-type chinook, precise estimates of the contribution of each type to unexploited spawning runs are desirable. Such estimates do not exist for several reasons. Firstly, sampling of spawning runs has generally been motivated by the presence of an intensive chinook fishery. The two life-history types, because of their different run timings, may have been subject to different exploitation rates. They may also differ in their stock and recruitment parameters. Samples taken decades after the start of commercial exploitation may, therefore, misrepresent the contribution of the two life-history types to the unexploited population. The estimates reported below are the earliest available for each river system, and should, therefore, be the least altered by exploitation. The estimates are, however, mainly from samples taken many years after the start of commercial fisheries. Secondly, some of the estimates are based on a single sampling. The contribution of stream- and ocean-type chinook to a spawning run can vary considerably from year to year (Snyder 1931; P. F. Starr, C. L. Cross and F. J. Fraser 1981 unpublished ms). A single sample may not represent the average contribution of the two life history types to the population. Finally, stream-type chinook in spawning runs are distinguished by the presence of a fresh water annulus on their scales. The identification of a fresh water annulus is not always a straightforward matter (Koo and Isarankura 1967; Tutty and Yole 1978), therefore some fish may be misclassified. In spite of these difficulties, it is unlikely that the patterns observed in the data are a result of sampling problems, and some important general conclusions are possible.

Most of the data on spawning run composition are from rivers along the British Columbia coast, although data are available from four Alaskan rivers, two Washington-Oregon rivers and two California rivers (Table 1). Stream-type chinook comprise 0-100% of spawning runs to these rivers.

In Alaska, including rivers crossing the panhandle, chinook populations are virtually 100% stream-type (Table 1) and some fish spend two years in fresh water before migrating to sea. In British Columbia, stream-type chinook comprise 0-57% of spawning runs. Low percentages of stream-type chinook are found in both northern and southern British Columbia rivers, although three populations with the highest recorded percentage of stream-type chinook (Nass, Skeena and Yakoun rivers) are on the northern British Columbia coast (Table 1). In the Washington, Oregon and California rivers the overall percentages of stream-type chinook is similar to British Columbia and ranges 11-22% among rivers (Table 1). While these data may be interpreted to represent a latitudinal cline in occurrence of stream-type chinook, there are many exceptions to the cline. Of particular importance to the theme of this paper are the rather abrupt change from predominantly ocean-type chinook to virtually 100% stream-type about 55-56° North latitude and the occurrence of high percentages of stream-type chinook in large rivers even to the southern limit of the chinook's range. Compare, for example, the Stikine River at 56° 40′ N which has 100% stream-type chi-

TABLE 1. Occurrence of stream-type Chinook Salmon in spawning runs to rivers along the west coast of North America. The rivers are ordered in descending latitude.

River System(s)	Approximate N. Latitude	Information Source	Percent Stream-Type
Alaska			
Yukon	60° 30′	Gilbert 1913	100
Cook Inlet	61° 30′	Yancey and Thorsteinson 1963	97-99
Taku	58° 30′	Mehan and Siniff 1962, Kissner 1973	100
Stikine	56° 40′	Kissner 1973	100
British Columbia			
Nass	55° 20′	Godfrey 1968	42
Skeena	54° 20′	Godfrey 1968	48
Kitimat	54° 0′	Canada, Fisheries and Marine Service (Unpublished Data)	12
Yakoun	53° 20′	Canada, Fisheries and Marine Service (Unpublished Data)	57
Bella Coola	52° 25′	Canada, Fisheries and Marine Service (Unpublished Data)	14
Wannock (Rivers Inlet)	51° 40′	Schutz 1975	3
Quinsam (Campbell)	50° 0′	Canada, Fisheries and Marine Service (Unpublished Data)	1
Big Qualicum	49° 25′	Canada, Fisheries and Marine Service (Unpublished Data)	0
Fraser	49° 20′	Godfrey 1968	34
Nanaimo	49° 10′	Healey Unpublished Data	5
Natinat	48° 50′	Healey Unpublished Data	1
Chemanus	48° 50′	Canada, Fisheries and Marine Service (Unpublished Data)	0
Cowichan	48° 50′	Canada, Fisheries and Marine Service (Unpublished Data)	10
Washington/Oregon			
Columbia	46° 10′	Rich 1925	22
Sixes	42° 50′	Reimers 1971	12
California			
Klamath	41° 30′	Snyder 1931	14
(Monterey Bay)	36° 40′	Snyder 1931, Rich 1925	11

nook with the adjacent Nass River at 55° 20′ N which has only 42% stream-type chinook. In fact, all rivers south of the Stikine are dominated by ocean-type chinook except for the Yakoun, while all those north of the Nass are virtually 100% stream-type. South of the Stikine, most larger rivers (Nass, Skeena, Fraser, Columbia, Klamath) have a substantial percentage of stream-type chinook while the smaller rivers tend to be primarily ocean-type.

Rather than a simple latitudinal cline, these data suggest a discontinuity in the coastal distribution of the two life-history types at the latitude of the Nass and Stikine Rivers. North of the Nass only stream-type chinook occur. South of the Stikine ocean-type fish predominate with stream-type being most successful in the headwater tributaries of the larger rivers (Table 2).

Temperature and Fresh-water Residence

Rich (1925) inferred that northern rivers and headwater tributaries have a more severe environment than southern rivers and lowland tributaries, resulting in slower growth of chinook fry and longer stream residence. The only indicator of environmental severity available for the rivers considered in this paper is temperatures collected at streamflow guaging sites (Environment Canada 1977). These data provide an indication of the length of the growing season and the temperature regime during the growing season, two important factors affecting whether juvenile chinook can reach smolting size during their first summer.

The temperature in rivers having 100% stream-type chinook (Yukon, Taku, Stikine) is not uniformly lower than in rivers having a high proportion of ocean-type chinook [Nass, Skeena, Yakoun, Kitimat, Bella Coola] (Table 3). Average annual temperatures in the Yukon, Taku and Stikine are only slightly lower than in the Nass, Skeena and Kitimat. Temperatures in the Yukon and Stikine during the summer growing season (June-August) are warmer than in the Nass, Skeena, Kitimat or Bella Coola (Table 3). The Yakoun, which has a high proportion of stream-type chinook, is much warmer throughout the year than either the Kitimat or Bella Coola, which have low proportions of stream-type chinook. The temperature data available for these rivers may not be directly representative of the temperatures in the microhabitats where juvenile chinook are found, so a detailed statistical analysis of these data is not warranted. Nor is temperature necessarily the best environmental severity indicator to correlate with the abundance of stream-type chinook. Nevertheless, the absence of a consistent relationship between river temperature, a factor commonly associated with fish growth and production, and the relative abundance of stream-type chinook, weakens the argument that length of stream residence is mainly environmentally determined.

Ocean Distribution of Stream- and Ocean-type Chinook Salmon

Information on the ocean distribution and migration patterns of stream- and ocean-type chinook comes from a variety of sources. Healey (1980a,b), Hartt (1980), and Argue (1970) present information on the occurrence of first ocean year chinook in coastal waters. Samples from the commercial troll fishery, which operates outside the surf line, provide information on the occurrence of older chinook within about 80 km of the coast (Milne 1964; Ball and Godfrey 1968b, 1969, 1970; Wright et al. 1972; Parker and Kirkness 1956). River mouth gillnet fisheries which operate in the estuaries of the major rivers provide information on the occurrence of maturing chinook near the river mouths (Godfrey 1968; P. F. Starr,

TABLE 2. Summary of characteristics distinguishing stream- and ocean-type Chinook Salmon.

Characteristic	Stream-Type	Ocean-Type
Distribution of spawning populations.	100% of runs to rivers north of the Nass.	Dominant in the Nass and all rivers to the south.
	In the Nass and rivers to the south dominant in headwater spawning populations.	Dominant in downstream spawning populations.
Timing of spawning runs.	Dominant in early runs.	Dominant in late runs.
Ocean distribution and migration.	Smolts move offshore during first summer at sea.	Smolts remain in inside sheltered waters during first summer at sea.
	Dominant in offshore waters throughout marine life.	Dominant in onshore waters throughout marine life.

TABLE 3. Monthly and annual average temperature (° C) of selected Chinook Salmon spawning rivers. Source, Environment Canada 1977.

	River							
Month	Yukon	Taku	Stikine	Nass	Skeena	Yakoun	Kitimat	Bella Coola
January	0.0	0.1	0.0	0.3	0.2	1.5	0.4	0.5
February	0.0	0.0	0.0	0.2	0.3	1.5	1.7	1.1
March	0.0	0.3	0.0	1.4	0.6	2.6	1.5	2.8
April	0.1	2.8	0.1	4.9	4.0	5.2	3.7	7.4
May	4.8	5.2	5.8	7.2	6.0	7.8	5.3	8.8
June	9.1	8.7	8.6	7.2	7.6	13.2	6.3	9.6
July	13.8	11.4	12.8	9.0	12.1	14.3	10.3	9.0
August	12.9	9.5	12.4	10.4	12.1	17.2	10.0	10.0
September	8.6	8.9	9.3	9.3	10.0	12.2	9.7	7.4
October	3.3	3.7	2.8	4.0	6.0	10.0	6.6	7.0
November	3.5	1.8	0.0	2.6	1.6	5.2	1.5	3.5
December	0.0	—	0.5	1.0	0.7	3.0	1.8	2.0
ALL	4.7	4.4	4.4	4.8	5.1	7.8	4.9	5.8
Percent Stream-type Chinook Salmon	100	100	100	42	48	57	12	14

C. L. Cross, and F. J. Fraser 1981 unpublished ms). Information on the high seas distribution of chinook comes from both published and unpublished data of the International North Pacific Fisheries Commission (Manzer et al. 1965; Vic Aro, personal communication, 1980). While none of these data are complete or convincing alone, together they provide a reasonable picture of the occurrence and migratory behaviour of the two life history types in the ocean.

The timing of seaward migration of stream- and ocean-type chinook juveniles is similar. Stream-type smolts generally migrate in April and May, slightly later than recently emerged ocean-type fry migrants but before the downstream movement of ocean-type smolts (Major and Meghell 1969; Healey 1980a and unpublished data). First ocean year stream-type chinook are present in the Strait of Georgia, a major juvenile salmon nursery area in southern British Columbia, for only about two months following downstream migration. Ocean-type chinook, however, remain abundant in the Strait of Georgia throughout their first and second years of ocean life, and contribute heavily to the local sport and commercial fisheries of this region (Healey 1980a; Argue and Marshall 1976). In Juan de Fuca Strait, which connects the Strait of Georgia with the open Pacific, Argue (1970) observed a peak in the catch of first ocean year chinook during September, most of which were stream-type. Thus, the disappearance of stream-type juveniles from the Strait of Georgia is followed by an increase in their abundance further seaward in Juan de Fuca Strait, suggesting an outmigration of stream-type juveniles from the Strait of Georgia in late summer. Most of the ocean-type juveniles appear to remain behind in the Strait of Georgia.

Hartt (1980) sampled by purse seine throughout the eastern north Pacific, and captured first ocean year chinook both nearshore and offshore. Greatest catches were in July, and in all months most fish were caught within 40 km of the shore. Of 253 fish whose ages were determined, 245 were stream-type (Colin Harris, personal communication 1979). Fifty of the fish had two fresh water annuli and these were a greater proportion of the catch north of 55° N than south (31.5% compared with 11.4%). Most of the fish with two fresh water annuli were probably from rivers in Alaska, where fresh-water residence times of more than a year have been observed. The other stream-type fish were presumably from populations all along the coast.

These observations indicate that many, if not most, ocean-type chinook spend their first ocean year in sheltered inside waters, or very close to shore. Stream-type chinook, on the other hand, begin to move offshore in July or August and during their first ocean year are most abundant along the open coast outside the surf line (Table 2).

The contribution of the two life-history types to catches on the high seas, in the commercial troll fishery, and in the river mouth gillnet fisheries shows that differences in ocean distribution also exist among fish at sea for more than one year. Manzer et al. (1965) reported that a sample of 847 chinook, mostly in their second and third ocean years, captured east of 170° E in 1960 by the Japanese mothership fishery, were all stream-type. About 10% of the fish had two fresh water annuli. This sample might, however, have included a considerable number of Asian chinook. Eighty chinook in their second to fifth ocean years captured on the high seas north of 45° N and east of 170° W during 1961-1967 by Canadian research vessels were 65% stream-type (Vic Aro, personal communication 1980). These fish were almost certainly from North American populations. Since stream-type chinook constitute about 25% of all chinook in spawning populations from the Columbia River to southeast Alaska, the percentage of stream type chinook in the high seas catches is greater than expected.

The high proportion of stream-type chinook in the high seas catch could be due to most samples coming from north in the Gulf of Alaska coupled with the possibility that ocean-type chinook have a southerly distribution in keeping with the southerly distribution of their spawning populations. If this were the case, a higher proportion of ocean-type chinook should be found in the most southerly areas sampled on the high seas. The total catch by Canadian research vessels was equally distributed north and south of 49° N and equal numbers of stream- and ocean-type chinook were captured north and south of 49° N. A high proportion of stream-type fish occur in offshore waters regardless of latitude (Table 2).

Closer to the coast the situation is reversed. The proportion of stream-type chinook in the British Columbia commercial troll fishery ranged from 3.4% in the Strait of Georgia to 20.6% in the Queen Charlotte Islands area during the 1960's (Table 4). Off Washington and southeast Alaska, troll catches of stream-type chinook were similar, at 15 and 15.7% respectively. The proportion of stream-type chinook in all troll fishery samples since 1940 has been less than 21% (usually below 15%) in all regions of the coast. This is low compared with the average proportion of 25% stream-type fish in the spawning populations.

Stream-type chinook undertake their spawning migration earlier on average than ocean-type chinook. One possible explanation for the low proportion of stream-type chinook in the coastal troll fishery is the early departure of maturing stream-type fish from the fishing grounds. However, stream-type chinook are a low proportion of both the immature and maturing fractions of the troll catch (Ball and Godfrey 1968a, b, 1969, 1970). Early departure of maturing stream-type chinook from the fishing grounds is not, therefore, a sufficient explanation of the low percentage of stream-type fish in the troll catch.

Before 1940 the percentage of stream-type chinook in the troll fisheries along the British Columbia coast was significantly higher, ranging from 17.5-28.0% ($t = 3.10$, $P < 0.05$) (Table 4). Several factors may explain this apparent decline in the contribution of stream-type chinook to the troll catch. Stream-type fish may have constituted a higher percentage of all chinook populations in the past. There is evidence that stream-type chinook have declined in abundance in the Columbia, Sacramento, and other major rivers due to human activities such as dam building and hydraulic mining. Stream-type fish might also be less able to withstand intensive fishing pressure than ocean-type and may have declined relative to them in recent years due to increased fishing pressure. Finally, prior to 1940, trollers may have fished closer to river

TABLE 4. Percent of stream-type Chinook Salmon in the coastal troll catch and the rivermouth gillnet catch during several decades

	Data	Decade					
Fishery	Source	1911-20	1921-30	1941-50	1951-60	1961-70	1971-80
Troll							
S.E. Alaska	1				15.7		
Northern B.C.	2		23.0		5.6	20.6	
Central B.C.	2					9.3	
Vancouver Island	2		20.0	12.4	10.9	3.9	
Georgia Strait	2	28.0	17.5		6.5	3.4	
Washington State	3					15.3	
Gillnet							
Fraser River	4				34.4	42.8	12.8
Skeena River	4					48.1	28.1
Nass River	4					46.2	

Data Source:

1. Parker and Kirkness 1956.
2. Milne 1964; Ball and Godfrey 1968b, 1969, 1970.
3. Wright et al. 1972.
4. Godfrey 1968; Ball and Godfrey 1968a; P. F. Starr, C. L. Cross and F. J. Fraser 1981: unpublished ms; Ginetz 1976.

mouths were maturing stream-type fish are relatively abundant (see below). Unfortunately, no suitable river mouth or high seas catch data are available for these early years to determine whether stream-type chinook were more abundant in all regions prior to 1940.

In river mouth gillnet fisheries the proportion of stream-type chinook is high (Table 4). Although the gillnet fisheries occur in rivers known to have a high percentage of stream-type fish, their abundance in the net catches shows that these fish are highly available in the river mouths even though they were not further offshore in the troll fishing areas.

These data suggest a predominantly coastal distribution of ocean-type chinook and an offshore distribution of stream-type chinook throughout their lives (Table 2). The low proportion of stream-type chinook in the troll fisheries further suggests that maturing stream-type fish complete their onshore migration quickly and are available for only a short time to the coastal troll fisheries. Following their rapid onshore migration, maturing stream-type chinook delay in the river estuaries for some time prior to upstream migration, at which time they are available to the river mouth gillnet fisheries.

Discussion

The data available show consistent differences between stream- and ocean-type chinook in adult run timing, in the distribution of their spawning populations both along the coast and within river systems, and in their ocean distribution and migration behaviour (Table 2). These differences cannot easily be explained on environmental grounds. Water temperature, as an example of the kind of environmental factor which might affect fresh-water residence, does not account for the absence of ocean-type chinook north of the Nass River or for the high proportion of stream-type chinook in the Yakoun River. Also, fresh-water environmental conditions that might result in a longer fresh-water residence seem unlikely to produce different oceanic distributions and adult run timings. In view of these difficulties, it seems unlikely that stream-type chinook are a phenotypic variant produced by fresh-water rearing conditions. Instead, it seems likely that stream- and ocean-type chinook represent genetically unique races as reflected by their different behaviour patterns.

A number of studies point to genetic segregation between chinook spawning populations. Although I know of no experiments dealing specifically with stream- and ocean-type chinook, Ricker (1972) cites studies on the Columbia and Sacramento Rivers in which spring run chinook (presumably mostly stream-type) were transplanted to tributaries having natural runs of fall chinook (presumably mostly ocean-type) and vice versa. Transplanted spring chinook consistently returned in the spring and fall chinook in the fall regardless of the characteristics of the stream to which they were transplanted. Adult run timing, therefore, appears genetically determined. More recently, Kristiansson and McIntyre (1976) found that the frequency of certain polymorphic enzymes in spring run Columbia River chinook was significantly different from fall run chinook. These results provide further support for genetic separation of the two life-history types. Both Ricker (1972) and Kristiansson and McIntyre (1976), however, also present evidence for significant genetic differences among fall run populations of chinook. Simply to demonstrate that stream- and ocean-type chinook differ genetically does not constitute sufficient evidence for racial separation, although this is a necessary condition. Further investigation is required to determine, unequivocally, that these life history types do constitute separate races.

Should racial classification of these life-history types prove correct, the question of their origin and maintenance arises. Various possibilities suggest themselves. The two life-history types may have arisen through allopatric evolution during the last glaciation with their present distributions representing post-glacial colonization of suitable habitats, or the life-history types may have arisen through a process of disruptive selection in the larger river systems. Under this scenario, spring and summer adult migration would be favoured in upriver areas because the rivers are easier to ascend to the headwaters during spring and summer high water levels, and longer fresh-water residence would be favoured because larger smolts are better able to undertake the longer downstream migration. Maintenance of the separate life-history patterns could result from behavioural or chemical isolating mechanisms during spawning. Physical separation of the life-history types at spawning is not universally the case, so that maintenance of the life-history patterns cannot result simply from allopatry and precise homing. As a final alternative, the two life-history patterns may exist in a balanced genetic polymorphism. Such a polymorphism would provide additional survival opportunities to a population living in an uncertain environment. A thorough consideration of these, and perhaps other, alternatives must, however, await a more formal analysis of the genetic relationships between stream- and ocean-type chinook.

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Wintering Biology of Mourning Doves, *Zenaida macroura*, in Ontario

EDWARD R. ARMSTRONG[1] and DAVID L. G. NOAKES

Department of Zoology, University of Guelph, Guelph, Ontario N1G 2W1
[1]Present Address: Ministry of Natural Resources, P.O. Box 730, Cochrane, Ontario P0L 1C0

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Mourning Dove, *Zenaida macroura*, populations in Ontario contain both migratory and non-migratory birds. Wintering doves often suffer damage to their feet, and moulting of immature and second-year doves declines or ceases during winter. Doves are overwintering in Ontario in increasing numbers, probably as a result of increasing availability of food supplies. Greatest early winter densities are found along northern Lake Erie and southern Lake Huron.

Key Words: Mourning Dove, *Zenaida macroura*, wintering, moult, Ontario

The Mourning Dove (*Zenaida macroura*) was originally migratory in Ontario and other northern areas of its range (Cole 1933; Saunders and Dale 1939). A changing food supply has been suggested as responsible for recent increases in overwintering of doves in northern areas (Hennessy and Van Camp 1963; Richards 1966; Alison 1976; Freedman and Riley 1980). During winter, doves in agricultural areas of Ontario feed almost exclusively on waste or stored corn (*Zea mays*) (Armstrong and Noakes 1981). There is no open hunting season on Mourning Doves in Ontario. As part of an ecological study of Mourning Doves in southern Ontario (Armstrong 1977), we investigated the relatively recent advent of overwintering in the Ontario Mourning Dove population. We were specifically interested in assessing recent trends in the number of doves overwintering, and relating this to possible food sources. We also investigated the implications of overwintering to moulting activity and frost damage to the feet.

Study Area and Methods

The major study area was Norfolk County on Lake Erie, with some work in Wellington and Huron counties to the north and northwest respectively. Three-quarters of the 100 000 ha of farm land in Norfolk County is in agricultural crops, mainly grain corn, winter wheat (*Triticum aestivum*) and tobacco (*Nicotiana* spp.) (Ontario Ministry of Agriculture and Food 1975). There are about 20 000 ha of woodland. The median period of snow cover is from 22 November to 30 March (Brown et al. 1974). Lowest mean monthly temperatures occur in January or February, being -5°C in 1975 and -9°C in 1976 (Environment Canada data, Simcoe, Ontario).

During the winters of 1974-75 and 1975-76, feeding and roosting doves were collected for this and related studies. All doves were examined for frost damage to their feet, ranging from loss of one claw to complete loss of several digits.

Doves with at least one buffy-tipped covert were classed as immature (before 1 January) or second-year birds (after 1 January) (Reeves et al. 1968). Doves lacking buffy-tipped coverts were similarly classified if the ninth and tenth primaries had smooth edges and buff-coloured fringes (Wight et al. 1967). Hatching dates were determined by moulting rates as reported for doves in Illinois (Hanson and Kossack 1963); that study was geographically closest to and therefore likely to be comparable to that of our study area. If a dove was not actively moulting its date of hatching was estimated by comparing the last moulted primary with known-age birds. The occurrence of suspended moult was also recorded, i.e. when one primary had been completely replaced while the next had not yet dropped (Mead and Watmough 1976).

Fourteen immature doves, captured live in August 1975, were maintained in an outdoor aviary with shelter at the University of Guelph during the following winter. Although maintained principally for other studies, they were examined at intervals for damage to the feet.

Christmas Bird Count data from 1970-73 were consulted to determine the early winter distribution of doves in southern Ontario and adjacent states by plotting the average number of doves seen per 10 party hours (Bystrak 1971). Christmas Bird Count data were also compiled for 1950 through 1974 for St. Thomas, Elgin County, to assess increases in wintering doves on the north shore of Lake Erie (Audubon Field Notes 1951-70; American Birds 1971-75; e.g. see Auckland 1975). Data on the annual area planted to grain corn in Norfolk County (e.g. Ontario Ministry of Agriculture and Food 1975) were also compiled for the same period and compared with the wintering dove count by correlation analysis.

Tests of association between occurrences of both suspended moult and damaged feet and time of year was done by chi-square tests. Expected frequencies were calculated from the assumption that the row and column classifications were not associated.

Results

There were significant seasonal differences in the proportion of adult doves (which would have included second-year doves that had completed moult) with damaged feet, with the highest incidence during January-March (Figure 1; $\chi^2 = 10.66$, $p<0.05$). There was no damage to the feet of immature doves in summer or fall, but four of seven known second-year birds collected during February and March had such injuries. None of the second-year birds in the aviary had this damage in early January, but by March five of seven doves did.

During summer most immature doves were moulting one to three primaries simultaneously; during fall and winter only one primary was replaced at any one time, and many doves had completely replaced one primary while the next one had yet to drop (Table 1). A chi-square test showed a significant association between this suspended moult and season (June - September versus October - February; $p < 0.005$).

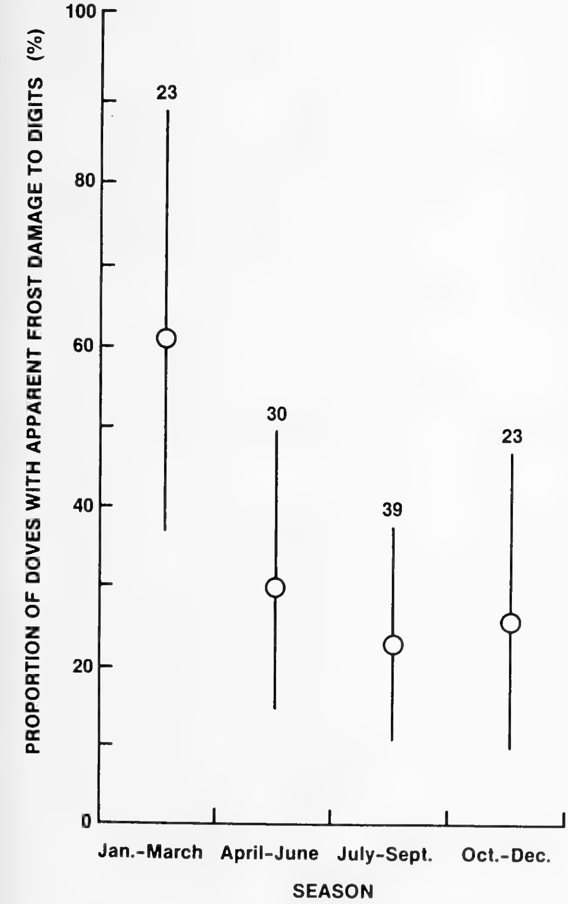

FIGURE 1. Trimonthly changes in the proportion of adult Mourning Doves with apparent frost damage to the digits.

TABLE 1. Occurrence of suspended primary feather moult in immature[a] and second-year[a] doves.

Period	n	No. with Moulting Primaries (%)	No. with Suspended Moult[b] (%)
June-September	101	99 (98.0)	2 (2.0)
October-November	24	18 (75.0)	6 (25.0)
December-February	12	2 (16.7)	10 (83.3)
March	2	2 (100.0)	0 (0.0)

[a] Includes all doves that had initiated primary feather moult, including live-captured birds on date of capture.

[b] Chi-square analysis of occurrence of suspended moult between June-September and October-February, $\chi^2 = 42.3$, d.f. = 1, $p < 0.005$.

The hatching period determined by backdating from immature doves collected prior to 1 October was April through August, with a peak during May and June similar to nesting study results (Armstrong 1977). However, when data after 1 October were included there was a less-pronounced hatching peak in late June, and 24% of all hatching was estimated to have taken place between September and November.

The greatest early winter concentration of doves in Ontario was along the northern shore of Lake Erie (including Norfolk County), continuous with similar populations in northern Ohio and southern Michigan (Figure 2). The Mourning Dove population on the north shore of Lake Erie has increased dramatically since the early 1950's, significantly correlated with increases in the area planted to grain corn (Figure 3; $r = 0.55$, $p < 0.01$).

Discussion

Frost damage to the feet is a common injury to doves wintering in northern areas (Thompson 1950; Hanson and Kossack 1963), reported for example in Ontario (Alison 1976), Ohio (Hennessy and Van Camp 1963) and Michigan (Nickell 1964). The highest proportion of such injuries occurred during winter, with a reduced proportion in spring as unaffected migrants joined the resident population. With refinement and larger sample sizes, the ratio of the proportion of summer to winter doves with frost damage may provide an estimate of the proportion of the local population that overwinters. Major assumptions include no regeneration of claws, and that doves with frost damage had wintered in the area. The initial estimate (33% overwintering) is comparable to the

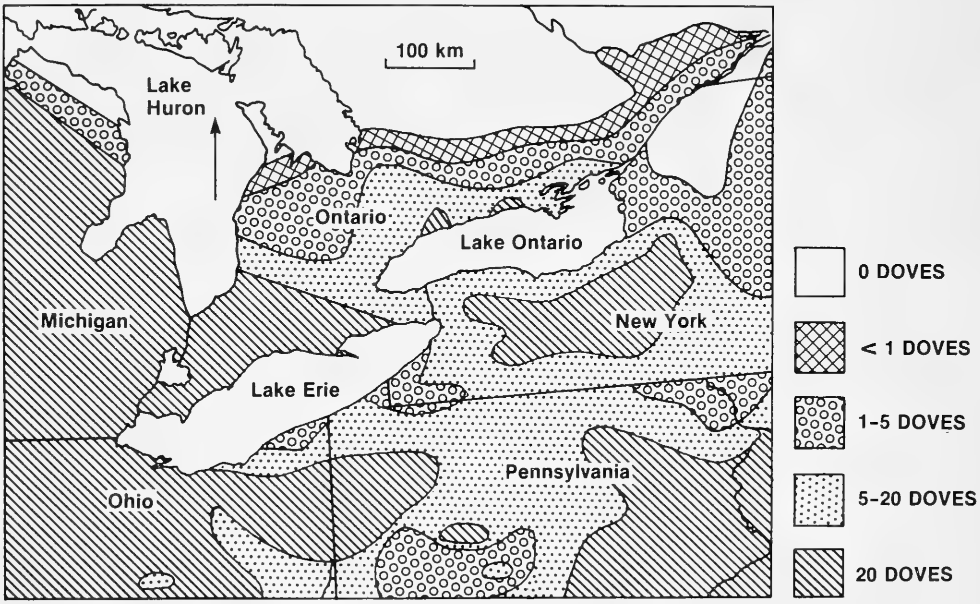

FIGURE 2. The early winter distribution of Mourning Doves in southern Ontario and neighbouring states.

estimate of 32% resulting from banding studies in Ohio (Ruble and Urban 1977). Mourning Doves apparently lack adaptations to the cold possessed by Wood Pigeons (*Columba palumbus*), which have foot papillae that are thicker and more pointed in winter than in summer to reduce heat transfer and substrate contact (Lennerstedt 1975). The tarso-metatarsal temperature of Mourning Doves falls rapidly with cold exposure, and the toes are still exposed when perching (Bartholomew and Dawson 1954). The extreme loss of several toes apparently had little effect on the doves, although perching behaviour would be affected.

The high proportion of immature doves with suspended moult indicated a cessation of moulting during the winter. This conclusion was confirmed by the discrepancy in nesting periods and peaks established by backdating all immature doves examined, and by backdating doves examined only before 1 October. The latter procedure corroborated concurrent nesting studies (Armstrong 1977), while results of the former method indicated an improbable and unsubstantiated nesting chronology with a delayed midsummer peak and a late fall extension. Similar delays in moult occurred in immature doves wintering in Wisconsin and Oklahoma (Thompson 1950; Ault et al. 1976). Suspended moult may occur in Mourning Doves as a result of severe environmental conditions, although we did not demonstrate a cause and effect relationship. Suspended moult would be advantageous for late-hatched doves, which are most likely to overwinter locally (Hanson and Kossack 1963; Hennessy and Van Camp 1963), and which would otherwise be completing moult during late fall and winter. Metabolic rates of immature doves are higher than those of adults even without the additional cost of moult (Ivacic and Labisky 1973).

Mourning Doves feed heavily upon waste or stored corn throughout the winter (Armstrong and Noakes 1981). The physiological consequences of this reliance on corn are uncertain, but immature wild doves feeding on corn during nonwinter months grew faster, weighed more, and had more body fat than those feeding on other foods (Hanson and Kossack 1957). The linear relationship between winter counts of doves and the amount of farmland planted to corn suggests that the increasing acreage in grain corn may be partially responsible for the increasing population of overwintering doves in southern Ontario. Other factors such as bird feeders probably are involved, as they have increased wintering populations of other birds (Bock and Lepthien 1976; Middleton 1977). The phenomenon of increasing Mourning Dove populations is consistent with Cohen's (1967) model of seasonal migratory behaviour, which predicts that the overwintering portion of a population will increase with the food supply and survival of the overwintering proportion.

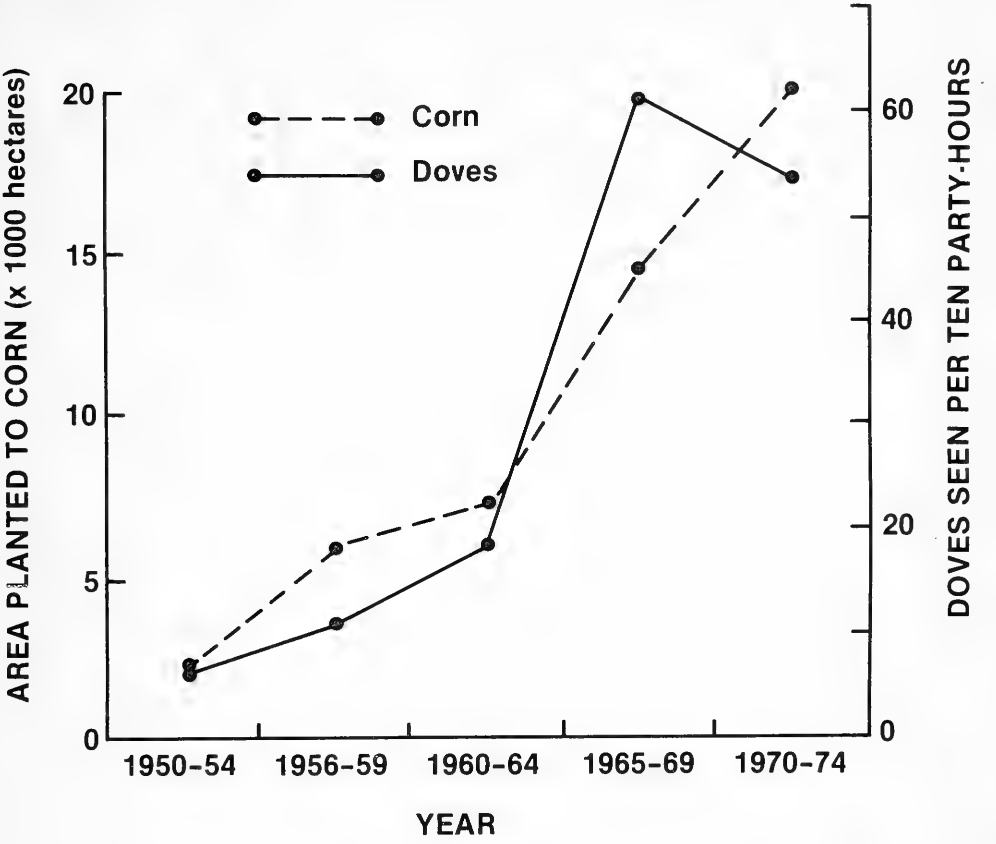

FIGURE 3. Recent trends in the area planted to grain corn in Norfolk County, and in the number of Mourning Doves seen per ten party-hours near St. Thomas, Elgin County.

A successfully overwintering Mourning Dove population could contribute substantially to local recruitment. Wintering doves avoid the hazards of migration and hunting, and are available to take advantage of favourable early spring conditions that may increase the length of the breeding season.

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Adaptation of Atlantic Salmon, *Salmo salar*, to a Restricted Freshwater Environment

J.-P. CUERRIER

P.O. Box 7196, Ottawa (Vanier), Ontario K1L 8E3

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In an experimental stocking of a restricted freshwater environment, Papin Lake, Pontiac County, Quebec, Atlantic Salmon fingerling (25-35 mm long) growth was remarkable because of the introduction and adaptation of smelts utilized by the landlocked salmon as forage food. After three summers, some salmon had reached 2.0-2.84 kg. In Papin Lake, salmon reached first sexual maturity after three summer growing seasons, age 2+. No natural propagation was successful due to the absence of an inflowing stream. The last catch of a landlocked salmon in Papin Lake was made at the end of June 1981. The specimen was 8 years old and had been stocked in 1973.

Key Words: Atlantic salmon, *Salmo salar*, landlocked salmon, growth, sexual maturity, smelt.

Des fretins de saumon atlantique mesurant 25-35 mm ont été ensemencés dans un milieu dulcicole, le lac Papin, comté de Pontiac, Québec. La croissance a été remarquable grâce à l'introduction et l'adaptation d'éperlans utilisés par le saumon dulcicole comme nourriture. Après trois étés, des saumons avaient atteint 2.0 à 2.84 kg. Au lac Papin, le saumon a atteint sa première maturation sexuelle après trois étés de croissance, soit à l'age de 2+ ans. Aucune propagation naturelle n'a été réussie à cause de l'absence d'une rivière de charge. La dernière prise d'un saumon dulcicole au lac Papin a été effectuée à la fin de juin 1981. Ce spécimen était âgé de 8 ans, ensemencé en 1973.

Mots clés: Saumon atlantique, *Salmo salar,* saumon dulcicole, croissance, maturité sexuelle, éperlan.

Landlocked salmon, also called freshwater salmon and ouananiche, occur in several lakes of North American states: Maine (Havey and Warner 1970), New Hampshire, Vermont (Lake Champlain) and New York (Anonymous 1977, 1981); in Trout Lake, near North Bay, in several other Ontario lakes (Scott and Crossman 1973; MacCrimmon and Gots 1979); in Memphremagog, Mégantic, Musquaro (Bryant 1964), Tremblant (Blais et Legendre 1976; Legendre 1980), Sorcier, St. John (Saguenay) lakes; in several lakes along the North Shore of the St. Lawrence River in Québec; and in several lakes in Newfoundland (including Labrador).

Some occurrences result from such natural phenomena as the ouananiche and sebago; others are man-made introductions such as the landlocked salmon.

For a detailed account on the nomenclature of anadromous (sea) salmon, freshwater salmon, landlocked salmon, lake salmon, ouananiche and sebago, and for a detailed list on the distribution of salmon in freshwater habitats, readers are referred to MacCrimmon and Gots (1979).

The adaptation of landlocked salmon to a freshwater environment offers an interesting challenge for biologists both as a management tool in the use of forage minnow and sucker populations for a fast growing fish and in providing angling opportunities (Legendre 1967). Authorities in the United States have comprehensive projects underway on landlocked salmon (Anonymous 1967 and 1981; Pfeiffer 1979; Ingham 1981).

This paper reports on experimental stockings of Atlantic salmon fingerlings, which started in 1961, in Papin Lake, Township of Auray, County of Pontiac, Québec (76°06′N, 46°09′W).

Stockings

On the basis of a policy of diversification in the availability of game fish in the former Pontiac Game Club waters, Papin Lake, with an area of nearly 160 ha, was selected for an experimental adaptation of Atlantic salmon because it seemed to offer suitable ecological conditions (oligotrophic) and because it was uninhabited by other species of game fish. The lake has a maximum depth of 33 meters. Data on the vertical distribution of temperature and dissolved oxygen on 23 August 1967 were as follows:

Depth (Meters)	Temperature (C°)	Dissolved Oxygen (mg/1)
0	20.0	
6.1	18.9	8.0
6.7	14.5	
7.0	11.1	
9.1	8.4	
12.2	6.7	8.5
18.3	6.1	7.0

Records on stockings carried out between 1961 and 1973 in Papin Lake are presented in Table 1.

TABLE 1. Stocking records of Atlantic Salmon, *Salmo salar,* and Rainbow Smelt, *Osmerus spectrum,* in Papin Lake, Quebec

Date	Species	Number	Size	Origin of Eggs
1961, June	Atlantic Salmon	4 000	35 mm	Tadoussac Hatchery
1965, May	Smelt	Millions	Eyed Eggs	Meach Lake, Gatineau Park
1966, May	Smelt	Millions	Eyed Eggs	Meach Lake, Gatineau Park
1966, May	Atlantic Salmon	10 000	25-35 mm	Gaspé Hatchery
1971, June	Atlantic Salmon	4 000	35 mm	Tadoussac Hatchery
1973, May	Atlantic Salmon	10 000	25-35 mm	Tadoussac Hatchery

On 24 June 1961, four thousand salmon fingerlings (about 25-35 mm in length) were planted in Papin Lake. They originated from eyed eggs obtained from the Tadoussac Hatchery, Tadoussac, Québec, where Atlantic salmon entering the Saguenay River are collected and stripped for fish culture purposes. Eyed eggs were hatched and fry raised at the Ripon Hatchery, Québec. The fingerlings were fed with dry feed for a month and a half prior to stocking.

During the spring of 1965, several million eyed smelt eggs (free of *Glugea*), taken from a creek flowing into Meach Lake, Gatineau Park, Québec, were released in shallow waters along a sandy beach at the south end of Papin Lake. The release of smelt eyed eggs was repeated in the spring of 1966. The objective was to establish a population of smelt that would provide a suitable forage food for salmon, a policy for years adopted in the states of Maine and New Hampshire and in Québec (Legendre 1967a). It was feared that the minnows (Cyprinidae) and suckers (Catostomidae) would drop in abundance and would not sufficiently sustain heavy predation by salmon.

In fact, large schools of minnows can no longer be observed in shallow waters. A smelt population is now well established in Papin Lake. A statement by Cooper (1940, p. 103) is quoted here: "These rather limited data on food habits of the salmon substantiated the already established and well known fact that the smelt is the chief food of landlocked salmon in Maine lakes". DeRoche (1976, p. 21) wrote similar comments in his study of Sebago Lake, Maine.

The smelt population in Meach Lake originated from Utopia Lake, New Brunswick. This pigmy smelt is now classified as *Osmerus spectrum* Cope, 1870 (Lanteigne and McAllister 1982).

Also during the spring of 1966, ten thousand Atlantic salmon fingerlings originating from eggs obtained from the Gaspé Hatchery, Gaspé, Québec, were released in Papin Lake.

In order to avoid complications in the identification between salmon which might originate from natural propagation and those originating from ulterior hatchery sources, no further plantings of salmon were carried out until the spring of 1971, when four thousand fingerlings were released. During the spring of 1973, ten thousand salmon fingerlings were again released. In both cases, the eggs were obtained from the Tadoussac Hatchery.

Results

Salmon caught by angling and by gill netting are presented in Table 2. Because angling activities during the early sixties were very limited and unsuccessful, sampling with gill nets was carried out on 2 October 1964, and resulted in the catch of five salmon (specimens 1 to 5 inclusive in Table 2). The first salmon caught by an angling Club member was reported on 19 May 1965. During 1966, several salmon, then five years old, were reported:

a) 5.0 kg: caught by angling;
b) 8.2 kg: found dead along the shore by a Club member; and
c) 7.5 and 7.3 kg: both caught with gill nets.

Although the salmon caught by gill netting between 1964 and 1968 inclusive were mature and in spawning conditions (see sex and stage of maturity in Table 2), there was no evidence by the fall of 1968 that the landlocked salmon in Papin Lake spawned successfully. Observations were carried out between 25 October and 5 November 1968, to examine the stage of salmon gonads and the possible spawning areas. Data on the four specimens netted appear in Table 2 (specimens no. 11-14 inclusive). Stomach contents of gill net catches revealed the presence of smelt ranging in length from 10.1 to 22.9 cm; the largest smelt specimen, being two years old, originated from the 1966 egg planting. Because salmon were still ripe, an intensive search was made of the shallow waters with a spotlight powered by a portable generator in an effort to locate salmon spawning areas. The entire shoreline, to a depth of 4 m was scanned between 2100 and 0100 h. Minnows, smelts and darters (Percidae) were observed, but no indication of spawning activities by salmon was obtained. The inlet creek with several small channels had a very low flow; several dams were maintained by beavers.

TABLE 2. Data on Landlocked Atlantic Salmon, *Salmo salar,* caught in Papin Lake, Québec

Specimen Number	Date	Length (Total) cm	Weight in kg	Sex	Stage of Maturity	Age in Years	Catch Method
1	2 October 1964	72.4	4.3	M	Immature	3+	Netting
2	2 October 1964	58.4	1.5	F	Ripe	3+	Netting
3	2 October 1964	69.8	3.2	M	Ripe	3+	Netting
4	2 October 1964	67.3	3.2	M	Ripe	3+	Netting
5	2 October 1964	65.4	3.1	M	Ripe	3+	Netting
6	19 May 1965	77.5	4.2	M	?	4	Angling
7	1966	?	5.0	?	?	5	Angling
8	16 July 1966	91.4	8.2	?	?	?	Found dead on shore
9	27 August 1966	83.8	7.5	M	Ripe	5+	Netting
10	27 August 1966	86.4	7.3	F	Ripe	5+	Netting
11	27 October 1968	65.0	2.8	M	Ripe	2+	Netting
12	27 October 1968	64.5	2.7	M	Ripe	2+	Netting
13	27 October 1968	59.4	2.0	M	Ripe	2+	Netting
14	3 November 1968	58.4	2.4	F	Ripe	2+	Netting
15	2 July 1974	48.9	1.4	M	?	3+	Angling
16	2 July 1974	27.3	0.3	?	?	1+	Angling
17	18 May 1975	57.1	2.0	?	?	2	Angling
18	23 July 1977	76.2	5.2	M	?	4+	Angling
19	13 May 1978	66.0	?	?	?	5	Angling
20	13 May 1978	?	6.1	?	?	5	Angling
21	13 May 1978	63.5	?	?	?	?	Angling
22	14 May 1978	78.7	4.9	M	Adult	5	Angling
23	14 May 1978	64.8	3.4	F	Adult	5	Angling
24	14 May 1978	76.2	4.6	M*	Adult	5	Angling
25	14 May 1978	63.5	?	?	?	5	Angling
26	16 May 1978	71.1	4.5	F**	Adult	5	Angling
27	21 June 1981	78.7	6.8	?	?	8	Angling

*Scales with spawning mark erosion in 1975, when this male salmon was 2+.

**Specimen with 10 ova of previous (1977) spawning still in body cavity; also 36 smelts were counted in the stomach.

After repeated examination of the scales, it was concluded that the four salmon caught in 1968 were 2+ years old, had completed three summer's growing seasons, and, therefore, were all from the 1966 stocking. The length and weight of the four specimens caught by netting in 1968 are remarkable, comparable to those reached by Atlantic salmon after two years at sea that return to spawn as grilse in the Alma River, Fundy National Park, N.B. (Dadswell 1968).

The landlocked salmon specimens caught in Papin Lake revealed that the spring fingerlings achieved excellent growth following planting. After three summers, some had reached between 2.0 kg and 2.84 kg. At five years, the weight of 7.3 kg had been obtained. The 7.3 kg female caught on 27 August 1966 (Table 2) had 11 200 ova attached to the ovarian tissues. This 7.3 kg female was to spawn in the fall. The 7.5 kg male caught on the same date was also sexually mature. The live weight of the 8.2 kg salmon found dead along the shore with the abdominal wall and the body cavity partly rotted and removed by scavenger animals might have been close to 9.1 kg.

During our contact with angling activities in Papin Lake, 27 landlocked salmon were reported and/or examined. The last specimen was caught on 21 June 1981. This salmon, 6.8 kg in weight, was 8 years old and from the 1973 stocking.

Conclusions

Atlantic salmon resulting from hatchery plantings grew exceptionally well in Papin Lake and thrived on introduced smelts. The smelts planted at the eyed-egg stage maintained themselves in large quantities through natural propagation.

The growth rate of landlocked salmon varied widely; the five-year-old salmon caught by angling or by gill netting ranged from 3.4 to 7.48 kg.

Salmon reached sexual maturity when 2+ years old, at the end of the third summer growing season, and had weight increment rates similar to sea-run grilse. However, the landlocked salmon in Papin Lake, which does not have a large inlet stream, did not spawn successfully. Females got rid of their ova but no progeny were caught.

Until 1981, we concluded that landlocked salmon in Papin Lake did not live beyond their sixth summer's growth. However, one salmon caught in Papin Lake, in 1981, was eight years old. The introduced salmon are believed to have disappeared from Papin Lake.

The observations on smelt in the lake and in the stomachs of salmon demonstrated that the habitat is suitable for this species of fish, and that salmon made good use of this forage food. The addition of smelt as forage indicates it resulted in furthering the growth of salmon. The size of the two-year-old salmon caught in 1968 compared advantageously with the three-year-old salmon caught in 1964.

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Elk, *Cervus elaphus*, Foraging Related to Forest Management and Succession in Idaho

LARRY L. IRWIN[1] and JAMES M. PEEK[2]

[1]Department of Zoology and Physiology, The University of Wyoming, Laramie, Wyoming 82071
[2]College of Forestry, Wildlife and Range Sciences, The University of Idaho, Moscow, Idaho

Irwin, Larry L., and James M. Peek. 1983. Elk, *Cervus elaphus*, foraging related to forest management and succession in Idaho. Canadian Field-Naturalist 97(4): 443–447.

Diets of Elk (*Cervus elaphus*) were correlated with availability of forage, indicating Elk were not selective of individual plant species. In spring, Elk preferred grasses and sedges in seral brushfields, forbs in clearcuts, and evergreen shrubs in timber stands. In summer, they preferred shrubs in seral brushfields and in timber stands, but fed more often in clear-cuts on forbs. In fall, Elk fed upon low-growing, evergreen shrubs in dense timber stands. In winter, they preferred shrubs in seral brushfields. Early successional stages provide large amounts of forage and were preferred feeding areas in all seasons except fall and early winter. Elk are generalist feeders which maximize energy intake through mechanisms of habitat selection rather than food selection.

Key Words: Elk, *Cervus elaphus*, forage selection, forest management, plant phenology, successional stage.

Food habits studies of Elk (*Cervus elaphus*) indicate that diets vary according to season and dominant vegetation (Kufeld 1973). However, relationships of forage selection to forage availability and to successional stages within an area are not well understood. This information is needed to better incorporate Elk habitat management with the intensive timber management typical of northern Rocky Mountain forests. This paper reports a three-year study of Elk foraging patterns in relation to forage availability and forest succession in northern Idaho. It was undertaken to clarify relationships between foraging and cover characteristics.

Study Area

The study area was along the Coeur d'Alene River within the Idaho Panhandle National Forest. Precipitation averages about 120 cm annually, and snow frequently accumulates in depths greater than 60 cm. Climax vegetation associations, or habitat types (Daubenmire and Daubenmire 1968), include primarily Western Hemlock (*Tsuga heterophylla*)/ Myrtle Pachistima (*Pachistima myrsinites*) and Grand Fir (*Abies grandis*)/ Myrtle Pachistima. The driest slopes at the lowest elevations are occupied by Douglas-fir (*Pseudotsuga menziesii*)/ Mallow Ninebark (*Physocarpus malvaceus*), while climax vegetation at the highest elevations includes Subalpine Fir (*Abies lasiocarpa*) or Mountain Hemlock (*Tsuga mertensiana*), with understories of Rusty Menziesia (*Menziesia ferruginia*) or Common Beargrass (*Xerophyllum tenax*).

Several successional stages are included within these habitat types. About half of the study area is covered by old growth Western Hemlock, Grand Fir, White Pine (*Pinus monticola*), and Western Larch (*Larix occidentalis*). These forests have few natural openings and average 86% canopy closure, as measured by a spherical densiometer (Lemmon 1957). The generally sparse understory includes Rocky Mountain Maple (*Acer glabrum*) and/or Pacific Yew (*Taxus brevifolia*).

The remainder of the area has either been clearcut during the past 15 years or is in other successional stages following wildfires in 1910, 1919, and 1931. Some areas have burned 3 times. The clear-cuts are comprised chiefly of forbs and sedges, including Fireweed Willow-herb (*Epilobium angustifolium*) and Elk Sedge (*Carex geyeri*). Mesic slopes within the wildfire-burned areas are covered by mature timber stands or by dense thickets of pole-sized timber. These stands average 82% canopy closure. Drier slopes are covered by scattered pole timber and seral brushfields mainly composed of Scouler's Willow (*Salix scouleriana*) and/or Snowbrush Ceanothus (*Ceanothus velutinus*). Breaks along the Coeur d'Alene River support a grass-shrub association which includes Elk Sedge, Bluebunch Wheatgrass (*Agropyron spicatum*), Saskatoon Serviceberry (*Amelanchier alnifolia*), and Mallow Ninebark.

Methods

The entire area was sampled once per week via an extensive network of logging roads and trails, which were generally equally distributed throughout all vegetative types. In winter only the winter range, composed of shrubs and pole-timber stands, was sampled. Feeding site examinations (Cole 1956, Knowlton 1960) occurred where Elk were observed feeding or where fresh Elk tracks were visible. If there was evidence that deer (*Odocoileus hemionus, O. vir-*

ginianus) recently fed in the feeding site, no data were recorded. An instance of use was considered to be that portion of a plant removed during 1 bite. If Elk fed in two distinct, adjacent cover types, two feeding sites were recorded. Data were summarized by average aggregate percent use (Martin et al. 1946).

Availability of plant species within each feeding site was determined by estimating relative percent cover in 10% classes within a circular 100-m^2 plot. All species present were assigned a relative percentage of the total plant cover. Field workers gained proficiency by measuring cover within practice plots. Because of similarities in understory, data were combined for mature, old-growth, and pole-timber stands. Shrubfields and grass-shrub types were also treated as a single type. Clear-cuts comprised a third successional stage sampled. Individual species eaten in each successional stage were designated as preferred (use > availability) using the electivity index of Alcoze and Zimmermann (1973). Seasonal groupings, based on plant phenology, Elk distribution, and shifts in habitat use (Irwin and Peek 1983), were: 21 April – 15 June (spring), 16 June – 8 September (summer), 9 September – 20 December (autumn), and 21 December – 20 April (winter).

The hypothesis that major foods were selected in relation to availability among all feeding sites in each season was tested by calculating correlations between use and availability. A positive correlation coefficient was used to indicate that Elk were not selective, i.e., most species were used in proportion to availability over all feeding sites, collectively (Nudds 1980). Preference refers to comparisons within feeding sites in a single successional stage in each season, and selection refers to comparisons of use and availability among all feeding sites in each season. To be selective, Elk would prefer or avoid certain species whenever they were available.

Results

Spring

Grass-shrub and Seral Brushfields. — In spring 3 903 bites were counted in 31 feeding sites. Most feeding activity was observed in grass-shrub types and seral brushfields (16 sites), and clear-cuts (11 sites).

When Elk fed in grass-shrub types and seral brushfields during early spring, Bluebunch Wheatgrass, Elk Sedge, and groundsels (*Senecio* spp.) accounted for about 62% of the diet (Table 1). Although 33 of 58 species available were eaten, only groundsels, Elk Sedge and penstemon (*Penstemon* spp.) were preferred, according to the electivity indices. Mallow Ninebark and Big Whortleberry (*Vaccinium membranaceum*) were abundant but not eaten.

Clear-cuts. — As snow receded, Elk used clear-cuts at higher elevations, and fed upon 34 of 66 available species, including Fireweed Willow-herb, Elk Sedge, and Siberian Minerslettuce (*Montia sibirica*). These species were abundant, and 60% of the diet in clear-cuts was comprised of succulent forbs. However, use was similar to availability and no preference was indicated. Green Mountain Ash (*Sorbus scopulina*), Mountain Bluebell (*Mertensia ciliata*), and currants (*Ribes* spp.) were preferred, and their combined use was about 25% of the diet in clear-cuts.

Timber Stands. — Myrtle Pachistima and Goldthread (*Coptis occidentalis*), the only species frequently used in the four feeding sites examined in timber stands during spring, were eaten prior to green-up. Both are evergreen plants.

All Areas. — Graminoids, shrubs, and forbs constituted 30, 38, and 42% of the spring diet, respectively. Diets varied among successional stages in relation to availability, as graminoids and shrubs, shrubs and forbs, and shrubs were most heavily used in shrub types, clear-cuts, and timbered stands, respectively. A positive correlation ($r = 0.60$, $P < 0.025$) between use and availability of all species among all successional stages indicated Elk were not selective, because they used the most abundant forage species in spring.

Summer

Grass-shrub and Seral Brushfields. — Eighty-five summer feeding sites were examined, 17 of which occurred in grass-shrub types and brushfields. Forty-six of 68 available species were used, but Elk fed mainly upon leaves and flowers of shrubs. Saskatoon Serviceberry, Snowbrush Ceanothus, and Scouler Willow comprised 50% of the diet chosen in these successional types (Table 1). Mallow Ninebark, Birch-leaf Spiraea (*Spiraea betulifolia*), and Common Snowberry (*Symphoricarpos albus*) were common but not eaten.

Clear-cuts. — We examined 58 feeding sites in clear-cuts and counted 11 653 bites. Ninety-seven species were available and Elk fed upon 74 species, mainly forbs. However, only Fireweed Willow-herb and Utah Honeysuckle (*Lonicera utahensis*) were preferred. Elk made heavy use of Western Thimbleberry (*Rubus parviflorus*), Fairybells (*Disporum oreganum*), and young shoots of Myrtle Pachistima in some clear-cuts during flowering. These species received progressively less use as they became less succulent.

Timber Stands. — After vegetation in clear-cuts matured in late summer, Elk were observed feeding more often in the nearly closed timber stands, where succulent forage was still available. We examined 10 feeding sites and found use on 51 of 76 available species. Elk preferred leaves and shoots of Rocky Mountain Maple and Utah Honeysuckle. Although

TABLE 1. Major species of plants available to and eaten by Elk in three successional stages in the Idaho Panhandle National Forest, 1975-77[a]

	Spring			Summer			Fall			Winter		
	Grass-shrub	Clear-cut	Timber	Grass-shrub	Clear-cut	Timber	Grass-shrub	Clear-cut	Timber	Grass-shrub	Clear-cut	Timber
Acer glabrum			1.4 1.3	3.2 3.1	0.9 0.9	20.0^{+} 13.3	0.0 4.5		2.3 2.0	11.8+ 6.1	—	0.0 4.5
Alnus sinuata									5.3 6.4			
Amelanchier alnifolia			0.0 1.2	21.3 18.1	0.6 0.5	0.6 0.8	0.0 4.5	0.0 0.8	—	20.8 18.1	—	0.0 4.5
Berberis aquifolium	1.2 2.5		2.6 2.8			0.0 3.1	0.0 4.5			2.1 2.2		
Ceanothus velutinus	4.8 4.4		0.4 0.6	20.3 18.4	0.4 0.4	0.0 0.9	0.0 9.0			9.5 12.8		
Lonicera utahensis			0.0 2.4	0.3 0.3	6.6^{+} 5.2	17.8^{+} 10.0		0.0 5.4				
Pachistima myrsinites	0.9 1.0		88.1 35.6	0.4 0.5	4.2 4.1	4.5 1.2	56.2 9.0	0.0 4.5	34.1^{+} 26.2	2.2 1.8		97.7 50.0
Ribes sp.		10.0^{+} 7.4										
Rubus parviflorus			0.0 4.0	2.2 2.2	6.1 6.5	1.8 4.6	0.0 4.5	0.0 3.2	9.7 7.9	0.0 5.0		
Salix scouleriana	0.3 0.3		2.1 2.3	8.3 7.2	1.9 1.9	0.6 0.7		0.0 3.7	—	47.5^{+} 19.9		0.0 4.1
Sorbus scopulina		6.0^{+} 4.5		3.4 3.4	2.1 2.0	1.2 1.2						
Spiraea betulifolia	6.6 6.9			0.0 13.2	0.0 1.2	0.0 0.9	0.0 4.5			0.0 5.0		
Agropyron spicatum	22.4 19.5											
Anaphalis margaritacea				0.0 0.1	3.3 3.2	0.3 0.3						
Arnica latifolia			0.0 1.5		0.0 1.2	0.0 1.5		19.2 8.6				
Bromus vulgaris		4.9 4.5			0.0 4.4			0.0 4.6				
Carex geyeri	21.4^{+} 16.1	19.5 17.0	0.1 0.1							1.7 2.1		1.2 4.5
Coptis occidentalis			4.5 14.5	0.0 5.1		0.0 12.2	43.2 25.0		33.4 30.2			
Disporum oreganum					4.4 4.2	0.0 3.1						
Epilobium angustifolium	0.2 0.2	19.9 22.4		0.4 0.4	29.2^{+} 23.2	4.5 4.2		46.0 51.5	6.8 5.4			
Mertensia ciliata		6.8^{+} 4.6										
Montia sibirica		14.2 13.4			2.3 2.0							
Penstemon sp.	4.9^{+} 3.8	2.0 1.7										

continued

TABLE 1 *(concluded)*

	Spring			Summer			Fall			Winter		
	Grass-shrub	Clear-cut	Timber	Grass-shrub	Clear-cut	Timber	Grass-shrub	Clear-cut	Timber	Grass-shrub	Clear-cut	Timber
Polemonium pulcherrimum		7.7/6.4										
Senecio	18.3^{+}/11.5											
Trillium ovatum		3.3/2.9			2.7/3.5	0.9/0.9						
All other species[b]	19.0/33.8	5.7/15.2	0.8/33.9	40.2/29.3	35.3/38.6	47.8/39.4	0.6/39.0	34.8/17.7	8.4/32.5	4.4/27.0		1.1/32.4
No. of sites examined	16	11	4	17	58	10	1	2	9	15	0	1
No. of bites tallied	1 611	1 853	439	2 767	11 653	1 143	74	408	1 143	2 375	0	87
No. of species eaten	33	34	8	46	74	51	3	6	22	15	0	3
No. of species available	58	66	17	68	97	76	31	52	41	31	0	17

[a] Average aggregate percent use/average relative cover in 100 m^2 circular plots. A plus sign indicates preference in relation to availability, using the electivity index of Alcoze and Zimmerman (1973).
[b] Includes species comprising less than 2% of the aggregate.

Elk preferred these shrubs, numerous forbs were eaten. Goldthread, American Trailplant (*Adenocaulon bicolor*), and Big Whortleberry were abundant but not eaten.

All Areas. — In summer, shrubs and forbs each constituted about 50% of the diet. Shrubs were most important when Elk fed in timber stands or seral brushfields, but forbs were most important when Elk fed in clear-cuts. As in spring, most species were eaten in proportion to availability; thus, Elk were not selective (r = 0.78, $P < 0.001$). Twenty-three of 31 prevalent species were used in proportion to availability, and 7 were avoided. Only Utah Honeysuckle appeared to be preferred wherever it occurred, i.e., it was selected.

Fall

Timber Stands. — In autumn, Elk were observed less often in open areas, where we found only 3 feeding sites. We examined 9 sites in timber stands where forbs and shrubs constituted 42 and 57% of the diet, respectively. Myrtle Pachistima, Goldthread, Western Thimbleberry, and Fireweed Willow-herb comprised 84% of the diet, but only Myrtle Pachistima was preferred. Only 24 species were used in fall, but the correlations between use and availability (r = 0.94, $P < 0.001$) were particularly high, indicating Elk were not selective.

Winter

Seral Brushfields. — The winter range occurred within a 1931 burn. Half the area was covered by grass-shrub types and seral brushfields, and no clear-cuts were present. Fifteen of 16 feeding sites examined were in seral brushfields, and only 16 species were used. Elk fed mainly on Scouler Willow, but also used Snowbrush Ceanothus, Saskatoon Serviceberry, and Rocky Mountain Maple. Scouler Willow and Rocky Mountain Maple were preferred. Elk pawed to Myrtle Pachistima and Elk Sedge when snow was not deep, but shrubs constituted 98% of the winter diet (Table 1). Correlations of use vs. availability of plant species indicated foraging was related to availability (r = 0.52, $P < 0.05$).

Discussion

Elk appear to be food generalists. While several species were preferred in certain successional stages, Elk were generally not selective, in comparisons among all successional stages. Thus, diets varied among the successional forest stages. Plant phenology also appeared to play a role in forage use, suggesting nutritional quality may influence forage selection. Elk preferred some species before or during flowering, but later shifted to other species in immature stages in other foraging areas. This information suggests that more emphasis should be placed in management and research on data describing mechanisms of habitat selection, including home range selection and food patch selection.

Because Elk appear to be generally non-selective, managers should worry less about species composition than the successional stages where feeding occurs. Black et al. (1976) defined distinct foraging and cover areas for Elk in eastern Oregon. However, forage areas are not distinct from optimal cover areas in northern Idaho. Late summer and fall feeding occurred primarily in nearly-closed timber stands, also suitable for thermal and security cover. Clearcuts and grass-shrub types apparently become less useful at that time due to phenological changes.

Condition of foraging areas used in late fall and early spring may be important in maintaining Elk herds in deep-snow areas. Importance of conditions prior to winter in maintaining winter ungulate populations has been noted by Julander et al. (1961), Verme (1965), Klein (1965), and Mautz (1978). While forage quality is important, use of early successional stages with highest quantities of forage in late summer and early fall also may increase survival of animals through winter when forage sources have naturally deteriorated in both availability and quality.

Managers should strive to enhance amounts and distribution of early successional stages which produce large quantities of forage. In our observations, early greening areas near winter ranges appear to be in relatively short supply, and should be protected as much as possible from development. Some of the drier timber areas adjacent to riparian zones and near known winter ranges could be clear-cut and burned to provide early-growing grasses, sedges, and forbs. Forage-producing clear-cuts or seral brushfields occur on many summer ranges, but we observed those on north or east slopes are used most. These develop rapidly into dense sapling and pole stands, which are important for Elk in autumn. Such thickets might be lightly thinned to encourage production of palatable understory plants such as Myrtle Pachistima, which will increase following thinning within the Western Hemlock type (Irwin and Peek 1979). Seral shrubfields currently used as winter range are very important and should be renovated as indicated by Leege (1969).

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Notes

Caspian Terns, *Sterna caspia*, Breeding in Labrador

A. R. LOCK

Canadian Wildlife Service, Bedford Institute of Oceanography, P.O. Box 1006, Dartmouth, Nova Scotia B2Y 4A2

Lock, A. R. 1983. Caspian Terns, *Sterna caspia*, breeding in Labrador. Canadian Field-Naturalist 97(4): 448.

In 1979 Caspian Terns (*Sterna caspia*) were found breeding in a colony of Ring-billed Gulls (*Larus delawarensis*) on an island at the eastern end of Lake Melville, Labrador. Although there are no previous records of this species breeding in Labrador, it is suggested that this record represents the first documentation rather than a range expansion.

Key Words: Caspian Tern, *Sterna caspia*, Labrador, breeding range.

On 7 July 1979 four adult Caspian Terns (*Sterna caspia*) were observed over a Ring-billed Gull (*Larus delawarensis*) colony on Gull Island (54°00′N, 58°43′W), a treeless grassy island about 40 m long situated at the eastern end of Lake Melville, Labrador. A search revealed a large, downy Caspian Tern chick approximately one week of age concealed in long grass about 6 m above water level. The adults hovered over the area in which the chick was concealed, screeching continuously. Nest sites were not positively identified nor did a thorough search discover further chicks. On the same island 322 pairs of Ring-billed Gulls, two pairs of Great Black-backed Gulls (*Larus marinus*) and two pairs of Arctic Terns (*Sterna paradisaea*) were also found breeding. This observation is the northernmost breeding record of Caspian Terns in eastern Canada.

Caspian Terns have a wide but disjunct breeding distribution (Voous 1960) with the majority of the Canadian population breeding in central Manitoba and the Great Lakes. In eastern Canada they are known to breed only in Quebec and insular Newfoundland (Godfrey 1966). Audubon (1897) noted them as breeding on the north shore of the Gulf of St. Lawrence in 1833 though he misidentified them as 'Cayenne Terns'. Their numbers have dwindled since that time and only four birds were counted on the 1977 census of the bird sanctuaries on the Gulf North Shore (Chapdelaine 1980). Caspian Terns are also suspected to breed in the Magdalen Islands but not in the Maritime Provinces. Their status on the island of Newfoundland is less certain: there are several past records of breeding (M. Martin 1978. Status Report on Caspian Terns; Committee on the Status of Endangered Wildlife in Canada) but the number breeding there at present is unknown.

There are no previous Labrador breeding records. Austin (1932) did not list the Caspian Tern as a species observed on the Newfoundland Labrador and Todd (1963) listed observations only in James Bay and on the Gulf North Shore. The only previous record of their being seen anywhere in Labrador is that of Grayce (1947), a July sighting of an individual at Antill Cove (52°13′N, 55°40′W) in southern Labrador, about 300 km SE of Gull Island. Todd (*op. cit.*, p. 769) dismissed this record as a doubtful identification but the present record of breeding in Lake Melville lends credence to Grayce's report. There is no reason to believe that Caspian Terns have extended their range northward in recent decades: they often breed in close association with Ring-billed Gulls, and that species was reported breeding in Lake Melville by Macoun (1900).

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Range Extension of the Sage *Artemisia rupestris* ssp. *woodii* in Southwestern Yukon

M. HOEFS, D. RUSSELL, and BETH EREAUX

Yukon Wildlife Division, P.O. Box 2703, Whitehorse, Yukon Y1A 2C6

Hoefs, M., D. Russell, and Beth Ereaux. 1983. Range extension of the sage *Artemisia rupestris* ssp. *woodii* in southwestern Yukon. Canadian Field-Naturalist 97(4): 449–450.

A new location is given for *Artemisia rupestris* ssp. *woodii*, some 130 km from its nearest reported locality in Kluane National Park.

Key words: *Artemisia rupestris* ssp. *woodii*, flora of Yukon.

The distribution of flora and fauna elements of the Yukon is incompletely known, and frequent documentations of range extensions can therefore be expected. The following observation, however, warrants official recording because of the very restricted North American occurrence of the species in question.

During a brief aerial assessment of Dall Sheep winter ranges in the southern Yukon, when short landings were made to compile species lists and physical parameters of representative sites, the occurrence of the sage *Artemisia rupestris* ssp. *woodii* was observed on the east side of Rose Lake. This location is shown on the accompanying map. The coordinates are approximately 135°55′W and 60°21′N. A number of

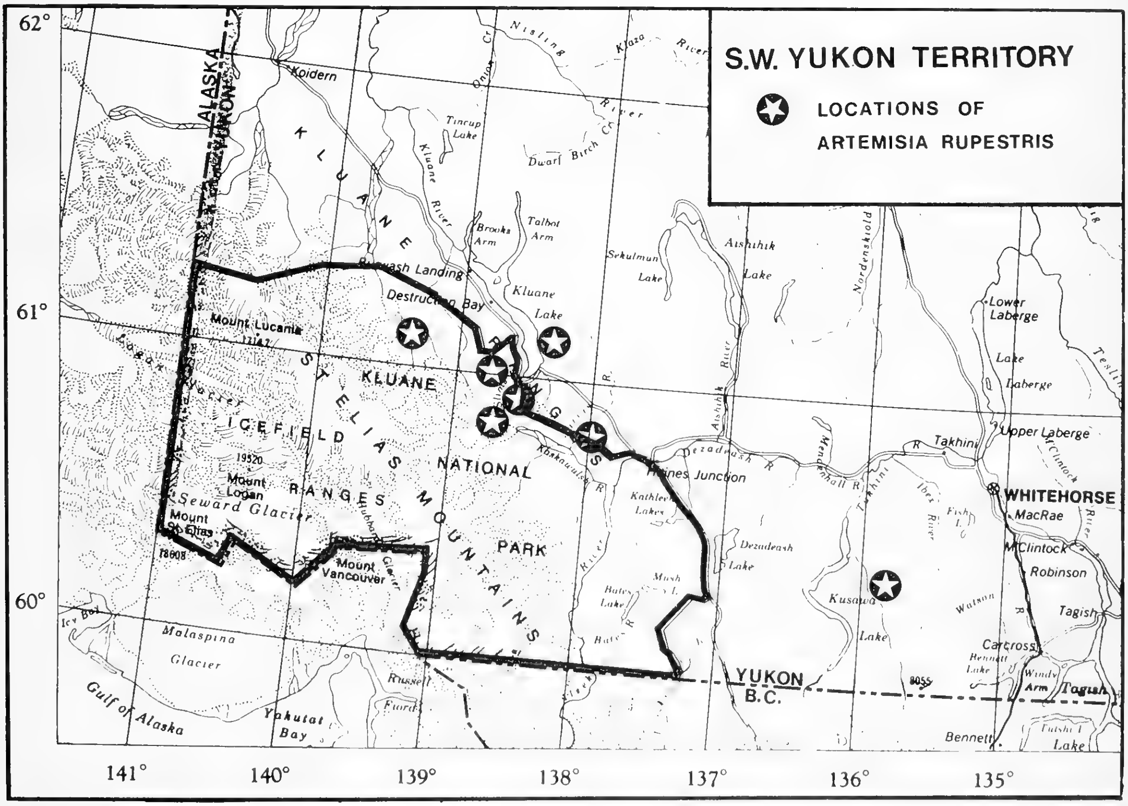

FIGURE 1. Map of the southwestern portions of the Yukon Territory showing the locations for *Artemisia rupestris* which are discussed in the text.

vigorous clumps of plants in bloom were located on 17 July 1982. The site was the southwest facing slope of Mt. Primrose at an elevation of about 1300 m and a slope gradient of 45°. This species was associated with *Oxytropis viscida, Artemisia frigida, Saxifraga tricuspidata* and *Calamagrostis purpurascens* in a typically dry, exposed "steppe association", as described by Hoefs et al. (1975) for Sheep Mountain, Kluane National Park, where *Artemisia rupestris* ssp. *woodii* constitutes a co-dominant or associate in a number of grassland communities. Specimens from this new site were preserved and are kept in the collection of the Yukon Wildlife Division.

Neilson (1968) was the first to report this species for North America. He collected it on Sheep Mountain, Kluane National Park. Douglas et al. (1981) documented additional locations in Kluane National Park, and the senior author also observed it at Cultus Bay, east of Kluane Lake. These previously known locations of this species are shown on the accompanying map.

The range of *Artemisia rupestris* ssp. *rupestris* is in the Lena River drainage of eastern Siberia, a distance of some 5200 km to the west. The newly reported location may also be disjunct, since it has not been reported for intermediate location, despite considerable vegetation work in the area during the past decade.

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Nesting of the Thick-billed Murre, *Uria lomvia*, in British Columbia

ANNE VALLEE[1] and RICHARD J. CANNINGS[2]

[1]Department of Animal Science, University of British Columbia, Vancouver, B. C. V6T 1W5. Deceased July 1982.
[2]Cowan Vertebrate Museum, Department of Zoology, University of British Columbia, Vancouver, B. C. V6T 2A9.

Vallee, Anne, and Richard J. Cannings. 1983. Nesting of the Thick-billed Murre, *Uria lomvia*, in British Columbia. Canadian Field-Naturalist 97(4): 450–451.

In 1981, about 19 pairs of Thick-billed Murres (*Uria lomvia*) breeding on Triangle Island represented the first breeding record for this species in British Columbia. Triangle Island is now the southernmost known breeding site of Thick-billed Murres in the eastern Pacific.

Key Words: Thick-billed Murre, *Uria lomvia*, British Columbia, breeding, range extension.

The Thick-billed Murre (*Uria lomvia*) is an arctic and subarctic alcid, breeding in the North Pacific, North Atlantic, and Arctic Oceans (Tuck 1961). In the Atlantic it is known to breed as far south as Cape St. Mary's, Nfld. (46°48′N, 54°12′W) (Brown et al. 1975). In southeast Alaska, Thick-billed Murres have been reported nesting only as far south as St. Lazaria Is. (56°59′N, 135°43′W) near Sitka, where a colony of 2 000 birds was discovered in 1981 (A. L. Sowls, USFWS, personal communication). They have never been found breeding on the Pacific coast of Canada. There are two breeding season (mid-June to late August: Birkhead and Nettleship 1981) records of Thick-billed Murres in British Columbia: S. G. Sealy (U. Man., personal communication) saw four in breeding (alternate) plumage along the east side of Langara Island, Queen Charlotte Islands, on 20 June 1970, and George Sirk photographed a bird in breeding plumage on the eastern side of the Houston-Stewart Channel at the south end of the Queen Charlotte Islands on 16 July 1980 (British Columbia Provincial Museum PDF#664). In this note, we report about 19 pairs of Thick-billed Murres nesting on Triangle Island, British Columbia.

Triangle Island (50°52′N, 129°05′W) is a small treeless island at the northern tip of Vancouver Island, 46 km west of Cape Scott. It harbours the largest breeding seabird colony of any site in British Columbia, including Cassin's Auklets, *Ptychoramphus aleuticus* (360 000 pairs), Tufted Puffins, *Fratercula cirrhata* (25 000 pairs), Rhinoceros Auklets, *Cerorhinca monocerata* (15 000 pairs), and Common Murres, *Uria* *aalge* (3 000 pairs) (Vermeer 1979, Vermeer et al. 1976, 1979). The topography, climate, and habitats of Triangle Island were described by Carl et al. (1951) and Vermeer et al. (1979).

Thick-billed Murres were first seen on the island on 5 July 1980 when AV photographed two in the Common Murre colony on the southwestern corner of the island. No Thick-billed Murres were seen again that year, but no extensive searches were made for them.

On 19 June 1981, AV saw five Thick-billed Murres on a different ledge in the Common Murre colony, and on 18 and 21 August RJC photographed two birds with eggs. On 27 August, AV and Robin Cohen photographed seven adults with chicks. Copies of these slides are on file at the British Columbia Provincial Museum (PDF#666). A search of the Common Murre colony yielded 19 pairs of Thick-billed Murres on 27 August, but several suitable but inaccessible areas were not censused, and the lower cliffs visible from above were only scanned through a 20X telescope from distances of about 200 m. Thick-billed Murres were still present on 29 August, but AV could not find any on 5 September, although Common Murres were still numerous. We assume, therefore, that the chicks seen on 29 August had fledged before 5 September.

In 1982, AV and Moira Lemon counted 68 Thick-billed Murres on ledges in the Common Murre colony, and Michael Rodway saw two Thick-billed and 20 Common Murres on cliffs on the east coast of the island.

These sightings apparently indicate a recent arrival of the Thick-billed Murre on Triangle Island. The murre colony there was censused thoroughly in 1978 (R. W. Campbell, B. C. Provincial Museum, personal communication), but a small number of Thick-billed Murres nesting in inaccessible areas easily could have been overlooked. To the north, Thick-billed Murres were not breeding on St. Lazaria Island in 1912 (Willett 1912; Sowls et al. 1978); thus the colony of 2 000 birds there in 1981 probably indicates a considerable population movement during the intervening years. Until that colony was discovered, the southernmost known breeding site in the eastern Pacific was on Middleton Island, Alaska (59°26′N, 146°21′W), 625 km northwest of St. Lazaria Island (Sowls et al. 1978). Triangle Island is almost 800 km southeast of St. Lazaria. Thick-billed Murres, therefore, seem to be extending their breeding range southeastward in the eastern Pacific, as are the Northern Fulmar (*Fulmarus glacialis*) (K. Vermeer, Canadian Wildlife Service, personal communication), and the Horned Puffin, *Fratercula corniculata* (Campbell et al. 1979). These two species have also been sighted on Triangle Island in the last few years and may breed there in very small numbers (personal observation, and K. Vermeer, personal communication).

Acknowledgments

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Ring-billed Gull, *Larus delawarensis*, Predation on Bat, *Myotis*, Injured by an American Kestrel, *Falco sparverius*

GEOFFREY L. HOLROYD[1] and ELISABETH G. BEAUBIEN[2]

[1]Canadian Wildlife Service, 1000, 9942-108 Street, Edmonton, Alberta T5K 2J5
[2]Parks Canada, Box 2440, Banff, Alberta T0L 0C0

Holroyd, Geoffrey L., and Elisabeth G. Beaubien. 1983. Ring-billed Gull, *Larus delawarensis*, predation on bat, *Myotis*, injured by an American Kestrel, *Falco sparverius*. Canadian Field-Naturalist 97(4): 452.

An American Kestrel (*Falco sparverius*) unsuccessfully attacked a small bat which was then killed and carried off by a Ring-billed Gull (*Larus delawarensis*).

Key Words: American Kestrel, *Falco sparverius*, Ring-billed Gull, *Larus delawarensis*, bat, *Myotis*, predation.

On 13 September 1981 at 1100 as we canoed across Lac des Arcs, Exshaw, Alberta (51°03′N, 115°10′W), we were overtaken by an American Kestrel *(Falco sparverius)* pursuing a small bat. The kestrel made numerous swoops from above and behind the bat but the bat managed to evade the falcon for a minute after we first saw them. The head movements of the bat indicated that it was visually avoiding the kestrel rather than relying on echolocation.

At this point an adult Ring-billed Gull (*Larus delawarensis*) joined the attack on the bat. A few seconds after the gull arrived the kestrel gripped the bat with its claws. The kestrel uttered a short sharp cry, (possibly the bat bit it) and released the bat within 5 seconds. The gull made two swoops at the bat, hit it with its bill, and then the bat fell to the water. The gull picked the bat off the water and flew away with it in its bill, only to be chased by six other adult Ring-billed Gulls which had been standing on a sandbar about one-half kilometer away. A chase ensued but the original gull still had the bat when we lost sight of them about 5 minutes later.

The attack occurred over water. The shore behind the bat and falcon when we first saw them is vegetated with shrubs and aspen (*Populus tremuloides*). The town of Exshaw is within 200 m of the shore. We do not know where the bat came from or why it was flying during daylight. The weather was sunny, calm, 15°C, with light cirrus cloud cover. The above observations were made with the aid of 8 x 35 binoculars in good light. The total observations took less than 5 minutes to the death of the bat and covered about 300 m. The relative size indicated that the victim was likely a Little Brown Bat (*Myotis lucifugus*), the commonest bat in nearby Banff National Park (unpublished data).

Although kestrels are known to eat bats (Stoner 1939; Baker 1962), this kestrel appeared to have considerable difficulty catching the bat, likely because kestrels catch most prey including birds on the ground (Jenkins 1970; Page and Whitacre 1975). Presumably, the arrival of the gull distracted the bat and the injuries inflicted by the kestrel facilitated the capture by the gull. The ultimate success of the Ring-billed Gull is an example of opportunistic feeding by this species.

Acknowledgments

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High Nesting Density of Ducks on an Island in Saskatchewan

PHILIP M. BROWNE[1], DAVID A. DUFFUS[2], and RONALD W. BOYCHUK[3]

[1]Ducks Unlimited Canada, Box 4465, Regina, Saskatchewan S4P 3W7
[2]Department of Geography, University of Regina, Regina, Saskatchewan S4S 0A1
[3]Ducks Unlimited Canada, 1290 South Mackenzie Avenue, Williams Lake, B.C. V2G 3Y1

Browne, Philip M., David A. Duffus, and Ronald W. Boychuk. 1983. High nesting density of ducks on an island in Saskatchewan. Canadian Field-Naturalist 97(4): 453–454.

Forty-seven duck nests, primarily Mallards (*Anas platyrhynchos*), were found on a small natural island of 0.4 ha near Meacham, Saskatchewan, in 1979. The secure nature of the site owing to dense vegetative cover and the island's distance from shore were felt to be responsible for this high nesting density.

Key Words: Ducks, dense nesting, natural island, Saskatchewan

On 24 May 1979, while assessing potential of waterfowl nesting habitat near Meacham, Saskatchewan, we discovered a remarkably high density of nesting ducks on a natural island 0.4 ha in size. Three species of ducks: Mallard (*Anas platyrhynchos*), Northern Pintail (*A. acuta*) and Gadwall (*A. strepera*) nested there as well as some Canada Geese (*Branta canadensis*).

The island was one of three searched for waterfowl nests in two adjacent sloughs in the area. On the island with high numbers of nesting ducks ('A') we found 47 nests, under dense shrub cover. Thirty-four active nests were of Mallard, with four abandoned, three hatched and three predated also of this species. One Pintail and two Gadwall nests were also present. Nesting density on island 'A' was 0.012 duck nests/sq. m. Spatial measurements were kept to a minimum to reduce disturbance; many of the nests were less than 1 m apart. Distance of duck nests from the water varied from 2 m to 28 m (the maximum possible). Common Crows (*Corvus brachyrhynchos*) from other islands in the immediate area may have been responsible for the predation noted.

A second island ('B') in the same wetland, approximately 150 m from island 'A', was also searched. Three nests, two of Pintail and one of Gadwall, were discovered. Initiation dates and clutch sizes were not determined for these nests. On the last island searched ('C'), in another nearby wetland, no nests were discovered.

Clutch initiation dates for nests on island 'A' were estimated using the method devised by Westerskov (1950) and back dating on the assumption that one egg was laid each day, with incubation starting on the day the last egg was laid. More than half of the clutches were started between 13 and 27 April (n = 22), with a second wave between 30 April and 11 May (n = 13) and two clutches 17-20 May, all dates plus or minus three days. The mean clutch size overall was 9.32 (n = 37), with the first wave averaging 10.8 eggs and the second 8.9 eggs. Lower mean clutch size of nests initiated between 30 April and 11 May suggests that these may have been re-nesting attempts. However, this was impossible to confirm as individual identities of nesting hens had not been previously established.

All three islands were located in moderately saline sloughs approximately 0.75 m deep. Both wetlands had soft flocculent/organic substrates. Island 'A' was 170 m from shore and oval in shape: 57 m wide and 92 m long. Island 'B' was approximately 80 m from shore, crescentic in shape and roughly three times the size of island 'A'. Island 'C' was less than 30 m from shore, 6.5 ha in size and rectangular in shape. This latter island is depicted on mapsheet 73A/4 (NTS 1:50 000 series, 1974) as being connected to the mainland. Inundation by high spring water levels of the isthmus between island 'C' and the mainland would appear to be temporary, as the depth of water was only approximately 0.4 m. Islands 'A' and 'B' were more permanent, although these shallow ponds probably dry out in some years.

The vegetation on island 'A' differed markedly from that of island 'B'. Shrub cover on island 'A' consisted primarily of round-leaved hawthorn (*Crataegus rotundifolia*) in dense stands approximately 3 m high, interspersed with lesser amounts of saskatoon (*Amelanchier alnifolia*) 1-2 m high. Low shrubs included mainly gooseberry (*Ribes* spp.), rose (*Rosa* spp.) and snowberry (*Symphoricarpos* spp.). Grasses and Cow Parsnip (*Heracleum lanatum*) were encountered throughout, with the latter being a major component of the ground cover. Island 'B' had few shrubs and a small number of trees (*Populus* spp.) which were 4-5 m high. The ground cover was predominantly grass. Island 'C' had vegetation similar to island 'A', but hawthorn stands appeared to be more dense at site 'C'.

Nesting ducks may have been attracted to island 'A' by its secure nature owing to the dense vegetative cover and the island's distance from shore. Island 'B' may not have provided adequate cover to attract high numbers of waterfowl to nest. Although the cover at island 'C' was similar to that at island 'A', easy access for terrestrial predators to island 'C' may have prevented ducks from nesting successfully there.

Acknowledgments

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Recoveries of Saskatchewan-Banded White-winged Scoters, *Melanitta fusca*

C. STUART HOUSTON[1] and PATRICK W. BROWN[2,3]

[1]863 University Drive, Saskatoon, Saskatchewan S7N 0J8
[2]Gaylord Memorial Laboratory, School of Forestry, Fisheries, and Wildlife, University of Missouri, Puxico, Missouri 63960
[3]Present address: School of Forest Resources, University of Maine, Orono, Maine 04473

Houston, C. Stuart, and Patrick W. Brown. 1983. Recoveries of Saskatchewan-banded White-winged Scoters, *Melanitta fusca*. Canadian Field-Naturalist 97(4): 454–455.

Of 23 White-winged Scoters, *Melanitta fusca deglandi*, banded in Saskatchewan, 12 were recovered in the west, 8 east and 1 south, and 2 were recovered locally. Only three recoveries occurred in the first six months. One bird represents a new longevity record for the species, at least 15½ years of age at death.

Key Words: White-winged Scoter, *Melanitta fusca deglandi*, migration, longevity.

In this note we report the recovery distribution and longevity records of 23 White-winged Scoters, *Melanitta fusca deglandi*, banded in central Saskatchewan in July and August. In addition to the 11 recoveries of adult females we banded on their nests, we use recoveries of 9, 2, and 1 local or juvenile scoters that were banded by D. C. Lowery and C. E. Graham, by W. Fuchs, and by A. J. Matheson, respectively.

These scoters take divergent routes from Saskatchewan to reach their wintering grounds on distant oceans (Figure 1). Of the 23 known recoveries to date, 11 have been from the Pacific Ocean, 4 from the Atlantic Ocean and 1 from the Gulf of Mexico, while 1 and 4 others were evidently on their way to the Pacific and Atlantic Oceans, respectively. Only two were recovered in Saskatchewan.

Ten birds were found dead, 10 had been shot by hunters, and single individuals were caught in a net, caught in a trap, and sighted by binoculars.

Only 3 recoveries were direct within the first calendar year and another 6 were between 6 and 12 months after banding. Three were recovered in the second year (1 and 2 years after banding), then 2, 2, 0, 3, 1, 0, 1, 0, 0, 1, 0 and 1 in consecutive years thereafter. The last, an adult female with band no. 637-97350, was found freshly dead on 22 January 1981 at Comox, British Columbia (May Carragher, personal communication); it was banded at Redberry Lake, Saskatchewan, on 16 July 1967. Since scoters do not nest until at least two years of age (Brown and Houston 1982), 637-97350 must have been at least 15½ years of age, 13½ years after her first and only capture on her nest. This surpasses the previous longevity record of an adult female scoter recaptured on her nest at Redberry Lake 11 years after banding, when at least 13 years of age (Brown and Houston 1982). These 23 recoveries offer further evidence that White-winged Scoters have a longer survival and lower annual mortality rate than most other ducks.

Bellrose (1976), in briefly summarizing the 12 early recoveries from Saskatchewan-banded scoters, and from those banded in Alberta and the Northwest Territories (NWT), speculated: "Band recoveries suggest that the farther north and east the whitewings breed, the more likely they are to migrate to the Atlantic Coast, and, conversely, the farther south and west they breed, the more likely that the migration is to the Pacific Coast." All four recoveries of scoters banded near Yellowknife, NWT, were from the Atlantic Coast. Our subsequent results are also consistent with

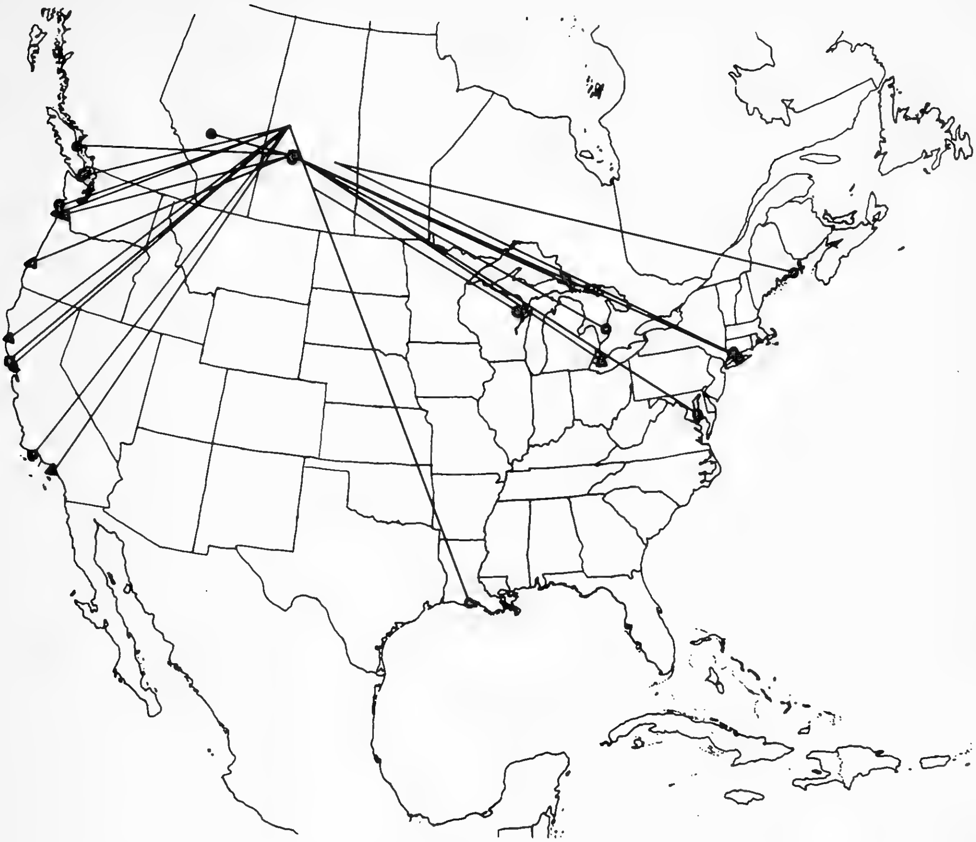

FIGURE 1. Places of recovery of White-winged Scoters banded during summer in central Saskatchewan. Squares denote recoveries in the same year as banding; triangles are recoveries within the first six months of the succeeding year; and circles are recoveries more than one year after banding.

a wide northwest-southeast line passing through central Saskatchewan, acting as a "migration divide," a bit east of the line postulated for Buffleheads banded in Alberta (Erskine 1972).

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Albino Eastern Garter Snakes, *Thamnophis sirtalis sirtalis,* from Ontario

WAYNE F. WELLER

9 Mississauga Road North, Mississauga, Ontario L4H 2H5

Weller, Wayne F. 1983. Albino Eastern Garter Snakes, *Thamnophis sirtalis sirtalis,* from Ontario. Canadian Field-Naturalist 97(4): 456.

Two albinos were present in a litter of 14 Eastern Garter Snakes (*Thamnophis s. sirtalis*) born in captivity to a female of normal pigmentation taken in 1970 at Moira Lake, Hastings County, Ontario. Although reports of albinistic newborn and adult Eastern Garter Snakes are not uncommon, this represents the first documented record for Ontario.

Key Words: Albinism, Eastern Garter Snake, *Thamnophis s. sirtalis,* Ontario.

Hensley (1959) presented records of albino or partially albino Eastern Garter Snakes, *Thamnophis s. sirtalis,* from Michigan and Indiana eastward through Ohio, Pennsylvania, and New York to Connecticut. Subsequently, Dyrkacz (1981) reported albinos from West Virginia and Maryland, and Bartlett (1981) from Massachusetts.

Two previous Ontario reports are vague. Hensley (1959: 155) noted that an albino specimen was "kept alive for some time in the Zoology Department, University of Toronto", but no locality was recorded. No records of albinistic garter snakes from Ontario are documented in the collections or files of the Royal Ontario Museum, Toronto (J. Lovisek, personal communication, May 1982) or the National Museum of Natural Sciences, Ottawa (F. R. Cook, personal communication, May 1982). An albino garter snake was reportedly collected at Fort Erie, Ontario, sometime in 1963-66 and given to the Buffalo Zoo but no other details are available (B. Froom, personal communication, May 1982).

The following record is therefore noteworthy in giving the first documented evidence of albinism in Ontario garter snakes.

A female of normal pigmentation for *Thamnophis s. sirtalis,* taken at Moira Lake (44°28′N, 77°28′W, near the town of Madoc, Hastings County), gave birth to 14 young on 10 August 1970. Of these, two were albino. No measurements were recorded at birth.

Both albinos were active from birth and fed initially on earthworms, Redback Salamanders (*Plethodon cinereus*), juvenile American Toads (*Bufo americanus*), and, in later months, on young-of-the-year Leopard Frogs (*Rana pipiens*). One albino lived 18 months, the other, 27 months. Colour slides taken of both individuals, (W. W. photo numbers 10-14; 147-154; 970-975) and one of these was earlier published by Froom (1972: 8e) who omitted any details of the specimen's origin. The eyes of both specimens were bright pink. The background colour was chalk-white, but the striped pattern was apparent as the dorsal stripe and the two laterals were bright yellow. The two blotches on the parietal head scales were also bright yellow. Regrettably no measurements or weight were recorded for these specimens and neither was preserved.

One other albino garter snake was seen in the Moira Lake area in 1970. The same week that the normal pigmented adult female was collected, a cottage resident on Moira Lake reported a "2-foot long white snake with yellow stripes and pink eyes". It had been seen basking on rocks at the shoreline of Moira Lake approximately 0.4 km from where the female which gave birth to the albinos was taken.

Acknowledgments

The assistance of F. R. Cook, J. Lovisek, and B. Froom in obtaining information on albino Ontario garter snakes is appreciated.

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Wolverine, *Gulo gulo*, in Lake St. John area, Quebec

JACQUES PRESCOTT

Jardin zoologique de Québec, Ministère du Loisir, de la Chasse et de la Pêche, 8191, avenue du Zoo, Charlesbourg, Québec G1G 4G4

Prescott, Jacques. 1983. Wolverine, *Gulo gulo*, in Lake St. John area, Quebec. Canadian Field-Naturalist 97(4): 457–458.

What could be the first sighting of a live Wolverine (*Gulo gulo*) in the Province of Quebec since one in Gatineau Park in 1972, was made in June 1982 at the Petite Manouane River, 240 miles north of Chicoutimi.

Key Words: Wolverine, *Gulo gulo*, Quebec.

A lone Wolverine was seen by Michel Gravel and his wife on 27 June 1982, on the banks of Petite Manouane River (50°00′N, 70°55′W), a few kilometres north of Lake Duhamel, and about 240 km north of Chicoutimi.

Mr. Gravel was cruising mid-stream up the Petite Manouane in a small 10 HP motor boat when at 1230 hr he noticed the presence of a bear-like animal on the west bank of the river. In that area, the river is 70 to 76 m wide. It flows at an altitude of 274 m and is borded to the west by a 250 m-high forested escarpment and to the east by a forested valley. The animal followed the boat at a good pace for 0.4 to 0.8 km (¼ to ½ mile) on the river bank and stopped each time the boat slowed down.

It was observed for about 10 minutes at a distance no greater than 25 to 45 m. The weather was sunny and clear with light wind, air temperature about 20°C.

Mr. Gravel described the animal as being about 1.2 m long (4 feet) and 45 cm tall (1.5 feet), face and body dark colored, slightly paler on the sides. Its tail was longer than a bear's and its front legs shorter than its hind legs.

The sighting was long enough for Mr. Gravel to make sure the animal was neither a bear, nor a canid, Fisher, or Otter. Mr. Gravel has 20 years experience as a hunter and trapper, and has hunted in different locations in New Brunswick, Quebec, and Maine. This was his third hunting and fishing trip to the Lake Duhamel area. He has killed nine bears over the years and trapped many different species of mammals. It is improbable that he could have confused the Wolverine with a bear or any other fur bearer.

He reported his observation to the Jardin zoologique de Quebec on 5 July 1982, and was interviewed by the author two days later. Confronted with color pictures of different mammals he unhesitantly recognized one of a Wolverine, as identical to the animal he saw.

The Lake Duhamel area is inhabited by Moose, Black Bear and Red Fox but no Wolf sign or tracks have been reported there for a long time. Mr. Gravel noticed no carrion or carcasses, and no crows or ravens were seen near the sighting area. However, a large logging campsite is located about 25 km to the west. Beaver and Showshoe Hare were trapped in the area last winter. Wolverine are known to visit trap lines and investigate cabins (Banfield 1974). The presence of these in the area may have attracted the animal.

Wolverine is considered extremely rare in Quebec (Harper 1961; Peterson 1966; Van Zyll de Jong 1975). From 1940-41 to 1981-82, only 72 Wolverine pelts have been registered in the Quebec Division of fur bearer production pelt statistics (Table 1). It is believed that most, if not all, of these pelts have been

TABLE 1. Wolverine pelts registered on the Québec fur market as being harvested in Québec in the seasons 1940-1941 to 1981-1982.

Years	Pelts
1940-41	2
1941-42	1
1942-43	0
1943-44	2
1944-45	0
1946 to 1962-63	0
1963-64	1
1964-65	0
1965-66	1
1966-67	1
1967-68	0
1968-69	2
1969-70	9
1970-71	4
1971-72	3
1972-73	0
1973-74	14
1974-75	13
1975-76	3
1976-77	6
1977-78	3
1978-79	6
1979-80	1
1980-81	0
1981-82	0

harvested outside Quebec, especially those since 1972, as no trapper has directly reported the capture of any Wolverine for a long time (M. Beaudet, personal communication). Due to the rarity of the species, Wolverine hunting and trapping has been forbidden in Quebec since 1981.

This observation confirms the actual presence of the Wolverine in Quebec and provides new evidence that the species still occurs farther south of the normal range (north of the 52nd parallel) given by Peterson (1966) and Van Zyll de Jong (1975).

Acknowledgments

I am indebted to Marcel Beaudet, Head of the Division of Fur-bearer Production, Ministère du Loisir, de la Chasse et de la Pêche, for providing me the statistics on Wolverine harvesting in Quebec.

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Presumed Breeding Record of Brewster's x Brewster's Warbler, *Vermivora chrysoptera* x *pinus*, in Ontario

A. GEOFFREY CARPENTIER

42 Wallis Drive, Peterborough, Ontario, K9J 6B7

Carpentier, A. Geoffrey. 1983. Presumed breeding record of Brewster's x Brewster's Warbler, *Vermivora chrysoptera* x *pinus*, in Ontario. Canadian Field-Naturalist 97(4): 458–459.

On 6 July 1982, a Brewster's Warbler was observed feeding a fledgling in Belmont Township, Peterborough County, Ontario. The two birds were attended by a male Brewster's Warbler. No nest was found, nor were any other fledglings. A careful search of the area revealed no Golden-winged or Blue-winged Warblers. This was a presumed successful Brewster's x Brewster's Warbler breeding record.

Key Words: hybrid, warbler, Brewster's Warbler *Vermivora chrysoptera* x *pinus, Vermivora leucobronchialis,* Ontario.

The Golden-winged Warbler (*Vermivora chrysoptera*) and Blue-winged Warbler (*V. pinus*) commonly hybridize where their ranges overlap, producing two hybrid forms known as Brewster's and Lawrence's Warblers. The former is by far the more common of the two. Both hybrids are fertile, readily leading to backcrosses with one of the parental types. Hybrid-hybrid matings are apparently very rare. K. C. Parkes (1951) reported finding only two published records of Brewster's x Brewster's matings — one in 1922 by Sutton in Pennsylvania and one in 1927 by Hicks in Ohio.

On 6 July 1982, at the south end of Hubbel Road, Belmont Township, Peterborough County, Ontario, the author with Clayton Vardy identified a Brewster's Warbler. The bird was skulking in a hawthorn (*Crataegus* sp.) tangle, and constantly scolded the observers. It apparently was a female, very similar to one pictured in Godfrey's *Birds of Canada* (1966) except that no yellow was evident on the breast, and the back was greenish. The bird was very drab with a gray-white breast, yellow crown, black eye-stripe and pale yellow wing bars. It represented the first known record of this hybrid for Peterborough County (D. Sadler, personal communication 1982).

Shortly thereafter, the bird was observed carrying food. A search for evidence of breeding revealed a recently fledged bird being fed by the adult. The fledgling was generally drab gray and white with few plumage contrasts. A small amount of yellow was seen on the wings. The breast was white, while the back and crown were grayish, with no striking patterns on the head, back or face. The young bird skulked during the entire observation period.

A third bird appeared shortly thereafter and started scolding us. It was a brightly plumaged Brewster's

Warbler, presumably a male. It resembled the female seen earlier except that it was much more brightly and boldly marked. The back was gray, the breast was immaculate white with no yellow wash, and the black eye-stripe was wider than that pictured by either Godfrey or Parkes.

This male constantly scolded us as the female and fledgling skulked away. The male followed the other two birds as they moved away through the underbrush after we ceased our observations. The entire observation period lasted approximately 20 min.

No other Brewster's, Golden-winged, or Blue-winged Warblers were found in that area on that date or subsequently. The birds reported here were not seen on later trips to the area.

We believe that this sighting represented a successful Brewster's x Brewster's Warbler nesting. In 1982, three Brewster's Warblers were reported during the spring migration period in Ontario (Weir 1982a) and a Brewster's x Golden-winged Warbler successful nesting was reported from Long Point, Norfolk County, Ontario (Weir 1982b).

Acknowledgments

The author is grateful to Ron Weir, Doug Sadler and Doug McRae for comments on earlier drafts of this paper and for historical data on Brewster's Warblers.

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Two Recent Ice Entrapments of Narwhals, *Monodon monoceros*, in Arctic Canada

D. E. SERGEANT[1] and G. A. WILLIAMS[2]

[1]Canada, Department of Fisheries and Oceans, Arctic Biological Station, 555 St. Pierre Blvd., Ste. Anne de Bellevue, Quebec H9X 3R4

[2]Arctic Bay, Northwest Territories, X0A 0A0

Sergeant, D. E., and G. A. Williams. 1983. Two recent ice entrapments of Narwhals, *Monodon monoceros*, in Arctic Canada. Canadian Field-Naturalist 97(4): 459–460.

A group of about 20 Narwhals stranded at the head of Dundee Bight, Bathurst Island (75°05′N, 100°15′W) some time prior to July 1979. The locality is close to a published sighting of 10 or more Narwhals in a polynya in September 1976. A second group of at least 108 animals stranded in Agu Bay, Gulf of Boothia (70°18′N, 86°30′W) in early October 1979. Both strandings were mainly of females and young. Possible reasons for this are discussed.

Key Words: Cetacea, Narwhals, arctic Canada, ice entrapment

Ice entrapments (savssats) of both White Whales (*Delphinapterus leucas*) and Narwhals (*Monodon monoceros*) are well known in both West Greenland (Porsild 1918, 1922) and arctic Canada. Freeman (1968) described an entrapment of 150-200 White Whales in winter 1966/67 in Jones Sound, and Freeman (1973) one of at least three White Whales in winter 1969/70 off SE Ellesmere Island. Hill (1967) described an entrapment of White Whales in winter 1966/67 in the Eskimo Lakes, Beaufort Sea. However we know of no detailed accounts of entrapment of Narwhals in the Canadian arctic. Two such events, observed in 1979, one current and one from an unknown, earlier date, are described here.

In early August 1979, Mr. Don Kushner, a geologist with Chevron-Standard Ltd., sent Mr. K. A. Hay photographs of about 20 dead Narwhals discovered by him in late July 1979, at Dundee Bight, Bathurst Island (76°05′N, 100°15′W, Figure 1). The carcasses were lying on top of the ice close to land, and were old. A few were partly eaten leaving the rib cage exposed. Most of the animals could be identified as tuskless animals (females or young males) with a few calves.

It is not clear how the animals reached the ice surface, but the agency of man can be discounted at this remote site. Freeman (1973) reported the removal from the water of three entrapped White Whales by a Polar Bear, *Ursus maritimus*. The whales were then partly eaten by bears and scavenged by Ravens, *Corvus corax*, and Glaucous Gulls, *Larus hyperboreus*.

The region is far northwest of the common occurrence of Narwhals in Lancaster Sound and Barrow Strait in summer. However, Roe and Stephen (1977) reported seeing a group of at least 10 mostly tusked Narwhals in a large polynya at 77°20′N, 103°30′W (Figure 1) on 6 September 1976. Ice charts of this period show open water in Queens, Maury and Wellington channels extending towards the region of the polynya. Since summer 1978 provided severe ice conditions in Lancaster Sound restricting the westward travel of Narwhals, it seems likely that the ice entrapment can be dated to 1977 or an earlier year, presumably in autumn.

A savssat was discovered at Agu Bay, NW Baffin Island (70°18′N, 86°30′W) on or before 9 October 1979. G. A. Williams arrived at the site on 14 October after arrangements had been made for Igloolik hunters, as well as those at Agu Bay, to hunt the animals. The animals were then 10-12 km from open water in Fury and Hecla Strait. Ice charts for the period show open water southward into Foxe Basin, from which direction the animals must have come; there was solid ice northward in the Gulf of Boothia.

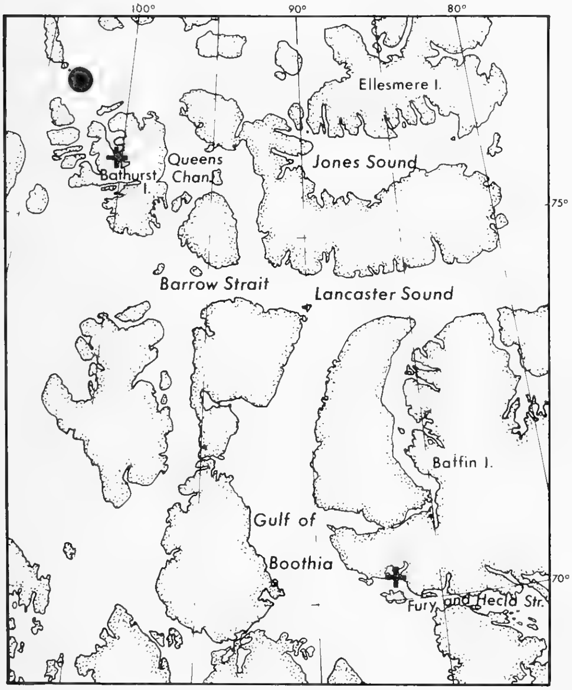

FIGURE 1. Map showing place names and sites of strandings (+) and extralimital occurrence (•) of narwhals described in text.

The hunting was organised to avoid wounding and waste, and 108 animals were removed, with an additional four lost. Of 89 animals killed on 15, 16 and 17 October, the composition by age and sex was: adult females 34; juvenile females 22; adult males 1; juvenile males 8; calves of the year of both sexes 24. There were no stomach contents except mud in a few animals.

This entrapment, and the earlier one, were therefore very deficient in adult male (long-tusked) animals. Several factors could account for this. Adult males, being more loosely attached to the herds, could break away and escape more readily. Also it is observed that adult male Narwhals in summer tend to inhabit deeper water than the females and calves, and so could be entrapped less often.

Acknowledgments

Mr. K. A. Hay, Canada Department of Fisheries and Oceans, St. John's, Newfoundland, most kindly supplied details of the northern entrapment.

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Accepted 20 July 1983

News and Comment

Second Announcement: The XIX International Ornithological Congress

The XIX International Ornithological Congress will take place in Ottawa, Canada, from 22 to 29 June 1986. Prof Dr. Klaus Immelmann (West Germany) is President and Dr. Henri Ouellet (Canada) is Secretary General. The programme is being planned by an international Scientific Programme Committee chaired by Professor J. Bruce Falls (Canada). The programme will include plenary lectures, symposia, contributed papers (spoken and posters), and films. There will be a mid-congress free day. Pre- and post-congress excursions and workshops are planned in various interesting ornithological regions of Canada.

Information and requests for application forms should be addressed to:

Dr. Henri Ouellet
Secretary General
XIX Congressus Internationalis Ornithologicus
National Museum of Natural Sciences
Ottawa, Ontario, Canada K1A 0M8

Alfred B. Kelly Ornithological Scholarships

Two Alfred B. Kelly Ornithological Scholarships valued at $500 each are available annually from the Province of Quebec Society for the Protection of Birds, Inc., to post-graduate students working on Quebec birds, regardless of place of residence. Selections will be based on the merit of both the application and his/her project, as well as need. Holders of major scholarships and bursaries do not qualify. For application forms, please write to:

Dr. David M. Bird
PQSPB Education Committee
P.O. Box 210
Macdonald College of McGill University
21 111 Lakeshore Road
Ste-Anne de Bellevue, Quebec H9X 1C0
Canada

The deadline for *completed* applications is 31 May 1984 and applicants will be notified by 30 June 1984.

Raptor Collisions with Utility Lines: A Call for Information

The United States Bureau of Land Management, Sacramento, in cooperation with the Pacific Gas and Electric Company, is assembling all available published and unpublished information concerning collisions of raptors with power lines and other utility lines. Actual case histories — no matter how circumstantial or fragmentary — are needed. Please acknowledge that you have such information by writing to Dr. Richard R. (Butch) Olendorff, U.S. Bureau of Land Management, 2800 Cottage Way, Sacramento, California 95825 U.S.A. (Phone (916) 484-4541). A form of which to record your information will then be sent by return mail.

Honorary Membership and 1983 Ottawa Field-Naturalists' Club Awards

Four Ottawa Field-Naturalists' Club awards were presented at the 1983 Soirée. Certificates were presented to the winners by Dan Brunton, President, and once again our thanks to Anne Gruchy for the caligraphy of the certificates. The Anne Hanes Natural History Award was not presented this year.

The award citations are reproduced here. They have been given earlier in *Trail & Landscape* 17(4): 198-200.

Honorary Member: **Hue N. MacKenzie**

A member of The Ottawa Field-Naturalists' Club for over twenty years, Hue has a long history of Club participation. He was a member of the Council between 1964 and 1980, was Vice-president in 1966 and was President from 1967 to 1969. He has been a member of various committees and chairman of several. His most recent chairmanship was that of the Centennial Steering Committee.

Hue was instrumental in developing what is now the very active Conservation Committee. He also served as Club representative to the Federation of Ontario Naturalists for many years. He played a key role as co-ordinator and participant in the Club's Native

Orchid Location Survey. Hue has contributed to both *Trail & Landscape* and *The Canadian Field-Naturalist*, has made presentations in the monthly meeting series and has led field trips on behalf of the Club. Indeed, it is difficult to point to a major Club activity over the past two decades that has not profited from the "MacKenzie Touch".

In the mid-1970s Hue carried out a study of Club operations which led to a report to the Council entitled "Club Policies and Management Practices". This report led, in turn, to increased efficiency in operations and a strengthening of Committees and better definition of their roles.

In 1974 Hue moved the resolution that led to the Centennial Planning Group, and subsequently, to the Centennial Steering Committee, which he chaired until its dissolution in late 1982. The enormous effort that Hue put into the preparation, planning and execution of Centennial Year projects is largely responsible for so many of these being so successful.

In his efforts on behalf of The Ottawa Field-Naturalists' Club, we have seen Hue's dedication to the Club and his achievement as a naturalist. We are happy indeed to have Hue MacKenzie join our select group of Honorary Members.

Member of the Year: **Roger Taylor**

The Member of the Year Award is given to the member judged to have contributed the most to The Ottawa Field-Naturalists' Club during the previous year. For the Club's second such award, the Awards Committee was unanimous in the selection of Roger Taylor.

Roger has a well-deserved reputation for stepping into the breach, to prevent an ongoing program from faltering, or to take a new initiative. In essence he is a catalyst.

The Member of the Year Award is in recognition of this type of activity, specifically the reorganization of *The Shrike* including the creation of a computer-based file of bird records; the lead role as a member, and later chairman, of the Conservation Committee in bringing Federal and Provincial Government attention to the potential damage that raccoon dogs could do to the Canadian environment; his co-ordination of letter writing campaigns on behalf of Ontario Parks and wetlands; and his co-ordination of the fight against Amendment 24 of the Regional Municipality of Ottawa-Carleton.

In addition to the foregoing, Roger is Chairman of the Conservation Committee and the Nominating Committee, a member of the Federation of Ontario Naturalists Board of Directors, liaison for the Membership Committee with the National Research Council Computation Centre, and is active in birding and other Club outings.

Service Award: **William H. Knight**

Behind every great man, they say, there is a great woman. Behind every great naturalists club there are those toilers who do all the important things that need to be done to keep things moving, and that are so often taken for granted in the smooth operation of the club. It is our pleasure this year to select from our band of background workers for the 1982 Service Award, Bill Knight.

Over the years Bill has been a tireless worker. He is the backbone and mainstay of the Education and Publicity Committee and often is the one to ensure that the Club meets its commitments for displays and publications. Bill prints and distributes *The Shrike*, and, as well, he prints notices, tickets, placemats (such as for the Centennial), certificates and awards.

He is familiar with the situation in which fast action is required because everything was left a little bit late, or because we all know Bill will get it done.

Bill has produced the OFNC Award certificates, so it is particularly fitting — and a real pleasure — to present him with one of these and to add to it our most sincere thanks for all his efforts on behalf of the Club.

Conservation Award: **H. Loney Dickson**

Loney Dickson was a Vice-President of the Club for a year and a half prior to his departure for Alberta in 1981. He was an active member, and later chairman, of the Conservation Committee, and by virtue of his leadership the committee broadened its outlook to cover the range of issues it now handles. His voice of reason has been heeded in times of controversy, and today the Conservation Committee is widely recognized as the most important conservation voice in eastern Ontario.

Loney co-authored (with Stephen Darbyshire) a report on significant natural areas for the National Capital Commission. It has been important in establishing protection for a number of valuable natural areas in Ottawa-Carleton.

Loney played a prominent role in the re-establishment of special interest groups within the Club. The success of this move his been quite evident.

The Ottawa Field-Naturalists' Club's 1982 Conservation Award is made to Loney Dickson as our recognition of this young man's energy and efforts to teach us all the value of natural areas and their contents.

BILL GUMMER

and members of the
Ottawa Field-Naturalists' Club Awards Committee

Book Reviews

ZOOLOGY

Fisheries and Wildlife Resources and the Agricultural Land Base in Alberta

By William M. Glasgow. 1982. Fish and Wildlife Division, Alberta Energy and Natural Resources and Environment Council of Alberta, Edmonton. 65 pp. Free.

The Environment Council of Alberta is presently considering threats to the Province's Agricultural land base. This report was prepared through the Alberta Fish and Wildlife Division as a background document on fish and wildlife resources in agricultural areas. The stated purposes are to document the general capabilities, the historical changes, and the uses made of the fish and wildlife resources as well as the land use conflicts caused by coexistence of agricultural and fish and wildlife government programs. Suggestions are made for future programs.

The abstract clearly states that agricultural land supports important fish and wildlife populations which are used by Albertans. Agricultural practices modify these resources. Cooperation and wise land use will be keys to fish and wildlife as well as agricultural productivity. The report states that management techniques will be discussed. However, it expands on most of these points, except management techniques. This is a result of the lack of distinction between agricultural and non-agricultural land, the general nature of the concepts considered, and the lack of attention to the costs of government programs.

Rarely is a distinction made between the fish and wildlife resource and its use in agricultural versus non-agricultural Alberta. Furthermore there are important differences among types of agricultural areas which are not addressed. It is very difficult to suggest techniques, except in the most general terms, if you don't know whether you are planning for a trout fishery or duck hunting on a body of water.

Superficial treatment of important concerns is frequent. For example the section on "Management Problems Common to Fish and Wildlife and Agriculture" discusses planning land use on private land, hunter access to private land, and wildlife damage to agricultural products. However, it ignores major problems such as level of water table, salinization, and soil erosion.

Curiously, the financial benefits of fishing and hunting, the money from fishermen and hunters earmarked for enhancement programs, and the cost of wildlife damage to crops and livestock are always explicitly stated but the costs of government enhancement programs are never stated. Whether stocking sloughs with Rainbow Trout or offering incentives to raise pheasants or controlling magpies are sensible programs depends on a comparison of the costs with the results. How much does each trout or pheasant cost to produce? How much does it cost to kill a magpie? Who benefits? One recommendation of this report is increased funding for wildlife management. This cannot be seriously considered without an assessment of the value of existing programs, future needs, and efficiency of use of present funding.

Glasgow states that "If goals for fish and wildlife management on agricultural land were more clearly defined, it is likely that Alberta Agriculture would be willing to discuss these goals along with their own and explore cooperative land management and assistance programs." This statement, like much of the report, is good common sense and common knowledge. However, this report does not clearly or explicitly define management goals or suggest a starting point for their definition.

DAVID McCORQUODALE

Department of Zoology, University of Alberta, Edmonton, Alberta T6G 2E9

The Park Buffalo

By Sheilagh C. Olgivie. 1979. National and Provincial Parks Association of Canada, Calgary. 68 pp. illus. $4.95 plus postage.

Seeing Bison in a National Park is a memorable experience for many people. This book details the history of these Bison from the days of overhunting, to the origin of captive herds, their subsequent growth and spread in Canada's National Parks. It will add a great deal of understanding and appreciation to seeing these Bison.

Much interesting information is presented in a very appealing fashion that is suitable for anyone high school age or older. Tales of colourful people (such as Samuel Walking Coyote, a Pend d'Oreille with a Flathead wife and a more than passing interest in a Blackfoot maiden, who used Bison calves — ancestors of today's park Bison — as an unsuccessful peace offering to his alienated Flathead relatives) maintain interest throughout as information is easily assimilated. Concentration on the actions of specific people and specific events is a major reason why this book is successful. An optimistic thread runs throughout, largely because of the success of Bison conservation. Despite this, unmitigated disasters, such as the introduction of diseased Plains Bison into the only known herd of Wood Bison in 1925, are not glossed over. The contrast of successes and failures allows reflection and consideration of how to best carry out a conservation program.

Occasionally, wording is sloppy or melodramaticism takes over, but generally the attention to detail and enthusiasm wins out. My only serious complaint is about the suggestion that some cattalo should have been released into northern Alberta instead of being slaughtered. After the Wood Buffalo National Park experience and the capability to introduce pure Bison, this should never have been considered.

The book is a sturdy paperback, relatively free of typographical errors, and reasonably priced. The illustrations, line drawings, historical photographs, and reproductions of C. M. Russell paintings, add a great deal to the value and appeal of the book. The reference list of technical and popular accounts of bison and conservation will allow the curious reader to pursue their interests at their own level.

Anyone who is interested in the origins of the Bison they have seen in Canada's National Parks will find this book worth reading.

DAVID MCCORQUODALE

Department of Zoology, University of Alberta, Edmonton, Alberta T6G 2E9

Eastern Chipmunks: Secrets of their Solitary Lives

By Lawrence Wisher. 1982. Smithsonian Institution Press, Washington. 144 pp., illus. U.S. $17.50.

The author, a professor of chemistry at Mary Washington College in Virginia, has written a detailed study of the eastern race of chipmunks (*Tamias striatus lysteri*) inhabiting Eastern Canada and the Northeastern United States. The 108 particular individuals of which he reports occupied 1½ acres of his land near Fredericksburg, and were observed over a period of six years.

His account is "structured as a chronological narrative into which are woven the details and conclusions concerning the chipmunk's life history." The last of the nine chapters in the book summarizes the essential biological and ethological data concerning the Eastern Chipmunk. Appendices provide biographical sketches of five of the individuals whose lives were most closely researched, a catalogue of chipmunk behaviors, the taxonomic history and description of the species, and the reproductive events in the lives of four female chipmunks.

The bulk of the book, after providing a family tree of North American squirrels and a brief assessment of chipmunks in nature, proceeds to a detailed discussion of the life and times of some of the individuals Wishner observed from 1973 through 1980. The 101 photographs (20 in color), maps, diagrams and drawings do much to enhance the reader's understanding of the text account.

One delightful example of the color camera's ability to freeze thousandths of a second in time is a picture showing a male cardinal and a chipmunk seemingly dining peacefully together on sunflower seeds on a tree stump. In fact, as the author indicates, the cardinal hadn't as yet divined the fact that it had company when the photo was taken, and "Within a fraction of a second both had fled the scene."

Tamias, the author reminds us, "is evolutionarily and behaviorally one of the most primitive of genera of living squirrels." They are solitary animals, "genetically programmed" to store food. One animal, it was estimated, collected some 928 acorns over her eight hours of harvesting activity in a single day. This would tend, as Wishner emphasizes, to encourage their solitary behavior. While chipmunks can distinguish "between perishable and non-perishable food for storage purposes," they "cannot seem to stay out of traps," even those which lack bait. The evidence for their intelligence would therefore seem to be mixed at best.

This is a most delightful and informative volume, and one worth careful reading as well as reference.

KEIR B. STERLING

Department of History of Science, University of Wisconsin, Madison, Wisconsin 53706

BOTANY

The Arctic-Alpine Element of the Vascular Flora at Lake Superior

By David R. Given and James H. Soper. 1981. Publications in Botany, No. 10. National Museum of Natural Sciences, Ottawa. 70 pp., illus. Free.

Ever since the time of Louis Agassiz, Lake Superior has been famous for the occurence of a disjunct arctic-alpine element on or near its shores. Although there has been much collecting of these plants and a number of articles on small areas or specific species, there has never been a general overview of the topic. Here we have one — a thorough and well illustrated treatment.

Prefaced by a brief introduction to the literature and historical background, a major part of this account is a thorough discussion of the arctic-alpine floristic element. Forty-eight species were selected as representative of this element. A few species that were admittedly more wide ranging, such as *Primula mistassinica*, were included "because although they do not occur north of the Low Arctic, they are intimately associated with typically arctic-alpine species throughout much of their range . . ." No author would come up with the same selection of representative species, but certainly, enough species, including all the major ones, were selected to give a clear picture of the phenomenon. The 48 species are treated in more detail in an annotated list appended after the bibliography. Note that *Carex heleonastes*, rejected on p. 6 as being unsubstantiated in the region, has recently been found in the Lake Superior region of Michigan (Michigan Botanist 21: 169. 1982). Future field work will undoubtably turn up additional species.

A discussion of the vegetation in which these species occur forms an important part of this account. Fragmentary shoreline and cliff and talus vegetation, which is the habitat of these species, is very difficult to classify. In fact, the first sentence introducing the vegetation section states that "Although discrete vegetation units have been described, most are probably part of a continuum." This states the case well, but then it is somewhat surprising to see the description of vegetation "units" go on for 13 full pages. One suspects that if more sites had been examined, there would have been still more "discrete units".

The distributions in the Lake Superior region (North America in the case of *Cerastium alpinum* and *Castilleja septentrionalis*) are mapped, very completely, for 14 species. The distributions of all 48 species are grouped into six patterns preliminary to the discussion of the microclimatological effects of Lake Superior on the distributions. Perhaps the most interesting part of this account is the discussion of the origins of the arctic-alpine element. Palynological, geological and climatological evidence is synthesized into a plausible account tracing the migration of the arctic-alpine element from the edge of the glacial front northward and describing how they may have later become "stranded" in the Lake Superior region.

If this account has any significant weakness, it is that there is too much concentration on Lake Superior, with its obvious climatic impact. The conclusions draw little from the occurence of arctic-alpine species (including a few, like *Rhododendron lapponicum* and *Saxifraga aizoides* that do not now occur near Lake Superior) in areas to the south such as the gorges in Algonquin Park, the driftless zone of Wisconsin, and even western New York. There is work to be done yet before these occurrences can be reconciled with those of Lake Superior to produce a comprehensive hypothesis for the disjunct ocurrence of northern species south of their continuous ranges. Also, little mention is made that other disjunct elements, notably western species and northern boreal forest species, which also are a prominant feature of the flora of the Lake Superior region. These might well provide clues to the survival of the arctic-alpine element.

These are minor quibbles. Everyone interested in the phytogeography floristics and vegetation of the Great Lakes region should get a copy of this account.

A. A. REZNICEK

University of Michigan Herbarium, North University Bldg.,
Ann Arbor, Michigan 48109

ENVIRONMENT

Mountain Islands and Desert Seas: A Natural History of the U.S.-Mexican Borderlands

By Frederick R. Gehlbach. 1981. Texas A and M University Press, College Station. xi + 298 pp. U.S. $19.95.

This book is the result of more than a quarter century of travel and study of the "Borderlands" from the mouth of the Rio Grande to California. The author, a professor of biology and environmental studies at Baylord University, skillfully weaves the natural and unnatural (i.e., man-made) histories of this region into an interesting, informative narrative. Gehlbach's approach to his subject is a combination of the scientist, naturalist, and philosopher. While pondering the inevitable changes wrought by humans, his observations are not only put in context of other studies done on a particular area since 1950, but are also compared to the observations of early naturalists visiting this region. Two of the 19th century naturalists were employed by the first U.S.-Mexican Boundary Survey, 1849-1855. They were John Bartlett, U.S. Boundary Commissioner (1850-53), and his successor William Emory (1854-55), whose itinerary is followed by Gehlbach. The author uses their personal discoveries, as recorded in their diaries, for comparative purposes. He also utilizes the writings of Edgar Mearns, army surgeon, ornithologist, naturalist, who was employed by the second U.S.-Mexican Boundary Survey of 1891-96 for a two year period (1894-96); and those of Vernon Bailey of the U.S. Biological Survey, who studied the border region early in the 20th century.

Contrasting the natural history of the varied terrain of the "Borderlands" as seen by a modern biologist in the second half of the 20th century with the observations of earlier naturalists enables the author to demonstrate both the natural changes in the mountains, canyons and deserts in this long study area and the destruction of the natural areas wrought by the "arch predator", man. Environmental changes inevitably followed habitat destruction, some of them having undesirable, far reaching effects.

Gehlbach uses side-by-side photographs, mostly in colour, to illustrate the natural and unnatural histories of certain areas. Other photographs depict natural communities, plants, birds, fish, amphibians, and reptiles found in the "Borderlands". There are three useful maps of the eastern, middle and western sections of the boundary. The numerous reproductions of Bartlett's and Emory's original illustrations of both landscape and plant and animal life, which are included in each chapter, add considerably to the interest of this work.

A word of warning! This book is not easy reading. Obviously the work of a university professor, every chapter is well-documented with a profusion of footnotes. These references, however, add considerably to the usefulness of the work. It is recommended for serious naturalists and conservationists.

MARIANNE GOSZTONYI AINLEY

4828 Wilson Avenue, Montreal, Quebec H3X 3P2

MISCELLANEOUS

Casey A. Wood (1856-1942): A Bio-Bibliography

Compiled by Effie C. Astbury. 1981. Occasional Papers. Graduate School of Library Science. McGill University. Montreal. 66 + vi pp. $5.00 (paper).

A quick perusal of the *Bibliography of Canadian bibliographies* assures one that bio-bibliographies, products of various library schools in Canada, are not on the endangered species list. Astbury's work on the existing data on ophthalmologist, naturalist, ornithologist, bibliographer and world traveller Casey Albert Wood is of particular interest to North American naturalists. Wood was born at Wellington, Ontario, of American parents, and received all his education in Canada. He graduated from the Medical Faculty of the University of Bishop's College, Montreal and Lennoxville, in 1877. He practiced general medicine and surgery in Montreal for a while and was also professor of chemistry at Bishop's. In 1886, Wood married Emma Shearer of Montreal and decided to leave for the U.S. to specialize in eye and ear diseases.

It is not clear from this bio-bibliography when Wood developed an interest in nature. Astbury cites his first "ornithological" paper, one published on the eye and eyesight of birds, in the journal *Ophthalmology* in 1907. This was obviously a precursor for his beautifully illustrated, much acclaimed book, the *Fundus Oculi of Birds*, which was published in 1917, the year Wood joined the American Ornithologists' Union. It was in 1917 that Wood retired from private practice and moved to California, and as far as one can gather developed a greater interest in ornithology and the bibliography of ornithology. In 1919 he founded and endowed the Emma Shearer Wood Library of Ornithology at McGill University. The following year he persuaded Robert R. Blacker, retired industrialist from Pasadena, to establish and endow a library of zoology at McGill, to be known as the Blacker Library of Zoology.

From the early 1920s until his death in 1942 Wood, accompanied by his wife, and their pet John III, a "double yellow-headed parrot from British Honduras" (which incidentally appears on many of the bookplates of the library), travelled around the world collecting treasures. These included manuscripts, books, and paintings on birds. His interest in ornithology earned Wood a number of honorary positions, such as honorary curator, collaborator, or lecturer at various North American institutions. In the mid-1920s Wood persuaded a number of well-known naturalists to deposit their correspondance in the archives of the Emma Shearer Wood Library of Ornithology. It was about this time that he began working on a catalogue of all zoological works in the McGill Libraries, which has constituted one of the important zoological reference works ever since.

Whilst Astbury is restricted to a brief chronology of Wood's life, there is enough material there to whet someone's appetite to write a proper biography. The remaining sections of this publication consist of a chronological listing of Wood's publications, and a list of sources used, both biographical and bibliographical. These are full of useful information on the productive Dr. Wood. The bibliography does not merely list his works, but also includes reviews, where appropriate, of Wood's writings. This section would have been even more useful to the naturalist if Wood's publications were separated and grouped under subject headings, such as ornithology, ophthalomology, etc., instead of chronologically. This may not be the way things are done, however, in library schools. Ms. Astbury is to be recommended for a thorough job. Its unprepossessing appearance notwithstanding, this is a useful and inexpensive publication.

MARIANNE GOSZTONYI AINLEY

4828 Wilson Avenue, Montreal, Quebec H3X 3P2

Dammed Indians: The Pick-Sloan Plan and the Missouri River Sioux, 1944-1980

By Michael Lawson. 1982. University of Oklahoma Press, Norman. xxvi + 261 pp., illus. U.S. $19.95.

The author, an historian with the Office of Rights Protection in the Bureau of Indian Affairs, is concerned here with the effects upon the Sioux Indians of U.S. Army Corps of Engineers dams constructed on the Missouri River in North and South Dakota from 1946 into the 1960's.

The Pick-Sloan Plan, devised and approved during the later stages of the Second World War, came about as the result of a political marriage between the two federal agencies most concerned with water engineering, the Engineers and the Bureau of Reclamation. These two agencies had responded to demands for better management of the Missouri River and certain of its tributaries following disastrous floods in the spring of 1943 and 1944. Though Col. Lewis A. Pick, then Divisional Engineer for the Corps in Omaha, and William Glenn Sloan, assistant director of the Bureau of Reclamation's Billings, Montana office, had come to cordially loathe one another when debate over the merits of their respective river plans became bogged down in Congress, they disliked the prospect of another Tennessee Valley Authority (TVA)-like public corporation in the area even more. The result was a quick coordination of plans in 1944 aptly termed by one critic "a shameless, loveless shotgun wedding." While the Engineers had stressed flood control and navigation and the Bureau irrigation and power development in their respective plans, Pick-Sloan simply incorporated most of the merits, as well as the defects of the original proposals. Some 107 dams were called for, and many details were left to be worked out later. Despite the admission by its proponents that there might not be enough water in the river "to provide for both irrigation and navigation," the plan was approved by Congress in 1944. Little consideration appears to have been given to the rights of Indians living in the river basin.

In building their dams, the Corps of Engineers destroyed much of the prime Sioux Indian lands and dislocated hundreds of families. The physical and psychological stresses which resulted were enormous, and seem not to have been anticipated by any of the government agencies involved. The problem was compounded by the fact that no central authority coordinated all aspects of the work and by the fact that the Army was preoccupied with engineering considerations. The Bureau of Indian Affairs was unfortunately hobbled by budget cuts and by threats to eliminate it altogether from the federal establishment.

Later efforts to revise and rework Pick-Sloan largely failed despite the wide publicity given the failures of the plan's administration. Public cries for more flood control in the wake of more disastrous floods and able public relations by the Corps kept everything essentially on track.

The Indians, therefore, concentrated on seeking cash settlements for their lands and additional funds for relocation and rehabilitation. These proved inadequate by most objective standards and did not compensate the Indians for the continuing damage done to their remaining property by various man-made projects. Nor have the prospects for electric power and irrigation panned out.

The amount of traffic on the Missouri River has not been adequate "to justify the huge expense in keeping the river open." Congress rejected proposals ten years ago for $60 billion in additional funding to keep the river dredged and open. Recreational use of the man-made reservoirs on the main stem of the river has been made difficult because, in some cases, entire forests had been left standing in areas that were later flooded, resulting in man-made lakes of limited use for boating due to navigational obstructions.

While the fishing in these reservoirs is generally excellent, the federal agencies having stocked them with game species, the boom in tourism and recreation hasn't benefitted the Indians, who suffer in some parts of the region from a "strong anti-Indian economic bias." Indians have not traditionally been concerned with fishing, boating, and swimming. Hunting, once their favorite sport, has been largely devastated by the destruction of much of the habitat for the local game animals by dammed-up waters.

The author concludes that Pick-Sloan "would certainly not have passed muster" in the 1970's because of better federal standards for the protection of the environment and the enhanced ecology mindedness of the general public. The Indians now have a good deal more political sophistication than they had forty years ago. Yet various federal agencies continue to propose land use plans which violate basic Indian treaty rights. The total picture is one which demonstrates "the sham of native rights and hypocrisy of federal Indian policies in the twentieth century." This is a sobering and provocative volume whose lessons should be read and digested.

KEIR B. STERLING

Department of History of Science, University of Wisconsin, Madison, Wisconsin 53706

Biogeographical Dictionary of Rocky Mountain Naturalists: A Guide to the Writings and Collections of Botanists, Zoologists, Artists, and Photographers, 1682-1932

By Joseph and Nesta Dunn Ewan. 1981. Bohn, Scheltema, and Holkema/Junk (North American distributor Kluwer, Boston). xvi + 253 pp. U.S. $37.50.

This excellent reference, originally published in 1950 under the title of *Rocky Mountain Naturalists*, has been expanded, revised, and updated, though the terminal date (for coverage) of 1932 has been retained. The introductory essays in the earlier work have been omitted here, and the biographical and bibliographical material has been expanded by about one third. Smaller type has been used in this edition, but the volume is well printed and bound.

In any work of this nature, there are bound to be errors, some trivial, as for example "Westpoint" for "West Point" in the sketch for Amiel Weeks Whipple (p. 237). Others, however, are a bit more serious. The sketch for Louis Agassiz, for example, makes no mention of his founding of the Museum of Comparative Zoology at Harvard. The sketch for Joel Asaph Allen neglects his role in the founding of the American Ornithologists' Union (AOU) in 1883, and his presidency of that organization, but does give credit for being a charter member and later president to C.F. Batchelder, not as central a figure. No mention is made of the AOU or their presidencies of it in the sketches of William Brewster or Elliott Coues either, though both of them and Joel Asaph Allen were important figures in the founding of this influential group.

The sketches for John and Joseph Le Conte are unfortunately not entirely accurate (pp. 130-131). John Le Conte was acting president of the University of California, rather than his brother Joseph. Nor was John Le Conte the first president, but rather the university's third chief executive. The reference to Frank M. Chapman as a "lifetime associate" of the American Museum of Natural History is a bit misleading; Chapman was an associate curator and later a long-time curator and chairman of the Department of Ornithology. Othniel C. Marsh was a professor of paleontology at Yale from 1866, not 1886, though he received no salary until 1896. Edward Drinker Cope, his great rival, is recorded here as having made his first trip to Europe in 1873-1874, whereas it actually was a decade earlier.

Despite these caveats, however, this volume is an essential one which ought to be on the shelves of every individual concerned with the Rocky Mountain region and its history. The authors have defined their geographical boundaries very broadly and point out that it is "not physiographically restricted." Naturalists, historians of science, biologists, taxonomists, wildlife management specialists, students of Western life and culture, and many others will find much information here not easily accessible in several shelves full of other references. It deserves wide circulation despite its comparatively high price.

KEIR B. STERLING

Department of History of Science, University of Wisconsin, Madison, Wisconsin 53706

Lucy Audubon: A Biography

By Carolyn De Latte. 1982. Louisiana State University Press, Baton Rouge. xiii + 148 pp. U.S. $15.95.

John James Audubon (1785-1851) was perhaps in many respects the quintessential North American artist-naturalist of the 19th century. His life and his portraits of North American birds and mammals have received repeated attention over the years from various authors. Library shelves groan with various editions of his works and extracts from them, to say nothing of the serried ranks of biographies which have been written about him. Very little attention, however, has been given to the indomitable lady who married him, shared his triumphs and trials for nearly 43 years, lost two daughters in infancy, raised two sons — themselves artists of no mean ability — and outlived all of them.

The English-born Lucy Green Bakewell enjoyed a life of genteel affluence for much of her life from the time of her birth in 1787 to her marriage in 1808. Her father suffered business reverses in the United States following his arrival in Pennsylvania in 1802, and Lucy's mother died several years later. Her father remarried, but it soon became apparent that the stepmother would increasingly try to improve her own position at the expense of that of her stepchildren.

De Latte does not essentially revise the standard accounts of John James Audubon's frequent lack of consideration for his long-suffering family, his decidedly mixed record in matters of business, his protracted absences in the field or in Europe, nor the fabrications about his origins and training which have sometimes misled students of his career over the years.

She does shed considerable light on part of Lucy's life, especially the period from 1807 until 1830, where the sources are fullest. We learn, for example, that "Lucy never lost the knack of making people, particularly other females, feel somehow inferior and always at a disadvantage." Since she had to accept employment as a teacher of young children during much of her early married life, her path cannot have been a very easy one, though De Latte records that most of her employers were very happy with her work.

Lucy's early circumstances cannot have prepared her for the "turbulent marriage, grim poverty, and life on the rowdy American frontier." On one occasion, Lucy and John James decided to visit her parents in Pennsylvania. This entailed a horseback trip of some 800 miles in the dead of winter with a two year old son who rode with his father most of the way and seems to have thrived on the experience. The trip was completed in 24 days, including a four day break with another relative. Lucy, whose "experiences with stagecoaches had been most unpleasant," seems not to have objected to this arrangement, for she was an accomplished horsewoman.

We are told that Lucy had a lively sense of humor, without which "she could not long have endured a man like John James." Fortunately, too, her "excellent education" prepared her to be a full partner to her husband in his various ventures, and he relied upon her judgement. She always felt that he could find recognition for his artistic and ornithological talents in her native country, and her convictions ultimately bore fruit. The strains of separation on this occasion, however (three years and eight months) brought serious misunderstandings in its train, and Lucy feared that her husband had placed his bird projects ahead of her. Once convinced that this was not the case, she labored long and hard to make the *Birds of America* a success. This was an unusual arrangement for that period, since through force of circumstance and "by mutual consent, Lucy became family provider [for some time] and guardian of the Audubon coffers."

Lucy's life "recedes into near obscurity" following Audubon's death in 1851, though we are told she had 15 grandchildren, some of whom helped lighten her last years. The oft-told tale of her having been forced to sell her husband's original bird paintings to the New York Historical Society for a tiny fraction of their value is not related here, though it would have been of interest to readers unfamiliar with it; indeed, the last 43 years of her life are compressed into but 14 pages. This gives the reader a strangely skewed picture of "Madame Audubon," and does some injustice to her accomplishments in this long period. This is not entirely the fault of De Latte, though one wishes she had made more generous use of the available secondary sources for this period.

One charming article by George Bird Grinnell, for example, later founder of the first Audubon Society and long time editor-publisher of *Forest and Stream*, was published in the *Auk* about 70 years ago. This told of his impressions of life in the Audubon Park neighborhood, where he lived as a child. Grinnell related something of Lucy's talents as a teacher and his delight when she left him a picture he was fond of which had hung in her house for many years. He also tells us something of Audubon's son John. Regrettably, this item is not mentioned in De Latte's notes, nor in her bibliography, though she has used other *Auk* articles among her sources.

Withall, it is refreshing to see the distaff side of this family given some well merited, if long overdue attention. Lucy Audubon had a good measure of courage and devotion and deserves greater credit than most writers have previously given her for her husband's successes.

KEIR B. STERLING

Department of History of Science, University of Wisconsin, Madison, Wisconsin 53706

NEW TITLES

Zoology

Antarctic wildlife. 1982. By Brian Sage. Facts on File, New York. 160 pp., illus. U.S. $22.95.

The canine clan: a new look at man's best friend. 1983. By John C. McLoughlin. Viking, New York. XIV + 162 pp., ills. U.S. $15.75.

†**Ce qu'il advient des truites ensemencées dans les eaux de la plaine de Montréal, d'après les expériences d'étiquetage et de recapture, de 1977 à 1981 inclusivement.** 1982. Par Jean-René Mongeau et Jocelyne Brisebois. Ministère du Loisir, de la Chasse et de la Pêche, Québec. 47 pp., illus.

Effects of highways on wildlife populations and habitats: phase I: selection and evaluation of procedures. 1982. By Lowell Adams and Aelred Geis. United States National Technical Information Service, Springfield, Virginia. 171 pp. U.S. $16.50.

†**A field guide to birds of the U.S.S.R.** 1983. By V. E. Flint, R. L. Boehme, Y. V. Kostin, and A. A. Kuznetsov. Princeton University Press, Princeton. c420 pp., illus. U.S. $65.00.

†**Five new world primates: a study in comparative ecology.** 1983. By John Terborgh. Princeton University Press, Princeton. c312 pp., illus. Cloth U.S. $40.00; paper U.S. $13.50.

The great extinction: the solution to one of the great mysteries of science, the disappearance of the dinosaurs. 1983. By Michael Allaby and James Lovelock. Doubleday, New York. x + 182 pp. U.S. $13.95.

Herbivorous insects: host-seeking behavior and mechanisms. 1983. Edited by Sami Ahmad. Academic Press, New York. c590 pp. no price given.

The king fisher. 1982. By David Boag. Blandford, New York. vii + 120 pp., illus. U.S. $14.39.

Mammalian biology in South America. 1982. Edited by Michael A. Mares and Hugh H. Genoways. Papers from a symposium, Linesville, Pennsylvania, May, 1981. University of Pittsburgh Pymatuning Laboratory of Ecology, Linesville. xii + 540 pp., illus. U.S. $30.00.

***Mammals of the northern great plains.** 1983. By J. Knox Jones, jr., David M. Armstrong, Robert S. Hoffmann, and Clyde Jones. University of Nebraska Press, Lincoln. xii + 379 pp., illus. U.S. $32.50.

Mosquito. 1982. By Oxford Scientific films. Putnam's, New York. 32 pp., illus. U.S. $8.95.

Parental behaviour of rodents. 1983. Edited by R.W. Elwood. Wiley-Interscience, New York. x + 296 pp., illus. U.S. $49.95.

The sharks of North American Waters. 1983. By Jose I. Castro. Texas A&M University Press, College Station. xii + 180 pp., illus. + plates. Cloth U.S. $19.50; paper U.S. $9.95.

***Vanishing fishes of North America.** 1983. By Dana Ono, James D. Williams, and Anne Wagner. Stone Wall Press, Washington, xiii + 257 pp., illus. U.S. $27.50 (Cdn. $34.95).

Waterfowl of the Chesapeake Bay. 1982. By B. Meanley. Tidewater Publications, Centreville, Maryland. xiv + 210 pp. U.S. $19.95.

Elk of North America: ecology and management. 1982. Edited by J.W. Thomas and D.E. Toweill. Stackpole, Harrisburg, Pennsylvania. 720 pp. U.S. $39.95.

Wolves of the world: perspectives of behavior, ecology, and conservation. 1982. Edited by Fred H. Harrington and Paul C. Paquet. Noyes, Park Ridge, New Jersey. 474 pp. U.S. $48.00.

Botany

Atlas of airborne fungal spores in Europe. 1983. Edited by S. T. Nilsson. Springer-Verlag, New York. 139 pp., illus. + plates. U.S. $50.00.

Biology and ecology of weeds. 1982. Edited by W. Holzner and M. Numata. Junk, The Hague. 464 pp. Dfl. 265.

Contributions to the ecology of halophytes. 1982. Edited by D. Navin Sen and K. Singh Rajpurohit. Task for Vegetation Science 2. Junk, The Hague. 272 pp. Dfl. 165.

The genus *Atriples* (Chenopodiaceae) in Canada. 1983. By J. J. Bassett, C. W. Crompton, J. McNeill, and P. M. Taschereau. Monograph No. 31. Agriculture Canada, Ottawa. 72 pp.

Grass genera of western Canadian cattle rangelands. 1983. By Susan G. Aiken and S. J. Darbyshire. Agriculture Canada Monograph No. 29. Supply and services Canada, Ottawa. 173 pp. $9.00 in Canada; $10.80 elsewhere.

Man's impact on vegetation. 1983. Edited by W. Holzner, M. J. A. Werger, and I. Ikusima. Junk, The Hague. xiv + 370 p. Dfl. 225.

†**Mate choice in plants.** 1983. By Mary F. Wilson and Nancy Burley. Princeton University Press, Princeton. c244 pp., illus. Cloth U.S. $35; paper U.S. $12.50.

Metals and micronutrients: uptake and utilization by plants. 1983. Edited by D. A. Tobb and Stan Pierpoint. Academic Press, New York. 358 pp. U.S. $49.50.

Monitoring of air pollutants by plants: methods and problems. 1982. Edited by L. Steubing and H. J. Jäger. Proceedings at a workshop, Osnabrück, Germany, 24 to 25 September, 1981. Junk, The Hague. 172 pp. Dfl. 80.

Plant extinction: a global crisis. 1983. By Harold Koopowitz and Hilary Kaye. Stone Wall Press (distributed by Stackpole Books, Harrisburg, Pennsylvania). x + 240 pp., illus. U.S. $16.95.

Principles of dispersal in higher plants. 1982. By L. van der Pijl. 3rd revised edition. Springer-Verlag, New York. 215 pp., illus. U.S. $27.50.

Sampling methods and taxon analysis in vegetation science. 1983. Edited by R. Knapp. Handbook of Vegetation Science 4. Junk, The Hague. 364 pp. Dfl. 155.

Selected climatic data for a global set of standard stations for vegetation science. 1982. By W. J. Muller. Junk, The Hague. 334 pp. Dfl. 200.

Then and now: a photographic history of vegetation change in the Central Great Basin Desert. 1982. By G. F. Rogers. University of Utah Press, Salt Lake City. 128 pp., illus. U.S. $15.

Vascular plants poisonous to livestock in Canada. 1. A preliminary inventory. 1983. By Biosystematics Research Institute. Agriculture Canada, Ottawa. 33 pp.

Vegetation dynamics in grasslands, healthlands, and Mediterranean ligneous formations. 1982. Edited by P. Poissonet et al. Proceedings of a symposium, Montpellier, France, September 1980. Junk. The Hague. x + 286 pp. Dfl. 195.

The vegetation of the subantarctic islands Marion and Prince Edward. 1982. By N. J. M. Gremmen. Junk, The Hague. 160 pp. Dfl. 110.

Environment

Acid deposition. 1983. Edited by S. Beilke and A. J. Elshout. Proceedings of a workshop, Berlin, 9 September, 1982. Reidel (distributed by Kluwer, Boston). c 250 pp. U.S. $32.50.

Canada's special places in the north: an environment Canada perspective for the 80's. 1982. By Environment Canada, Ottawa. 22 pp. + map.

Conceptual issues in ecology. 1982. Edited by Esa Saarinen. Reidel, Higham, Massachusetts. vii + 374 pp. U.S. $15.95.

Costa Rican natural history. 1983. Edited by Daniel H. Janzen. University of Chicago Press, Chicago. 832 pp., illus. Cloth U.S. $50; paper U.S. $30.

Cost-benefit analysis and environmental regulations: politics, ethics, and methods. 1982. Edited by D. Swatzman, R. A. Liroff, and K. G. Groke. Conservation Foundation, Washington. 196 pp. U.S. $11.50.

Ecology of tropical savannas. 1982. Edited by B. J. Huntley and B. H. Walker. Springer-Verlag, New York. 669 pp., illus. U.S. $49.

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