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Their Excellencies the Governor General and Madame Jules Léger

The objectives of this Club shall be to promote the appreciation, preservation, and conservation of Canada's natural heritage; to encourage investigation and publish the results of research in all fields of natural history and to diffuse information on these fields as widely as possible; to support and co-operate with organizations engaged in preserving, maintaining, or restoring environments of high quality for living things.

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* This Council is in office until the Annual Business Meeting in January 1976.

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The Canadian Field-Naturalist

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All material intended for publication should be addressed to the Editor:

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Cover: Female Gray Jay (*Perisoreus canadensis*) incubating her three eggs. The nest is in a black spruce (*Picea mariana*) in the Mer Bleue Bog, Ottawa, Ontario. Photo by Henri Ouellet on 23 March 1974. See article on page 5.

The Canadian Field-Naturalist

Volume 90, Number 1 January-March 1976

Canadian Women Natural Scientists—Why Not!

The past year, designated International Women's Year, has focused attention on the role of women in society. Even so, little recognition was given to women scientists. The National Museum of Natural Sciences, Ottawa, however, in a temporary and travelling exhibit "Why? Why Not? " has honored 19 Canadian women natural scientists. In doing the research and writing the story line for this exhibit I was impressed with and awed by the significant accomplishments of some Canadian women despite almost insurmountable obstacles. These women are an important part of our history, of our society, and of science; their names and accomplishments should not be forgotten. Before naming them, however, for those who have not seen the exhibit I must set the stage by pointing out that serious studies of natural science in Canada really began only in the 1800s and that many of these women who have made noteworthy contributions to science are still living.

Pioneers of Canadian Sciences, a book edited by G. F. G. Stanley and published for the Royal Society of Canada by the University of Toronto Press in 1966, documents the early history of science and scientists in Canada. When the study of the natural sciences began in the early nineteenth century, one person could become knowledgeable in several fields of natural history. Although Canadian pioneers were, of necessity, interested in their physical and biological environment, there were few serious studies in the natural sciences. Before 1870 almost all studies in this area were carried out by well-informed amateurs; it was amateurs who made most of the earliest collections of plants, animals and minerals. The role of the natural history societies was then, and to some extent still is today, to inspire amateurs to observe and record. After 1870, as knowledge grew, specialization began and natural scientists directed their studies towards the flora, fauna, or geology of an area. Because Canada had an agricultural economy, the early lines of professional development were in botany and entomology, but geology advanced too, largely because of Canada's mineral wealth. As knowledge advanced and technology developed, specialization increased and new fields of study opened up. By the late nineteenth century professionals trained in the natural sciences began to take over some of the work of the amateurs. Nevertheless to this day, dedicated and knowledgeable amateurs can, and often do, contribute to our knowledge of the natural sciences.

But what of *women* in the natural sciences? The first women working in the natural sciences in Canada did not fear to enter a man's world; they were exceptional women who had the drive and determination to succeed. Although they were few in number, they were able to elucidate problems and advance our knowledge, but, perhaps most important of all, they opened the door for other women to follow.

Fortunately the role of women in our society is changing. Until the 1950s or even later professional women had the problem of being women; if married, their problems were even greater. Women, of course, are expected to demonstrate competence in a range of roles. Most studies comparing the careers of men and women in science have consistently shown that a much larger proportion of the women scientists are not married, and even the married women scientists on the average have fewer children. Until well into this century there was a lack of teaching jobs at the university level for women. Today there are still very few women in the upper echelons of acadaemia. Women have been more successful in finding jobs with the government.

Chance still plays a role in successful careers, but without their dedication and persistence, most successful women scientists would not have made good. This was clearly brought out in the proceedings of a recent conference "Successful women in the sciences: an analysis of determinants" published in 1973 in the *Annals of the New York Academy of Sciences* 208: 1–255. Women today know that all fields of human endeavor should be open to them, yet the doors are still not completely open.

Why are the vast majority of manuscripts submitted to *The Canadian Field-Naturalist* for publication still written by men? The natural sciences appeal to women but where are their contributions, their manuscripts? In addition to professional women scientists, observant, well-read, and perhaps self-taught amateurs can also carry out studies in natural history. Do women need to be encouraged to observe and record happenings in the natural world around them? By pointing out the low level of input by women to scientific publications in general and to *The Canadian Field-Naturalist* in particular and by focusing attention on some outstanding women natural scientists, I hope I will in a small way be able to influence and encourage women to be more productive in the natural sciences.

The exhibit at the National Museum of Natural Sciences honors 19 women and displays their work in many disciplines. Unfortunately space limitations precluded the inclusion of other women who also have a place in the history of Canadian science. Seven of the women featured in the museum exhibit are no longer living.

EDITH BERKELEY (1875–1963) worked as a volunteer investigator at the Fisheries Research Board of Canada biological station at Nanaimo for 44 years. Initially she organized the taxonomy of the polychaetes (marine worms) on the west coast and this led her to become an authority on polychaete systematics in general.

LULU ODELL GAISER (1896–1965) was a pioneer cytotaxonomist who studied plant relationships from the chromosomes in plant cells. Because of her concern for the rapid destruction of native habitats, she began a floristic study of Lambton County, Ontario in 1957 in order to document the changes from 50 years previously.

MARCELLE GAUVREAU (1907–1968), although a botanist who collaborated with the renowned Frère Marie-Victorin, is best remembered for her dedication to publicize the natural sciences and for her unique school to teach youngsters about the joys of nature.

MARGARET NEWTON (1887–1971) was one of the first women to graduate from an agricultural college in Canada. Her work on cereal rusts was an integral part of the project that developed for western Canada varieties of wheat resistant to the rust fungi.

CATHARINE PARR (STRICKLAND) TRAILL (1802–1899) immigrated to Canada in 1832 and pioneered on the land near Peterborough, Ontario. She was one of the first to study and make extensive collections of Canadian plants. Her book *Canadian wild flowers* was the first of its kind in Canada; she wrote the text and her niece lithographed and painted the plates.

NORMA FORD WALKER (1893–1968) was trained as an entomologist but became a pioneer in the study of human genetics. She was well known as an authority on multiple births and for introducing the study of dermatoglyphics (skin prints) as an aid in diagnosis of genetic abnormalities.

ALICE EVELYN WILSON (1881–1964) was Canada's first woman geologist and the first woman (1938) to become a Fellow of the Royal Society of Canada. She was an active member of The Ottawa Field-Naturalists' Club and she led many outings. Her specialty was the study of the fossils and sedimentary rocks of the Ordovician strata. She contributed papers to *The Canadian Field-Naturalist* over a period of years and her *Guide to the geology of the Ottawa district* published in 1956 as Volume 70(1) of *The Canadian Field-Naturalist* is still a standard reference.

The other 12 women featured in the museum display are living and most are still actively working in the natural sciences.

JEAN BURNHAM ADAMS is an entomologist who studies aphids and their physiology. Her main research is directed towards the economics of potatoes, i.e. on methods of stopping the transmission of potato virus by aphids.

HELEN IRENE BATTLE was the first Canadian woman to receive a doctorate (1928) in marine biology. She is one of our most gifted teachers and has inspired many students to be interested in biology. Although she has carried out research on many different aquatic organisms, she is especially known for her work on the embryology and development of teleostean fish.

HELEN REYNOLDS BELYEA is a geologist who is highly esteemed by the petroleum industry. She has worked extensively on the Devonian stratigraphy of western Canada.

ANNE INNIS DAGG is one of Canada's few women mammalogists. She is an authority on giraffes and is particularly interested in the gaits of animals. She was one of the first scientists who saw the need for initiating studies in urban wildlife and ecology. She has contributed papers to *The Canadian Field-Naturalist*, has served as the journal's Book Review Editor, and has written books including *Mammals of Ontario* and *Canadian wildlife and man.*

MOIRA DUNBAR was educated as a geographer but has become an expert on the dynamics and distribution of sea ice and the physiography of the Arctic. She played a significant role in opening the way for women to work in the north.

MADELEINE ALBERTA FRITZ was one of the first Canadian women to pursue the conventional study of geology and to become an academic in the earth sciences. Her special interest is the study of Palaeozoic bryozoans.

BARBARA FROOM is an ardent conservationist who has tried through her interviews with the media to enlighten the public regarding its attitudes towards amphibians and reptiles. Her book *The snakes of Canada* is the first publication to treat the appearance and natural history of all Canadian snakes. A companion volume, *The turtles of Canada*, is in preparation.

HELEN SAWYER HOGG is an astronomer who has received many honors for her work. She is a world authority on variable stars in globular star clusters. Moreover, she likes to communicate her knowledge to the public and has for years written a weekly newspaper column on astronomy.

LOUISE DE KIRILINE LAWRENCE was not formally trained as a scientist but she has become a recognized ornithologist. Particularly noteworthy are her contributions to the life histories of several species of North American birds, especially woodpeckers. She was the first Canadian to win the John Burroughs Memorial Medal (1969) for distinguished writing in natural history (for her book *The lovely and the wild*).

MARGARET RAE MACKAY is one of the few entomologists to have studied the larvae of Lepidoptera. Not only did she make a significant contribution to insect taxonomy but her studies have led to better forest management. For some years she served as Editor of *The Canadian Entomologist.*

MILDRED KATHARINE NOBLES is a mycologist who worked out techniques and keys for the identification of wood-destroying fungi. Her work has been a considerable aid to better forest management. She used the cultural characters of the fungi not only as a guide to their identity but also as a guide to their evolution.

DORIS HUESTIS SPEIRS began her ornithological studies as an amateur when relatively few people were interested in nature. Her in-depth study of Evening Grosbeaks has made her *the* expert on the species. She is also the co-author (with her husband) of the life history of the Lincoln's Sparrow. Some of her work has been published in *The Canadian Field-Naturalist.*

Other women, albeit relatively few, have also made significant contributions to the natural sciences in Canada. The following are among them.

SUSAN SQUIRES, a New Brunswick naturalist, published articles in *The Canadian Field-Naturalist* between 1926 and 1934.

ISABEL PRIESTLY founded the Yorkton Natural History Society (later The Saskatchewan Natural History Society) and the journal *The Blue Jay*.

HELEN R. QUILLIAM, an active ornithologist, has edited *The Blue Bill* for The Kingston Field Naturalists for many years; in 1973 she revised her book *History of the birds of Kingston, Ontario*.

PAULINE SNURE for many years served as the Supervising Editor of the National Research Council of Canada biological journals; she set high standards for scientific writing particularly in the *Canadian Journal of Botany*. She has also served as President of The Ottawa Field-Naturalists' Club.

I have drawn attention to the contributions and accomplishments of a few women working in the natural sciences in Canada. I hope others will be encouraged and challenged to follow in their footsteps. If the intermittent flow of quality manuscripts from Canadian women naturalists and natural scientists eventually increases to a level commensurate with those submitted by men, my hopes will be realized.

LORRAINE C. SMITH

Gray Jay Nesting in the Mer Bleue Bog, Ottawa, Ontario*

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Ouellet, Henri, Stephen J. O'Donnell, and Roger A. Foxall. 1976. Gray Jay nesting in the Mer Bleue Bog, Ottawa, Ontario. Canadian Field-Naturalist 90(1): 5–10.

Abstract. The Gray Jay (*Perisoreus canadensis*) was previously known to occur in the lowlands of the lower Ottawa River only as a transient or a winter resident. A nest, discovered in March 1974 in the Mer Bleue Bog, near Ottawa, Ontario, was outside the known breeding range of the species. This nest was some 200 km ESE of Algonquin Park, 160 km east of Round Lake, Renfrew County, in Ontario, and approximately 175 km south of La Vérendrye Park in Quebec, the closest localities where Gray Jays are known to breed. The nest contained three eggs; one hatched and the young was banded after it had left the nest. Observations on the nesting behavior of the adults, and descriptions of the nest structure and eggs are recorded. The importance of the Mer Bleue Bog as a nesting site for several boreal avian species is stressed.

Résumé. Le Geai gris (*Perisoreus canadensis*) ne s'est rencontré jusqu'à maintenant que comme une espèce de passage ou résidente d'hiver dans les basses terres du cours inférieur de la rivière Outaouais. On a découvert, en mars 1974, un nid dans la tourbière Mer Bleue, près d'Ottawa, Ontario, à quelque 200 km à l'est-sud-est du Parc Algonquin (Ontario), à quelque 160 km à l'est du lac Round, comté de Renfrew (Ontario) et à environ 175 km au sud du Parc la Vérendrye (Québec), au sud de l'aire de nidification connue de l'espèce. Ce nid contenait trois oeufs dont l'un a éclos et l'on a bagué le jeune après son départ du nid. Cet article contient de plus des données sur le comportement des adultes durant la couvaison et la période de croissance du poussin, ainsi qu'une description du nid et des oeufs. Les auteurs soulignent l'importance de la tourbière Mer Bleue en tant que lieu de nidification pour les espèces d'oiseaux dites boréales.

The Gray Jay (*Perisoreus canadensis*), one of the most characteristic birds of the northern coniferous forests of North America, is found fairly regularly throughout the coniferous biome and arctic ecotone of eastern Canada (Ouellet 1966). In the eastern part of the continent its breeding distribution coincides for the most part with the range of the boreal coniferous forest. It extends farther to the south, however, in certain areas where suitable forest occurs, notably as far as southern Nova Scotia (Godfrey 1966), central Maine (Palmer 1949), northern New Hampshire, northern Vermont (A.O.U. Check-list 1957, p. 367), and northeastern New York (Bull 1974).

In Ontario it is known to nest as far south as Algonquin Park, Round Lake (Renfrew Co.), and Lake Nipissing (Godfrey 1966, p. 272). In Quebec it has nested as far south as La Vérendrye and Laurentide provincial parks. In neither province has it been recorded to date as a breeding bird in the lowlands of the St. Lawrence and lower Ottawa valleys, although it may have nested in the bogs of that region in the distant past.

During fall and winter it wanders sporadically out of its breeding range. Such wanderings have been reported irregularly in the Montreal area (Ouellet 1974, p. 105), in the Ottawa region (Lloyd 1944, p. 163; Audubon Field Notes and American Birds 1960–1974), and at several localities farther south in Ontario (Audubon Field Notes and American Birds 1960–1974).

Gray Jay Movements in the Ottawa Region

Lloyd (1944, p. 163) considered the Gray Jay as an "irregular winter visitor; in some years fairly numerous" over a long period in the Ottawa region. More recently, probably as a result of the intensive bird-watching that is taking place locally, invasions and movements, even of single birds, have been detected with some regularity. These movements have varied in intensity; the irruption that took place during the fall and winter of 1972–73 was of considerable magnitude. Up to 19

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*Contribution Number 7 to "Scientific and Cultural Studies of the Mer Bleue."

individuals were reported in one day in a radius of approximately 12 km from the center of Ottawa (American Birds, 1973, 27(2), p. 162), whereas only a few individuals, not more than three in a single day, were found in the same area during the two following winters.

Some individuals involved in the winter invasion of 1972–73 may have remained in the Ottawa region. Two birds were seen on 23 June 1973 in the Mer Bleue Bog (*fide* G. R. Hanes), in the area in which a nest was to be discovered in 1974. Ouellet observed another bird in the Gatineau Hills near Meach Lake, Quebec in late April 1973.

Mer Bleue Bog

This bog is located some 19 km (12 mi) east of the Parliament Buildings in Ottawa. It has been classified as an ombrotrophic sphagnum and black spruce bog (Joyal 1972, p. 1209). Black spruce (*Picea mariana*) and tamarack (*Larix laricina*) form the main forest stands at the periphery and grow in mixed clumps in the better-drained sectors of the interior (Figure 1). Trembling aspen (*Populus tremuloides*) occurs in stands of various sizes at the edges and on the ridges. It is primarily an open bog with small isolated clumps of trees. It has been disturbed to some extent in the past, primarily as a result of human activities. Fires have occurred at various times and these have undoubtedly contributed to keeping the open aspect of the bog.

Observations

Nesting Chronology

On 2 March 1974, while searching for two Gray Jays that had been reported for some time near the western extremity of the Mer Bleue Bog, O'Donnell and Foxall located one of the birds in the bog some 1.5 km northeast of the east end of the Borthwick Ridge Road. The bird perched in the top of a dead black spruce, in a small clump of conifers approximately 50 m from the nearest conifer stand (Figure 1). When flushed, the bird flew into the forest. Shortly afterwards a Gray Jay returned to the same conifer clump and was soon

FIGURE 1. The clump of black spruces and tamaracks in the Mer Bleue Bog, where a nest of the Gray Jay was found. Photo by Henri Ouellet on 18 March 1974.

followed by another that carried a small twig in its bill. After a careful search, a rudimentary nest structure, consisting of a crude platform of loose twigs, was discovered in a black spruce. Not wishing to disturb the birds further, the observers left the area.

The following day, Foxall and Ouellet visited the nesting site and, according to Foxall no material had been added to it since its discovery. Neither bird was seen on that occasion.

On 5 March, O'Donnell checked the nest again and noticed that little construction had taken place. The adults were not seen near the nest on these days, nor on subsequent visits on 6 and 8 March. Both birds were seen, however, near the nest on 11 March when more twigs and other materials had been added. The nest then consisted of a loose bowl. On 14 and 15 March, O'Donnell observed both birds at the nest. On both occasions one of the birds was still arranging twigs into the nest structure. Ouellet inspected the nest on 18 March and observed an adult near it. Nest construction appeared to be completed but no egg had been laid.

When Foxall and R. M. Poulin visited the nest on 23 March, they found two eggs. On the afternoon of the same day, Ouellet visited the nest which appeared to be somewhat more voluminous than on 18 March. It contained three eggs. One of the adults was incubating and proved to be the female (Figure 2). The bird was taken by hand from the nest, sexed (presence of brood patch and absence of cloacal protuberance), and marked by clipping a small portion from the end of the two central rectrices. The male remained at a distance of some 50 m and called frequently. The call was a low whistled raspy "kwuuk." The wind was strong and penetrating on that occasion and the female kept her tail up almost vertically and into the wind direction, blinking her eyes frequently. She was sitting very low on the nest. Each time the male called she moved her head in his direction. Otherwise, she remained motionless.

Additional visits were made (by O'Donnell and Ouellet) on 25, 26, 28, and 31 March but no additional changes were noted, except that a few

FIGURE 2. Female Gray Jay incubating eggs. Note coarse outside structure of nest in black spruce. Photo by Henri Ouellet on 23 March 1974.

domestic chicken (*Gallus gallus*) feathers had been inserted near the rim of the nest (Figure 3). As incubation progressed, however, entirely by the female as far as this could be determined from our observations, the male remained farther away from the nest site and became more silent, which is similar to the information obtained by Strickland (personal communication) in La Vérendrye Park. This behavior was also noted by Rutter (1969) in Algonquin Park.

On 7 April, the female was still incubating her three eggs (Ouellet). O'Donnell noted the female on the nest on 13, 14, and 15 April but did not check inside the nest. On 16 April, he observed one young and two eggs, but could not determine the age of the young. The female was somewhat more nervous on 18 April when Ouellet visited the nest. The male was seen but he remained at a considerable distance and whistled a few "kwuuk's," to which the female, sitting on the nest, answered in the same manner. She left the nest and disappeared in the forest for a few minutes. In the meantime, the male came to the nest, fed the young, and left. The female returned to the nest almost immediately. The age of the young was estimated to be about 7 to 8 days, by using photographs of young of known age as a reference (Ouellet 1971).

O'Donnell went back to the nest site on 19 and 23 April but noticed no change.

Ouellet, accompanied by R. M. Poulin, visited the nest again on 2 May. It contained only two cold eggs and many of the feathers of the lining were gone. The female nearby was accompanied by one young, which was captured, banded, and released. It could fly only with great difficulty but was well attended by the female. It had a very short tail and it was estimated to have left the nest that day or the day before. The nest and remaining eggs were collected. The eggs proved to be infertile, and have been deposited with the nest in the collections of the National Museum of Natural Sciences (Number E3644).

Nest and Eggs

The nest was placed on a lateral branch against the trunk of a black spruce (DBH: 15.0 cm; height: 4.6 m) some 1.25 m from the surface of the snow. It was well protected from above by a series of thick branches and made of medium to coarse twigs, 8.0 to 12.0 cm in length. Alder (*Alnus* sp.), tamarack, and black spruce twigs had been used on the outside coarse structure. Pieces of black spruce and tamarack bark appear here and there on the interior, next to the twigs. The outside of the inner bowl consists primarily of sphagnum moss, cat-tail strippings, and small amounts of cat-tail down, several domestic chicken feathers, and a few Common Crow (*Corvus brachyrhynchos*) and Ruffed Grouse (*Bonasa umbellus*) feathers (Figure 3). Ruffed Grouse feathers have been identified previously by Rutter (1969) and Strickland (personal communication) in nests from Algonquin and La Vérendrye parks. Gray Jay feathers from the rump area and down from the apteria (probably ventral) appear here and there in the inner lining of the nest, as recorded earlier (Ouellet 1971, p. 157). Construction of the nest took place from 2 March to at least 18 March and probably until 20 March, assuming that the first egg was laid on 21 March. Construction and material gathering may have started two to three days before the nest was discovered, so construction probably extended over 19 to 22 days.

Two of the eggs, of which one hatched, were very similar, whereas the third was significantly different. The first two have a dull white base, coarsely marked with beige, grayish brown, olive brown, and lilac spots and blotches, more heavily towards the blunt end where a poorly defined crown is present. The other is much paler in general appearance. Its base coloration is dull white but densely marked with fine lilac spots and blotches giving it a peppered effect. Fine grayish brown and olive brown markings are present but much subdued when compared to the other two eggs.

Discussion

The nesting described here extends the known breeding range of the Gray Jay into the lowlands of the lower Ottawa River, an area where it was previously known to occur only as a transient or a winter resident and where suitable nesting sites are rare or absent, except in habitats such as bogs. As the Gray Jay is one of the most characteristic bird species of the boreal coniferous forest, it is noteworthy that this breeding event has occurred in the Great Lakes – St. Lawrence Forest Region some 200 km ESE of Algonquin Park (Godfrey 1966), some 175 km south of La Vérendrye Park.

FIGURE 3. Nest of Gray Jay showing position near trunk of black spruce, on lateral branches. Feathers of domestic chicken, Ruffed Grouse, and down from rump and apteria of Gray Jay in the inner bowl and at the rim of the nest. Photo by Henri Ouellet on 28 March 1974.

The Round Lake area, where evidence of nesting has been recorded, probably is at the extreme southern part of the breeding range of the species in Ontario. Furthermore the nesting took place near a city of moderate size, and was adjacent to farmlands and other centers of intensive human activity. Despite its location, however, the Mer Bleue Bog offers conditions that duplicate admirably the boreal habitat of the Gray Jay and of several other species found mainly in the boreal forest or habitats closely associated with it.

Currently, the following bird species, characteristic of the boreal coniferous forest, have been recorded as nesting or found in summer in Mer Bleue Bog: Hawk Owl, *Surnia ulula* (Smith 1970); Yellow-bellied Flycatcher, *Empidonax flaviventris* (Ouellet, personal observation); Red-breasted Nuthatch, *Sitta canadensis* (Lloyd 1944); Hermit Thrush, *Catharus guttatus* (Lloyd 1944); Ruby-crowned Kinglet, *Regulus calendula* (Ouellet, personal observation); Yellow-rumped Warbler, *Dendroica coronata* (Lloyd 1944); Palm Warbler, *Dendroica palmarum* (Lloyd 1944); and Dark-eyed Junco, *Junco hyemalis* (Lloyd 1944; Ouellet, personal observation). They, in additon to the numerous plant species, confirm the boreal character retained by this restricted habitat, which is a relict of a plant and animal community now largely confined to higher latitudes or elevations.

Two Gray Jays observed on 23 June 1973 near the nest site described above may have nested in 1973. But since at that time of the year the members of a family group are usually still together (Ouellet, personal observation) it does not appear that these birds, if they formed a pair, had nested successfully. If these two birds were the individuals that were to breed in the Mer Bleue in 1974, they were probably on that date gathering and caching food for future use, as recently reported by D. Strickland (personal communication) and Rutter (1969).

Despite the many visits to the nest detailed above, it is not possible to determine accurately the incubation and fledgling periods. The observations, however, are consistent with a large sample provided by D. Strickland (personal communication), from which he has determined the average incubation and fledgling periods to be 18 and 23 days, respectively.

The nest construction, location, and structure agree with the most recent published descriptions (Rutter 1969). The laying period and beginning of incubation agrees also with the dates recorded in Algonquin and La Vérendrye parks (Rutter 1969).

In conclusion, we should like to emphasize that the nesting of the Gray Jay in the Mer Bleue, in spite of the fact that it may be an isolated case, demonstrates the value and importance of this bog as an irreplaceable habitat not to be found elsewhere near the outskirts of Ottawa. There is an urgent necessity to prevent any further damage to this fragile habitat and to preserve it as a living laboratory and museum for our contemporaries and the generations to come.

Acknowledgments

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Literature Cited

American Ornithologists' Union. 1957. Check-list of North American birds. Fifth edition. American Ornithologists' Union, Baltimore.

Audubon Field Notes and **American Birds.** 1960–1974.

Bull, John. 1974. Birds of New York State. Doubleday/Natural History Press, New York, Garden City.

Godfrey, W. E. 1966. The birds of Canada. National Museum of Canada Bulletin 203. 428 pp.

Joyal, R. 1972. Description de la tourbière à sphaignes Mer Bleue près d'Ottawa. II, Quelques facteurs écologiques. Canadian Journal of Botany 50: 1209–1218.

Lloyd, Hoyes. 1944. The birds of Ottawa, 1944. Canadian Field-Naturalist 58(5): 143–175.

Ouellet, Henri. 1966. Biomes et écotones dans la péninsule Québec-Labrador. Naturaliste Canadien 93: 177–186.

Ouellet, Henri. 1971. Contribution à l'étude de la ptérylose chez *Perisoreus canadensis* (Linnaeus), (Aves: Corvidae). Canadian Journal of Zoology 49(2): 147–158.

Ouellet, Henri. 1974. Les oiseaux des collines montérégiennes et de la région de Montréal, Québec, Canada. Musée national des Sciences naturelles, Publication de Zoologie, numéro 5. 167 pp.

Palmer, R. S. 1949. Maine birds. Museum of Comparative Zoology, Bulletin 102: 1–656.

Rutter, R. J. 1969. A contribution to the biology of the Gray Jay (*Perisoreus canadensis*). Canadian Field-Naturalist 83(4): 300–316.

Smith, D. A. 1970. Observations on nesting Hawk Owls at the Mer Bleue, near Ottawa, Canada. Canadian Field-Naturalist 84(4): 377–383.

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Food Habits of Moose, *Alces alces*, in Alaska: A Preliminary Study Using Rumen Contents Analysis

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Cushwa, Charles T. and John Coady. 1976. Food habits of moose, *Alces alces*, in Alaska: a preliminary study using rumen contents analysis. Canadian Field-Naturalist 90(1): 11–16.

Abstract. One hundred and sixty-six samples of moose (*Alces alces*) rumen contents from the Fairbanks and Kenai areas of Alaska were analyzed to quantify regional and seasonal moose habitat interactions in Alaska. We are 95% confident that the frequency of major food items from 44 to 51 samples collected during winter near Fairbanks and Kenai, Alaska, have been established within ± 15% deviation.

Six studies of moose (*Alces alces*) food habits have been reported from Alaska (Peek 1973). In the Susitna Valley in south-central Alaska, Chatelain (1951) found, through analysis of moose rumen samples, that mat willow (*Salix* spp.), birch (*Betula papyrifera* var. *kenaica*), cottonwood (*Populus trichocarpa*), and aspen (*Populus tremuloides*) constituted practically all the winter food of moose in this area. Alder (*Alnus fruticosa*), rose (*Rosa acicularis*), highbush cranberry (*Viburnum edule*), or other plants were rarely consumed; and spruce (*Picea* spp.) was not eaten.

Spencer and Chatelain (1953) found that plant succession on areas burned by wildfire in south-central Alaska followed a variety of patterns, resulting in creation of useful moose winter range from 0 to 50 years. Under average conditions, stands appeared to furnish good forage for 15 to 20 years after the fire. Spencer and Chatelaine (1953) felt that the 290 000-acre fire in 1947 on the Kenai Peninsula induced an increase in moose populations of approximately 400% between 1950 and 1953. In the 3 years following this fire, significant forage was produced, 96% of which was aspen sucker growth. Some of this conclusion was based on analysis of 96 samples of moose rumen contents. Details of this analysis were not reported.

Leopold and Darling (1953a, b), Chatelain (1952), Spencer and Hakala (1964), and Hakala et al. (1971) wrote about the effect of fire on moose-habitat interactions in the Copper River, Susitna, and Kenai areas of Alaska. They agreed that fire improved moose habitat through increased productivity and availability of deciduous woody plants (willow, aspen, birch, alder, and cottonwood) and that moose populations in these areas increased in response to improved habitat conditions.

The previous observations are primarily qualitative and do not permit comparative analysis. This effort initiated a study to quantify moose food habits in Alaska as determined by rumen content analysis.

The moose rumen samples were collected from the Fairbanks and Kenai Peninsula areas of Alaska. Winter (November to March) habitats of moose near Fairbanks consist primarily of shrub and deciduous tree communities. Vegetation in shrub habitats ranges from pure to mixed stands of willows (*Salix* spp.) and alders (*Alnus incana, A. crispa*), frequently with a dense understory of herbs and low shrubs (*Rosa acicularis, Potentialla fruticosa, Ledum palustre, Vaccinium uliginosum, Viburnum edule*). Deciduous tree communities consist of paper birch, quaking aspen, and balsam poplar (*Populus balsamifera*). Understory vegetation ranges from a dense herbaceous cover in balsam poplar stands to mixed herbs and low shrubs in aspen and birch stands. Pure or mixed stands of coniferous trees (*Picea glauca, P. mariana, Larix laricina*) occurring throughout areas are used by moose during both winter and summer.

Winter habitats of moose on the Kenai Peninsula consist primarily of shrub and deciduous tree communities. Shrub communities are composed of willows and alders (*Alnus tenuifolia, A. sinuata*); deciduous tree habitats consist of paper birch and quaking aspen. Understory vegetation is dominated in many areas by mountain-cranberry (*Vaccinium vitis-idaea*).

Winter weather conditions contrast sharply between interior Alaska and the Kenai Peninsula (Johnson and Hartman 1969). In interior Alaska, snow-cover thicknesses of 70 cm or more persisting for 4 to 6 months in winter moose habitat are the rule, and thicknesses in excess of 90 cm are not unusual. Winter thawing is rare, and snow cover tends to persist until spring. On the Kenai Peninsula, however, snow-cover thicknesses in winter moose habitat range near 40 cm for short periods and seldom reach 60 cm. Winter thaws are common, and bare ground may be exposed at any time throughout the winter. Snow conditions in interior Alaska differed somewhat between the winters of 1970–72. During the winter of 1970–71, the National Weather Service in Fairbanks documented a record snowfall of 307 cm (average total snowfall is 177 cm). Snow-cover thicknesses in excess of 90 cm persisted from December through March. During the winter of 1971–72, total snowfall in Fairbanks was 230 cm, and snow-cover thicknesses ranged between 60 and 73 cm from December through March. Snow-cover thicknesses on winter moose range around Fairbanks were somewhat greater during both winters than indicated by National Weather Service records.

Fall (September and October) and spring (April and May) represent periods of transition between winter and summer habitats. Rumen samples obtained during spring and fall, however, were collected primarily from moose on winter range. During summer (June–August), habitats of moose consist primarily of herbaceous and heath bogs.

Methods

In this preliminary study approximately three-fourths of the 166 rumen samples examined were collected and frozen prior to this exploratory study. The quantity of material collected from individual moose varied from one to several litres. In our study, 1 litre of rumen content was analyzed. This was done without knowing whether the 1 litre was representative of materials in a moose rumen.

The 1-litre sample was emptied into a gang of sieves and washed for several minutes with fresh water. Material retained in a 6.35-mm mesh sieve was separated to species when possible and sorted into plant parts such as fruits, green leaves, dry leaves, succulent twigs and buds, or roots. Unidentified items were categorized into 26 groups. The volume of each plant part was determined by water displacement and the importance calculated by adding the frequency of occurrence of a plant part to volume and dividing the sum by 2.

$$\text{Importance index} = \frac{\text{volume + frequency.}}{2}$$

Results*

Winter (November–March)

During the winter of 1970–71, examination of 44 samples of moose rumen contents from the Fairbanks area revealed a diet of primarily deciduous woody plants (Table 1). Of the identified food items, twigs of willow, birch, aspen, and alder, in decreasing order, were most frequently eaten. Other foods, by decreasing frequency, included fruit, dry aspen leaves, spruce twigs, willow fruit, and dry leaves. A small quantity of unidentified herbaceous material was found in one sample.

During the winter of 1971–72, 10 samples of moose rumen contents from the Fairbanks area were analyzed. As was the case during the previous winter, the diet consisted primarily of deciduous woody materials. The different snow conditions between the winters of 1970–71 and 1971–72 in interior Alaska did not influence the frequency of major food items found in rumen contents of moose. Also, during periods of greater than normal snow cover when moose died from starvation (winter of 1970–71), only one of the 44 samples contained spruce. It therefore appears that spruce is not consumed by moose near Fairbanks, even during periods of thick snow cover when the availability of deciduous browse is severely restricted.

A total of 51 samples collected from the Kenai Peninsula during the winter of 1971–72 was analyzed. Twigs of birch, aspen, and willow, in decreasing order, were most frequently eaten. The other most frequently eaten foods, in decreasing

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*Details of analysis available from Forest Service, USDA, Forest Environment Research, Washington, D.C. 20250.

TABLE 1 –Seasonal occurrence of plants in a 1-litre sample of moose rumen contents from the Fairbanks and Kenai regions, Alaska. Data are expressed as percentages of animals

Plants	Winter			Spring			Summer and Fall		
	Fairbanks		Kenai	Fairbanks		Kenai	Fairbanks		
							Summer	Fall	Fall
	1970–71	1971–72	1971–72	1971	1972	1972	1972	1971	1972
	n=44	n=10	n=51	n=15	n=6	n=8	n=10	n=7	n=15
Woody									
Identified									
Trees									
1. Aspen									
Twigs									
Hardened	56.8	20.0	76.5	20.0	16.7	75.0	0	28.6	6.7
Succulent	0	0	0	6.7	0	0	0	0	0
Leaves									
Dry	2.3	0	0	0	0	12.5	0	0	0
Green	0	0	0	0	0	0	10.0	0	13.3
2. Birch									
Twigs									
Hardened	70.5	90.0	78.4	80.0	100.0	62.5	40.0	71.4	66.7
Succulent	0	0	0	0	0	0	10.0	0	0
Leaves									
Dry	0	0	13.7	0	0	50.0	0	14.3	20.0
Green	0	0	0	0	0	0	0	28.6	6.7
Fruit	0	70.0	3.9	0	50.0	0	0	42.9	0
3. Cottonwood									
Twigs									
Hardened	0	20.0	17.0	0	16.7	0	0	0	20.0
Succulent	0	0	2.0	0	0	12.5	0	0	0
Leaves									
Green	0	0	0	0	0	0	0	0	6.7
4. Spruce									
Twigs									
Hardened	2.3	0	0	6.7	0	12.5	0	0	0
Needles									
Dry	0	0	0	0	0	12.5	0	0	6.7
Green	0	10.0	2.0	0	0	0	0	0	0
5. Larch									
Twigs									
Hardened	0	0	2.0	0	0	0	0	0	6.7
Tall shrubs									
1. Willow (unknown)									
Twigs									
Hardened	86.4	100.0	52.9	86.7	100.0	62.5	0	85.7	86.7
Succulent	0	0	0	13.3	0	0	90.0	0	0
Leaves									
Dry	2.3	10.0	0	26.7	0	0	0	42.9	40.0
Green	0	0	2.0	20.0	0	0	100.0	42.9	6.7
Fruit	2.3	10.0	0	26.7	0	0	0	0	0
2. Shrub birch									
Twigs									
Hardened	0	0	0	6.7	0	0	0	14.3	0
Succulent	0	0	0	0	0	0	10.0	0	0
Leaves									
Dry	0	0	0	0	0	0	10.0	14.3	13.3
Green	0	0	0	0	0	0	60.0	0	0

TABLE 1 – *continued*

Plants	Winter			Spring			Summer and Fall		
	Fairbanks		Kenai	Fairbanks		Kenai	Fairbanks		
							Summer	Fall	Fall
	1970–71	1971–72	1971–72	1971	1972	1972	1972	1971	1972
	n=44	*n*=10	*n*=51	*n*=15	*n*=6	*n*=8	*n*=10	*n*=7	*n*=15
3. Alder									
Twigs									
Hardened	25.0	30.0	3.9	13.3	50.0	0	0	28.6	20.0
Succulent	0	0	0	0	0	0	10.0	0	0
Leaves									
Dry	0	0	0	0	16.7	0	10.0	0	6.7
Green	0	0	0	0	0	0	10.0	0	6.7
Fruit	4.6	20.0	9.8	6.7	16.7	0	0	0	6.7
Low shrubs									
1. *Vaccinium* sp.									
Twigs									
Hardened	0	0	0	13.3	0	0	0	0	0
Leaves									
Green	0	0	29.4*	6.7	0	62.5*	0	14.3	6.7
2. *Ledum*									
Leaves									
Green	0	0	3.9	0	0	0	0	0	6.7
3. *Arctostaphylos*									
Leaves									
Dry	0	0	2.0	0	0	0	0	0	6.7
Green	0	0	2.0	0	0	0	0	0	0
4. *Rosa*	0	0	2.0	0	0	0	0	0	0
Unidentified									
Twigs									
Hardened	93.2	100.0	96.1	100.0	100.0	87.5	0	100.0	86.7
Dead + Bark	34.1	10.0	31.4	33.3	0	37.5	0	0	0
Leaves									
Dry	31.8	40.0	21.6	13.3	0	0	0	14.3	20.0
Green	2.3	5.0	0	0	16.7	0	0	28.6	53.3
Herbaceous									
Identified									
Lichens	0	0	3.9	0	0	0	0	0	0
Selaginella	0	0	2.0	0	0	0	0	0	0
Equisetum	0	0	5.9	0	0	12.5	90.0	28.6	20.0
Unidentified									
Fruit	0	0	0	0	0	0	0	14.3	0
Grass	0	0	17.7	6.7	0	12.5	50.0	14.3	6.7
Mushrooms	0	0	0	6.7	0	0	0	0	13.3
Sedges	0	10.0	0	13.3	0	0	0	14.3	0
Dry stems	2.3	0	0	0	0	0	0	14.3	0
Green stems, leaves	0	0	3.9	0	0	0	0	0	0

* *Vaccinium vitis-idaea.*

order, were green leaves of mountain-cranberry, grass, cottonwood twigs, dry birch leaves, alder fruit, *Equisetum*, lichens, green *Ledum* leaves, alder twigs, and birch fruit. The remaining identified food items occurred in only one of the 51 samples. The increase in use of herbaceous and ericaceous plants on the Kenai Peninsula versus the Fairbanks area is attributed primarily to the greater availability during winter of low-growing plants on the Kenai, due to mild snow conditions (LeResche and Davis 1973). Moose at Fairbanks most frequently ate willow, birch, and aspen, in decreasing order; but at Kenai, they most frequently ate birch, aspen, and willow. This difference is attributed primarily to food availability, not to differences in preference. LeResche and Davis (1973) observed the winter feeding habits of three semi-tame moose at the Kenai Moose Research Center. They found that between February and May, birch twigs, mountain-cranberry, willow, alder, and white spruce comprised 72, 21, 3, 3, and 1% of the diet, respectively. Our examination of 51 samples of rumen contents of animals from this same general area during winter revealed birch, aspen, willow twigs, green mountain-cranberry leaves, cottonwood twigs, and grass as the more frequently eaten foods.

Spring (April–May)

During the spring of 1971, analysis of 15 samples from Fairbanks revealed that hardened twigs of willow and birch were most frequently eaten. Other foods, in descending order of importance, were fruit and dry leaves of willow, hardened aspen twigs, green willow leaves, hardened alder twigs, sedges, hardened *Vaccinium* twigs, and succulent willow twigs.

During the spring of 1972, six samples collected near Fairbanks showed hardened willow and birch twigs in all samples, birch fruit and hardened alder twigs in half the samples. Analysis of eight samples collected from Kenai during spring of 1972 revealed hardened aspen twigs, followed by hardened willow and birch twigs, green leaves of mountain-cranberry, and dry birch leaves to be the most frequently eaten items.

Summer (June–August)

During the summer of 1972, 10 samples were collected near Fairbanks. All samples contained green willow leaves. Succulent willow twigs and *Equisetum* were found in nine samples. Six samples contained green shrub birch leaves, five had grass, and four had hardened birch twigs.

Fall (September–October)

During the fall of 1971, seven samples were collected near Fairbanks. Hardened twigs of willow and birch were followed in descending order by birch fruit, dry and green willow leaves, hardened aspen twigs, green birch leaves, hardened alder twigs, and *Equisetum*.

During the fall of 1972, 15 samples from the Fairbanks area contained hardened willow and birch twigs, dry willow and birch leaves, hardened twigs of cottonwood and alder, and *Equisetum*.

Conclusions and Recommendations

Results in this report are indicative of seasonal and regional variations in moose-habitat interactions. The small sample size within season and location precludes statistical analysis. Based on the formula developed by Hanson and Graybill (1956) we are, however, 95% confident that the frequency of major food items from 44 to 51 samples collected during winter near Fairbanks and Kenai has been established within ± 15% deviation.

These preliminary data, although more detailed, are in basic agreement with what Chatelain (1952) reported after analyzing moose rumen contents from Susitna to determine winter food habits. Locational and seasonal differences in moose food habits are evident from these data; however, to obtain food frequency information with a deviation of ± 10%, approximately 100 rumen samples should be examined for each season within specific geographic regions. This sample size is based on calculations from the formula of Hanson and Graybill (1956) and variations in the frequency of major food items in moose rumen samples from Fairbanks and Kenai, Alaska.

Acknowledgments

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Literature Cited

Chatelain, E. F. 1951. Winter range problems of moose in the Susitna valley. Proceedings of the 2nd Alaskan Science Conference. pp. 343–347.

Chatelain, E. F. 1952. Distribution and abundance of moose in Alaska. Proceedings of the 3rd Alaskan Science Conference. pp. 134-136.

Hakala, John B., Robert K. Seemel, Robert A. Richey, and **John E. Kurtz.** 1971. Fire effects and rehabilitation methods—Swanson-Russian Rivers fires. *In* Fire in the northern environment, a symposium. United States Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station, Portland, Oregon. pp. 87–99.

Hanson, W. R. and **F. Graybill.** 1956. Sample size in food-habits analysis. Journal of Wildlife Management 20: 64–68.

Johnson, P. R. and **C. W. Hartman.** 1969. Environmental atlas of Alaska. University of Alaska, Institute of Arctic Environmental Engineering and Institute of Water Resources, Fairbanks, Alaska. 111 pp.

Leopold, A. S. and **F. F. Darling.** 1953a. Wildlife in Alaska: An ecological reconnaissance. Ronald Press Co., New York. 129 pp.

Leopold, A. S. and **F. F. Darling.** 1953b. Effects of land use on moose and caribou in Alaska. Transactions of the 18th North American Wildlife Conference. pp. 553-562.

LeResche, R. L. and **J. L. Davis.** 1973. Importance of non-browse foods to moose on the Kenai Peninsula, Alaska. Journal of Wildlife Management 37: 7–8.

Peek, J. M. 1973. A review of moose food habit studies in North America. Science Journal Series, Paper 8170. Minnesota Agricultural Experiment Station, St. Paul. 30 pp.

Spencer, D. L. and **E. F. Chatelain.** 1953. Progress in the management of the moose of south central Alaska. Transactions of the 18th North American Wildlife Conference. pp. 539-552.

Spencer, David L. and **John B. Hakala.** 1964. Moose and fire on the Kenai. Proceedings of the 3rd Annual Tall Timbers Fire Ecology Conference. pp. 11-33.

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Woodland Caribou and Plant Communities on the Slate Islands, Lake Superior

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Abstract. A unique predator-free population of woodland caribou has existed on the Slate Islands since about 1907. While they seem to prefer mature coniferous portions of their range in winter, extensive use of non-mature areas indicates they are not dependent on mature forests for survival.

During 3–14 June 1974 we investigated the winter distribution of woodland caribou (*Rangifer tarandus caribou*, Gmelin) on the Slate Islands (Figure 1). These caribou have two choices of habitat on the islands, either mature conifer forest with virtually no hardwoods present, or a mixedwood forest in relatively early stages of succession. Woodland caribou sometimes have been considered animals of mature boreal forests (Simkin 1965) and management efforts have been directed towards providing mature forest conditions. Other evidence (Bergerud 1972) implies that mature forests may not be necessary. It is instructive to study woodland caribou activities on a restricted range where their choice of habitat is limited and their preferences can be measured.

The Study Area and the Caribou Population

The Slate Islands lie within the boreal forest zone of Canada about 12.9 km south of Terrace Bay, Ontario in Lake Superior (Figure 1). They include eight major islands with a combined land area of some 36.3 km^2. The topography is rugged and steep cliffs along the water edge are prominent features. Characteristic tree species include white spruce (*Picea glauca*), black spruce (*Picea mariana*), balsam fir (*Abies balsamea*), and white birch (*Betula papyrifera*). In disturbed areas mountain ash (*Sorbus americana*), balsam poplar (*Populus balsamifera*), trembling aspen (*Populus tremuloides*), pin cherry (*Prunus pensylvanica*), and mountain maple (*Acer spicatum*) are common. In the absence of disturbance, the mature forest is composed primarily of spruce and fir, with scattered patches of relict white birch and a few white cedar (*Thuja occidentalis*).

At least one large fire occurred in the early 20th century on Patterson Island; consequently much of the largest island's forests date from this period (Parsons 1918). Logging activity occurred during the 1930s on a portion of the islands but the extent of coverage is unknown (D. King, personal communication).

When Cringan (1956) studied caribou on these islands he described, after Seely (1949), the following major forest types: (*A*) dry and medium moisture hardwoods, mostly white birch with some mountain ash, aspen, and balsam fir regeneration; (*B*) dry and medium moisture mixedwood composed primarily of birch and balsam fir with some mountain ash, black spruce, and white spruce; and (*C*) dry and medium moisture conifer essentially balsam fir, white and black spruce with a few birch. In 1949, 13.8% of the islands' area was covered with pure conifer, 62.7% with mixedwood, and 23.5% with hardwood cover (Cringan 1957). The general successional trend is for aspen and birch to invade recently cut or burned areas and persist for some 60–80 years. Balsam fir, white and black spruce regenerate under the hardwood canopy and eventually, perhaps 150–200 years later, tend to become dominant. Increment borings taken in June 1974 indicated that much of the extensive mixedwood forest originated 70 to 75 years ago. Substantial balsam fir became established in these stands some 10 to 30 years ago or about 40–60 years following the disturbance.

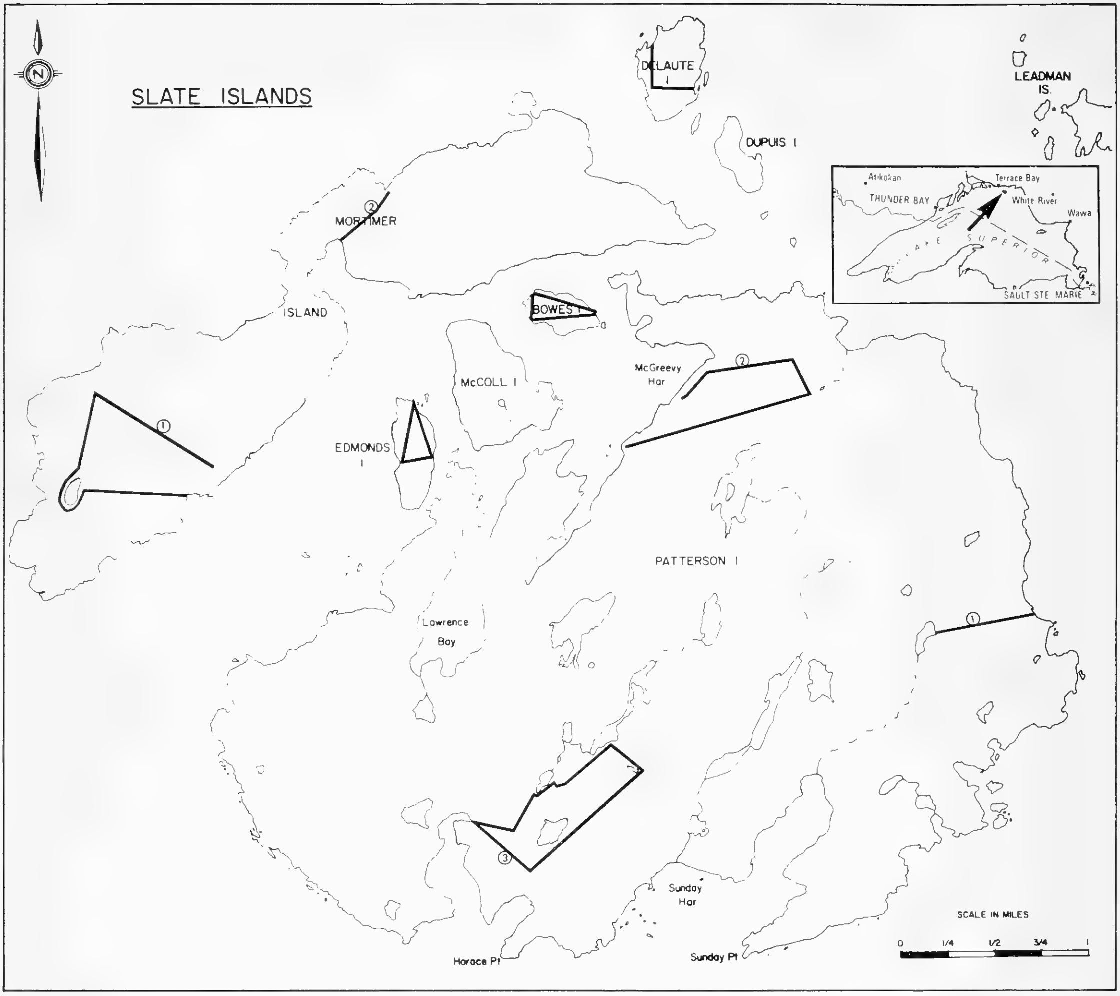

FIGURE 1. Map of the Slate Islands showing locations of transect lines used to sample woodland caribou pellet groups.

There are no records which indicate that woodland caribou existed on the islands prior to 1907. In 1907 D. King (personal communication) wintered on the islands and hunted extensively for caribou during the first part of the winter. He could not find any of these animals. In March of 1907, however, he reported caribou tracks over the ice leading from the mainland. The animals became established and have persisted to the present. Most winters the water between the islands and the mainland remains open but occasionally, as in 1907, it freezes and provides a route to the mainland. No wolves or wolf sign has ever been reported, and the islands are apparently free of caribou predators. Occasional reports of caribou swimming to the mainland have been received by Ministry of Natural Resources personnel, but no verification by a biologist or conservation officer is available. This population of woodland caribou constitutes a unique example of an insular population without predators.

A comprehensive and accurate census of the animals is very difficult to obtain. Several investigators have made aerial and ground surveys but these estimates are subject to many possibilities of error. Information from these ground and aerial surveys taken from the Ontario Ministry of Natural Resources Files is summarized in Table 1.

The number of animals estimated by all observers over the 25-year period has been very consistent until November 1974. This may be in part as a result of an inherent bias to agree with the known count of previous investigators. The counts in June 1959 and April 1972, however, reveal that there were at least 26 and 31 animals, respectively, on the islands at those times. In addition during the 1974 aerial survey, observers actually sighted six animals, but also saw tracks of 27 different animals in fresh snow (Chappel, personal communication). Recent estimates in an unpublished report by A. T. Bergerud (1974 Wildlife investigations on the Slate Islands. 46 pp.) put the total at about 140 animals. This estimate is of course, substantially higher than the others and may reflect either a fairly recent population increase or a better estimate. This work is continuing and will be reported in detail at a later date.

Forest composition has changed through natural succession since Cringan (1956) studied caribou on these islands. The 23.5% of the islands' area covered with hardwood stands has been significantly reduced as the balsam fir and spruce have grown up under the hardwood canopy. Those stands of hardwood which remain are small and scattered and are probably not significant to the animals. Present forest composition is estimated by the authors at 5% or less hardwood, 70–75% mixedwood, and 20–25% conifer. This estimate is based on an extensive ground survey of plant communities and an aerial survey, both in June 1974.

Methods

Pellet groups were counted to indicate presence or absence of animals within a forest type. These pellet groups were deposited after the leaves had fallen in November, and reflect average distribution of caribou over the entire 5- to 6-month winter period from mid-November to mid-May. No attempt was made to subdivide this winter period into smaller units of time correlated with the severity of the weather. This measurement is a method to determine the relative amount of time these caribou spent in a given forest type over the entire winter period. Pellet groups deposited after green vegetation was available in early spring were easily distinguished from winter groups by their amorphous shape.

Forest types were selected from a forest-type map of the islands to include representative stands throughout the islands' area. The transect lines were selected at random within each forest type and divided into study plots approximately 50 by 2 m. All winter pellet groups within each study plot were counted between 3 and 14 June 1974. One hundred eighty-one study plots were tallied in

TABLE 1—Estimation of the number of caribou on the Slate Islands by 14 observers over a 25-year period

Investigator	Date	Estimated caribou population	Actual number seen
A. T. Cringan	Summer 1949	30–40 (ground survey)	?
C. W. Douglas	February 1954	25 (aerial survey)	8
C. E. Perrie	January 1954	30 (aerial survey)	2
H. G. Cumming	July 1956	25–30 (aerial survey)	11
J. Goddard	March 1959	? (aerial survey)	0
J. Goddard	June 1959	40 (ground survey)	26
J. Chappel	February 1965	22–24 (aerial survey)	16
D. W. Simkin	June 1965	25 (ground survey)	11
B. H. Gibson	March 1972	25–30 (aerial survey)	18
B. H. Gibson	April 1972	35–40 (aerial survey)	31
J. Chappel	March 1974	30–35 (aerial survey)	6
D. Euler, B. Snider, H. Timmerman	June 1974	25–40 (ground survey)	10
Bergerud	November 1974	140 (ground survey)	?

mixedwood and 108 in conifer. Conifer stands were somewhat oversampled because the discontinuous nature of the islands' forest cover made exact proportional sampling difficult. Location of transect lines is shown in Figure 1. Student's *t* test was used to compare pellet groups per study plot in mixedwood and conifer.

Results and Discussion

The number of winter pellet groups per study plot revealed that caribou were active in both habitat types and widely distributed over the islands (Table 2). The percentage of study plots with one pellet group was considerably higher in mixedwood than conifer (Figure 2). The number of study plots with two or more pellet groups, however, was higher in conifer than mixedwood stands. For the data taken together, the mean number of pellet groups per study plot in conifer was significantly higher than in mixedwood (Table 2). There were some interesting exceptions. Delaute and Bowes Islands mixedwood stands had more pellet groups than Edmonds and Patterson Islands conifer stands. In these cases factors other than the successional stage of the forest may have been more important in influencing caribou distribution in winter than forest maturation.

The distribution of caribou over the islands indicates that, in general, they spend more time in conifer than in mixedwood forests during winter. Conifer stands occupy about 20–25% of the area and may serve as staging areas from which forages are made into the mixedwood. The wide distribution of pellet groups and the high proportion of study plots in mixedwood with one pellet group, supports the contention that the animals are wide-ranging in both habitat types during winter.

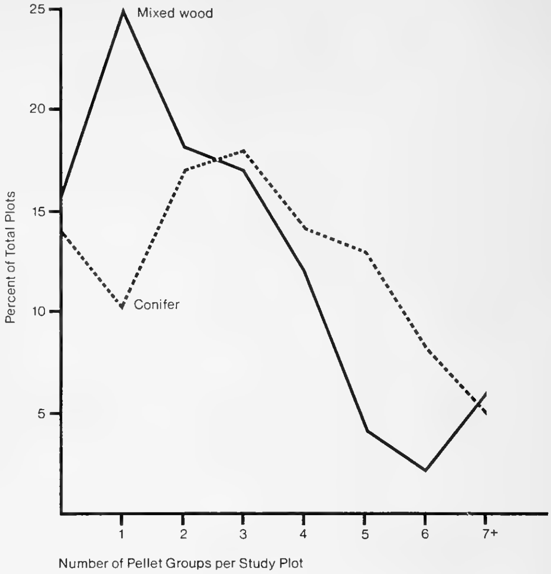

FIGURE 2. Graph of the percentage of 100-m^2 study plots having woodland caribou pellet groups in the two major habitat types on the Slate Islands.

The value of the conifer stands to caribou is not entirely clear because time spent in this area may be for protection from winter weather, for gathering food, or both. It is clear, however, that

TABLE 2—Average number of pellet groups per 100-m^2 quadrat by habitat types on the Slate Islands

Island sampled	Habitat type	Mean pellet groups per study plot	Number of study plots
Mortimer (2)	Conifer	5.06 ± 3.28	16
Edmonds	Conifer	3.03 ± 2.05	35
Patterson (3)	Conifer	2.87 ± 1.98	57
		3.19 ± 2.34	108
Mortimer (1)	Mixedwood	2.46 ± 1.72	61
Delaute	Mixedwood	4.80 ± 3.41	20
Bowes	Mixedwood	3.17 ± 1.83	24
Patterson (1)	Mixedwood	2.04 ± 1.40	25
(2)	Mixedwood	1.15 ± 1.29	51
		2.22 ± 2.02*	181

* indicates significance at $P < 0.05$ (Student's *t* test).

these caribou spend substantial time in winter away from the climax forest, perhaps in search of food supplies not present in the mature areas.

A major unresolved question of woodland caribou ecology concerns their dependence on climax forest. Cringan (1957) concluded that woodland caribou are dependent on mature forest because they need the lichens associated with this type. His studies on the Slate Islands showed that lichen utilization was very heavy and that more lichens were associated with mature forest than with other types. In contrast, Bergerud (1972) reported "Although caribou are adapted to a diet of lichens, lichens are not essential (Murie 1953, p. 36) or even preferred (Ahti 1959, p. 6)." Scotter (1970) thought the destruction of mature forest and the associated loss of lichens was a factor in the decline of barren-ground caribou in Canada. Simkin (1965, p. 67) stated "Caribou is the one big game species well adapted to living in climax coniferous forests. . . ."

Conditions of the caribou and plant communities of the Slate Islands may shed some evidence on this problem. A massive disturbance (burning) to the island ecosystems occurred at about the same time that caribou colonized the islands. They have maintained a viable population for about 67 years in an area that was primarily in early stages of vegetative succession. It is clear that extensive forest disturbance and continuing caribou populations were not mutually exclusive in this example. The first measurement of forest cover by Cringan (1956) indicated less than 15% of the islands' area was at or near the climax phase of succession. This measurement was some 40–45 years after caribou became established. In order for a population of at least 30–40 animals to exist at that time the habitat must have been reasonably adequate for the animals. Most of the islands' area is not climax forest at present, yet the caribou population appears to be relatively stable. These facts tend to support the hypothesis that woodland caribou, to survive, do not necessarily need a major portion of their range in climax forest.

It is well known that woodland caribou are adapted to a diet of lichens (Bergerud 1972; Simkin 1965), but it seems lichens may not be essential for their survival. Studies of caribou food habitats reveal that a wide variety of lichens, woody browse, and herbaceous plants are consumed (Banfield 1954; Tener 1963; Bergerud 1972). In this case, habitat management for woodland caribou may well consist of prescribed burning or logging to provide early successional plant communities over part of the range.

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Literature Cited

Ahti, T. 1959. Studies on the caribou lichen stands of Newfoundland. Annales Botanici Societatis Zoologicae Botanicae Fennicae 'Vanamo' 30(4). 44 pp. (Finnish Summary.)

Banfield, A. W. F. 1954. Preliminary investigations of the barren ground caribou. Part II, Life history, ecology, and utilization. Canadian Wildlife Service, Wildlife Management Bulletin, Series 1, Number 10B. 112 pp.

Bergerud, A. T. 1972. Food habits of Newfoundland caribou. Journal of Wildlife Management 36(3): 913–923.

Cringan, A. T. 1956. Some aspects of the biology of caribou and a study of the woodland caribou range of the Slate Islands, Lake Superior, Ontario. M.A. thesis, University of Toronto, Toronto. 300 pp.

Cringan, A. T. 1957. History, food habits and range requirements of the woodland caribou of continental North America. Transactions of the North American Wildlife Conference 22: 485–501.

Murie, O. J. 1935. Alaska-Yukon caribou. United States Department of Agriculture, Bureau of Biological Survey, North American Fauna, Number 54. pp. 1–93.

Parsons, A. L. 1918. Slate Islands, Lake Superior. Ontario Department of Mines XXVII (part 1): 155–167.

Scotter, G. W. 1970. Wildfires in relation to the habitat of barren ground caribou in the taiga of northern Canada. Proceedings of the Tenth Annual Tall Timbers Fire Ecology Conference 10: 85–105.

Seely, H. E. 1949. Meeting of the committee on surveys research, Canadian Society of Forest Engineers, Ottawa, February 4th, 1949. Forestry Chronicle 25: 62–65.

Simkin, D. W. 1965. A preliminary report of the woodland caribou study in Ontario. Ontario Department of Lands and Forests Research Report Number 59. 76 pp.

Tener, J. S. 1963. Queen Elizabeth Island game survey, 1961. Canadian Wildlife Service Occasional Paper Number 4. 50 pp.

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Insect Pollinators of the Mer Bleue Peat Bog of Ottawa*

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Small, Ernest. 1976. Insect pollinators of the Mer Bleue peat bog of Ottawa. Canadian Field-Naturalist 90(1): 22–28.

Abstract. Insect visitors to flowers of the major insect-pollinated plants of the Mer Bleue peat bog of Ottawa were studied. Ten hours of collecting on each of 13 plant species produced 1362 insects belonging to 184 species, mostly of Hymenoptera and Diptera. All major entomophilous species of the bog flowered in May and June; this suggests a possibility of competition for pollinators. The plant species generally attracted a diverse but somewhat numerically small assemblage of insect species. There was a notable segregation of insect species to certain of the plant species considered. There were differences in the abilities of the abundant plant species to draw pollinators. *Vaccinium myrtilloides* proved to be the most successful in attracting pollinators, and *Kalmia angustifolia* the least successful.

The Mer Bleue peat bog of Ottawa is an important scientific and cultural resource. The usefulness of this outstanding wilderness area has been enhanced by the publication of descriptions of various facets of the natural history of the area which have appeared in *The Canadian Field-Naturalist* in the series introduced by Baldwin and Mosquin (1969). The present study attempts to add to this knowledge by providing a preliminary evaluation of the pollination relationships of the major entomophilous plant species of the Mer Bleue.

The reproductive success of many outcrossing plant species is partly dependent on their ability to attract suitable pollinators. Competition for pollinators between cultivated and wild plants has been extensively studies (e.g., Free 1970), and it is clear that in both domesticated and natural habitats there is frequently a dearth of pollinators in relation to the needs of the plants (Hocking 1968; Mosquin 1971; Kevan 1972). Natural communities of plants and animals are the results of millenia of selection, and study of such communities may be expected to reveal pollination relationships which represent the outcome of co-evolution.

Many areas are populated by highly diverse communities of pollinator-requiring plants. The complex interactions of numerous plant species are difficult to interpret, and it is desirable to examine competition in habitats that are populated by few pollinator-requiring plants, and that are sufficiently extensive to monopolize the interests of a pool of pollinating agents. In north temperate areas, perhaps no other habitat better satisfies these criteria than peat bogs, as these are depauperate in plant species diversity (Small 1972), and often occupy very extensive tracts of land. The Mer Bleue peat bog of the Ottawa area is large (6300 acres), well-described (Joyal 1970; Small 1974), and has existed for several thousand years (Camfield 1969). It therefore provides an ideal area for the study of how a natural plant community shares the available pollinator resources.

It is well known that pollinators are attracted to specific plant species in order to obtain nectar and pollen; this attraction is effected by a variety of olfactory and visual stimuli. Some bog plant species, including many orchids, require particular pollinators (Thien and Marcks 1972). An additional determinant of a plant species' ability to attract pollinators is the density of that species in the area. As embodied in "Arnell's dominating flower phenomenon" (Faegri and van der Pijl 1971, p. 60) many Lepidoptera and bees tend to ignore rare plant species. Time of flowering is another aspect that is important to a plant species' success in attracting pollinating agents (Robertson 1924). By spreading flowering time throughout the season, the members of a plant community reduce the demand for pollinators at a given time (Levin and Anderson 1970; Mosquin 1971). Previous phenological studies (Judd 1958; Pojar 1974; Heinrich 1975), have indicated that flowering of species in bogs is staggered.

In a study of the major bee (Apoidea) pollinators of five Ericaceous plant species (four of which

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*Contribution Number 8 to "Scientific and Cultural Studies of the Mer Bleue."

were also examined in the present study), Reader (1975) calculated coefficients expressing possible competitive relationships for pollinators by the plant species. Evidence for interspecific competition for pollinators in bog species has not yet been obtained, however, and is not available from the present study.

Materials and Methods

During the 1973 season, collections of flower-visiting insects were made on 13 plant species of the Mer Bleue. The plants included all except the infrequent entomophilous plants of the bog proper, and two species from the margin of the bog, *Salix fragilis* and *Spiraea alba.* The latter two species flowered before and after, respectively, the major entomophilous species of the bog proper, and provided a means of evaluating the availability of pollinators outside the competitive season of the major bog plant species.

The site studied was near the end of the Dolman Ridge Road. This road is built on a large sand ridge, that narrows to a width of 500 m near the study area, and extends well into the bog. The location was chosen because it appeared representative of much of the bog which is in a late successional stage; it is dominated by ericaceous shrubs with pockets of larch (*Larix laricina*) and black spruce (*Picea mariana*). Most collections were made at least 100 m into the bog proper, and all collections were made within 500 m of each other. Most soil-dwelling bees avoid residing in much of the bog because of the moistness of the substrate (Osgood 1972), but do inhabit its margins. As the study area was not distant from the sand ridge, the available pollinator pool was larger than in more remote sites within the bog.

Ten man-hours were spent netting or aspirating insects on each of the 13 plant species examined. The 10 hours spent on a given plant species were devoted entirely to that species, while ignoring pollinators on other plants. Collections were made between 1000 and 1500h, during the peak flowering period of the species. Collecting was curtailed on windy, rainy, overcast, or cold days, because any one of these conditions markedly reduced insect-visiting activity. In an attempt to acquire only insects whose activities might effect pollination, insects stopping casually at flowers were not collected. Collectors were free to wander in the study area, and the attempt was made to collect as many insects as possible within the allotted time. Insects previously not collected or rarely collected from the Mer Bleue are deposited in the Canadian National Collection of Insects (CNC).

In an attempt to evaluate the necessity for insects for seed set, inflorescences of 10 plants of each species were bagged with insect-excluding bags, and subsequently examined for seed set.

Observations

The progression of flowering of the major entomophilous species in the Mer Bleue is shown in Figure 1. Flowering of these species was more or less confined to May and June. A number of relatively infrequent species flowered somewhat later: *Vaccinium oxycoccus* L. and *Sarracenia purpurea* L. in late June, and *Drosera rotundifolia* L. and *Cypripedium acaule* Ait. in middle to late July.

The insect species of which at least 10 individuals were collected, and the plant species on which they were obtained, are listed in Table 1. A table giving this information for all insects collected is available from the Depository of Unpublished Data, National Science Library, National Research Council of Canada, Ottawa, Canada K1A 0S2. Table 2 presents a statistical summary of the numbers of insect species and of individuals taken on each of the 13 plant species studied. Altogether 184 insect species of six orders were collected; 71 of these were represented by only one individual, and 32 by only two individuals. During the 130 hours of collecting 1362 insects were captured—approximately one insect every 6 minutes.

Kalmia polifolia, Smilacina trifolia, Andromeda galucophylla, and *Calopogon pulchellus* were sparsely present in the study area (Figure 1) and attracted relatively few insects. *Vaccinium myrtilloides* was visited almost exclusively by bees (Apoidea) and clearly was the most attractive plant to bees. In relation to its abundance, *Kalmia angustifolia* received notably few insect visitors.

Two insect orders, Diptera and Hymenoptera, accounted for 91.4% of the individuals collected. The Diptera were especially diverse, and of the 107 species collected, few were represented by large numbers of individuals. On the other hand, a number of bee species were represented by many

TABLE 1. Species of insects collected on plant species. Only insect species for which at least ten individuals were collected are shown.
☿ = worker caste (for Apidae only).

Insect species	Number of individuals	Plant species												
		1. *Salix fragilis*	2. *Chamaedaphne calyculata*	3. *Nemopanthus mucronata*	4. *Andromeda glaucophylla*	5. *Kalmia polifolia*	6. *Smilacina trifolia*	7. *Vaccinium myrtilloides*	8. *Aronia melanocarpa*	9. *Ledum groenlandicum*	10. *Gaylussacia baccata*	11. *Kalmia angustifolia*	12. *Calopogon pulchellus*	13. *Spiraea alba*
LEPIDOPTERA														
Adela purpurea Wlk.	20	20												
Thymelicus lineola Ochs.	10												7	3
COLEOPTERA														
Macrodactlyus subspinosus F.	15													15
Cyphon prob. *variabilis* (Thunb.)	37	37												
DIPTERA														
Hybomitra minuscula (Hine)	12													12
Hybomitra typhus (Whit.)	14										1	13		
Dilophus caurinus McAtee	87			87										
Spilogona fatima (Huckett)	13	1	7	4			1							
Sphaerophoria sp. (spp?)	15		1				2		8	4				
Pyrophaena rosarum (Fab.)	11			2			6			1		1		1
Melanostoma sp.	26		1	15			9		1					
Sericomyia transversa (Osb.)	32					4		1		2	23	2		
Eristalis dimidiata Wied.	18								2	5	7			4
Helophilus latifrons Lw.	19								1	14	4			
Helophilus fasciatus Walk.	11		1						2	4	3	1		
Helophilus laetus Lw.	10								3	4				3
Syritta pipiens (L.)	19						1		14			3		1
Toxomerus marginatus (Say)	14												14	
Syrphus torvus O.S.	14			1					13					

HYMENOPTERA												
Apis mellifera L.	24	1☿		1☿		1☿	20☿			1☿		
Bombus terricola terricola Kby.	82	3♀					2♀-12☿		3♀,19☿	1♀,6☿		36☿
Pyrobombus impatiens (Cress.)	30		1♀		2♀	1♀	17♀		5♀	3♀		1☿
Pyrobombus perplexus (Cress.)	21	2♀				1☿	3♀,11☿	2☿				2☿
Pyrobombus sandersoni (Flkn.)	34	2♀	1☿			1☿	7☿	2☿	3☿	5♂,9☿	2♀	2☿
Pyrobombus ternarius (Say)	50	2♀	1♀	1♀	1♀	1♀,2☿	5♀,11☿	1♀	3♀,6☿	2♀,4☿	1♀,2☿	7☿
Andrena alleghaniensis Vier.	11			6♀				3♀	2♀			
Andrena bradleyi Vier.	48	5♂	8♀,17♂			2♀	12♀			4♀		
Andrena carlini Ckll.	11	1♀	6♂	1♀,1♂			1♀		1♀			
Andrena carolina Vier.	16	1♂					6♀		4♀	5♀		
Andrena mandibularis Robt.	34		1♀	6♀,1♂		9♀,4♂	1♀		9♀		2♀,1♂	
Andrena regularis Mall.	66		4♂	1♂		6♀	10♀	7♀	31♀	7♀		
Andrena vicina Sm.	83	2♀,9♂	2♀,17♂	1♀,3♂		1♀	7♀	1♀	11♀	29♀		
Colletes inaequalis Say	73	4♀,47♂	3♀,3♂				11♀	2♀	3♀			
Dialictus pilosus (Sm.)	12			1♀		4♀		7♀				

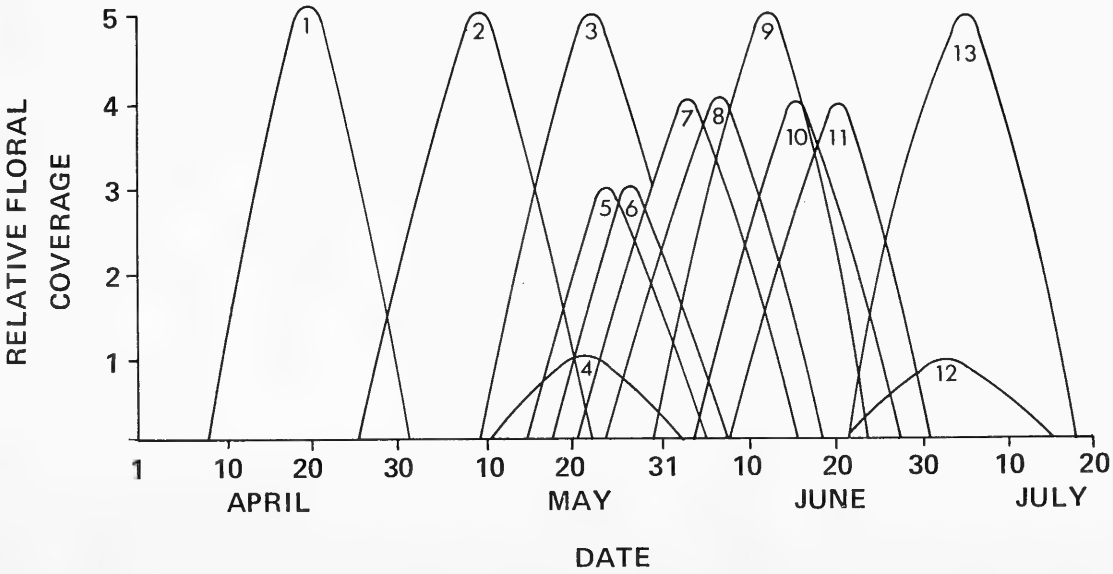

FIGURE 1. Relative floral coverage (relative percentage area covered by open flowers) and flowering periods of species examined. The numbers correspond to the plant species given in the tables.

TABLE 2—Summary of numbers of species (with numbers of insects in parentheses) collected on each species of plant

Plant species	Insect order						Sums	% of total individuals
	Homoptera	Hemiptera	Lepidoptera	Coleoptera	Diptera	Hymenoptera		
1. *Salix fragilis* L.	1(1)	1(1)	1(20)	3(45)	11(22)	17(92)	34(181)	13.3
2. *Chamaedaphne calyculata* (L.) Moench.			2(6)	1(1)	13(22)	12(68)	28(97)	7.1
3. *Nemopanthus mucronata* (L.) Trel.					31(148)	18(47)	49(195)	14.3
4. *Andromeda glaucophylla* Link.			1(1)		1(1)	2(3)	4(5)	0.4
5. *Kalmia polifolia* Wang.			1(5)		6(12)	17(40)	24(57)	4.2
6. *Smilacina trifolia* (L.) Desf.				1(1)	18(39)	3(3)	22(43)	3.2
7. *Vaccinium myrtilloides* Michx.					2(2)	21(152)	23(154)	11.3
8. *Aronia melanocarpa* (Michx.) Ell.			1(1)	1(1)	28(75)	16(36)	46(113)	8.3
9. *Ledum groenlandicum* Oeder					27(63)	16(108)	43(171)	12.6
10. *Gaylussacia baccata* (Wang.) K. Koch					9(42)	18(91)	27(133)	9.8
11. *Kalmia angustifolia* L.					10(25)	9(16)	19(41)	3.0
12. *Calopogon pulchellus* (Sw.) R. Br.			1(7)		3(17)		4(24)	1.8
13. *Spiraea alba* du Roi			6(12)	2(16)	31(64)	9(56)	48(148)	10.9
Sums	1(1)	1(1)	10[1](52)	7(64)	107(532)	58(712)	184(1362)	
% of total individuals	0.1	0.1	3.8	4.7	39.1	52.3		

[1] Columns are not additive for numbers of different insect species; a given species often was collected on different plant species.

individuals. Prominent among these were honey bees (*Apis mellifera*), bumblebees (of the genera *Bombus, Megabombus,* and *Pyrobombus*; some Hymenopterists (e.g., Mitchell 1962) refer all bumblebees except *Psithyrus* to *Bombus*), and other bees of the genera *Andrena* and *Colletes*.

All of the bagged influorescences exhibited no, or drastically reduced, fruit and seed set.

Discussion

The present study has been particularly concerned with assessing how pollinator resources are apportioned to a natural plant community composed of a limited number of plant species attracting pollinators. Given the failure of bagged flowers to set seed, it appears that pollinators were required. Whether the supply of pollinators was in fact limiting seed set cannot be deduced from the present study.

Generally two or three insect species accounted for half of the individuals collected on a given plant species, and not infrequently all, or almost all, individuals of a particular insect species were collected on a given plant species. At the same time most insect species did not exhibit marked restriction to certain plant species, and indeed the majority of insect species collected occurred very infrequently in the bog, suggesting lack of dependence on the bog plant species. It should be kept in mind that the host specificity shown by insects in this particular study does not necessarily reflect either general fidelity or independence; for example, most of the individuals of *Colletes inaequalis* were collected from *Salix* and *Vaccinium*, but it is known that this bee visits a wide range of flowering plants (Mitchell 1960, p. 41). On the whole there was a pronounced segregation of insect species visiting the species of plants considered.

The insects collected likely vary considerably in pollinating ability. (See Faegri and van der Pijl (1971) for discussions of pollinating abilities of various insect groups.) No attempt was made to assess foraging behavior, stomach contents, or pollen load, and consequently short-term fidelity which characterizes good pollinators. It would seem reasonable to postulate, however, that the bees, as in other studies, by virtue of a variety of behavioral and structural features, are the most important pollinating agents. The "bees" (including species of the Apidae, Andrenidae, Colletidae, Halictidae, Megachilidae, and Anthophoridae) composed the bulk of the Hymenoptera collected. The "social-bees"—the Apidae—appear to be especially important pollinators in the bog. Twenty individuals of the Ichneumonidae (which include parasitoids of lepidopteran larvae) were collected; these probably are not significant as pollinators. The Diptera are considered less efficient pollinators than the bees, but one family, the Syrphidae, which was richly represented in the bog, is likely quite significant in effecting pollination. Lepidoptera were very inconspicuous in the present study, although it may be noted that no attempt was made to sample for possible nocturnal visits by moths. Coleoptera, which comprised 4.7% of the collected insects, also do not appear to represent important pollinating agents in the bog.

Vaccinium myrtilloides, the bog species most attractive to bees, is a frequently cultivated low-bush blueberry. A great deal of research literature is available on the pollination ecology of the cultivated blueberry (Free 1970, Chapter 27). All of the abundant bees found on *V. myrtilloides* in this study have been previously recorded on *Vaccinium* (Mitchell 1960, 1962; Boulanger et al. 1967). Bumblebees, which were very abundant on blueberry in the Mer Bleue, have long tongues capable of reaching the nectaries at the base of the flower; these can only be reached by pushing the tongue between the stamen filaments surrounding the nectaries. A large bee population appears essential for adequate seed set of most varieties of blueberries. Small bogs, where *Vaccinium* is cropped, have often been found to have a sufficient wild bee population for adequate pollination, whereas large bogs such as the Mer Bleue usually require the introduction of honeybees (Free 1970, p. 342.). To judge by the observation of Kinsman (1957), that sufficient pollination of low-bush blueberries requires one pollinating insect per square metre during favorable weather, the *Vaccinium* population of the Mer Bleue was under-pollinated, but not drastically so.

In contrast to *V. myrtilloides, Kalmia angustifolia* was the least attractive major plant species of the Mer Bleue. The reasons for this are not clear, as the less abundant *Kalmia polifolia,* which has very similar flowers, appeared fairly attractive to insects in relation to its abundance.

In terms of relative flowering time, it was somewhat surprising to find that all of the major competitors within the bog flowered in early and middle summer. Early flowering provides plant species ample time to mature fruit, but one might expect some species to flower later and thereby take advantage of possible reduced competition for pollinators late in the season. The large number of insects collected on *Salix* and *Spiraea*, which flowered before and after, respectively, the major bog species, indicated a large pollinator pool was available for early and late flowering plants. As noted, a number of infrequent plants—*Sarracenia purpurea, Drosera rotundifolia, Vaccinium oxycoccus* and *Cypripedium acaule*—flowered in late summer, perhaps indicating a measure of adaptive displacement in flowering time. As well, the unusual flowers of these species may be adapted to, and especially attractive to specific pollinators.

More extensive study than that reported here, preferably over several seasons, will be required to evaluate the competitive interspecific pollination relationships of the plants of the Mer Bleue. The present finding of apparently pronounced superiority of some plant species over others in ability to attract pollinators suggests that this factor may partly determine success in the bog.

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Literature Cited

Baldwin, W. K. W. and **T. Mosquin.** 1969. Scientific and cultural studies of the Mer Bleue. Canadian Field-Naturalist 83: 4–6.

Boulanger, L. W., G. W. Wood, E. A. Osgood, and C. O. Dirks. 1967. Native bees associated with the low-bush blueberry in Maine and eastern Canada. Maine Agricultural Experiment Station, and Canada Agricultural Research Station, Fredericton, Technical Bulletin 26. 22 pp.

Camfield, M. 1969. Pollen record of the Mer Bleue. Canadian Field-Naturalist 83: 7–13.

Faegri, K. and L. van der Pijl. 1971. The principles of pollution ecology. Second edition. Pergamon Press, Toronto. 291 pp.

Free, J. B. 1970. Insect pollination of crops. Academic Press, New York. 544 pp.

Heinrich, B. 1975. Bee flowers: a hypothesis on flower variety and blooming times. Evolution 29: 325–334.

Hocking, B. 1968. Insect-flower associations in the high Arctic with special reference to nectar. Oikos 19: 359–388.

Joyal, R. 1970. Description de la tourbière à sphaignes Mer Bleue près d'Ottawa. I. Végétation. Canadian Journal of Botany 48: 1405–1418.

Judd, W. W. 1958. Studies of the Byron Bog in southwestern Ontario. II. The succession and duration of blooming of plants. Canadian Field-Naturalist 72: 119–121.

Kevan, P. G. 1972. Insect pollination of high arctic flowers. Journal of Ecology 60: 831–847.

Kinsman, G. B. 1957. The low-bush blueberry in Nova Scotia. Department of Agriculture and Marketing, Halifax, Nova Scotia, Publication 1036. 22 pp.

Levin, D. A. and W. W. Anderson. 1970. Competition for pollinators between simultaneously flowering species. American Naturalist 104: 455–467.

Mitchell, T. B. 1960. Bees of the eastern United States. Volume 1. North Carolina Agricultural Experimental Station Technical Bulletin Number 141. 538 pp.

Mitchell, T. B. 1962. Bees of the eastern United States. Volume 2. North Carolina Agricultural Experimental Station Technical Bulletin Number 152. 557 pp.

Mosquin, T. 1971. Competition for pollinators as a stimulus for the evolution of flowering time. Oikos 22: 398–402.

Osgood, E. A., Jr. 1972. Soil characteristics of nesting sites of solitary bees associated with the low-bush blueberry in Maine. The Life Sciences and Agriculture Experiment Station, University of Maine, Technical Bulletin 59. 8 pp.

Pojar, J. 1974. Reproductive dynamics of four plant communities of southwestern British Columbia. Canadian Journal of Botany 52: 1819–1834.

Reader, R. J. 1975. Competitive relationships of some bog Ericads for major insect pollinators. Canadian Journal of Botany 53: 1300–1305.

Robertson, C. 1924. Phenology of entomophilous flowers. Ecology 5: 393–407.

Small, E. 1972. Plant survival in sphagnum peat bogs. Greenhouse–Garden–Grass 11: 2–5.

Small, E. 1974. Vegetation and plant ecology of the Mer Bleue. *In* Proceedings of the Mer Bleue Seminar. National Capital Commission, Ottawa. 87 pp.

Thien, L. B. and B. G. Marcks. 1972. The floral biology of *Arethusa bulbosa, Colopogon tuberosus,* and *Pogonia ophioglossoides* (Orchidaceae). Canadian Journal of Botany 50: 2319–2325.

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Estimates of the White-tailed Deer Population and Mortality in Central Ontario, 1970-1972

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King, Dennis R. 1976. Estimates of the white-tailed deer population and mortality in central Ontario, 1970–1972. Canadian Field-Naturalist 90(1): 29–36.

Abstract. Extensive pellet-group and dead deer surveys were conducted in Ontario in the forested central range of white-tailed deer (*Odocoileus virginianus*) in the spring of 1971 and 1972. A stratified random sampling technique was used in a number of survey units, each stratum being based on the expected deer use during the winter. The deer population averaged 5.31 ± 21.4% and 3.74 ± 16.0% deer/mi^2 (2.05 and 1.44 deer/km^2) in the fall of 1970 and 1971 respectively. The estimated decline, following the severe winter of 1970–71, was statistically significant. The estimated mortality in the winter of 1970–71 was 0.68 ± 0.43 deer/mi^2 (0.26 deer/km^2). The dead deer survey was an underestimate of winter mortality and must be considered as only an index. Densities of deer were lowest in the northern units, North Bay and Sudbury mainland, with only about 1 deer/mi^2. The observed densities reflect the continued southward recession of the northern limit of the deer's range in Ontario.

The white-tailed deer (*Odocoileus virginianus*) is the most important big game animal in North America. Not only is it the most numerous and widely distributed species, but it also provides the greatest amount of recreation and is of great esthetic value.

Deer hunting annually provides 400 000–500 000 man-days of hunting recreation in Ontario. The deer is also an important part of the landscape and its mere presence is highly valued. There is probably more public sentiment about deer than about any other wildlife species. Deer management is thus controversial as well as important.

Population estimates are important in wildlife management because they facilitate the determination of the impact of the harvest and other mortality and environmental factors on the population. Deer populations are difficult to census, simply because the animals are difficult to see. Even when they can be seen and counted there is no reliable way to estimate the proportion of the population that is seen. As a result, indirect methods such as observing and counting animal "sign," are often used. A count of deer pellet-groups is such a method, pellet-groups being the "sign." Deer populations can be estimated by counting pellet-groups on sample plots, and the number of deer that died from natural causes can be estimated by counting the dead deer on sample transects.

Deer pellet-group surveys have been conducted in North America for many years (Bennett et al. 1940) and in Ontario since 1960 (Cumming 1961). Originally these surveys were conducted only in winter habitat or deer yards. The number of deer-days of use were estimated from the pellet-group density and the population was computed by assuming all deer were inside a given boundary for the winter period, usually about 150 days. This technique is still used in many areas (Smith et al. 1969) but in the forested deer range of the Great Lakes area and in northeastern North America, yard boundaries are often not distinct. The entire population is not inside a static yard boundary for a given period.

Extensive surveys over large areas have been conducted in the Great Lakes States (Eberhardt 1957; Ryel 1971; Karns 1971). The entire area of deer range was sampled with a stratified random survey. Dead deer surveys have also been conducted in conjunction with pellet-group surveys (Ryel and Bennett 1971). This paper reports on extensive pellet-group and dead deer surveys conducted in the spring of 1971 and 1972 to obtain population and mortality estimates for about 20 000 mi^2 (51 800 km^2) on southern Laurentian Shield deer range of central Ontario. Comparison of results indicates the magnitude of winter mortality caused by the extremely severe winter of

1970–71. This was the first time that such an extensive survey had been conducted in Canada.

Methods

Neff (1968), Van Etten and Bennett (1965), and Ryel (1972) have provided excellent reviews of the basic technique. Surveys, however, have to be modified to meet local conditions and objectives and therefore the sampling design for this survey will be described in some detail.

Three parameters must be determined to estimate deer populations from pellet surveys: (1) defecation rate, the number of times a deer defecates per day, (2) deposition period, the number of days over which pellet groups are deposited, and (3) the mean pellet-group density over the area sampled. The average deposition rate used for this survey was 12.7 pellet-groups per deer per day (Eberhardt and Van Etten 1956). Neff (1968) reviewed the literature and found that the average defecation rate for many ungulates varied little and that any variations are probably a source of only small errors. The deposition period used for this survey was from leaf-fall to the mean survey date. The leaf-fall date was determined for each survey unit by field personnel when 90% of the deciduous leaves had fallen. The deposition period for each survey unit varied from 205 to 230 days. By using this deposition period, and sampling the entire deer range, both winter and summer range, there is no need to make estimates of the amount of time deer spend on winter range (i.e., in yards). The mean pellet-group density was estimated by averaging counts on sample plots within each survey unit.

Experimental Design

The area surveyed was the primary deer range of central Ontario (Figure 1) and differed slightly between the two years. In 1972 the Sault Ste. Marie and Sudbury mainland units were deleted and the Lanark unit added. Most of the area is forested, and it is located on the southern edge of the Laurentian Shield. The area included about

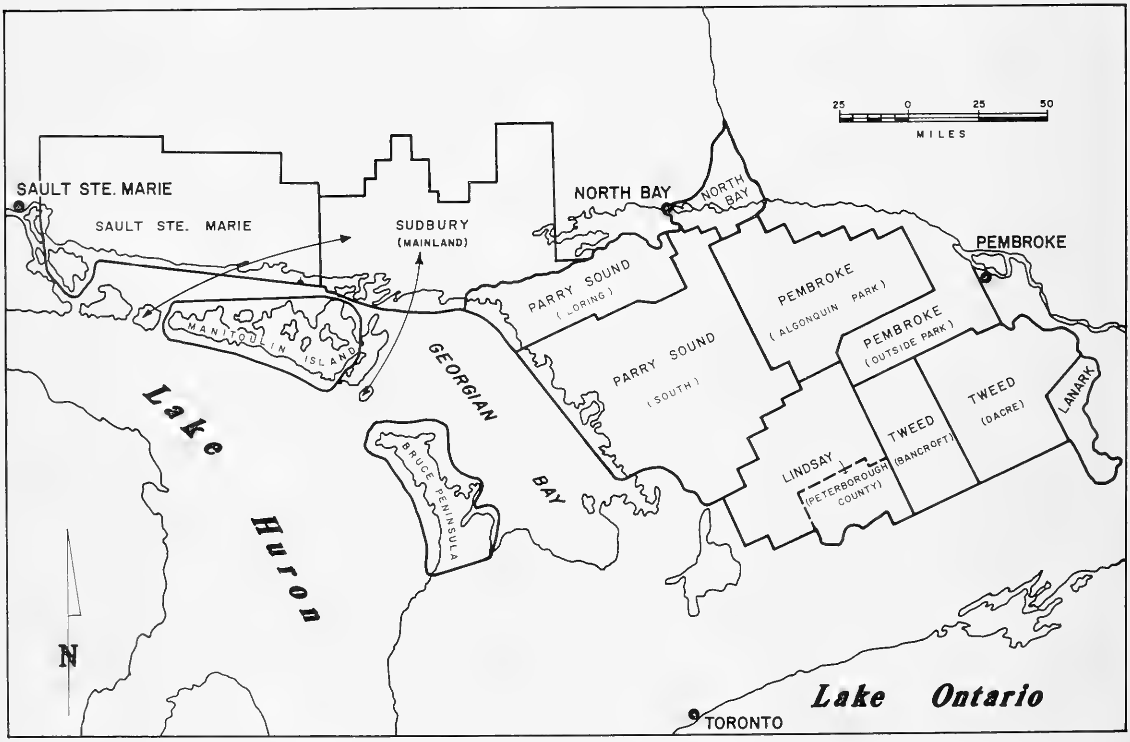

FIGURE 1. Area surveyed and survey units for central Ontario in 1971 and 1972.

21 500 and 18 000 mi² (55 685 and 46 620 km²) in 1971 and 1972 respectively. The area of permanent water and settlements was deleted when estimating the area surveyed.

The survey design was a stratified random sample within each survey unit. Stratification was based on expected winter deer density (i.e., according to known yarding patterns). Three strata in decreasing order of deer density were used: (I) large yard or yard complex, (II) peripheral yard, lightly used or small yard, and (III) areas outside yards. The strata were delineated by field personnel from maps made during aerial observations of tracks during the winter. A random sample was taken in each stratum, with sample allocation being based on proportions calculated by multiplying expected deer density times the area of the stratum. Randomization was achieved by selecting a sample of grid squares from the kilometre grid system on topographic maps.

The sample unit (hereafter referred to as the "triangle") consisted of an equilateral triangle, 50 chains (1005.8 m) on each side. Along the perimeter 15 pellet plots, 2 chains × 6.6 ft (40.23 × 2.01 m) or 1/50 of an acre (.008 hectares), were placed at 10-chain (201.2-m) intervals between plot centers. The entire distance around the triangle served as a transect for searching for dead deer. The transect was 1 to 3 chains wide depending on crew size and experience. The number of triangles completed in each survey unit varied from 26 to 100.

The pellet-group sampling design was the two-stage sample of Freeze (1962, p. 50), with the triangle being the primary samples and the 1/50-acre plots being the secondary samples. Ryel (1972) determined that the most efficient design would be a primary sample with only five secondary samples under Michigan conditions, thus making it possible to complete more primary samples. Under Ontario conditions, however, where many areas are inaccessible, it was decided to increase the number of secondary samples since in many areas only one primary sample (triangle) could be completed by a crew in a day because of the time spent getting to some of the randomly selected triangles.

A few deviations from this basic design were used because of the previous history of pellet surveys in some survey units and differing objectives in others. The North Bay unit contained only one major yard along the Mattawa River. In order to conduct a more intensive survey of the yard it was divided into three strata and lines were randomly selected as primary samples. The area outside the yard was surveyed with 15 triangles located at random. Previous surveys had been conducted in the Pembroke unit from 1967 through 1970 (Wilton and Trodd 1970). These surveys had been conducted only inside the yards with the assumption there was no deer use outside the yards for about a 150-day winter period. The 1971 survey in Pembroke did not include any sample outside of the yards and thus, it again had to be assumed that there was no deer use outside the yards. A period of 146 days of deer use inside the yards was estimated by district personnel for 1971. Pembroke was the only unit where this correction had to be made. In 1972, 10 triangles were completed outside the yards and a normal deposition period, leaf-fall to the mean survey date, of 222 days, was used.

Field Procedures

Triangles were located on 1/50 000 topographic maps and the distance and direction from the starting point to landmarks (highways, lakes, rivers, etc.) were measured. Field crews then located the triangles in the field by compass and pacing. Plots were numbered in a counterclockwise direction around the triangle and distances between plots were measured by pacing. The length of the pellet plots was measured with a 2-chain steel tape and plots extended 3.3 ft on either side of the tape. Plots which fell in permanent water were deleted from the survey as the area of permanent water was not counted. Dead deer were counted on a 1- to 3-chain-wide transect around the entire length of the triangle.

Many workers (Van Etten and Bennett 1965; Neff 1968; Ryel 1972) have found that the most critical error in pellet-group surveys is in finding and counting groups. The observers in this study were trained and cautioned to exercise great care in the differentiation of deer pellet-groups from one another and from other species, the aging of pellet-groups, and the finding of all pellet-groups on each plot.

Calculations

Statistical calculations for the survey follow the calculations suggested by Cochran (1953) and Freeze (1962) for stratified random surveys. Stratum means, densities of pellet-groups, and densities of dead deer were weighted by the proportional area of each stratum to determine the means for each survey unit. Stratum variances were weighted by the square of the proportional areas to determine standard errors. Pellet-group density was converted to uncorrected deer density by the following formula:

$$\text{deer per mi}^2 = \frac{\text{(pellet-group density)} \times \text{(640/area sampled per triangle)}}{\text{(deposition period)} \times \text{(12.7 pellet groups/deer/day)}}$$

The uncorrected deer density represents the average density of deer during the period, leaf-fall to the mean survey date. Because some deer died during that period, corrections were made to convert the uncorrected estimate to spring and fall population estimates. The spring population was computed by subtracting the number of "deer-winters" of pellet-groups contributed by the deer harvested in the fall plus the deer which died during the winter, from the uncorrected estimate. The preceding fall population was computed by adding the number of deer harvested plus winter mortality to the spring population.

Results

The population estimates for the various units ranged from 1.06 deer/mi^2 (0.41 deer/km^2) in Sudbury mainland to 13.11 deer/mi^2 (5.06 deer/km^2) in Tweed for the fall of 1970 (Table 1). The average density in the fall of 1970 was 6.30 deer/mi^2 (2.43 deer/km^2) and 2.66 deer/mi^2 (1.03 deer/km^2) in the southern and central regions respectively (Table 1). There were 5.31 deer/mi^2 (2.05 deer/km^2) in the entire 21 508 mi^2 (55 705-km^2) area or about 114 000 deer.

Population density estimates for the fall of 1971 ranged from 1.03 deer/mi^2 (0.40 deer/km^2) in North Bay to 6.66 deer/mi^2 (2.57 deer/km^2) on the Bruce Peninsula (Table 2). The area surveyed was 17 937 mi^2 (46 457 km^2) in 1972 with an average of 3.74 deer/mi^2 (1.44 deer/km^2), or about 67 000 deer in the fall of 1971.

Because the number of dead deer found is always small, reasonable precision for each individual survey unit in the dead deer survey could not be achieved at reasonable cost. For the total survey area, however, precision of the results is acceptable. The 541 dead deer counts on triangles and transects made in 1971 in the survey area resulted in a dead deer estimate of 0.68 ± 0.43 dead deer/mi^2 (0.26 ± 0.17 dead deer/km^2) or 14 685 dead deer for the winter of 1970–71

TABLE 1—Density estimates from the 1971 deer pellet-group surveys

Unit	Area (mi^2)	Deer/mi^2 Uncorrected	Deer/mi^2 Fall 1970	Deer/mi^2 Spring 1971	95% confidence limits (%)
Bruce Peninsula	536	9.07	10.11	8.42	±54.4
Lindsay	2531	4.63	6.40	3.31	±37.9
Tweed	3058	12.11	13.11	12.01	±48.4
Pembroke	4316	2.67	2.93	2.55	±23.7
Parry Sound	5204	3.71	4.59	3.23	±36.9
Southern region	15 645	5.40	6.30	4.95	±24.5
North Bay	697	1.02	1.17	0.91	±30.9
Sudbury mainland	2526	0.80	1.06	0.55	±45.5
Manitoulin Island	710	5.11	6.47	4.44	±35.1
Sault Ste. Marie	1931	3.35	3.91	2.79	±40.5
Central region	5864	2.19	2.66	1.80	±23.6
Total	21 509	4.52	5.31	4.09	±21.4

TABLE 2—Density estimates from the 1972 deer pellet-group surveys

Unit	Area (mi^2)	Deer/mi^2			95% confidence limits (%)
		Uncorrected	Fall 1971	Spring 1972	
Bruce Peninsula	695[1]	5.63	6.66	5.32	±49.9
Lindsay	2531	2.47	3.57	1.91	±30.8
Tweed	3058	3.84	5.03	3.63	±29.8
Pembroke	4367	2.29	2.70	2.02	±56.2
Parry Sound	5204	2.87	3.64	2.74	±30.3
Lanark	635	3.13	3.59	3.12	±46.1
Southern region[2]	16 490	2.96	3.76	2.71	±17.0
Southern region[3]	15 713	2.96	3.79	2.70	±17.6
Southern region[4]	10 092	3.31	4.28	3.05	±18.0
North Bay	697	0.98	1.03	0.85	±33.5
Manitoulin Island	750[1]	4.24	5.58	3.68	±34.1
Provincial Total	17 937	2.94	3.74	2.68	±16.0

[1] Areas were added to these survey units and they were larger in 1972 than in 1971.
[2] Entire area surveyed in 1972.
[3] Units surveyed in 1972 that were also surveyed in 1971.
[4] Units surveyed in 1972 where similar surveys were conducted in 1971. Includes only Bruce Peninsula, Lindsay, Dacre, and Parry Sound.

(Table 3). The 1972 counts on 638 triangles and transects resulted in an estimate of 0.38 ± 0.15 dead deer/mi^2 (0.15 ± 0.06 dead deer/km^2) or 6906 dead deer for the winter of 1971–72 (Table 3).

Comparisons of the mean pellet-group density represents the best way to determine the differences in the relative deer population between the two years. There was a decrease in pellet-group density in all units (Table 4). Because of the con-

TABLE 3–Estimates from the 1971 and 1972 dead deer surveys

Unit	1971		1972	
	Number of dead deer	Dead deer/mi^2	Number of dead deer	Dead deer/mi^2
Bruce Peninsula	533	.99	338	.49
Lindsay	5826	2.30	2383	.94
Tweed	370	.12	978	.32
Pembroke	870	.20	1982	.45
Parry Sound	3675	.71	583	.11
Lanark	—	—	0	0
Southern region	11 274	.72 ± .52	6264	.38 ± .16
North Bay	100	.14	129	.19
Sudbury mainland	999	.40	—	—
Manitoulin Island	561	.79	513	.68
Sault Ste. Marie[1]	1751	.91	—	—
Central region	3411	.58 ± .30	—	—
Total	14 685	.68 ± .43	6906	.38 ± .15

[1] Estimated from Mantle (1971).

TABLE 4—Pellet-group density estimates for units surveyed in 1971 and 1972

Unit	Mean pellet-group density (P. G.)/0.3 acres 1971	1972	Percent change
Bruce Peninsula	11.04	7.98	−28
Lindsay	5.90	3.09	−48
Tweed	14.83	5.15	−65
Bancroft	19.37	3.19	−84
Dacre	11.67	6.52	−44
Pembroke[1]			
Algonquin Park	2.61	1.01	−61
Outside Park	1.92	1.36	−29
Parry Sound	4.73	3.82	−19
Southern region[2]	6.44 ± 1.58	3.89 ± .68	−40
Southern region[3]	6.60 ± 1.87	4.32 ± .77	−34
North Bay	1.32	1.27	− 4
Manitoulin Island	6.70	5.36	−20

[1] Pellet-group density in stratum III (outside deer yards) is assumed to be 0 in 1972 as it was in 1971 in order to make a valid comparison.

[2] Includes all units surveyed in 1971 and 1972. The difference is significant ($P < 0.01$).

[3] Includes all units in (2) except Pembroke because of dissimilar surveys in the two years and Bancroft because of the large discrepancy between the two years. The difference is significant ($P < 0.05$).

fidence limits on individual unit estimates, most of these differences are not statistically significant. Considering all units surveyed in both years in the southern region, the pellet-group density declined from 6.44 ± 1.58 in 1971 to 3.89 ± 0.68 in 1972. This decline of 40% was significant ($P < 0.01$, $t = 2.93$, $df = 685$). The Pembroke unit could be excluded because the surveys were dissimilar each year, and the Bancroft sub-unit could be excluded because of the very large and possibly unreal difference between the two years. If these two units are deleted, the difference is still significant: 6.60 ± 1.87 in 1971 and 4.32 ± 0.77 in 1972; $P < 0.05$, $t = 2.19$, $df = 527$.

Discussion and Conclusions

The deer population estimate for the southern Laurentian Shield deer range in Ontario is low compared to other deer ranges in the northeast. Average population densities are reported to be 2 to 4 times greater in many areas from New York State to Minnesota than the estimated population density in central Ontario (Lang 1969; Karns 1971; Ryel 1971). The habitat and climate are different and usually more favorable for deer in most of those areas. In central Ontario most of the southern Laurentian Shield is covered with pole-size to mature timber, and winter conditions are usually more severe with an average total snowfall of greater than 80 in. One of the few areas of deer range which compares with central Ontario is the northern half of Michigan's Upper Peninsula. Ryel (1971) reported a population density of 5.76 deer/mi^2 on Michigan's Upper Peninsula in the fall of 1970. His estimates compare well with the 5.31 deer/mi^2 estimated on Ontario's southern Laurentian Shield in the fall of 1970.

In central Ontario the density of deer is greater in the southern part of the area surveyed than in the northern part. Density estimates for the fall of 1970 can be arranged in a progression from north to south: North Bay and Sudbury mainland, about 1 deer/mi^2; Pembroke and Sault Ste Marie, 2–4 deer/mi^2; and Tweed, Lindsay, Parry Sound, Bruce Peninsula, and Manitoulin Island, over 4 deer/mi^2.

Deer densities by survey unit reflect the pattern of the decreases in numbers of deer on the northern part of the range in Ontario. Prior to about 1850 deer did not occur on the Shield but only in the southern hardwood area of Ontario. Dawson (1963) described the northward expansion of the deer range in conjunction with logging and settlement. Deer first occurred in the Lake Nipissing area in 1880 and rapidly expanded their range northward in the area between Lake Superior and the Quebec border after 1900, with the maximum expansion being reached about 1940. With fire control and the regrowth of the forest the quality of the deer habitat has declined greatly since that time and the deer on the northern range have fared poorly during severe winters. The particularly severe winters of 1958–59 and 1959–60 caused heavy losses of deer in Ontario (Cumming 1961) and the populations in North Bay, Sudbury mainland, and parts of Sault Ste. Marie have never recovered. By 1960 only scattered individuals occurred north of the area surveyed in 1971. As habitat quality continues to decline as a result of forest succession, there may be an even further reduction in northern deer herds and a further recession of the white-tailed deer's northern limit in Ontario.

The snow severity index (Passmore 1953) for most stations in the central deer range was higher in the winter of 1970–71 than at any time since the ministry began keeping records in 1953, and more than twice as high as the long-term average (unpublished data Wildlife Branch, Ontario Ministry of Natural Resources). The average reduction of about 50% from 1970 to 1971 in pellet-group density was in large part caused by winter mortality.

Many more deer than the estimated 14 685 must have died in the winter of 1970–71. The estimated winter mortality would have to be increased by a factor of 2 to 3 times to account for the decline in the population from the fall of 1970 to the fall of 1971. The estimated 1970–71 winter mortality was about 13% of the population present in the fall of 1970, and the legal kill was 10%. Recruitment to the spring population should have replaced those losses, even though the age-class distribution in the fall of 1971 did indicate a slight reduction in reproduction in the spring of 1971 (unpublished data Wildlife Branch, Ontario Ministry of Natural Resources). Dead deer surveys can be confounded by predators and scavengers scattering the carcasses. This situation makes finding dead deer difficult, and as the total area searched in this study was small, missing only a few deer might result in greatly underestimating total winter mortality. The dead deer survey can thus be considered only as an index to winter mortality and not a complete count.

The confidence limits of the 1972 survey were generally better than those in 1971. In some instances the differences can be attributed to improvements in design and in others to improved stratification. The extensive pellet-group survey appears to be a feasible way to estimate deer populations in central Ontario.

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Literature Cited

Bennett, L. J., P. F. English, and **R. McCain.** 1940. A study of deer populations by use of pellet-group counts. Journal of Wildlife Management 4(4): 398–403.

Cochran, W. C. 1953. Sampling techniques. John Wiley and Sons, Incorporated, New York. xvii + 413 pp.

Cumming, H. G. 1961. Spring deer yard surveys and the outlook for deer hunting in 1961. Ontario Fish and Wildlife Review 1(2): 21–29.

Dawson, J. B. 1963. The white-tailed deer in Ontario—past, present and future. Ontario Fish and Wildlife Review 2(3): 3–11.

Eberhardt, L. L. 1957. The 1956 and 1957 pellet-group surveys. Michigan Department of Conservation, Game Division Report Number 2133. 37 pp.

Eberhardt, L. L. and **R. C. Van Etten.** 1956. Evaluation of the pellet-group count as a deer census method. Journal of Wildlife Management 20(1): 70–74.

Freeze, F. 1962. Elementary forest sampling. United States Department of Agriculture, Forest Service, Agriculture Handbook Number 232. iv + 91 pp.

Karns, P. 1971. 1970 deer pellet survey. Minnesota Game Research Quarterly 31: 1–14.

Lang, L. 1969. Determination of the condition and size of the deer herd in Pennsylvania for the purpose of making harvest recommendations. Pennsylvania Game Commission, P-R Project W-48-R. 34 pp.

Mantle, E. F. 1971. 1971 assessment of deer mortality, Sault Ste. Marie District. Ontario Department Lands and Forest, Fish and Wildlife Branch, Unpublished District Report. 10 pp.

Neff, D. J. 1968. The pellet-group count technique for big game trend, census and distribution: a review. Journal of Wildlife Management 32(3): 597–614.

Passmore, R. C. 1953. Snow conditions in relation to big game in Ontario during the winter of 1952–53. Ontario

Department of Lands and Forests, Research Division, Wildlife Research Report Number 2. 12 pp.

Ryel, L. A. 1971. The 1971 deer pellet-group surveys. Michigan Department of Natural Resources, Research and Development Report Number 239. 29 pp.

Ryel, L. A. 1972. Evaluation of pellet-group surveys for estimating deer populations in Michigan. Michigan Department of Natural Resources, Research and Development Division Report Number 250. iv + 237 pp.

Ryel, L. A. and **C. L. Bennett, Jr.** 1971. Technical report on the spring 1971 dead deer searches. Michigan Department of Natural Resources, Research and Development Report Number 247. 32 pp.

Smith, R. H., D. J. Neff, and **C. Y. McCullough.** 1969. A model for the installation and use of a deer pellet-group survey. Arizona Game and Fish Department, Special Report Number 1. iv + 30 pp.

Van Etten, R. C. and **C. L. Bennett, Jr.** 1965. Some sources of error in using pellet-group counts for censusing deer. Journal of Wildlife Management 29(4): 723–729.

Wilton, M. L. and **L. L. Trodd.** 1970. Deer population estimates, Pembroke District 1970. Ontario Department of Lands and Forests, Wildlife Branch, Unpublished District Report. 14 pp.

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Weight of the Eye Lens as an Indicator of Age in *Peromyscus*

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Abstract. Weight of the eye lens is a reasonable indicator of age for young *Peromyscus leucopus noveboracensis* and *Peromyscus maniculatus maniculatus*. Eye-lens weight varied between species and among sub-species of *Peromyscus*, and a single lens weight on age regression formula does not apply to all *Peromyscus*. Reduced food intake by lactating *P. l. noveboracensis* affected the eye-lens weight of 18-day-old nestlings, but such restrictions may not be applicable to wild mice. Freezing did not affect eye-lens weights and no difference in lens weight of 18-day-old mice was attributed to litter size.

Weights of dried eye lenses have been used as indicators of age for many species of mammals, particularly game mammals (Lord 1959; Sanderson 1961; Beale 1962; Davis 1964; Friend 1967), but few attempts have been made to use lens characteristics to age small mammals. Dapson and Irland (1972) used biochemical composition of lenses to age old-field mice (*Peromyscus polionotus*) and found the technique to be reasonably accurate between 45 and 308 days of age. Gourley and Jannett (1975) found eye-lens weights of *Microtus pinetorum* and *M. montanus* to be a better indicator of age than other measures, such as body weight. This study examined the growth of the eye lenses in white-footed mice (*Peromyscus leucopus*) and deer mice (*Peromyscus maniculatus*) and evaluated the suitability of dried eye-lens weight for aging young animals.

Methods

Many of these data were collected incidentally to other studies so that sample sizes and handling procedures varied considerably.

Peromyscus leucopus noveboracensis (Fischer) were live- or snap-trapped in the vicinity of London, Ontario during 1972 and 1973. Live-trapped females were maintained in the animal quarters at the University of Western Ontario in 30 × 27 × 15 cm cages provided with sawdust bedding and *ad libitum* food (Purina rat chow) and water. Seventy-one known-age young from these wild caught females were killed at ages varying from 18 to 148 days. In some cases only one member of a litter was killed; in other cases whole litters were sacrificed.

Peromyscus maniculatus maniculatus (Wagner) were live-trapped at the Whiteshell Nuclear Research Establishment, Pinawa, Manitoba and housed in the animal quarters there. Females were maintained in 28 × 18 × 14 cm cages provided with spruce shavings bedding and *ad libitum* food (Purina mouse chow and oats) and water. Six known-age litters containing 40 young were killed between 26 and 80 days of age.

One hundred and forty-six *P. l. noveboracensis* that were raised in the laboratory by females on different nutritional regimes (Millar 1975) provided a check on variability of lens weight caused by nutrition. Fifty-nine young were from females on *ad libitum* diets, 77 were from females restricted to 75% of their *ad libitum* intake during late lactation, and 10 were from females restricted to 46% of their *ad libitum* intake during late lactation. All these animals were killed at 18 days of age.

Effect of freezing on lens weight was determined with 19 *P. l. noveboracensis*. One eyeball was immediately processed, the other was frozen *in situ* for 3 days before processing.

Eye lenses were also collected from 266 live-trapped *P. l. noveboracensis* (immediately after the animals were killed, the eye lenses were collected and processed); 24 *P. l. noveboracensis* (snap-trapped and therefore processed a few hours after death); 7 live-trapped *P. m. maniculatus* from Pinawa, Manitoba; 56 snap-trapped *P. m. inter-*

dictus Anderson from Port Alberni, British Columbia; and 75 snap-trapped *P. m. borealis* Mearns from Bow Forest, Alberta.

Processing of all animals involved removing entire eyeballs and fixing in 10% formalin buffered with $CaC0_3$. All eyeballs were fixed for more than 3 weeks, then the lenses were removed, blotted dry, dried for 72 h at 90–100°C and immediately weighted to the nearest 0.1 mg on a Sartorius model 2462 balance with an accuracy of ± 0.1 mg. The recorded lens weight for each animal was based on the average weight of both lenses. Throughout the text, means are given ± 1 standard error.

Results

Known-age animals were not available from all populations so that only lens weights of adult animals could be compared among geographic areas. This was done in two ways. One involved the lens weights of overwintered animals that were collected before or early in the breeding season prior to the presence of large offspring. Breeding of *P. l. noveboracensis* and *P. m. maniculatus* appears to cease by the end of October and during September, respectively (unpublished data), so that these overwintered animals were probably more than 5 months old. The *P. m. interdictus* population was sampled in late June when there may have been large young of the year present, since coastal populations of *Peromyscus* may begin breeding in March (Sadleir 1974). For this reason, a second comparison, that of the largest 12% of the lens weights in each population was made. These data (Table 1), analysed by a multiple comparisons test (Sokal and Rolf 1969, p. 242), indicated that overwintered *P. l. noveboracensis* had significantly heavier dried eye lenses than overwintered *P. m. maniculatus* and *P. m. borealis* ($P < 0.01$). Lens weights of overwintered *P. m. borealis* and *P. m. maniculatus* were not significantly different ($P > 0.05$). The heaviest 12% of the eye lenses of *P. l. noveboracensis* were significantly heavier than those of *P. m. interdictus* and *P. m. borealis* ($P < 0.01$). Those of *P. m. borealis* were significantly heavier than those of *P. m. interdictus* ($P < 0.01$).

Eye-lens weights of adult males and females were compared only between the large sample of overwintered adult *P. leucopus*. Mean lens weight of males (12.65 ± 0.11 mg; $N = 31$) were not different ($t = 0.11$; $P > 0.05$) from those of females (12.33 ± 0.14 mg; $N = 61$).

Nutritional status of lactating females appears to influence the growth of eye lenses of nestlings. Eye-lens weights of 18-day-old young *P. leucopus* whose mothers were given *ad libitum* diets (mean lens weight = 3.55 ± 0.07 mg; $N = 59$) were significantly heavier ($t = 6.70$; $P < 0.001$) than those raised by females restricted to 75% of an *ad libitum* diet (mean lens weight = 3.06 ± 0.04 mg; $N = 77$) and those raised by females restricted to 46% of an *ad libitum* diet (mean lens weight 2.49 ± 0.17 mg; $N = 10$) ($t = 6.3$; $P < 0.001$).

Stresses related to being from litters of different size does not appear to affect growth of the eye lens of *Peromyscus*. Among 18-day-old young from *P. leucopus* females on *ad libitum* diets,

TABLE 1—Comparison of mean eye lens weights (mg) among subspecies of *Peromyscus*. Sample sizes are in parentheses

	Mean weight of eye lenses (mg) ± 1 SE			
	P. m. interdictus	*P. m. borealis*	*P. m. maniculatus*	*P. l. noveboracensis*
Overwintered adults	—	9.90 ± 0.37 (7)	9.67 ± 0.19 (7)	12.54 ± 0.09 (92)
Heaviest 12% of total sample	9.18 ± 0.23 (7)	11.30 ± 0.19 (9)	—	13.93 ± 0.09 (32)

NOTE: Analysis by a Multiple comparison test (Sokal and Rolf 1969, p. 242) indicates that overwintered *P. l. noveboracensis* have heavier lenses than overwintered *P. m. borealis* and *P. m. maniculatus* ($P < 0.01$). Overwintered *P. m. borealis* do not have heavier lenses than overwintered *P. m. maniculatus* ($P > 0.05$). The heaviest 12% of the sample of *P. l. noveboracensis* is significantly heavier than *P. m. interdictus* and *P. m. borealis* ($P < 0.01$), and *P. m. borealis* is significantly heavier than *P. m. interdictus* ($P < 0.01$).

lenses of those from litters of three (mean lens weight = 2.9 ± 0.20 mg; $N = 5$) and five (mean lens weight = 3.5 ± 0.08 mg; $N = 28$) were not significantly different ($t = 2.24$, $P > 0.05$ and $t = 1.52$, $P > 0.05$, respectively) than those from litters of seven (mean lens weight = 3.3 ± 0.09 mg; $N = 11$).

Freezing did not have a significant effect on dried eye-lens weight. Among 19 *P. leucopus* that had one lens fixed immediately, and one frozen *in situ* for 3 days before fixing, lens weights averaged 11.39 ± 0.69 and 11.26 ± 0.70 mg respectively.

Actual growth of the eye lens is not linear. A Log_n transformation of the independent variable (here considered to be age), however, makes the relationship linear (Figure 1). Growth of the eye lens of *P. l. noveboracensis* based on 71 known-age

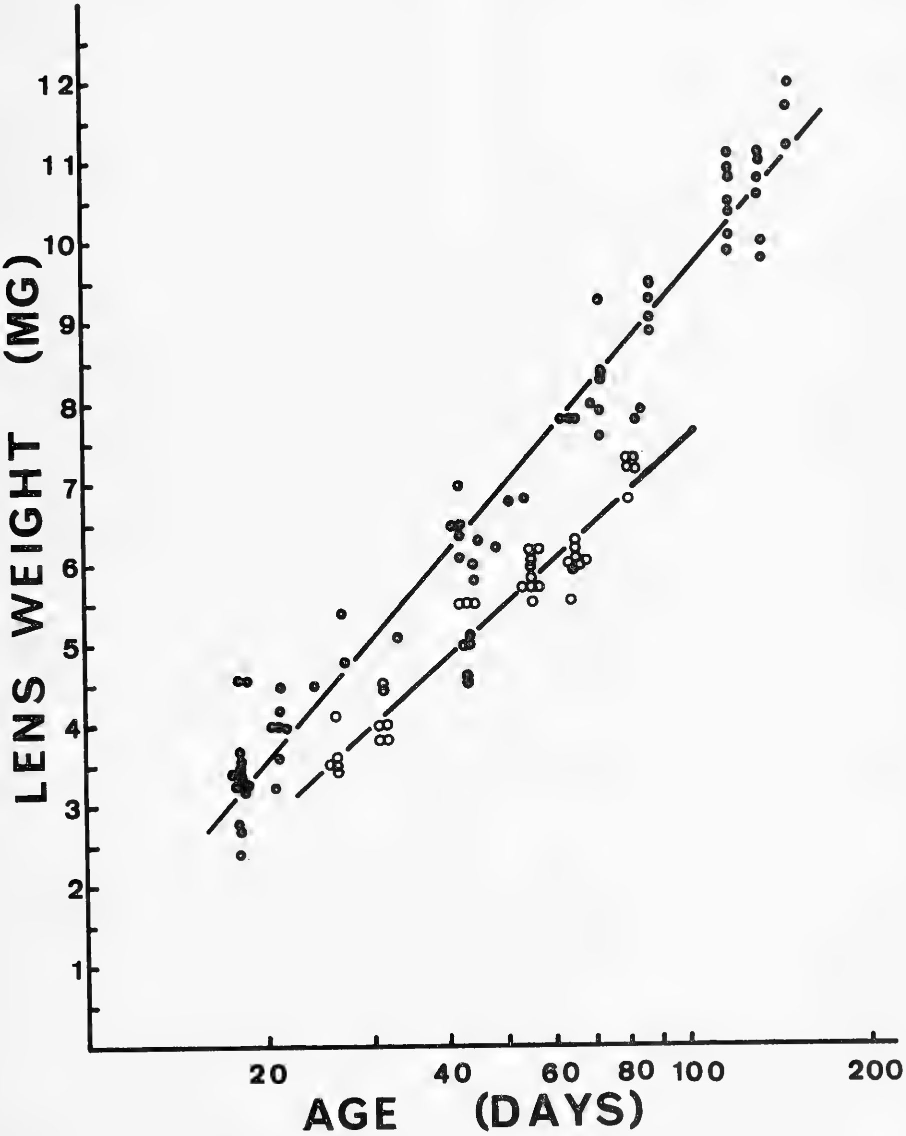

FIGURE 1. Eye lens weight (mg) in relation to age (days) for *Peromyscus leucopus noveborancensis* (solid circles) and *Peromyscus maniculatus maniculatus* (open circles).

animals between 18 and 148 days of age is described by $Y = -7.3099 + 3.6679 \text{ Log}_n X$, where Y = lens weight in mg and X = age in days. The coefficient of determination r^2 equals 0.965, indicating that 96.5% of the variation in lens weight is attributable to age. Growth of the eye lens of *P. m. maniculatus,* based on 40 known-age animals between 26 and 80 days of age is described by $Y = -6.1478 + 2.9853 \text{ Log}_n X$, where Y = lens weight in mg and X = age in days. The coefficient of determination r^2 equals .922, indicating that 92.2% of the variation in lens weight is attributable to age.

Confidence limits on individual predictions of age from lens weight, following the method of Sokal and Rolf (1969, p. 446), are presented in Table 2.

Discussion

Growth of the eye lens is generally considered to be independent of physiological condition, but lens weight may vary with handling and processing procedures (Friend 1967; Montgomery 1963; Longhurst 1964) and geographic area (Myers and Gilbert 1968; Friend and Severinghaus 1967; Ronstad 1966). In *Peromyscus*, freezing does not appear to have an effect on lens weight. Since it is frequently much more convenient to freeze collected animals than to process them immediately, the use of frozen lenses for aging *Peromyscus* appears acceptable.

Nutritional status does not appear to influence the growth of eye lenses of independent young (Friend 1967; Friend and Severinghaus 1967) but data presented here indicates that nutrition can influence growth of eye lenses of nestlings. The importance of this to the analysis of wild caught animals is uncertain since the degree of nutritional restriction for wild females during lactation is unknown. But as growth of young *Peromyscus* does not appear to be affected by litter size (Millar 1975), and as young mice are raised only when environmental conditions are optimum (Sadleir et al. 1973) and food may be superabundant, natural energy restrictions that influence eye-lens growth may not occur. Support for this view is seen in the lack of difference in lens weights among 18-day-old mice from different litter sizes. Eye-lens weights of *Microtus montanus* do vary among litter sizes (Gourley and Jannett 1975); this apparent difference between *Peromyscus* and *Microtus* may be attributed to generally different patterns of growth in relation to litter size in the two genera (see Millar 1975).

Weight of the eye lens appears to be a reasonable indicator of age in *Peromyscus*. The confidence limits for individual predictions of age from lens weight are similar to those for predictions of age by biochemical analysis of the lens (Dapson and Irland 1972) and the technique is procedurally easier.

The age-weight relationships presented here should not be applied to other *Peromyscus* populations. Growth of the eye lens of *P. l. noveboracensis* and *P. m. maniculatus* differs in both magnitude and rate, and lens weights of two of the three subspecies of *P. maniculatus* that we examined appear to differ in magnitude.

Acknowledgments

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TABLE 2–95% confidence limits for individual predictions of age for *Peromyscus leucopus noveboracensis* and *Peromyscus maniculatus maniculatus*. Y values denote lens weight in mg; X values denote age in days.

P. l. noveboracensis				*P. m. maniculatus*			
Y (mg)	X (days)	Lower age limit	Upper age limit	Y (mg)	X (days)	Lower age limit	Upper age limit
3.7	20	15	27	2.8	20	16	25
6.2	40	30	54	4.9	40	32	50
7.7	60	45	81	6.1	60	48	75
8.8	80	60	108	6.9	80	64	101
9.6	100	74	135				
10.2	120	89	162				
10.8	140	104	189				

Research Council of Canada and Atomic Energy of Canada, Limited. K. Schmidt, and C. Canny recorded data from the Pinawa and London laboratory colonies, respectively.

Literature Cited

Beale, D. M. 1962. Growth of the eye lens in relation to age in fox squirrels. Journal of Wildlife Management 26: 208–211.

Dapson, R. W. and **J. M. Irland.** 1972. An accurate method of determining age in small mammals. Journal of Mammalogy 53: 100–106.

Davis, D. E. 1964. Evaluation of characters for determining age of woodchucks. Journal of Wildlife Management 28: 9–15.

Friend, M. 1967. A review of research concerning eye-lens weight as a criterion of age in animals. New York Fish and Game Journal 14: 152–165.

Friend, M. and **C. W. Severinghaus.** 1967. Influence of nutrition on eye-lens weight in deer. New York Fish and Game Journal 14: 166–175.

Gourley, R. S. and **F. J. Jannett, Jr.** 1975. Pine and montane vole age estimates from eye lens weights. Journal of Wildlife Management 39: 550–556.

Longhurst, W. M. 1964. Evaluation of the eye lens technique for aging Columbian black-tailed deer. Journal of Wildlife Management 28: 773–784.

Lord, R. D., Jr. 1959. The lens as an indicator of age in cottontail rabbits. Journal of Wildlife Management 23: 358–360.

Lord, R. D., Jr. 1961. The lens as an indicator of age in the gray fox. Journal of Mammalogy 42: 109–111.

Millar, J. S. 1975. Tactics of energy practitioning in breeding *Peromyscus*. Canadian Journal of Zoology 53: 967–976.

Montgomery, G. G. 1963. Freezing, decomposition, and raccoon lens weight. Journal of Wildlife Management 27: 481–483.

Rongstad, O. J. 1966. A cottontail lens-growth curve from southern Wisconsin. Journal of Wildlife Management 30: 114–120.

Sadleir, R. M. F. S. 1974. The ecology of the deer mouse *Peromyscus maniculatus* in a coastal coniferous forest. II. Reproduction. Canadian Journal of Zoology 52: 119–131.

Sadleir, R. M. F. S., K. D. Casperson, and **J. Harling.** 1973. Intake and requirements of energy and protein in wild deermice (*Peromyscus maniculatus*) relative to breeding duration. Journal of Reproduction and Fertility Supplement 19: 225–250.

Sanderson, G. C. 1961. The lens as an indicator of age in the raccoon. American Midland Naturalist 65: 481–485.

Sokal, R. R. and **F. J. Rolf.** 1969. Biometry. W. H. Freeman and Co., San Francisco. 776 pp.

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Notes

The Sheepshead, *Archosargus probatocephalus*, and the Feather Blenny, *Hypsoblennius hentzi,* Two Additions to the Canadian Atlantic Ichthyofauna

Abstract. The sheepshead, *Archosargus probatocephalus,* (Family Sparidae) is verifiably recorded from Canada for the first time. The family Blenniidae is first recorded from Canada with two specimens of *Hypsoblennius hentzi.* It is believed that these specimens reached the Nova Scotia coast by means of disjunct eddies of the Gulf Stream.

Until the present, only one species of Sparidae, the scup, *Stenotomus chrysops* (Linnaeus, 1766) has been verifiably present in Canadian Atlantic waters (Leim and Scott 1966). Furthermore, no species of the family Blenniidae has been recorded from Canada.

The present paper records the occurrence of a second species of sparid, the sheepshead, *Archosargus probatocephalus* (Walbaum, 1792) and the feather blenny, *Hypsoblennius hentzi* (Le Sueur, 1825) from Nova Scotia. Some comments on the probable reason for their occurrence in Canadian waters are included. Descriptive and biological data on these species were not readily available without a survey of the literature; we therefore provide these data in the format used by Leim and Scott (1966).

Collection Data

The collections in which these species were found were made by scuba diving with a dip net during a federal government Opportunities for Youth Program. The project, a study of the fauna of Shelburne Harbour, was carried out by Peter MacLeod, Danny Acker, and Kelsie Williams. Shelburne Harbour (43°41′ N, 65°20′ W) is located near the southern extremity of Nova Scotia in Shelburne County. No ecological data are available for the collection sites.

The specimen of sheepshead is catalogued in the Nova Scotia Museum as NSM 974-Z-229-48. One feather blenny is catalogued at the Nova Scotia Museum as NSM 974-Z-229-50, the other is catalogued in the National Museum of Natural Sciences as NMC74-312.

Family SPARIDAE Porgies

Sheepshead **Spare tête-de-mouton**

Archosargus probatocephalus (Walbaum, 1792) (Figure 1)

OTHER COMMON NAMES: sheepshead porgie

DESCRIPTION: Body compressed, deep, greatest depth below second dorsal spine, 2.5 in standard length, caudal peduncle depth 10 in standard length. Head 3.0 in standard length, anterior profile straight but not as steep as in adult, somewhat rounded over nape. Mouth terminal, maxillary reaching to front of orbit. Anterior teeth incisiform and shallowly bifid, prominent; posterior teeth smaller and molariform. Orbit 3.4 in head. Fins: dorsal (1), XII,11 (this count does not include the procumbent first immovable dorsal spine), origin over opercular membrane, insertion just anteriad peduncle, spinous portion approximately two-thirds dorsal fin length, third and fourth spines longest, approximately 2 in head, rays somewhat longer than posterior spines, entire fin depressible in a groove; caudal moderately forked, lobes pointed; anal, III, 11, spines stout, second longest, anal origin beneath last dorsal spine, insertion just anteriad peduncle, depressible in a groove; pectorals, 15:15 pointed, equal to head; ventrals I,5:I,5, 1.4 in head, bases posteriad to pectoral bases. Lateral line distinct, moderately arched, 62 pored scales. Scales on body large, smaller scales on middorsum of head and on cheeks to end of upper jaw, smallest scales on breast anterior to pelvic bases.

Color of preserved specimen silvery gray above, blending to silver laterally, and white on ventral. With seven broad dark vertical bands on body, first over nape, last well posterior on peduncle, all angled slightly postero-ventrally.

A summary of meristic and mensural data appears in Table 1.

DISTINCTIONS: The sheepshead is similar to the scup, *Stenotomus chrysops,* but can be distinguished from it by its prominent incisors, and the seven dark vertical bands.

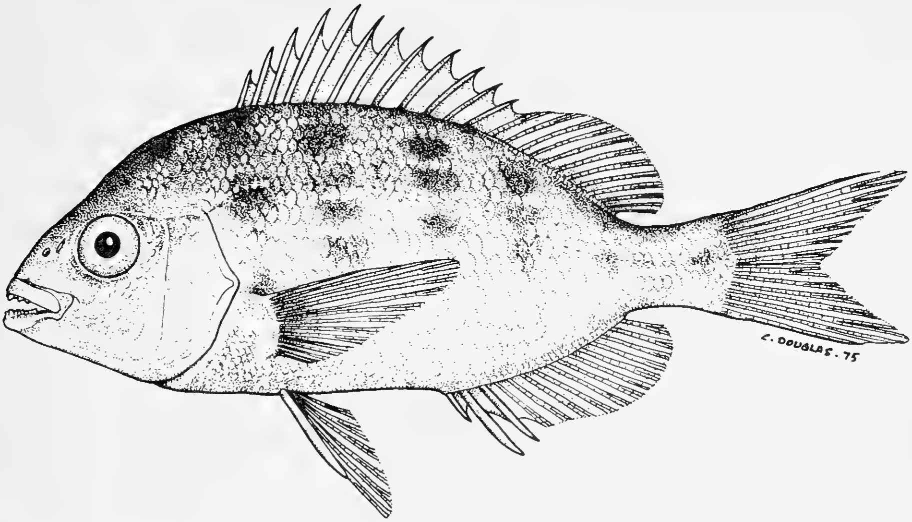

FIGURE 1. *Archosargus probatocephalus* (NSM 974-Z-229-50) from Shelburne Harbour, Nova Scotia.

SIZE: According to Bigelow and Schroeder (1953) the sheepshead reaches a length of 30 in (76.2 cm) and a weight of 20 pounds (9.1 kg).

RANGE: Normally from the Texas coast of the Gulf of Mexico to Cape Cod, and formerly not uncommon as far north as New York (Bigelow and Schroeder 1953). Cox (1896) stated that it was occasionally taken in St. John Harbour, New Brunswick, but there are no known specimens to substantiate his record.

BIOLOGY AND ECONOMICS: The sheepshead is primarily a bottom-fish and feeds on small molluscs. It is not considered a migratory species, nor does it occur in schools. The spawning season is reported to be in February, although it may extend into April. It has been found running in rivers in Florida. It is sought both commercially and by sportsmen as a food fish. Data are from Jordan and Evermann (1905). Because of its rarity in Canada, it has no economic importance here.

Family BLENNIIDAE Combtooth Blennies

Feather blenny **Blennie plume**

Hypsoblennius hentzi (Le Sueur, 1825)

(Figure 2)

OTHER COMMON NAMES: Spotted seaweed blenny, spotted seaweed fish

DESCRIPTION: Body moderately elongate, compressed, greatest depth 3.5 to 4.1 in standard length, occuring at base of pelvics, from whence the body tapers slightly to the caudal fin. Head 3.2 to 3.4 in standard length, blunt, snout profile almost vertical, nape forming a crest behind eye. Mouth terminal, almost horizontal, jaw reaching level of mid-orbit, 16 to 17 incisors in left premaxillary, 20 to 21 in left dentary, teeth in both forming an even cutting edge, no canines, palate toothless. Orbit moderate, 4.2 to 4.3 in head length. Nostril with simple cirrus, upper eye with feather-like cirrus bearing four filaments. Gill slit extending down to opposite middle pectoral fin. Fins: dorsal (1) XII, 15 to 16, a slight dip where spinous meets rayed portion; caudal rounded; anal II, 16 to 17, first ray in male preceded by a rugose fleshy papilla; pectorals broad, rounded, with 14 rays; pelvics 13, curved. Lateral line canal with about 15 pores above and below, ending above anal origin. Head and body without scales, small wart-like lumps scattered over head, body, and fins. Shield-shaped tip on first anal spine. Meristic and mensural data are given in Table 1.

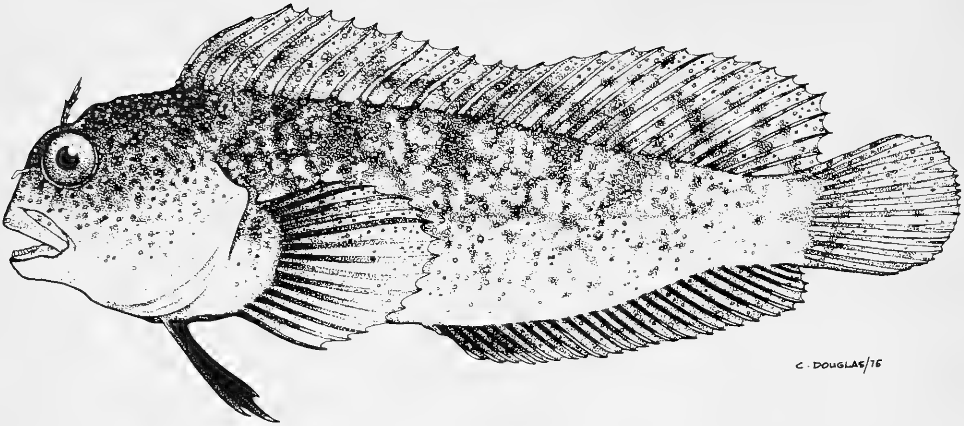

FIGURE 2. *Hypsoblennius hentzi* (NMC74-312) from Shelburne Harbour, Nova Scotia.

Color of preserved specimens a mottled dark brown, a faint stripe through middle of spinous dorsal, anal almost black but fading in posterior third; tips of rays light. Small dark spots on gill cover and above pectoral fin.

DISTINCTIONS: The incisor-like teeth forming a cutting edge in both jaws, the feather-like orbital cirrus and simple nasal cirrus distinguish this species from other Atlantic Canadian Fish.

Three western Atlantic species of *Hypsoblennius* are known: *Hypsoblennius hentzi*, the eastern North American *H. ionthas* (Jordan and Gilbert) reported from South Carolina to Texas, and the Bahamian *H. extochilus* Böhlke.

Hubbs (1939) distinguished *H. hentzi* and *H. ionthas* and gave their distribution. *Hypsoblennius hentzi* can easily be distinguished on the basis of head length in standard length, it being contained less than, instead of more than, 3.5 times, the basis of conspicuous dark spots on the head, which are lacking in *H. ionthas*, the angled light bar behind and below the eye absent instead of conspicuous, and the shield-shaped rather than lanceolate tip on the first anal spine. But like *ionthas* and contrary to the usual condition in *hentzi* our specimen lacks a slight fold across the isthmus. Our specimens lack the pale body and fins, the huge orbital cirrus, and the fleshy flap that juts laterally from the lower lip near the angle of the mouth which together characterize *H. extochilus* (Böhlke and Chaplin 1968).

SIZE: The present specimen 65.9 mm (2.6 in) in standard and 77.1 mm (3 in) in total length but the species is known up to 104 mm (4.1 in) in standard length (Hubbs 1939).

RANGE: Known from the present record in Nova Scotia, otherwise from New Jersey to Yucatan (Hubbs 1939).

Canadian Distribution: Known only from the present specimens taken at Shelburne Harbour, Shelburne County, southern Nova Scotia.

BIOLOGY AND ECONOMICS: According to Smith (1907) this species is abundant on sandy shores and among seaweeds. It is of no economic importance. Hildebrand and Cable (1938) report on its embryology and life history in North Carolina from which the following has been abstracted. It inhabits shelly, shallow bottoms with plants, sponges, ascidians, hydroids, etc. in summer, retiring to deeper channels and holes in winter. When caught by hand it will seize the skin and hold on in bulldog fashion allowing itself to be lifted by its grasp.

An extended spawning season is suggested by the presence of eggs of several sizes in the ovary at one time and the finding of fry of 5 mm or less from May 13 to September 13, and the finding of "nests" with many eggs from May 31 to June 27. Eggs are deposited in empty oyster shells near the low-tide line. The eggs are deposited in a single layer separated by adhesive disks, not all at the same time. Up to 3750 eggs may be laid in a "nest" which is apparently guarded by the male.

TABLE 1–Meristic and mensural data for *Archosargus probatocephalus* and *Hypsoblennius hentzi* from Shelburne Harbour. Mensural data include actual measurements (mm)/measurements of parts as thousandths of standard length (N. A. = not appropriate)

Character	Species		
	A. probatocephalus	*H. hentzi*	
	NSM 974-Z-229-48	NMC74-312	NSM 974-Z-229-50
Dorsal fin rays	XII, 11	XII, 16	XII, 15
Anal fin rays	III, 11	II, 16	II, 17
Ventral fin rays	I,5: I,5	13	13
Pectoral fin rays	15:15	14:14	14:14
Pored scales in lateral line	62	15	15
Branchiostegals	5	6	6
Gill rakers	7, 1, 12	16	–
Vertebrae (including urostyle)	24	32	–
Total length	81.0	86.8	77.1
Standard length	63.0	71.3	65.9
Body depth	25.0/.397	20.1/.282	16.1/.244
Head length	20.5/.325	22.0/.309	17.6/.297
Orbit diameter	6.0/.095	5.1/.073	4.6/.070
Pectoral length	20.0/.317	18.2/.255	17.8/.270
Ventral length	14.0/.222	13.6/.191	11.6/.176
Pre-anal length	40.5/.643	39.7/.557	35.9/.545
Upper jaw length	6.5/.103	7.6/.107	6.1/.093
Snout length	7.0/.111	6.6/.092	–
Gill slit length	N.A.	7.9/.111	–

Discussion

The occurrence along the Nova Scotia coast of unfamiliar fishes from warmer southern waters is no longer considered unusual. Increased research activity and closer contact with inshore fishermen in recent years have resulted in reports of many species previously not recorded or considered rare or accidental in Canadian waters (MacKay and Thomas 1969; Gilhen 1972; MacKay and Gilhen 1973; Gilhen and Gruchy, unpublished).

Cox (1896) reported the sheepshead from Canadian waters, and on that basis Halkett (1913) included it in his list of Canadian fishes. Vladykov and McKenzie (1935) did not include the sheepshead in their list of marine fishes of Nova Scotia, and Bigelow and Schroeder (1953) questioned Cox' record. Leim and Scott (1966) suggested that Cox' observation involved another species, but the present record lends credibility to Cox' report.

The family Blenniidae has not previously been recorded in Canadian waters.

The sheepshead is commonly found as far north as Cape Cod, and the feather blenny as far north as New Jersey, and it is not inconceivable that some of these fishes could have strayed along the coast to Nova Scotia. Such a migration is, however, somewhat improbable, and there is a more plausible explanation for their occurrence in Nova Scotia.

It seems more likely that these two species were swept north by the Gulf Stream and were subsequently carried inshore by disjunct eddies of warm surface waters. The phenomenon of water replacement along the Nova Scotia coast is related to the force and duration of wind. This is well documented by Hachey (a series of papers, summarized 1961) and Platt et al. (1972). Although best documented for August–October, water replacement on the Nova Scotia coast appears to occur all year round (Platt et al. 1972). This water replacement phenomenon readily accounts for the occurrence of southern pelagic and littoral species of fishes (as well as invertebrates) on the Nova Scotia coast. It would move animals passively, obviating extensive migrations, and would allow them to avoid regions of cold water. We consider that the cooler, turbulent water of the Bay of Fundy (Hachey 1961) could present a significant barrier for southern species migrating north along the coast.

We thank Peter MacLeod, Danny Acker, and Kelsie Williams for bringing the specimens to our attention, and V. G. Springer, U. S. National Museum, for confirming our identification of *Hypsoblennius hentzi.*

Literature Cited

Bigelow, H. B. and **W. C. Schroeder.** 1953. Fishes of the Gulf of Maine. United States Fish and Wildlife Service, Fish Bulletin 53. 577 pp.

Böhlke, J. E. and **C. G. Chaplin.** 1968. Fishes of the Bahamas and adjacent tropical waters. Livingston Publishing Company, Wynnewood, Pennsylvania. 771 pp.

Cox, P. 1896. History and present state of the ichthyology of New Brunswick. Natural History Society of New Brunswick, Bulletin 13: 27–61.

Gilhen, J. 1972. The white mullet, *Mugil curema,* added to and the striped mullet, *Mugil cephalus,* deleted from the Canadian Atlantic fish fauna. Canadian Field-Naturalist 86: 74–77.

Hachey, H. B. 1961. Oceanography and Canadian Atlantic waters. Fisheries Research Board of Canada Bulletin 134. 120 pp.

Halkett, A. 1913. Checklist of the fishes of the Dominion of Canada and Newfoundland. King's Printer, Ottawa. 138 pp.

Hildebrand, J. F. and **L. E. Cable.** 1938. Further notes on the development and life history of some teleosts at Beaufort, N. C. United States Bureau of Fisheries, Bulletin 48: 505–642.

Hubbs, C. L. 1939. The characters and distribution of the Atlantic coast fishes referred to the genus *Hypsoblennius.* Papers of the Michigan Academy of Science, Arts and Letters 24(2): 153–157.

Jordan, D. S. and **B. W. Evermann.** 1905. American food and game fishes. Doubleday, Page and Company, New York. 572 pp.

Leim, A. H. and **W. B. Scott.** 1966. Fishes of the Atlantic coast of Canada. Fisheries Research Board of Canada Bulletin 155. 485 pp.

MacKay, K. T. and **J. Gilhen.** 1973. *Hirundichthys rondeleti, Cookeolus boops, Priacanthus arenatus, Seriola dumerili,* four species new to the Canadian Atlantic ichthyofauna. Journal of the Fisheries Research Board of Canada 30: 1911–1913.

MacKay, K. T. and **G. Thomas.** 1969. First records of *Ariomma bondi, Caranx crysos,* and *Selar crumenophthalmus* (Pisces) in the Gulf of St. Lawrence. Journal of the Fisheries Research Board of Canada 26: 2769–2771.

Platt, T., A. Prakash, and **B. Irwin.** 1972. Phytoplankton nutrients and flushing of inlets on the coast of Nova Scotia. Naturaliste Canadien 99: 253–261.

Smith, Hugh M. 1907. The fishes of North Carolina. North Carolina Geological and Economic Survey 2: 1–453.

Vladykov, V. D. and **R. A. McKenzie.** 1935. The marine fishes of Nova Scotia. Proceeding of the Nova Scotian Institute of Science 19(1), 1934: 17–113.

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Lynx Attack on Man Carrying Hares in Newfoundland

On 1 November 1974 at 1620 hours a peculiar aspect of lynx (*Lynx lynx*) behavior was observed 4 km west of Port Union, Newfoundland (48°30′ N, 53°5′ W). Boyd Duffett, a trapper in that area, was walking through a 5- to 7-m high black spruce – balsam fir (*Picea mariana – Abies balsamea*) forest carrying 12 snowshoe hares (*Lepus americanus*) over his left shoulder when a medium-sized female lynx sprang 3 m from a balsam fir tree onto the man's back. A struggle ensued and the trapper succeeded in choking the lynx to death with his hands approximately 10 min later. The trapper was not seriously injured but suffered severe scratches on his hands and legs.

From the trapper's account it seems likely that the lynx's main intent was to obtain the hares, and that the attack was not a direct one upon the trapper. As the lynx hunts primarily by sight (Saunders 1963) and will usually attack at night from the ground rather than from a perch, it appears unlikely that the trapper was pursued by the lynx. Rather it would seem that this was a chance encounter between the man and lynx, precipitated by the dead hares on the man's back.

No evidence can be found in the literature that a lynx will intentionally attack man. Seton (1925) states: "the lynx has never yet been known to attack man openly, knowingly, voluntarily." He records only one similar incident when a lynx attacked a man, apparently mistaking the man for a deer because of the man's buckskin clothing. Goudie (1973) described a winter incident in Labrador when a lynx ran from a forest onto a frozen lake and charged directly towards her. This animal was shot by a friend before any physical contact was made.

From interviews with experienced Newfoundland trappers, there is a consensus that the lynx normally will not attack a man, but in fact is a wary animal and will back away when caught in a snare. Although this Newfoundland incident indicates a definite aggressive behavioral pattern by the lynx in the presence of man, it is not indicative of typical behavior by the species. Winter observations have been made by trappers of a lynx following at a distance in the tracks of a man, but this behavior probably facilitates travelling in the soft snow and does not necessarily denote predatory tendencies.

It is interesting to note that the attack occurred in a year when the lynx and its principal prey, the snowshoe hare, were at a low in their cycle, as indicated by Newfoundland fur returns. Further documentation of the low lynx population has been provided by Arthur Butt, a trapper in the central Newfoundland area. With equal trapping pressure each year he has recorded a catch of 50, 41, 30, 24, 19, and 11 lynx for the years 1969–70 to 1974–75, respectively.

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Literature Cited

Goudie, E. 1973. Woman of Labrador. Peter Martin Associates Limited, Toronto, Ontario. 166 pp.

Saunders, J. K., Jr. 1963. Movements and activities of the lynx in Newfoundland. Journal of Wildlife Management 27(3): 390–400.

Seton, E. T. 1925. Lives of game animals. Volume 1, Cats, wolves, and foxes. Doubleday, Doran and Company, Inc., Garden City, New York. 640 pp.

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Photosynthetic Period Length for the Woody Plants of Two Deciduous Forest Sites

Abstract. The timing of leaf emergence and leaf discoloration, i.e., chlorophyll disappearance, was recorded for native woody deciduous plants at forest sites in North Carolina and southern Ontario. Leaf buds closest to the ground were the first to open at both sites. Leaf discoloration was first noted in understory plants and later in canopy and ground-layer plants. The difference between leaf discoloration and emergence dates, i.e., photosynthetic period length, was greatest for ground-layer species and least for canopy species. Photosynthetic period length ranged from 168 to 227 days at the North Carolina site and from 136 to 174 days at the Ontario site. Differences in the photosynthetic period lengths of species found at both sites resulted more from differences in leaf emergence dates than from differences in leaf discoloration dates.

The seasonality of leaf emergence and leaf discoloration, i.e., chlorophyll disappearance, is both distinct and obvious for deciduous-leaved plants native to forests of eastern North America. Trelease (1883) and Britton (1898a, b) were among the first to record the dates of leaf emergence and leaf fall for deciduous forest species. Neither they, nor subsequent investigators, however, have recorded the dates of leaf discoloration. Consequently, the length of the photosynthetic period is unknown for most woody deciduous-leaved plants. As part of a study investigating the relationship between photosynthetic period and landscape productivity (Reader 1973), the length of the photosynthetic period was estimated for some deciduous forest plants by recording the dates of their leaf emergence and discoloration. It was assumed that any photosynthetic contribution made by young branches was negligible compared to leaf photosynthesis. Following the preliminary study of Lieth and Radford (1971), detailed observations were made at two forested sites, one in North Carolina and the other in Ontario, to examine the effect of site location on the length of a species' photosynthetic period.

Materials and Methods

In 1973, leaf emergence and leaf discoloration dates were recorded for woody plants native to a deciduous forest site in the North Carolina

Botanical Garden (NCBG). The NCBG is located 1 km south of Chapel Hill, North Carolina (33.9°N, 79.0°W, 105 m elevation). The species composition and spatial distribution of vegetation types in the NCBG has been described by Mew and Lieth (unpublished). Oaks (*Quercus* spp.) and hickories (*Carya* spp.) dominate the forest canopy at this site, with an understory of predominantly flowering dogwood (*Cornus florida* L.), sourwood (*Oxydendrum arboreum* (L.) DC.), and red maple (*Acer rubrum* L.). The groundlayer, i.e., woody plants less than 1 m tall, is characterized by *Viburnum* spp. and isolated oak and hickory seedlings.

In 1974 leaf emergence and leaf discoloration dates were recorded at a deciduous forest site located 6 km west of Galt, Ontario (43.3°N, 80.3°W, 335 m elevation). Dale (1975) has recently surveyed and analyzed the vegetation present at the Galt site. The canopy contains a mixture of oaks (*Quercus* spp.), hickory (*Carya glabra* (Mill) Sweet), and beech (*Fagus grandifolia* Ehrh.), while the understory is characterized by ash (*Fraxinus americana* L.), sugar maple (*Acer saccharum* Marsh.), and ironwood (*Ostrya virginiana* (Mill.) K. Koch). The groundlayer is densely populated by cherry (*Prunus* spp.) and sugar maple seedlings.

The following procedure was used to collect data at both sites. A number of plots, 20 × 1 m, were positioned at random in the forest. Four plots were surveyed at the Galt site and 27 in the NCBG. The undulating topography of the NCBG made it necessary to use the increased number of plots. Galt forest plots were located on almost level ground. Only woody plants found in the plots were tagged. The tagged plants were observed at 3-day intervals for evidence of leaf emergence (first leaf visible on the plant) or leaf discoloration (leaves naturally discolored on at least one branch of the plant). Canopy trees were observed with 7 × 35 binoculars. The first dates of leaf emergence and leaf discoloration were recorded for each of the tagged plants. The difference between the onset of leaf discoloration and leaf emergence represents a *minimum* estimate of photosynthetic period length. The onset of leaf discoloration rather than its cessation was selected for observation based on the results of a preliminary study in which independent observers were asked to estimate the onset, mid-point, and termination of leaf discoloration for a set of trees. The observers agreed most closely in their estimates of the onset of leaf discoloration.

The first emergent leaves on a plant may or may not be those that discolor first, so it was impossible to calculate precisely the length of the photosynthetic period for each of the tagged plants. Photosynthetic period length was estimated for each species by subtracting the average date of leaf emergence from the average date of discoloration.

Results and Discussion

Leaf emergence at the Galt site was first noted during the last week of April (Table 1). Leaves of ground-layer species were the first to emerge, followed by the leaves of understory and canopy species. By the end of May all plants had leafed out. The progression of leaf emergence from the ground upwards parallels the vertical air temperature gradient characteristic of deciduous forests at this time of year (Wilson 1968; Christy 1952). Leaf buds of ground-layer plants are exposed to the highest air temperatures and therefore are the first to expand and open.

The vertical pattern of leaf discoloration differed from the progression recorded for leaf emergence. Leaf discoloration was first observed on understory plants during the last week of September (Table 1), while the leaves of canopy and ground-layer plants did not lose their chlorophyll until the second week of October. The factors responsible for this discoloration sequence are not apparent at the present time.

Ground-layer plants had the longest photosynthetic periods, i.e., 164–174 days. It must be emphasized that this represents a minimum estimate of photosynthetic period length. The photosynthetic period of understory and canopy plants was from 10 to 38 days shorter than that of ground-layer species.

The patterns of leaf emergence and leaf discoloration observed at the NCBG site were similar to those recorded at the Galt site. Leaves of canopy plants were the last to emerge and the last to lose their chlorophyll (Table 2). Understory leaves were generally the first to discolor, while ground-layer leaves were the first to emerge.

TABLE 1—Timing of leaf development at the Galt, Ontario site in 1974

Species	Position[a]	Number of plants observed	Leaf emergence yeardate[b] $\overline{x} \pm 1$ SD	Leaf discoloration yeardate $\overline{x} \pm 1$ SD	Photosynthetic period (days)
Quercus alba L.	C	9	144 ± 2	280 ± 4	136
Quercus rubra L.	C	3	142 ± 2	286 ± 2	144
Carya glabra (Mill.) Sweet	C	7	137 ± 15	275 ± 3	138
Fagus grandifolia Ehrh.	C	4	137 ± 0	282 ± 5	145
Fraxinus americana L.	U	53	131 ± 5	274 ± 4	143
Acer rubrum L.	U	9	127 ± 9	276 ± 3	149
Acer saccharum Marsh.	U,G	74	125 ± 6	280 ± 6	155
Ostrya virginiana (Mill.) K. Koch	U	37	124 ± 4	279 ± 6	155
Hamamelis virginiana L.	U	4	124 ± 2	273 ± 3	149
Prunus serotina Ehrh.	G	13	116 ± 3	280 ± 5	164
Prunus virginiana L.	G	26	114 ± 2	279 ± 5	165
Rubus odoratus L.	G	3	113 ± 0	287 ± 0	174

[a] C = canopy; U = understory; G = ground layer.

[b] Yeardate 1 = January 1.

Understory and ground-layer species at the NCBG site showed a greater range of leafing and discoloration dates than at the Galt site. This variability made the vertical patterns of leaf emergence and discoloration less obvious at the NCBG site.

Photosynthetic period length was also quite variable at the NCBG site (Table 2). *Oxydendrum arboreum* had the shortest photosynthetic period, 168 days, and *Ostrya virginiana* had the longest, 227 days. Ground-layer plants at the NCBG site generally had longer photosynthetic periods than either understory or canopy plants.

Nine species were present at both the Galt and NCBG sites. Their photosynthetic period lengths were from 45 to 72 days shorter at the Galt site than at the NCBG site (Table 3). This difference resulted more from differences in the dates of their leaf emergence than from differences in their leaf discoloration dates. The reduction from spring to fall in the magnitude of the timing difference between the two sites probably reflects a similar seasonal change in the rate of isotherm movement. The northward movement of isotherms in spring normally takes twice as long as their southward movement in the fall (Visshser 1954). While the

TABLE 2—Timing of leaf development at the North Carolina Botanical Garden in 1973

Species	Position[a]	Number of shoots observed	Leaf emergence yeardate[b] $\bar{x} \pm 1$ SD	Leaf discoloration yeardate $\bar{x} \pm 1$ SD	Photosynthetic period (days)
Fagus grandifolia Ehrh.	C	4	105 ± 2	302 ± 6	197
Fraxinus americana L.	C	24	98 ± 5	286 ± 3	188
Quercus velutina Lam.	C	30	96 ± 4	298 ± 3	202
Quercus stellata Wang.	C	18	96 ± 4	296 ± 6	200
Quercus rubra L.	C	8	96 ± 4	300 ± 1	204
Quercus alba L.	C	29	93 ± 5	298 ± 3	205
Carya glabra (Mill.) Sweet	C,G	20	86 ± 6	291 ± 8	205
Carya ovata (Mill.) K. Koch	C	2	85 ± 0	277 ± 0	192
Carya tomentosa Nutt.	C	47	83 ± 5	290 ± 6	207
Liriodendron tulipifera L.	C	21	85 ± 6	281 ± 3	196
Liquidambar styraciflua L.	C	10	84 ± 6	299 ± 5	215
Morus rubra L.	U	3	106 ± 1	283 ± 2	177
Acer saccharum Marsh.	U	2	105 ± 2	305 ± 2	200
Diospyros virginiana L	U	3	102 ± 4	292 ± 9	190
Oxydendrum arboreum (L.) D.C.	U	102	99 ± 4	267 ± 6	168
Crataegus flava Ait.	U	11	94 ± 2	284 ± 3	190
Sassafras albidum (Nutt.) Nees.	U	8	93 ± 1	294 ± 9	201
Nyssa sylvatica Marsh.	U	48	94 ± 3	268 ± 5	174
Cercis canadensis L.	U	10	91 ± 3	275 ± 4	184
Acer rubrum L.	U	176	91 ± 6	295 ± 6	204
Carpinus carolinianum Walt.	U	4	81 ± 3	295 ± 3	214
Cornus florida L.	U	252	79 ± 3	268 ± 4	189
Ostrya virginiana (Mill.) K. Koch	U	2	76 ± 3	303 ± 7	227
Styrax grandiflora Ait.	U	1	76 ± 0	283 ± 0	207
Vitis rotundifolia	G	5	97 ± 2	276 ± 8	179

Table 2 – *Continued*

Species	Position[a]	Number of shoots observed	Leaf emergence yeardate[b] $\overline{x} \pm 1$ SD	Leaf discoloration yeardate $\overline{x} \pm 1$ SD	Photosynthetic period (days)
Vaccinium spp.	G	68	92 ± 3	283 ± 5	191
Ulmus alata Michx.	G	1	85 ± 0	277 ± 0	192
Viburnum acerifolium L.	G	60	88 ± 3	297 ± 3	209
Viburnum rafinesquianum Schultes	G	146	78 ± 3	295 ± 6	217
Viburnum rufidulum Raf. G	G	16	77 ± 2	264 ± 5	187
Prunus serotina Ehrh.	G	8	79 ± 4	291 ± 7	212

[a] C = canopy; U = understory; G = ground layer.

[b] Yeardate 1 = January 1.

TABLE 3 – Between-site differences in the timing of leaf development for nine species found at the Galt and North Carolina Botanical Garden Sites

Species	Difference (days)		
	Leaf emergence	Leaf discoloration	Photosynthetic period
Quercus alba L.	51	18	69
Quercus rubra L.	46	14	60
Carya glabra (Mill.) Sweet	51	16	67
Fagus grandifolia Ehrh.	32	20	52
Fraxinus americana L.	33	12	45
Acer rubrum L.	36	19	55
Acer saccharum Marsh.	20	25	45
Ostrya virginiana (Mill.) K. Koch	48	24	72
Prunus serotina Ehrh.	37	11	48

results of this study illustrate significant ($P < 0.01$) differences in the photosynthetic periods of species found at both sites, further studies must be undertaken to evaluate the effect of annual variation in weather patterns on the magnitude of these differences.

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Literature Cited

Britton, N. L. 1898a. When the leaves fall. Bulletin of the Torrey Botanical Club 6: 211–213.

Britton, N. L. 1898b. When the leaves appear. Bulletin of the Torrey Botanical Club 6: 235–237.

Christy, H. R. 1952. Vertical temperature gradients in a beech forest in central Ohio. Ohio Journal of Science 52: 199–209.

Dale, M. 1975. The use of graph theory in the analysis of the phytosociological structure of plant communities. M.Sc. thesis, University of Toronto, Toronto, Ontario.

Lieth, H. and **J. S. Radford.** 1971. Phenology, resource management and synagraphic computer mapping. BioScience 21: 62–70.

Reader R. J. 1973. Leaf emergence, leaf coloration, and photosynthetic period-productivity models for the eastern deciduous forest biome. Ph.D. thesis, University of North Carolina, Chapel Hill, North Carolina.

Trelease, W. 1883. When the leaves appear and fall. Wisconsin Agricultural Experiment Station Annual Report. pp. 56-73.

Vissher, S. S. 1954. Climatic atlas of the United States. Harvard University Press, Cambridge.

Wilson, R. 1968. Topographic influences on a forest microclimate. M.Sc. thesis, McGill University, Montreal, Quebec.

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Accidental Mortality and Cannibalization of a Nestling Gray Squirrel

Accidents are obscure factors causing mortality in populations of wild animals. It is therefore of value to document and attempt quantification of these phenomena. In the gray squirrel (*Sciurus carolinensis pennsylvanicus*), cannibalism has been anecdotally reported (Barkalow and Shorten 1973, p. 54). There is, however, little published information concerning this behavior. Here I report the accidental mortality and subsequent cannibalization of a nestling gray squirrel, one of a population under observation at Mount Pleasant Cemetery, Toronto, Ontario.

On 19 August 1974 an adult (18+ months) female was observed transferring her litter; the transfer of two young was witnessed. She grasped the first nestling by the skin of the upper chest while the nestling clung to her by wrapping both hind and fore feet about her neck and lower abdomen respectively. No vocalizations were heard from either animal. This method of carriage was identical to both those observed in the six other litter transfers witnessed by the author, and that described by Barkalow and Shorten (1973, p. 45). The female entered an apparently fresh leaf-nest located about 8 m aboveground in the crotch between the main stem and a side branch of a sugar maple (*Acer saccharum*). After a period of 1 min the female descended and ran off.

Approximately 2 min later she reappeared with a second nestling held in an identical manner. On reaching the leaf nest she paused, then climbed onto the side branch. At this point the nestling apparently slipped from her, fell, struck several branches, and landed heavily on the ground. On impact it began to give shrill distress cries (see Horwich 1972, p. 8). The volume of the cries rapidly diminished and ended after several seconds with death.

The female began to sniff about her immediate surroundings and, after 1 min, descended. She did not initially approach the dead nestling but eventually sniffed it several times. She grasped the nestling by the skin of the upper chest and then dropped it. After pawing the body several times she again attempted to pick it up. She then moved several metres away and began to feed on fallen maple seed. After eating several, she returned to the body and, grasping it by the nape of the neck, dragged it up onto the base of a monument. She then fed on the nestling. Initially she held it in the typical upright feeding posture. In this position she was seen to work the body in a manner similar to the manipulations involved in opening a shelled nut. This posture alternated with a crouch over the body similar to that described by Horwich (1972, p. 35). After 5 min she dropped the nestling, climbed the tree, and entered the nest. There was fresh blood on the ground where the nestling had fallen.

The nestling was a male, 28–35 days old

(Uhling 1955). There was a large (1–2 mm) puncture wound on its left side, posterior to the last rib and immediately ventral to the vertebral column. Large hemorrhages surrounded the left kidney, apparently originating from its surface. As there were several sharp projections on the branches that the nestling hit, death was likely a result of the puncture and associated blood loss. The other organs appeared normal. A large amount of subcutaneous fat was present suggesting the nestling was in good health. The female had eaten the entire skull and contents. The majority of the skin covering these areas was left untouched as was the rest of the body.

Litter movements appear to be a common phenomenon in the gray squirrel. Cordes and Barkalow (1972, p. 126) note that the disturbance of a nest will often cause females to transfer their nestlings from the original nest to another. No data were presented on the frequency of such transfers; however, one case was noted of a nestling which was either not moved or was lost during a transfer. In this study a total of 28 successful litters comprising 87 individuals were located prior to weaning of the young. Of these, six litters totaling 14 nestlings were known to have been moved, and only one individual was known to have been lost during transfer.

Dasmann (1964, p. 102) considers accidents to be a small constant mortality factor in wild populations. While the extent of nestling mortality as a result of accident during transfer is difficult to measure, it would appear low, only some 1% of the nestlings being lost to this cause in this study.

A 1967 Science Scholarship to the author by the National Research Council of Canada supported this study. Members of the Toronto General Burial Grounds Authority and A. K. Clark, Superintendant Mount Pleasant Cemetery, were kind enough to provide access to the study area. J. F. Bendell critically reviewed an earlier draft.

Literature Cited

Barkalow, F. S. and M. Shorten. 1973. The world of the gray squirrel, J. B. Lippencott Co., Philadelphia and New York. 160 pp.

Cordes, C. L. and F. S. Barkalow. 1972. Home range and dispersal in a North Carolina gray squirrel population Proceedings of the 26th Annual Conference Southeastern Association of Game and Fish Commissioners. pp. 126–135.

Dasmann, R. F. 1964. Wildlife biology. John Wiley and Sons, New York, London, and Sydney. 231 pp.

Horwich, R. H. 1972. The ontogeny of social behaviour in the Gray Squirrel (*Sciurus carolinersis*). Verlag Paul Parey, Berlin and Hamburg. 103 pp.

Uhling, H. G. 1955. The determination of age of nestling and subadult gray squirrels in West Virginia. Journal of Wildlife Management 19: 479–483.

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Additions and Rediscoveries of Five Plant Species in Prince Edward Island

Abstract. Two introduced species, *Erodium cicutarium* and *Scrophularia nodosa*, are reported for the first time from Prince Edward Island. *Angelica atropurpurea* is now known from the eastern part of the province, and two introduced species, *Conringia orientalis* and *Tussilago farfara* have been rediscovered in the province.

During the summer of 1974, while engaged with the Prince Edward Island Department of Agriculture on a ragweed survey project, the junior author observed and gathered specimens of several interesting plants which proved to be either new records, extension of range, or rediscoveries in the province. These are reported below.

Angelica atropurpurea L.

P.E.I.: Kings County, Murray River (46° 01′ N, 62°36′ W), single plant on roadside near moist ditch, 13 August 1974. *R.B. MacLaren* (Herbarium P.E.I. Department of Agriculture, Charlottetown; Photo DAO).

The map in Erskine (1960) shows three locations in the western part of Prince County. The collection reported here is thus the first from the eastern part of the province. *Angelica atropurpurea* occurs sporadically in rich moist thickets and swamps from southern Labrador south to West Virginia and west through southern Quebec and southern Ontario to Indiana, Illinois, and Minnesota, with apparently disjunct stations on Hudson and James Bays. In Nova Scotia recent collections have proved this species to be more common in Cape Breton Island than previously supposed, but on the mainland it is known only from near Shelburne (Roland and Smith 1969).

Conringia orientalis (L.) Dumort.
P. E. I.: Kings County, Murray River (46°01′ N, 62°36′ W), a few scattered plants in wasteland across from railroad siding, 9 July 1974, *R. B. MacLaren* (Herbarium P. E. I. Department of Agriculture, Charlottetown; Photo DAO).

This species was reported by Groh (1947) on the basis of an observation made in 1942 by R.R. Hurst at Point de Roche, Queens County. The report was repeated by Erskine (1960). Apparently no voucher specimen was taken. *Conringia orientalis* has been reported as a casual introduction in Nova Scotia from Yarmouth to Cumberland County (Roland and Smith 1969), and elsewhere in the Maritime Provinces from Newfoundland and New Brunswick, and in addition is found across Canada to British Columbia. It is a common weed of grain fields in the Prairie Provinces (Frankton and Mulligan 1970).

Erodium cicutarium (L.) L'Hér.
P. E. I.: Kings County, Machon's Point (46°01′ N. 62°31′ W), one plant only, 6 August 1974, *R. B. MacLaren* (Herbarium P. E. I. Department of Agriculture, Charlottetown; Photo DAO).

This is the first report for Storksbill on Prince Edward Island. The species is rather common in parts of British Columbia, but not so in eastern Canada, although it has been reported from all provinces from Nova Scotia to British Columbia (Boivin 1966, 1967). In Nova Scotia Roland and Smith (1969) reported the species from only two sites: Centerville in Kings County and Halifax.

Scrophularia nodosa L.
P. E. I.: Queen County, Vernon River (46°13′ N, 62°49′ W), six plants in damp, very stony ground adjoining a stream, 3 July 1974, *R. B. MacLaren* (Herbarium P. E. I. Department of Agriculture, Charlottetown; DAO).

Scrophularia nodosa was considered by Fernald (1933) to be indigenous in Newfoundland, and Fernald (1950) stated that it was, in addition, locally adventive from Europe in southern New England and formerly, on ballast, to New Jersey. Boivin (1966, 1967) believed that it was an introduced species in Canada, and in addition to its presence in Newfoundland, doubtfully reported it from Quebec as well. The present collection is the first from Prince Edward Island.

Tussilago farfara L.
P. E. I.: Kings County, Bangor, Indian Bridge (46°22′ N, 62°41′ W), two small colonies, one beside the road, the other beside the stream, 9 May 1974, *R. B. MacLaren* (Herbarium P. E. I. Department of Agriculture, Charlottetown; DAO).

This is the second location for Coltsfoot on the island. It is located about a quarter of a mile from any cultivated land. The clones were treated with Picloram (Tordon) in an effort to eradicate them, but not before many seeds had been dispersed by the wind. The other location was at Charlottetown (DAO; Erskine 1960), where attempts have been made to eradicate it.

Another stand of *Tussilago* was later observed in Northport near Alberton in Prince County. Leaves were noted in almost every crevice of some rocky fill which had been dumped over a bank. No flowering stems were noted at the time of observation (19 July 1974).

Tussilago farfara is of rather spotty occurrence in eastern Canada, but extensive stands have been noted in parts of Quebec such as Ile d'Orléans (*Cody 18 524*, DAO).

Literature Cited

Boivin, B. 1966, 1967. Enumération des plantes du Canada. Naturaliste Canadien 93: 253–274, 371–437, 583–646, 989–1063; 94: 131–157, 471–528, 625–655. (*Reprinted as* Provancheria 6. 404 pp., without change of pagination but the addition of an index.)

Erskine, D. E. 1960. Plants of Prince Edward Island, Canada Department of Agriculture, Publication 1088. 270 pp.

Fernald, M. L. 1933. Recent discoveries in the Newfoundland flora. Rhodora 35: 265–283.

Frankton, C. and **G. A. Mulligan.** 1970. Weeds of Canada. Canada Department of Agriculture Publication 948. 217 pp.

Groh, H. 1947. Canadian weed survey, Fourth annual report, 1945. Division of Botany and Plant Pathology, Canada Agriculture, Ottawa. 56 pp.

Roland, A. E. and **E. C. Smith.** 1969. The flora of Nova Scotia. The Nova Scotia Museum, Halifax. 706 pp.

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Second Breeding Record of the Semipalmated Plover at Vancouver, British Columbia

The Semipalmated Plover (*Charadrius semipalmatus*) breeds in Canada mainly in arctic and subarctic regions and along the Atlantic coast (Godfrey 1966, p. 132). In British Columbia, it has been recorded breeding in the extreme northwest in Chilkat Pass (Weeden 1960) and in the Atlin area (Swarth 1926); at Le Blanc Lake in the central interior (Hesse and Hesse 1962); and near Masset and Sandspit in the Queen Charlotte Islands (Brooks 1920; R. W. Campbell, personal communication). Only one breeding record is known for southwestern British Columbia: in 1967, an adult accompanied by three small young was seen at the Iona Island sewage treatment plant near Vancouver (Campbell and Luscher 1972). We are recording, therefore, in this note a second breeding record at Iona Island in 1974.

The first indication of nesting in 1974 was on 7 June, when RWP found a pair which flew about, calling excitedly, on the Iona Island west jetty almost 1 km from its base. This jetty, which extends for about 3.5 km into the Gulf of Georgia, is built of rock fill, with a gravelled roadway about 8 m wide on top. The nest, which contained four eggs, was found by JAR at the edge of the roadway on 16 June. Several photographs of nest and eggs were obtained by RWP, JAR, and G. Allen Poynter, and copies have been deposited (Number 349) in the Photoduplicate File of British Columbia vertebrate records (see Campbell and Stirling 1971).

At least two eggs hatched on 4 July. JAR photographed the nest in early evening, when it contained two unhatched eggs and two chicks; RWP photographed it later the same evening, but one chick was no longer there. Successful hatching occurred despite the presence of many Norway rats (*Rattus norvegicus*) and at least one feral house cat on the jetty. The chicks were not seen after 4 July, but the adults were still quite agitated when RWP saw them on 12 July, so at least one young was probably still alive then.

Although Semipalmated Plovers are known to have bred at Iona Island only in 1967 and 1974, they may have done so in the intervening years as well. Single adults or pairs were seen there during June and early July of 1968, 1969, 1970, and 1972. Migrant plovers are not known to occur at Vancouver between late May and mid-July (Campbell et al. 1974), so these summer records may involve birds that bred or attempted to.

The Vancouver breeding records of Semipalmated Plovers, in conjunction with a recent record of two pairs nesting at Ocean Shores, Washington (Morris 1974), suggest that the species may breed regularly in future on the coasts of southern British Columbia and Washington. Habitat which appears suitable for nesting (sandy or gravelly beaches adjacent to intertidal mudflats) is present at numerous localities in this region.

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Literature Cited

Brooks, A. 1920. Notes on the Limicolae of southern British Columbia. Condor 22: 26–32.

Campbell, R. W. and **R. E. Luscher.** 1972. Semipalmated Plover breeding at Vancouver, British Columbia. Murrelet 53: 11–12.

Campbell, R. W., M. G. Shepard, B. A. Macdonald, and **W. C. Weber.** 1974. Vancouver birds in 1972. Vancouver Natural History Society, Vancouver. 96 pp.

Campbell, R. W. and **D. Stirling.** 1971. A photoduplicate file for British Columbia vertebrate records. Syesis 4: 217–222.

Godfrey, W. E. 1966. The birds of Canada. National Museum of Canada Bulletin 203. 428 pp.

Hesse, W. and **H. Hesse.** 1962. Sight record of downy young Semipalmated Plover in the Chilcotin of British Columbia. Murrelet 43: 35–36.

Morris, J. R., Jr. 1974. Breeding record for the Semipalmated Plover at Ocean Shores, Washington. Western Birds 5: 22.

Swarth, H. S. 1926. Report on a collection of birds and mammals from the Atlin region, northern British Columbia. University of California Publications in Zoology 30: 51–162.

Weeden, R. B. 1960. The birds of Chilkat Pass, British Columbia. Canadian Field-Naturalist 74: 119–129.

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Colonization of Isolated Aquatic Habitats

In a recent article Peck (1975) has briefly discussed the interesting problem of how non-flying aquatic invertebrates may be transported from one isolated habitat to another. There is no doubt that such movements take place. Indeed, when the flora and fauna of a single pond are studied for several successive years, it is readily apparent that the species composition of the community is subject to considerable variation from year to year (Daborn 1971, 1974; Rosenberg 1973). Even slight changes in important environmental parameters (temperature, precipitation, etc.) may show a correlation with sharp changes in the species inhabiting small static or astatic ponds.

The rapid substitution of one species for another of similar life history and trophic relations leaves one with the impression that small isolated habitats are subjected to an almost perpetual bombardment of invaders. The success of an invader presumably depends upon how closely prevailing environmental conditions match the ecological requirements of the species-in-residence (Talling 1951; Daborn 1974).

Some of the mechanisms for such invasive movements have been well described for phytoplankton (e.g., Maguire 1963, 1971; Schlichting and Sides 1969; Schlichting and Milliger 1969; Sides 1970, 1971) and anostracan and cladoceran eggs (e.g., Procter 1964; Procter et al. 1967; Moore and Faust 1972). It is notable, however, that these studies all deal with disseminules that are capable of surviving prolonged exposure out of water. Evidence concerning dispersal of adult forms that are much larger in size and generally do not share the physiological tolerance of eggs is much more sparse (but see Segerstråle 1954; Arnold 1966). For several reasons I feel that Peck's (1975) evidence is unconvincing.

The two amphipods mentioned by Peck, *Gammarus lacustris* (Sars) and *Hyalella azteca* (Saussure), are extremely common and important inhabitants of prairie sloughs and ponds. They occur wherever basin depth is sufficient to allow some water to remain unfrozen throughout the winter, but are eliminated from aestival habitats by winter freezing (Daborn 1969). Nonetheless, during a study of such a pond in Alberta a few *Gammarus* or *Hyalella* were found during summer months. They were not present in spring nor reproduced in the pond. I assumed they were introduced by ducks that flew in to feed during the day and returned at night to a larger slough nearby in which amphipods were abundant.

To test this I examined the plumage of 12 ducks (seven Mallards, four Green-winged Teal, and a Pintail) that were shot as they rose from the larger slough and flew overland. All fell on land, were quickly retrieved, placed in separate plastic bags, and examined carefully in the laboratory within a few hours. One of these birds (a male Green-winged Teal) carried six 3- to 5-mm *Hyalella azteca* and a single *Oculobdella lucida* (Hirudinea). The other 11 carried no aquatic invertebrates that were visible to the naked eye.

Three other Mallards fell into the water near shore and were retrieved by hand within a few minutes. Significantly, all three carried amphipods: one had two *Hyalella* and a *Gammarus*, another carried five *Gammarus*, and the third had one individual of each species. The first also carried three *Chydorus sphaericus* and one *Oculobdella lucida*. Although the sample sizes are small, the disproportionate occurrence of amphipods on birds that fell in the water indicates that such data bear little relationship to the probability that amphipods would be carried some distance within the plumage of waterfowl.

Peck (1975) also suggests that *Gammarus* and *Hyalella* may exhibit a pattern of concealment behavior that would increase their chances of transport in the plumage of birds or the fur of mammals. Such a pattern is quite at variance with normal behavior. When disturbed, normal *Gammarus* react by swimming downwards and clinging to vegetation or other substrates well below the water surface. When *Gammarus*, however, are infected with the cysts of *Polymorphus paradoxus* (Acanthocephala) their normal behavior is reversed: upon disturbance infected animals remain close to the water surface and cling to any floating object (W. Bethel, personal communication). Such a parasite–host interaction is interpreted as an appropriate mechanism for increasing the probability that infected animals will be ingested by the parasite's final hosts, the Mallard, muskrat, and beaver (J. Wolford, personal communication).

These observations are presented to demonstrate the difficulty of drawing firm conclusions from Peck's data and to emphasize the lack of information available on transport of non-flying macroinvertebrates. The matter is of considerable importance to our understanding of the causes of present-day species distribution. One may say with fair confidence that any large organism habitually moving between isolated aquatic habitats is a potential vehicle for the translocation of aquatic invertebrates. There is also the possibility that some species display behavior effectively increasing their chances of movement; behavior that is therefore essentially phoretic. Before such intricate explanations are advanced, however, it is as well to provide unequivocal evidence that transport of non-flying macroinvertebrates takes place with sufficient frequency. The data are not yet available.

Literature Cited

Arnold, J. T. 1966. Observations on *Lepidurus arcticus* in East Greenland. Annals and Magazine of Natural History 9: 599–617.

Daborn, G. R. 1969. Transient ecological succession in a shallow pond. Unpublished M.Sc. thesis, Department of Zoology, University of Alberta, Edmonton. 104 pp.

Daborn, G. R. 1971. Survival and mortality of coenagrionid nymphs (Odonata: Zygoptera) from the ice of an aestival pond. Canadian Journal of Zoology 49: 569–571.

Daborn, G. R. 1974. Biological features of an aestival pond in western Canada. Hydrobiologia 44: 287–299.

Maguire, B. 1963. The passive dispersal of small aquatic organisms and their colonization of isolated bodies of water. Ecological Monographs 33: 161–185.

Maguire, B. 1971. Community structure of protozoans and algae with particular emphasis on recently colonized bodies of water. *In* The structure and function of freshwater microbial communities. *Edited by* J. Cairn. Research Division Monograph 3, Virginia Polytechnic Institute and State University, Blacksburg, Virginia. pp. 121–149.

Moore, W. G. and **B. F. Faust.** 1972. Crayfish as possible agents of dissemination of fairy shrimp into temporary ponds. Ecology 53: 314–316.

Peck, S. B. 1975. Amphipod dispersal in the fur of aquatic mammals. Canadian Field-Naturalist 89: 181–182.

Procter, V. W. 1964. Viability of crustacean eggs recovered from ducks. Ecology 45: 656–658.

Procter, V. W., E. R. Malone, and **V. L. DeVlaming.** 1967. Dispersal of aquatic organisms: viability of disseminules recovered from the intestinal tract of captive killdeer. Ecology 48: 672–676.

Rosenberg, D. 1973. Effects of dieldrin on diversity of macroinvertebrates in a slough in central Alberta. Unpublished Ph.D. thesis, Department of Entomology, University of Alberta, Edmonton. 2 volumes. 282 pp.

Schlichting, H. E. and **L. E. Milliger.** 1969. The dispersal of microorganisms by a hemipteran, *Lethocerus uhleri* (Montandon). Transactions of the American Microscopical Society 88: 452–454.

Schlichting, H. E. and **S. L. Sides.** 1969. The passive transport of aquatic microorganisms by selected Hemiptera. Journal of Ecology 57: 759–764.

Segerstråle S. G. 1954. The freshwater amphipods *Gannarus pulex* (L.) and *Gammarus lacustris* (Sars) in Denmark and Fennoscandia–a contribution to the late and post-glacial immigration history of the aquatic fauna of northern Europe. Societas Scientiarum Fennica Commentationes Biologicae 15. 91 pp.

Sides, S. L. 1970. Dispersal of algae and protozoa by the mud dauber wasp (*Sceliphron caementarium* Drury). Proceedings of the Oklahoma Academy of Sciences 49: 9–12.

Sides, S. L. 1971. Observations on dispersal of algae and protozoa by the cabbage butterfly. Transactions of the American Microscopical Society 90: 96-97

Talling, J. F. 1951. The element of chance in pond populations. Naturalist (London) Oct.–Dec. pp. 157–170.

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A “Speckle” Phenotype in *Rana clamitans*

In late August 1974, I collected an interesting specimen of *Rana clamitans* at the Leslie Frost Natural Resources Centre on Lake St. Nora, about 7 mi southeast of Dorset, Ontario. This specimen, one of 27 green frogs collected, was a female possessing an unusual pigment pattern which has not been reported in this species. The frog had gold speckles dorsally and laterally with a dark chocolate background on the dorsal surface which became lighter on the lateral surface. A green mask (Mecham, J. S. 1954. Geographic variation in the Green Frog, *Rana clamitans latreille.* Texas Journal of Science 6(1): 1–25) usually covers the upper jaw in this species but in this frog it was greatly reduced; consequently there were patches of translucent skin in this area and also around the tympanic membrane which also showed traces of gold speckling. The ventral surface of the body was a pale white with mottled areas of translucent skin; the ventral surfaces of the fore and hind limbs were translucent. The eye had gold speckles and an incomplete gold pigment ring bordering the iris.

The pigmentation of this specimen may be similar to that found in the homozygous (guanophore, xanthophore reduced) "speckle" mutant found in *Rana pipiens* (Browder, L. W. 1968. Pigmentation in *Rana pipiens*. I. Inheritance of the speckle mutation. Journal of Heredity 59: 163–166). Normally *Rana pipiens* and *Rana clamitans* possess three kinds of pigment cells: melanophores which appear black, guanophores which are iridescent, and xanthophores which appear yellow. These cells must be present to produce the green skin color while shades of brown are produced by a predominance of melanophores. The white of the ventral surface is produced by a predominance of guanophores. In Browder's homozygous (guanophore, xanthophore reduced) "speckle" mutant, the gold speckles were due to the clustering of guanophores and xanthophores while there was a reduction of guanophores and xanthophores in the background coloration. The incomplete gold ring bordering the iris was another indication of reduced guanophores and xanthophores. The belly showed a reduction in guanophores.

Since the *Rana pipiens* "speckle" mutant and the *Rana clamitans* reported here show so much similarity in appearance, the pigment cell analysis of the former may well apply to that of the latter. Thus the *Rana clamitans* "speckle" phenotype most likely has clusters of guanophores and xanthophores in its speckles with a reduction or even absence of guanophores and xanthophores in the other abnormal areas.

The frog fed well on crickets and attained a snout–vent length of 7 cm. The abdominal cavity contained growing pigmented eggs. Unfortunately, the frog died while in cold storage with other green frogs before appropriate crosses could be made. The specimen and color photographs of it will be sent to F. R. Cook, Curator of Herpetology, National Museum of Natural Sciences, Ottawa, Ontario K1A 0M8.

I captured the specimen while taking a field course at the University of Toronto. I am indebted to R. P. Elinson and F. W. Schueler for their comments and suggestions concerning the manuscript. This work has been supported by the National Research Council of Canada, Grant #A 6356 to R. P. Elinson.

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A Second Brood in the Ovenbird, *Seiurus aurocapillus*

The Ovenbird (*Seiurus aurocapillus*) is usually considered to be single brooded (Bent 1953). In his extensive study of the species in southern Michigan, Hann (1937) reported a single instance of a male raising a second brood. This bird raised a fledgling to at least 35 days of age, and late in the season was found caring for another young bird out of the nest. No further details were given. Kendeigh (1945) studied nesting behavior of wood warblers (Parulidae) in New York State and noted that two broods were raised by the Ovenbird. No data were presented to support this conclusion. The nest record files of Ontario, Quebec, and the Maritimes contain a number of records of nests in late July; however, there is no definite evidence of any second brood.

While we were conducting a study of the Ovenbird at the Wildlife Research Station in Algonquin Park, Ontario in 1973, a color-marked male was observed raising two broods. This instance of a double brood was coincidental with a high population of spruce budworm (*Choristoneura fumiferana*) and it may have occurred in response to an abundant food supply (Zach and Falls 1975). The breeding cycle, along with behavioral and territorial changes, was documented.

On 30 May, the first nest was found, still under construction, and by 8 June incubation had begun on a complete clutch of five eggs. Two of the eggs hatched on 19 June and the remaining three eggs disappeared shortly thereafter. The two young fledged on 27 June. The second nest was found on 20 July with four young, 3 to 4 days old. They all fledged on 24 July.

Both the male and female cared for the nestlings of the first brood until fledging. On 26 June, the day before fledging, the male started exhibiting intense territorial behavior characterized by frequent singing and confrontations with males of neighboring territories, which in turn began to sing more frequently as well. This resulted in a shift in territory away from the old nest towards the location of the new nest. Intense territorial behavior continued until 28 June, even though the male began caring for both fledged young, leaving the female, who was subsequently sighted only infrequently, without any young to care for.

Courtship, usually quite conspicuous in Ovenbirds, was not observed in this period and, after 28 June, the frequency of singing by the male dropped rapidly. The male continued to care exclusively for the two young until at least 16 July, i.e., into the semi-dependent stage (Hann 1937).

Both parents cared for the nestlings of the second brood and when fledging occurred, the male took over part of the brood while the female disappeared from the territory with the rest of the young, as is usually the case. By this time the young of the first brood had apparently left the territory as well.

While polygyny rarely occurs in the Ovenbird (Hann 1937), in the absence of any evidence of a second female it is likely that both broods involved the same pair. Using average values for nest building, egg laying, incubation time, and nestling stage (4, 4, 12, and 7 days) (Hann 1937), the construction of the second nest commenced on 27 June, the day the young of the first nest fledged. This tight schedule is surprising. We have observed, however, if a nest is lost, and renesting occurs, the female begins construction of the new nest within a day. The two young of the first brood were taken over by the male, leaving the female free to commence construction of a second nest. As only the female engages in nest building and incubation (Hann 1937), the male can devote all his time to the care of the fledged young and the defense of the territory. In this fashion, two broods can be raised in a relatively short time interval. In fact, in the present study, the second nest was approximately synchronized with the third nests of two pairs which had each lost two earlier nests.

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Literature Cited

Bent, A. C. 1953. Life histories of the North American wood warblers. United States National Museum Bulletin 203. 734 pp.

Hann, H. W. 1937. Life history of the Ovenbird in Southern Michigan. Wilson Bulletin 49: 145–237.

Kendeigh, S. C. 1945. Nesting behavior of wood warblers. Wilson Bulletin 57: 145–164.

Zach, R. and **J. B. Falls.** 1975. Response of the Ovenbird (Aves: Parulidae) to an outbreak of the spruce budworm. Canadian Journal of Zoology. (*In press.*)

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First Quebec Record of *Limnodromus griseus hendersoni*, the Inland Race of the Short-billed Dowitcher

On 25 May 1972, while taking a bird census in the area for the Mirabel Montreal II international airport (McNeil et al. 1973), the junior author noticed, among a group of 10 Short-billed Dowitchers (*Limnodromus griseus*), one individual with the cinnamon color of the underparts extending over the belly and also over the under-tail coverts; these birds were feeding on the grassy margin of a freshwater pond located in a pasture 2 mi south of Lachute, Quebec. The bird described above was collected and its preserved skin has been deposited in the ornithological collection of the Department of Biological Sciences of the University of Montreal under catalogue number 03 046.

The specimen, an adult female, was subsequently examined by Henri Ouellet of the National Museum of Natural Sciences of Canada and identified as *Limnodromus griseus hendersoni*. The fresh measurements were these: tail 54.6 mm, wing 141 mm, tarsus 33.4 mm, culmen 59.1 mm. In addition to the solid and extensive cinnamon color of the underparts, the ventral spotting of this specimen is sparse and scattered over breast and belly (not densely restricted on upper breast as in nominate *griseus*); the unworn dorsal feathers have wide buff edgings (wider and buffier than in *griseus*). The figures for wing, tarsus, and culmen lengths are somewhat below the averages given by Rowan (1932) and Pitelka (1950); the tarsus is notably short, 34 mm being the smallest figure recorded by these authors. Since nominate *griseus* averages smaller than *hendersoni* (Pitelka 1950), the small measurements of the Lachute specimen may indicate that it could be an individual of a population from the James Bay area where *griseus* may be intergrading with *hendersoni* (Pitelka 1950). Todd (1963), however, never met with the species on the east coast of James Bay; on the west coast, he collected only three fall migrants, all nominate *griseus*. Because of its well-marked plumage characters (showing no tendency toward nominate *griseus*), the Lachute specimen was identified as a small variant of *hendersoni*.

This is the easternmost Canadian record for *Limnodromus griseus hendersoni*, which breeds in the northern parts of Alberta, Saskatchewan, and Manitoba and north to Great Slave Lake in the Northwest Territories (Godfrey 1966). It migrates (A. O. U. 1957) through the Mississippi Valley and along the Atlantic coast, chiefly south of Chesapeake Bay. In northbound spring migration, this inland race of the Short-billed Dowitcher has not been recorded on the Atlantic coast north of Virginia (Pitelka 1950). It has occurred in the areas of Toronto, Ontario, however, on 23 May 1895 and 16 May 1896 (Rowan 1932) and of West Seneca, New York, on 20 May 1890 (Beardslee and Mitchell 1965).

Literature Cited

American Ornithologists' Union. 1957. Check-list of North American birds. Fifth edition. Baltimore, Maryland. 691 pp.

Beardslee, C. S. and **H. D. Mitchell.** 1965. Birds of the Niagara Frontier Region. Bulletin of the Buffalo Society of Natural History. Volume 22.

Godfrey, W. E. 1966. The birds of Canada. National Museum of Canada Bulletin 203. 428 pp.

McNeil, R., N. David, and **P. Mousseau.** 1973. Contrôle écologique du péril aviaire à l'aéroport international de Montréal, à Mirabel, Québec. Ecologie de la zone de l'aéroport international de Montréal, rapport final numéro 3. Centre de Recherches écologiques de Montréal.

Pitelka, F. A. 1950. Geographic variation and the species problem in the shore-bird genus *Limnodromus*. University of California Publications in Zoology 50: 1–108.

Rowan, W. 1932. The status of the Dowitchers with a description of a new subspecies from Alberta and Manitoba. Auk 49: 14–35.

Todd, W. E. C. 1963. Birds of the Labrador Peninsula and adjacent areas. University of Toronto Press, Toronto. 819 pp.

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Red Squirrel Introduction to Newfoundland

Abstract. A 1963 introduction of an unknown number of red squirrels (*Tamiasciurus hudsonicus*) from Labrador to two locations on the Northern Peninsula resulted in a linear dispersal of 19 km and occupancy of about 1743 km^2 by winter 1969.

In July 1964, four male and two female red squirrels were introduced from Labrador to 68-hectare Camel Island. By fall 1967, squirrels were distributed throughout the island, and live-trapping that fall and each spring through 1971 indicated an annual population between 115 and 202 squirrels. Local fishermen probably caught squirrels in rabbit snares on Camel Island, and in 1969 transplanted them to distant islands and the Newfoundland mainland. Natural dispersal occurred to one island over a 200-m expanse of water. No squirrels were found on other islands. An expanse of ice and open water greater than 200 m probably has been an effective barrier to normal distribution of red squirrels.

Only 14 species of mammals, belonging to five orders, are native to insular Newfoundland (Cameron 1958). Cameron's zoological evidence suggested the three northern islands—Newfoundland, Anticosti, and the Magdalens—in the Gulf of St. Lawrence were colonized randomly by means of drifting ice. Although insular Newfoundland is separated from Labrador by only 18 km, the strength of the current evidently prevented the formation of a permanent ice bridge (Cameron 1958). The red squirrel (*Tamiasciurus hudsonicus ungavensis*) is the most recent of nine mammalian introductions.

In order to provide another source of fur to Newfoundland trappers, the Newfoundland Wildlife Division began a study of red squirrel adaptability to insular Newfoundland. In July 1964, four males and two females were introduced from Labrador to 68-hectare Camel Island in Notre Dame Bay (Figure 1). This introduction provided an opportunity to study dispersal patterns of red squirrels and the influence of open water and ice expanses on distribution. Vegetation on Camel Island is dominated by balsam fir (*Abies balsamea*) and black spruce (*Picea mariana*). Logging and a burn in 1946 caused the establishment of 33 hectares of a young stand of trembling aspen (*Populus tremuloides*), balsam fir, and black spruce.

In 1969 the Newfoundland Wildlife Division learned of an unauthorized introduction of red squirrels to the Northern Peninsula in 1963 by residents.

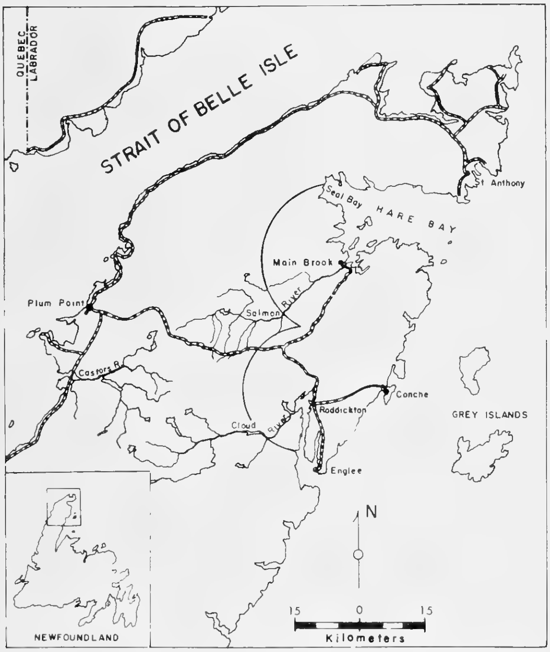

FIGURE 1. Location of Notre Dame Bay islands and mainland of insular Newfoundland surrounding the red squirrel release site of Camel Island.

Methods

To obtain a population estimate on Camel Island, usually 16 and 12 live-traps were used in the recently undisturbed and disturbed (logged and burned) habitats, respectively, with traps generally spaced 61 m (200 ft) apart. Squirrels were tagged in both ears with numbered aluminum eartags. Traps were checked twice daily for 1 week every spring from 1968 to 1971, and two falls, 1967 and 1968. On the small areas sampled, 7–13 collection periods were adequate to obtain a population estimate by the Schnabel Estimator (Overton and Davis 1969). Using that density, an estimate was derived for the entire island. Other islands and the mainland were examined for squirrels, and the residents were interviewed.

Reports of red squirrels in the Roddickton and Main Brook area on the Northern Peninsula in 1969 prompted an investigation there in March 1969. Residents were interviewed, and searches were made for squirrels and their tracks in the snow.

Results and Discussion

Status in Notre Dame Bay

No attempt was made to monitor the abundance of squirrels on Camel Island until fall 1967, when 68 squirrels (1.94 per hectare) were estimated in the recently undisturbed area (Table 1). At that time, red squirrels were distributed throughout the island. Live-trapping that fall and each spring through 1971 indicated an annual population between 115 and 202 squirrels on the island.

Both one and two litters per year have been reported for Canadian red squirrels, although two litters per year are uncommon (Kemp and Kieth 1970; Millar 1970). Assuming one litter per year, four squirrels per litter, an even sex ratio, yearling breeding, 100% pregnancy, and no mortality, the two introduced females could have produced a population of 110 squirrels in the three breeding seasons from 1964 to 1966, and 326 from 1964 to 1967, if they bred in 1964 when released. This number of squirrels probably would have been sufficient to saturate the island. Mortality during the population's expansion probably was low. The only important predator present was the short-tailed weasel (*Mustela erminea*). Few avian predators were observed.

The population estimate of 115 squirrels obtained on Camel Island in the spring of 1968 results in a density of 1.69 squirrels per hectare. Lower densities from indigenous red squirrel populations in various habitat types and seasons have been reported as 0.25 to 0.75 per hectare in New York (Layne 1954), 0.41 to 0.91 in British Columbia (Smith 1968), 0.08 to 1.58 in the Northwest Territories (Zirul and Fuller 1970), and 0.10 to 0.56 in Alberta (Kemp and Keith 1970).

In October 1967 two of the nearest islands, Tinker and Sivier, were checked for squirrels, and none was found. These islands are 1300 and 1550 m, respectively, from Camel Island. In May

TABLE 1–Population estimates of red squirrels on Camel Island, Newfoundland

Trapping period	Recently undisturbed habitat (35 ha)			Disturbed habitat (33 ha)		
	Number trapped	Number estimated	Total estimate	Number trapped	Number estimated	Total estimate
30 Sept.–4 Oct. 1967	5	5	68	–[a]	–[a]	–[a]
18–26 April 1968	6	6	56	12	13	59
25–31 Oct. 1968[b]	6	–	–	3	–	–
25 April–1 May 1969	5	5	40	13	16	131[c]
20–25 May 1970	14	14	83	8	8	60
1–7 June 1971	14	14	83	14	16	119[c]

[a] Not trapped.

[b] Inadequate number of red squirrels recaptured to facilitate population estimate.

[c] Probably too high; the sex ratio in the disturbed habitat trapped was 4 males : 9 females in 1969, with no males retrapped. In 1971 the sex ratio was 7 : 7 in the recently undisturbed habitat, but in the disturbed habitat, it was 12 males: 2 females, with 5 males never retrapped, and 6 males retrapped only once. This suggests transient males moving through the disturbed habitat.

1970 these islands and several others nearby were checked. No squirrels were found on Tinker and Knights islands, but some were found on Sivier Island, and also Birchy Island, 200 m from Sivier Island (Figure 1). Both islands were examined only on the side facing Camel Island. Fresh cone-cuttings were not as abundant there as on Camel Island, suggesting relatively low numbers on these newly populated islands. Local fishermen have seen red squirrels on Sivier and Birchy islands since 1969.

Between 14 and 26 June 1971, all islands surrounding Camel Island, as well as several locations on the Newfoundland mainland, were checked for red squirrels. Cone-cuttings indicated Sivier and Birchy islands were populated throughout. Squirrels were discovered for the first time on Passage Island, about 200 m from Birchy Island. No other islands showed sign of red squirrels, but squirrels were observed at two locations near Comfort Cove on the Newfoundland mainland, where residents have reported them since 1969. Comfort Cove is 7500 m from the nearest squirrel-inhabited island. No squirrels were reported on the Newfoundland mainland 200 m southwest of Birchy Island (Figure 1).

Status on the Northern Peninsula

Reports from local residents indicated an unknown number of squirrels were brought from Labrador in 1963 by Main Brook and Roddickton residents. Residents saw red squirrels in Englee 16 km south of Roddickton in 1967. In winter 1968–69, residents observed squirrels in Conche, 19 km east of Roddickton on the coast.

The March 1969 investigation revealed squirrel tracks in the snow near the junction of the roads to Plum Point and Main Brook. Red-squirrel tracks were observed in cutover black spruce – balsam fir stands, in bogland of dense dwarf spruce-fir "islands" (locally called "high tuckamore"), in bogland of thin spruce-fir stands, as well as in dense mature spruce-fir forest. No tracks were seen 8 km west of the junction at that time. Therefore, since their release in 1963 until winter 1969, red squirrels populated an area with a radius of about 19 km from Main Brook and Roddickton, or about 1743 km^2 (Figure 2)

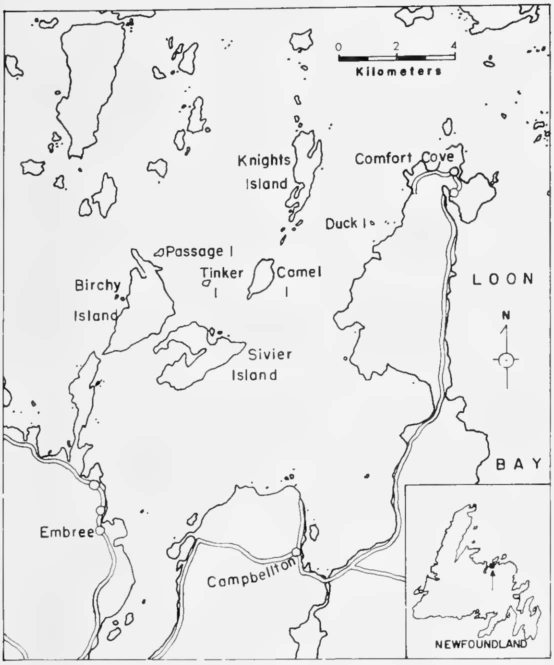

FIGURE 2. Calculated red squirrel distribution surrounding the red squirrel release sites of Main Brook and Roddickton on insular Newfoundland's Northern Peninsula.

Dispersal

Notre Dame Bay freezes over almost every winter. Red squirrels in Alaska and the Northwest Territories normally do not move about much in winter (Pruitt and Lucier 1958; Zirul and Fuller 1970). Those in Newfoundland probably do not either, although winters are more mild. Dispersal of young does not occur then, and tree squirrels are reluctant to cross open expanses (Mosby 1969). The two islands nearest Camel Island, Tinker 1300 m west and the unnamed island 660 m northeast, had no red squirrels. Knights Island, 500 m north of the unnamed island, also had no squirrels, although the distance between Camel and Knights islands is divided by four smaller islands (Figure 1) which could have aided colonization. Thus, Knights Island appears to be the most easily reached island, yet no squirrels occurred there in 1971. Natural dispersal probably did not occur across water. In October 1968, snowshoe hares (*Lepus americanus*) were abundant on Camel Island, and residents of the Newfoundland mainland had snares set. These snares catch the occasional red squirrel by the body as the squirrel runs along the rabbit lead. Squirrels probably were inadvertently snared on Camel Island, and, surviving the snare, were brought back to Comfort Cove by residents, and also released on Sivier and Birchy islands. Comfort Cove is the closest community to Camel Island, and the only community in Notre Dame Bay reporting red squirrels. Sivier and Birchy islands are favorite resting places for fishermen, some of whom maintain cabins there.

Red squirrels crossed the 200 m from Birchy Island to Passage Island, but not the 600 m from Camel Island to the unnamed island northeast. It appears that an expanse of ice and open water greater than 200 m has been an effective barrier to normal distribution of red squirrels in Notre Dame Bay.

Once on the mainland, the squirrels spread rapidly, possibly because "... certain young individuals inherit an instinct to disperse considerable distances.... that is why the range of introduced species is often greatly extended by the time the earlier occupied habitats become crowded" (Howard 1960, p. 154). Assuming 10 females were introduced to the Northern Peninsula in late summer 1963, and using the aforementioned breeding parameters, in the five seasons through 1968, the population would have been 4860 squirrels for the 174 300 hectares calculated to be occupied, or 0.03 per hectare. Compared to results of other workers, this density is very low, and tends to support Howard (1960). The dispersal pattern eventually may resemble that for the introduced gray squirrel (*Sciurus carolinensis*) in Great Britain. From 1889 to 1929, there were 30 separate introductions (Middleton 1930). Lloyd's (1962) data, beginning from 1930, indicated a slow initial increase of about 1414 km^2 per year for 7 years, an acceleration to about 5425 km^2 per year for 8 years, a decline to about 2842 km^2 per year for 7 years, and a further decline and leveling off at about 2357 km^2 per year for the 7 most recent years. The dispersal rate for Newfoundland's red squirrels will not be comparable particularly since the gray squirrels were released at 24 sites in Great Britain's interior. In contrast, Newfoundland's red squirrels were released on the coast, without opportunity to disperse circumferentially.

Red squirrels can be expected to spread south from Comfort Cove and Birchy Island into central Newfoundland, and then east and west. They can be expected to spread south down the Northern Peninsula into western Newfoundland, where the two distributions should eventually merge.

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Literature Cited

Cameron, A. W. 1958. Mammals of the islands in the Gulf of St. Lawrence. National Museum of Canada Bulletin Number 154. 165 pp.

Howard, W. E. 1960. Innate and environmental dispersal of individual vertebrates. American Midland Naturalist 63: 152–161.

Kemp, G. A. and **L. B. Keith.** 1970. Dynamics and regulation of red squirrel (*Tamiasciurus hudsonicus*) populations. Ecology 51: 763–779.

Layne, J. N. 1954. The biology of the red squirrel, *Tamiasciurus hudsonicus loquax* (Bangs), in central New York. Ecological Monographs 24: 227–267.

Lloyd, H. G. 1962. The distribution of squirrels in England and Wales, 1959. Journal of Animal Ecology 31: 157-165.

Middleton, A. D. 1930. The ecology of the American grey squirrel (*Sciurus carolinensis* Gmelin) in the British Isles. Proceedings of the Zoological Society of London 1930: 809–843.

Millar, J. S. 1970. The breeding season and reproductive cycle of the western red squirrel. Canadian Journal of Zoology 48: 471–473.

Mosby, H. S. 1969. The influence of hunting on the population dynamics of a woodlot gray squirrel population. Journal of Wildlife Management 33: 59–73.

Overton, W. S. and **D. E. Davis.** 1969. Estimating the numbers of animals in wildlife populations. *In* Wildlife Management Techniques. *Edited by* R. M. Giles, Jr. The Wildlife Society, Washington. pp. 403–455.

Pruitt, W. O., Jr. and **C. V. Lucier.** 1958. Winter activity of red squirrels in interior Alaska. Journal of Mammalogy 39: 443–444.

Smith, C. C. 1968. The adaptive nature of social organization in the genus of three [sic] squirrels *Tamiasciurus*. Ecological Monographs 38: 31–63.

Zirul, D. L. and **W. A. Fuller.** 1970. Winter fluctuations in size of home range of the red squirrel (*Tamiasciurus hudsonicus*). Transactions of the North American Wildlife and Natural Resource Conference 35: 115–127.

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The Lumpfish (*Cyclopterus lumpus L.*) in Newfoundland Waters[1]

No detailed research has been reported on the lumpfish, *Cyclopterus lumpus* L. of the Atlantic region of Canada since the work of Cox (1920) and Cox and Anderson (1922). At that time, Cox advocated not only the use and exploitation of this previously unused species, but also recommended further research into the biology of the fish. Fifty years have passed and our knowledge of this potentially useful species has progressed little.

This species is now becoming more important to the economic fisheries of the region, both as a source of roe (used as a sturgeon caviar substitute) and as fresh fish. In the Newfoundland area, no major work has previously been reported on this species. Previously there have been a few records of occurence in insular waters reported by the Newfoundland Fishery Research Commission (1932, 1933, 1934), and in the coastal waters of Labrador and the Straits of Belle Isle by Jeffers (1932) and Backus (1957). Commercial fishing for female lumpfish began at several locations around insular Newfoundland in 1969 as a result of the efforts of the Provincial Department of Fisheries and Agriculture Research Commission.

As a result of this increased interest in the lumpfish, I began a research study of various aspects of the biology of *C. lumpus* in 1971, and now report the initial results.

Materials and Methods

Considerable information was gained by col-

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[1] Marine Sciences Research Laboratory Contribution Number 187.

FIGURE 1. A male lumpfish taken from Conception Bay, Newfoundland. Total length 30 cm, weight 0.82 kg.

lating a survey conducted in 1968 and 1969 by the Newfoundland Department of Fisheries and Agriculture Research Commission. This survey was used to gain information on the distribution, migratory habits, size, and uses of the fish. The survey produced by this department in 1968 was completed in 1968 and 1969 by fisheries officers of the Federal Department of Fisheries, regional representatives of the Provincial Department of Community and Social Development, and field representatives of the Extension Service of Memorial University. I examined all 54 completed questionnaires.

In 1971 I made a collection of both adult male and female fish from Conception Bay to obtain information on the total lengths and weights of the two sexes.

Samples of eggs taken by divers from Conception and Logy Bays in 1973 and 1974 were used to measure egg diameters and to record color differences. Several sets of these eggs were hatched under laboratory conditions; hatching times and lengths of the newly hatched larval fish were recorded. Divers also kept under their surveillance several undisturbed egg nests to find out the hatching period under natural conditions.

Results

The survey indicated that *C. lumpus* was generally distributed around the island, and was common as far north as the Nain region of Labrador. Lumpfish measuring up to 61 cm in total length had been caught in the past. The lumpfish of Newfoundland waters are similar to those of other areas in their migratory habits, coming into shallower coastal waters in late spring or early summer (April onwards) and leaving for deeper water in late summer and early fall (as late as October).

The species occurred in sufficiently large quantities in certain localities to justify the starting of commercial fisheries in several areas in 1969. Adult fish have been caught by commercial trawlers in various depths offshore in winter, specifically 182, 275, and 329 m (Andrews 1972, personal communication).

Lumpfish have been used in the past for various purposes, ranging from food for dogs and pigs, as bait for lobster traps, to human consumption. The survey also showed that the flesh of the male is eaten in at least seven communities on the island, and is considered to be a great delicacy, superior to herring, mackerel, or salmon. This is quite a tribute to a fish which is considered to be a trash species, fit only for pigs and dogs in other parts of North America.

From a fish plant in Conception Bay in 1972, I obtained a sample of 13 fish, 8 females (length range 35 to 49 cm, weight 1.96 to 4.49 kg), and 5 males (length range 30 to 32.5 cm, weight 0.91 kg to 1.53 kg). Figure 1 shows a male lumpfish which died after guarding and aerating an egg mass.

Observations by divers seem to indicate that egg masses are laid by the females when the water warms up to 4°C, even though they arrive a week or two before in coastal waters. The eggs are laid in several masses, though it appears that on occasions males may be absent from the vicinity. Egg masses observed in the natural environment and in laboratory tanks maintained at ambient temperature have taken as long as 54 days to hatch (when the starting temperature was 4°C), and as short as 21 days (when the starting temperature was 9°C). The diameter of samples of eggs taken from Conception and Logy Bays varied from 1.8 to 2.4 mm (average of 2.0 mm). The color of the eggs is exceedingly variable from mass to mass (a single mass is normally uniform in color). The author has recorded color ranging from black to brown, red, pink, orange, yellow, green, and purple. The length of the newly hatched larval fish is uniformly 5 mm.

I found no signs of food in the stomachs of adult fish during the summer season, but specimens taken in winter have contained food. Fish taken in the Gulf of St. Lawrence and off St. John's have contained coelenterates (*Aurelia aurita, Cyanea capillata*), ctenophores (*Pleurobrachia pileus*), chaetognaths (*Sagitta elegans*), annelids (*Nereis pelagica*), crustaceans (*Hyperia* sp., *Meganyctiphanes norvegica, Parathemisto gaudichaudi, Thysanoessa* sp.), and some larval fish (Khan 1973, personal communication).

Discussion

The survey indicated, as was previously suspected, that *C. lumpus* was generally distributed around the whole coastline of the island of Newfoundland and most of Labrador, and that there were large concentrations in many areas.

The lumpfish of Newfoundland waters appear to be as long as the largest recorded for other parts of the world. The maximum recorded length for a female lumpfish caught in United States waters is 60 cm (Gordon 1954). This specimen was taken off the coast of New Jersey. The longest lumpfish on record is a European specimen measuring 61 cm in total length (Leim and Scott 1966). The lengths and weights of the males caught in Conception Bay are about the same as those of Cox's (1920) specimens from Cheticamp, Nova Scotia. No comparisons can be made between females, as Cox collected only one specimen.

The diameter of samples of eggs taken from several bays are much smaller than those previously reported from Canadian waters (2.5 to 3.1 mm, Cox and Anderson 1922). The eggs are also smaller than those measured from other localities (2.2 to 2.6 mm in the USA (Bigelow and Schroeder 1953), 2.25 to 2.5 mm in Scotland (McIntosh and Masterman 1897), 2.3 to 2.5 mm in Greenland (Jensen 1944), 2.4 to 2.7 mm in White Sea (Andriyashev 1954)).

The hatching period of 21 to 54 days falls within the range of 14 to 70 days quoted for other parts of the world (Cox and Anderson 1922). The length of the newly hatched larval fish is slightly smaller than that measured by Cox (1920) at 5.5 mm and is approximately equal to those recorded for the White Sea (4 to 6 mm, Andriyashev 1954) and for New England (4.5 mm) but smaller than that measured in European waters (6.7 mm, Cox 1920).

Previous authors (Cox and Anderson 1922) suspected that adult lumpfish fed only in winter, as specimens taken in summer did not contain recognizable stomach contents. It now appears certain that this supposition is true, from the information concerning adults caught in winter in the Gulf of St. Lawrence and in the Atlantic Ocean off St. John's, Newfoundland. With the exception of the Chaetognath, *Sagitta elegans*, the prey species are similar to those previously recorded elsewhere (Cox and Anderson 1922; Leim and Scott 1966).

Leim and Scott (1966, p. 370) stated that "In North America lumpfish have only been used as food for dogs" while Templeman (1966, p. 115) mentioned that "This fish is an excellent and tasty article of food and is eaten at Cook's Harbour and Port au Port and very likely in other Newfoundland localities." The survey showed that lumpfish have been used in the past in Newfoundland for a greater variety of purposes than was previously recorded, and is presently used as a source of lumpfish roe.

I thank D. Andrews for kindly supplying me with the completed questionnaires for my personal use; J. Green and his graduate students who collected egg samples and made other underwater observations for me; and R. Khan who supplied me with a list of animals identified from the stomachs of lumpfish that he had examined.

Literature Cited

Andriyashev, A. P. 1954. Fishes of the northern seas of the USSR. (Translated by Michael Artman, 1964.) Israel Program for Scientific Translations, Jerusalem, Israel. (Available from office of Technical Services, U.S. Department of Commerce, Washington, D. C.) 566 pp.

Backus, R. H. 1957. The fishes of Labrador. Bulletin of the American Museum of Natural History 113: 322.

Bigelow, H. B. and **W. C. Schroeder.** 1953. Fishes of the Gulf of Maine; the lumpfishes, Family Cyclopteridae. U.S. Fish and Wildlife Service Fish Bulletin 74: 459–463.

Cox, P. 1920. Histories of new food fishes: the lumpfish. Bulletin of the Biological Board of Canada 2: 1–28.

Cox, P. and **M. Anderson.** 1922. A study of the Lumpfish (*Cyclopterus lumpus*, L.). Contributions to Canadian Biology 1: 1–20.

Gordon, B. L. 1954. My bout with a lumpfish. Natural history. The American Museum of National History, New York 63: 68-71

Jeffers, G. W. 1932. Fishes observed in the Strait of Belle Isle. Contributions to Canadian Biology 7: 203–211.

Jensen, A. D. 1944. The Greenland species of the Genera *Cyclopterus, Eumicrotremus,* and *Cyclopteropsis.* Contributions to the Ichthyofauna of Greenland 4: 40–48.

Leim, A. H. and **W. B. Scott.** 1966. Fishes of the Atlantic Coast of Canada. Fisheries Research Board of Canada Bulletin 155. 485 pp.

McIntosh, W. C. and **A. T. Masterman.** 1897. British marine food fishes. C. J. Clay and Sons Ltd., Cambridge, England. 516 pp.

Newfoundland Fishery Research Commission. 1931. 1(4): 107–110.

Newfoundland Fishery Research Commission. 1932. 2(1): 125–127.

Newfoundland Fishery Research Commission. 1933. 2(2): 115–117.

Templeman, W. 1966. Marine resources of Newfoundland. Fisheries Research Board of Canada Bulletin 154. 170 pp.

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Bartonia (Gentianaceae) in Ontario

Abstract. The status of *Bartonia virginica* in Ontario is reviewed and a station of *Bartonia paniculata* ssp. *paniculata*, new to Canada, is reported. Known Ontario sites for the two species are mapped and substantiating specimens cited. The ecology of the two species in Ontario is briefly discussed.

Bartonia is a small genus of annual semi-saprophytic herbs endemic to eastern North America. Two species occur in Canada, *B. paniculata* (Michx.) Muhl. (*B. virginica* var. *paniculata* (Michx.) Boivin (Boivin 1966) and *B. virginica* (L.) BSP. As shown by Gillett (1959, 1963), *B. paniculata* is completely restricted to the coastal regions in the northern part of its range and *B. virginica* ranges inland to Wisconsin. No Ontario records were mapped by Gillett (1959, 1963) for either species; however, judging from its distribution in Quebec, New York, Michigan, and Wisconsin, one would expect the occurrence of *B. virginica* in Ontario. *Bartonia paniculata* would not

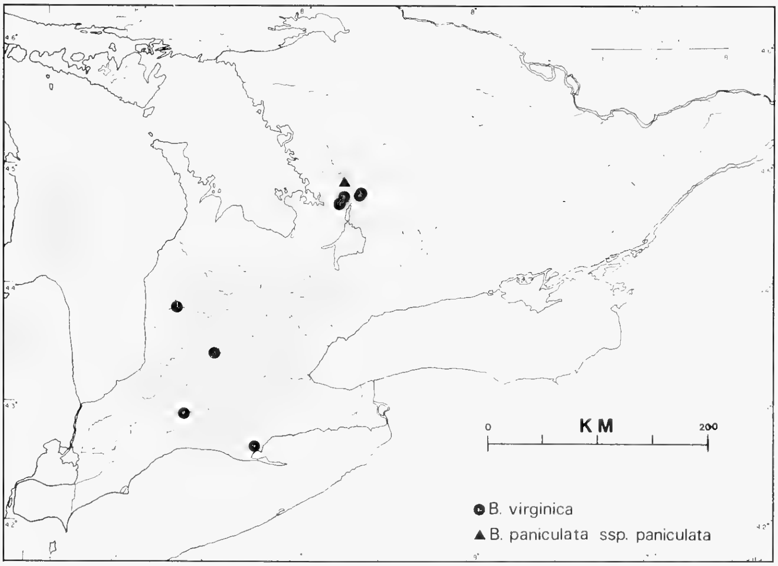

FIGURE 1. Distribution of *Bartonia virginica* and *Bartonia paniculata* ssp. *paniculata* in Ontario.

be expected to occur inland from the coast in Canada.

Recent field work and the searching out of a few older records has disclosed, as expected, that *B. virginica* is distributed very sparingly in southern Ontario. Eight sites are now known and these are mapped in Figure 1. The plant is illustrated in Figure 2. It was apparently first collected in Ontario by John Dearness in 1932. *Bartonia virginica* was also reported from Lambton County by Dodge (1914) but no herbarium voucher could be found to substantiate this report.

In addition to records of *B. virginica*, recent field work by R. E. Whiting has disclosed a remarkable disjunct colony of *B. paniculata* ssp. *paniculata* in Muskoka district, Ontario. As well as being the first record of *B. paniculata* for Ontario, this discovery is also the first record of ssp. *paniculata* in Canada, *B. paniculata* being represented on the east coast exclusively by the more northern ssp. *iodandra* (Robins.) J. M. Gillett (Gillett 1959). The location of the colony is mapped in Figure 1 and the plant is illustrated in Figure 3. The location is about 600 km northwest of the nearest known colonies of ssp. *paniculata* in Connecticut.

The habitat of *B. virginica* appears quite consistent. Most Ontario records indicate open to lightly-shaded moist *Polytrichum* and/or *Sphagnum* mats. It does not seem to occur in wet boggy sites. On the Canadian Shield sites, we have found it on moist peaty *Polytrichum* turf over granitized rock with *Danthonia spicata, Vaccinium angustifolium, Myrica asplenifolia*, and *Rubus hispidus*. The site for *B. paniculata* ssp. *paniculata* was a very wet *Sphagnum* bog on the Canadian Shield between low ridges of granitized rock. It grew in openings among scattered clumps of *Larix laricina, Nemopanthus mucronata, Aronia prunifolia*, and *Chamaedaphne calyculata*. These openings were dominated by *Rhynchospora alba, Scheuchzeria palustris, Woodwardia virginica, Eriophorum virginicum*, and *Habenaria blephariglottis. Bartonia* occurred in the bog with a high density and in some areas it was difficult to walk without stepping on plants.

The locations of *B. virginica* in Ontario are, as mentioned above, consistent with the overall range of the species. The colony of *B. paniculata* ssp. *paniculata*, however, is a striking inland disjunction. The plant must be placed on the growing list of eastern species such as *Rhexia virginica, Listera australis, Juncus militaris, Gratiola aurea, Linum striatum* and others whose occurrence in the Muskoka area of Ontario, far from their major continuous distribution, has long puzzled plant geographers.

FIGURE 2. Herbarium specimen of *Bartonia virginica*.
FIGURE 3. Herbarium specimen of *Bartonia paniculata* ssp. *paniculata*.

Specimens substantiating all records mapped for the two species in Figure 1 are listed below. The herbaria checked in this study were CAN, DAO, TRT, QK, WLU, OAC, HAM, UWO, MICH, MTMG and the private collections of G. E. Waldron (GEW), R. E. Whiting (REW), and the Simcoe County collection of A. A. Reznicek and R. S. W. Bobbette (SIM).

Bartonia virginica

Huron County: East Wawanosh Township, 3½ mi WSW of Wingham, *G. E. Waldron*, 20 August 1972 (GEW).

Middlesex County: Westminster Township, Munro's Sphagnum, *J. Dearness*, 20 August 1932 (MTMG); *J. Dearness*, 25 August 1931 (CAN); *J. Dearness*, 5 September 1932 (CAN).

Muskoka District: Morrison Township, III-5, 0.3 mi N of Clearwater Lake, *R. E. Whiting* and *T. Reznicek, 1509*, 28 August 1972 (TRT.)

Morrison Township, III-5, 2.2 mi NNW of Cooper's Falls, *R. E. Whiting, 515*, 29 August 1972 (REW).

Morrison Township, III-1, 2.2 km SW of Riley Lake Community, *R. E. Whiting*, 2045, 14 August 1974 (REW).

Norfolk County: Charlotteville Township, Lot 12, Conc. II, *M. Landon*, 8 August 1937 (OAC).

Perth County: Ellice Township, Sta. 3, Thames River Conservation Area, *A. A. Wellwood*, 1 October 1972 (WLU, CAN); *David Weber*, 30 July 1973 (WLU, CAN).

Simcoe County: Orillia North Township, Lot 22, Conc. IX, *T. Reznicek, 1052*, 2 September 1970 (OAC, SIM, GEW).

Orillia North Township, Conc. XIII, Lot 24, *R. S. W. Bobbette, 1904*, 5 August 1972 (SIM).

Orillia Township, Lot 24, Conc. XIII, on rocky promontory NW of Duck Bay, west side of Sparrow Lake, *J. M. Gillett* and *J. H. Soper, 16645*, 13/08/1974 (CAN).

Bartonia paniculata ssp. *paniculata*

Muskoka District: Muskoka Township, IV-31, 1.3 mi NW of Leg Lake Community, *R. E. Whiting, 1732*, 15 August 1973 (REW, DAO); *R. E. Whiting, 1783*, 5 September 1973 (TRT, REW); *R. E. Whiting, E. W. Greenwood*, and *D. R. Gunn, 1803A*, 10 September 1973 (REW, SIM, CAN).

We thank J. H. Soper and J. M. Gillett for their helpful comments and company in the field at sites for the two Bartonias; J. M. Gillett for checking our determination of *B. paniculata* ssp. *paniculata;* A. A. Wellwood and G. E. Waldron who informed us of, respectively, the Perth and Huron County sites for *B. virginica*; B. Boivin who informed us of records for *B. virginica* in OAC and MTMG; and R. McVaugh who checked the Dodge collection at MICH for vouchers of *B. virginica*.

Literature Cited

Boivin, B. 1966. Enumération des plantes du Canada. Naturaliste Canadien 93: 989–1063.

Dodge, C. K. 1914. The flowering plants, ferns and fern allies growing without cultivation in Lambton County, Ontario. Michigan Academy of Science Annual Report 16: 132–200.

Gillett, J. M. 1959. A revision of *Bartonia* and *Obolaria* (*Gentianaceae*). Rhodora 61: 43–62.

Gillett, J. M. 1963. The Gentians of Canada, Alaska and Greenland. Canada Department of Agriculture, Research Branch, Publication 1180.

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Range Extension of the Ribbon Snake in Eastern Ontario

In July 1972 a colony of Northern Ribbon Snakes, *Thamnophis sauritus septentrionalis* Rossman, was located by D. Alguire, R. Roy, and J. Woods at Mallorytown Landing, St. Lawrence Islands National Park, Leeds County, Ontario. This appears to be the first record for the Canadian portion of the Thousand Island region and is the easternmost station for the species in Ontario.

Werner (1959. Amphibians and reptiles of the Thousand Islands Region, New York. Copeia 1959(2): 170–172) reported Ribbon Snakes in the New York section of the Thousand Islands. He listed them from Wellesley Island (7 mi SE of Mallorytown Landing) and the American mainland.

Logier and Toner (1961. Check list of the amphibians and reptiles of Canada and Alaska. Life Sciences Division, Royal Ontario Museum Contribution 53) presented an Ontario distribution map for Ribbon Snakes which gave Octono, Frontenac County, as the easternmost station. The National Museum of Nautral Sciences, however, has a specimen from an area 25 mi SE of Octono, at Morton in Leeds County. Mallorytown Landing is approximately 45 mi SE of the nearest published record (Octono) and 20 mi ESE of the nearest previous collection site (Morton).

The Northern Ribbon Snake is similar in appearance to the Eastern Garter Snake, *Thamnophis sirtalis sirtalis* Linnaeus, in eastern Ontario (where both are black with yellow stripes), and therefore easily overlooked. *Thamnophis sauritus* may be distinguished by its more slender appearance and particularly by the position of the lateral stripe on the *third* and *fourth* scale rows (counting from the ventrals) in contrast to its position on the *second* and *third* scale rows in *Thamnophis sirtalis.* Relatively little herpetological research has been carried out in the southeastern counties of Ontario and perhaps the Ribbon Snake is more widespread in that region than present distribution maps indicate.

Two adult females from Mallorytown Landing have been deposited in the National Museum of Natural Sciences (NMNS 15 020) together with 13 young born to them (and mixed in captivity).

The two adults measured (after preservation) 45 and 51 cm body length and 64 and 60 cm total length; the second specimen had lost a portion of its tail. Both have 19-19-17 dorsal scale rows, 1 preocular on each side of the head, 7 supralabials, and 10 infralabials on each side. One specimen has 3 postoculars, the other individual has 2 on each side. Ventrals are 153 and 157 and the subcaudals in the snake with a complete tail total 99.

The young snakes varied (after preservation) from 19.8 to 21.6 cm in total length for five males and 15.5 to 21.2 cm for six females, with body lengths of 13.8 to 14.9 cm in males and 10.8 to 15.1 cm in females. All had one preocular on each side. Nine had 3 postoculars, one male had 3 on the right side but 2 on the left, the remaining male had 2 on each side. Twelve had 7 supralabials on each side, one male had 8 on each side. Twelve had 10 infralabials on each side, one female had 10 on the right side and nine on the left. Ventrals were (range, mean, standard deviation), males: 153-159, 156.0, ± 2.87; females: 151-157, 154.7, ± 2.07. Subcaudals were, males: 106-113, 111.2, ± 2.95; females: 98-106, 100.7, ± 3.08. All counts were complete on the five males and six females.

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Additions to the Vascular Flora of Melville Island, Franklin District, Northwest Territories

Abstract. A brief history of botanical collecting on Melville Island is given, and comments are presented on 15 species which are added to the known flora of the island.

Melville Island in the western Canadian Arctic Archipelago, is north of Banks and Victoria Islands. It is largely north of 75°N latitude and is about 200 mi (320 km) in length and from 30 to 130 mi (48 to 208 km) in width. It was here that officers of Parry's Expedition of 1818-20—E. Sabine, J. Edwards, James Clark Ross,[1] A. Fisher, C. J. Beverly, and W. E. Parry himself—gathered the specimens which formed the basis of Robert Brown's (1823) classic study, *Chloris Melvilliana.* Five of these men were commemorated by Brown by the genus name *Parrya,* and the species *Stellaria Edwardsii, Sieversia Rossii, Ranunculus Sabinii,*[2] *Eutrema Edwardsii, Arenaria Rossii, Pleuropogon Sabinii,*[2] and *Dupontia Fisheri.*

Brown listed 67 vascular plant species from the island. During his expedition of 1850-54, M'Clintock gathered 21 species of plants (Simmons 1913). Four of these, *Cerastium alpinum* [*C. Beeringianum*], *Oxytropis nigre-*

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[1] Not to be confused with his uncle Captain John Ross who in 1818 erred in not pushing into Lancaster Sound.

[2] It should be noted that the spelling of the specific epithet *Sabinii* as used by Robert Brown (1823) is now, according to Recommendation 73(7) of the International Code of Botanical Nomenclature (Stafleu et al. 1969), to be spelled *Sabinei.*

scens [*O. arctica*], *Pedicularis hirsuta,* and *Potentilla emarginata* [*P. hyparctica*], were new to the flora of the island. Hennessey and McMillan, members of the Canadian Arctic Expedition of 1908–09, added a few species to those listed by Robert Brown (Macoun 1910).

Porsild (1955) in his *Vascular Plants of the Western Canadian Arctic Archipelago,* recorded 87 species of plants from Melville Island. Porsild (1964), in the second edition of the *Flora of the Canadian Arctic Archipelago* showed 101 species on his distribution maps, thus indicating an increase in botanical activity in the area by various collectors. In this latter work, three species, *Antennaria compacta, Taraxacum lacerum,* and *T. pumilum,* included by him in 1955, were omitted from the flora of Melville Island.

Mosquin and Hayley (1966) and Mosquin and Martin (1967) recorded five species as part of the known flora of Melville Island for the first time, although they were not specifically noted as new to the island: *Poa glauca, Cerastium alpinum, Stellaria humifusa, Antennaria angustata,* and *Taraxacum arctogenum.* In addition, *Taraxacum pumilum,* which was recorded from the island by Porsild in 1955 but omitted in 1964, was again reported.

During the summer of 1974, G. R. Parker and D. B. M. Lamperd were at Bailey Point (74°58′ N, 115°01′ W) on the southwest side of Melville Island, Northwest Territories to study the feeding habits of muskoxen *(Ovibos moschatus)* and Peary caribou *(Rangifer tarandus pearyi).* An area about 38.5 km^2 was examined to determine plant species composition and annual production. A complete collection of vascular plants was made during a field season from 24 June to 20 August.

When they arrived the snow still covered 80% to 90% of the ground, and the study area was not free of snow until mid-July.

Fifteen of the species collected were new to the known flora of Melville Island, and several, according to the maps in Porsild (1964) represent considerable extensions of their known range. These are presented below. Comments are based on Porsild's publications (1955, 1964) and the senior author's extensive herbarium studies. All specimens are preserved in the Vascular Plant Herbarium of the Biosystematics Research Institute (DAO). Collection numbers are shown in italics and are preceded by the initials of the collector.

Equisetum arvense L.–Wet clay slope, *G. P. 47D;* gravel alluvial plain, *G. P. 50A, D. L. 74-125.*

The map in Porsild (1964) shows collections in the eastern arctic from northern Ellesmere Island and the northernmost parts of Greenland, but in the western arctic only from western Victoria Island and widely on Banks Island. The specimens reported here from Bailey Point are the northernmost reported from the western Arctic Archipelago.

Lycopodium selago L.–Polar desert and clay barrens, *G. P. 35C;* late snow bed, *G. P. 40B;* hydric meadow, *D. L. 74-84.*

This is not a common plant in the western Arctic Archipelago where it was previously known from western Victoria Island and Prince Patrick Island. In the eastern Arctic, however, *Lycopodium selago* is found on Ellesmere Island almost to latitude 80° and in the extreme northern parts of Greenland.

Arctophila fulva (Trin.) Anders.–Shallow tundra pond, *G. P. 43;* hydric meadow, *G. P. 48D;* pond, *D. L. 74-144.*

In the eastern Arctic, *Arctophila fulva* does not extend north of latitude 70°, but in the west it is known from several localities on Victoria Island, eastern Banks Island, and Prince Patrick Island.

Poa alpina L.–Polar desert and clay barrens, *G. P. 52B.*

This species has not previously been reported from the western Arctic Archipelago; in the east, however, it extends north to eastern Baffin Island and reaches the latitude of Melville Island in east Greenland.

Carex nardina Fries var. *atriceps* Kük.–Polar desert and clay barrens, *G. P. 37B.*

In the western Arctic Islands this is a rare plant which was previously known only from the western part of Victoria Island. In the eastern Arctic, however, it appears to be a rather frequent species which is found to the extreme north end of Ellesmere Island and in northern Greenland.

Carex rupestris All.–Polar desert and clay barrens, *G. P. 33A.*

In the western Arctic *Carex rupestris* is found on Victoria Island and on northernmost Banks Island. In the eastern Arctic, however, this species is found almost to latitude 82° at Hazen Camp in the interior of northern Ellesmere Island (Savile 1964) at Alert at 82°31′ on northeastern Ellesmere Island and in the northernmost parts of Greenland.

Eriophorum vaginatum L.–Mesic meadow, *G. P. 1D;* hydric meadow, *G. P. 22A.*

The map in Porsild (1964) indicates collections in the archipelago from southwestern Banks Island and central and southern Victoria Island. The collections reported here are the northernmost for the Canadian Arctic Archipelago.

Salix polaris Wahlenb. ssp. *pseudopolaris* (Flod.) Hultén –Hydric meadow, *G. P. 54B, D. L. 74-186.*

This willow occurs in eastern Asia and northwestern America and was previously known in the Canadian Arctic Archipelago from Banks Island and Victoria Island.

Sagina intermedia Fenzl–Moist creekside with *Cochlearia, D. L. 74-140;* streamside in moist clay, *D. L. 74-164.*

In the western Arctic Archipelago *Sagina intermedia* was known from Prince Patrick, Banks, and Victoria Islands; in the east it extends as far north as Axel Heiberg and Ellesmere Islands and northernmost Greenland.

Stellaria crassifolia Ehrh.–Hydric meadow, *G. P. 58B.*

This is not a common species in the Canadian Arctic Archipelago. Two collections from southeastern and western Victoria Island are the closest to the collection reported here, which is the northernmost yet found.

Ranunculus gmelinii DC.–Floating in tundra pond, *D. L. 74-58.*

This is a rare plant in the western Arctic Archipelago. It has previously been found on Prince Patrick, Banks, and Victoria Islands.

Cardamine pratensis L. var. *angustifolia* Hook.–Hydric meadow, *G. P. 51C, D. L. 74-150.*

In the western Canadian Arctic Archipelago, this species is otherwise known from Prince Patrick, Banks, and Victoria Islands and, in the east from localities as far north as northern Ellesmere Island.

Epilobium arcticum Samuelss.–Hydric meadow, *G. P. 47C, D. L. 74-126.*

The previously known northernmost collections were in northern Baffin Island, Prince of Wales Island, and northeastern Banks Island, but it has also been reported from Hazen Camp in northern Ellesmere Island at 81°50′ N (Savile 1964, *sub E. davuricum* var. *arcticum*). This collection is the northernmost in the western Canadian Arctic Archipelago.

Androsace septentrionalis L.–Polar desert and clay barrens, *G. P. 33B.*

In the western Arctic Islands, this species is otherwise known from several localities about Victoria Island and one locality in southwestern Banks Island. In the eastern Arctic it is a rare plant which has been gathered on southern Southampton Island, northern Baffin Island, northern Ellesmere Island, and adjacent northwestern Greenland.

Taraxacum lacerum Greene–Polar desert and clay barrens, *G. P. 21B, G. P. 51D, D. L. 74-98,* and *D. L. 74-135;* dry tundra, *D. L. 74-112.*

As mentioned above, *Taraxacum lacerum* was reported by Porsild (1955) as occurring on Melville Island, but not on the map for that species in the Arctic Archipelago flora (Porsild 1964). The specimens cited here confirm the presence of this dandelion.

Literature Cited

Brown, R. 1823. Chloris Melvilliana. A list of plants collected in Melville Island, in the year 1820 by the officers of the voyage of discovery under the orders of Captain Parry. W. Clowes, London. 52 pp.

Macoun, J. M. 1910. Appendix to Capt. J. E. Bernier. Report on The Dominion of Canada Government Expedition to the Arctic Islands and Hudson Straits on board the D. G. S. Arctic. Ottawa. 529 pp.

Mosquin, T. and **D. E. Hayley.** 1966. Chromosome numbers and taxonomy of some Canadian arctic plants. Canadian Journal of Botany 44: 1209–1218.

Mosquin, T. and **J. E. H. Martin.** 1967. Observations on the pollination biology of plants on Melville Island, N.W.T., Canada. Canadian Field-Naturalist 81: 201–205.

Porsild, A. E. 1955. The vascular plants of the Western Canadian Arctic Archipelago. National Museum of Canada Bulletin 135: 1–226.

Porsild, A. E. 1964. Illustrated flora of the Canadian Arctic Archipelago. 2nd edition, revised. National Museum of Canada Bulletin 146: 1–218.

Savile, D. B. O. 1964. General ecology and vascular plants of the Hazen Camp area. Arctic 17(4): 237–255.

Simmons H. G. 1913. A survey of the phytogeography of the Arctic American Archipelago. Kungliga Fysiografiska Sällskapets Handlingar N. F. (Band 24) 19: 183.

Stafleu, F. A. et al. 1969. International code of botanical nomenclature. International Association for Plant Taxonomy, Utrecht. 426 pp.

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First Winter Record of the Black Guillemot from the Mackenzie District, Northwest Territories

Between 1 and 7 February 1974 R. Letkeman captured a black Guillemot (*Cepphus grylle*) in first-year plumage at Fort Good Hope, Northwest Territories (66°15′ N, 128°37′ W). When the bird was found beside the town school by children it was alive but could not fly. Despite attempts at care and feeding by R. Letkeman the bird died in captivity one day after capture.

Meteorological records do not provide any evidence of a weather system which might have pushed the bird to the area. We think that the bird was utilizing some of the open water existing in the Mackenzie River about 32 km south of Fort Good Hope. Local residents reported other waterfowl to be using these sites during the winter of 1973–74. Late January was extremely cold in the area. The extreme weather may have frozen over the open-water sites forcing the bird to move. Possibly during such a move the bird flew into a window of the school or one of the many aerials and mast support wires of a Ministry of Transport station adjacent to the school.

W. E. Godfrey (1966. The birds of Canada. National Museum of Canada Bulletin 203) reports that the species normally breeds in the eastern Canadian Arctic. G. J. Divoky, G. E. Watson, and J. C. Bartonek (1974. Breeding of the Black Guillemot in northern Alaska. Condor 76(3): 339–343) give evidence of breeding in northern Alaska, and E. Kuyt (personal communication) observed the species breeding on Herschel Island. Godfrey (personal communication to J. P. Ryder) reports no other record for the interior of the Mackenzie District. Because the specimen was not sexed, Godfrey could not clearly establish the race of the specimen but suspects it to be closer to *Cepphus grylle ultimus* than to *mandtii*.

The specimen has been deposited in the National Museum of Natural Sciences, catalogue number 60 749.

We thank W. Earl Godfrey for examining the specimen, John P. Ryder for examining the specimen and a draft of this note, and D. N. Nettleship who reviewed the note for publication.

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Predation on a Bat by a Western Yellow-bellied Racer

On 30 May 1975 at about 1940 hours, we caught a female western yellow-bellied racer (*Coluber constrictor mormon*) in the process of swallowing a long-eared myotis (*Myotis evotis*) in Ellison Provincial Park, about 17 km south of Vernon, British Columbia. The area where this snake was caught is a rocky ridge with many crevices and is littered with large rocks and logs. The racer measured 555 mm in snout–vent length and the bat was about 75 mm long from snout to tip of tail. When first seen, the snake had only the head of the bat in its mouth and the bat was dead, possibly as a result of suffocation. The bat was apparently fresh so that there was no reason to believe that it had not been taken alive by the snake. Upon capture, the snake was palped and forced to regurgitate its stomach contents, yielding remains of three crickets (*Acheta*). Presumably the bat had been resting in a crevice or under a rock or the bark of a log (as suggested in *Bats of America* by R. W. Barbour and W. H. Davis. 1969. University Press of Kentucky. 286 pp.) prior to leaving on its evening flight when encountered by the snake. Racers are very active predators and would be likely to search such places as they forage. The snake was released after examination, but the bat is now included in the collection of the B.C. Provincial Museum (No. 9258).

While predation on bats by snakes is well-known, it has not been previously reported for the racer as far as we know. This is perhaps surprising since the diet of the racer is an extremely varied one (H. S. Fitch. 1963. Natural history of the racer *Coluber constrictor*. University of Kansas Publications, Museum of Natural History 15(8): 351–468), reflecting its apparently opportunistic feeding strategy.

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Sighting of a Porcupine, *Erethizon dorsatum*, in Northern Quebec

At midday on 26 July 1968, I saw a North American porcupine, *Erethizon dorsatum*, on the south bank of the Leaf River (Riviére aux Feuilles) in northern Quebec. The animal, which I observed for nearly 10 min, was about 2.5 ft (75 cm) long, very dark brown, almost black in color, with lightish-brown quill tips. The observation was made where the Province of Quebec, Ministère des Richesses Naturelles maintains an automatic hydrographic station at 58°39′ N, 70°25′ W (about 100 mi (160 km) west of Fort Chimo). Although the whole summer from 22 June to 9 September was spent in that area of the Leaf River Valley no other sightings were made. No feeding signs or tracks were observed and the animal seen may have been an isolated individual.

Almost all the Leaf River drainage is north of the permafrost line given by Jenness (1949). The climate is as severe or more severe than areas much further north (Hare 1950a, b). The Leaf River Valley is at the northern limit of trees (Hustich 1952; Rousseau 1968), and the opinion of Polunin (1948) that the few trees in the valley represent an isolated extension beyond the principal treeline seems reasonable. The commonest trees are tamarack (*Larix laricina*) and black spruce (*Picea mariana*) with a few white spruce (*Picea glauca*). The glacial terrace is covered with *Cladonia rangiferina* interspersed with patches of sphagnum bog, arctic blueberry (*Vaccinium* sp.), and occasional patches of scrub birch (*Betula glandulosa*). The higher river banks and gullies are covered with willow (*Salix* spp.) and alder (*Alnus crispa*).

The porcupine has previously been recorded as far north in Quebec–Labrador as Fort Chimo (Hall and Kelson 1959) and there are several reported sightings and specimens from the Koksoak River and its tributaries (Petersen 1966). Anderson and Rand (1943) state that the species is generally distributed in Labrador and northeastern Quebec from the Gulf of St. Lawrence northwards to the semi-barrens and west to Chimo. These authors are unsure of the distribution west of Chimo but consider that it is probably found here and there in Ungava south of the treeline. There does not, however, seem to be any record of the species from any major watershed northwestward of Chimo and the Koksoak River. The Koksoak and other major rivers east of Chimo drain into Ungava Bay after flowing northwards from the center of Quebec–Labrador and provide a relatively sheltered route for porcupines northwards along wooded valleys. Between the valley of the Leaf River, which has a southwest to northeast orientation, and the valleys of the Koksoak and Larch to the southeast, are nearly 100 mi (160 km) of barren uplands cutting the valley off from other forested areas. Thus there is no continuous forest cover between the Leaf River and the coniferous forests further south. Owing to this isolation and the severity of the climate it would be of further interest to know by what route porcupines could colonize the Leaf River drainage.

Literature Cited

Anderson, R. M. and **A. L. Rand** 1943. Variations in the porcupine (genus *Erethizon*) in Canada. Canadian Journal of Research 21(D): 292–309.

Hall, E. R. and **K. R. Kelson** 1959. The mammals of North America. Ronald Press, New York. 1083 pp. (plus 78 pp. index).

Hare, F. K. 1950a. Climate of Eastern Canadian Arctic and Subarctic and its influence on accessibility. Ph.D. thesis, University of Montreal, Montreal.

Hare, F. K. 1950b. Climate and zonal divisions of the boreal forest formation in Eastern Canada. Geographical Review 40: 615–635.

Hustich, I. 1952. Boreal limits of conifers. Arctic 6(2): 149–162.

Jenness, J. L. 1949. Permafrost in Canada. Arctic 2(1): 13–27.

Peterson, R. L. 1966. The mammals of Eastern Canada. Oxford University Press, Toronto. 465 pp.

Polunin, N. 1948. Botany of Canadian Eastern Arctic, III. Canada Department of Mines and Resources, National Museum of Canada Bulletin 104, Biological Series Number 32. 304 pp.

Rousseau, Jacques 1968. The vegetation of the Quebec-Labrador Peninsula between 55°and 60°N. Naturaliste Canadien 95(2): 469–563.

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Black Guillemots' Breeding Range Extended into the Western Canadian Arctic

Divoky et al. (1974) have supplied the first nesting records of the Black Guillemot (*Cepphus grylle*) in the Beaufort Sea. They reported 17 nests, most of them under man-made structures, on three of the many barrier islands occurring in Chukchi and Beaufort Seas off the Alaskan coast. These authors suggest that the Black Guillemot could extend its breeding range eastward, partly as a result of man's recent littering practices, which provide suitable debris for nesting.

The purpose of this note is to provide the first nesting record of the Black Guillemot for the western Canadian Arctic on Herschel Island (69°34′ N, 138°55′ W), an eastward breeding range extension of about 600 km. Observational records, some of which predate those of Divoky et al. (1974), are summarized in Table 1. Records show that by 1971 guillemots had found access to the inside of the abandoned Anglican mission house built on Herschel Island in 1920.

TABLE 1—Observations of Black Guillemot in western Canadian Arctic

Observer	Date	Observation	Number of nests	Location
T.W. Barry	1958	6 guillemots	Several?	Under metal warehouses, Herschel Island
T.W. Barry	2 Sept. 1960	10 guillemots		On Pauline Cove, Herschel
T.W. Barry	1964		Several?	Under metal warehouse, Herschel
T.W. Barry	1965	8 guillemots		On Pauline Cove
T.W. Barry	20 July 1965		At least 2 pairs nesting	Under metal warehouses
T.W. Barry	Aug.–Sept. 1966, 1967, 1968	6–12 guillemots		Pauline Cove
B. MacKenzie	1973	guillemots nesting on Herschel for last 3 years		
N. Cooper	1972	3 pairs of guillemots	3	Herschel
N. Cooper	summer 1973	30 pairs breeding	30	Herschel
G.W. Frame (1973)	9 Aug. 1973	2 flying guillemots		55 km NNE of Herschel
T.G. Smith (1973)	July 1971	2 observations of Black Guillemot		Holman Island
Parmelee et al. (1967)	1960	Badly decomposed specimen		Cambridge Bay
P.S. Taylor	12 Aug. 1973	Active nests	10+	Abandoned frame building, Herschel
B.E. Johnson	30 July 1974	Active nests	6	Same building

Taylor and Johnson visited Herschel village in two successive years and found evidence of nesting Black Guillemots in this abandoned frame building (Table 1). The guillemots' nests were approximately 2.7 m (9 ft) above the floor and located on top of a side wall, and between rafters. Several of the lower boards of the interior roof were missing, giving the birds access to the nests, after they had entered the building through the open door or windows (Figure 1). On 30 July one of the latter nests contained two downy young, both measuring about 10 cm (4 in) in length and an adult which was captured, photographed, and released.

FIGURE 1. Abandoned building containing Black Guillemot nests, Herschel Island.

Photographs of this bird and a dead short-winged juvenile collected by Taylor in 1973 (Number 59248 in the collection of the National Museum of Canada) were examined by W. Earl Godfrey, National Museum of Natural Sciences, Ottawa and he confirmed that the birds in question were Black Guillemots.

The eastern North American population of the Black Guillemot nests in individual pairs or small colonies on low flat islands, at the base of escarpments, on talus slopes, and among rock rubble and on cliff ledges, sometimes at considerable height (Godfrey 1966). This type of nesting habitat is poorly represented in the western Canadian Arctic.

Only two other alcids occur in the western Canadian Arctic, but the Dovekie (*Alle alle*) is a rare visitor and the Thick-billed Murre (*Uria lomvia*) breeds only in a small colony near Cape Parry.

The hypothesis presented by Divoky et al. (1974) of an eastward extension of the Black Guillemot's breeding range has been borne out by our observations. As yet, guillemots have not been found nesting in suitable debris which exists on islands lying between Herschel Island and Igalik Island, Alaska. Southeast of Herschel Island, potential nest sites would be found in the form of abandoned buildings and piles of driftwood occurring from Herschel Island to Shingle Point, with similar habitat available on offshore islands such as Garry, Pelly, Hooper, Rae, and Pullen Islands. This suggests the possibility of future population increase and range expansion for Black Guillemots in this area.

Greatest danger to the small Herschel Island colony would lie in the destruction of the abandoned building or the harassment of birds by children during the nesting season. Taylor saw children throw stones at the birds and their nests and Johnson found considerable numbers of stones, presumably thrown, but possibly the result of vestigial nest building, mixed with droppings in the nest cavities.

Taylor, at time of observations, was working for L.G.L. Ltd., Environmental Research Associates, and was supported by Northern Engineering Services Co. Ltd., Calgary, and Canadian Arctic Gas Study Ltd.

Literature Cited

Divoky, George J., George E. Watson, and James C. Bartonek. 1974. Breeding of the Black Guillemot in northern Alaska. Condor 76: 339–343.

Frame, George W. 1973. Occurrence of birds in the Beaufort Sea, summer 1969. Auk 90: 552–563.

Godfrey, W. E. 1966. The birds of Canada. National Museum of Canada Bulletin 203, 428 pp.

Parmelee, D. F., H. A. Stephens, and R. H. Schmidt. 1967. The birds of southeastern Victoria Island and adjacent small islands. National Museum of Canada Bulletin 222: 1–229.

Smith, T. G. 1973. The birds of the Holman region, western Victoria Island. Canadian Field-Naturalist 87(1): 35–42.

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Distribution of Biting Lice (Mallophaga) on Two Wild Mallards (*Anas platyrhynchos*)

As many as five different species of Mallophaga have been observed on Mallards (Zlotorzycka 1961). Zlotorzycka found that the genera *Docophoues* and *Esthiopterum* were restricted to locations on the head, neck, and wings and speculated that the genera *Menopon* and *Trinoton* have little or no preferential habitat on the host. Nelson and Murray (1970) showed that the distribution of species of mallophagans on the Rock Dove (*Columba livia*) was related to their structure and the birds' preening behavior.

The present study dealt specifically with the distribution of Mallophaga on Mallards, *Anas platyrhynchos*, and the regions and populations of mallophagan egg deposition on this host. Two adult male Mallards (one of which retained some feathers of the eclipse plummage on the head and neck) were shot 28 September 1974 near Camrose, Alberta and were examined for evidence of biting lice. At the time of collection paper-towelling was placed under the wings to prevent transfer of lice from wings to side. Each bird was then fully wrapped and sealed in a plastic bag, along with a cotton wad soaked in chloroform, and frozen. The feathers from each of the regions recognized by Murray and Nelson (1970) were examined separately.

The lice were boiled in 10% KOH, cleared in 2-ethoxyethanol, mounted in Canada balsam – methyl salicylate, and identified using the key by Séguy (1944). Eggs found were presumed to be those of Mallophaga that were observed in the same region. Identification was based on the relation of the egg's length and size with that of the nymph.

Anatoecus icterodes (Nitzsch 1818), *Anaticola crassicorne* (Scopoli 1763), *Trinoton querquedulae* (Linné), and *Menopon leucoxanthum* (Nitzsch and Burmeister 1838) were found on each duck (Table 1).

Anatoecus icterodes, short and broad with numerous protuberances, was restricted to the head and neck, where it is relatively free from preening activities. Eggs, presumed to be those of *A. icterodes*, were abundant on the head and neck of the duck which had completed its molt, but were rare on the duck that was still molting. These observations may indicate that eggs are not deposited until after the molt, presumably to ensure a sufficient period of time for development. *Anaticola crassicorne* has an elongated body and

TABLE 1–Distribution of lice and their eggs on two mallards.

		Region of Body							
Species		Head	Neck	Back	Sides	Breast	Abdomen	Legs	Wings
Trinoton querquedulae	Adults and nymphs	0	0	0	1	0	2	0	9
	Eggs	8	3	0	0	0	0	0	21
Anatoecus icterodes	Adults and nymphs	1	11	0	0	1	0	0	0
	Eggs	37	22	0	0	0	0	0	0
Menopon leucoxanthum	Adults and nymphs	0	5	1	5	1	3	0	1
Anaticola crassicorne	Adults and nymphs	0	0	38	1	0	0	0	20
	Eggs	0	0	9	0	0	0	0	390

was always found close to the wings; a few specimens were between the barbs of the primary feathers. Its eggs were mostly on the wings, characteristically between the barbs. They were the most abundant eggs found. *Trinoton querquedulae* was a large, powerful species with a smooth body. Its large eggs were found at the bases of coverts on the wing, or on the head and neck. Long, numerous setae cover the entire exoskeleton of *M. leucoxanthum,* which was observed in virtually all areas of the body; no eggs were found.

There were few specimens and no eggs present in the breast region; this is the area of extensive host preening. These data support the suggestion by Nelson and Murray (1970) that morphological adaptations and specific areas of habitation and oviposition are not in preference to feather types but instead to prevent loss of eggs or lice by way of the host's preening.

This study was done as a special project at Bonnie Doon Composite High School, Edmonton, Alberta. It was conducted at the University of Alberta under the direction of J. C. Holmes, his graduate staff, and C. Adams.

Literature Cited

Nelson, B. C. and **M. D. Murray.** 1970. The distribution of Mallophaga on the Domestic Pigeon (*Columba livia*). International Journal for Parasitology 1: 21–29.

Séguy, Eugene. 1944. Faune de France, 43 insectes ectoparasites (Mallophages, Anoploures, Siphonapteres). Paul Lechevalier and Sons, Paris, France.

Zlotorzycka, Jadwiga. 1961. Mallophaga from birds associated with the water environment in Poland. (English text, Polish and Russian summaries.) Acta Zoologica Cracoviensis 6: 273–343.

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A Range Extension of the Coyote in Quebec

Over the past 30 years the range of the coyote, *Canis latrans,* has rapidly expanded in Quebec. The first recorded occurrence of the species in the province was made near Luskville, Gatineau County in 1944 (Young 1951). By 1963 the range extended throughout the southwestern region of the province as far east as Islet, Islet County on the south shore of the St. Lawrence River and to La Malbaie, Charlevoix County on the north shore (Lord 1961; R. Ouellet, personal communication). Coyotes were also noted in the Rivière du Loup area as early as 1971; however, these reports were never documented with identified specimens (R. Tanguay, personal communication).

Early in 1972 I began to receive reports from farmers in the Ste Anne des Monts area (Matane County) that they were suddenly losing a number of sheep to predators. Although these reports were investigated I was unable to identify the animal(s) responsible for the deaths. At that time I reluctantly attributed the killings to either black bear (*Ursus americanus*), lynx (*Lynx lynx*), or domestic dogs which were then the only known predators in the region that were large enough to attack and kill sheep.

In March 1973 I investigated a report that a large wolflike animal had been trapped and shot by a farmer near Tourelle, 3 mi east of Ste Anne des Monts. I identified the animal as an adult male coyote. Dr. C. G. van Zyll de Jong, National Museum of Natural Sciences, later examined the skull and confirmed my identification.

In October 1974, two more adult coyotes were killed within a mile of each other near St-Ulric, 7 mi southwest of Matane. The skulls were collected and identification was again confirmed by Dr. C. G. van Zyll de Jong.

Coyote range extension has also been recently reported in neighboring Maine (Richens and Hugie 1974) and New Brunswick (Cartwright 1975).

Although Young (1951) states that one determining factor in the range extension of the coyote is the opening up of forested areas, the coyote in its movement eastward has penetrated and occupied a wide variety of habitats ranging from forest and wilderness areas to farmlands and urban parks. Richens and Hugie (1974) suggest that there is no barrier to coyote spread into areas where adequate food (small game, rodents, carrion) is available.

The occurence of sheep farming in the Ste Anne des Monts – Matane area undoubtably favors the coyote by providing a dependable and easily accessible food supply in its new range. If the past experience from Ste Anne des Monts can be used as an indication, then the recent unexplained

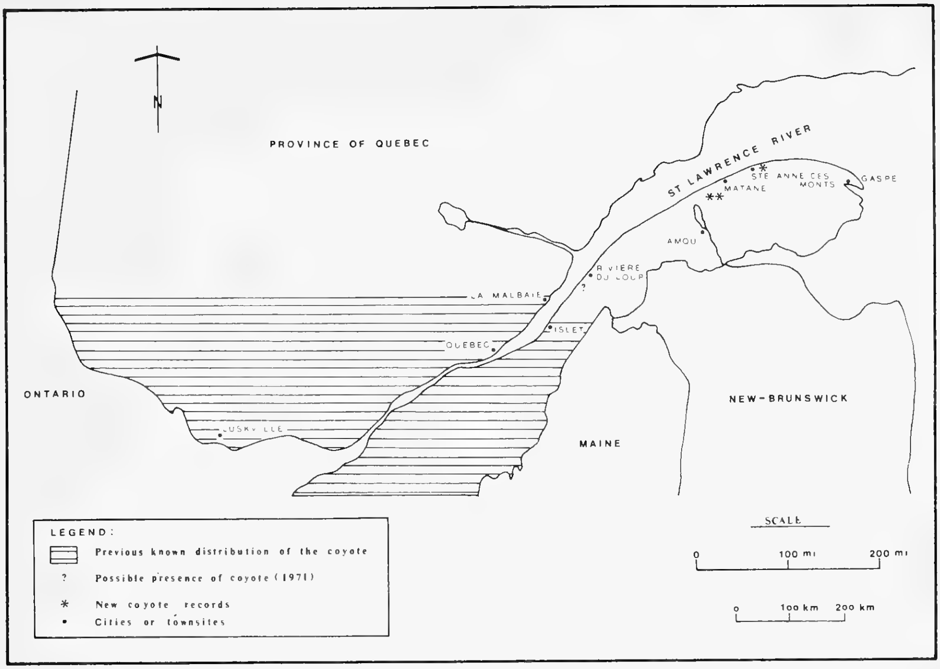

FIGURE 1. Distribution of the coyote in Quebec, showing new range extension.

killings of 27 sheep in September 1974 near Amqui, Matapédia County would suggest that the coyote has already extended its range into that region.

The previously known distribution of the coyote in Quebec, as well as the new records cited are shown in Figure 1. The indicated range limit was determined from bounties paid for predators in each county of Quebec for the year 1968–1969.

I thank D. Heyland and G. Lemay for their comments and criticism of this manuscript, and N. Lizotte and J. Scrosati for preparing the distribution map.

Literature Cited

Cartwright, D. J. 1975. The appearance of the eastern coyote. Volume 1, Number 1. Canadian Wildlife Administration (Section New Brunswick).

Lord, L. A. 1961. Les carnets de zoologie. La Société Zoologique de Québec Inc., Orsainville, Québec.

Richens, V. B. and **R. D. Hugie.** 1974. Distribution, taxonomic status, and characteristics of coyotes in Maine. Journal of Wildlife Management 38(3): 447–454.

Young, S. P. 1951. The clever coyote, Part 1. Wildlife Management Institute, Washington, D.C.

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The Blue Camas, *Camassia quamash*, a Plant New to Waterton Lakes National Park, Alberta

The Blue Camas, *Camassia quamash* (Pursh) Greene, occurs in moist meadows of the northwestern United States and southern British Columbia. One variety, *quamash,* extends into the extreme southwestern corner of Alberta (Hitchcock et al. 1969); however, it has not been reported from Waterton Lakes National Park (Breitung 1957; Kuijt 1973). Standley (1921) lists it as being pre-

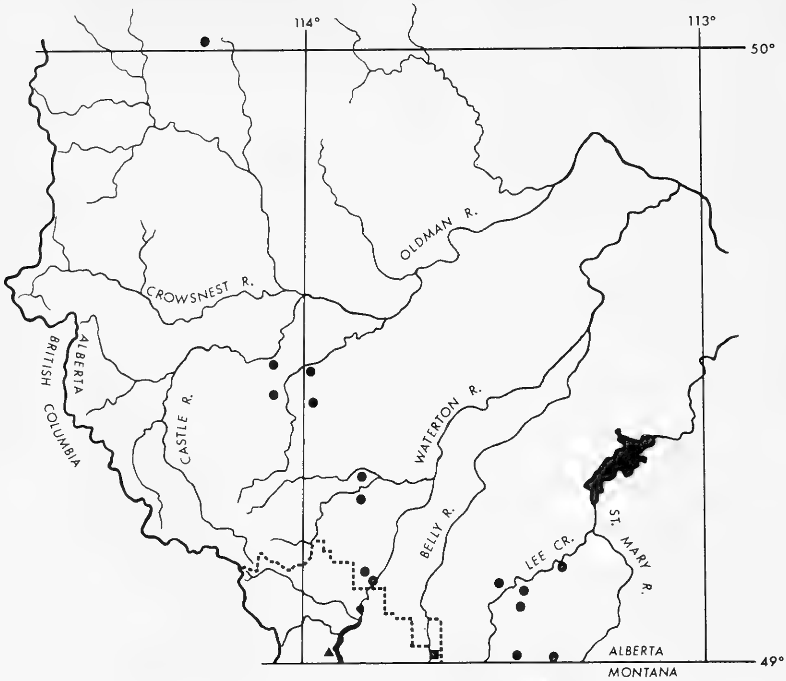

FIGURE 1. Distribution of *Camassia quamash* in southwestern Alberta. ■ Authors' sighting; ▲ Shaw's 1966 collection; ● Previous Alberta collections from the herbaria of Canadian Department of Agriculture (Ottawa and Lethbridge), National Herbarium of Canada, University of Alberta, University of Calgary, Cardston High School, and K. Shaw of Cardston, Alberta. Dotted line indicates boundary of Waterton Lakes National Park.

sent in Montana's Glacier National Park immediately south of Waterton, and Brown (1954) mentions that there are fields of it close to the highway near the entrance to Waterton. Brown's report is supported by E. H. Moss's collection in 1935 from "near Waterton Park." Thus it is surprising that to date it has not been recorded within the park boundaries.

One of the authors (TD), however, observed and photographed *Camassia quamash* in bloom on 15 June 1974 in Waterton Lakes National Park. Its identity was confirmed by the second author. Less than a dozen plants were growing in a small meadow on a terrace above the Belly River. As the authors did not have a permit to collect plants within the park, no specimens were taken. It should be noted, however, that the personal collection of K. Shaw of Cardston, Alberta contains one specimen from "West shore of Waterton Lake, open meadow, Hadfield Logging Camp" dated 1 July 1966, Collection number 399. Recent communication with Dr. Shaw indicates that this colony is still in existence despite some successional changes on the site. Figure 1 depicts the distribution of *Camassia quamash* in Alberta.

Literature Cited

Breitung, A. J. 1957. Plants of Waterton Lakes National Park, Alberta. Canadian Field-Naturalist 71: 39–71.

Brown, A. 1954. Old man's garden. Gray's Publishing Ltd., Sydney, British Columbia. 264 pp.

Hitchcock, C. L., A. Cronquist, and M. Ownbey. 1969. Vascular plants of the Pacific Northwest. Part I, Vascular cryptogams, gymnosperms, and monocotyledons. University of Washington Press, Seattle. 914 pp.

Kuijt, J. 1973. New plant records in Waterton Lakes National Park, Alberta. Canadian Field-Naturalist 87: 67–69.

Standley, P. C. 1921. Flora of Glacier National Park, Montana. Bulletin of the United States National Museum, Contributions from the United States National Herbarium 22 (Part 5): 235–438.

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An Extension of the Range of the Northern Long-toed Salamander, *Ambystoma macrodactylum columbianum* in Alaska

Ambystoma macrodactylum columbianum (Ferguson 1961) has been reported to occur in southeastern Alaska by Stebbins (1966), Ferguson (1961, 1963), and Hodge (1973). Hodge (1973), however, provided the only locality record and specimen from the state. The collection of a single specimen from the Taku River (58°32′ N, 133°45′ W) near Colby's Landing extends the known range by 224 km north from the site described by Hodge (1973) in Alaska and 168 km north from the site described by Ferguson (1961) in British Columbia (Figure 1).

The specimen was found 27 August 1974 at the bottom of a shallow, partially dug well. Three sheets of corrugated metal roofing material had been placed over the hole to prevent it from filling with debris. Several *Bufo boreas* (Baird and Girard) had been previously retrieved from the hole. The well was located 72 m from the Taku River and 27 m from a water-filled depression. The area which surrounded the well had been cleared of underbrush. The mature trees and ground debris, however, were undisturbed. The area was shaded throughout the day and remained cool and damp.

The specimen is an adult female. Standard measurements for the specimen are 11.4 cm total length, 6.0 cm snout–vent length, 5.05 cm tail length, and 0.35 cm vent length. The combined vomerine teeth count is 33 and each side has 13 costal grooves. The uninterrupted yellow-green dorsal stripe exhibits irregular borders without

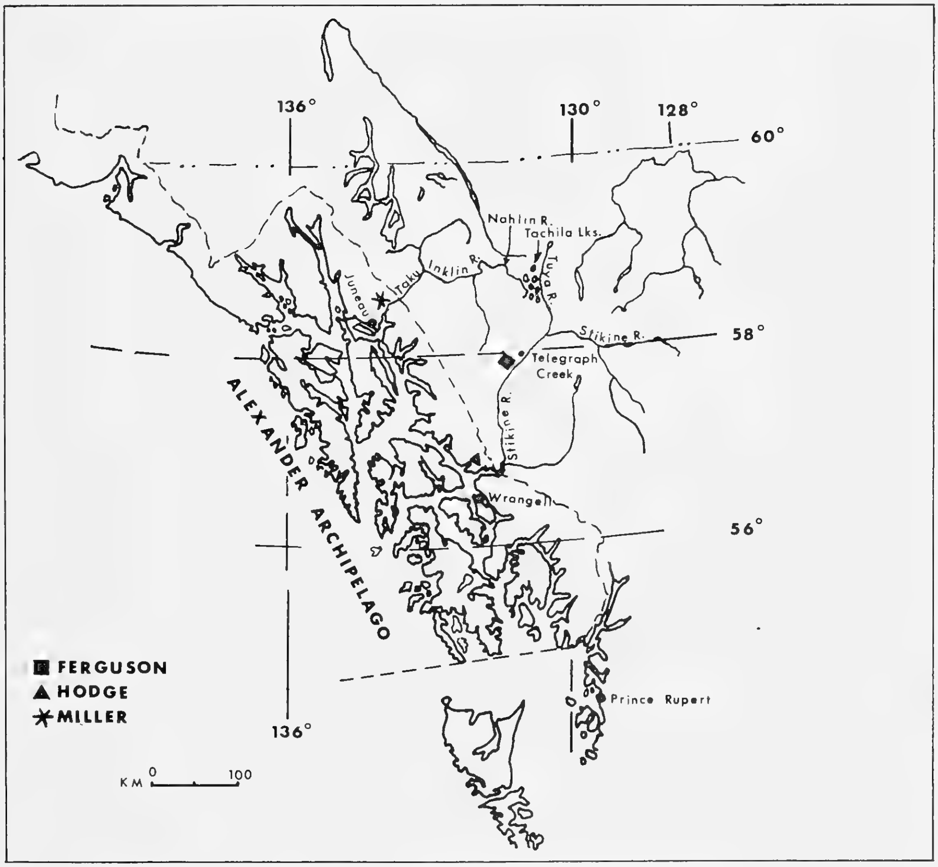

FIGURE 1. Sites of collection of *Ambystoma macrodactylym columbianum* in Alaska and British Columbia.

deep undulations. The dorsal color on the head is spotted with irregular islands of ground color; the ground color is black. The apparent grayish color of the lower sides results from the infusion on the ground color of numerous small white flecks. This description is consistent with that provided by Ferguson (1961).

Analysis of the stomach contents established that the specimen had eaten prior to capture. The stomach contained the elytra from two members of the Scolytidae. The lower gut contained other body parts of the Scolytidae and numerous small particles of sand. The specimen (UMZ 740 804) has been placed in the Museum of Herpetology at the University of Montana, Missoula, Montana.

The Taku River provides possible access for the subspecies through the coastal mountain range to the present site of collection. No reported collections of *Ambystoma macrodactylum columbianum,* however, exist for the area which is drained by the Taku River and its tributaries in British Columbia.

The collections of Hodge (1973) and Ferguson (1961) from the Stikine River provide a basis for speculation of an inland connection, which may or may not be currently populated, between the presumed populations on the Stikine River and the population on the Taku River. The natural barriers to the distribution of amphibians of the region (including ice fields, mountains, temperature and moisture regimes, and general climatic conditions) coupled with the requirements of the animals for breeding sites, which allow the maturation of the larvae, and for habitat, which allows the survival of the adults, limit the number of routes which may have been used at one time to distribute the subspecies over its present range. The post-Pleistocene climate may have allowed a greater distribution than is observable today. The most probable route of connection which may be observed today follows up the Stikine River to the confluence of the Stikine and the Tuya Rivers. From the Tuya River the animals may gain access to the Tachilta Lakes and subsequently the Nahlin River. The Nahlin River drains to the Inklin River which, in turn, flows into the Taku River. Other than by following north along the coast, the proposed route of access between the populations on the Taku and Stikine Rivers presents the fewest barriers.

Further collections must be made to substantiate the proposed connection.

Literature Cited

Ferguson, Denzel, E. 1961. The geographic variation of *Ambystoma macrodactylum* (Baird), with the description of two new subspecies. American Midland Naturalist 65: 311–338.

Ferguson, Denzel, E. 1963. *Ambystoma macrodactylum.* Catalogue of American Amphibians and Reptiles: 4.1–4.2.

Hodge, Robert Parker. 1973. The longtoed salamander *Ambystoma macrodactylum* discovered in Alaska. HISS (Herpetological Information Search Systems) News-Journal 1(1): 23.

Stebbins, Robert C. 1966. A field guide to western reptiles and amphibians. Houghton Mifflin Co., Boston. XIV + 297 pp.

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A Northern Record for the Heather Vole, *Phenacomys intermedius*, in the Northwest Territories

During field studies in the Northwest Territories in the summer of 1974, five heather vole specimens were collected. The first specimen, captured in a live-trap on 28 May 1974, was a female from which a skin and skull were prepared. This specimen was later destroyed in an accidental tent fire. The second specimen was a skull found in an owl casting with two northern bog lemming (*Synaptomys borealis*) skulls on 6 September 1974. The skull was identified as *Phenacomys intermedius* by A. W. F. Banfield, and was deposited in the Royal Ontario Museum as specimen 74 050. The other three specimens were cheek teeth found in marten scats collected near the same area. These are in our possession.

The skull was found near the southeast end of Chick Lake and the live specimen northwest of Chick Lake. Chick Lake (65°51′ N, 128°02′ W; Figure 1) is located 90 km northwest of Norman Wells, Northwest Territories. Both Hall and Kelson (1959) and Banfield (1974) considered the northern limit for heather vole to be at the same latitude as Wrigley, Northwest Territories (63°16′ N). The Chick Lake specimens were found 290 km

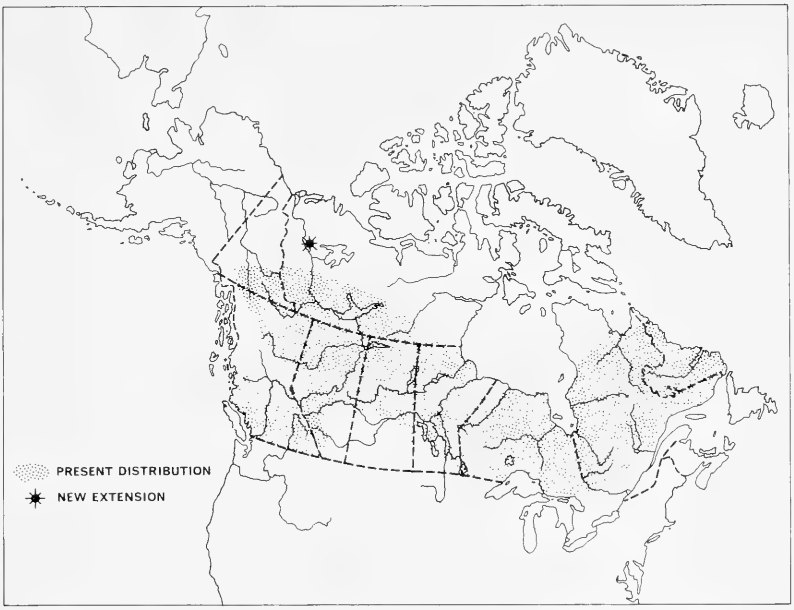

FIGURE 1. Canadian distribution of the heather vole, *Phenacomys intermedius*, with range extension indicated.

north of that latitude.

The first specimen was captured on a comparatively dry knoll moraine in a dense stand of black spruce (*Picea mariana*) with some intermixed larch (*Larix laricina*) and birch (*Betula papyrifera*). The ground cover was predominantly lichen (*Cladonia* spp.) and mosses (*Hylocomium* sp. and *Aulocomium* sp.) with a light covering of *Ledum groenlandicum, Vaccinium vitis-idaea,* and *V. uliginosum*. Although similar to the heather vole habitat described by Foster (1961) this habitat was not as open as that which Banfield (1974) described as typical habitat for this species.

In 70 000 trap-nights expended at Chick Lake, only one heather vole was captured. This constitutes less than 0.008% of the total captures in the Chick Lake area during 1973 and 1974. Heather vole teeth, however, occurred in 5% of the marten scats collected in the area and may indicate that live-trapping grossly undersampled the heather vole population.

Four other species of rodents were captured in the same plot as the heather vole. These were, in descending order of number of captures: northern red-backed mouse (*Clethrionomys rutilus*), meadow vole, (*Microtus pennsylvanicus*), yellow-cheeked vole (*M. xanthognathus*), and the northern bog lemming. On other plots in the area, captures of more than two species rarely occurred.

The heather vole specimens were discovered while field studies were being conducted for Canadian Arctic Gas Study Limited by Renewable Resources Consulting Services Ltd.

Literature Cited

Banfield, A. W. F. 1974. Mammals of Canada. University of Toronto Press, Toronto. 438 pp.

Foster, J. B. 1961. Life history of the phenacomys vole. Journal of Mammology 42(2): 181–198.

Hall, E. R. and **K. R. Kelson.** 1959. The mammals of North America. Volume I. Ronald Press, New York. 1083 pp.

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News and Comment

Ecological Sites in Northern Canada

There are areas of biological, geological, and historical importance in northern Canada that urgently require special protection. Because of the vastness of the Canadian north, this may not be readily apparent. Here, as elsewhere, however, man's expanding activities increasingly threaten a number of unique areas, ecosystems, and species. The necessity for carefully controlled development of non-renewable resources and the prevention of irreversible disturbance call for a detailed documentation of these biologically important regions. In response to this need, the members of CCIBP-CT (The Canadian Committee for the International Biological Programme—Conservation Terrestrial)—Panel 9, a diverse group of scientists, experts, and leaders from governments, universities, industry and the public, have to date identified 71 sites in the Canadian arctic tundra areas (western high Arctic; eastern high Arctic; western low arctic islands; north slope and Mackenzie District; Keewatin District; islands in James, Hudson, and Ungava Bays; and Baffin Island region) that should be given a high level of consideration for protection, special management, or study.

The publication of the book, *Ecological sites in northern Canada*, is to assist in land-use planning on the national and territorial levels and to provide preliminary guidelines for the establishment of a resource habitat preservation program in northern Canada. This cataloguing of significant ecological sites by the CCIBP-CT will provide a means by which conservation plans and thinking can enter easily into land-use decision-making processes in arctic regions, and will ensure that renewable resource conservation is no longer secondary, or not considered at all. Each of the 71 site descriptions includes a detailed map of the area, a general description of the physical environment and biota, and an outline of exceptional features supplemented by a comprehensive bibliography. The bibliographies provide a detailed documentation and comprise the most extensive reference source in existence on these valuable and unique biological sites. The book is available for $3.75 from Co-ordinator, International Biological Programme Committee, Conservation Terrestrial—Panel 9, c/o Canadian Wildlife Service, Ottawa, Canada K1A 0H3.

Ocean Dumping Controlled by New Canadian Law

It is now illegal to dump any substance at sea without a permit, and a permit will not normally be granted to dump substances that are known to cause harm to the marine environment. The Ocean Dumping Control Act also covers disposal of wastes on ice and incineration at sea. Permits may be issued to allow dumping under controlled conditions of substances not deemed too hazardous, and annexes to the Act cover specific substances in "prohibited" and "restricted" categories.

Environment Minister Jeanne Sauvé said: "This Act and the London Convention on the Dumping of Wastes and Other Matter are needed to protect Canadian fisheries, recreational areas, and coastal waters from dumping by ships plying Canadian waters. Contamination of ocean waters anywhere in the world has to be prevented, and Canadian vessels will have to conform with the Act wherever they may be. Foreign vessels will be subject to its provisions while in Canadian waters."

The London Convention, which Canada signed in 1972 along with some 80 other nations, covers marine waste disposal around the world and will come into force automatically as soon as 15 nations have ratified it. Thirteen nations have done so already.

In administering the Act, Canada will work to fulfill the objectives of the London Convention, which are as follows: to prohibit the dumping of substances that are highly injurious to the marine environment; to control the dumping of all other substances; to monitor dumping sites in order to ascertain the effects of dumping; to compile information on dumping practices; and to establish the effects on the marine environment of substances not expressly mentioned in the London Convention.

Red Data Book, Volume 3, *Amphibia* and *Reptilia*

The completely revised Volume 3 of the IUCN (International Union for the Conservation of Nature and Natural Resources) Red Data Book, *Amphibia & Reptilia*, has been issued. Rene Honegger, author of the original volume published in 1969, has provided sheets for all species covered in the index and has prepared a separate index listing the amphibians and reptiles considered to be under some threat of extinction but on which data are presently lacking, and their distribution.

The standard format of the revised Red Data Book, Volume 1, *Mammalia*, has been used, which incorporates vulnerable species and systematic coding. Revisions to the volume will be made regularly and will be sold by sheet at a nominal cost. The price for the complete set including looseleaf binder, dividers, and 162 sheets, is US $15, including surface postage and packing. Present owners of Volume 3 can order the replacement set of 162 sheets for US $10, including surface postage.

Endangered Species Convention in Force

The ratification of the Convention on International Trade in Endangered Species of Wild Fauna and Flora by ten states (Canada was the eleventh adherent) brought the Convention into force on 1 July 1975. The adherents are Canada, Chile, Cyprus, Ecuador, Nigeria, Sweden, Switzerland, Tunisia, United Arab Emirates, United States of America, and Uruguay. This is a major step towards stopping the devastating drain on wild animal and plant communities. IUCN considers it vital that other governments adhere as soon as possible so that no loopholes are left which could be exploited to the detriment of endangered animals and plants. (From IUCN Bulletin, New Series 6(5), May 1975)

Federal-provincial Accords on Environmental Protection

Agreements to develop complementary programs for the protection and enhancement of environmental quality were signed on 8 October 1975 by Canada and the provinces of Alberta, Saskatchewan, Manitoba, New Brunswick, Prince Edward Island, and Nova Scotia. It is planned that the Accord with Ontario will be signed soon. Similar accords will probably be signed shortly with the remaining provinces.

Canada and the signing provinces have agreed to determine and establish desirable levels of baseline environmental quality; develop national requirements and guidelines for pollution control by industry and municipalities; consult on methods of monitoring environmental quality and exchanging assessment data; implement pollution control programs; develop contingency plans to deal with environmental emergencies such as oil spills; cooperate in research, exchange of techniques, and staff training; and share costs for joint programs.

Environment Canada Sponsors Stratosphere Ozone Probe

The most comprehensive probe ever launched into the stratosphere is soon to be carried out by a team of 25 Canadian scientists stationed near Yorkton, Saskatchewan. Four giant balloons, each one lifted by 15 million cubic feet of helium and carrying 3500 pounds of scientific equipment to a height of over 20 miles, will analyze the effects of aerosol propellants, known as freons, and exhaust gases from supersonic aircraft, on the destruction of ozone, the protective layer of gas which partly filters out ultraviolet radiation from the sun. The probe is being conducted by the Atmospheric Environment Service of Environment Canada in cooperation with York University, the Universities of Calgary and Saskatchewan, and a U. S. Government agency, the National Centre for Atmospheric Research, of Boulder, Colorado.

The ozone layer gives protection against certain effects of solar radiations and recent reports have raised concerns about such effects. Theoretical estimates suggest that a 5% reduction in ozone would result in an increase of 10% in ultraviolet radiation at the surface which, in turn, might increase the incidence of skin cancer.

Expansion Approved for Bedford Institute

Romeo LeBlanc, Minister of State for Fisheries, announced on 7 May 1975 that expenditures of $18 million have been approved for an expansion program to the Bedford Institute of Oceanography, Dartmouth, Nova Scotia. The present structure—an interdisciplinary establishment whose members undertake scientific research and surveys in the marine environment—houses three major units: the Atlantic Oceanographic Laboratory and the Marine Ecology Laboratory, both units of Environment Canada's Fisheries and Marine Service, and the Atlantic Geoscience Centre (part of the Department of Energy, Mines and Resources).

"The activities of the Bedford Institute are recognized as central to the implementation of the federal government's Oceans Policy," Mr. LeBlanc said. "The proposed expansion of the Institute's facilities for ocean-related research and development for use by both government and industry will help speed up the implementation process."

The population of the Institute is expected to increase during the next five years as a result of the current federal government thrust towards "buying" rather than "making." A portion of the research will be conducted by industry. "It is predicted that a very substantial part of the total research program will be bought by 1984. In order to transfer the expertise which currently exists in the Institute, it is most desirable to provide facilities so that a proportion of the industrial researchers may be accommodated at the Institute," said Mr. LeBlanc.

Conservation for Decision-makers

This theme "conservation for decision-makers" was chosen for the IUCN (International Union for Conservation of Nature and Natural Resources) meetings in Kinshasha, Zaire from 7 to 19 September 1975 to emphasize the vital role conservation will play in the progress of the developing world.

Robert Allen, science writer for IUCN says "Decision-makers live in the cruel world of realpolitik. It is a world where policy is based not on ideals but on power, and where choice is limited not by what is possible but by what is practicable." (From IUCN Bulletin, New Series 6(5), May 1975)

Book Reviews

ZOOLOGY

Bird Life

By I. Rowley. 1974. Taplinger Publishing Co., Inc., New York. pp. $17.25.

In this contribution to the Australian Naturalist Library, Ian Rowley has undertaken a formidable task. It is not easy to deal in a single volume with an avifauna comprising some 700 species. Yet the author has done so and has succeeded in producing a most readable account of Australian birds. The book is written in an informal, casual style, and yet in most instances it is carefully documented and scientifically sound. The illustrations, both black-and-white and color, provide a valuable dimension to the text, giving the reader an insight into the diversity of the Australian countryside and the splendor of its avifauna. The list of references is reasonably up to date, its greatest contribution being for the novice to Australian ornithology. Finally, the book is well indexed.

The text is divided into three parts, which unfortunately are not indicated in the table of contents. Part one provides a general introduction to ornithology, a description of the Australian environment, and a discussion of behavior and reproduction within an Australian context. Of the four chapters in Part one, chapter 2 on the Australian environment is the best. In ten pages Rowley provides the reader with a succinct introduction to the continent, its climate, and habitats. This chapter is an invaluable aid in helping the reader to comprehend the unique nature of Australia and the biological problems which must be coped with by the birds which live there.

Part two entitled, "Mainly Residents," to my mind is the best of the book's three sections. Here the author seems to be on familiar ground. As a result the chapter groupings are the most logical of the three parts, and the accounts of the various species are authoritative and intriguing. In his life history accounts Rowley highlights many of the fascinating species and problems which make Australian ornithology so exciting. For example one is amazed at the number of species which employ helpers during the nesting season, while the accounts of such fascinating birds as the Mallee Fowl, *Leiopa ocellata,* and Lyrebird, *Menura novaehollandiae*, fill the reader with wonderment.

In Part three, devoted to migrants and nomads, the author seems less at ease than elsewhere. His attempts to classify the various forms of nomadism are unconvincing and one wonders why the author strives so hard to do so. In addition it is difficult to find the rationale for the inclusion of a chapter on "Conflict and Conservation" within this section. Nevertheless there is a wealth of exciting reading here. One cannot help but be amazed at the response of Wood Swallows (Artamidae) to rain, and the synchrony with which the population of the Mutton-bird, *Puffinus tenuirostris*, completes its migration and returns to produce its eggs within a two-week span.

Good as this book may be it could have been better had the author been a little more rigorous in his approach. As a scientist he is often remiss in statements which are made. For example, in his discussion of flight a clear differentiation is made between gliding and soaring, yet the Mutton-bird is referred to as being a glider. He also suggests the Mutton-bird uses its wings under water, but no authority is given for this unlikely event. On occasion, references given in the text are not cited in the reference list, e.g., p. 252, Minton and Spencer, 1963 and on p. 77 reference to Table 1 should be to Table 2. The author also commits several inexcusable *faux pas*. Surely he should know that Charles Darwin was the author of *The Origin of Species* and not as stated on p. 15 *The Origin of the Species,* and surely someone of his background should know that data are plural. Finally, several glaring errors in syntax were detected which careful proofreading should have prevented.

One can always find faults with a book and though "Bird Life" has its share of them it must be classed as a successful publication. Reading it brought back happy memories of species seen and times spent in the Australian bush. For anyone who wishes to become familiar with Australian ornithology, Ian Rowley's book provides a valuable starting point. I recommend it to scientist and layman alike.

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Taschenlexikon zur Biologie der Insekten [Dictionary of Insect Biology]

By Werner Jacobs and Maximilian Renner. 1974. Gustav Fischer Verlag, Stuttgart. 635 pp. DM 38.

German common names of insects together with the scientific names and concise articles on insect orders and families, as well as entomological terms, are presented in alphabetical order. This comprehensive single-volume reference is highly reliable and will, among others, be an aid in finding English common names by way of the Latin names. (Unfortunately, no Latin index is given.) Illustrations and diagrams amplify the definitions; well drawn, they are clear, detailed, and altogether apt, illuminating, functional, and instructive.

Where can we find a similar work in English?

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The Ipswich Sparrow

By W. T. Stobo and I. A. McLaren. 1975. Nova Scotian Institute of Science, Halifax. 106 pp. $5.

Many years ago, when being driven through Massachusetts, I begged the driver to stop at Ipswich so that I might search for the Ipswich Sparrow. So ignorant was I of this now famous bird that I did not realize the predestined futility of my quest. It was summer. The bird would have been nesting then on Sable Island, off the coast of Nova Scotia, far, far to the northeast. It was therefore with particular interest that I commenced reading this definitive monograph by Stobo and McLaren, the results of their intensive study for six years (1968–1972) of this elusive bird.

The book is not, strictly speaking, a life history of the species. "Our aims," the authors write, "are to describe quantitatively the main features of territoriality, breeding biology, migration, and distribution of the Ipswich Sparrow, the ways in which its populations are regulated, its differences from the closely related Savannah Sparrow, to consider the adaptive significance of the characteristics that we have described, and to discuss requirements for its preservation." In the text, 24 figures, 20 tables, with the addition of 4 tables in the appendix, assist in clarifying these points.

Each winter, a small number of Ipswich Sparrows remain precariously on Sable Island. Mortality is high. In spring, birds which wintered on coastal dune beaches from Halifax County, N. S. south (rarely) to Florida, commence returning. There is evidence that nighttime flights are taken from the Nova Scotian mainland north of the latitude of Sable Island, the birds arriving during or shortly after periods of westerly and relatively light winds. Birds continue arriving at least until early May: 2000 to 3000 returned to the island during the last few springs.

Males proclaim territory by perching conspicuously, singing frequently, and driving away intruders. At least one perch is necessary which gives complete territorial surveillance. Females disperse themselves in a relatively even pattern for the first nests. In late spring 1967, it was estimated that there were 4000 adults present. In June 1971, 2424 adult birds were found.

Clutches vary from two to six eggs. The period of incubation in this study ranged from 9–15 days, averaging 12.5 days. Incubation was by the female only. Most broods stayed on the nest for 10–12 days. The young Ipswich Sparrow leaves the nest before it can fly, as is typical for related genera. The parents continue to feed the young for approximately two weeks. This island species suffers practically no predation. The birds have an unusually high nesting success, from 77.5% in 1968 to 84.2% in 1967. A remarkable number of eggs hatched (92%). There was a 100% hatching success from both the Main and Sparse areas of the small fourth clutches in 1970.

At times there was remarkable territorial tolerance. Territorial birds around the 'Lily Pond' allowed birds from the north unmolested access to the water's edge. Females were not attacked by territorial males when in search of food. Young out of the nest crossed territorial boundaries unopposed until well fledged or giving their first fragmentary songs.

The Main Study Area of approximately 11 hectares was near the West Light and was densely vegetated with shrubs, forbs, grasses, and sedges. It bordered on a series of ponds. The Sparse Study Area of 25 hectares was located 11.5 km east of the Main Area. Clear maps show the various features of the areas and indicate their vegetation. During the four years of study, 99 territories were mapped and practically every bird banded, color-marked, and numbered. A total of 232 nests was found in the study areas. Maps are given for the various years showing the boundaries of the many territories.

It was a surprise to many of us when in 1973 the American Ornithologists' Union decided to designate the insular Ipswich Sparrow as a subspecies of the mainland and widely distributed Savannah Sparrow. Some interbreeding has occurred but the two forms are easily distinguished in the field, the Ipswich Sparrow being diagnostically paler, larger, with shorter tail than the Savannah Sparrow. It walks rather than hops, sings louder and on a lower key, defends larger territories, is more given to polygyny, nests on one island. And, say the authors, "the island was much larger during glacial advances, and has presumably been exposed since at least the last interglacial (p. 10), the bird could have existed as a distinct form for tens or even hundreds of thousands of years."

The incidence of polygyny in the Ipswich Sparrow is higher than in the Savannah Sparrow. This may promote, through selection, more robust males, given to more aggressive territorial defence. Polygyny is probably more widespread among species living in two-dimensional habitats. In 1968, 47% of males were polygynous, in 1970 only 5%. Males adjusted the boundaries of their territories to new nest-sites chosen by females; polygynous males had on average larger territories than monogamous males and, as individuals, raised more young. But the females of polygynous males raised fewer young that the females of monogamous males. (I was interested to note that twice females of bigamous males were seen fighting among themselves.)

The food of adults during the nesting season was largely insectivorous, with the addition of fruit (strawberries and blueberries). The young were fed adult midges (Chironomidae), caterpillars, moths and butterflies (Lepidoptera), and little bits of strawberries and blueberries. Between 1967 and 1970, 687 nestlings and flying young were banded. Only 11 ot these remained as territorial birds. The peak of the fall migration is in October. The bird suffers heavy mortality on its winter range.

"The long-term preservation of the Ipswich Sparrow will depend" the authors write, "on repair and maintenance of the Sable Island habitats. Its present population size may depend on the availability of beach-grass habitat on the U. S. coast, which will also need to be preserved. It may also depend somewhat on the continuing integrity of beaches in Halifax Co., N. S."

Having perused it twice, I can highly recommend this excellent monograph of the Ipswich Sparrow, particularly to those ornithologists interested in territory and bird life. The frontispiece is a fine painting on an Ipswich Sparrow by Lloyd Fitzgerald. The references run to nearly three pages. I commend the authors for their quantitative approach.

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Dolphins and Porpoises: A comprehensive, annotated bibliography of the smaller Cetacea

Compiled by Deborah Truitt. 1974. Gale Research Company, Book Tower, Detroit, Michigan. 582 pp. $45.

The literature of cetology, the study of porpoises, dolphins, and whales, is scattered widely in medical, physiology, systematic, anatomical, and other journals, and much of the older work is still the main and often the only source of information. Those who have attempted to work on the smaller cetaceans usually compile their own extensive card index and after considerable work, usually find that their coverage is woefully inadequate. This compilation comes at a time when many international agencies and other groups are concerned with the heavy exploitation of the porpoises and dolphins. It is a welcome addition to the already considerable efforts of earlier bibliographers such as J. A. Allen, A. Fjeld-Andersen, J. T. Jenkins, T. Pedersen, and others. As with the existing cetacean bibliographies, however, it is not complete. Rather, it attacks a narrow subject, and does a creditable job.

The author has unfortunately omitted most references to the genera *Feresa, Globicephala, Pseudorca* and *"Orca"* (=*Orcinus*), "Because references to them are more closely associated with whales and whaling. And the whaling literature is immense." The literature of *Feresa* can in no way be related to the whaling literature. Unfortunately, most references to all these genera involve biological data most directly comparable to the other delphinids she regards as true dolphins. Thus, the bibliography covers the smaller species of the Delphinidae and some other small cetaceans, but omits the larger delphinids. This is a major failing and the book cannot be regarded as comprehensive except within highly artificial bounds.

The book is arranged as follows: Introduction; then main entry citations listed chronologically in over 70 chapters arranged by subject; and three indexes for author, taxonomic name, and subject, which refer to citation by number only. The book lists 3549 main entries, not by author but by year in various chapters, classified by subject material. This may be how librarians like to find references, or it may be of use to the uninitiated checking into the field for the first time, but some professional cetologists of my acquaintance find the volume cumbersome and difficult to use. If you wish to find literature on a particular kind of dolphin, for example, *Delphinus delphis*, you will find more than two pages (four columns) of solid number citations. Each citation will take more than a few moments to turn to and examine. Checking on a particular subject, the subject chapter (e.g., Circulatory system) will list entries chronologically up to 1970. The subject index (under e.g., blood) also will lead to a few other references, not listed in the chapter on Circulatory system. Often the problem is to verify one or more of a given author's works, but if the author was prolific, you find a great list of citation numbers in the index. Then each citation will have to be looked up to see if it is the year or subject in question. This also can be extremely time-consuming. By the very nature of the articles cited, it is difficult to arrange each precisely into subject chapters, and there is overlap and omission here.

I have found some errors in main entry citations, but these are often traceable to some ambiguity in the original article. The author has done a good job of digging. For those references she copies from other sources and was not able to verify, however, it would have been useful to have more information on the sources used. In tracking a number of these down, I found that fuller annotation of the original source would have allowed me to pinpoint the error more rapidly. These points should not obscure the real merit in bringing together a substantial portion of the modern literature on small odontocetes. Specialists will turn to it time and again.

The paper quality of the volume is adequate, the binding appears to be rugged, and the contents are of much worth, but the inordinately high price will preclude many from using the volume. It will prove to be a necessity for any library or research institute, but individual scientists may hesitate before purchasing a copy. It is laborious and time-consuming to use. By no means can it be used in place of an adequate and wide-ranging literature search by specialists publishing the results of their own research.

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Trees: structure and function

By M. H. Zimmermann and C. L. Brown. 1974. Springer-Verlag, New York, Heidelberg, Berlin. 336 pp. $12.

The authors emphasize in a precise and concise way those mechanisms and structures characteristic for the function of trees. Since the first appearance of this volume in 1971 it has filled a gap in plant physiology by dealing only with aspects particular to trees. Therefore, this volume was well appreciated not only by all those seeking advanced knowledge in this particular field, but also by all those with a general interest in woody plants and their structural function. The book not only transmits knowledge in an excellent way, but also stimulates and guides the student seeking advance knowledge in the most important world literature in tree morphology and physiology. The complexity and difficulties in assessing tree function, and how deep one must penetrate into other fields of science for a better understanding of some mechanisms in tree function, becomes particularly evident in a chapter on the thermodynamics of translocation.

The seven chapters of the book include Primary Growth, Secondary Growth, Growth and Form, Transport in the Xylem, Transport into Phloem, The Stady State Thermodynamics of Translocation in Plants, Storage, Mobilization and Circulation of Assimilates. The first three chapters are written by C. L. Brown, Chapters Four, Five, and Seven by M. H. Zimmermann, and Chapter Six by M. T. Tyree. Although there is uniformity among the chapters, the individuality of the authors is evident in each. The relatively simple and clear arrangement of the material as well as the selection of great numbers of clear illustrations, supporting the examples of the text, contributed greatly to the fact that this volume is on its way to becoming a standard book in tree physiology. The volume was so well received that a second printing became necessary in December 1974. Opportunity has been taken to eliminate some printing errors.

Although the authors clearly state that the book is devoted to trees one would wish that certain mechanisms, for example heartwood formation, dormancy, xylem differentiation, aging and flowering, might be more elaborated. The good presentation of the material on trees is probably a major factor contributing to the popularity of this book among students and professionals. The volume is highly recommended to all those who love trees and choose to work with them.

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ENVIRONMENT

Our Search for Wilderness

By. C. Edward Graves. 1975. Exposition Press, Hicksville, New York. 224 pp. $8.00

According to Graves; "this is not a formal autobiography and I shall not follow the usual pattern of such books in describing in detail my family life and my relations with my parents." Rather "I am concerned mainly for the rest of the book with incidents and travels often isolated from each other, that have to do with my search for wilderness in its various forms." In so following this theme, Graves' book, *Our Search for Wilderness*, might best be considered as a travelogue with most of his adventures occurring in the west central United States.

In the early chapters of the book the author provides a very acceptable definition of wilderness. "I decided that to me there were five outstanding qualities or characteristics of wilderness." These included "solitude," "Quietude (not silence, which can never be an integral quality of wilderness)," "remoteness," "a sense of adventure," and "primeval beauty that transcends the visual organs." From this definition one hopes the author might be able to convey to the reader a truer understanding of wilderness; however, the author reverts to the narrative travelogue style, failing to pursue the meaning of wilderness.

Another theme the author fails to pursue is that of wilderness preservation. "Wilderness appreciation following a personally developed concept of its meaning is the necessary approach to wilderness preservation." The reader has no doubt that Graves has a sincere interest in the out-of-doors, but wilderness preservation as presented in *Our Search for Wilderness* amounts to solely autobiographical notes on the author's accomplishments.

In several different parts of the text the author refers to pictures he has taken. "I decided in 1960 to develop a slide program that I called 'Beauty in Wilderness' combining my color slides from years of wilderness travel with Bible quotations, poetry, and music." Noticeably absent from *Our Search for Wilderness* are photographs. The combination of quality photographs with the written word is definitely needed to portray the essence of nature.

In his closing chapters the author reviews the 'now and then' features of some of the areas he has visited. Had Graves concentrated solely on this theme, his *Our Search for Wilderness* travelogue, would have been more interesting and of value to many resource managers.

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The Nature of the Stratigraphical Record

By Derek V. Ager. 1973. Halsted (Wiley), New York. 114 pp., illus. $9.50.

The early observations made at the dawn of development of the science of geology already recognized the discontinuous nature of the geological record and led to what appeared as a logical conclusion—a series of catastrophic events. This explanation was clearly supported by the biblical Deluge idea and provided a simple answer to what we now know is a complex problem. Catastrophism and fatalism have always captured the imagination of the human mind and filled man with morbid curiosity about events that he observed but could not adequately explain. Events such as volcanic eruptions, earthquakes, floods, landslides, intense atmospheric storms, and other like events are recorded and remembered because they appear to be exceptional and can have a disruptive impact on human activities and mind—they are *newsworthy*. There is a vast difference between the meaning of the word *catastrophe* in the geological sense and in the sense of its usage by our current, or ancient, news media. Commonly man understands catastrophe to mean a sudden event of disastrous nature. Events that are "sudden" in a geological sense (certain mass extinctions of biota, glaciations, the presence of some very widespread deposits) may have taken, in fact, thousands or a few million years to occur and leave a recognizable "signature" in the geologic record.

Ager's book deals with some selected aspects of the stratigraphical record: the persistence of facies; the problems of the fossil record; gaps in the record; the catastrophic nature of stratigraphy, and uniformitarianism; the process of sedimentation; the "golden spike" principle; and the processes controlling the accumulation of the record.

The Nature of the Stratigraphical Record is a provocative book. It appears to challenge some of the very basic principles of geology and in doing so brings into clear focus the need in geology to examine and re-examine, and reinterpret the record in the light of new technological and theoretical advancements made in the geological sciences and related natural sciences. I interpret Ager's message to mean that we in geology should be never completely satisfied with our understanding of the stratigraphical record and that we should be always prepared to reconsider existing hypotheses in view of new evidence from all possible sources.

While discussing the abruptness of some of the major changes in the history of life Ager states that, "It is both easy and tempting (and very much in line with the other ideas expressed in this book) to adopt a neocatastrophist attitude to the fossil record" (page 19). He hastens to explain, however, that "In case this book should be read by some fundamentalist searching for straws to prop up his prejudices, let me state categorically that all my experience (such as it is) has led me to an unqualified acceptance of evolution by natural selection as a sufficient explanation for what I have seen in the fossil record. I find divine creation, or several such creations, a completely unnecessary hypothesis." What Ager is saying is that rates of geological processes have varied significantly through time and that "most evolution proceeds by sudden short steps or quanta."

In his discussion of mass extinctions of biota, Ager considers a number of causes that have been proposed (including meteoritic impacts) and he seems to imply that we should keep an open mind in respect to a search for such causes and evaluate them on the basis of all available evidence. He states that "clearly we cannot blame a single organic agent for the simultaneous extinction of all the varied and unrelated groups of dinosaurs, the pterosaurs, the marine reptiles, the ammonites, the belemnites, the rudistids and many minor groups besides at the end of the Mesozoic."

Ager's discussion of the fragmentary nature of both the sedimentary and fossil records confirms what has already been commonly accepted by stratigraphers and paleontologists. We know that many gaps exist in the stratigraphical record, and that these gaps are gradually being filled by new information obtained during further investigations.

Under the heading of "catastrophic uniformitarianism" Ager gives special attention to relatively rare geological events. He illustrates the point by saying that "given time, the rare event becomes a probability and given enough time, it becomes a certainty." As one example, he refers to the frequency of tsunamis as known from historical records and concludes that "this would allow us more than 100 000 tsunamis in a million years." On the basis of this reasoning Ager feels that, "given all the millennia we have to play with in the stratigraphical record, we can expect our periodic catastrophes to do all the work we want of them." Although Ager challenges apparently some aspects of uniformitarianism, he claims that, "I do not deny uniformitarianism in its true sense, that is to say, of interpreting the past by means of the processes that we see going on at the present day, so long as we remember that the periodic catastrophe (including sudden events like the rush of a turbidity current) is one of those processes."

Ager challenges some concepts relating to certain aspects of the process of sedimentation, and emphasizes the question of diachronism of stratigraphic units and boundaries. In this context he concludes, in part, that "most sedimentation in the continental areas is lateral rather than vertical."

In the final paragraphs of his book Ager observes that, "In our near-sighted way of looking at the stratigraphical column, we tend to forget that these recent events (Pleistocene glaciations), if considered on the normal geological time-scale, were virtually instantaneous and certainly catastrophic. The whole of the Pleistocene ice-age would fit within an ammonite zone or two." Obviously what may appear as a catastrophe on the geological time-scale can be a slow process on the human time-scale. In fact, the appearance of man on earth would be very much a catastrophic event on the geological time-scale.

Although Ager's book tends to be provocative and challenging in respect to several basic geological principles, and the unfortunate over-emphasis of the word catastrophe, the main value of this book is in the forcing of geologists to scrutinize the stratigraphical record with an open mind and not to be constrained by traditional views to the point where these stifle progress. From this viewpoint the book can be recommended as stimulating reading to geologists and others interested in the history of the earth.

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The Changing Flora and Fauna of Britain

Edited by D. L. Hawksworth. 1974. Academic Press, London & New York. (Systematics Association Special Volume 6). 461 pp. $23.75.

Canada has a land area of 3 560 238 square miles and a population of around 22 million; it has, therefore, an average of about six persons per square mile. The corresponding figures for the British Isles, are 110 463 square miles, 60 million people, and an average population density about 90 times that of Canada. In Canada we are rightly concerned that an increasing population, making increasing demands on the environment, is threatening to impoverish our flora and fauna. Is it surprising, then, that Canadians sometimes wonder what plants and animals can, in fact, survive a population density of more than 500 persons per square mile, coupled with two centuries of industrialization, and many more of intensive agriculture? This attractive volume, representing the proceedings of a symposium held by the Systematics Association in April 1973, answers this question admirably. It does a great deal more, however, for it provides in separate chapters an informed appraisal of the present status and future prospects for survival of 20 different groups of organisms, ranging from birds and vascular plants to spiders and "arthropod ectoparasites of man"!

Inevitably there is some unevenness of treatment because, whereas the occurrence and distribution of vascular plants and vertebrates in the British Isles (despite its title the book covers Ireland also) have been the subjects of detailed study for over two centuries, knowledge of groups such as the microfungi, freshwater algae, and some of the freshwater invertebrates is still rudimentary. In most other groups the situation is in between, with new records of species of bryophytes, macromycetes, and most terrestrial invertebrates being reported at a steady rate. This is well summarized by E. A. G. Duffey who comments with regard to the British spider fauna that "many species thought to be very rare have been shown to be more widely distributed as a result of work during the last 15–20 years."

It is interesting that elements of the fauna and flora of such small islands peopled with so many enthusiastic amateur and professional naturalists are still so incompletely known—when, if ever, can we hope to approach that level of knowledge in Canada? —but it is not very helpful in terms of monitoring changes due to man's increasing influence on the environment. For this we must look primarily to the vertebrates and vascular plants, and to a lesser extent to the lichens, through their sensitivity to atmospheric pollution, the terrestrial molluscs, through the long-standing interest in conchology, and the orthoptera, well-known because of the few British species.

From these the overall picture is one of remarkable resistance to extinction with, in some cases, more aliens becoming established than native species lost. Knowledge of British mammals goes back to Roman times, and Dr. J. B. Corbet considers that only six species have become extinct in the British Isles in the past 2000 years, the last being the wolf, exterminated in the eighteenth century. Against this must be set the establishment in the same period of 17 introduced species, although one of these, the North American gray squirrel (*Sciurus carolinensis*) has spread to the critical detriment of the native red squirrel (*Sciurus vulgaris*).

Changes independent of man's influence are considered in several of the chapters, as in the effect of climate on "good" and "bad" years for lepidoptera, and in changes in the mean path of the Atlantic storm-track in increasing the number of new "sightings" of passage-migrant birds. Nevertheless, the inescapable conclusion, is that man has exercized and will continue to exercize far greater influence on the British fauna and flora than any changes in physical factors. And with this in mind most contributors to the symposium were at pains to emphasize that threats to major ecosystems were more serious today than they had ever been. In the opinion of Dr. K. Mellanby, who introduces and sums up the volume, agriculture, by its increasing intensification (removing hedges, etc.), is probably the greatest present danger to the British fauna and flora.

Apart from its insight into the effects of relatively dense human populations on other species, this volume is of importance to readers outside of Britain for the evidence it reveals of the importance of methods of recording species occurrence. The electronic data-banking on a 10-kilometre grid system, which is being applied to mapping distributions in many groups under the aegis of the Biological Records Centre, is making a major contribution. It provides a broadly-based yet fairly sensitive standard for monitoring general changes in the biological environment, as against considering only the more spectacular rarities. Although a 10-kilometre square is an unrealistic unit in Canada, until we do have some comparable data base of records of biological distributions we run a grave danger of detrimental changes to the Canadian fauna and flora occurring without our even being aware of them.

And a final word on ectoparasites! Were Robert Burns writing today, would he still have the inspiration for his 'To a Louse'? Probably not, although interestingly enough head lice were commoner in Britain in 1973 than in 1945. Body lice, however, are nearly extinct. Where, I wonder, does a conservationist stand on that?

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Vignettes of Nature in Southern Ontario

By William W. Judd. 1974. Carlton Press, Inc., New York. 96 pp. $3.

This is a collection of observations which will appeal primarily to the layman. Such is their detail and acuteness, however, that I believe anyone will be able to find something interesting here, something that he has not noticed or thought about before.

There are 35 essays about natural phenomena carefully observed and recorded by the author near his home in London, Ontario, or at his summer cottage on Lake Erie. He tells us about things such as unusual concentrations of dragonflies, land snails on the snow, or lady beetles on the beach. He writes of birds, moths, butterflies, snakes, plants, toads, spiders, mice, and salamanders, and other living things on which his wide-ranging interests focus.

Often a chord is struck in the reader as he happily exclaims about something he has wondered about but not been able fully to explain previously. It was the description of the activities of the burrowing wasp, the "Great Golden Digger," that clarified a mystery for me.

The book is illustrated with some good line-drawings by the author, and by his photographs. The photographic reproduction is unfortunately of poor quality. This book shows us how much of interest can be observed in one's own backyard. It would make a very nice gift for anyone interested in the outdoors.

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A Voice for Wildlife

By V. B. Scheffer. 1974. Scribners, New York. 245 pp. $8.95.

Within the first two pages, Scheffer states the justification for his text: "I am alive at the beginning of the Age of Ecology, or, if you wish, the Age of Environmental Awareness, or the Age of the New Conservation" and the theme of his book "the way men will 'use' wildlife in the future will be sharply unlike that in the past." Through the course of 17 chapters, the author attempts to examine the use and abuse of wildlife resources that have occurred to date. At the same time, Scheffer proposes the direction that management should take for the future of these resources.

Scheffer's personal experience as a wildlife biologist has allowed him to understand fully the limitations and problems of his profession: "dealing with people is perhaps the hardest operation in wildlife management"; "though the statisticians can estimate the numbers and characteristics of hunters in the United States they seem unable to tell us much about the hunted"; "if you would argue that shooting is not a significant factor in wildlife depredation, count the bullet holes in road signs the next time you drive to your favorite hunting area"; "the phrase multiple use has a fine democratic sound but is often employed by logging, mining, and water power interests to justify the penetration of beautiful wild regions that have greater value when left alone."

An underlying attitude throughout *A Voice for Wildlife* is the possessive nature of the wildlife resource user. "In England, a man hiding in a wood with his eyes fixed on the distance might be watching a nightingale or a willow warbler; in Africa, he would be hunting for food; in the United States he would be arrested for trespassing." According to Scheffer, wildlife is not respected as a national resource, but to date has been managed for the benefit of a select few; "the sportsman and the fur trapper will complain that the new conservationists are mixing emotion with fact to the confusion of the voting public which cannot distinguish one from the other;" "wildlife managers and the hunters whom they principally serve began only in the current decade to hear the voices of outsiders asking to share in decisions about wildlife use."

According to Scheffer "American wildlife exists today not because of management but in spite of it." The author feels that this poor record of accomplishment is history, and for the future wildlife management must become effective if wild animals are to remain in existence.

A Voice for Wildlife deserves to be read by every individual, professional or layman, concerned with the future of wildlife resources. All should recognize, as does Scheffer, that the resource has been grossly abused, that it is not a never-ending resource, and that the future of our wildlife resources depends upon the attitudes of today's managers.

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OTHER BOOKS

The Contrasumers: A citizen's guide to resource conservation

By Albert J. Fritsch. 1974. Praeger, New York. 182 pp. Cloth $7.95; paper $3.50.

It was in 1973 that the average North American began to realize what professional conservationists had been talking about for years, namely that our earth has only finite resources which we in the western world are rapidly depleting through our luxurious life-style. Actual food and fuel shortages brought the point home far more forceably than press releases from various academic conferences had ever done. In his book, *The Contrasumers*, Fritsch attempts to supply the reading public with a factual survey of the present situation and a guide to future action. His argument is that by a shift in national mood from the citizen as consumer to the citizen as contrasumer we can avert the disastrous outcome of our current mode of living.

The Contrasumers opens with a comparison between the life of an average American family in 1876 and one 100 years later. In this 100-year's time, Americans have perfected their weakness, as

Fritsch describes it, of elevating luxuries to necessities. In this time we have reached the point where each American consumes 28 tons each year of materials from the environment. We now need a ton of cereal to meet a person's annual food and meat requirements, whereas in the Third World only 400 pounds are sufficient. Cars are the chief culprits in our wasteful 1976 society, using three tons of nonrenewable hydrocarbons yearly. Throughout the book, Fritsch argues persuasively that cars should be more efficient, longer-lasting, stripped of their energy-consuming luxury features, and de-emphasized in favor of mass transportation and bicycles. Since one out of six workers in the United States depends on the car industry for his livelihood, and cars are such an emotional item in our society, they seem to epitomize the current crisis, where our profit-motivated economy has run headlong into the fact of world shortages.

The media has now made us painfully aware of world energy shortages. *The Contrasumers* fills the reader in with the economic and environmental difficulties of various energy alternatives, and suggests more research is needed, partially funded by taxes, on inefficient use of our present energy supply. Having outlined the crisis, the author emphasizes the global nature that environmental planning must now take. He cites the 26 principles formulated at the UN Conference on The Human Environment in 1972 at Stockholm as a basis for a new global environmental philosophy.

What conservation strategies are open to us? Fritsch offers suggestions on four levels—individual, community, national, and international. They include individual restraint, collective citizen action, and more monitoring and policing of international activities. Certain so-called "individual rights" will have to be abandoned in favor of social rights, and the closing chapters of the book deal with this move, "good versus goods." Where will the next 100 years take us? Fritsch is one environmentalist who sounds a note of optimism. He feels the citizen will, by becoming aware of the energy consumed by his present way of life (graphically illustrated at the end of the book by a Life-Style Index by which the reader can rate himself on a world-wide scale), demand change. Our society will swing from commercialism to a service-oriented economy, which the author sees as a second American Revolution. Perhaps this optimistic social philosophy which pervades the book is a reflection on the author's training as a Jesuit. Let us hope he is right.

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Der Mensch und die Graugans: eine Kritik an Konrad Lorenz [The man and the Greylag Goose: a critique of Konrad Lorenz]

By Gunter Pilz and Hugo Moesch. 1975. Umschau Verlag, Frankfurt/Main. 220 pp. DM 22.

Extrapolating from his detailed observations of the ritual behavior of creatures as diverse as geese, rats, and fighting fish, Konrad Lorenz in his celebrated book *Das sogenannte Böse* (*On Aggression*) argued that aggression is an innate, rather than an acquired, characteristic of man—and that in many cases it is a beneficial one. This thesis has given rise to critiques—some not well founded and some fair—regarding the lessons to be learned regarding our own aggressive behavior.

Gunter Pilz, a sociologist, and Hugo Moesch, a biochemist, give their readers a detailed review of Lorenzian concepts and the scientific literature on aggression. They take issue with Lorenz's attempts to explain warfare on the basis of generalizations about animal behavior, pointing out that these conclusions rely far too heavily on extrapolation from animals. The authors demonstrate that Lorenz has chosen to ignore a large part of the scientific literature and that much of his evidence is of questionable value, particularly that which relies on anecdotes and unsophisticated observation. The Lorenzian argument overlooks moral values which are far superior to any kind of stereotyped ritual.

Pilz and Moesch deal interestingly, if rather roughly, with Lorenzian views and notions of agressive drive and, in conclusion, present a pluralistic model of aggression for discussion.

The bibliography is excellent, and there appears to be no significant omission.

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A Boater's Guide to the Upper Yukon River; Carcross, Yukon, to Fort Yukon, Alaska

By the Publishers of Alaska Magazine. 1975. Alaska Northwest Publishing, Anchorage, Alaska. 66 pp. $3.95.

This small book should be invaluable for trippers setting out to explore the Yukon River, and it may inspire other readers to plan such a trip. Although travellers on the river are advised to check in with various RCMP posts along their route, the river itself is not a dangerous one. There is only one set of rapids and one portage along the greater part of its length, and if care is taken to stay close to shore on the large lakes, there should be little chance of mishap as long as one has taken along enough food to wait out rough water or high winds.

The book begins with a brief history of the river, explored first by prehistoric men seeking their livelihood among mastodons and mammoths, much later by Russians and Hudson's Bay Company men seeking furs, then by prospectors hunting for gold, and finally by rivermen. The river banks are well worth loitering along, as there may still be found strings of colored trade beads of the fur trade, old books in various languages, and prospectors' rusted shovels. None of these historic relicts or artifacts may be removed, so that the atmosphere of early days on the river still remains.

The body of the text is divided into five parts, each dealing with one stretch of the Yukon River, beginning at Carcross, Yukon, and ending in Alaska at the Bering Sea. Each section, complete with map, describes what geographic features one can expect along that part of the river, what historical incidents occurred there, and sometimes what wildlife may be seen. The text is also eminently practical. One is told, for example, that for 60 miles below Whitehorse the river is unfit for drinking; water here should be boiled or taken from side streams. It is also uneconomic to fly your boat out when your trip is completed. Most craft are therefore abandoned near one of the many airstrips which serve the small settlements scattered along the 2000-mile waterway.

For anyone planning a trip by powerboat or canoe down the Yukon, or for anyone interested in the north, this book will be most welcome. I recommend it heartily.

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NEW TITLES

Zoology

Alces: écologie de l'orignal/Moose ecology. 1975. Edited by J. Bedard. Les Presses de l'Universite Laval, Québec. International symposium on moose ecology, Quebec City, 26-28 March, 1973. 776 pp. $27.50.

Among the elephants. 1975. By I. Douglas-Hamilton and O. Douglas-Hamilton. Viking Press, New York. 288 pp. $14.95.

The biology of penguins. 1975. Edited by Bernard Stonehouse. University Park Press, Baltimore. 556 pp., illus. $29.50.

Birding from a tractor seat. 1975. By Charles T. Flugum. Fitzhenry and Whiteside, Don Mills. 448 pp. $10.30.

†**The birds of Manitoba.** 1975. By Ernest E. Thompson. Premium Ventures, Winnipeg. Second edition. (First edition: Government Printing Office, Washington, 1891). Proceedings of the U.S. National Museum 8:457-643. $5.

†**Birds of the Kananaskis Forest Experimental Station and surrounding area:** an annotated checklist. 1975. By John M. Powell, Tom S. Sadler, and Margaret Powell. Environment Canada, Edmonton. Information Report NOR-X-133. 36 pp. Free.

†**The blackbass in America and overseas.** Angling, culture, bioecology, distribution, management, fishing waters. 1975. By Harvey Robbins and Hugh MacCrimmon. Biomanagement and Research Enterprises, Sault Ste. Marie. 196 pp. Cloth $12.95; paper $7.95.

***Les Carabidae du Québec et du Labrador.** 1975. Par André Larochelle. Départment de Biologie du Collège Bourget, Rigaud, Québec. Bulletin I. 255 pp. $15.

The ecology of small mammals. 1975. By M.J. Delany. Arnold, London. 60 pp. Paper $2.75.

Ecology, utilization, and management of marine fisheries. 1975. By George A. Rousenfell. Mosby, St. Louis. 516 pp., illus. $24.95.

A field guide to birds' nests. 1975. By Hal H. Harrison.

Houghton Mifflin, Boston. The Peterson Field Guide Series, 21. 258 pp., illus. $8.95.

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The flora of the eastern Himalaya. Third report. Results of botanical expeditions to eastern Himalaya in 1972. 1975. Compiled by H. Ohashi. University of Tokyo Press, Tokyo. (Distributed by International Scholarly Book Services, Portland, Oregon). 500 pp., 33 plates. $39.50.

***Flore du Canada.** 1974. By Canada Secrétariat d'État, Bureau des Traductions, Information Canada, Ottawa. Bulletin de Terminologie 156 (anglais-latin-français). Catalogue No. S52-2/156. 634 pp. Paper $7.75.

The flowering phenology of North American plants. A bibliography. 1975. By Keith E. Roe and Eunice M. Roe. Pennsylvania State University, University Park. 25 pp. $1.

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Grasslands of the United States. Their economic and ecological importance. 1974. Edited by H.B. Sprague. University of Iowa Press, Ames. A symposium of the American Forage and Grassland Council.

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The native orchids of the United States and Canada excluding Florida. 1975. By Carlyle A. Luer. New York Botanical Garden, Bronx. 361 pp., 96 color plates. $40.

Les plantes sauvage printanières. 1975. Compiled by Gisèle Lamoureux. Ministère des Communications, Québec. Série sciences naturelles collection connaissance du Québec. 247 pp. $3.75.

Report on endangered and threatened plant species of the United States presented to the Congress of the United States of America by the Secretary, Smithsonian Institute. 1975. Presented by S. Dillon Ripley. Government Printing Office, Washington. (Available from Endangered Flora Project, Smithsonian Institute, Washington). 200 pp.

Vegetation and environment. 1974. Edited by B.R. Strain and W.D. Billings. Junk, The Hague. Part 6 of the Handbook of Vegetation Science. 194 pp. Dutch Guilders 60.

Wildflowers of the southeastern United States. 1975. By Wilbur H. Duncan and Leonard E. Foote. University of Georgia Press, Athens. 296 pp. $12.

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Forest soils and forest land management. 1975. Edited by B. Bernier and C.H. Winget. Les Presses de l'Université Laval, Quebec. Proceedings of a conference, Quebec, August, 1973. 674 pp. $18.90.

†**Glacier Bay.** 1975. By William D. Boehm. Alaska Northwest Publishing, Anchorage. 134 pp., illus. Paper $9.95.

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Losing ground. 1975. By John G. Mitchell. Clark Irwin, Toronto. Sierra Club. $7.95.

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Perspectives of biophysical ecology. 1975. Edited by David M. Gates and Rudolf B. Schmerl. Springer, New York. Ecological studies volume 12. Papers presented at a symposium, University of Michigan, August, 1973. 609 pp., illus.

Population, environment, and the quality of life. 1975. Edited by Parher G. Marden and Dennis Hodgson. Halsted (Wiley), New York. 328 pp. Paper $4.95.

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The urban ecosystem. A holistic approach. Edited by Forest Stearns and Tom Montag. Illustrated by Charles Holzbog. Dowden, Hutchinson, and Ross, Stroudsburg, Pa. (distributer, Halsted (Wiley), New York). 218 pp. $18.

*__The urban organism.__ The city's natural resources from an environmental perspective. 1974. By S.W. Havlick. MacMillan, New York. 515 pp. $12.95.

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Canadian conservation directory 1975/1976. 1975. By the Canadian Nature Federation. CNF, Ottawa. $2.50.

Sources of information in water resources. 1975. By Gerald J. Giefer. Water Information Center, Port Washington, N.Y. 312 pp. $20.

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The Canadian Field-Naturalist is a medium for publication of research papers in all fields of natural history. If possible, major articles should be illustrated.

Notes

Short notes on natural history and related topics written by naturalists and scientists are welcome. Range extensions, interesting behavior, pollution data, and other kinds of natural history observations may be offered. It is hoped, however, that naturalists will also support local natural history publications.

Letters

Letters commenting on items appearing in this journal or on any developments or current events affecting natural history and environmental values are welcome. These should be brief, clear, pertinent, and of interest to a wide audience.

News and Comment

Informed naturalists, biologists, and others are invited to present documented narratives and commentaries upon current scientific and political events that affect Canadian natural history and the environment. Contributions should be as short as possible and to the point.

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Most manuscripts with a content suitable for *The Canadian Field-Naturalist* must undergo revision – sometimes extensive revision. After resubmission, manuscripts that required major revision are usually returned to the original referees for re-evaluation. Some manuscripts must be rejected if they are scientifically unsound, unimportant (i.e., they do not contribute any worthwhile information), or are otherwise unsuitable for publication. The Editor makes the final decision on whether a manuscript is acceptable for publication and in so doing aims to maintain the scientific quality and overall high standards of the journal.

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Mailing date of previous issue 21 January 1976.

Errata

1975. Canadian Field-Naturalist 89(4). *The distribution and abundance of the wolverine (Gulo gulo) in Canada* by C.G. van Zyll de Jong. Page 434, column 2, line 14 should read "2000 km^2 (approximately 772 mi^2)." Page 435, Figure 9 caption should read "extralimital records are indicated by circles. Solid circles indicate specimens, and open circles reports."

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The Ottawa Field-Naturalists' Club

FOUNDED IN 1879

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The objectives of this Club shall be to promote the appreciation, preservation, and conservation of Canada's natural heritage; to encourage investigation and publish the results of research in all fields of natural history and to diffuse information on these fields as widely as possible; to support and co-operate with organizations engaged in preserving, maintaining, or restoring environments of high quality for living things.

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Back Numbers

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All material intended for publication should be addressed to the Editor:

Dr. Lorraine C. Smith, Department of Biology, Carleton University, Ottawa, Ontario, Canada K1S 5B6

Cover photograph: Arctic wolf (*Canis lupus*) encountered at close range on Devon Island on 25 May 1970 by W.O. Pruitt, Jr. See article on page 149.

The Canadian Field-Naturalist

Volume 90, Number 2 April-June 1976

Communication via Scientific Writing

Our aim is to transmit sound science to the greatest possible number of readers—to communicate information. Published manuscripts would do this properly if their authors wrote simply, clearly, and precisely.

Unfortunately, poor writing is not uncommon. Basic grammar and composition that should be learned by students in our public and high schools, so often are not. Although universities train students to carry out research, very few North American universities teach students how to communicate the results of their research. There is a strong need for the universities to provide formal training in scientific writing; I plead that they do so soon, for a course in scientific writing should be an essential feature of a scientist's training. Research cannot be considered complete until its findings are presented in the literature. Thus if the community (scientific, field-naturalist, political, etc.) is to profit from observations and results of research, these must be published.

Journals serve to varying degrees both writer and reader by preserving permanently valuable information that has advanced knowledge. Ideally authors should publish only after they have found a convincing answer to an important question. Publication is often justified, however, when a partial answer is available and a complete answer will be a long time coming. Through the years *The Canadian Field-Naturalist* has served as an important medium for the communication of information regarding the natural sciences in Canada.

Unfortunately, a ritualistic mode of expression has grown up among some scientists. But scientific writing does not need to be pretentious, verbose, or dull. It should be clear, concise, simple, precise, logical, and *interesting*. Authors who rely on overworked fancy words and technical jargon when meanings can usually be conveyed more clearly in the natural idiom are trying to impress the reader rather than express ideas. In so doing, they are inhibiting rather than promoting the exchange of ideas beyond a very specialized group. It is particularly important that papers published in a general journal such as *The Canadian Field-Naturalist* should be direct and clear about stating the purpose of their research, the conclusions drawn, and the significance of these conclusions. By avoiding woolly thinking, overworked 'in' and fancy words, and by carrying the clear stream of a discussion through to logical conclusions, good communication results.

With the current expansion of the scientific literature, it should be obvious, but often isn't, that journals cannot publish everything a researcher has done; e.g., all extraneous matter and unnecessary data, detail, and discussion must be deleted. Furthermore, journals must avoid publishing variants of the same information on the same subject; we should report only what deserves reporting and do so only once.

In order to write clearly, simply, and precisely, authors must plan, organize, and think clearly. They should avoid ambiguity, obscure meanings, and the desire to create the impression of superior knowledge (opinion must be based on relevant facts). We know that the language of scientists has sometimes been highly inflated (it sounds impressive but what does it mean?) but this pretentiousness merely distracts from the substance of a paper and deters communication. Before submitting a manuscript for publication to this journal, authors are advised to read the instructions to contributors, write a first draft and then revise it, ask friends and colleagues to appraise the paper, shelve the manuscript, and finally revise the manuscript again and polish the style. Too many first drafts are now submitted to editors. For the sake of simplicity and clarity authors are encouraged to use the active voice, verbs instead of abstract nouns, appropriate prepositions to break up noun clusters, and the concrete rather than the abstract. For example, one writes "Table 2 shows that. . ." instead of "It will be seen from consideration of the data in Table 2 that. . ."; or "The dates of several observations are in doubt" rather than "It should be mentioned that in the case of several observations there is room for considerable doubt concerning the correctness of the dates on which they were made." Who can discern the meaning amongst the jargon in the sentence "Insufficient data are at present available to completely negate the possibility that removal of the above-mentioned species from the population is not a factor of importance"? Many further examples of good writing that replace verbose passages full of jargon with words that are simple, direct, and concise are given in the CBE Style Manual. In a natural history journal, moreover, we must pay particular attention that modern statistics, albeit a useful tool, does not subordinate the biology.

Although H. G. Wells' statement that "No passion in the world, no love or hate, is equal to the passion to change someone else's draft" may indeed be true, the reviewing system, despite its deficiencies, is important to maintain standards. The suggestions and criticisms of the reviewer can often be accepted by authors with advantage and with gratitude. Only rarely does an author rebut the referees' comments. All authors, of course, hope that their papers will be accepted as submitted and published promptly. A blue pencil sometimes causes a deep wound. Occasionally authors finger an innocent referee as their enemy. Authors who are requested to condense their manuscripts but who return them virtually unchanged, although the number of pages is shortened by using narrower margins and finer type, do not fool us. When asked to revise a manuscript, an author may at first be sensitive and annoyed but most will eventually become objective and consider the merits of the referees' points. Generally authors do the revisions and thus produce better papers.

As many readers of *The Canadian Field-Naturalist* have a broad interest in the natural sciences, and as the work of specialists often becomes more important when interpreted for generalists, we must endeavor to keep all the lines of communication open. I conclude with the thought that manuscripts submitted to scientific journals should represent the best efforts of which authors are capable if the goal of effective communication with readers is to be achieved.

LORRAINE C. SMITH

Autumn Migration of Shorebirds in the Kingston Area of Ontario, 1964–1974

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[2]Department of Biology, Queen's University, Kingston, Ontario K7L 3N6

Weir, R. D. and F. Cooke. 1976. Autumn migration of shorebirds in the Kingston area of Ontario, 1964–1974. Canadian Field-Naturalist 90(2): 103–113.

Abstract. We describe the timing and relative abundance of 25 species of migrating shorebirds seen in autumn in the Kingston area of Ontario between 1964 and 1974. Weekly numbers for 12 species are presented and the characteristic patterns of the birds' appearance in the area are correlated with plumage details as recorded in the field. Differential age migration, with adults preceding immatures, is suggested in seven of the common species and probably in two others. Differential sex migration occurs in the only species with an observed sexual size dimorphism that is visible from field observations.

Systematic censusing of an area over several years can provide useful quantitative and qualitative information on migration. Studies on shorebirds have been carried out both in Europe (Nisbet 1957; Meltofte et al. 1973; Wilson 1973; Wolff 1973) and in North America. The North American studies are confined mainly to the Atlantic and Pacific coast areas (Longstreet 1934; Urner and Storer 1949; Storer 1951; Dyke 1955; McNiel and Cadieux 1972; McNeil and Burton 1973). Notes were published on shorebird migration from two inland areas, Montreal (Terrill 1951) and Kingston–Ottawa (Erskine 1955), although these were apparently unsystematic studies. More recently Oring and Davis (1966) published the first study from the central United States; no comparable data are available from areas eastward from the western Great Lakes to Montreal. Such studies on and near the shores of the Great Lakes are therefore of interest.

The purpose of our study was to document the timing and abundance of shorebirds seen at the eastern end of Lake Ontario, in the Kingston area; to stimulate similar documentation from other areas, especially on the Great Lakes; and to attempt to explain the patterns of migration in terms of the life histories of some of the species.

Study Area and Methods

The study area is defined by a circle with a 48-km (30-mi) radius with its center at Kingston Ontario (45° 12′ N, 76°29′ W). Figure 1 shows the following areas covered in the study: the shoreline on Lake Ontario including Prince Edward Point (43°57′ N, 76°54′ W), the large islands, Wolfe Island and Amherst Island, and the St. Lawrence River. The shores along Lake Ontario and of the islands are mostly rocky with pebbly beaches or low shelves of flat limestone rock. Away from these shores, areas visited were muddy flats of rivers, partially flooded fields, and sewage lagoons. A complete and detailed description of the area is given by Quilliam (1965).

The data for the weekly number were collected over an 11-yr period by F. Cooke (1964–1969) and R. D. Weir (1969–1974). Detailed plumage notes, size variations within species, and behavior were carefully recorded by R. D. Weir. The five local breeding species of shorebirds are excluded: Killdeer (*Charadrius vociferus*), American Woodcock (*Philohela minor*), Common Snipe (*Capella gallinago*), Upland Sandpiper (*Bartramia longicauda*), and Spotted Sandpiper (*Actitis macularia*).

The southward migration period was divided into 21 weekly periods and all birds seen in each week in all years combined were recorded. For sites visited once per week, each observation is recorded. When sites were visited more than once per week, the highest daily count for a species was recorded for that site during that week. The choice of weekly periods is an arbitrary one based on convenience. Records from

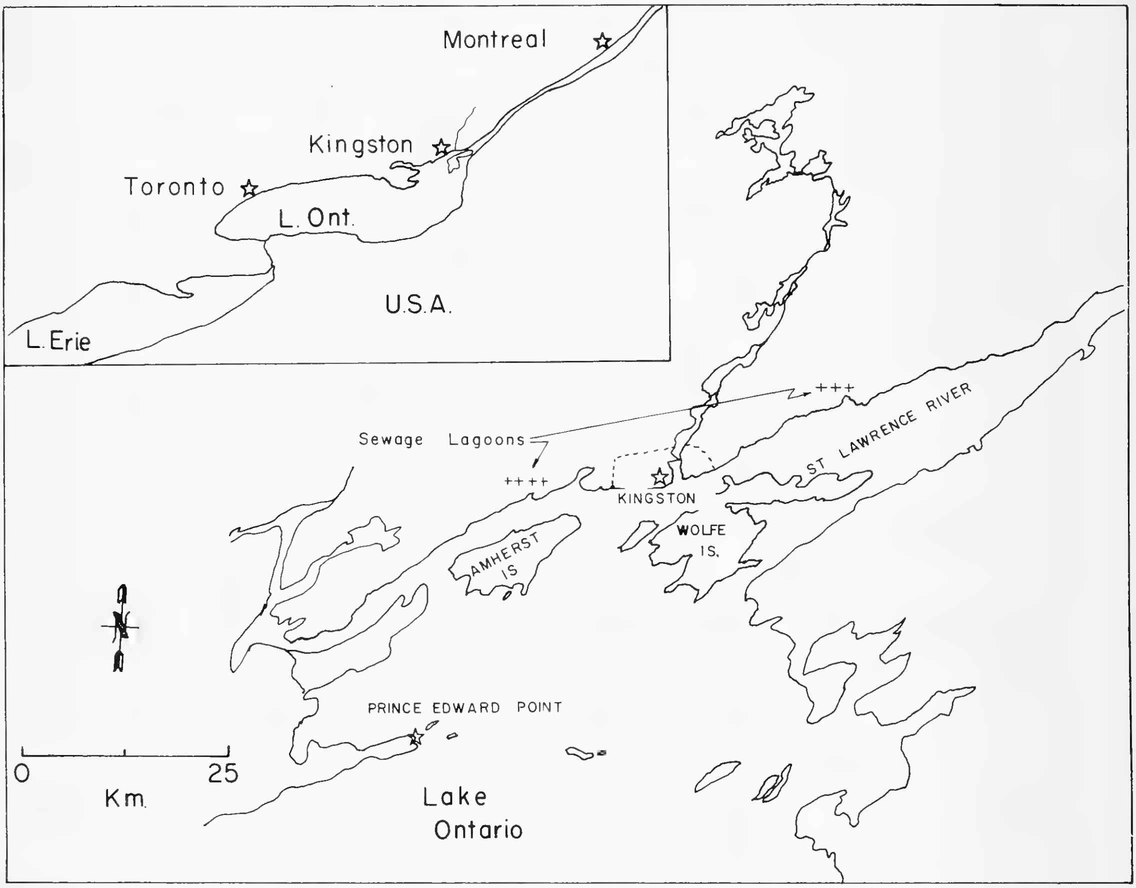

FIGURE 1. Study area in the Kingston area of Ontario.

the files of the Kingston Field Naturalists (KFN) have been included with those of the present authors in compiling the totals for 14 species (asterisked in Table 2) which are uncommon to rare; the inclusion of these extra data was felt worthwhile since KFN members report all of their sightings of these species so that they are not biased toward early and late dates. In most cases these KFN records amount to not more than 10% of the totals for each species.

Our techniques used for plumage identification were guided by the outline and details given by Palmer (1967). The pattern of plumage succession in shorebirds consists of a juvenile dress followed by Basic (winter) and Alternate (summer) plumages, the last two repeated with variations until the birds were fully mature at up to an age of 2 or 3 yrs. In many cases, it is possible by careful field observation to separate birds of the year from breeders. In a few cases it is possible to designate the sex from field observations alone.

The number of trips made in each year of the last five years to various localities is summarized in Table 1. For the entire autumn migration season in some years, some sites were dried up, while during times of abnormally high lake levels other sites were flooded out. This accounts for most of the variation in Table 1. With rare exceptions, several sites were visited at least once a week. Observation periods were 1 to 2 h per site, usually in the morning and evening, but rarely in the afternoon.

At the first three localities in Table 1, most shorebirds were located along the flat limestone shorelines where algae had accumulated. By contrast, in the remaining three localities, most shorebirds were seen feeding in muddy lagoons or river-sides where limestone was absent. The relative frequency of visits to shoreline versus muddy localities in the years 1970–1974 was tested by comparing numbers of visits to each type of habitat using a contingency χ^2 test. No significant differences were noted ($\chi^2 = 4.95$ and $0.5 > P > 0.25$). It appears therefore that although the areas visited were not identical the proportions of each type of locality visited did not differ significantly from year to year. The fact that similar habitat coverage was obtained each year does not indicate how that coverage was distributed. Although these data are not presented in Table 1, there was no major change in the relative frequency of visits to the two major habitat types during the course of any season.

Results

Table 2 shows the data collected for the 25 migrant species of shorebirds in the Kingston area. Species such as Baird's Sandpiper, Stilt Sandpiper, and Purple Sandpiper proved to be more common in the Kingston area than was believed prior to this study, and Western Sandpiper and Red Phalarope had not been previously recorded with certainty (Quilliam 1965). We are aware of the fact that the Western Sandpiper is one of the most difficult shorebirds to identify in eastern Canada (Ouellet et al. 1973) and only those individuals which showed substantially longer and down-curved bills combined with the presence of russet-colored dorsal feathers were included.

Examination of the histograms of weekly numbers for the 12 species for which adequate sample sizes are available (Figure 2) suggests characteristic patterns of appearance. Although no rigorous mathematical definition of a peak has been attempted, it appears that four of the species exhibit clear-cut dual peaks: Semipalmated Plover and Lesser Yellowlegs, Greater Yellowlegs and Semipalmated Sandpiper. Least Sandpiper may also have a dual peak. Three species are characterized by a single peak: dowitcher (sp.), White-rumped Sandpiper, and Dunlin. Additionally, three species mentioned in Table 2 but not shown in Figure 2 appear to have a single peak; these are Ruddy Turnstone, Solitary Sandpiper, and Purple Sandpiper.

In some cases it is difficult to comprehend the pattern. This is partly because of the tendency of shorebirds to fly in flocks. Migrants such as Golden Plover and Sanderling apparently pass through in several waves and any peaks that occur may be masked by this flocking tendency. The Pectoral Sandpiper and Black-bellied Plover appear to have three peaks.

It was noted above that fluctuating water levels, weather, and variation in feeding conditions were some of the factors that varied from year to year. Also conditions on the breeding ground sometimes differ markedly between years. Given this variation, it may be unwise to pool results over a 10-yr period and conceivably the patterns noted above could be artifacts of our pooling the data. To test for this possibility, histograms showing annual patterns of appear-

TABLE 1—Number of counts at various localities

Locality	1970–71	1971–72	1972–73	1973–74	1974–75	Totals
Prince Edward Point	8	8	15	14	11	56
Wolfe Island	6	5	4	1	2	18
Amherst Island	8	6	1	12	7	34
Cataraqui River	27	12	7	11	1	58
Elginburg Swamp and sewage lagoons	21	8	15	14	25	83
Little Cataraqui Creek	21	25	12	17	15	90
Totals	91	64	54	69	61	339

TABLE 2—Weekly numbers of autumn migrating shorebirds from 1964–1974 inclusive

Species	July				August					September				October				November				Total
	5	12	19	26	2	9	16	23	30	6	13	20	27	4	11	18	25	1	8	15	22	
Semipalmated Plover, *Charadrius semipalmatus*		—	3	11	42	22	13	38	69	59	34	12	13	3	1	3	3	—	2	—	—	328
American Golden Plover, *Pluvialis dominica*	—	—	—	—	—	1	19	59	90	51	30	49	20	36	3	33	—	—	3	2		396
Black-bellied Plover, *Pluvialis squatarola*	—	—	—	—	3	8	118	102	27	41	60	41	47	20	33	89	75	88	76	3	—	831
Ruddy Turnstone, *Arenaria interpres*	—	—	—	5	6	7	10	8	21	14	20	1	1		—	3	1	—	1	—	—	98
Whimbrel, *Numenius phaeopus**	—	—	—	—	1	—	3	1	—	—	3	—	—	—	—	—	—	—	—	—	—	8
Solitary Sandpiper, *Tringa solitaria**	—	—	2	6	16	15	20	7	10	7	4	6	2	1	—	—	—	—	—	—	—	96
Greater Yellowlegs, *Tringa melanoleucus*	—	—	—	13	2	1	3	2	11	22	5	6	5	37	19	25	22	14	8	—	—	195
Lesser Yellowlegs, *Tringa flavipes*	—	6	30	75	188	104	99	59	86	136	70	63	29	28	22	20	5	4	2	—	—	1026
Red Knot, *Calidris canutus**	—	—	—	—	—	—	4	14	5	1	1	—	1	3	—	—	—	—	—	—	—	29
Purple Sandpiper, *Calidris maritima**	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	2	11	25	1	40
Pectoral Sandpiper, *Calidris melanotos*	—		8	24	27	22	11	7	17	36	48	36	52	85	118	91	58	19	1	—	1	661
White-rumped Sandpiper, *Calidris fuscicollis**	—	—	1	—	2	—	1	—	—	1	—	3	1	1	15	36	87	29	15	—	—	192

Baird's Sandpiper, *Calidris bairdii**	—	—	—	—	2	4	2	6	11	5	—	8	—	—	3	6	—	—	—	—	—	47
Least Sandpiper, *Calidris minutilla*	—	20	11	30	74	95	69	147	146	91	61	31	5	16	8	1	1	1	—	—	—	807
Dunlin, *Calidris alpina*	—	—	—	—	—	—	—	2	4	2	2	10	11	77	290	593	912	280	314	69	2	2568
Semipalmated Sandpiper, *Calidris pusillus*	—	6	83	49	292	119	39	239	293	160	51	9	14	18	19	4	2	1	—	—	—	1398
Western Sandpiper, *Calidris mauri**	—	—	—	—	—	1	1	1	2	—	—	—	—	—	—	—	—	—	—	—	—	5
Sanderling, *Calidris alba*	—	—	—	1	35	3	16	12	31	96	68	1	1	—	16	—	10	—	5	—	—	295
Dowitcher (sp), *Limnodromus* (sp)*	1	1	6	10	11	22	48	31	41	19	2	6	1	7	2	2	—	1	—	—	—	211
Stilt Sandpiper, *Micropalama himantopus**	—	—	2	4	3	4	3	2	5	2	2	4	2	1	—	1	1	1	—	—	—	37
Buff-breasted Sandpiper, *Tryngites subruficollis**	—	—	—	—	—	—	—	3	3	1	1	1	—	—	—	—	—	—	—	—	—	9
Hudsonian Godwit, *Limosa haemastica**	—	—	—	—	—	—	3	—	—	—	—	—	—	2	4	—	—	—	—	—	—	9
Red Phalarope, *Phalaropus fulicarius**	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	2	—	3
Wilson's Phalarope, *Steganopus tricolor**	—	—	3	2	6	5	2	1	2	—	—	—	—	—	—	—	—	—	—	—	—	21
Northern Phalarope, *Lobipes lobatus**	—	—	—	—	—	—	1	—	3	12	7	1	—	1	—	3	—	—	1	—	—	29
Totals	1	33	149	230	710	434	485	741	877	756	469	288	205	337	553	910	1177	446	439	101	4	9345
Numbers of species	1	4	10	12	16	17	21	20	20	19	18	18	16	17	14	15	12	11	12	5	3	25

*Includes Kingston Field Naturalists' records.

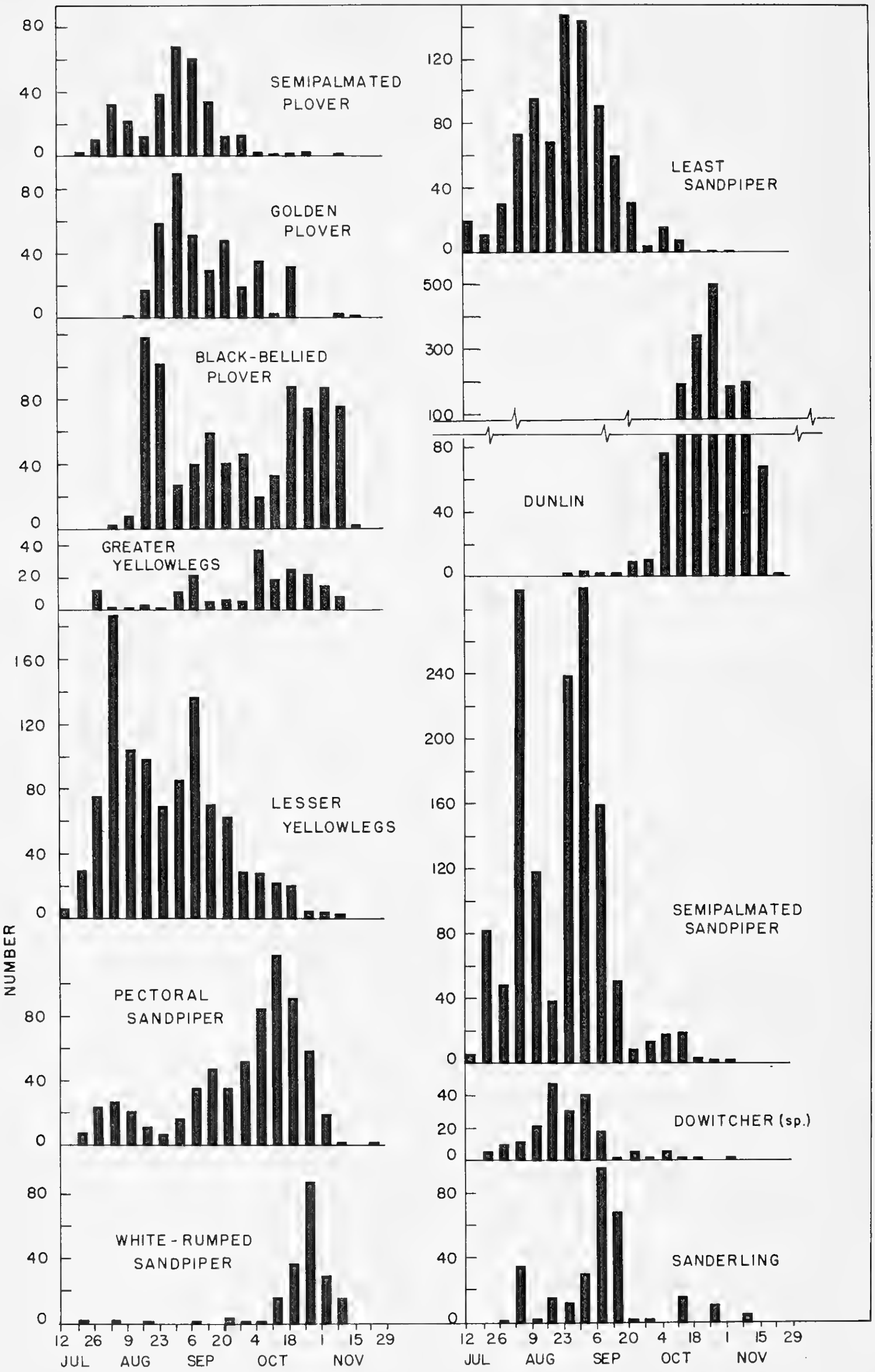

FIGURE 2. Weekly numbers of 12 species of migrating shorebirds, 1964–1974 inclusive.

ance were constructed for these species where sample sizes were sufficient. These are shown in Figure 3. In the case of all three species the patterns deduced from the composite histogram in Figure 2 can be detected in most of the individual year's data. It is interesting to note that a possible exception occurred in 1972 where only a single peak is evident. This coincides with the disastrous arctic breeding conditions in that year resulting from exceptionally late snowfalls and lack of available nesting sites (S. D. MacDonald, High Arctic Research Station at Bathurst Island, personal communication).

Where possible our observations included

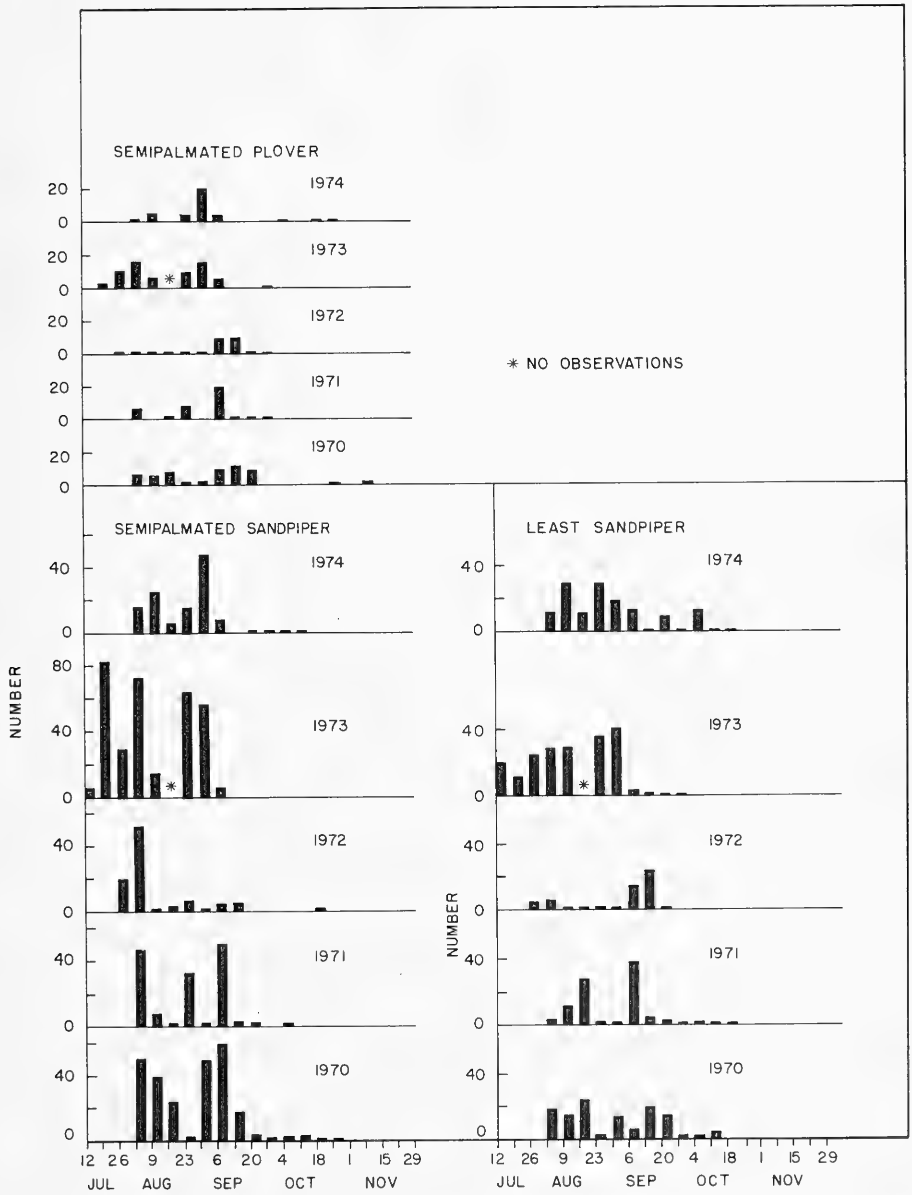

FIGURE 3. Weekly numbers of three species of migrating shorebirds in each of the years 1970–1974.

information on plumage variation; this allows us in some cases to assess the age (and in one case the sex) composition of the peaks. The capture or collection of birds would have allowed this to be done with much more precision, as was achieved for example with Least and Semipalmated Sandpipers by Page and Bradstreet (1968). Our field observations, however, point the way for more precise studies on migrating shorebirds.

Details of the 12 species (see Figure 2) follow.

SEMIPALMATED PLOVER, *Charadrius semipalmatus*. Peaks occurred in early August and early September. Our records indicate that early August peak is due to returning adults. Immatures, identified by the broken breast band, account for many of those birds in the September peak. The earliest record of an immature plumaged bird is 31 August. Bent (1929) reports that in Massachusetts adults arrive earlier than young birds.

GOLDEN PLOVER, *Pluvialis dominica*. We were seldom able to identify young birds with any certainty. Some of the early flocks consisted of birds entirely in definitive alternate plumage with only partial signs of molt. As the season progressed, flocks were made up of adults in varying stages of molt.

BLACK-BELLIED PLOVER, *Pluvialis squatarola*. Birds of the first peak are adults in breeding plumage. September and October flocks comprise both immature and birds with adult plumage. The trimodal peak detected in our data is similar to that reported by Urner and Storer (1949). Dates of their peaks are late August, mid-October, and December. The reasons for the triple peak are unclear.

GREATER YELLOWLEGS, *Tringa melanoleucus*. The early September peak comprised birds with adult plumage. The second peak contained many immature birds which were dusky on the throat and upper breast. The earlier birds were much more vocal than the later ones.

LESSER YELLOWLEGS, *Tringa flavipes*. The early August peak consisted of birds in adult plumage. The later peak contained adults and immatures. As in the previous species the earlier birds were more vocal.

PECTORAL SANDPIPER, *Calidris melanotos*. Size is difficult to assess in field situations, but birds in the late July – early August peak were mainly large birds, probably males. Smaller birds began to appear in early August, with a dramatic increase in the proportion of smaller birds in early September. This probably signifies the arrival of females. In October most of the flocks were composed of smaller birds. The trimodal peak appears then to result from a differential sex migration with males appearing in the Kingston area considerably earlier than the females.

WHITE-RUMPED SANDPIPER, *Calidris fuscicollis*. The few early records that we have are of adults in definitive alternate plumage, perhaps undergoing some molt. The late peak comprised basic plumaged birds, but it was impossible for us to differentiate adults from immatures. The contrast is striking between the timing of this species through Kingston compared with that of the Pectoral Sandpiper. The males of both species take no part in the incubation and raising of young (Parmelee et al. 1968; Pitelka et al. 1974). In view of this common factor in their breeding cycle, one might expect the pattern of early peaks in the Pectoral Sandpiper migration to repeat itself in the White-rumped Sandpiper. Such is not the case; this therefore suggests either a different migration route or that adults and young migrate simultaneously through Kingston late in the season (see discussion).

LEAST SANDPIPER, *Calidris minutilla*. No plumage details of this species were recorded. Our histogram is consistent with the more detailed examination of banded birds carried out at Long Point, Ontario by Page and Bradstreet (1968). They showed that the early peak consisted almost entirely of adult birds and the later peak predominantly of immatures.

DUNLIN, *Calidris alpina*. This is our commonest migrant shorebird and one of the latest to arrive. The single peak contains adult and immature plumaged birds, the latter identified by the more extensive streaking on the breast.

SEMIPALMATED SANDPIPER, *Calidris pusillus*. Birds in immature plumage with a buffy cast appear in the later peak but not in the early one. This is consistent with the findings of Page and Bradstreet (1968) and of Page and Middleton (1972).

DOWITCHER (sp.), *Limnodromus* (sp). The later birds were both in adult and immature plumages. Since this superspecies consists of two species, one of which has three subspecies, it is difficult to draw meaningful conclusions with our small sample of observations without collecting or capturing birds. It is not possible to compare our findings with the extensive study of Jehl (1963) on the New Jersey coast or with those of McNeil and Cadieux (1972) and McNeil and Burton (1973) on the Magdalen Islands.

SANDERLING, *Calidris alba*. We did not differentiate the ages of this species. No birds were in breeding plumage.

Discussion

Ideally, a study of migrant populations should attempt to correlate the observations of migrant birds with observations at their breeding or wintering grounds. There are, however, many factors that determine when or whether birds will actually appear at a particular location during migration. Important factors influencing the timing of migration in breeding adults are the termination of breeding and the molt cycle. Differences may occur among shorebird species depending upon whether the post-breeding molt takes place on the breeding grounds before migration is started or in the wintering areas after migration is complete or whether it occurs en route. Their appearance at a specific location is influenced by food availability and weather conditions there and, at earlier stages of migration, the direction of prevailing wind, as well as breeding success. Pitfalls in interpretations are well summarized by Edelstrom (1972). Despite these pitfalls, a number of conclusions are possible.

Differential age migration, based on plumage observations, occurs in seven of the common species (Semipalmated and Black-bellied Plover; Lesser and Greater Yellowlegs; Pectoral, White-rumped, and Semipalmated Sandpiper; and dowitcher (sp.)) and probably in Golden Plover and Least Sandpiper. Our data support the findings of other workers that young-of-the-year arrive later than the adults.

Differential sex migration occurs in the Pectoral Sandpiper, the only species observed with a sexual size dimorphism visible from field observations. Adult males arrive in late July and are augmented by adult females in early September. The early arrival of the males is consistent with the findings of Pitelka (1959) who showed that incubation and brood rearing are carried out only by the females. The males leave the breeding areas soon after incubation has commenced.

Among the 12 species analyzed in detail in Figure 2, 10 arrive in late July or early August and migration occurs over a considerable period. The Dunlin and White-rumped Sandpiper, apart from the occasional early arrival, do not appear until October and remain in the Kingston area for a relatively short time.

An active molt is compatible with a slow and leisurely coastal flight rather than a long rapid overseas journey (Holmes 1966b). Our data on Golden and Black-bellied Plover is consistent with this conclusion. An active molt also appears to be present with Greater and Lesser Yellowlegs, Least and Semipalmated Sandpipers, and dowitchers. McNeil and Cadieux (1972) have shown that in the Magdalen Islands during July and August, these species are in varying stages of post-nuptial molt. For all these species, there are some individuals who suppress the post-nuptial molt to enable a long overseas journey to be made. McNeil (1970) has documented arrivals from North America into Venezuela during the period August to October and there the birds show varying amounts of nuptial plumage. The fact that some of these species are widely distributed in winter from the Gulf Coast of the United States to areas in South America (e.g., Least and Semipalmated Sandpipers, Greater and Lesser Yellowlegs) leads to the suggestion that those southbound migrants using the coastal or inland North American routes might winter in the southern United States, Central America, Greater Antilles, and Western South America whereas migrants undertaking an overseas route from Atlantic Canada and New England might winter in the Lesser Antilles and eastern South America (McNeil and Cadieux 1972).

In the case of Dunlin, the extensive studies by Holmes (1966a, b, c, 1971) on the North American races in Alaska show that their molt is completed before the southward migration begins. Although these data are not currently published for the race which migrates through Kingston, it seems probable that their late arrival here is a result of the molt. Our field observations bear this out and netting begun by us in the autumn of 1975 shows that Dunlin have completed their post-breeding molt by the time they arrive in Kingston at the end of September. Dunlin, particularly young birds, remain common in the Churchill, Manitoba area into early September but where the birds sojourn prior to their southward migration is unknown (Jehl and Smith 1970). It is interesting to note that the movement of adult and immature Dunlin in Alaska from the breeding areas to the western

Alaska coast where they apparently remain for most of September, occurs between July and early September. Then in late September and in October, they fly rapidly to the coast of California where about equal numbers of adults and immatures arrive together (Holmes 1966a). There may be a comparable situation in their late passage through Kingston, presumably on their way to the Atlantic coast. The only existing specimen for the Kingston area (National Museum of Canada, Ottawa, NMC 62530) is a *Calidris alpina pacifica*, taken on 10 November 1974. Whether the race *C.a. hudsonia* (Todd), which is not presently recognized by the AOU, migrates through Kingston is unknown (see Todd 1953; MacLean and Holmes 1971).

The latest report for White-rumped Sandpiper for the Churchill area is 23 August (Taverner and Sutton 1934). Bent (1927) reports the main flight of adults at Cape Cod in September and of young birds in October. Parmelee et al. (1968) note that juveniles leave the breeding areas by early August but do not move far away. Our late peak of this species may consist of juvenile birds in view of the fact that the adult White-rumped Sandpiper peaks in the Magdalen Islands in August (McNeil and Cadieux 1972) and some arrive in Venezuela in August while still in partial nuptial plumage. It is probable that the main fall migration of White-rumped Sandpiper misses Kingston, as the birds use the trans-oceanic route from Atlantic Coast and New England to South America and the West Indies (Palmer 1967). This seems to be a clear-cut example of the elliptical migration pattern of shorebirds discussed by McNeil and Cadieux (1972).

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Literature Cited

Bent, A. C. 1927. Life histories of North American shorebirds. Part 1. United States National Museum Bulletin, Number 142. 359 pp.

Bent, A. C. 1929. Life histories of North American shorebirds. Part 2. United States National Museum Bulletin, Number 146. 340 pp.

Dyke, S. H. 1955. Shorebirds on the Conejohela Flats: A 5-year summary. Atlantic Naturalist 10: 260–268.

Edelstrom, C. 1972. The visible migration of birds at Ottenby, Sweden. Var Fagelvarld, Supplement 7. 360 pp.

Erskine, A. J. 1955. Notes on fall shorebird migrations. Blue Bill 2: 24–26.

Holmes, R. T. 1966a. Breeding ecology and annual cycle adaptations of the Red-backed Sandpiper (*Calidris alpina*) in northern Alaska. Condor 68: 3–46.

Holmes, R. T. 1966b. Moult cycle of the Red-backed Sandpiper (*Calidris alpina*) in western North America. Auk 83: 517–533.

Holmes, R. T. 1966c. Feeding ecology of the Red-backed Sandpiper (*Calidris alpina*) in Arctic Alaska. Ecology 47: 32–45.

Holmes, R. T. 1971. Latitudinal differences in the breeding and moult schedules of Alaskan Red-backed Sandpipers (*Calidris alpina).* Condor 73: 93–99.

Jehl, J. R. 1963. An investigation of fall migrating dowitchers in New Jersey. Wilson Bulletin 75: 250–261.

Jehl, J. R. and **B. A. Smith.** 1970. Birds of the Churchill Region, Manitoba. Manitoba Museum of Man and Nature, Winnipeg, Special Publication # 1. 87 pp.

Longstreet, A. J. 1934. Five-year shore bird census at Daytona Beach, Florida. Auk 51: 97–99.

MacLean, S. F. and **R. T. Holmes.** 1971. Bill lengths, wintering areas and taxonomy of North American Dunlins. Auk 88: 893–901.

McNeil, R. 1970. Hivernage et estivage d'oiseaux aqatiques nord-américains dans le nord-est du Venezuela (mue, accumulation de graisse, capacité de vol et routes de migration). Oiseau et la Revue Française d'Ornithologie 40: 185–302.

McNeil, R. and **J. Burton.** 1973. Dispersal of some southbound migrating North American shorebirds away from the Magdalen Islands, Gulf of St. Lawrence, and Sable Island, Nova Scotia. Caribbean Journal of Science 13: 257–278.

McNeil, R. and **F. Cadieux.** 1972. Fat content and flight range capabilities of some adult spring and fall migrant North American shorebirds in relation to migration routes on the Atlantic Coast. Naturaliste Canadien 99: 589–606.

Meltofte, H., S. Pihl, and **B. Sorensen.** 1973. Autumn migrations of waders at Blavandshuk, W. Jutland 1963–71. Dansk Ornithologisk Foren Tidsskrift: 63–69.

Nisbet, I. C. T. 1957. Wader migration at Cambridge sewage farm. Bird Study 4: 131–148.

Oring, L. W. and **W. M. Davis.** 1966. Shorebird migration at Norman, Oklahoma: 1961–63. Wilson Bulletin 78: 166–174.

Ouellet, H., R. McNeil, and **J. Burton.** 1973. The Western Sandpiper in Quebec and the Maritime Provinces. Canadian Field-Naturalist 87: 291–300.

Page, G. and **M. Bradstreet.** 1968. Size and composition of a fall population of Least and Semipalmated Sandpipers at Long Point, Ontario. Ontario Bird Banding 4: 82 88.

Page, G. and **A. L. A. Middleton.** 1972. Autumn fat in Semipalmated Sandpipers. Bird Banding 43: 85 96.

Palmer, R. S. 1967. Species accounts. *In* The shorebirds of North America. *Edited by* G. D. Stout. Viking Press, New York. 270 pp.

Parmelee, D. F., D. W. Greiner, and **W. D. Graul.** 1968. Summer schedule and breeding biology of the White-rumped Sandpiper in the central Canadian Arctic. Wilson Bulletin 80: 5 29.

Pitelka, F. A. 1959. Numbers, breeding schedule and territoriality in Pectoral Sandpipers of Northern Alaska. Condor 61: 233 264.

Pitelka, F. A., R. T. Holmes, and **S. F. MacLean.** 1974. Ecology and evolution of social organization in Arctic Sandpipers. American Zoologist 14: 185 204.

Quilliam, H. R. 1965. History of the birds of Kingston, Ontario. Published privately. 212 pp. Second edition 1973, 209 pp.

Storer, R. W. 1951. The seasonal occurrence of shorebirds on Bay Farm Island, Almeda County, California. Condor 53: 186 193.

Taverner, P. A. and **G. M. Sutton.** 1934. Birds of Churchill, Manitoba. Annals of the Carnegie Museum 23: 1 83.

Terrill, L. M. 1951. Shorebird migration at Montreal. Canadian Field-Naturalist 65: 87 98.

Todd, W. E. C. 1953. A taxonomic study of the American Dunlin, *Erolia alpina* subspp. Journal of the Washington Academy of Science 43: 85 88.

Urner, C. A. and **R. W. Storer.** 1949. The distribution and abundance of shorebirds on the north and central New Jersey Coast 1928 1938. Auk 66: 177 194.

Wilson, J. 1973. Wader populations of Morecambe Bay, Lancashire. Bird Study 20: 9 23.

Wolff, W. J. 1973. Results of five years of wader counts on the Island of Schouwen. Limosa 46: 21-41.

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Additional Bird Observations on the West Mirage Islands, Great Slave Lake, Northwest Territories

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Trauger, David L. and Robert G. Bromley. 1976. Additional bird observations on the West Mirage Islands, Great Slave Lake, Northwest Territories. Canadian Field-Naturalist 90(2): 144–148.

Abstract. An annual survey of breeding birds was conducted between 1969 and 1973 on the West Mirage Islands, Great Slave Lake, Northwest Territories. Forty-five species of birds were observed, of which 26 were confirmed or suspected of nesting and rearing young; the remainder were summer transients or accidental visitants. Fourteen species were observed that had not been previously recorded. An estimated 1500 birds were associated with the islands during summer. The most abundant species were the California Gull, Arctic Tern, Savannah Sparrow, Herring Gull, and Greater Scaup. Designation of the area as an avian sanctuary is proposed to protect the unique avifauna and habitats from human encroachment and exploitation.

In 1968, Weller et al. (1969) inventoried the breeding birds of the West Mirage Islands, Great Slave Lake, Northwest Territories. They listed 35 species recently occurring on the islands, of which 17 species were nesting or caring for young. Subsequent to this initial study, the West Mirage Islands were designated as a "Natural Area" in Canada's International Biological Program (La Roi and Babb 1974).

From 1969 through 1973 we conducted an annual survey of breeding birds on the West Mirage Islands in conjunction with studies of Greater Scaup (*Aythya marila*). This paper summarizes additional observations of birds occurring on these islands and incorporates notes collected by the late William L. McDonald over the past five decades. McDonald, whose avocation was bird study, was a geological consultant residing in Yellowknife, Northwest Territories.

The West Mirage Islands (62°16′ N, 114°29′ W) consist of 97 rocky islets and islands in Great Slave Lake. This discrete insular complex is located approximately 13 mi (21 km) SSW of Yellowknife. Weller et al. (1969) presented a detailed description of the avian habitats found on the islands. Ecological characteristics of the area are also described in the IBP Directory (La Roi and Babb 1974).

Our observations were recorded while we were searching for duck nests on the islands in late June, July, and early August (Figure 1). Two trips were made to the islands each year during 1969, 1970, and 1971. The islands were visited once in 1972 and 1973. The inclusive dates of our visits were 29 June and 10–13 July 1969, 3–4 July and 17–18 July 1970, 23–24 June and 13 August 1971, 22 July 1972, and 4–6 July 1973. Two to five observers were involved in the bird surveys. A total of 48 man-days was expended during the eight trips.

Common and scientific names are listed in Table 1 for all species observed on the West Mirage Islands. Nomenclature follows the American Ornithologists' Union Check-list (1957) and incorporates recent taxonomic revisions (American Ornithologists' Union 1973). The following annotated list presents information on the principal species recorded by us from 1969 through 1973. Significant unpublished observations by McDonald between 1920 and 1970 are also included.

Species Accounts

COMMON LOON. *Gavia immer.* This species was frequently observed swimming and feeding in close proximity to the islands. One to three pairs were often seen in midsummer, but no evidence of nesting was found. Perhaps these loons represented nonbreeders because flocks of four to six birds have been noted. Common Loons were fairly common breeding birds on mainland lakes north and east of Yellowknife.

RED-THROATED LOON. *Gavia stellata.* A breeding population of four to six pairs was regularly observed on the islands. In 1969, two nests were found with one egg on 29 June and two eggs on 12 July. Two pairs, each with one young, were also observed on 11 July. In 1973, five pairs were counted within the island complex during a visit, 4–5 July. Two pairs were sighted with downy young; one had two young and the other had one young. A third pair was observed near a nest containing two pipped eggs. McDonald found three nests each with two eggs on 24 June 1956. Weller et al. (1969) found two nests each with two eggs in 1968. Clutches contained one to two eggs and averaged 1.7 for the 17 nests. Between 1969 and 1973, eight pairs were accompanied by nine flightless young (mean 1.1 young per pair).

FIGURE 1. Observers searched the islands and recorded information on birds and nests. Note the rugged terrain and abrupt shorelines which provided a diversity of rock, pool, tundra, wood, and lake habitats.

CANADA GOOSE. *Branta canadensis.* McDonald once observed a pair with three goslings here but noted this species was a rare breeding bird among the islands of Great Slave Lake. Canada Geese regularly nest west of the lake and north of the MacKenzie River. A pair with young was observed on Kam Lake, 1.5 mi (2.4 km) southwest of Yellowknife, by local residents in 1972.

MALLARD. *Anas platyrhynchos.* Lone females have been sighted during several visits in late June and early July. A pair was observed on 5 July 1973. McDonald considered this species to be an occasional nesting bird. Weller et al. (1969) found one nest.

PINTAIL. *Anas acuta.* One to three pairs regularly nested on the islands and transients, mostly females, were frequently observed. In 1968, Weller et al. (1969) found two nests with five and six eggs. A nest with seven eggs was found on 23 June 1971, and a female with five Ia ducklings was observed on 18 July 1970. A total of 4 pairs, 2 males, and 16 females (6♂♂:20♀♀) were counted on the islands during various visits (1969–1973). This species was observed most often on the smaller, outer islands which were more barren.

GREEN-WINGED TEAL. *Anas crecca carolinensis.* A breeding population of three to five pairs regularly occurred on the larger, more wooded interior islands of the complex. Adults were recorded on every visit; nine males and five females were counted in 1973. Weller et al. (1969) found one nest and sighted six adults in 1968. A female with five IIa ducklings was observed on 17 July 1970, and another female with seven III ducklings was sighted on 22 July 1972. Both broods were found on small interior pools of the larger islands. On 4 July 1973, a female was flushed from a nest containing six eggs.

AMERICAN WIGEON. *Anas americana.* One pair exhibiting territorial behavior was observed circling an island during a nest search on 4 July 1973. No nest was found and no previous nesting is known. This species may be an infrequent visitor or rare breeder.

GREATER SCAUP. *Aythya marila.* This species was one of the most abundant breeding birds and the most numerous breeding duck. Weller et al. (1969) reported on clutch sizes, nest characteristics, and interspecific relationships of 40 nests found during their 1968 survey. Trauger and Bromley (unpublished data) recently summarized additional data obtained from more intensive studies of Greater Scaup between 1969 and 1973. Breeding populations ranged from 50 to 75 pairs, depending on weather conditions and seasonal phenology. A total of 123 nests was found; clutches ranged

TABLE 1—Birds observed on the West Mirage Islands, Great Slave Lake, Northwest Territories

Species	This study	Weller et al. (1969)	McDonald
Common Loon (*Gavia immer*)	O[1]	O	O
Yellow-billed Loon (*Gavia adamsii*)	—	O	O
Red-throated Loon (*Gavia stellata*)	N[2]	N	N
Canada Goose (*Branta canadensis*)	—	—	N
Mallard (*Anas platyrhynchos*)	N	N	N
Pintail (*Anas acuta*)	N	N	N
Green-winged Teal (*Anas crecca carolinensis*)	N	N	N
American Wigeon (*Anas americana*)	O	—	—
Greater Scaup (*Aythya marila*)	N	N	N
Lesser Scaup (*Aythya affinis*)	—	E[3]	N
Common Goldeneye (*Bucephala clangula*)	O	O	O
Oldsquaw (*Clangula hyemalis*)	—	—	N
White-winged Scoter (*Melanitta deglandi*)	O	—	O
Surf Scoter (*Melanitta perspicillata*)	O	—	O
Black Scoter (*Melanitta nigra*)	—	O	—
Common Merganser (*Mergus merganser*)	O	O	O
Red-breasted Merganser (*Mergus serrator*)	N	N	N
Bald Eagle (*Haliaeetus leucocephalus*)	N	E	N
American Kestrel (*Falco sparverius*)	O	—	—
Willow Ptarmigan (*Lagopus lagopus*)	E	E	E
Sora (*Porzana carolina*)	—	O	—
American Coot (*Fulica americana*)	O	—	—
Semipalmated Plover (*Charadrius semipalmatus*)	—	—	O
Spotted Sandpiper (*Actitus macularia*)	O	O	N
Lesser Yellowlegs (*Tringa flavipes*)	O	—	—
Pectoral Sandpiper (*Calidris melanotos*)	O	—	O
White-rumped Sandpiper (*Calidris fuscicollis*)	O	—	—
Least Sandpiper (*Calidris minutilla*)	O	—	N
Semipalmated Sandpiper (*Calidris pusillus*)	O	O	O
Hudsonian Godwit (*Limosa haemastica*)	O	—	N
Northern Phalarope (*Lobipes lobatus*)	N	N	N
Pomarine Jaeger (*Stercorarius pomarinus*)	—	—	O
Parasitic Jaeger (*Stercorarius parasiticus*)	N	N	N
Herring Gull (*Larus argentatus*)	N	N	N
California Gull (*Larus californicus*)	N	N	N
Ring-billed Gull (*Larus delawarensis*)	—	—	O
Mew Gull (*Larus canus*)	N	N	N
Common Tern (*Sterna hirundo*)	—	—	N
Arctic Tern (*Sterna paradisaea*)	N	N	N
Caspian Tern (*Hydroprogne caspia*)	N	N	N
Short-eared Owl (*Asio flammeus*)	—	E	—
Yellow-shafted Flicker (*Colaptes auratus auratus*)	O	E	N
Yellow-bellied Sapsucker (*Sphyrapicus varius*)	E	—	—
Northern Three-toed Woodpecker (*Picoides tridactylus*)	—	E	—
Eastern Kingbird (*Tyrannus tyrannus*)	—	—	O
Eastern Phoebe (*Sayornis phoebe*)	-	—	O
Western Wood Pewee (*Contopus sordidulus*)	—	—	O
Barn Swallow (*Hirundo rustica*)	—	—	O
Common Raven (*Corvus corax*)	N	O	O
Brown Thrasher (*Toxostoma rufum*)	O	—	—
Black and White Warbler (*Mniotilta varia*)	O	—	—
Yellow Warbler (*Dendroica petechia*)	O	O	N
Myrtle Warbler (*Dendroica coronata coronata*)	N	N	N
Red-winged Blackbird (*Agelaius phoeniceus*)	O	—	—
Rusty Blackbird (*Euphagus carolinus*)	O	—	—
Pine Grosbeak (*Pinicola enucleator*)	O	—	—

Table 1 (continued)

Species	This study	Weller et al. (1969)	McDonald
Common Redpoll (*Acanthis flammea*)	O	O	N
Savannah Sparrow (*Passerculus sandwichensis*)	N	N	N
Pine Siskin (*Spinus pinus*)	O	—	—
Tree Sparrow (*Spizella arborea*)	—	—	N
Chipping Sparrow (*Spizella passerina*)	O	—	—
White-crowned Sparrow (*Zonotrichia leucophrys*)	N	N	N
White-throated Sparrow (*Zonotrichia albicollis*)	—	O	N
Swamp Sparrow (*Melospiza georgiana*)	O	—	—
Song Sparrow (*Melospiza melodia*)	N	N	N

[1] O = Observed no evidence of young or nest.
[2] N = Nesting nest or young observed.
[3] E = Not observed evidence consisting of feathers, eggs, or bones collected.

from 1 to 21 eggs and averaged 8.1 for all nests. Completed clutches ranged from 4 to 21 eggs and averaged 9.0 ($n = 101$). Seven nests were obviously parasitized by one or more females. Scaup nested on both wooded and unwooded islands but most utilized the latter, often in association with Arctic Terns, California Gulls, and Herring Gulls. Although nesting success was apparently high, gull predation on ducklings lowered production. Elsewhere, the impact of gulls on ducklings was recently studied by Vermeer (1968) and Dwernychuk and Boag (1972). Of the 21 adult females trapped and banded, two recoveries have been obtained from birds shot in Quebec and Maryland.

LESSER SCAUP. *Aythya affinis.* An occasional breeding pair was observed among the scaups frequenting the islands. McDonald found several nests over the years, usually on the larger, more wooded islands. One nest contained six eggs on 24 June 1956. Weller et al. (1969) found Lesser Scaup eggs in two Greater Scaup nests in 1968. This species is the most common of the breeding waterfowl on the adjacent mainland (Trauger 1971).

COMMON GOLDENEYE. *Bucephala clangula.* This species is considered to be an infrequent summer transient, based on a few observations of flying individuals and small flocks, mostly males.

OLDSQUAW. *Clangula hyemalis.* McDonald found at least four nests on the islands over the years. On 24 June 1956, he recorded specific information on a nest containing seven eggs. This species has not been observed as a breeding bird on the islands in recent years.

WHITE-WINGED SCOTER. *Melanitta deglandi.* A flock of 15 was observed flying by the eastern end of the island complex on 22 July 1972. McDonald also noted the occasional presence of this species among the islands during July. No nesting has been recorded. Flocks were usually sighted among the Shoreward Islands of Great Slave Lake.

SURF SCOTER. *Melanitta perspicillata.* Observations of this species were more frequent than of White-winged Scoters. Small flocks composed of several males and a few females were sighted on each visit to the islands. Presumably these were nonbreeding or premolting birds because there was no evidence of nesting on the islands. Large numbers were frequently encountered among the Shoreward Islands of Great Slave Lake.

COMMON MERGANSER. *Mergus merganser.* A flock of 1 male and two females were observed on 11 July 1969. This species does not breed on the islands and is infrequently observed during the summer.

RED-BREASTED MERGANSER. *Mergus serrator.* Although the breeding population has ranged from 8 to 12 pairs, this species is the second most abundant of the nesting waterfowl on the islands. Weller et al. (1969) reported four nests with seven to eight eggs (mean 7.7). A nest with 10 eggs was found on 4 July 1970, and two nests with eight and nine eggs were located on 4 and 5 July 1973. Mean clutch size for the seven nests was 8.3 eggs. Typically, merganser nests were situated under overhanging spruce boughs or in dense shrub cover on the larger islands, making their discovery more difficult than other ducks' nests. On 3 July 1970, three pairs, five males, and eight females (8♂♂ :11♀♀) were observed among the islands.

BALD EAGLE. *Haliaeetus leucocephalus.* Bromley and Trauger (1974) recently reported on the nesting history of the Bald Eagle on the West Mirage Islands. At least one pair of eagles has nested on the islands periodically since 1929, when McDonald found a nest in a 30-ft spruce tree. Following destruction of this nest in 1970, the eagles constructed a ground nest on a rocky peninsula. Two eaglets have been hatched and reared each year from 1971 to 1973.

WILLOW PTARMIGAN. *Lagopus lagopus.* Each year numerous feathers provided evidence of the winter occurrence of this species. Weller et al. (1969) reported similar observations.

AMERICAN COOT. *Fulica americana.* One was sighted on a small interior pool of a large central island on 5 July 1973. This bird flushed and flew to a protected bay between two islands where it was seen several times. During summer 1973, an unusually large number of breeding coots was observed in the Yellowknife area, perhaps in response to the drought conditions prevalent in some portions of the prairies and parklands of northern United States and southern Canada.

SPOTTED SANDPIPER. *Actitus macularia.* This is a species seen and heard on several trips to the islands in 1971 and 1973. Weller et al. (1969) also recorded one Spotted Sandpiper. McDonald found five nests of this species on the larger central islands; two nests were located on 24 June 1956.

LESSER YELLOWLEGS. *Tringa flavipes.* Although not seen on earlier surveys by McDonald and Weller et al. (1969), at least one was sighted on nearly every visit to the islands from 1970 through 1973. One pair may have nested adjacent to a pool on an interior island.

PECTORAL SANDPIPER. *Calidris melanotos.* McDonald listed this species as a summer visitor to the islands. On 4 July 1970 one was observed on a rocky reef off the southern outer islands. The next day a migrating flock of seven was observed in approximately the same location.

LEAST SANDPIPER. *Calidris minutilla.* McDonald recorded one nest on the large central island. On 5 July 1973, a flock of eight was observed.

SEMIPALMATED SANDPIPER. *Calidris pusillus.* An infrequent summer visitor, one was seen on 10 July 1969. Weller et al. (1969) saw one also in 1968. This species was noted by McDonald during summer visits in the 1950s and 1960s.

HUDSONIAN GODWIT. *Limosa haemastica.* On 17 and 18 July 1970, one was observed several times on the large central island adjacent to the camp island. McDonald found a nest on this island during the 1950s. This unique observation contributes some knowledge to the poorly understood breeding range of this species (Godfrey 1966).

NORTHERN PHALAROPE. *Lobipes lobatus.* Between 5 and 10 pairs nested on the larger eastern and central islands. Nests containing four eggs were found on 29 June 1969, 24 June 1971, and 22 July 1972. McDonald found nests with completed clutches on 11 July 1947, 23 June 1949, and 24 June 1956; on the last date he found six nests. Family groups were observed composed of two adults with four young on 3 July 1970 and with three young on 4 July 1970 and 4 July 1973. Weller et al. (1969) also recorded the nesting of this species on the islands. The Northern Phalarope apparently breeds regularly in very restricted localities from Lake Athabasca to the Barren Grounds (Nero 1963). Godfrey (1966) stated that this species breeds along the Arctic coast and indefinitely southward; the breeding range extended to approximately 75 mi (120 km) northeast of Yellowknife.

POMARINE JAEGER. *Stercorarius pomarinus.* In McDonald's records, this species was noted several times in Yellowknife Bay during late June. One year a pair remained on the West Mirage Islands all summer, but they did not nest.

PARASITIC JAEGER. *Stercorarius parasiticus.* In recent years two or three pairs have nested annually on the islands. Five pairs were recorded on 3 July 1970. Four of these pairs were polymorphic with one light and one dark bird; the other pair was dark. In 1973 a dark pair was observed nesting on the same island where the dark pair nested in 1970. Five nests with one or two eggs were found in late June and early July between 1969 and 1973. Mean clutch size was 1.6 ($n = 8$) for these nests and the three nests reported by Weller et al. (1969). Nests were generally located on high barren islands. As observed earlier by Weller et al. (1969), few species nested near the jaegers. One downy young was captured and banded on 18 July 1970. According to Godfrey (1966), the breeding range of the Parasitic Jaeger begins 150 mi (240 km) northeast of Yellowknife. This species occurs principally along the Arctic coast and is scarce in the interior. The breeding records on the West Mirage Islands represent a significant southward extension of the known breeding range.

HERRING GULL. *Larus argentatus.* An estimated 40 to 60 pairs nested regularly on the islands. In 1968 Weller et al. (1969) reported 22 nests containing one to three eggs (mean 1.7). Between 1969 and 1973, 35 additional nests were found with one to three eggs (mean 1.9). Herring Gulls most frequently nested on the small to medium treeless islands, particularly the eastern and central islands of the complex. Hatching began in early July as many downy young and pipped eggs were observed on 3 and 4 July 1970 and 4 and 5 July 1973. Sixteen young were banded during the study, but no recoveries have been reported. On 17 July 1970, a gull was observed devouring a young Arctic Tern that was nearly fledged. White primaries were seen protruding from the bill of the gull. This species was also considered a predator of Greater Scaup eggs and young even though they nested on the same islands (Weller et al. 1969; Trauger and Bromley, unpublished data).

CALIFORNIA GULL. *Larus californicus.* This species was the most abundant breeding bird on the islands. Between 1969 and 1973 an estimated 150 to 200 pairs nested annually in four colonies. Barren, rocky islands principally on the west and south islands of the complex, were utilized for nesting. Apparently the gull population was considerably larger in the past because McDonald estimated 250 nests on the westernmost island in June 1956. He also stated that smaller colonies occurred on the eastern islands. Although no attempt was made to record nesting data for all gulls, 114 nests were noted. Clutch size ranged from one to three eggs (mean 2.1). Weller et al. (1969) found 92 nests with clutches ranging from one to three eggs (mean 1.9). Hatching chronology of California Gulls was similar to that of Herring Gulls with most nests hatching in early July. A total of 26 young gulls was banded, but no recoveries have been reported. Greater Scaup nested in close proximity to California Gulls; one nest was 27 in (68.5 cm) from a gull nest. On 17 July 1970, several gulls attacked a brood of Greater Scaup during an inter island movement. Two ducklings were devoured before the brood reached shore. In island situations gulls have the potential to eliminate duckling production (Vermeer 1968; Dwernychuk and Boag 1972). We were unable to appraise fully the significance of gull predation on ducklings. Godfrey (1966) included Great Slave Lake in the breeding range of the California Gull but excluded the North Arm and the Yellowknife region. The most northern breeding colonies of this species may occur on the West Mirage Islands.

MEW GULL. *Larus canus.* Three to five pairs nested on the larger wooded islands. One nest containing two eggs was found on 3 July 1970. Weller et al. (1969) reported one nest with three eggs in 1968. McDonald reported several groups of young in 1956. One young was banded in 1970.

COMMON TERN. *Sterna hirundo.* McDonald discovered two nests of this species on the easternmost island, but it was not observed during the 1968–1973 period.

ARCTIC TERN. *Sterna paradisaea.* A breeding population of 75–100 pairs ranked this bird as the second most abundant species on the islands. Although a few pairs nested on a number of islands, the majority of the terns nested in three large colonies. Medium-sized islands were selected for nesting. Nest sites ranged from lichen-covered rocks to heavy tundra mats. Since Weller et al.'s (1969) visit to the islands in 1968, a noticeable decline has occurred in the number of breeding Arctic Terns. McDonald found 36 nests on one island and smaller numbers on others in late June 1956. Weller et al. (1969) recorded 48 nests with one to two eggs (mean 1.7). In subsequent years 23 additional nests were noted; 78% of the nests contained two eggs. Clutch sizes ranged from one to two eggs and averaged 1.8 eggs. Hatching began in early July; young were noted on 3 and 4 July 1970 and 4 and 5 July 1973. Young with well developed primaries were observed on 17 July 1970 and 22 July 1972. On the latter date an estimated 60 juvenile terns were flying. Weller et al. (1969) noted the close association between nesting terns and ducks. This relationship has also been noted by other observers (Koskimies 1957; Hilden 1964; Vermeer 1968).

CASPIAN TERN. *Hydroprogne caspia.* Three pairs nested on the islands annually from 1969 through 1973. Weller et al. (1969) recorded three nests in 1968. Apparently this population has remained stable for several years. McDonald found two nests on 24 June 1956. Clutch size of eight nests examined by all observers ranged from one to two eggs (mean 1.8) with a clutch of two the most frequent (75%). On 4 July 1970 two newly hatched young were observed. These observations may represent the northernmost breeding record for this species (Godfrey 1966).

YELLOW-SHAFTED FLICKER. *Colaptes auratus auratus.* On 4 and 5 July 1973 this species was seen and heard by several observers. Weller et al. (1969) found wing and tail feathers on the islands and considered the flicker to be a rare breeding bird or summer resident. McDonald found a nest on the largest island at the northwestern edge of the main complex.

YELLOW-BELLIED SAPSUCKER. *Sphyrapicus varius.* Prominent borings typical of this species were observed on several trees along the western perimeter of the camp island in July 1973. No birds were seen but sufficient evidence was found to indicate the former occurrence of this species.

COMMON RAVEN. *Corvus corax.* One or two birds were sighted on nearly every visit to the islands between 1969 and 1973. Weller et al. (1969) and McDonald also have observed ravens on the islands and considered this species to be a potential nest predator. On 12 July 1969 a pair with one fully fledged young was found on a large wooded island. Numerous broken gull and duck eggshells were scattered around the tree where the ravens nested. The nest was near the top of a 25-ft spruce in one of the taller denser stands of trees on the islands.

BROWN THRASHER. *Toxostoma rufum.* On 23 June 1971 one was observed on two of the easternmost islands in the complex. Although this observation is approximately 650 mi (1040 km) north of the species breeding range (Godfrey 1966), Aleksiuk (1964) observed this species in the Perry River region, 500 mi (800 km) northeast of Yellowknife.

YELLOW WARBLER. *Dendroica petechia.* Although no nests or young have been observed in recent years, this species was considered a breeding bird on the islands. McDonald found a nest on the large western island. A few birds have been sighted on nearly every visit to the islands. In 1973 at least nine pairs were counted during a survey of the islands. They were found on islands having rather dense stands of trees and thickets.

MYRTLE WARBLER. *Dendroica coronata coronata.* Weller et al. (1969) found one nest during the 1968 survey of breeding birds on the islands. McDonald noted several earlier nesting records. A few birds have been seen on every recent visit to the islands, but the breeding population may not exceed five pairs.

RED-WINGED BLACKBIRD. *Agelaius phoeniceus.* A flock of five females was sighted on 5 July 1973 perched in trees on one of the large central islands. Previously this species had not been observed on the islands. Krapu (1973) considered it a common breeder in suitable locations on the adjacent mainland.

PINE GROSBEAK. *Pinicola enucleator.* A family group of one pair and two juveniles was observed and photographed near camp on the largest central island on 11 July 1969. These birds were probably transients. This species is rarely seen on the mainland north of Great Slave Lake.

COMMON REDPOLL. *Acanthis flammea.* McDonald once found three nests on the largest western island. In recent years a few birds have been sighted during each visit. A small breeding population of less than five pairs may occur on the wooded islands. Many transients were seen and heard on the islands in 1973 when this species was also prevalent throughout the Yellowknife region.

SAVANNAH SPARROW. *Passerculus sandwichensis.* An estimated breeding population of 60 to 75 pairs ranked this species as the third most abundant bird on the islands. At least half of the islands had one or more Savannah Sparrows, which made this bird the most frequently encountered species. No attempt was made to locate nests, but three with five, four, and four eggs were found during surveys of the islands. Young of varying ages and family groups were observed throughout July. Brood size ranged from one to three young per family. Weller et al. (1969) and McDonald also considered the Savannah Sparrow to be an abundant nesting bird on the islands.

TREE SPARROW. *Spizella arborea.* McDonald recorded one nest on the large western island. It was not observed during recent visits to the islands. This locality is near the southern limit of the breeding range of this species (Godfrey 1966).

CHIPPING SPARROW. *Spizella passerina.* One or two pairs may have nested on the islands. This species was seen and heard on the large camp island on 3 July 1970 and 4 July 1973. Others have been sighted on large wooded islands.

WHITE-CROWNED SPARROW. *Zonotrichia leucophrys.* Recent visits to the islands indicated a breeding population of 5 to 15 pairs. Weller et al. (1969) found five nests. No attempt was made to find additional nests, but nesting and brooding behavior were observed on several occasions. This species is a common breeding bird in the Yellowknife region.

WHITE-THROATED SPARROW. *Zonotrichia albicollis.* Weller et al. (1969) sighted one individual, but this species has not been seen on recent visits. McDonald found one nest on the large western island. It is a fairly common breeding bird on the adjacent mainland.

SONG SPARROW. *Melospiza melodia.* One to three breeding pairs were seen on the larger wooded islands. Weller et al. (1969) found one nest. This species was seen and heard on several recent visits. It is a fairly common breeding bird on the adjacent mainland.

McDonald listed the following species as summer visitors to the islands: Semipalmated Plover (*Charadrius semipalmatus*), Ring-billed Gull (*Larus delawarensis*), Eastern Kingbird (*Tyrannus tyrannus*), Eastern Phoebe (*Sayornis phoebe*), Western Wood Pewee (*Contopus sordidulus*), and Barn Swallow (*Hirundo rustica*). Most of these species regularly breed or occur in the Yellowknife region, but they have not been observed on the islands in recent years.

We recorded single observations of the following species which were considered summer transients: American Kestrel (*Falco sparverius*), White-rumped Sandpiper (*Calidris fuscicollis*), Black and White Warbler (*Mniotilta varia*), Rusty Blackbird (*Euphagus carolinus*), Pine Siskin (*Spinus pinus*), and Swamp Sparrow (*Melospiza georgiana*). Although several of these species are common breeding birds on the adjacent mainland, they apparently do not nest on the islands.

Discussion

Between 1969 and 1973, 45 species of birds were recorded on the West Mirage Islands (Table 1). Nineteen of these species were observed nesting or rearing young. Of the 26 other species noted, seven were probably breeding on the islands, but no nests or young were found. The remainder were considered summer transients and accidental visitants. Evidence was found of the occurrence of two additional species.

Overall, 65 species have been observed or known to breed or visit the West Mirage Islands (Table 1). Weller et al. (1969) reported 35 species, and McDonald (unpublished notes) recorded 47 species. We observed 14 species not seen by previous observers. McDonald had records of 11 species not noted during recent surveys. Weller et al. (1969) reported four species not observed by either McDonald or us.

The description of the West Mirage Islands included in the Canadian IBP Directory erroneously listed the Arctic Loon (*Gavia arctica*), Red-necked Grebe (*Podiceps grisegena*), Horned Grebe (*Podiceps auritus*), and Canvasback (*Aythya valisineria*) as representative species (La Roi and Babb 1974). These birds were not recorded by recent observers (Weller et al. 1969; this study). The Yellow-billed Loon (*Gavia adamsii*), Oldsquaw (*Clangula hyemalis*), and White-winged Scoter (*Melanitta deglandi*) should be considered rare transients rather than representative species.

Of 30 species known to breed on the islands in the past, 19 species were found nesting or rearing young between 1968 and 1973 (Table 1). Seven species that formerly nested on the islands were observed during recent surveys, and all but the Hudsonian Godwit probably were breeding birds. Three species were recently found nesting or probably nesting that formerly were not known to breed on the islands. Four species no longer occur there.

An estimated 1500 birds were associated with the West Mirage Islands during the breeding season. Each year 400–600 pairs of birds representing 19–26 species nested on these rugged islands. The remainder were non-breeders and transients.

The density and diversity of breeding birds was related to the variety of terrestrial and lacustrine habitats within the island complex. The delayed phenology of the islands caused by the severe climate of Great Slave Lake has resulted in the development of subarctic conditions typical of the environment 150–200 mi (240–320 km) northeast of Yellowknife. The occurrence of Red-throated Loons, Greater Scaups, Red-breasted Mergansers, Northern Phalaropes, Parasitic Jaegers, and Arctic Terns as breeding birds was indicative of these conditions. None of these species breed on the adjacent mainland. Breeding records for the Northern Phalarope and Parasitic Jaeger represent southward extensions of the known range for these species (Godfrey 1966). In contrast, the availability of suitable food and habitat allowed such species as the California Gull and Caspian Tern to breed on the islands. Both species are at the northern limits of their respective ranges (Godfrey 1966).

Weller et al. (1969) analyzed species occurrence in relation to island size. Our observations conformed with this general pattern of greater diversity of birds with increasing area of islands. Eleven of the 13 species previously not sighted on the islands were found on the larger 10- to 16-acre (4- to 7-ha) islands.

We propose that the West Mirage Islands be designated the "William L. McDonald Avian Sanctuary" in memory of the keen observer who knew more about the birds of the Great Slave Lake region than probably anyone. Long before we visited this rugged insular complex, McDonald was aware of the unique avifauna associated with these islands. For five decades he recorded the species nesting and occurring there.

Although the West Mirage Islands were listed as a "Natural Area" in Canada's International Biological Program (La Roi and Babb 1974), additional protection is warranted. The birds, most of which are ground nesters, are highly vulnerable to human disruption and destruction. Eagles, ducks, terns, gulls, and jaegers are in particular jeopardy because several of these species are represented by small populations and are characterized by low tolerance to human intrusion. Increased human settlement and activity in the Yellowknife area in combination with increased tourism and recreational use of Great Slave Lake pose a real threat to the West Mirage Islands. Whether such an avian sanctuary is established by a private conservation organization or public government agency, the breeding birds will benefit from the recognition of their natural values and protection from further human encroachment.

Acknowledgments

We are deeply indebted to the late William L. McDonald, who initially inspired our interest in the birds of the West Mirage Islands and accompanied us on several visits to the area. Before his death in 1971, McDonald gave us a notebook containing his bird observations recorded on the islands between 1922 and 1970.

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Literature Cited

Aleksiuk, M. 1964. Observations of birds and mammals in the Perry River Region, N.W.T. Arctic 17: 263–267.

American Ornithologists' Union. 1957. Check-list of North American birds. Fifth edition. Lord Baltimore Press, Baltimore, Maryland. 691 pp.

American Ornithologists' Union. 1973. Thirty-second supplement to the American Ornithologists' Union Check-list of North American birds. Auk 90: 411–419.

Bromley, R. G. and **D. L. Trauger.** 1974. Ground nesting of Bald Eagles near Yellowknife, Northwest Territories. Canadian Field-Naturalist 88: 73–75.

Dwernychuk, L. W. and **D. A. Boag.** 1972. Ducks nesting in association with gulls—an ecological trap? Canadian Journal of Zoology 50: 559–563.

Godfrey, W. E. 1966. The birds of Canada. National Museum of Canada Bulletin 203. 428 pp.

Hilden, O. 1964. Ecology of duck populations in the island group of Valassaaret, Gulf of Bothnia. Annales Zoologici Fennici 1: 153–277.

Koskimies, J. 1957. Terns and gulls as features of habitat recognition for birds nesting in their colonies. Ornis Fennica 34: 1–5.

Krapu, G. L. 1973. Red-winged Blackbirds nesting near Great Slave Lake, N.W.T. Blue Jay 31: 147–149.

La Roi, G. H. and **T. R. Babb.** 1974. Canadian National

Directory of IBP areas, 1968–1974. University of Alberta, Edmonton.

Nero, R. W. 1963. Birds of the Lake Athabasca region, Saskatchewan. Saskatchewan Natural History Society, Special Publication 5. 143 pp.

Trauger, D. L. 1971. Population ecology of Lesser Scaup (*Aythya affinis*) in subarctic taiga. Ph.D. thesis, Iowa State University, Ames. 118 pp.

Vermeer, K. 1968. Ecological aspects of ducks nesting in high densities among larids. Wilson Bulletin 80: 78–83.

Weller, M. W., D. L. Trauger, and **G. L. Krapu.** 1969. Breeding birds of the West Mirage Islands, Great Slave Lake, N.W.T. Canadian Field-Naturalist 83: 344–360.

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Distribution and Movements of White-tailed Deer in Southern New Brunswick in Relation to Environmental Factors

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Abstract. White-tailed deer (*Odocoileus virginianus*) were marked and followed by telemetry between December 1969 and May 1972 to determine their seasonal home ranges, distribution by forest cover types, and their movements in response to snow depth, precipitation, barometric pressure, temperature, wind, windchill, and time of day. Twenty-eight deer were radio-equipped and 22 (12 adults, 5 yearlings, and 5 fawns) were relocated. Sizes of home ranges were measured by computerized movement maps: 949 ha for three deer in a snowfree winter; 88 ha for seven deer in a winter of deep snow, 341 ha for five deer in a winter of average snowfall, and 266 ha for five deer in two summers. In a winter of deep snow, the area used declined to 7.3% and distance travelled per hour to 76% of their respective values in a snowless winter. Windchill, barometric pressure, and temperature had less effect on deer movements as snow accumulated. Deer moved mostly in later afternoon–evening and early morning in winter, and mid-day and evening at other times of the year. Relocations indicated a preference of deer for mixedwood cover throughout the year, but as snow accumulated use of softwood increased. Deer moved to winter ranges when snow accumulated to 30 cm in hardwood stands and returned to summer ranges after several days of temperatures above 5.5°C. Some deer moved up to 20 km from summer to winter ranges. Improved interspersion obtained by modifying sylvicultural practices could provide ample winter habitat in areas considerably smaller than the 300–400 ha measured. Areas of 300–400 ha with many small clear-cuts provided adequate summer habitat.

I determined daily and seasonal movements and use of forest cover types by white-tailed deer (*Odocoileus virginianus*) on a study area in southern New Brunswick, and related my results to measured environmental factors. Such information is needed to understand the habitat requirements of deer, so that sylvicultural practices can be adapted to maintain or improve the habitat (Krefting 1962).

The study was begun on the Acadia Forest Experimental Station, 24 km east of Fredericton in southern New Brunswick during December 1969. The area has a diversity of forest cover types that deer use during the summer. The station has little winter habitat, however, so winter studies were conducted in a peripheral area to the southeast and southwest, where extensive wintering areas are found.

Softwood stands are mainly pure stands of spruce (*Picea* spp.), but also mixtures of spruce, fir (*Abies balsamea*), cedar (*Thuja occidentalis*), larch (*Larix laricina*), hemlock (*Tsuga canadensis*), and pure stands of cedar. Mixedwood stands consist of yellow birch (*Betula alleghaniensis*) and sugar maple (*Acer saccharum*) with 30–70% of spruce, or of red maple (*Acer rubrum*) and white birch (*Betula papyrifera*) with various proportions of fir and spruce. Hardwood stands are mostly composed of red maple, white birch, or both. The term "shrubs" as used in the text refers to willows (*Salix* spp.) growing on abandoned beaver ponds; clear-cuts are of all sizes, and openings include roads, gravelled areas, railroad tracks, etc.

The study area has a modified continental climate despite its maritime location. Winters are mild with a great snowfall: mean annual precipitation, 1050 mm; mean annual snowfall, 2800 mm; mean low of −10.0°C in January.

Methods

Deer were captured in all seasons using baited sliding-door box-traps and were handled with a holding-box or immobilized with a CapChur gun using syringes loaded with succinylcholine chloride or using Pneudarts (Liscinsky et al. 1969). The deer were equipped with collars carrying radio transmitters. The radios (150 megacycle range) were obtained from AVM Instrument Company, or built by the author after Cochran's (1967) description.

Radios were located using AVM Instrument receivers and hand-revolved antennae, at ½-h intervals for continuous periods of 6 to 24 h once a week, and one or more times on each intervening day. The bearings obtained were processed on an IBM 360 computer at the University of New Brunswick in a similar way to Siniff and Tester's (1965) method. Deer locations were calculated on a grid system, and a map showing the consecutive locations was drawn by an XY plotter at a scale of 1:15 480. Distances travelled between observations were calculated. Each radio fix was located on aerial photograph, and the forest cover type identified by photo interpretation and from existing cover-type maps. Area of home range was measured with a planimeter by joining the perimeter relocation points to form a polygon (Odum and Kuenzler 1955).

Weather data were obtained from the Ministry of Transport Weather Station at the Fredericton Airport, located 3 km from the winter study area and, during the winters 1969–70 and 1970–71, also from stations measuring temperature, humidity, and wind speed in two different cover types at Acadia Forest. In winter 1971–72, two windchill meters (Verme 1968) were installed in dense softwood stands, and one in the open. Meter readings were automatically photographed to provide a continuous record. Windchill was calculated for the first two winters (1969–70 and 1970–71), using equations derived in a similar fashion to Verme's (1968). Snow depths were recorded with rules permanently installed in three types of forest cover and read whenever snow levels changed.

Three parameters, area used daily, distance travelled hourly, and type of cover used, were examined for correlation with environmental factors. Distance travelled per hour was obtained for periods as short as 6 h to demonstrate the influence of the period of the day. Multiple correlation analysis programs (Nie et al. 1970) and simple regressions were used to test for correlations between the parameters and the daily weather data. Displays for parameters were also obtained by cross-tabulation for different types and different levels of weather data whenever the straight-line correlation hypothesis was not applicable.

Results

Of the 28 radio-equipped deer, 22 were detected during 30 months of observation (December 1969 to May 1972) for a total of 1905 individual relocalizations. The relocations were distributed seasonally: spring (April), 15%; summer (May to September), 27%; fall (October and November), 4%; winter (December to March), 54%. Three of the five fawns and all five yearlings were males. Of the 12 adults tracked seven were males. Transmitter life averaged 3.1 months, with a range of a few days to 7 months.

Weather

The winter of 1969–70 had little snow accumulation except for a short period in December (Figure 1): total snowfall was less than normal (176 vs. 280 cm), whereas rainfall was nearly three times greater (230 vs. 91 mm). The total precipitation of 381 mm was near the long-term winter average of 370 mm. In winter 1970–71 the snow came early and attained a record overall fall of 4272 mm; a large accumulation remained all winter and total precipitation (620 mm) was nearly twice the long-term winter average. Precipitation in 1971–72 was intermediate to that of the previous two winters with little recorded until 19 February when snow cover began to increase rapidly; total snowfall was 3487 mm and rainfall was 123 mm. Mean temperatures were above normal in winter 1969–70 (-0.8° C), and below normal in the two following winters (-6.0 and -6.3° C).

Home Range Characteristics

The average size of ranges differed significantly ($P < 0.01$) between seasons: in summer, ranges were smaller than in the 1971–72 winter (266 vs. 241 ha), and smaller than in the 1969–70 winter (Table 1). Summer ranges were larger than in the severest (1970–71) winter. The average size of ranges differed significantly ($P < 0.01$) during the three winters (Table 1). The maximum individual range size recorded was 1433 ha for an adult male in the snowless winter of 1969–70, twice as large as for fawns in the same year. Range sizes were smallest in the

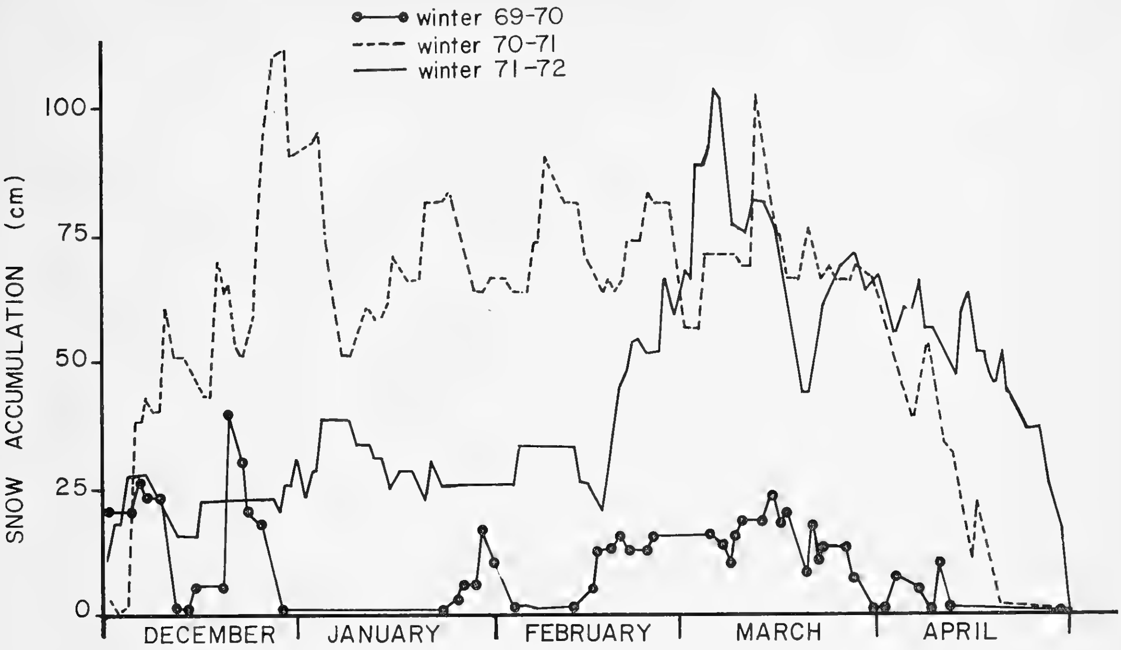

FIGURE 1. Snow accumulation in the open for the three winters of the study period.

severe winter of 1970–71 and intermediate in the average winter of 1971–72. Fall ranges were measured over shorter intervals than summer or winter ranges, and cannot be compared to them. Spring ranges are highly variable as the transition between winter and summer distribution is abrupt. Both fall and spring are periods of extensive movements: rut and migration to and from winter ranges.

The longest period of observation was 262 days for a male fawn captured in December 1969. The fawn's overall range of 763 ha was only slightly larger than his winter range of 708 ha (Table 1). When last detected he was probably shifting his range, as he killed 12.5 km from his last known location.

The greatest linear dimension of seasonal ranges are given in Table 1. This measure (Heezen and Tester 1967) follows the same trend as total size for winter ranges, the snowless winter having the greatest linear dimension, followed by the other two winters in order of increasing mean snow depth.

Factors Affecting Daily Movements

During the study period the size of the area used daily was mostly affected by the season ($r = 0.47$) or expressions of season: mean temperature ($r = 0.38$) and windchill ($r = 0.31$).

Winter

In winter, deer used daily an average area of 27.6 ± 5.5 ha compared to a summer average of 50.1 ± 12.5 ha (16 days, 10.4 h average observation length in summer, and 48 days, 10.9 h average observation length in winter). The distance travelled hourly varied from 301 ± 30 m in winter, to 364 ± 43 m in summer. (Figure following ± sign is standard error.)

Snow was the main factor affecting movement in winter. Snow depths in excess of 30 cm influenced travel, and depths over 55 cm retarded travel and reduced the area used daily. A simple regression analysis between snow depth classes and mean range sizes gave an r value of -0.94 ($P < 0.02$). In the snowless winter of 1969–70, the average area used daily was 65.7 ± 12.9 ha (19 days, 18 h average observation period). This average dropped to 10.7 ± 2.3 ha for the 1971–72 winter (13 days, 7 h average observation period) and to 4.8 ± 1.5 ha in the 1970–71 winter (16 days, 6 h average

TABLE 1 — Size of seasonal home ranges (greatest dimensions and total area) of white-tailed deer in southern New Brunswick

	Home range (ha)	Greatest linear dimension (km)	Date of first and last observation	Length of period (days)	Number of different days observed	Number of observations	Month of maximum observations
Winter 1969–70							
Adult male	1433.7	5.5	07-01-70 04-04-70	87	67	147	February
Fawn male	708.5	2.1	02-02-70 31-03-70	57	45	124	February
Fawn male	708.5	2.1	02-02-70 31-03-70	57	45	124	February
Mean	950 ± 2.41						
Winter 1970–71							
Adult male	59.4	0.8	26-01-71 08-04-71	72	43	29	Feb.–Mar.
Adult male	141.6	2.0	04-02-71 05-04-71	60	29	34	Feb.–Mar.
Adult female	119.7	1.6	28-01-71 28-02-71	31	20	46	February
Adult female	123.8	0.9	01-03-71 31-03-71	30	22	40	March
Adult female	93.0	1.7	20-01-71 23-03-71	62	31	56	February
Adult female	27.5	0.9	26-02-71 21-03-71	21	18	30	March
Yearling female	56.6	1.1	31-03-71 22-04-71	22	17	20	April
Mean	88.8 ± 5.4						
Winter 1971–72							
Adult male	234.7	2.2	09-12-71 30-12-71	21	20	31	December
Yearling male	336.3	1.6	03-12-71 30-03-72	118	53	63	Dec.–Mar.
Adult female	545.9	0.9	17-12-71 24-04-72	129	63	83	Jan.–Apr.
Fawn female	588.8	2.5	29-11-71 28-03-72	120	63	106	Dec.–Feb.
Mean	341.1 ± 60.9						
Summer							
Yearling female	321.3	1.1	12-05-71 05-08-71	85	23	31	June
Adult male	465.3	4.2	22-06-71 22-07-71	30	16	78	July
Yearling male	394.1	3.0	01-05-70 30-09-70	153	36	142	July
Fawn female	75.2	0.9	02-09-70 25-09-70	23	8	10	September
Yearling female	329.8	—	13-05-70 24-06-70	2	13	78	May
Mean	276.8 ± 12.5						

observation period). The above averages are significantly different from one another ($P < 0.05$). The distance travelled hourly varied between the snow-free and the snowy winters: from 355 ± 44 m in the 1969–70 to 326 ± 119 m for the relatively snow-free first part of the 1971–72 winter, to 243 ± 36 m in the rest of the 1971–72 winter, and 270 ± 72 m in the 1970–71 winter.

In all three winters, deer travelled more in early morning (448 ± 106 m/h) and in late afternoon and evening (320 ± 62 m/h) than during mid-day (284 ± 49 m/h). The distance travelled hourly declined with an increase in temperature: 383 m/h for 20°C and colder vs. 280 m/h for 4.4°C and warmer.

The effects of all factors except snow depth were more important during 1969–70, a snowless winter. Distance travelled hourly increased significantly ($r = 0.43$, $P < 0.05$) with barometric pressure. The area used daily also increased with barometric pressure ($r = 0.34$) and length of sunshine period ($r = 0.36$), two factors intercorrelated at the 95% confidence level. Each accounted for 20% of the variability of daily area used. I found that the length of sunshine period, barometric variation, total rainfall, period of the day, wind and windchill accounted for 55% of the variability of the distance travelled hourly, with a total multiple r value of 0.74.

In the winters of 1970–71 and 1971–72, only snow had a measurable effect on the size of the area used daily or distance travelled hourly, apparently because of the masking effect of snow depth, and undoubtedly snow hardness, although the latter was not measured. A number of factors taken together, however, were found to have interesting effects. A multiple r value of 0.83 was found for the following factors and a distance travelled hourly in 1970–71 winter: snow depth, wind speed, barometric pressure, hours of bright sunshine, weather, windchill, period of the day, and temperature.

In the winter of 1971–72, period of the day, age and sex of the animal, barometric variation, temperature, wind speed, and snow depth accounted for 99% of the variability of the distance travelled hourly. Total area used daily was correlated with the same variables plus windchill with a multiple r value of 0.99.

Adult males had consistently larger ($P < 0.05$) mean areas used daily than all other classes in snowy winters (6.4 ± 3.9 vs. 4.0 ± 1.4 ha in 1970–71, and 17.2 ± 5.3 vs. 8.8 ± 3.0 ha in 1971–72). In the snowless 1969–70 winter, however, fawns used a significantly ($P < 0.05$) larger mean area daily than did adult males (69.9 ± 24.7 vs. 54.0 ± 15.8 ha).

Summer

In summer periods, I found a weak correlation between age and area used daily ($r = 0.42$), and between age and distance travelled hourly ($r = 0.50$). Fawns travelled an average of 130 ± 34 m/h, yearlings 342 ± 48 m/h, and adults 519 ± 92 m/h.

Minimum temperature had an inverse effect on area used daily ($r = 0.48$) and on distance travelled hourly, though to a lesser extent ($r = 0.31$). There was a significant difference ($P < 0.05$) between the intensity of movement in different periods of the day: deer travelled less on average during night and early morning (272 ± 68 m/h) as compared to mid-day and evening (392 ± 67 m/h and 373 ± 76 m/h). This same difference was also noticed in spring, when average distances travelled hourly were 181 m (one measure only) for the night and 232 ± 37 for the day and evening. During hot periods (above 21°C), the distance travelled hourly dropped significantly ($P < 0.05$); the pattern was not progressive but it was more marked at higher temperatures.

Factors Affecting Use of Forest Cover

Cover Use by Season

The use by deer of most cover types varied throughout the year, but remained relatively constant for dense mixedwoods (Figure 2). The more open covers (particularly clear-cuts) were used more during the mild season, but the use of hardwoods peaked in December (Figure 2).

Most use of dense softwood occurred during the winter, but the preference levels (Figure 3) show that deer selected this type at a lower rate than would be expected on the basis of relative availability. The preference levels (Figure 3) were computed as the quotient of the percentage of time an animal was found in a cover type by the percentage of availability of that cover type in a given seasonal range. This manner of deter-

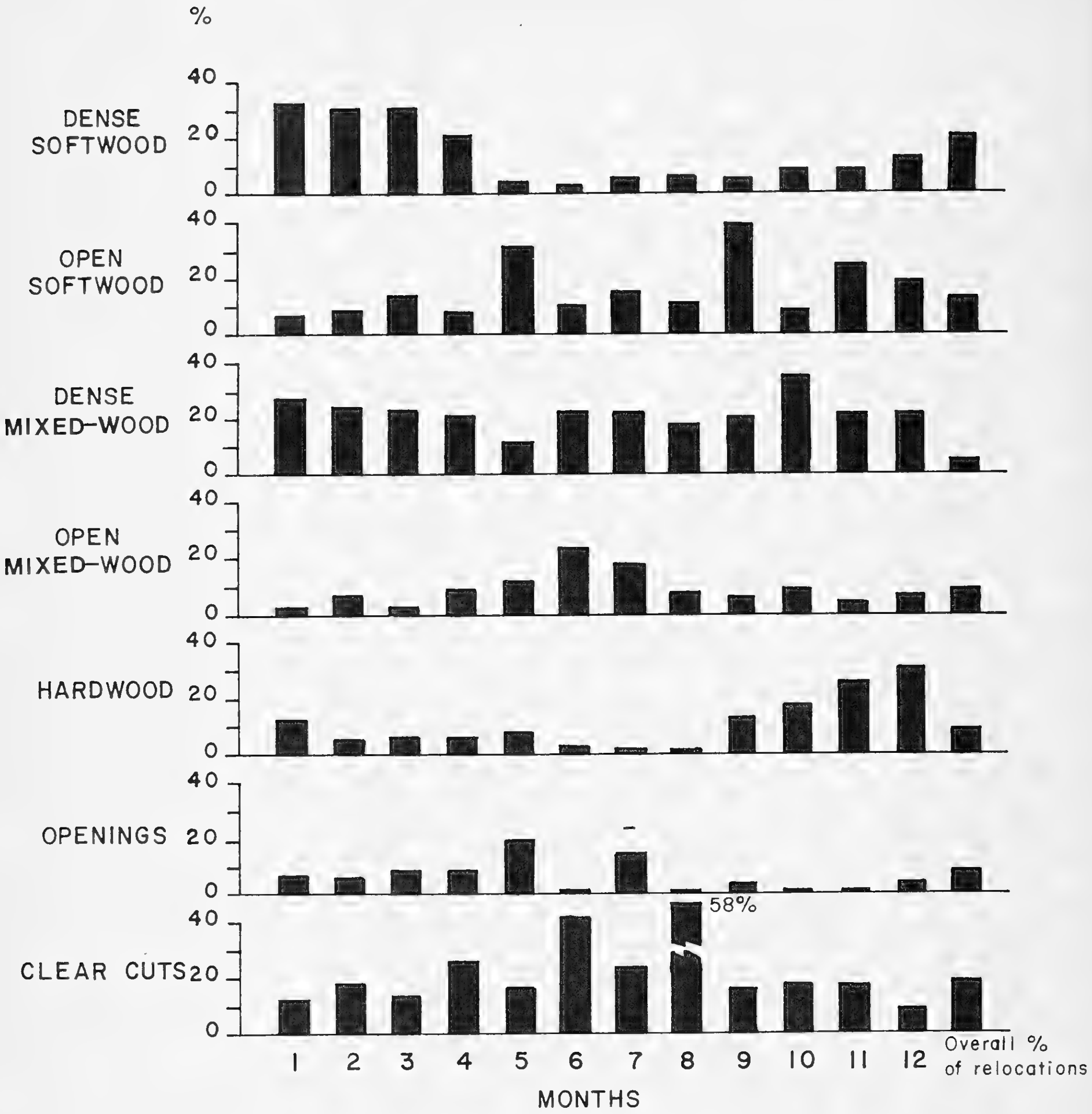

FIGURE 2. Monthly percentages of deer locations in various forest cover types.

mining preferences does not fully account for variations in habitat selection resulting from the deer's activity: shelter vs. forage. The seasonal value of dense softwood, a habitat type that occurs as a high percentage of the wintering area, is masked by its relatively large denominator. Dense softwood is selected for in winter, but relatively unused in relation to its frequency of occurrence.

Cover Use and Snow

Preference levels for cover varied between winters (Figure 3). As the most variable factor between winters was snow accumulation (Figure 1), it is evident that snow depth had a pronounced effect on the choice deer were making of cover types. In winter 1971–72, the percentage of relocations in dense softwoods increased from 22.9% to 71.7% while snow depth increased from

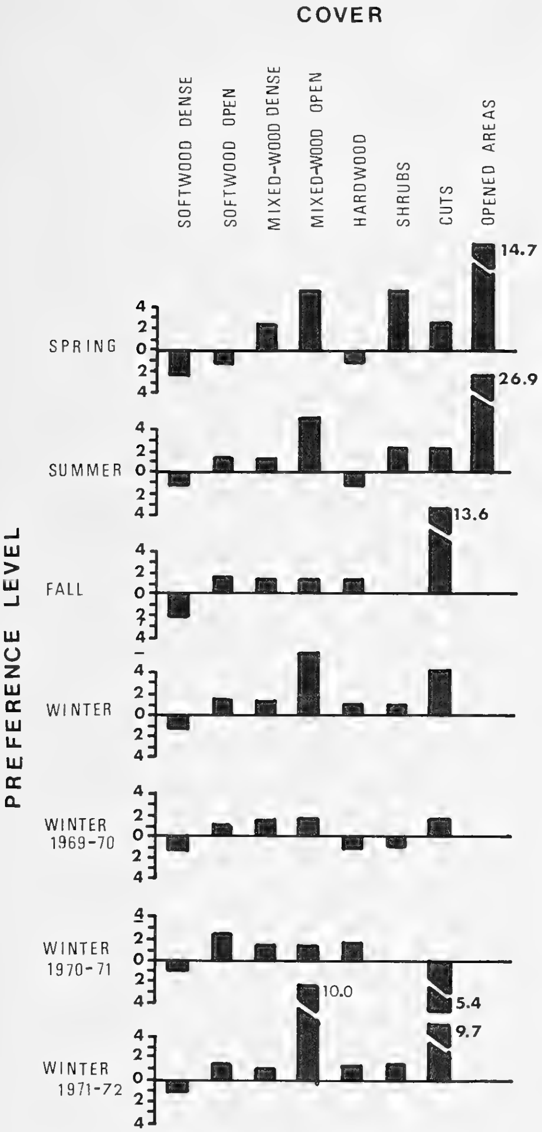

FIGURE 3. Preference level of cover selected by white-tailed deer in various seasons. Above 0 line: preference. Below 0 line: avoidance.

level 1 to level 3 (Figure 4). The use of open softwood and dense mixedwoods decreased with increasing snow depths (Figure 4). In 1970–71 the use of open softwood decreased with increases in snow depth, although the use of dense softwood did not change substantially (Figure 4). The increase in the use of cuts observed in 1970–71 is due to the type of cut present in the vicinity of yards used by deer as snow increased: they were mostly selective cuts, with more than 9.0 m²/ha basal area and more than 14% crown closure left standing.

Cover Use and Period of the Day

Deer chose different cover types according to light condition (Figure 5). In summer, deer used food types (mixedwood, hardwood, and clear-cut areas) in morning, mid-day, and evening in decreasing order, and cover types in the opposite order. During the 1969–70 winter, a correlation coefficient of 0.88 (significant at $P < 0.01$) was found between the density of cover used and the period of the day. In winter 1970–71 the coefficient was 0.78 ($P < 0.01$) indicating greater selection of more open cover during broad daylight than at all periods and more in morning and evening than at night.

Cover Use and Temperature

The number of relocations increased in open mixedwoods, and decreased in dense mixedwoods with increasing temperature in the winter of 1969–70. Clear-cuts were used in direct relationship to temperature in 1969–70. In the winters of 1970–71 and 1971–72, the influence of temperature was marked by other factors, probably snow depth and snow hardness and also availability of food. In summer, the use of softwood cover decreased and the use of mixedwood increased with increasing temperature, but deer's use of softwood increased at higher temperatures (above 24°C). Conversely, the percentage of relocation in clear-cuts dropped from 30% at temperatures of 5 to 21°C.

Cover Use and Wind

The only apparent effect of wind on selection of cover by deer in summer was a slight decrease in the use of open softwood types with increasing velocity. In winter 1969–70, the use of open mixedwoods and clear-cuts increased directly with wind velocity: from 0% to 14.6% of relocations in mixedwoods and 3.7% to 13.6% in clear-cuts with wind velocity increasing from 0–5 km/h to more than 20 km/h in the open. No effect of wind was noted in the other winters.

Cover Use and Windchill

In the winter of 1969–70, snow being absent,

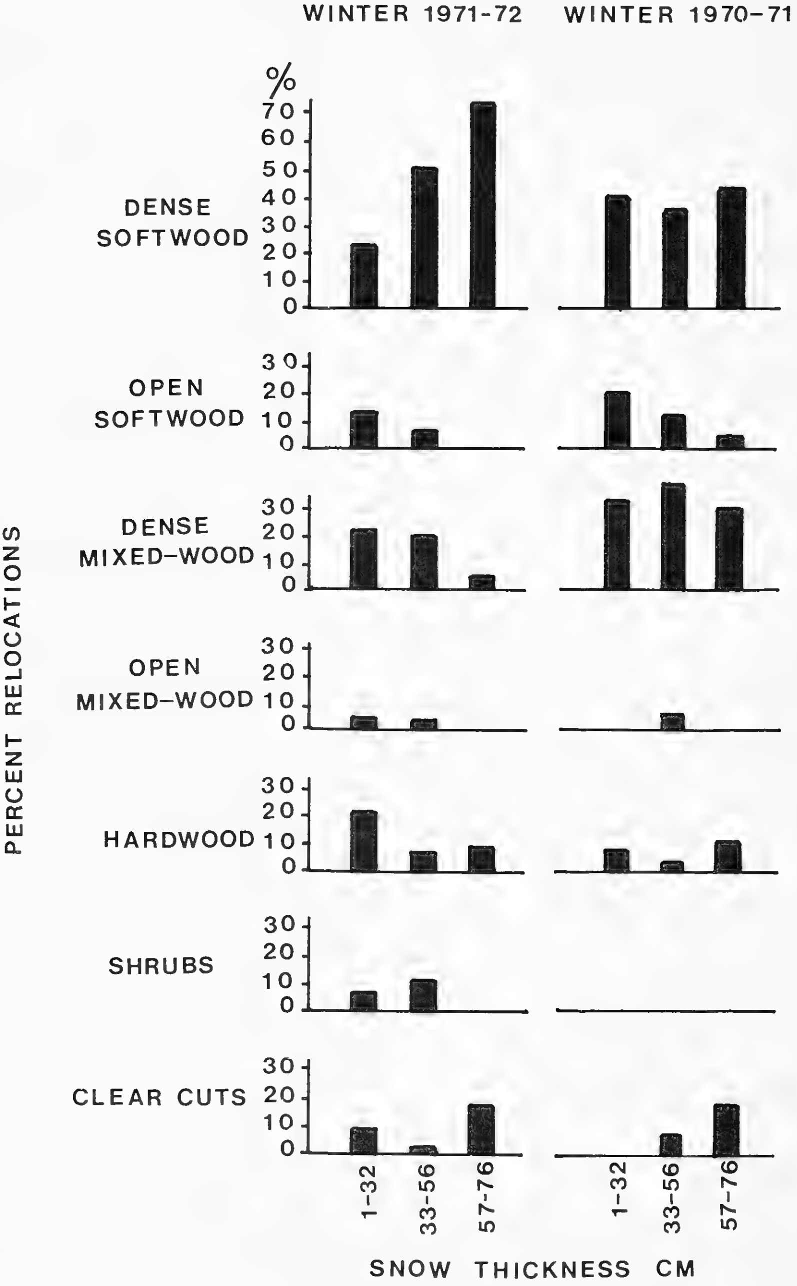

FIGURE 4. Percentages of deer locations in selected cover types by snow-depth classes.

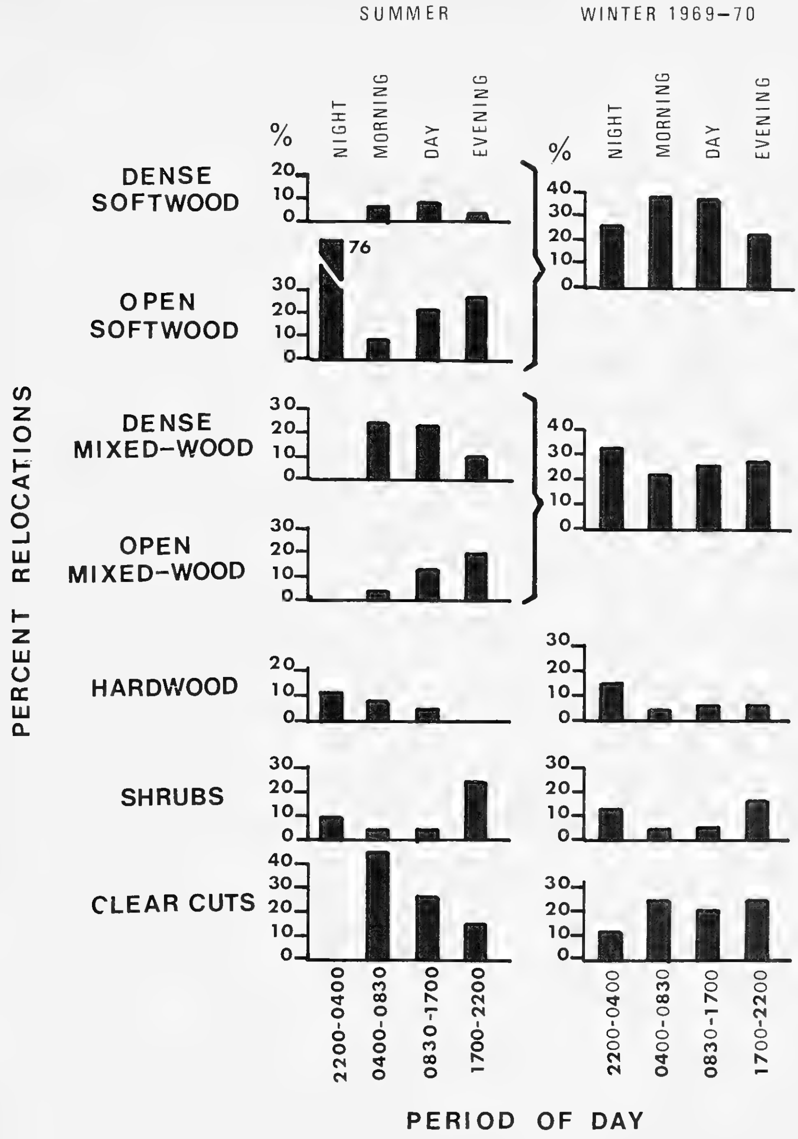

FIGURE 5. Percentages of deer locations in selected forest cover types by period of the day in summer and in winter 1969–70.

the effect of windchill on the choice of cover by deer was paramount. The use of dense mixed-wood increased with windchill ($r = 0.85$ and 0.91, respectively) (Figure 6). In contrast, the use of dense softwood decreased with windchill ($r = 0.82$).

Cover Use and Rain

Decreased use of dense mixedwoods ($r = 0.99$) and increased use of hardwoods ($r = 0.99$) and softwoods ($r = 0.97$) occurred when the weather changed from clear to rain in summer. The same trend occurred in the winter of 1969–70 when winter rainfall was abnormally high, but there was no clear trend in the 1970–71 and 1971–72 winters, possibly due to the lower rainfalls and the effect of deep snow.

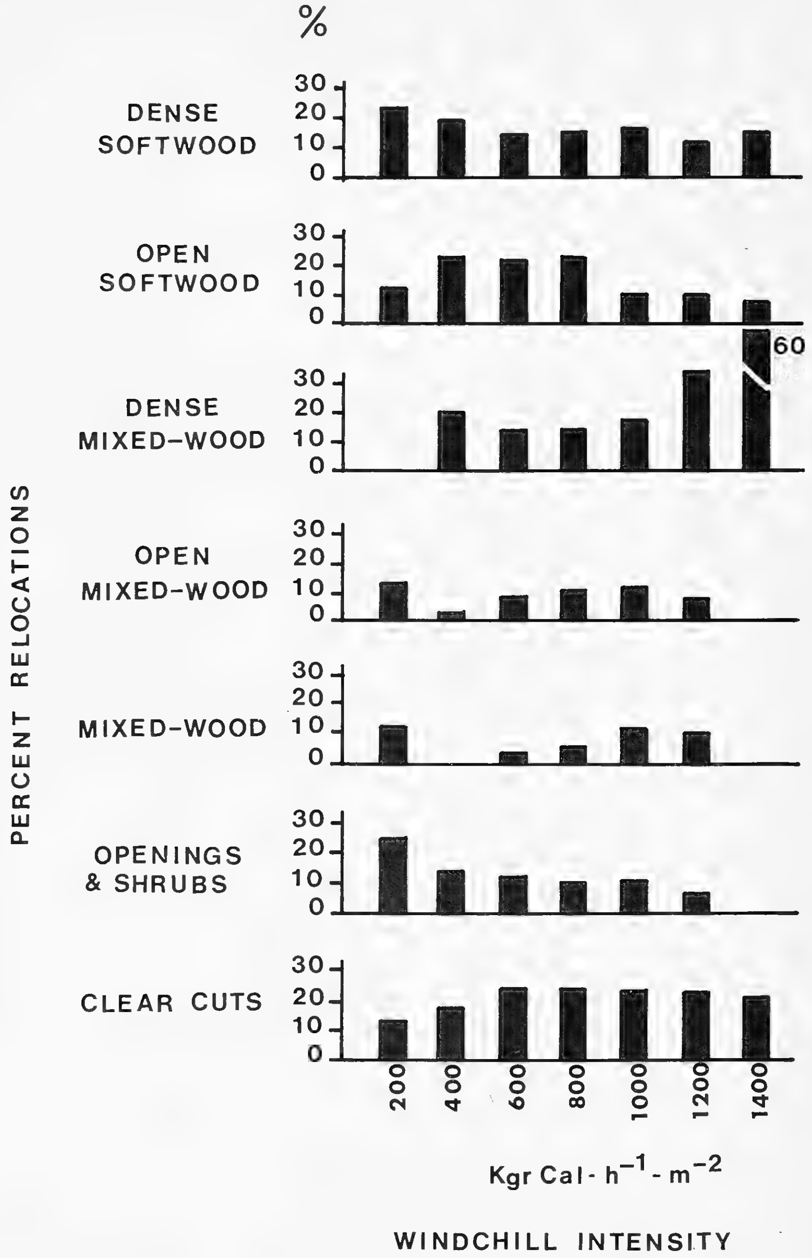

FIGURE 6. Percentages of deer locations in selected forest cover types by windchill intensity classes in winter 1969–70.

Heavy rainfall affected the choice of cover made by an adult male deer in winter 1969–70; he used dense softwood when nearly 25 mm of rain per day fell for 3 consecutive days. He used more open cover in fair weather.

Seasonal Movements

Late Fall — Early Winter Movements

No seasonal movements were observed in early winter of 1969 when snow depth did not exceed 30.4 cm. Deer were observed all winter in the same range they continued to occupy the following summer. Apart from the constant observations of the three marked deer, occasional track surveys showed that many other deer remained on their summer range that winter.

In early winter 1970, the situation differed markedly after heavy snowfall occurred early in the season. Many southward movements toward winter ranges occurred, but no animal was collared at the time of the migration.

In early winter 1971, as snow accumulated, deer began moving toward dense cover (spruce–cedar). As snow depth increased, the three deer collared at the time eventually moved toward more extensive winter ranges (mostly cedar–conifer swamps). The spruce–cedar cover used by two of them before their movement had been used by a few deer the preceding winter when snow depth was greater. A female fawn made the first movement on 24 December, when snow was 15 to 18 cm in the softwood–mixedwood cover and 25 cm in the hardwood. She moved 10 km to winter cover (spruce–cedar) located across a frozen river. On the way, she passed through similar cover that had been used by numerous deer the winter before. The second deer to depart was a spikehorn which left the area on 31 December, when snow had reached 20 to 25 cm in the softwood–mixedwood cover and 30 cm in the hardwood. He moved 14 km to a winter range (dense spruce–cedar–hemlock) located along the Saint John River. A third deer, another spikehorn which had been captured together with the second one, began moving after snow depth had peaked and decreased to 20–25 cm in the softwood–mixedwood and 32.5 cm in the hardwoods. He left the area on 11 January and moved the same distance as his companion, whom he rejoined on 14 January. They spent the rest of the winter together. On 20 October at the peak of the rutting season, a yearling buck suddenly left the range he had occupied since birth. He was shot 12.8 km away 5 days after the last observation.

Spring Movements

Spring movement to summer range was observed directly for four animals, and indirectly for one. Two female yearlings were recorded leaving their winter range (spruce–cedar) and migrating 7.7 and 12.8 km respectively toward their summer range (mixedwoods). We tracked the first deer within the same 300-ha area for most of the summer, but lost the second. Their departure from the winter range coincided with a rise in temperature to above 5.5° C for several days, and the disappearance of snow in the open. One of the two had left the area two weeks earlier only to return to the winter cover when a new snowfall occurred.

The spikehorns were followed back to the same summer range they had occupied the previous fall. They left their wintering area coincident with a spring flood and several days above 5.5° C. A yearling female also left her winter range on 10 May, coincident with daytime temperatures above 5.5° C, but without flooding.

Behavior

The fact that two spikehorns returned to the summer range they had left the preceding fall suggests tradition in the movement of deer. Two spikehorns captured together demonstrated the capacity to reunite on a winter range located 12.8 km from their separation point.

Response to handling varied greatly among individual deer. Some continued to use the same range in spite of repeated captures. Others changed their home or abandoned the area near the capture site, for reasons unknown, during the remainder of the tracking period.

Discussion and Conclusions

A dense forest of conifers and mixedwoods provides more protection against adverse weather than does a more open mixed and hardwood forest. Snow is not as deep in softwoods and mixedwoods than in hardwoods (Verme 1965). Ozoga (1968) reported that wind and windchill are less intense in dense softwood than in hardwoods. By using dense cover in winter deer conserve heat energy. In summer, tree crowns reflect heat; the denser and taller the stand, the less heat that reaches the air and soil beneath (Sukachev and Dylis 1964). In winter, however, the radiation balance between the rates of heat absorption and heat loss is clearly in favor of the deer, when the animal stands under a closed canopy. Heat gain is greater if the canopy is dense (Moen 1968). Moen (1968) and Reifsynder and Lull (1965) provide detailed reviews of radiation and forests. Choice by deer of different forest cover types reflected the particular shelter value of these cover types.

Deer responded dynamically to change of snow depth in the choice of cover. In a severe winter, deer showed preference for open softwood (with cedar as a constant characteristic), mixedwood, and hardwood, and showed less preference for dense softwood and clear-cuts, whereas in a less severe winter, they preferred open mixedwood and clear-cuts. Telfer (1970) also found less preference for dense softwood than for dense mixedwood in early winter; the preference was massively for dense softwood in greater snow depth later in the same winter.

It was fortunate to experience three winters of greatly different total snow accumulations during the study. Winter distribution patterns are flexible and deer stayed on their summer range when the snowfall was less than average. The increase in size of range in winter (mostly 1969–70) is comparable to the increase in South Dakota reported by Sparrowe and Springer (1970). Snow depths greatly influenced daily movements and movements toward and from winter ranges; deer did not restrict their movements in the absence of snow.

The size of deer range varied in relation to many environmental factors, but mostly snow depth (inverse correlations), as also stated by Rongstad and Tester (1969), windchill (positive correlation), and temperature (inverse correlation) (as also reported by Behrend 1966, who found that temperature accounted for 44% of the variability of the range size in winter). My results show that adaptation of deer to windchill may be more in the direction of seeking cover that offers food in quantity, as reported by Moen (1968). It may be questioned whether more energy is required at the temperatures experienced in New Brunswick; physiological changes may compensate for seasonal changes in temperature as reported by Silver et al. (1971) for deer in New Hampshire.

I believe that the polygon method of measurement exaggerated range size. The typical image given by the movement maps was a dense central activity core surrounded by peripheral points of occasional use. This pattern follows well the findings of Sparrowe and Springer (1970), who also reported ranges composed of a variable number of sub-areas that supply all the basic requirements of deer.

Deer travelled more during the night and evening in winter. The opposite pattern was recorded in Michigan by Ozoga and Gysel (1972), who found 60% of deer activity between sunrise and sunset, with a peak in mid- to late afternoon.

Spring dispersal is well correlated with temperature rise (number of degree-days above 5.5° C). Similarly, Hammerstrom and Blake (1939) found that in Wisconsin, spring dispersal of deer occurred only when the weekly average temperature had risen to 20° F (-6.6°C). Bartlett (1950) found that decreasing snow depth allowed deer to move more from the yards, and Gill (1957) indicated that top crusts were instrumental in causing deer to depart from yarding areas.

In summer, deer distribution did not seem independent of forest types, as found by Behrend (1966) in New York. The choice by deer of cover, mostly immature mixedwood, openings, and clear-cuts, varied with the period of summer, time of day, and weather conditions. Kohn and Mooty (1971) found that deer in Minnesota also exhibited consistent patterns of habitat selection in summer. Deer, at least young males, were persistent in their use of summer and winter cover.

My data show that in summer, deer movement is governed by the period of the day, as was also found by Behrend (1966) for white-tailed deer and by Miller (1970) for black-tailed deer (*O. hemionus columbianus*). Both observed, as I did, an increase of deer activity during the day. I found that higher summer temperatures restricted the movements of white-tailed deer. Linsdale and Tomich (1953) and Miller (1970) found the same relationships for black-tailed deer, and Loveless (1964) for mule deer (*O. h. hemionus*).

The size of summer ranges was the same as that measured by Sparrowe and Springer (1970) in South Dakota, 1.0 mi^2 (259 ha) and was larger that that measured by Kohn and Mooty (1971), (67–190 ha) for does in Minnesota. Summer range quality has been recognized by a few authors (Morton and Cheatum (1964) on white-tailed deer; Julander et al. (1961) on mule deer) as having the potential to affect productivity and growth rates of deer. Good management of summer range seems a necessity in order to attain maximum herd productivity. This study has shown that summer range consisting of a maximum of dense and open mixedwoods, well interspersed with small (50–75 ha) clear-cuts will be most used by deer. Range units containing those requirements should be not less than 300 to 400 ha.

The study has shown that wintering areas can be as far as 15 to 20 km from summer ranges, but all such movements observed were made through continuous forest cover. Wintering areas should contain a high percentage of softwood at advanced maturity with sufficient crown closure to ensure proper protection from snow accumulation and wind. Interspersion with small cuts is also desirable. Further studies by the author (unpublished data) tend to demonstrate that selective cuts, where 30% of the softwood (spruce–cedar) is still standing, are more readily used by deer in deep snow conditions (above 45 cm) than clear-cuts. My data show that groups of deer will use units of 300 to 400 ha of winter range. In years of shallow snow cover during the course of this study, a few deer have been observed in smaller areas (50 to 100 ha), but as snow increased, larger yards were sought. Well managed winter yards may not need to be as large as 300 to 400 ha, however, as deer will readily congregate wherever a food supply is abundant.

Results of this study support the concept of deer management units based on the area of influence of groups of winter ranges. Through improved harvest management, the level of deer populations in those units would be better balanced with the carrying capacity of the winter ranges than the existing county-based units.

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Literature Cited

Bartlett, I. H. 1950. Michigan deer. Game Division, Michigan Department of Conservation. 50 pp.

Behrend, D. F. 1966. Correlation of white-tailed deer activity, distribution and behavior with climatic and other environmental factors. Job Completion Report, State of New York, Project W-10S-R-7, Job V-A. 78 pp. mimeo.

Cochran, W. W. 1967. 145-160 MHZ beacon (Tag) transmitter for small animals. American Institute of Biological Sciences Bioinstrumentation Advisory Council, Information Module M15. 12 pp.

Gill, J. D. 1957. Review of deer yard management. State of Maine Department of Inland Fisheries and Game, Game Division, Bulletin 5. 61 pp.

Hammerstrom, F. N., Jr. and **J. Blake.** 1939. Winter movements and winter foods of white-tailed deer in central Wisconsin. Journal of Mammalogy 20(2): 206–215.

Heezen, K. L. and **J. R. Tester.** 1967. Evaluation of radio tracking by triangulation with special reference to deer movements. Journal of Wildlife Management 31(1): 124–141.

Julander, O., W. L. Robinette, and **D. A. Jones.** 1961. Relation of summer range condition to mule deer herd productivity. Journal of Wildlife Management 25(1): 54–60.

Kohn, B. E. and **J. J. Mooty.** 1971. Summer habitat of white-tailed deer in North Central Minnesota. Journal of Wildlife Management 35(3): 476–487.

Krefting, L. W. 1962. Use of sylvicultural techniques for improving deer habitats in the Lake States. Journal of Forestry 60: 40–42.

Liscinsky, S. A., G. O. Howard, and **R. B. Waldeisen.** 1969. A new device for injecting powdered drugs. Journal of Wildlife Management 33(4): 1037–1038.

Linsdale, J. M. and **P. O. Tomich.** 1953. A herd of mule deer. University of California Press, Berkeley. 567 pp.

Loveless, C. M. 1964. Some relationships between wintering mule deer and the physical environments. Transactions of the North American Wildlife Conference 29: 415–431.

Miller, F. L. 1970. Distribution patterns of black-tailed deer (*Odocoileus hemionus columbianus*) in relation to environment. Journal of Mammalogy 51(2): 248–260.

Moen, A. N. 1968. Surface temperatures and radiant heat loss from white-tailed deer. Journal of Wildlife Management 32(2): 338–344.

Morton, G. H. and **G. L. Cheatum.** 1964. Regional differences in feeding potential of white-tailed deer in New York. Journal of Wildlife Management 10: 242–248.

Nie, N. H., D. H. Bent, and **C. H. Hull.** 1970. Statistical package for the social sciences. McGraw Hill Book Co. 343 pp.

Odum, E. P. and **E. J. Kuenzler.** 1955. Measurement of territory and home range size in birds. Auk 72(2):

128–130.

Ozoga, J. J. 1968. Variations in microclimate in a conifer swamp deeryard in Northern Michigan. Journal of Wildlife Management 32(3): 574–585.

Ozoga, J. J. and **L. W. Gysel.** 1972. Response of white-tailed deer to winter weather. Journal of Wildlife Management 36(3): 892–896.

Reifsnyder, W. E. and **H. W. Lull.** 1965. Radiant energy in relation to forest. United States Department of Agriculture Technical Bulletin 1344. 111 pp.

Rongstad, O. J. and **J. R. Tester.** 1969. Movements and habitat use of white-tailed deer in Minnesota. Journal of Wildlife Management 33(3): 366–379.

Silver, H., J. B. Holter, N. F. Colovos, and **N. H. Hayes.** 1971. Effect of failing temperature or heat production in fasting white-tailed deer. Journal of Wildlife Management 35(1): 37–46.

Siniff, D. B. and **J. R. Tester.** 1965. Computer analysis of animal movement data obtained by telemetry. BioScience 15(2): 104–108.

Sparrowe, R. D. and **P. F. Springer.** 1970. Seasonal activity patterns of white-tailed deer in eastern South Dakota. Journal of Wildlife Management 34(2): 420–431.

Sukachev, V. and **N. Dylis.** 1964. Fundamentals of forest biogeocoenology. Oliver and Boyd, Edinburgh. 672 pp.

Telfer, E. S. 1970. Winter habitat selection by moose and white-tailed deer. Journal of Wildlife Management 34(3): 553–559.

Verme, L. J. 1965. Swamp conifer deeryards in Northern Michigan. Journal of Forestry 63(7): 523–529.

Verme, L. J. 1968. An index of winter weather severity for northern deer. Journal of Wildlife Management 32(3): 566–574.

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Factors Influencing Desertion of Colony Sites by Common Terns (*Sterna hirundo*)

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Morris, Ralph D. and Rodger A. Hunter. 1976. Factors influencing desertion of colony sites by Common Terns (*Sterna hirundo*). Canadian Field-Naturalist 90(2): 137–143.

Abstract. During the years 1972 to 1974, factors affecting the breeding biology of Common Terns (*Sterna hirundo*) were studied at five colony locations in the lower Canadian Great Lakes. At three of these colonies, no terns returned to breed in 1974, but at two other locations numbers remained stable or increased. We consider availability of nesting substrate, reproductive failure, food supply, human disturbance, predation, and exploitation competition by Ring-billed Gulls as explanations for these observations. We conclude that whereas the most probable cause of desertion can be suggested for specific colonies, experimental work is required to identify the actual cause(s), which may be multiple.

During the past three years we have studied the breeding biology of Common Terns (*Sterna hirundo*), Ring-billed Gulls (*Larus delawarensis*), and Herring Gulls (*L. argentatus*) at selected colony sites in the Canadian Great Lakes. During this period several major changes occurred in the numbers of gulls and terns. Most notably, at two colonies the numbers of terns returning to breed in 1974 were similar to, or higher than, levels recorded in previous years, whereas in three other colonies at widely separated locations no terns returned to breed in 1974.

Long-term changes in numbers have been reported for several species of colonial fish-feeding birds. Herring Gull numbers in New England colonies doubled every 12 to 15 years since 1900 (Kadlec and Drury 1968) although a more recent interpretation suggests that the population as a whole has been gradually stabilizing over the last two decades (Drury and Kadlec 1974). The Herring Gull population of Lakes Huron and Michigan increased from 24 000 to 43 000 individuals from 1960 to 1965 (Ludwig 1966). The Ring-billed Gull population of the Great Lakes increased from an estimated 27 000 pairs in 1960 to 141 000 pairs in 1967 (Ludwig 1974). Conversely, the Common Tern population in Massachusetts decreased from about 30 000 to 40 000 pairs in the 1920s, to 7500 pairs in the 1970s (Nisbet 1973a). Widespread decreases in Common Tern numbers have been related to occupancy of nesting islands by gull species (Crowell and Crowell 1946; Ludwig 1962; Nisbet 1972), which in some cases resulted in the terns nesting on less preferred islands where they may be more vulnerable to human disturbance, pollution, and predation (Nisbet 1973a). There is also some evidence that a recent reduction in breeding success may reflect local food shortage (Nisbet 1973a).

Marples and Marples (1934) and other naturalists since noted that Common Terns appear unstable in their attachment to colony sites. Such behavior is characterized by fluctuations in numbers or in nesting site location at the same colony, or occasionally by removals from one colony site to another for no obvious cause. Conversely, Austin (1949) and Chestney (1970) suggested that Common Terns exhibit a high degree of philopatry and site tenacity, returning to breed at the same colony location for many years. McNicholl (1975) argued that in larids generally, nest site tenacity is strongly developed in highly stable habitats. In unstable habitats, site tenacity is reduced while group adherence assists in the rapid pioneering of newly available, suitable habitats. He further suggested that both phenomena operate in fluctuating habitats, which permits colonization of new sites or recolonization of previously used sites. It would seem desirable therefore to consider further probable causes for desertion of colony sites by Common Terns so that those of biological importance can be further investigated.

This paper reports changes in numbers of

Common Terns, Ring-billed Gulls, and Herring Gulls at five colony loctions in the Canadian Great Lakes and presents several explanations for the changes in numbers of Common Terns.

Study Areas

Five colony sites were studied (Table 1). The Hamilton Harbor colonies were on two small (ca. 30 × 35 m each) artificial islands of limestone rock at the western end of Lake Ontario. The Muggs Island colony was on the edge of a sandy hillock on Muggs Island, one of a chain of six islands offshore from Toronto in western Lake Ontario. The Port Colborne site contained two colonies, one near a lighthouse at the Lake Erie terminus of the Welland Canal, the other approximately 1 km away near an industrial property (Algoma Steel Company, Canada Furnace Division) on the east bank of the canal. The substrate of both colonies varied from loose pebbles to a smooth concrete base and was covered by variable amounts of vegetation. The South Limestone colony was centrally located on one of three islands which form the South Limestone Island group, approximately 10 km offshore in eastern Georgian Bay, northwest of Parry Sound, Ontario. The limestone substrate was mostly covered by an extensive stand of mossy stonecrop (*Sedum acre*).

Nesting associates of Common Terns at the colony sites were as follows. On Muggs Island a large Ring-billed Gull colony occupied the major portion of the sandy hillock with one edge completely contiguous to the tern nesting area. Herring Gull nests were widely scattered with the closest one 20 m from the tern colony. Ring-billed Gulls and Herring Gulls also nested at both Port Colborne colonies. At the lighthouse site both gull species were spatially separated from the terns that were nesting on a low concrete shelf (approximately 7 × 300 m). The gulls were nesting on elevated piles of loosely grouped limestone rock, above and about 10 m to the west ot the tern colony. At the Canada Furnace site, portions of the tern colony were contiguous to a large Ring-billed Gull colony although the extent and nature of this distribution changed from one year to the next. Herring

TABLE 1—Estimated numbers of adult Common Tern, Ring-billed Gull, and Herring Gull individuals at colony sites in the lower and middle Great Lakes

Colony site	Year	Total estimated numbers		
		Common Tern	Ring-billed Gull	Herring Gull
Lake Erie				
Port Colborne 'Canada Furnace'	1973	2200	25 000–28 000	52
	1974	2200	27 000–30 000	86
Port Colborne 'Lighthouse'	1973	2500	750+	100+
	1974	2500–2750+	1000–1200 ±	128
Lake Ontario				
Hamilton Harbor Islands	1972	150+	0	0
	1973	42*	0	0
	1974	0	0	0
Muggs Island	1972	600–700	4500–5000	22
	1973	112	6000+	72
	1974	0	7000+	28
Lake Huron				
South Limestone Island, Georgian Bay	1972	1500–1800	25 000–28 000	150–200
	1973	1500–1800	30 000–33 000	150–200
	1974	0	35 000–38 000	150–200

*Nesting on the adjacent mainland.

Gull nests were widely scattered. At South Limestone Island, one edge of a large Ring-billed Gull colony was completely contiguous to the tern colony. No gull species were nesting with the terns at the Hamilton Harbor site.

Methods

Colonies were visited on a regular basis each year, most commonly daily or every other day from early May to late August. The exceptions were the South Limestone colony which was visited six to eight times in each year, Muggs Island, visited four times in 1974, and Hamilton Harbor, visited about 12 times in 1974. Numbers of Herring Gulls at each site (except for South Limestone) were based on actual nest counts during each breeding season. All birds appeared to be attached to a nest site and thus numbers represent known breeders. Estimated numbers of Common Terns for all colonies except South Limestone were based on a detailed knowledge of the number of incubated clutches within substantial portions of the total areas occupied by each colony. This was facilitated by the construction of extensive fenced enclosures around the major nesting sites at the Port Colborne lighthouse and Muggs Island colonies, around substantial portions of the Port Colborne Canada Furnace colony, and by the small size and isolated nature of the Hamilton Harbor colonies. Estimated numbers of Ring-billed Gulls were calculated on the basis of average nest density in representative areas of each colony and on the known extent of the total nesting areas.

Results and Discussion

The estimated number of birds of each species at each colony site in each year is shown in Table 1. The Port Colborne sites were not censused in 1972. The most striking aspect of these data is the disappearance of Common Terns at three colony locations in 1974 whereas numbers at the two other colonies remained stable or increased in this year. The numbers of Ring-billed Gulls continuously increased at all colony locations. We consider several explanations for these observations.

Available Nesting Substrate

The reduction in numbers of Common Terns at the Hamilton Harbor site in 1973 is most readily explained by the almost complete inundation of the islands, caused by unusually high water levels in the Great Lakes, the highest in 21 years (Department of Transport, Hydrological Records Division, Ottawa, Ontario). The 42 Common Terns which nested in Hamilton Harbor in 1973 used an alternative site on the adjacent mainland. In 1974, despite the availability of the islands as a nesting area due to reduction in water levels, no birds nested anywhere in the harbor area. Failure to colonize the islands in 1974 was possibly due to the former island nesters returning to an alternative site established elsewhere during the 1973 breeding season.

Failure of Common Terns to nest at the South Limestone and Muggs Island sites in 1974 (Table 1) cannot readily be explained by the absence of nesting habitat. At both locations, extensive areas of nesting substrate, apparently identical to that used by terns in previous years, were immediately adjacent and contiguous to former nesting sites. Furthermore, these areas were not occupied by either gull species in 1974 nor in other years. The extent of the suitable but unoccupied habitat on South Limestone Island was approximately 1.5 ha. No Common Tern adults or nests were seen during a visit to South Limestone Island on 28 May 1974 although visits to the island in 1972 and 1973 revealed that most terns were incubating completed clutches by the first week of May. No terns were seen during return visits in June and July 1974 although the Common Tern colony had been large and active at least since 1969 (D. Christie, personal communication and Table 1). Muggs Island contained in 1974 approximately 0.5 ha of sandy beach identical and immediately adjacent to similar habitat used by the terns in the two previous years. No adult terns or nests were seen when the island was visited on 16 May 1974, a time when in previous years most Common Terns were incubating completed clutches. No terns were seen during return visits in June and July despite the continued availability of extensive nesting habitat.

Thus, while the absence of suitable nesting substrate was a major factor contributing to the desertion of the Hamilton Harbor colony in 1973, it does not seem adequate in itself to explain the failure of the colonies at Muggs and South Limestone Islands.

Reproductive Failure

Serious reproductive failure over a number of years would result in a gradual numerical reduction and finally in abandonment of a colony site. Common Terns are believed to exhibit the characteristic of deferred maturity (Palmer 1941; Austin and Austin 1956), which results in individuals remaining on the wintering ground after their initial fall migration, returning to breed in their third or fourth year. We do not have breeding data for the colonies prior to 1972 and so cannot comment on the extent of reproductive success or failure which may have influenced numbers present in 1974. The recent fledging rates for the Port Colborne colony, however, are well within the range cited from other locations in North America and England (Table 2), while those reported for the Muggs Island colony are in the lower end of the recorded range for the species. Thus it is possible that a suboptimal recruitment rate caused by unknown factors in the years preceding our observations, contributed to the reduction in numbers of adults at Muggs Island (Table 1) and finally to the abandonment of the colony. One factor known to have contributed to a reduced recruitment rate at the Muggs Island colony, at least in 1972, was the loss of a substantial number of nests by water erosion of the sand substrate in June (Morris and Hunter, unpublished data). The nests lost contained both eggs and chicks. Similar losses in previous years would result in a continuous depression of the annual recruitment rate and, unless extensive renesting occurred, contribute to the observed decline in numbers at the Muggs Island colony.

Continual reproductive failure may also have contributed to the eventual abandonment of the Hamilton Harbor colonies. The fledging rates of these colonies (Table 2) were the lowest recorded at any of our study locations (Morris and Hunter, unpublished data) and, if representative of the reproductive success of the colonies in previous years, may have contributed to the eventual reduction in numbers observed in 1974. There is some suggestion from our data that pollutant (PCB and DDE) loads in the eggs and tissues of the Hamilton Harbor birds were contributing to the low reproductive success of the colonies, although this interpretation awaits further analysis.

Unfortunately, no precise reproductive data are available for the South Limestone Island colony. Eight visits to the island between 2 June and 8 August 1972 (S. Teeple, personal communication) showed that several reproductive parameters were similar to those of the relatively successful Port Colborne colony in the same year. The mean recorded clutch size was 2.49 ($n = 113$) on South Limestone Island, compared to 2.61 ($n = 348$) at Port Colborne. The calculated hatching rate from 910 marked eggs at the Port Colborne colony was 80.5%. Three hundred and twenty-five eggs were marked at the South Limestone colony of which 49 were nonviable. Assuming that all the remaining marked eggs hatched, the calculated hatching rate of 85.0% exceeds that of the Port Colborne colony. Of the eggs which failed to hatch at Port Colborne, however, 32 (18.1%) disappeared between daily visits to the colony. Assuming a similar disappearance rate at South Limestone, the estimated realized hatchability of 81.5% indicates a hatching performance similar to that of the Port Colborne colony.

We recognize that hatching rates alone are incomplete indicators of ultimate reproductive success in a given year. But there was never any indication during visits to the South Limestone colony that serious reproductive failure was occurring. Indeed, on several occasions during June and July in 1972 and 1973, RDM noted numerous active nests with healthy pre-fledge chicks and very few weak or dead chicks anywhere within the colony. On the basis of these considerations we suggest that reproductive failure alone cannot explain the reduction in numbers of Common Terns on South Limestone Island.

Food Supply

A few quantitative studies have related food supply to reproductive success in Common Terns but none have suggested inadequate local food supplies as a cause for sudden and permanent desertion of tern colonies. Nisbet (1973b) suggested that adequate food supplies were necessary for good pair bond formation and subsequent breeding success in Common

TABLE 2—Realized fledging rates of selected Common Tern colonies

Colony site	Year	Number of chicks fledged per nest	Source
Muggs Island	1972	0.185	Morris and Hunter, unpublished
	1973	0.34	
Port Colborne	1972	0.945*	Morris and Hunter, unpublished
	1973	0.32–1.4**	
Hamilton Harbor	1971	0.20:0.21†	Gilbertson, unpublished
	1972	0.07;0.16†	Morris and Hunter, unpublished
Coquet Island	1965	1.22	Langham 1968
Plymouth Island	1970	0.54	Nisbet and Drury 1972
Bird Island	1970	1.59	Nisbet and Drury 1972
	1971	2.09††	Nisbet and Drury 1972
Scott Head Island	1958–1968	0.25–0.30	Chestney 1970
Chip Lake	1969	0.113	Switzer et al. 1971

* Port Colborne, Lighthouse colony.
** Extremes from eight locations within the Port Colborne area.
† Known values for the two island sites.
†† Deserted nests excluded; birds nesting at peak of season.
NOTE: Nisbet and Drury (1972) reported fledging rates in 13 plots. The three values cited represent plots with the greatest number of visits by the investigators.

Terns, and Lemmetyinen (1973) proposed that reduced breeding success in offshore colonies of Arctic Terns (*S. paradisaea*) was related to inadequate supplies of their fish food, principally three-spined sticklebacks (*Gasterosteus aculeatus*).

We did not measure food supply at any of the colonies and therefore cannot comment extensively on the possibility that a gradual or sudden reduction in food supply contributed to declines in numbers of terns at Muggs and South Limestone Islands. Extensive daily observations at the Lake Erie and Lake Ontario colonies in 1972 and 1973 never revealed any indication that adult birds were experiencing difficulty feeding their chicks. Numerous casual observations at the South Limestone colony similarly revealed no sign of an acute local food shortage. It seems unlikely therefore that a reduction in local food supplies was solely responsible for the simultaneous decrease in numbers of terns at two widely separated locations.

Human Disturbance and Predation

Several authors have suggested that human disturbance (Austin and Austin 1956; Nisbet 1973a) and predation (Nisbet 1975; Hunter and Morris, *in press*) are factors contributing to reduced breeding success in Common Terns. None of the tern colonies which we studied was subject to extensive human disturbance, as all were either protected bird sanctuaries or on privately controlled land. Furthermore, our more frequent visits and consequent potential disturbance to the colonies on Lake Ontario and Lake Erie did not result in reduced breeding success or colony desertion as the Port Colborne colonies experienced relatively high breeding success (Table 2).

Kadlec and Drury (1968) commented on predation of Common Tern eggs and chicks by gull species, and Hatch (1970) suggested that the annual toll of Arctic Tern chicks taken by Herring Gulls may be as high as 0.48–1.2 chicks per adult tern pair. Despite intensive diurnal observations at all Lake Erie and Lake Ontario colonies we never saw Common Tern eggs taken by either Ring-billed or Herring Gulls and only a few, almost-fledged chicks were attacked. Furthermore, during many nocturnal visits by RAH to the Muggs Island and Port Colborne colonies, nocturnal predation by either gull species was never observed. We have shown (Hunter and Morris, *in press*) that a Black-crowned Night Heron (*Nycticorax nycticorax*) caused the temporary departure of adult terns from the Port Colborne colony during several nocturnal periods in 1973 and consumed small numbers of tern eggs and chicks. Except for these incidents, there is no evidence that extensive predation by resident or transient predators was sufficient to explain the failure of terns to colonize any of the three geographically isolated colony locations in 1974.

Exploitation Competition

Our estimates of Ring-billed Gull numbers reflect a stable or moderately increasing population on Muggs Island and a rapidly increasing population on South Limestone Island (Table 1). To accomodate this increase, the Ring-billed Gulls on Muggs and South Limestone Islands expanded their nesting areas to include substantial portions of the substrate occupied by Common Terns in previous years. The expansion on Muggs Island in 1973 and 1974 was an estimated 0.25 ha per year; on South Limestone Island, the Ring-billed Gull colony markedly expanded at its southern edge at a rate of 20–30 m per year. Expansion at both sites occurred without a reduction in total area occupied and without any apparent reduction in nest density in formerly occupied sites. Furthermore, nest density in newly occupied areas was, on average, similar to that of other areas in each colony (2 nests per m^2).

Ring-billed Gulls initiate and complete egg-laying in advance of Common Terns. For example, egg-laying by Ring-billed Gulls in a fenced central portion of the Muggs Island colony was 50% complete by 7 May 1972 and 90% complete by 9 May 1972 ($n = 105$ nests). The corresponding dates for Common Terns at Port Colborne were 25 May 1972 and 6 July 1972 (Morris and Hunter, unpublished data). Directly comparable data for terns at Muggs Island are unavailable. Our data, however, show that egg-laying in all Common Tern colonies in 1972 was 50% complete by 22–25 May and 90% complete by 3–12 July.

It follows that occupancy of a nesting area by Ring-billed Gulls would directly or indirectly preclude use of those sites by Common Terns. Occasional interactions occur between individuals of the two species nesting in immediate proximity to one another. But the intensity and frequency of these interactions do not appear sufficient to cause either displacement or reproductive failure of either species *during* the nesting season. This statement is based on casual and extensive observations over three years during both diurnal and nocturnal periods with the express purpose of identifying possible negative interactions between individuals of these two species. Thus, as a consequence of earlier arrival and initiation of nesting by Ring-billed Gulls at colony sites also occupied by Common Terns, a long-term gradual displacement of terns by gulls could be a major factor influencing the permanence of tern colonies. Such competition for a common and limited resource would be exploitative rather than direct behavioral interference (*cf.* Miller 1967), or in Nicholson's (1954) terms, a 'scramble' rather than a 'contest' with the most efficient competitor gaining access to the resource.

Previous authors have noted displacement of Common Terns by Ring-billed and Herring Gulls where either species coexists on islands with Common Terns (Crowell and Crowell 1946; Ludwig 1962; Howard 1968; Nisbet 1972), and Beardslee and Mitchell (1965) stated the cause of reduction in numbers of terns on Mohawk (Gull) Island in Lake Erie as "recent nesting of Herring and Ring-billed Gulls on the island" (p. 260). It is not clear, however, from any of these studies whether sudden reductions in numbers of terns ever occurred or whether suitable habitat remained unoccupied by gulls after disappearance of terns from the nesting sites.

At the Port Colborne Lighthouse colony, where numbers of terns increased between 1973 and 1974 (Table 1), competition for nesting sites by Ring-billed Gulls did not occur as a result of the spatial separation of the two species. At the Canada Furnace colony, where numbers of terns remained the same in 1973 and 1974, portions of the tern colony were contiguous with the Ring-billed Gull nesting area in all years, and areas used by terns in 1973 were occupied in 1974 by gulls. As a test for the importance of competition by gulls we predict an imminent reduction in the numbers of Common Terns at the Port Colborne Canada Furnace site.

In summary, we suggest that loss of habitat and reduced reproductive success possibly reinforced by toxicant chemicals explains the loss of the Hamilton Harbor colonies, whereas at the Muggs Island colony, a reduced reproductive success caused by unknown factors and competition by Ring-billed Gulls for nesting sites resulted in desertion of the colony in 1974. On the basis of the available evidence, the disappearance of the previously large and active Common Tern colony at South Limestone Island seems best explained by continued exploitation competition by Ring-billed Gulls possibly hastened by some factor unknown to us. We suggest the urgent need for experimental studies designed to determine which combination of factors are causing an apparent widespread reduction in the numbers of Common Terns at colonies in the Great Lakes and elsewhere in North America.

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Literature Cited

Austin, O. L. 1949. Site tenacity, a behavioural trait of the Common Tern. Bird-Banding 20: 1–39.

Austin, O. L., and **O. L. Austin, Jr.** 1956. Some demographic aspects of the Cape Cod population of Common Terns (*Sterna hirundo*). Bird-Banding 27: 55–66.

Beardslee, C. S. and **H. D. Mitchell.** 1965. Birds of the Niagara frontier region. Bulletin of the Buffalo Society of Natural Science, Volume 22.

Chestney, R. 1970. Notes on the breeding habits of Common and Sandwich Terns on Scolt Head Island. Transactions of the Norfolk Norwich Society 21: 353–363.

Crowell, E. M. and **S. Crowell.** 1946. The displacement of terns by Herring Gulls at the Weepicket Islands. Bird-Banding 17: 1–10.

Drury, W. H. and **J. A. Kadlec.** 1974. The current status of the Herring Gull population in the northeastern United States. Bird-Banding 45: 297–306.

Hatch, J. J. 1970. Predation and piracy by gulls at a ternery in Maine. Auk 87: 244–254.

Howard, D. V. 1968. Do New England Terns have a future? Massachusetts Audubon, September 1968.

Hunter, R. A. and **R. D. Morris.** 1976. Nocturnal predation by a Black-crowned Night Heron at a Common Tern colony. Auk. (*In press.*)

Kadlec, J. A. and **W. H. Drury.** 1968. Structure of the New England Herring Gull population. Ecology 49: 644–676.

Langham, J. P. 1968. The biology of terns, *Sterna* spp. Ph.D. thesis, University of Durham.

Lemmetyinen, R. 1973. Clutch size and timing of breeding in the Arctic Tern in the Finnish archipelago. Ornis Fennica 50: 19–28.

Ludwig, J. P. 1962. A survey of the gull and tern populations of Lakes Huron, Michigan and Superior. Jack Pine Warbler 40: 104–119.

Ludwig, J. P. 1966. Herring and Ring-billed Gull populations of the Great Lakes, 1960–1965. Great Lakes Research Division, University of Michigan, Publication 15. pp. 80–89.

Ludwig, J. P. 1974. Recent changes in the Ring-billed Gull population and biology in the Laurentian Great Lakes. Auk 91: 575–594.

Marples, G. and **A. Marples.** 1934. Sea terns or sea swallows. Country Life Press, London.

McNicholl, M. K. 1975. Larid site tenacity and group adherence in relation to habitat. Auk 92: 98–104.

Miller, R. S. 1967. The pattern and process of competition. *In* Advances in ecological research IV. *Edited by* J. B. Cragg. Academic Press, New York. pp. 1–74.

Nicholson, A. J. 1954. An outline of the dynamics of animal populations. Australian Journal of Zoology 2: 9–65.

Nisbet, I. C. T. 1972. Disaster year for terns. Man and Nature, December 1972.

Nisbet, I. C. T. 1973a. Terns in Massachusetts: present numbers and historical changes. Bird-Banding 44: 27–55.

Nisbet, I. C. T. 1973b. Courtship, feeding, egg size and breeding success in Common Terns. Nature (London) 241: 141–142.

Nisbet, I. C. T. 1975. Selective effects of predation in a tern colony. Condor 77: 221–226.

Nisbet, I. C. T. and **W. H. Drury.** 1972. Measuring breeding success in Common and Roseate Terns. Bird-Banding 43: 97–106.

Palmer, R. S. 1941. A behavioural study of the Common Tern. Proceedings of the Boston Society of Natural History 42: 1–119.

Switzer, B., V. Lewin, and **F. H. Wolfe.** 1971. Shell thickness, DDE levels in eggs and reproductive success in Common Terns (*Sterna hirundo*) in Alberta. Canadian Journal of Zoology 49: 69–73.

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Protection of Vegetation in Ecological Reserves in Canada[1]

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Abstract. Security of the land is necessary for the preservation of vegetation growing on it; governmental legislation is required to achieve this in Canada. The concept of ecological reserves offers the best protection for native plants if appropriate management plans are made. Most of the publicly owned lands in Canada are under the control of provincial governments so that legislation has to be prepared at this level. At present, only British Columbia, Quebec, and New Brunswick have passed special legislation that deals specifically with ecological reserves. Ontario and some of the other provinces use existing legislation to protect natural areas that are equivalent to ecological reserves. For adequate control and management, an ecological reserve system should have a director-in-charge with a technical advisory committee; British Columbia, Quebec, and New Brunswick have such a structure. Management plans for each reserve are necessary, based on the objectives of the reserve. In the plan, a mechanism should be outlined for the reporting of activities, resolving of conflicts between users, and the reviewing of plans by participants. Research which forms the ecological basis for management, including that which is designed to lead to improved management of the area, must be encouraged.

Canada has large tracts of undisturbed land, some of which are very suitable for ecological reserves. Fortunately, both federal and provincial governments and private groups have recognized the value of ecological reserves in general terms, but unfortunately, to very different degrees. The federal government especially, seems unaware of the urgency of the matter or reluctant to act in the face of strong industrial lobbies. A number of agencies, including several federal and provincial government departments, such as the Canadian Committee for the International Biological Program, Canadian Institute of Forestry, Nature Conservancy, and National Second Century Fund, are now involved in the search for, as well as the establishment and management of, such reserves. The National Research Council of Canada has recently established an Associate Committee on Ecological Reserves with representatives from all of the regions of the Canadian Committee for the International Biological Program—Conservation of Terrestial Communities Subcommittee (CCIBP-CT) Regions. It is significant that the role of this group is largely coordinative and advisory since it has no budget. A central agency should be established to coordinate the above activities.

Under the National Parks Act, "national parks are hereby dedicated to the people of Canada for their benefit, education, and enjoyment, subject to the provisions of this Act and the regulations, and such Parks shall be maintained and made use of so as to leave them unimpaired for the enjoyment of future generations" (National Parks Branch 1969). The establishment of national parks in Canada does not fill the requirement for scientific use of natural areas although protection of plants is given through land-use zoning (Weetman 1973). It is unlikely that enough national parks would be established to protect all types of flora and fauna that require protection. There is considerable variation in purpose and use of the individual national parks but basically they are associated with the recognition of recreation as a major resource use, defining recreation in broad terms (Sheard and Blood 1973; Nelson 1970). The intention of the National Parks Act needs more interpretation and purposes of parks need to be clearly defined for the guidance of park administrators. National park policy is restrictive in

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possibilities for doing research, particularly if the purposes of "education" and "enjoyment" are interfered with (Cragg 1969). More recent proposals include the recognition of five land-use classes for national parks (Falkner and Carruthers 1974) according different degrees of protection and types of use. The five classes are strict preservation, wilderness, natural environment, outdoor recreation, and intensive use areas. Destructive use and research which need not be done within park boundaries, however, would not be permitted.

For adequate protection of plants and animals in Canada, we must look to ecological reserves. Several terms are used for this type of reserve: in the USA, "research natural areas" and "reference areas" are widely used; in the USSR, "state nature areas" (or "zapovedniks"); in Great Britain many terms are used including "nature reserves"; while at recent international meetings of Man and the Biosphere, the term "biosphere reserves" has been adopted (Peterson 1974).

For a definition of ecological reserves, the statement contained in the 1974 report from the Maritimes (Taschereau 1974) could be applied throughout Canada:

> "Ecological Reserves are legally protected natural areas where human influence is kept to a minimum. Change, itself a natural phenomenon, is not interfered with, but is allowed as far as possible to proceed uninterrupted by man. They contain examples of characteristic or rare plant and animal communities, or are areas of biological or physiographical importance. Though most natural areas comprise ecosystems with a history of relatively little human disturbance, ecosystems that have been modified by man have value for scientific research. Such areas offer an opportunity to observe developmental processes in the modified ecosystem and to study distinctive habitats, soil conditions and plant associations that result from man's influence."

Control of Land Base

Security of the land area is necessary for the preservation of the plant and animal populations on it. In Canada, governmental legislation is required for the protection, long-term management, and use of ecological reserves (Franson 1972). There can be and are many forms of legislation to protect such areas. Most of these legislative mechanisms, however, are lacking in general guidelines for selection criteria and management requirements for long-term use (Peterson 1974). Such guidelines can be useful if they are not too specific or confining. Legislation should offer security or permanency of tenure, at least to the point of requiring a public hearing before being revoked. In the long term, understanding and support from the public is necessary for the establishment and successful maintenance of a national network of ecological reserves.

Ecological reserves are held in several ways in Canada: the principal ones are federally-owned lands, provincially-owned lands, and those held by private environmental organizations. The federal lands have no long-term assurance of statutory protection as ecological reserves nor a government declaration recognizing that such areas require long-term protection and special management plans (Peterson 1974).

With regard to provincially-controlled lands, only British Columbia, Quebec, and New Brunswick have legislation covering ecological reserves. These provinces have advisory committees or councils, British Columbia and Quebec have directors-in-charge of their ecological reserve projects (Krajina et al. 1974; Lemieux 1975; New Brunswick 1975). Ontario has a director and committee operating under existing rather than specific ecological reserves legislation. Alberta, Saskatchewan, and Newfoundland are presently considering the necessity of developing specific ecological reserve legislation or determining if the concept can be dealt with under existing legislation. In British Columbia, the Ecological Reserves Act precludes disposition of the ecological reserves under any other Acts of the province. Sixty-five reserves had been set aside under the above legislation as of June 1975, and have been selected on the basis of biogeoclimatic zones, plant habitat types, and special zoological features such as seabird islands (Krajina et al. 1974).

Ecological reserves on private lands are important components of a national system of reserves since representative samples of many plant habitat types are only available on privately owned lands. The purchase of these lands often becomes necessary if another form of tenure cannot be obtained. Areas are being purchased for ecological reserves mostly through the Nature Conservancy in several provinces and the National Second Century Fund in British Columbia.

Most public land in Canada is owned by the provinces so that the main impetus for control and management of ecological reserves has to come at this level. The reserves programs of the various provinces and of managing agencies should be coordinated at the federal level, however, if all biogeoclimatic zones and habitat types are to be represented. A significant effort towards coordination of ecological reserves has been made through the Conservation of Terrestrial Communities Subcommittee of the Canadian Committee for the International Biological Program which has subdivided Canada into ten regions (Fuller 1970). The CCIBP-CT has also published a national directory of IBP areas (La Roi and Babb 1974). Also, the Canadian Institute of Forestry has established a national registration system for forested natural areas (Weetman 1973) and the Society for Range Management is doing the same for rangeland areas in parts of Canada and the United States (Laycock 1975).

Management Planning

After the purposes of each ecological reserve are identified (eg., study of plant succession towards climax, maintenance of specified seral communities, preservation of specific plant or animal species, gene pools, etc), it must be established that there is minimal interference from the land use in the area surrounding the reserve. Next, sound management plans have to be drawn up in line with the purpose of the reserve before management techniques can be put into practice. Criteria and standards for the nature of use, control of research, and allowable improvements must be set out in the administrative and management plans. Mechanisms for the reporting of activities, resolving of conflicts between users, and review of detailed plans by participants should also be outlined. Technical advisory committees are of great assistance in planning.

Research is a necessary adjunct to good management planning on ecological reserves. Research should be suggested and encouraged by the advisory committees for the reserves since it forms the ecological basis for managing the plant and animal life in the ecosystems involved. As part of the management plan, the flora and fauna must be described for the area, both qualitatively and quantitatively, and the degree of fragility assessed. Methods must be worked out for maintaining particular seral species or communities for research or simulating natural processes where the natural balance has been destroyed. Many scientists also believe that it is important for management plans to include the use of reserves as education centers (Maini and Carlisle 1974) and this has become a major issue in some parts of Canada. Possible uses of a reserve depend greatly on the nature of the site, its fragility and sensitivity. The writer has been involved for many years with a reserve which forms an environmental study center for a large school district in the Drybelt of British Columbia. The survival of this sensitive area has only been made possible because of a concerned advisory committee, a knowledgeable, alert, and conscientious director, and a sound management plan. The plan is continually under revision based on site monitoring, carrying-capacity estimates, use of alternate sites, etc.

The Canadian Institute of Forestry (Weetman and Cayford 1972) recommends against research within an ecological reserve that involves habitat or species manipulation, that is, scientific use of these areas should be essentially observational. A similar policy is suggested for the northwestern portion of the United States (Franklin and Trappe 1968). There is disagreement among our scientists, however, as to what extent manipulative research should be allowed; a significant number would permit such research. It seems that the decision should be site-specific depending on the objectives for the reserve. A compromise would be to disallow such research in an experimental-control portion of the reserve but have other parts zoned for various types of research to meet the objectives of the particular reserve.

Management Techniques

Any vegetation complex can be preserved only by controlling the complicated successional forces that have created it and which, if unchecked, will in turn destroy it (Stone 1965). Since vegetation is never static, preservation must consist of managing change, that is, determining what changes can be tolerated and what techniques will bring these about and meet the objectives for which the particular reserve was established. The emphasis for management should be based on habitats rather than on occupying organisms since the maintenance of suitable habitats is necessary for the survival of species. Much of ecological reserve management involves preventing or compensating for man's effect on the area being managed, or on adjacent areas (Houston 1971).

Weetman and Cayford (1972) suggest that physical improvements in forested reserves should be limited to unobtrusive trails, fences, and sheds needed for scientific and educational work and be confined to those that do not impair the function of the reserve. Construction, including roads, trails, and buildings should be discouraged at or near the reserve boundaries. Manipulative techniques such as burning must be carefully considered to see if they will have the desired effect and that natural conditions will be approximated if they are applied. The Canadian Institute of Forestry suggests that wildfires originating within or adjacent to the reserves be brought under control as quickly as possible and that no clean-up or reforestation be undertaken. Insect control may be necessary where other natural ecological processes will be disrupted by insect activity or where the results would destroy an ongoing research program. It may be necessary to fence an area to keep domestic livestock or wildlife out, to maintain a desired balance of seral species, or to simulate grazing pressure from a source now removed. Sometimes, wildlife, such as deer, has to be controlled by hunting or by re-introducing predators to maintain the ecological balance and prevent possible destruction of a segment of the community.

If part of the reserve is destroyed accidentally, natural plant succession should usually be allowed to proceed normally except where recovery by natural means does not appear to be feasible within an acceptable time framework. In such cases, artificial seeding or planting of native species, preferably using local seed, may be considered after careful evaluation of the consequences. The intentional introduction of exotic species by man should not be permitted. Artificial practices may sometimes be necessary to eliminate populations of exotic species that have overpopulated the area and have no natural enemies or means of being controlled.

In Canada, we have reached some of our goals only in the establishment and management of ecological reserves, but there is an awareness among enough people of the importance and urgency of the situation for us to be encouraged that we may soon have a national system of reserves that is sound and functional if a concerned public continues to pursue this goal with vigor.

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Literature Cited

Cragg, J. B. 1969. Research in national and provincial parks: possibilities and limitations. *In* Canadian parks in perspective. *Edited by* J. G. Nelson and R. S. Scace. Harvest House, Montreal. pp. 111–122.

Falkner, A. C. and **J. A. Carruthers.** 1974. National Parks in Canada. *In* Conservation in Canada: a conspectus. *Edited by* J. S. Maini and A. Carlisle. Canadian Forestry Service Publication 1340. pp. 143–168.

Franklin, J. F. and **J. M. Trappe.** 1968. Natural areas: needs, concepts, and criteria. Journal of Forestry 66: 456–461.

Franson, R. T. 1972. Legislation to establish ecological reserves for the protection of natural areas. Osgood Hall Law Journal 10: 583–605.

Fuller, W. A. 1970. International Biological Program—Conservation of terrestrial communities. Canadian Field-Naturalist 84: 189–190.

Houston, D. B. 1971. Ecosystems of national parks. Science (Washington) 172: 648–651.

Krajina, V. J., P. A. Larkin, J. B. Foster, and **D. F. Pearson.** 1974. Ecological reserves in British Columbia. Canada Committee of International Biological Program. Conservation of Terrestrial Communities Subcommittee, Region 1 (British Columbia). Vancouver. 185 pp.

La Roi, G. H. and **T. A. Babb.** *(Editors).* 1974. Canadian National Directory of IBP areas. Canada Committee of International Biological Program, Conservation of Terrestrial Communities Subcommittee. Botany Department, University of Alberta. 915 pp.

Laycock, W. A. *(Chairman).* 1975. Rangeland reference areas. The Society for Range Management, Denver, Colorado. 72 pp.

Lemieux, G. 1975. Quebec Ecological Reserves Act: A social approach to the conservation of our biological heritage. Social Science in Canada (Social Science Research Council of Canada). (*In press.*)

Maini, J. S. and **A. Carlisle.** 1974. Conservation of ecological reserve in Canada. *In* Conservation in Canada: a conspectus. *Edited by* J. S. Maini and A. Carlisle. Canadian Forestry Service Publication 1340. pp. 169–187.

National Parks Branch. 1969. National Parks policy. Canada Department of Indian Affairs and Northern Development, Ottawa. 21 pp.

Nelson, J. G. *(Editor).* 1970. Canadian parks in perspective. Harvest House, Montreal. 343 pp.

New Brunswick. 1975. Ecological Reserves Act. Province of New Brunswick. Queen's Printer, Fredericton. 8 pp.

Peterson, E. B. 1974. A national system of ecological reserves for Canada. Brief for Canadian Committee of International Biological Program. Conservation of Terrestrial Communities Subcommittee for submission to Environment Canada, Edmonton, Alberta. 31 pp.

Sheard, J. W. and **D. A. Blood.** 1973. The role of national parks in Canada and criteria for their management. Canadian Field-Naturalist 87(3): 211–224.

Stone, E. C. 1965. Preserving vegetation in parks and wilderness. Science (Washington) 150: 1261–1267.

Taschereau, P. M. 1974. Ecological reserves in the Maritimes. Canadian Committee of International Biological Program, Conservation of Terrestrial Communities Subcommittee Terminal Report, Scientific Advisory Panel for Region 7 (Nova Scotia, New Brunswick, Prince Edward Island). Part 1. Halifax. 26 pp.

Weetman, G. F. 1973. Forested natural areas in Canada. Forestry Chronicle 49: 95–98.

Weetman, G. F. and **J. H. Cayford.** 1972. Canadian Institute of Forestry policy for selection, protection and management of natural areas. Forestry Chronicle 48: 41–43.

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Interactions between Men and Wolves at an Arctic Outpost on Ellesmere Island

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Abstract. For three months in the summer of 1973 and one month in the winter of 1974 the behavior of wolves in the vicinity of an arctic weather station was recorded, in order to note their use of, and response to, human settlement. Records of wolves from the early years of the weather station are reported and compared with current data. Most wolves seen near the settlement foraged at the garbage dump. They generally avoided humans and domestic dogs. Several different wolves were seen near the dump in summer, and most stayed only briefly, whereas in winter a single local pack visited and remained for several hours at a time. These observations illustrate the possible deleterious impact of human settlement on arctic wildlife and suggest that these effects can be avoided by better planning and regulations.

As the Canadian Arctic is increasingly used for a variety of human activities it is of growing importance that we examine the consequent effects, direct and indirect, on wildlife, so that we can assess more completely the social costs and benefits of these activities. In this study I attempted to determine the influence of human presence on the behavior and ecology of the high arctic wolf, *Canis lupus arctos.* This northernmost subspecies of wolf occupies the arctic islands north of 74°N (Banfield 1974) and little is known of its abundance and habits within this range. This paper describes both direct encounters between men and wolves and the indirect effect on wolves of human concomitants such as garbage and domestic dogs (*Canis familiaris*).

Study Area and Methods

Observations were centered around the Atmospheric Environment Service weather station complex at Eureka (80°00′ N, 85°56′ W), Ellesmere Island, from 27 May to 27 August 1973 and from 14 February to 13 March 1974. The main weather station buildings and fuel supplies are situated on the north shore of Slidre Fiord at the mouth of Station Creek (Figure 1). Additional storage and accomodation buildings are grouped near the western end of an airstrip 1.5 mi (3.3 km) to the northeast. A garbage dump situated in a gully at the other end of the mile-long airstrip marks the eastern extent of the settlement. The human population of Eureka was 11 in the winter and fluctuated between 20 and 44 during the summer.

Observations in summer were made from a tent, used as a blind, erected on a ridge ¼ mi (400 m) east of the garbage dump. The area was surveyed using binoculars and telescope, and whenever possible, wolves were followed on foot after they left the area visible from the tent, or at about ½ mi (800 m) distance. In the winter the area between the weather station and the dump was surveyed for wolves throughout the course of daily walks occupying the daylight hours. Other data were obtained from incidental observations and from the weather station records.

Direct Encounters Between Men and Wolves

Historical Review

From the establishment of the weather station at Eureka on 8 April 1947 until 28 February 1954 (and with the exception of January to September 1952), a daily journal written by the station personnel recorded the presence of wolves on 102 occasions. Just over half (58) of these records specified that the wolves were shot or "driven off" when seen, and a total of 31 wolves was killed and 7 injured during this period. The remaining 44 records were too terse or ambiguous to make clear the human response but 21 suggested that the wolves were unmolested

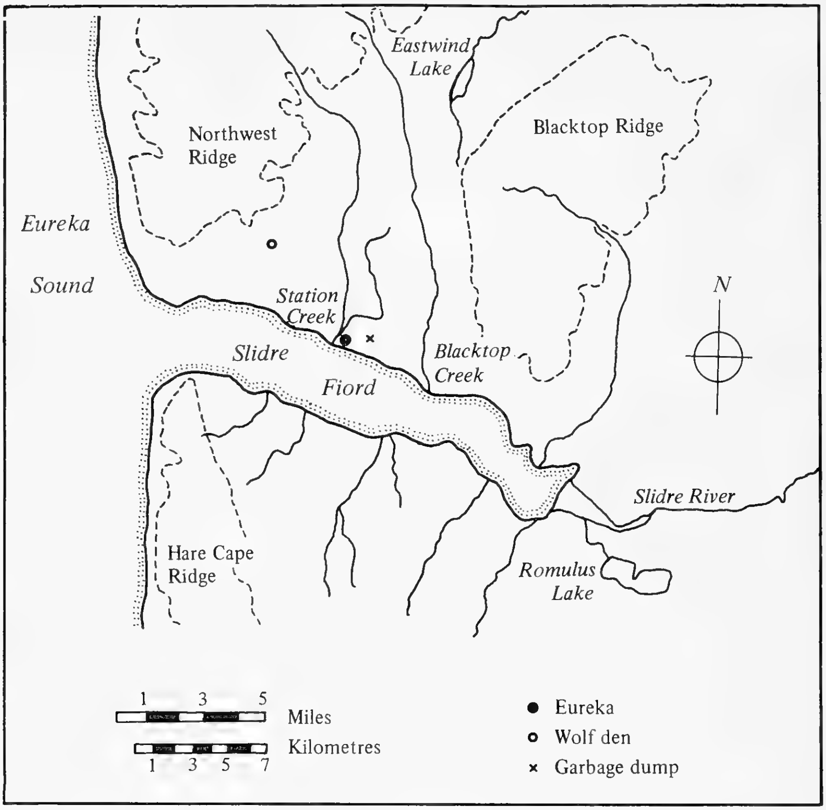

FIGURE 1. Study area near Eureka, Ellesmere Island.

because it was too dark, or they were too distant, or because they were discerned only from tracks or howls.

Although these records may suffer bias in that non-aggressive encounters were less likely to be recorded than aggressive ones, they clearly illustrate the predominant human response to wolves during these years, made explicit in a journal entry for 10 December 1947 stating that instructions were given to treat wolves as "dangerous predators." There were no records of wolves chasing or attacking the men.

From 1954 to the present no records of the number of wolves killed at Eureka are available; however, a single wolf was shot in March 1973 on suspicion of being rabid (R. Heartz, personal communication).

We can conclude from these early records that wolves were common visitors to the weather station from the moment it was founded, and that their visits were not discouraged by the frequent use of firearms against them. Direct encounters with men were generally inimical to wolves.

Response of Wolves to Observer

Are wolves, as was believed, a danger to humans? The absence of hostility to men by wolves has been described by a number of researchers, in anecdotal form (e.g., Parmelee 1964; Mech and Frenzel 1969). In an attempt to quantify wolves' responses to man I noted their behavior and mine on each encounter.

I observed wolves on 42 (45%) of 94 days in the summer and on 11 (44%) of 25 days in the winter. On 27 occasions in summer and seven in winter the wolves also saw and responded to me. On seven encounters in summer and two in winter I was within 20 ft (6 m) of a wolf; the maximum distance for recorded encounters was about 440 yd (0.4 km). The number of wolves per encounter ranged from one to seven, but with few exceptions the individuals in a group all responded alike.

During encounters my behavior, in crude terms, included standing still, lying still, approaching (walking towards), or walking (in any direction other than straight towards). The behavior of the wolves included standing and lying still, approaching, circling (encompassing more than 180°), retreating (moving straight away from an approaching figure or abruptly changing direction to move away from an immobile figure), and howling. More than one of these behaviors could occur in a single encounter.

The most common response of wolves to myself was to retreat or continue on their course (Table 1). These two responses accounted for 58% of all outcomes of encounters. With one exception wolves always retreated when I approached them, even when they were with cubs or by a kill. The exception was a male wolf on neighboring Axel Heiberg Island (which has no history of permanent human settlement). He stood while I approached to within a few feet, although his female companion retreated. When I walked away he followed me. Two days later the same wolf approached me as I stood by a tent.

Four encounters near Eureka comprised the remaining cases in which I was approached by wolves, but in all four the wolves' goal was apparently not myself. In the winter five wolves ran towards me as I stood on the garbage dump by some burning, fresh garbage. I walked away and they continued as far as the garbage. Another time in winter I was walking to the dump when I noticed two wolves following me. I turned aside and stopped. The wolves also stopped, looked, then continued to the dump. In summer two male wolves, which I had caused to leave a seal they had killed on fiord ice, lay at a distance then returned to the seal directly after I walked away. Finally, as I lay on a track near the dump in summer I was approached by a female wolf intent on watching a retreating truck. She saw me when only about 5 yd (4.5 m) away, started, walked up and sniffed me, then stood still. When I moved slightly she jumped and ran away.

We can conclude from this evidence that wolves with experience of man are generally wary of humans, even when there are several wolves and a single unarmed man. There is no evidence that they are "dangerous predators" of our species.

Indirect Effects of Men on Wolves

Use of Garbage Dump

Scavenging by wolves on human refuse is the most conspicuous of the indirect relationships between wolves and men. In order to evaluate the influence of the dump on wolf behavior it is necessary to know when and how often wolves visited it, how long they stayed, and how many different animals were involved. Summer and winter data will be considered separately.

(1) *Frequency and Duration of Visits*

On nine days in June and four in July I undertook, with an assistant, continuous 24-h watches on the dump. On all other days in summer, observations of the dump were at random and for variable periods of time. No more than two wolves at a time were seen at the dump in summer, and of the total 40 observed visits, 25 were by single wolves and 15 by pairs (Table 2). There was a small gradual increase in

TABLE 1—Responses of wolves to a human observer

Observer actions	Responses of wolves							Total
	Stand	Lie	Approach	Circle	Retreat	Continue	Howl	
Stand	2	6	2	3	8	10	3	34
Lie		2	1	2		6	2	13
Approach	1				13			14
Walk		1	4			4		9
Total	3	9	7	5	21	20	5	70

TABLE 2—Recorded visits by wolves to Eureka dump

	June	July	August
Total days dump watched	23	13	21
Total days wolves seen at dump	9	3	11
Total visits by wolves	14	5	21
Mean visits per day seen	1.5	1.7	1.9
Total visits by pairs	5	5	5

TABLE 3—Duration of visits by wolves to Eureka dump in summer

	June	July	August
Total wolves seen (singles)	9	0	11
(pairs)	10	8	6
Minimum minutes at dump			
(singles)	9	—	1
(pairs)	11	66	9
Maximum minutes at dump			
(singles)	86	—	172
(pairs)	94	187	109
Mean minutes at dump (singles)	21	—	37
(pairs)	33	120	51

the frequency of visits from the beginning to the end of the summer.

The total duration of visits in summer was recorded on 32 occasions on which both the arrival and departure of the wolves were seen (Table 3; Figure 2). In the case of pairs the time spent at the dump by each animal was listed separately. The mean length of visit thus obtained was 50 min, but the duration was on average over twice as long for pairs as for single wolves (67 min vs. 30 min). This may reflect the added confidence given by an extra pair of eyes and ears.

In winter I visited the dump regularly throughout daylight hours (ranging from 4 to 9 h) on 25 days, and saw wolves at the dump on eight of those days. The number of individuals present together ranged from two to seven (Table 4). Only one visit (by a pair) was seen to begin and end within a single daylight period, and had a duration of 90 min. At all other times wolves were at the dump either on my arrival near dawn or my departure near dusk. Twice wolves present at dusk were seen at dawn the following day, which suggests they had remained at the dump overnight. It is, in any case, quite clear that the pattern of use of the dump in winter differed from that in summer in that wolves visited in larger groups and remained for longer in the winter.

(2) *Timing of Visits*

For most of the year in the high Arctic there is no strong diurnal light or temperature rhythm, which is known to influence the movements of wolves in more southerly latitudes (Joslin 1966; Murie 1944). Therefore, I postulated that the rhythm of human activity near the dump in summer (negligible in winter) might determine the timing and duration of visits by wolves during that season. During thirteen 24-h observations I found that 76% of human visits to the dump occurred between 0600 and 1800 CST, but that wolf visits were more equally divided between the two halves of the day, with a slightly higher frequency during the period of least human activity (Table 5). The duration of wolf visits, however, was slightly greater when most human visits took place, perhaps because wolves were then more likely to find food unplundered by gulls or foxes (unpublished data on feeding habits).

Wolves were seen at the dump during all but 1 of the 24 h, and did not always leave on the arrival of humans. The termination of 42 visits was seen, of which human disturbance was responsible for 18 (43%). Wolves visited the dump on all days of the week and, during a continuous 1-week watch in June, appeared on 4 of the 7 days. I conclude that there was no regular diurnal or hebdomadal pattern in wolves' visits to the dump, and that human activity by the dump did not seriously affect the timing of visits.

(3) *Occurence of Different Wolves*

How often would any individual wolf or group visit the dump? It was not possible to distinguish individuals with accuracy on every occasion, but at least 12 different animals were seen at the dump during the summer (5♂♂, 6♀♀, 1 unknown). Five of these (2♂♂ and 3♀♀) were members of one pack which had a

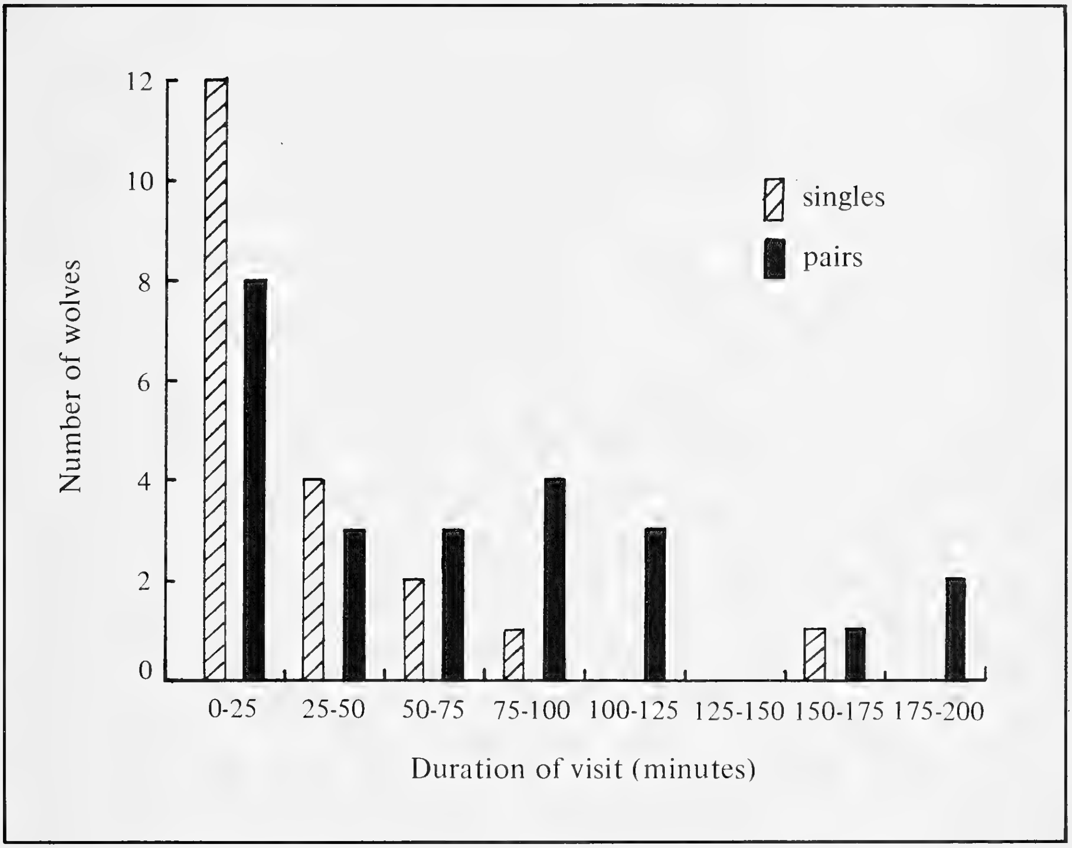

FIGURE 2. Duration of visit by single and paired wolves at Eureka dump in summer.

den with three cubs 4.5 mi (7.2 km) northwest of the dump: between them they were responsible for 27 (67%) of the total 40 recorded visits. A male from this pack, easily distinguished by a limp in his right hind leg, was seen at the dump 20 times (alone on 11 occasions and with a companion on 9). There was a marked increase in the frequency of his visits between June (when he was seen five times on 4 days) and August (seen 13 times on 8 days).

Of the seven wolves not from this pack, one pair of males was seen twice on 1 day only, in June, arriving from the west and departing southeast across the fiord; and one 1-year-old wolf of unknown sex was seen once only on the same day, also arriving from the west and leaving southeast. One female was seen three times in June, arriving from and departing southeast over the fiord ice each time. One pair (male and female), together with a third wolf which did not join them on the dump, was seen once only in July. They arrived from the north, chased off a pair of the "den pack" wolves, and eventually departed east. Finally, one female was seen on four occasions in August, always arriving from and departing east.

The evidence indicates that two categories of wolf visited the dump: local wolves in whose normal range the dump was included, and who visited it frequently; and non-local wolves which were "passing through" the area and were not regular visitors.

In winter the male with a limp was seen at the dump with a group of seven wolves. This group was presumably the same "den pack," with grown cubs, seen the preceding summer. The male was identified on 19, 23, and 25 February, and 11 March. Assuming the wolves seen on 20

TABLE 4—Observations of wolves at Eureka dump in winter

Date	Number of wolves	Notes on wolves	Duration (minutes)
Feb. 16	4+	Scared by observer. Ran north at 1145	—
19	7	Arrived from west 1445. Remained until dusk at 1615	90+
20	7	Present on arrival 1200. Left to east at 1445	165+
23	6	Present on arrival 1300. Scared away at 1430	90+
25	5	Arrived from south 1200. Remained until dusk at 1615	255+
26	4	Present on arrival 1115. Left to north at 1215	60+
Mar. 9	2	Arrived from west 1515. Left to west at 1645	90
11	6	Present on arrival 0930. Remained until dusk at 1800	510+

and 26 February to be the same group as seen on the respective preceding days (see Table 4), then this single pack was responsible for at least six of the eight visits by wolves to the dump in winter. (The variation in pack number from four to seven is explained by the temporary absence of some pack members or my failure to see all the wolves present.) I conclude that human refuse attracts most strongly those wolves normally found close to the site of garbage disposal, and that these wolves learn to include the dump regularly in their foraging range.

Response of Wolves to Dogs

A variable and unspecified number of dogs has been kept at the weather station since its foundation, and a total of 19 interactions between wolves and dogs was recorded in the station journal. In 10 of these encounters the dogs "chased away" the wolves. (The number of dogs involved was not recorded, but in eight incidents they chased a single wolf and in two cases two wolves.) On six occasions the wolves were hostile to the dogs—two times each in February and October and once each in December and August. (One dog was killed by six wolves, a pup was killed by an unknown number of wolves, and two wolves were seen eating a dog. The other three incidents involved packs of 3, 3, and 12 wolves "attacking" one or two dogs.) In the remaining three cases, one wolf "played with" one dog (September); one wolf "played with" an unknown number of dogs for 2 h (October); and an unknown number of dogs went "to meet" two wolves (June). Wolves, we may conclude, can be considered potential predators or potential mates of dogs (Gipson et al. 1975), and dogs may both attract and repel wolves.

TABLE 5—Diurnal distribution of wolf and human visits to Eureka dump during thirteen 24-h observations in summer

	Time (CST)	
	0600–1800	1800–0600
Number of human visits	68	21
Number of wolf visits	5	8
Mean duration of wolf visits (minutes)	75	61

Two dogs were resident at the weather station throughout the summer and winter: a male German Shepherd cross and a female St. Bernard cross. Two other dogs had been killed by wolves before the summer, one in March and one in April 1973.

I observed three encounters between dogs and wolves in the summer. In June a female wolf was chased by both dogs near the dump. She was overtaken and the three animals walked around the dump for 50 min, the dogs with erect tails and the wolf crouching with tail between legs. The wolf was ignored unless she withdrew from the dogs, whereupon the latter approached and the wolf stood still. When the dogs left the dump the wolf followed them at about 50 yd (45 m) until they were lost from view.

In July the two dogs chased a pair of wolves (1♂, 1♀) from near the dump. Whenever the dogs came to within about 10 yd (9 m) of the wolves the male wolf turned and the dogs stopped. After about 15 min the dogs returned and the wolves lay watching them.

In August the dogs accompanied me to the wolf den and chased a hare (*Lepus arcticus*) nearby, while I was on a ridge ¼ mi (400 m) from the den. Three wolves (1♂, 2♀♀) appeared by the den, howling, and three cubs ran behind them over a ridge. The dogs returned to me while the three wolves lay watching. After 75 min the dogs approached the den whereupon the wolves advanced and the five animals met in the valley between the ridges. They stood within a few feet of each other, slowly walked around, then lay with the dogs facing the wolves. After 20 min the bitch returned to the ridge on which I was concealed. Five minutes later the remaining dog rose and turned. The three wolves instantly rose and approached, the dog looked back, and the wolves stopped and watched while he retreated. Five minutes later the dogs chased another hare near the den and the wolves ran after them until all were lost from sight. The five animals returned a few minutes later running together. The wolves stopped on their ridge and the dogs returned to me. The cubs had remained out of sight all this time, and shortly thereafter the dogs and I left.

Genetically and behaviorally wolves and dogs are very similar, and it is generally believed that domestic dogs are derived from the wolf (Iljin 1941). The observations on their interactions detailed here suggest that they generally react to one another as conspecifics, at least when the dogs are of a size and form resembling the wolves.

Discussion

The relatively simple ecosystem of the remoter northern Arctic, to which man is but a recent addition, provides a situation in which the effects of human intrusion can most vividly be seen and measured. Evidence shows that the role of man in the ecology of the wolf near Eureka has changed over the past quarter century. Whereas in early encounters the wolf commonly fell prey to man (despite a fixed belief by the latter that the reverse was usually the case), hostility to wolves today is virtually absent in the area. From conversations with regular personnel and visitors at Eureka I conclude that feelings of prestige, pleasure, and interest were commonly associated with seeing wolves in the wild, although there remains an attitude that they were not to be trusted at close quarters.

Current regulations establish the entire arctic archipelago as a game preserve in which only Eskimos may hunt or trap, although an ordinance provides for the issue of licences for the removal of a limited number of specimens for scientific purposes. The Northwest Territories, however, is also the last remaining large area of Canada in which a bounty for wolves is offered by the government. In view of the fact that wolves present no threat to human interests in the area it is clearly well past the time when this archaic and useless regulation was removed.

In the long term, indirect human influence seems likely to be a more important factor in wolf ecology than bounty hunting. Data show that both local and non-local wolves foraged at the dump throughout the summer and that local wolves spent long periods there in winter. Locally-born wolves undoubtedly learn to consider the dump as a source of food.

We can speculate what the results of a widespread dump-foraging habit among wolves might be, as this situation has arisen in the case of polar bears (*Thalarctos maritimus*) in the vicinity of Churchill, Manitoba. One result may be the impairment of health and a decreasing effectiveness of wolves as predators, reinforcing the dump habit. Alternatively, the extra food supply may increase wolf survival and thereby increase pressure on their prey. Finally, dump foraging encourages close contact between men and wolves. The breeding of contempt by familiarity, on both sides, may lead to a situation in which human life is endangered. The only possible positive result of the habit is that it leads to wolves being commonly seen. Since the potential consequences of dump foraging are deleterious to wolves, and possibly to man, it is reasonable to recommend that the habit be discouraged by incineration of garbage or the fencing off of dumps.

Dogs, introduced to the Arctic by man, probably have little or indirect effect on wolf ecology when in small numbers. (They possibly have greater impact on other species such as hares, which they kill, and musk-ox, *Ovibos moschatus*, which they harrass.) The many stringent regulations intended to conserve wildlife in the Arctic include no mention of the introduction or control of dogs, however, which breed at liberty. A small pack of dogs would seriously affect the local animals and, since they are kept today largely as pets, their numbers in remoter settlements should be limited.

In addition to the effects of men on wolves described, minor influences seen during the study include the use of man-made tracks by wolves (which would tend to lead them to sites of human activity); and the scattering of wolves' usual prey (hares and musk-ox) by low-flying aircraft, which, in separating herds, may change their susceptibility to wolf predation.

Man, often unwittingly, frequently subtly, is changing the arctic ecosystem by his activities there. Recognition of the mechanisms of change is a first step towards a wiser use of this land for the benefit of all. The influence of men on wolves outlined here shows some of these mechanisms and indicates how we need to be more considerate of the wolf and other animals.

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Literature Cited

Banfield, A. W. F. 1974. The mammals of Canada. University of Toronto Press, Toronto. 438 pp.

Gipson, P. S., I. K, Gipson, and **J. A. Sealander.** 1975. Reproductive biology of wild *Canis* (Canidae) in Arkansas. Journal of Mammalogy 56(3): 605–612.

Iljin, N. A. 1941. Wolf–dog genetics. Journal of Genetics 42: 359–414.

Joslin, P. W. B. 1966. Summer activities of two timber wolf (*Canis lupus*) packs in Algonquin Park. M.Sc. thesis, University of Toronto. 99 pp.

Mech, L. D. and **L. D. Frenzel, Jr.** 1969. Continuing timber wolf studies. Naturalist 20(1): 30–35.

Murie, A. 1944. The wolves of Mount McKinley. United States National Park Service Fauna Series Number 5. 238 pp.

Parmelee, D. F. 1964. Myth of the wolf. Beaver 1964 (spring issue): 4–9.

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Weights and Growth of Dall Sheep in Kluane Park Reserve, Yukon Territory

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Bunnell, Fred L. and Neil A. Olsen. 1976. Weights and growth of Dall sheep in Kluane Park Reserve, Yukon Territory. Canadian Field-Naturalist 90(2): 157–162.

Abstract. Age-specific, live weights of 14 adult and 11 subadult Dall sheep (*Ovis dalli dalli*) are presented. The animals weighed 3–4 kg at birth and attained weights of 27–30 kg within 9 months.Rams sustained their weight growth longer than ewes, and males in the age class 4 years and older weighed 23–27 kg more than females of this age class. Length measures show less disparity between sexes, although hindfoot length is slightly larger in males than in females. Known weight measures for Dall sheep are summarized.

In their paper on weights and growth of Rocky Mountain bighorn sheep (*Ovis canadensis canadensis*) Blood et al. (1970) noted that "Despite increased wildlife research activity in the last 20 years, basic descriptive data for some of our most important game species are still not found in published literature." For several game species, published information is still rare. A recent annotated bibliography of North American wild sheep (Post 1971) records one note presenting weights of Dall sheep (*Ovis dalli dalli*). That note (Ulmer 1941) presents four weights of adult rams plus earlier estimates of Sheldon (1909), Shiras (1912), and Seton (1909). Our review of the literature has revealed only two further published records. Rausch (1951) reported weights of a single adult male and single adult female; Hoefs (1974) published the changes in weight of a single captive Dall ram over a 17-month period.

As wildlife management becomes increasingly intensive and addresses such questions as energetics and range utilization (e.g., Moen 1973) or the influences of snow on mammal movement (Kelsall and Telfer 1971), such basic information as individual weight becomes increasingly important. Although the acquisition of weight and other morphological measures was not a major objective of our studies of Dall sheep, some measurements were made during the course of the studies.

The objective of this paper is to provide weights and measures that will be useful for comparison with other herds of *O. d. dalli* and that will assist characterization of wild sheep taxa. Similarly, these weights may be useful to workers engaged in studies such as those of Moen (1973) and Kelsall and Telfer (1971) cited above.

Study Area and Methods

Observations reported here were collected during study of the "Sheep Mountain" herd west of Kluane Lake in the southwestern Yukon Territory. "Sheep Mountain" is a member of the Kluane Range, a "front range" of the St. Elias Range, and is encompassed by the boundaries of the proposed Kluane National Park. The dominant trees of the area are white spruce (*Picea glauca*) and aspen (*Populus tremuloides*). Common graminoids include *Carex stenophylla, Deschampsia caespitosa,* and *Calamagrostis purpurescens,* while *Artemisia frigida, Arctostaphylos uva-ursi,* and *Rosa acicularis* are the most abundant shrubs. A more comprehensive description of the study area is provided by Hoefs and Benjey (1971).

Sheep were trapped on winter range at elevations of 915–1000 m. Most individuals were measured in the months of January through April 1971 and 1972. Two rams were measured in November 1970 and three lambs were measured in May 1970 and June 1971. Animals were trapped in unbaited corral traps which intersected their normal travel routes. They were blindfolded and weighed to the nearest pound by hoisting them from the ground in a canvas sling suspended from a spring scale. Length and girth measurements were taken at the time of weighing. Measurements follow the definitions of Anderson (1948) and were recorded to the nearest ⅛ inch. To avoid undue harassment not all measures were taken when several individuals were captured simultaneously. Thus, the sample size for individual measures is not constant (Table 1).

Age was estimated from annuli on the horns (Hemming 1969). Among the few recaptures there were no discrepancies in estimated ages.

Results and Discussion

Weight gain over the period from birth in May or June until the following January is rapid (Figure 1). Female Dall sheep weigh about 7–9 lbs (3–4 kg) at birth and 60–65 lbs (27.3–29.6 kg) 9 months later. The single male lamb measured weighed 9 lbs. Data of Blood et al. (1970) and McEwan (*in press*) indicate that lambs of Rocky Mountain bighorn sheep attain much of their first year complement of weight (66–70 lbs or 30.0–31.8 kg) by October. We measured no weights of young-of-the-year in the fall months, and note only that by January of the year following birth Dall sheep and Rocky Mountain bighorn sheep have attained approximately the same weight (sample size is small but Dall sheep probably weigh 2–3 kg less than bighorn at this time).

Dall sheep rams appear to sustain their growth for longer than ewes and may still be increasing their weight at age 6 years while ewes have attained full weight by age 4 years (Figure 1). Sexual differences in growth pattern are thus similar to those documented for Rocky Mountain bighorn (Blood et al. 1970), barren ground caribou and muskoxen (McEwan, *in press*). At the time of his monograph on the distribution and variation in native North American sheep, Cowan (1940) noted that there were too few data to comment on sexual dimorphism in thin-horned sheep. Although our data are still few, we can state with some confidence that males in the age class 4 years and older weigh approximately 25 kg or 56 lbs more than females of this age class (Table 1). Average weights of animals 6 years and older are 107.4 ± SE 1.03 lbs ($n = 8$) for females and 164.2 ± 6.45 lbs ($n = 6$) for males.

The heaviest ram recorded weighed 181 lbs (82.3 kg); the heaviest ewe weighed 111 lbs

TABLE 1—Weights and measures of adult[1] Dall sheep, *Ovis dalli dalli*

	Males					Females				
	n	$\bar{x} \pm$ SE	CV[2]	Minimum	Maximum	n	$\bar{x} \pm$ SE	CV[2]	Minimum	Maximum
Live weight (kg)	6	74.6 ± 2.9	9.6%	72.5	82.3	8	48.8 ± 0.5	2.8%	46.4	50.5
Heart girth (cm)	5	115.9 ± 2.5	4.9%	110.0	124.0	2	108.5 —	—	105.0	112.0
Neck girth (cm)	5	50.7 ± 0.7	3.2%	49.0	53.0					
Shoulder height (cm)	5	102.6 ± 1.9	4.1%	109.0	98.0					
Ear length (cm)	6	8.9 ± 0.1	2.2%	8.5	9.2	9	8.7 ± 0.1	3.9%	8.0	9.0
Tail length (cm)	5	8.7 ± 0.5	13.8%	7.0	10.0	9	8.4 ± 0.2	8.8%	7.0	9.0
Hindfoot length (cm)	6	39.9 ± 0.7	4.3%	37.0	41.6	9	37.1 ± 0.4	3.6%	35.0	39.0
Total length (cm)	6	163.3 ± 3.9	5.8%	155.0	174.0	9	152.6 ± 2.1	4.0%	142.0	162.0

[1] Only sheep 72 months of age or older are included in the table.
[2] $\mathrm{CV} = \frac{\mathrm{SE}}{\bar{x}} \times 100\%$

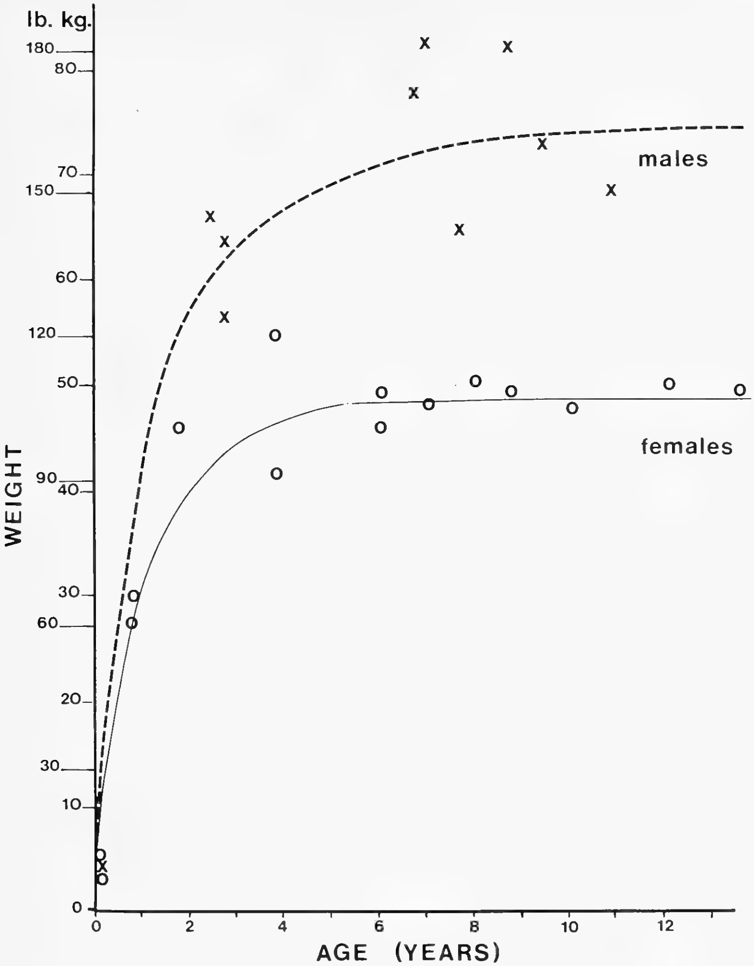

FIGURE 1. Weight versus age for wild male and female Dall sheep (curves are fit by eye).

(50.5 kg). Average weights of adult ewes are about 66% of average weights of adult rams. This value falls within the range of 61–77% reported for sheep of four subspecies of *Ovis canadensis* by Blood et al. (1970).

Patterns of growth in chest-girth are similar to those for weight. Chest-girth in rams appears to increase at least to 10 years of age (Figure 2). There are fewer measures for ewes, but the full adult girth is apparently attained earlier. The differences in weight between sexes are not clearly reflected in differences in chest-girth or total length (Figure 3), particularly in the 2- to 4-year-old age classes. Although length measures are slightly larger in males than in females there generally is less sexual differentiation in these measures than in weight measures (Table 1). There is a weak tendency for growth in total length to continue past the age of 4 years in both sexes. Growth in hindfoot length, tail length, and ear length (data not shown), however, does not continue past 4 years of age for either sex (Figure 3). These patterns of growth are similar to those documented for Rocky Mountain bighorn (Blood et al. 1970) and California bighorn, (*O. c. californiana* (Sugden 1961), and corroborate the general observations made for the genus *Ovis* by Cowan (1940).

Coefficients of variation for most measures are less than 0.05 (Table 1). Live weights of rams

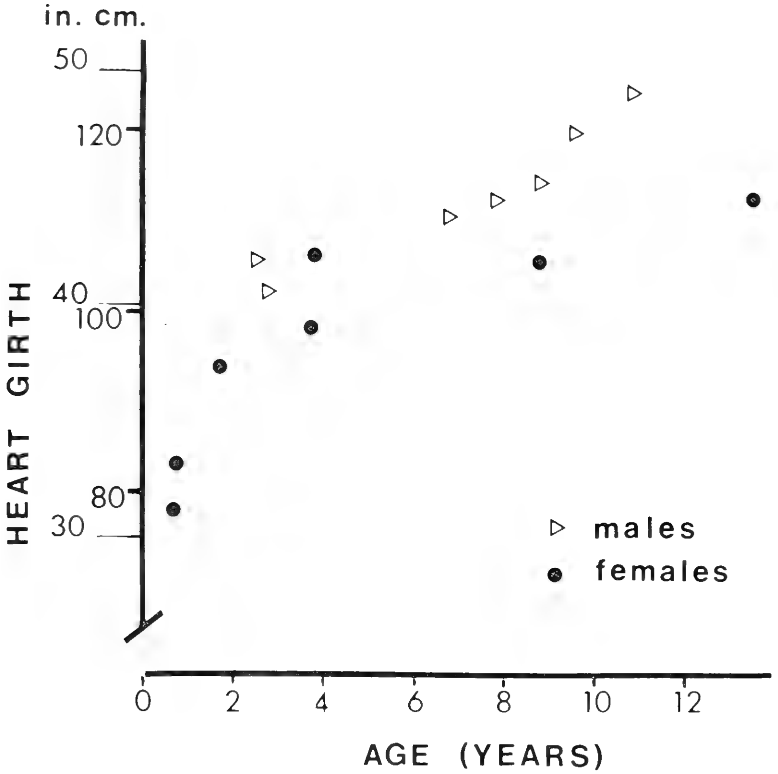

FIGURE 2. Heart girth versus age for wild male and female Dall sheep.

TABLE 2—Live whole weights of adult *Ovis dalli* (in pounds)

Race	Rams			Ewes			Source
	n	$\bar{x}$	Range	*n*	$\bar{x}$	Range	
dalli	4	180	173–185	—	—	—	Ulmer 1941
dalli	1	190	—	1	115	—	Rausch 1951
dalli	1	226	—	—	—	—	Geist 1967
dalli	1	145	—	8	125	—	Nichols 1968
dalli	1	242	—	—	—	—	Hoefs 1974
dalli	6	164	143–181	8	107	102–111	This study
stonei	1	170	—	1	135	—	Geist 1971

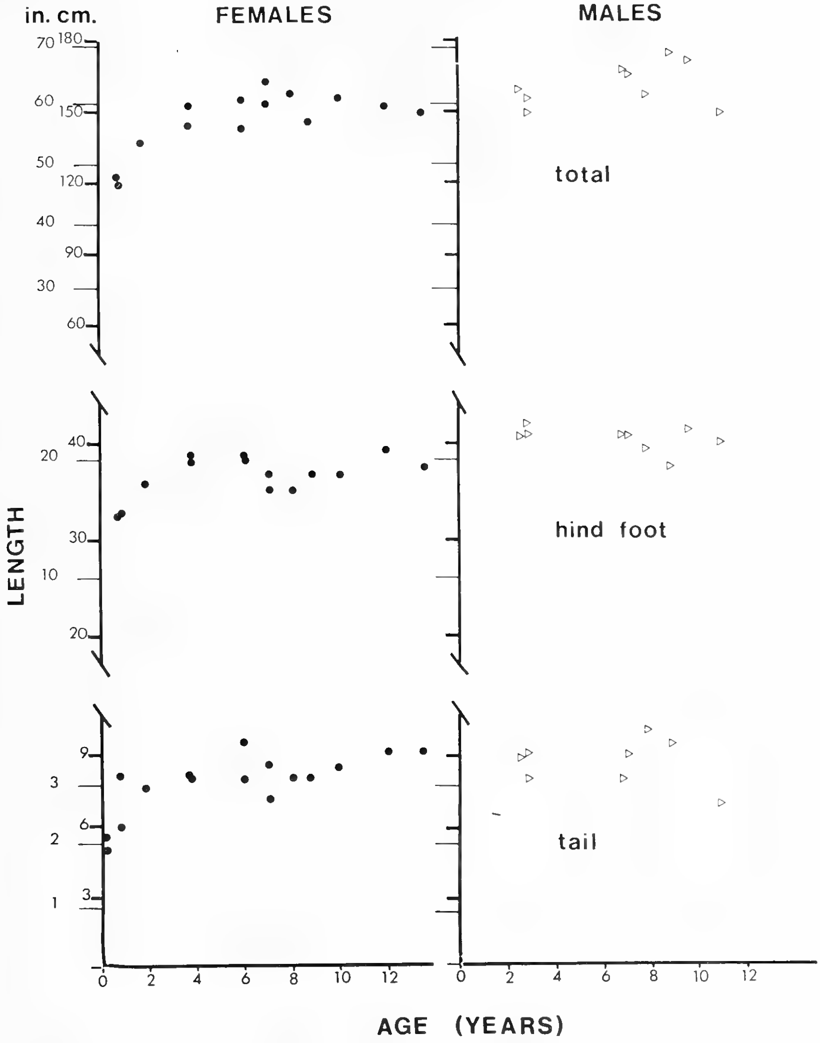

FIGURE 3. Total, hindfoot, and tail lengths versus age for wild male and female Dall sheep.

and tail lengths of both sexes are exceptions. Tail length shows the highest variability, presumably because it is relatively unconstrained by structural relations with other portions of the body. The high degree of variability in ram weights is noteworthy, particularly in view of the consistency in heart girth and total length measurement. Variation in live weights of rams does not appear to be related to weight losses associated with rut, growth periodicity, or a worsening of condition over winter. Five of the six adult rams were weighed in the 31-day period 31 January to 2 March 1971, well after the onset of the period of low or no growth. There was no trend in weight loss with time over this period. Our data suggest that much of the variation in weights of adult rams is attributable to differences in horn mass. Females, which exhibit less variation in horn size and have a smaller portion of their total weight vested in horns, also show far less variation in total weight.

Weights of *Ovis dalli* measured by other workers are summarized in Table 2. The weights presented by Sheldon (1909), Shiras (1912), and Seton (1909) appear to be estimates and are not included. Weights reported by Nichols are taken from a 1968 unpublished Annual Progress Report to the Alaskan Department of Fish and Game (Project W-15-R-2, Work Plan N).

Nutrition plays an important role in determining the weight attained. Rams receiving supplemental winter feed at the Yukon Game Farm are 70 lbs (32 kg) heavier than the average ram in the population from which they were captured. The measures of wild sheep indicate that among North American members of the genus *Ovis* there is no clear relationship between latitude and weight. Average weights of wild Dall sheep appear to approximate those reported by Russo (1956), Blood (1961), and Sugden (1961) for *O. c. mexicana* and *O. c. californiana*. Thus they appear 20–40 lbs (9–18 kg) lighter than *O. c. canadensis* (Blood et al. 1970) and about 10 lbs (4.5 kg) heavier than *O. c. nelsoni* (Aldous et al. 1958).

Acknowledgments

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Literature Cited

Aldous, M. C., F. C. Craighead, Jr., and **G. A. Devan.** 1958. Some weights and measurements of desert bighorn sheep (*Ovis canadensis nelsoni*). Journal of Wildlife Management 22: 444–445.

Anderson, R. M. 1948. Methods of collecting and preserving vertebrate animals. National Museum of Canada Bulletin 69. 1169 pp.

Blood, D. A. 1961. An ecological study of California bighorn sheep (*Ovis canadensis californiana* (Douglas) in southern British Columbia. M.Sc. thesis, University of British Columbia, Vancouver. 127 pp.

Blood, D. A., D. R. Flook, and **W. D. Wishart.** 1970. Weights and growth of Rocky Mountain bighorn sheep in western Alberta. Journal of Wildlife Management 34: 451–455.

Cowan, I. McT. 1940. Distribution and variation in the native sheep of North America. American Midland Naturalist 24: 505–580.

Geist, V. 1967. On the behaviour and evolution of American mountain sheep. Ph.D. thesis, University of British Columbia, Vancouver. 165 pp.

Geist, V. 1971. Mountain sheep. A study in behaviour and evolution. University of Chicago Press, Chicago. 383 pp.

Hemming, J. E. 1969. Cemental deposition, tooth succession, and horn development as criteria of age in Dall sheep. Journal of Wildlife Management 33: 552–558.

Hoefs, M. 1974. Food selection by Dall's sheep (*Ovis dalli dalli* Nelson). *In* The behaviour of ungulates and its relation to management. Volume 2. *Edited by* V. Geist and F. Walther. IUCN Publications New Series Number 24, Morges, Switzerland. pp. 759–786.

Hoefs, M. and **W. G. Benjey.** 1971. The park in perpetual planning: The Kluane Park Reserve, Yukon. Canadian Field-Naturalist 85: 261–265.

Kelsall, J. P. and **E. S. Telfer.** 1971. Studies of the physical adaptation of big game for snow. *In* Snow and ice in relation to wildlife and recreation. *Edited by* A. O. Haugen. Iowa Cooperative Wildlife Research Unit, Ames, Iowa. pp. 134–146.

McEwan, E. H. The adaptive significance of the growth patterns in Cervids compared with other ungulate species. Zoologitcheskyi Tschurnal. (*In press.*)

Moen, A. N. 1973. Wildlife ecology. W. H. Freeman and Co., San Francisco. 485 pp.

Post, G. (*Editor.*) 1971. An annotated bibliography of the wild sheep of North America. Rachelwood Wildlife Research Preserve Publication Number 1. 86 pp.

Rausch, R. 1951. Notes on the Nunamiut Eskimo and animals of the Anaktuvuk Pass region, Brooks Range, Alaska. Arctic 4: 146–195.

Russo, J. P. 1956. The desert bighorn sheep in Arizona. Arizona Game and Fish Department, Wildlife Bulletin Number 1. 153 pp.

Seton, E. T. 1909. Lives of game animals. Volume 3. Doubleday, Doran and Company, New York. 780 pp.

Sheldon, C. 1909. Forest and Stream 72: 173. (Original not seen; *cited from* Ulmer 1941.)

Shiras, G. 1912. National Geographic Magazine 23: 485. (Original not seen; *cited from* Ulmer 1941.)

Sugden, L. G. 1961. The California bighorn in British Columbia with particular reference to the Churn Creek herd. British Columbia Department of Recreation and Conservation, Victoria. 58 pp.

Ulmer, F. A. 1941. On the weights of Dall's sheep. Journal of Mammalogy 22: 448–449.

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Notes

A Northern Range Extension for the Western Chorus Frog, *Pseudacris triseriata triseriata* (Wied), in Ontario

Abstract. Eighteen localities in south-central Ontario at which the Western Chorus Frog, *Pseudacris triseriata triseriata,* has been collected and/or heard calling are reported. Those in the Parry Sound District represent a northern extension of the known Ontario range of this species. Localities and regions where *Pseudacris* was not heard, but where other spring breeding amphibian species were heard are also reported. Descriptions of habitats both above and below altitudes of 305 m in which amphibian species were collected and/or heard calling are presented. Factors that we hypothesize limit the northern and eastern dispersal of this western population are discussed.

The known northern limit of the distribution of the Western Chorus Frog in Ontario is based on the collections of specimens and/or auditory records from the following localities (from west to east, Figure 1): Lucknow, Bruce County (Logier and Toner 1943); Cape Rich, Grey County (Logier and Toner 1961); Sand Bay, Parry Sound District (Carnegie Museum, two specimens, CM 28622–23, unpublished); Tosorontio Township, Simcoe County (Royal Ontario Museum, two specimens, ROM 9687–88, unpublished); Port Carling, Muskoka District (Logier and Toner 1943); Mountain Lake, Haliburton County (ROM, one specimen, ROM 10042, unpublished); Detlor, Hastings County (Toner 1957); Shady Nook, Renfrew County (National Museum of Natural Sciences, two specimens, NMC 9062, unpublished); Arden, Frontenac County (Logier and Toner 1943).

Observations

Recent field investigations in the Districts of Parry Sound, Muskoka, and Haliburton and the County of Renfrew have verified the presence of the Western Chorus Frog near, and at considerable distances north of, the known northern extent of its range. C. A. Campbell, Waterloo, Ontario, has heard this species at the following three localities in the Parry Sound District (west to east, Figure 1): Shawanaga (45°31′ N, 80°16′ W), a loud chorus calling under sunny sky in the late morning of 13 May 1972 from a grassy, cattail (*Typha* sp.), and willow (*Salix* sp.) swale; Parry Sound (45°21′ N, 80°02′ W), several specimens calling with *Hyla crucifer* in the mid-morning and late afternoon of 10 May 1970 and 5 May 1973, respectively, from wet disturbed habitats; Orrville (45°23′ N, 79°47′ W), three specimens calling under sunny sky at midday of 2 May 1975 from a roadside ditch near the open part of a bog.

From the Georgian Bay region of Parry Sound District, we heard this species from two localities (the two westernmost solid squares, Figure 1): a single specimen under sunny sky in the early afternoon of 16 May 1973 from a beaver pond which had inundated a black spruce (*Picea mariana*) forest at Bayfield Wharf (45°38′N, 80°27′W; and eight to ten specimens under sunny sky in the early afternoon of 16 May 1973 from a pond near a cattail marsh at Shawanaga River, 3 km north of Shawanaga (45°33′ N, 80°17′ W). We also found *Pseudacris triseriata triseriata* at six localities in the inland portion of this district (solid squares, north to south, Figure 1) in May 1974 and 1975: 3.2 km west of Maple Island (45°42′ N, 79°55′ W), nine specimens calling with *Hyla crucifer* and *Rana sylvatica* under clear sky after sunset on 4 May 1974 from a wet depression in farmland inundated by sedges, cattails, and alders (*Alnus* sp.), and three specimens calling with *Hyla crucifer* and *Bufo americanus* under clear sky (air temperature 10°C) in the pre-sunrise morning of 18 May 1975; Maple Island (45°42′ N, 79°53′ W), 11 specimens calling with *Hyla crucifer* under partly cloudy sky (air temperature 6°C) at midnight of 4 May 1974 from a wet depression in farmland encroached upon by sedges and cattails, and four specimens calling with *Hyla crucifer* and *Bufo americanus* under clear sky (air temperature 12°C) in the pre-sunrise morning of 18 May 1975; 1.3 km south and 1.6 km west of Dunchurch (45°38′ N, 79°52′ W), a single specimen calling with *Hyla crucifer* under partly cloudy sky after sunset on 4 May 1974 from the open area of a marsh at the margin of a black spruce and cedar (*Juniperus* sp.) forest; 1.5 km north and 0.2 km west of McKellar (45°31′ N, 79°56′ W), two specimens calling with *Hyla crucifer* under partly cloudy sky after sunset on 4 May 1974 from flooded farmland near a black spruce forest; 4.5 km north and 0.8 km east of Waubamik (45°29′ N, 80°00′ W), a single specimen calling with *Hyla crucifer* under clear sky in the pre-sunrise morning of 18 May 1975 from a wet depression in farmland; and 3.9 km south and 1.5 km west of Waubamik (45°25′ N, 80°02′ W), eight specimens calling with *Hyla crucifer* under partly cloudy sky after sunset on 4 May 1974 from a cattail, sedge, and alder marsh in a wet farmland depression. Two specimens (fresh measurements: snout–urostyle length, 24.1 and 24.5 mm; tibial length, 10.2 and 10.5 mm, respectively, NMC 15858) were collected from 3.2 km west of Maple Island in 1974, and three

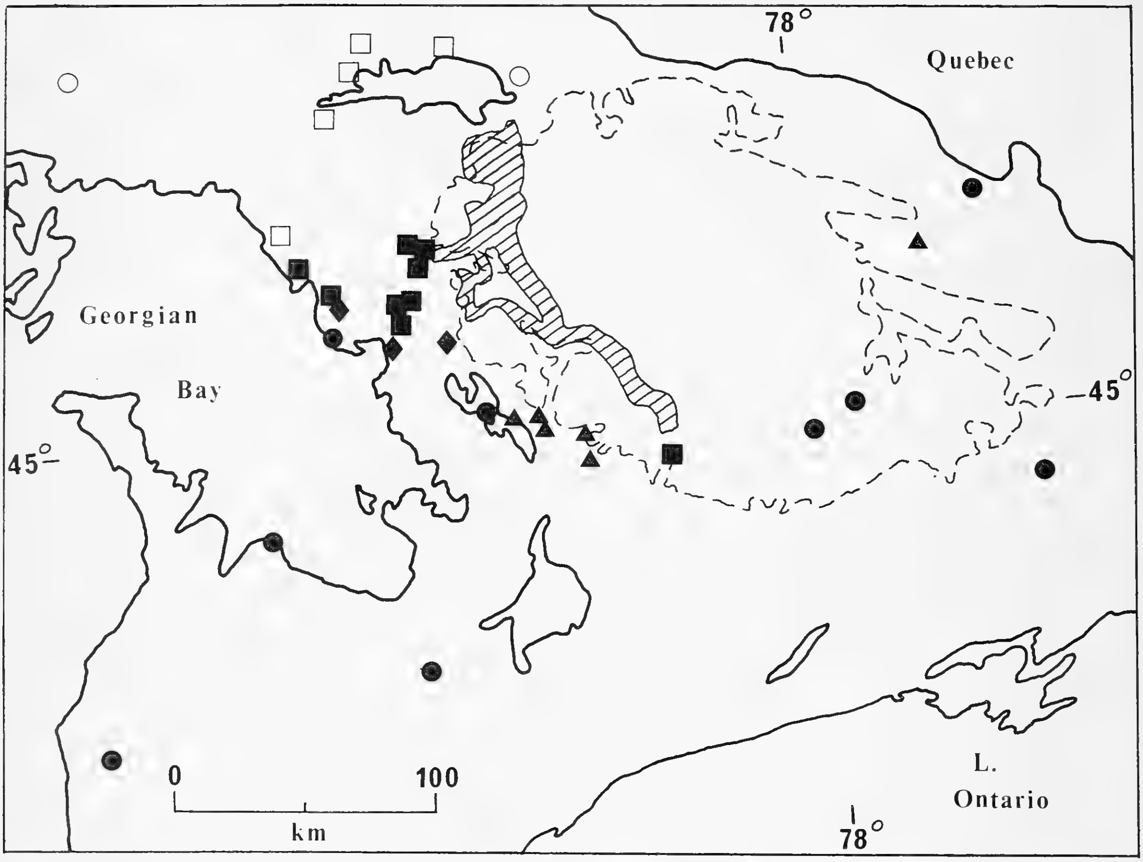

FIGURE 1. Map of south-central Ontario showing the northern limital records (●) of *Pseudacris triseriata triseriata*, based on all available data. Those new localities reported in this paper at which this species was collected and/or the choruses heard are represented by ▲ (R. J. Rutter), ◆ (C. A. Campbell), and ■ (the authors). The ○ represent localities at which Cook (1964) heard spring breeding amphibians, but not *Pseudacris*. The hatched portion represents a region, and the □ individual localities, where we could not find *Pseudacris* during searches on 15–16 May 1973, 21–23 May 1974, and 16–18 May 1975. The broken line represents the approximative margin of 305 m (1000 ft) of altitude in south-central Ontario.

specimens (fresh measurements: snout–urostyle length, 21.7, 21.7, and 25.4 mm; tibial length, 10.1, 9.5, and 11.4 mm, respectively, NMC 16675) were collected from Maple Island in 1975 and deposited in the herpetological collection of the National Museum of Natural Sciences, Ottawa. Recordings of the call of three individuals from Maple Island were made with a Uher 4000 Report-L recorder. These tapes have also been deposited in the National Museum of Natural Sciences' herpetological collection.

Discussion

The observation that *Pseudacris triseriata triseriata* prefers shallow ditches, marshes, temporary field and woodlot ponds for breeding, and occupies cutover woodlots and grassy fields of lowlands and valleys at other times, has been noted by Bleakney (1959), Conant (1975), Cook (1964), Dickerson (1906), Rand (1944), and Toner (1957). The observations we report for this species at localities visited in the Districts of Parry Sound and Haliburton are consistent with the published descriptions of breeding habitats. Without exception, all localities show evidence of being disturbed by man's activities of agriculture, road construction, or lumbering.

Bleakney (1959) contends that the eastern extent of the distribution of *P. t. triseriata* in the Eastern Townships of Quebec is limited by the lack of suitable habitat above altitudes of 224 m (800 ft) in the Appalachian Mountain Range, rather than the altitude *per se* or the cold temperatures. Toner (1957) offered a similar explanation for the distribution of this species in the area of Bancroft and Detlor, Hastings County.

Most of the localities visited within the hatched portion of south-central Ontario (Figure 1) are at altitudes above 305 m. In the southeastern portion only *Hyla crucifer* and *Bufo americanus* were heard calling from lake shorelines and cattail and sedge meadows between 1830 and 2300 hours of 15 May 1973; and only *Hyla crucifer, Rana pipiens,* and *Hyla versicolor* from these same localities from 21–23 May 1974. We are of the opinion that the absence of *P. t. triseriata* in this region is real, and not an artifact of sampling due to cold night temperatures (air temperature 3°C) in 1973. Bleakney (1959) has observed that *Pseudacris* does not cease to call on cold evenings, as do other spring breeders, and we have observed *Pseudacris* in the Toronto area calling from terrestrial environments at 3.5°C air temperature. Since *Hyla versicolor*, which we have observed to cease calling at air temperatures below about 10°C, was calling, *Pseudacris* would certainly have been heard calling in 1974.

The most intensive search for this species was within the northwestern section of the hatched area (Figure 1). At virtually all of the six marshy areas visited between 2300 and 0300 hours of 15–16 May 1973, only *Hyla crucifer* was heard calling. During a 26-h continuous survey in 1975 (0900 hours, 17 May to 1100 hours, 18 May), *Hyla crucifer* was heard calling during both dark and daylight hours from 36 localities within this northwestern section. After sunset *Rana pipiens, Rana sylvatica, Hyla versicolor,* and *Bufo americanus* were heard calling from several of these localities. We have heard *Pseudacris* in chorus with other spring breeding amphibians both in the Toronto area and at localities between Parry Sound and Maple Island in the Parry Sound District, and noted that its vocalizations were not overpowered by those of other species. We therefore conclude that *P. t. triseriata* was not heard because it was absent.

The network of roads in this northwestern portion makes it possible to ascend to or descend from the 305-m margin of the height of land by driving a distance of a few kilometres. One common characteristic among 12 such areas is that there was apparently suitable *Pseudacris* breeding habitat both above and below 305 m of altitude; however, the intermediate terrain was relatively steep, forested, and apparently not recently disturbed, and if water was present, it existed as streams.

Cook (1964) did not find *Pseudacris* south of North Bay (the easternmost hollow circle, Figure 1) in the evening of 17 May 1963, nor at Narin Centre (the westernmost hollow circle, Figure 1) on 24 May 1959, despite hearing choruses of *Hyla crucifer, Hyla versicolor, Rana pipiens,* and *Bufo americanus.* The authors did not find *Pseudacris* during an overcast period between 0700 and 1230 hours on 16 May 1973 at any of the following localities in this region (north to south, hollow squares, Figure 1): Nipissing District, Verner (46°25′ N, 80°07′ W), Meadowside (46°22′ N, 79°45′ W), Lavigne (46°20′ N, 80°10′ W); Sudbury District, Monetville (46°10′ N, 80°22′ W); and Parry Sound District, Byng Inlet (45°46′ N, 80°33′ W). The previous four localities are within intensively farmed areas, and are presumably too disturbed by farming activities to be suitable breeding habitat, as Bleakney (1959) observed at localities west of the 224-m margin of the Appalachian Mountain Range in Quebec.

Further field work is required to determine whether this species does exist at altitudes below 305 m to the north of Bayfield Wharf and Maple Island, and at altitudes above 305 m to the east of Maple Island and Orrville, and to the north of Minden and of those localities reported to us by R. J. Rutter. On the basis of our present knowledge, we hypothesize that the limiting factors to the distribution of the western population of *Pseudacris triseriata triseriata* in south-central Ontario are (1) to the north, unsuitable breeding habitat in farmed areas; and (2) to the east, inaccessibility to habitats above 305 m due to the unsuitability of breeding habitats at the margin of relatively steep terrains. Observations of *Pseudacris* at Mountain Lake and Detlor suggest that the limiting factor in the eastern part of south-central Ontario is not the boundary of 305 m *per se.*

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Literature Cited

Bleakney, J. S. 1959. Postglacial dispersal of the Western Chorus Frog in eastern Canada. Canadian Field-Naturalist 73: 197–205.

Conant, R. 1975. A field guide to reptiles and amphibians of eastern and central North America. 2nd Edition. Houghton Mifflin Co., Boston. 429 pp.

Cook, F. R. 1964. Additional records and a correction of the type locality for the Boreal Chorus Frog in northwestern Ontario. Canadian Field-Naturalist 78: 186–192.

Dickerson, M. D. 1906. The frog book. North American toads and frogs with a study of the habits and life histories of those of the northeastern United States. Doubleday, Doran and Co., Garden City, New York. 253 pp.

Logier, E. B. S. and **G. C. Toner.** 1943. The Swamp Cricket Frog, *Pseudacris nigrita triseriata*, in Canada. Canadian Field-Naturalist 57: 104–105.

Logier, E. B. S. and **G. C. Toner.** 1961. Checklist of the amphibians and reptiles of Canada and Alaska. Royal Ontario Museum Life Sciences Division, Contribution 53: 1–92.

Rand, A. S. 1944. The Swamp Cricket Frog, *Pseudacris nigrita triseriata* (Wied), in Quebec. Canadian Field-Naturalist 58: 68.

Toner, G. C. 1957. Some northern limits of the Western Chorus Frog. Canadian Field-Naturalist 71: 83.

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The Foraging Range of Breeding Dovekies, *Alle alle*[1]

On 31 July 1974 *CSS Hudson* was in northeastern Baffin Bay. The weather was almost calm, with local fog patches. Occasional icebergs were present, but there was no pack-ice. From about 1400 hours ADT onwards (at 75°00′ N, 67°30′ W; see Figure 1) very large numbers of Dovekies, *Alle alle*, all in breeding plumage, were seen. These flocks continued as we steamed to 75°05′ N, 69°08′ W and turned north, until observations ended at about 0100 hours ADT (75°52′ N, 69°28′ W). Many of these birds were on the water, diving and presumably feeding; those in flight were heading either north or south. The numbers were so large that they could only be guessed at, but at the peak there must have been over a thousand birds present during a 10-min watch.

For most of the time the ship was 100–150 km south of the Greenland coast, where very large numbers of Dovekies breed (Salomonsen 1950). The nearest known colonies (see Figure 1) are in Parker Snow Bay (ca. 76°10′ N, 67°30′ W), along the coast between Agpat and Cape York (ca. 76°05′ N, 66°30′ W), between Cape Atholl and Pitugfik Glacier (ca. 76°22′ N to 76°11′ N, 69°20′ W), and in the areas of Savik Peninsula (ca. 76°07′ N, 65°00′ W) and Cape Melville Peninsula (76°04′ N, 64°02′ W). The size of this breeding population is unknown, but probably runs into the millions.

Despite the distances involved, it seems quite probable that the Dovekies I saw were breeding birds from these colonies. The north-or-south flight directions suggest that they were commuting to and from a colony, rather than that they were on migration. In any case, the season seems too early for the start of fall migration; at this time of year the birds are still bringing food to young in the nest (Salomonsen 1950). (Dr. A. R. Lock (personal communication) confirms that Dovekies were still abundantly present at the Cape York colony on 23 August 1973.) Dovekies lose their summer plumage immediately after they finish breeding (e.g., see Bent 1919); the fact that my birds had not yet done so also suggests that they were breeding birds. They could, of course, have been failed breeders, or pre-breeders displaying on the colony, who could feed well offshore without the need for frequent return visits with food for the young. Birds returning to their young can be identified by the bulging neck pouches in which the food is carried; unfortunately, I did not look for this. The object of this paper, however, is to show that in theory it is perfectly possible for actively breeding Dovekies to forage for their young at a range of at least 100 km from their colony.

There are several other observations of Dovekies apparently foraging at some distance from their colonies. In July 1900 Kolthoff (1903) saw them commonly up to 100 km west of their colonies in northwest Spitsbergen, and the same distance northeast of those in Jan Mayen. Dovekies were abundant in June and July 1896 in leads in the ice 280 km north of Spitsbergen (Collett and Nansen 1900). This seems too far for breeding birds to travel. In June and July 1895, however, Nansen (Collett and Nansen 1900) saw

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[1]An investigation associated with the program "Studies on northern seabirds," Canadian Wildlife Service, Environment Canada (Report Number 32).

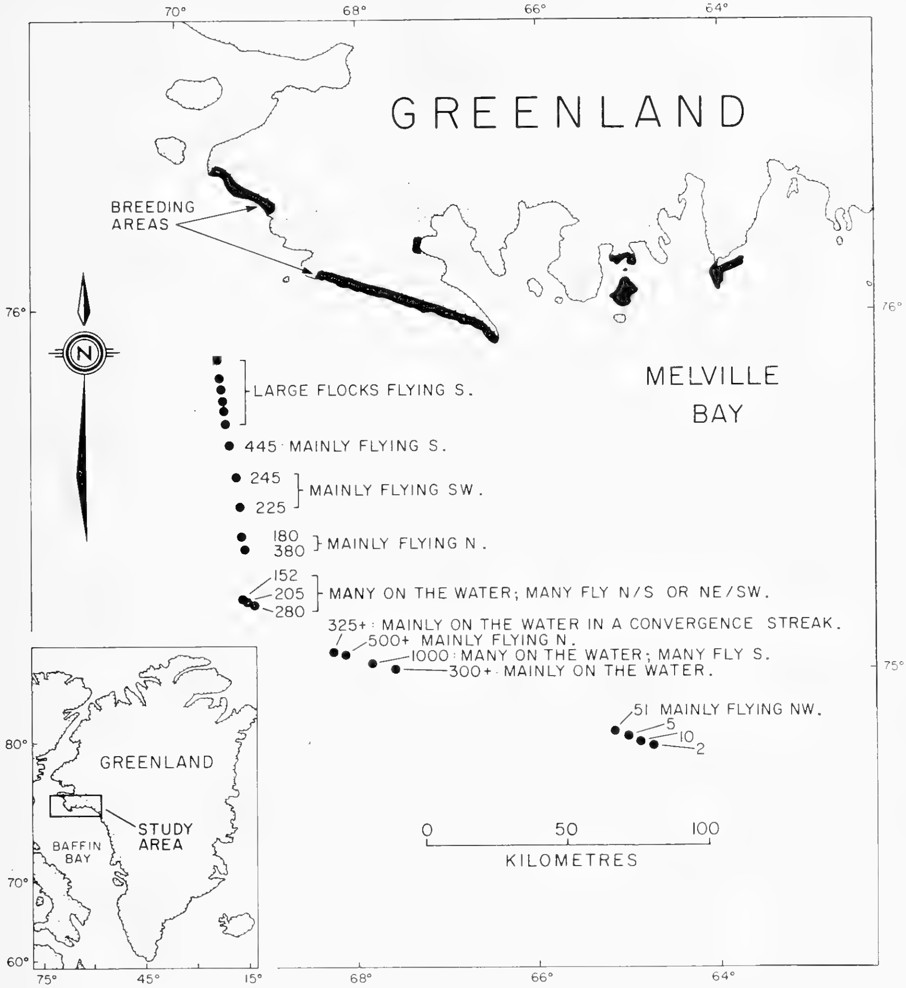

FIGURE 1. The distribution of Dovekies, *Alle alle*, in northeastern Baffin Bay, 31 July 1974. Each filled circle represents a separate observation. Numbers show the estimated total of Dovekies present during a 10-min watch.

large numbers in the ice north of Franz Joseph Land, "always coming from the south and returning towards the south" (p. 39); he was then about 30 km east of the nearest colony, but perhaps twice that distance from the nearest one to the south. On 25 July 1911 Mathey-Dupraz (1913) saw large numbers of Dovekies feeding among pack-ice north of Spitsbergen, about 25 km from the nearest colony. Cody (1973) claims that Dovekies, with a foraging range of only 12–16 km, had the greatest range of all the alcids breeding in northeast Iceland; however, his observations did not extend any further offshore than 16 km.

A 100-km foraging range is consistent with what is known of the rate at which the young are fed: an average of 8.5 times in 24 h in Spitsbergen (Norderhaug 1970). Both parents feed the young (Salomonsen 1950). Foraging is possible at any time of day in summer at these high latitudes, and the 11-h spread of my observations suggests that the birds do indeed collect food around the clock. Pennycuick (1969, Figure 8) calculates the Dovekie's most economical flight speed as about 14 m/sec (50 km/h). At this speed each parent could make six round-trips, out to 100 km and back, in 24 h if it flew non-stop. A more realistic figure might be four trips. This would still give the young bird eight feeds a day, and would allow each parent a total of 16 h in the air and another 8 for rest, maintenance, and actually catching the food. The flying time would be broken down into eight 2-h sections, allowing the bird to rest between flights at the colony and on the water in the feeding area.

Is this metabolically feasible? The energetics of Dovekie flight have not been investigated, but it is informative to use the surveys by Pennycuick (1969), and by Tucker (1971, 1974), as bases for speculation. Tucker calculates that the Starling, *Sturnus vulgaris*, a flapping-flier like the Dovekie and of similar weight, can in theory fly 1000 km non-stop in still air; this would cause a loss of 25% in its initial weight, used up as fuel. He points out that long-distance non-stop flights are well documented even for the smallest migrant birds. Migrants accumulate large fat reserves, often making up 25% or more of their total weight, before they set off. The fat reserves of a breeding Dovekie are not known, but they are unlikely to be as large as that. For the present argument, one might assign a value of 5%. Using Pennycuick's (1969) equations (p. 525), it would appear that a Dovekie could fly about 300 km for a 5% loss of body weight. This seems sufficient for a 200-km round-trip from the feeding area to the colony, and back again to refuel. In practice, of course, the nutritive value of the food and the energy spent catching it should also be taken into account, but the necessary information is not yet available.

One can only speculate on why the birds should need to travel so far to feed. Spitsbergen Dovekies are known to exploit prey concentrated at the surface near glacier faces (Hartley and Fisher 1936), and there must be comparable opportunities at glacier faces close to these Greenland colonies. Most of the birds I saw at 75°03′N, 68°18′W were in small groups, sitting on the water and diving, at the edge of a long narrow streak of very calm water, apparently a convergence front. Such fronts tend to concentrate plankton and other animals (e.g., see Pingree et al. 1974). This front was not investigated, but a surface tow for oil particles nearby showed that copepods and small pteropods were common in the area. Dovekies are known to feed on both of these (Bruemmer 1972; Norderhaug 1970). It is, therefore, possible that the reason for this long foraging flight was to exploit an exceptionally rich food supply. Certainly, the energy budget for such a flight would be improved if the food was so concentrated that the birds needed to spend little time in catching it.

Finally, a foraging range of this width carries a further implication. Any attempt to understand the pelagic ecology of breeding Dovekies must take into account the distribution and abundance of food at a considerable distance from the breeding site. Assessments of the environmental impact of oil spills and other forms of chemical pollution, in the Arctic and elsewhere, must be equally wide-ranging.

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Literature Cited

Bent, A. C. 1919. Life histories of North American diving birds. United States National Museum Bulletin 107. 239 pp.

Bruemmer, F. 1972. Dovekies. Beaver 303: 40–47.

Cody, M. L. 1973. Coexistence, coevolution and convergent evolution in seabird communities. Ecology 54: 31–44.

Collett, R. and **F. Nansen.** 1900. An account of the birds. *In* The Norwegian North Polar Expedition 1893–1896. *Edited by* F. Nansen. Scientific Results 1: 1–53.

Hartley, C. H. and **J. Fisher.** 1936. The marine foods of birds in an inland fjord region in west Spitsbergen. Part 2. Birds. Journal of Animal Ecology 5: 370–389.

Kolthoff, G. 1903. Bidrag till kännedom om norra polartrakternas däggdjur och fåglar. Kungliga Svenska Vetenskaps-Akademiens Handlingar 36(9): 1–104.

Mathey-Dupraz, A. 1913. Notes ornithologiques receuillies au cours de la croisière du "Grosser Kurfurst" au Spitzberg entre le 18 juillet et le 16 août 1911. Neuchâtel Bulletin de la Société de Science Naturelle 39.

Norderhaug, M. 1970. The role of the Little Auk *Plautus alle* (L.) in arctic ecosystems. *In* Antarctic ecology. Volume 1. *Edited by* M. W. Holdgate. Academic Press, London. pp. 558–560.

Pennycuick, C. J. 1969. The mechanics of bird migration. Ibis 111: 525–556.

Pingree, R. D., G. R. Forster, and **G. K. Morrison.** 1974. Turbulent convergent tidal fronts. Journal of the Marine Biological Association of the United Kingdom 469–479.

Salomonsen, F. 1950. Grønlands fugle. Ejnar Munksgaard, Copenhagen.

Tucker, V. A. 1971. Flight energetics in birds. American Zoologist 11: 115–124.

Tucker, V. A. 1974. Energetics of natural avian flight. *In* Avian energetics. Publications of the Nuttall Ornithological Club 15: 298–328.

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The Fauna of a Hibernation Nest of a Meadow Jumping Mouse, *Zapus hudsonius*

On 22 January 1974 a nest containing a hibernating meadow jumping mouse (*Zapus hudsonius* (Zimmermann, 1780) was found in the burrow of a woodchuck (*Marmota monax*) in a dike along the Wabash River, 6 mi (10 km) NW of Terre Haute, Vigo County, Indiana. The burrow had collapsed because of heavy rains and floods, thus exposing the nest. The burrow had been abandoned by the woodchuck but was utilized by raccoons (*Procyon lotor*) and opossums (*Didelphis virginiana*) during the winter of 1973–74 (L. L. Schmeltz, personal communication). The nest was about 14 cm in diameter and constructed entirely of the leaves of *Festuca* sp., the principal plant on the dike.

The jumping mouse was an adult female; the skull and skeleton are preserved in the collection of G. S. Jones (#2284). The specimen contained 3 g subcutaneous fat and 1 g fat in the peritoneal cavity. The stomach was empty. The small intestine was empty except for a small amount of nondescript material near the posterior end. The caecum contained finely ground material in the distal fifth. The large intestine contained nine pellets composed of highly digested parts of grass seeds, vegetation, and fungal spores which appeared to have been in place for a long time. No endoparasites were found and there were no placental scars or embryos.

The only ectoparasites found on the jumping mouse were eight mites, *Androlaelaps fahrenholzi* (Berlese). After the nest was placed in a Berlese funnel, the following invertebrates were recovered: Collembola—*Hymenaphorura sibirica* (Tullberg) 25, *Folsomia ?diplophthalma* (Axelson) 1, Coleoptera larva 2; Hymenoptera—Pteromalidae, *Dorcatomophaga* sp. 6; Bethylidae 1; Pauropoda—*Allopauropus gracilis* var. *sabaudianus* (Remy) 2; Nematoda 11.

Acarina: Glycyphagidae—*Dermacarus* probably *newyorkensis* Fain 1♂, 1♀, 1 larva; Acaridea—*Tyrophagus* probably *putrescentiae* (Schrank) 2♂♂, 2♀♀, 6 numphs; Stigmaeidae 1 nymph; Oribatei 1 nymph; Pyemotidae 2; Chortoglyphidae—*Chortoglyphus arcuatus* (Troupeau) 2; Anoetidae 1; Tarsonemidae—*Tarsonemus sp.* 1♂, 11♀♀; Tydeidae—*Tydeus* sp. 4 nymphs; Parasitidae—*Pergamasus* near *nasellus* Karg 1♂; Laelapidae—*Hypoaspis* angustus Karg 1♀; *Ascidaecgamasellodes* sp. in *bicolor* complex 3♀♀.

The specimens of *Hymenophorura sibirica* are the first taken in Indiana and only the third record in North America (Hart, *in press* and personal communication). The specimens of *Dorcatomophaga* sp. represent the first record of this genus from the Western Hemisphere and apparently represent a new species (Yoshimoto, personal communication). The two adults of *Dermacarus* probably *newyorkensis* were the first adults of this species known; Dr. Alex Fain, Edwin J. Spicka, and the authors are studying the life cycle of this species since the discovery of the adults in this nest.

Discussion

Only two of the invertebrates from the nest are known to be regular associates of the meadow jumping mouse: these are *Dermacarus newyorkensis* and *Androlaelops fahrenholzi.* Whitaker (1963) and Whitaker and Mumford (1971) found that these two species are among the most abundant mites found on the meadow jumping mouse in New York and Indiana. A third common species on *Zapus* is *Radfordia ewingi* (Fox) (Whitaker and Mumford 1971); there was no evidence of this species in the nest.

Representatives of *Tydeus* have been found in bird nests (Krantz 1970), *Dermacarus hypudaei* (Koch) adults have been reported from rodents' nests in Europe (Rupes 1967), and pyemotids and acarids were found in rodent nests in Egypt by Yunker and Guirgis (1969).

Vysotzkaja (1967) discussed the relationships of invertebrates in rodent nests, suggesting that some species move into the nests during cold periods in order to make use of the host as a "hot water bottle" hibernaculum. He further emphasized that the inhabitants within rodents, nests form a community, termed acarocoenosis by Lundqvist (1974) and acarinium by Rosicky and Mrciak (1967). The coleopterous larvae, collembolans, pauropods, nematodes, oribatids, tarsonemids, and anoetids all live in the soil or humus and feed on detritus. Some pyemotids and stigmaeids are known to be predators as are some *Tydeus.* Both hymenopterans are parasitoids and Bethylidae, at least, is known to prey on coleopterous larvae (Borror and Delong 1971).

Although several *Zapus* hibernation nests have been found, this is the first that had its arthropod inhabitants collected and studied. The distribution records, possible new species, and discovery of an adult of a form previously known only from hypopi, illustrate the value of such a study.

We acknowledge the assistance of Josef J. Chalupsky, Prirodovedecka Fakulta Karlovy University, Praha, Czechoslovakia who identified the pauropods; Alex Fain, Institut de Medecine Tropical Prince Leopold, Antwerpen, Belgium who verified the adult *Dermacarus* as probably *D. newyorkensis* and the *Tydeus* sp., *Oribatei, Tarsonemus, Chortoglyphus, Tyrophagus, Pyemotidae* and *Stigmaeidae;* John W. Hart, Hayes Research Foundation, Richmond, Indiana who identified the collembolans; E. E. Lingquist, Biosystematics Research Institute, Agriculture Canada, Ottawa who identified the Parasitidae, *Hypoaspis,* and Ascidae; C. M. Yoshimoto, Biosystematics Research Institute, Agriculture Canada, Ottawa who identified the hymenopterans; and L. L. Schmeltz, Terre Haute, Indiana who found the nest.

Literature Cited

Borror, D. J. and **D. W. Delong.** 1971. An introduction to the study of insects. Holt, Rinehart, and Winston, New York. 812 pp.

Hart, J. W. 1975. New records of Indiana Collembola. Proceedings of the Indiana Academy of Science 84. (*In press.*)

Krantz, G. S. 1970. A manual of Acarology. Oregon State University Book Stores, Inc., Corvallis, Oregon. 335 pp.

Lundqvist, L. 1974. Gamasina mites (Acari, Parasitiformes) from nest of the mole, *Talpa europaea* L. Entomologia Scandinavica 5: 39–48.

Rosicky, B. and **M. Mrciak.** 1967. The concept of the acarinium and the acarinia zones. Folia Parasitologica (Praha) 14: 349–360.

Rupes, V. 1967. The mites of subfamily Labidophorinae Zachvatkin, 1941 (Acarina, Acarinae) from the nests of small mammals. Vestnik Ceskoslovenske Spolecnosti Zoologicke 31: 68–79.

Vysotzkaja, S. O. 1967. The interrelations between the ectoparasites of rodents and the inhabitants of their nests. Proceedings of the First International Congress of Parasitology, Rome, 21–26 September 1964. Pergamon Press, Oxford. pp. 152–153.

Whitaker, J. O., Jr. 1963. A study of the meadow jumping mouse, *Zapus hudsonius* (Zimmermann), in central New York. Ecological Monograph 33: 215–254.

Whitaker, J. O., Jr. and **R. E. Mumford.** 1971. Jumping mice (Zapodidae) in Indiana. Proceedings of the Indiana Academy of Sciences 80: 210–209.

Yunker, C. E. and **S. S. Guirgis.** 1969. Studies of rodent burrows and their ectoparasites in the Egyptian desert. I. Environment and microenvironment; some factors influencing acarine distribution. Journal of the Egyptian Public Health Association 44: 498–542.

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Natural Mortality in Richardson's Ground Squirrel

Abstract. Young Richardson's ground squirrels appear to suffer proportionately heavier winter mortality than adults, as indicated by the remains disinterred by squirrels and deposited in their burrow mounds. This suggests that winter mortality of young is an important determinant of age structure and population density in this species.

Populations of Richardson's ground squirrels (*Spermophilus richardsonii richardsonii* (Sabine)) in southern Saskatchewan are characterized by the disappearance of large numbers of juveniles between July of one year and May of the next. Thus, Michener and Michener (1971) observed that only 12% of 382 young marked by them in 1969 were present on their study area in 1970. The interyear residence of young increased in the following year to 28%.

In addition, the interyear residence frequency of young male Richardson's ground squirrels is less than that of young females (Michener and Michener 1971). This results in an uneven adult sex ratio of 1 male to 3 or 4 females (Michener and Michener 1971; Nellis 1969; Sheppard 1972). The disappearance of young has been attributed to the combined effects of dispersal, predation, and winter mortality (Michener and Michener 1971).

From 1970 through 1972 skeletal remains of Richardson's ground squirrels were collected in a community pasture 80 mi (128 km) southwest of Regina (49°40′ N, 105°10′ W). Population and behavior studies were also in progress (Michener and Michener 1971, 1973; Michener 1973a, b) and a detailed description of the area can be found in Michener (1972).

Ground squirrel skeletal remains were available from two sources. Ground squirrels that died below ground were sometimes disinterred by other squirrels and cast out on the burrow mounds. Rarely was any skin or soft tissue associated with the disinterred bones, indicating that they had been buried for at least one year. Predator feces collected in June and July when the young were active aboveground provided a second source of material. Most were badger (*Taxidea taxus*) feces, but a few red fox (*Vulpes vulpes*) and long-tailed weasel (*Mustela frenata*) feces were also included. Only lightly weathered and fresh feces were included in the analysis.

The age at death of the ground squirrels was determined from tooth wear and epiphyseal closure of humeri. With these methods, ground squirrels less than 1 year old can be reliably distinguished from older squirrels (Sheppard 1972). An attempt was also made to determine the sex of the dead squirrels from sex differences in pelvis morphology (Dunmire 1955), but pelvic remains were usually poorly preserved or incomplete so the results are not reported here.

Of 92 predator feces collected, 38 contained remains of Richardson's ground squirrels and the age at death of 32 individual squirrels was determined. Seventeen (53%) were young 6 to 12 weeks of age. The remainder were adults 1 year or older. By comparison, the ground squirrel population in June on the study area contained a minimum of 75% young in 1969 (n = 506), 62% in 1970 (n = 363), and 61% in 1971 (n = 490) (Michener 1972). In fact, the actual proportion of young was somewhat higher because the young were not trapped as thoroughly as the adults (Michener 1972). Since the population of ground squirrels on the study area contained proportionally more young than the predator feces, selective predation on young ground squirrels is not indicated. This conclusion agrees with the results of Luttich et al. (1970) in Alberta, who observed that the proportion of young Richardson's ground squirrels killed by Red-tailed Hawks (*Buteo jamaicensis*) in July did not differ significantly from the proportion of young in the ground squirrel population.

The ground squirrel remains from burrow mounds included a higher proportion of young. Of the 72 specimens for which age could be determined, 55 (76%) were young squirrels more than 6 weeks but less than 1 year old. The proportion of young in the remains taken from predator feces differs significantly (*chi*-square test) from the proportion of young in the burrow mound collection ($\chi^2 = 5.74$, $P < 0.05$).

It is also possible to compare the age ratio of the disinterred remains with the age ratio of the spring population. If the two ratios are not statistically different it suggests that underground mortality is non-selective with regard to age. The comparison assumes that the disinterred remains represent overwinter mortality and that no age-differential dispersal occurs immediately after spring emergence. Michener (1972) estimated the 1971 spring population of ground squirrels on the study area to be 189 adults, including 120 yearlings. This age structure differs significantly from the age ratio in the burrow mound collection ($\chi^2 = 3.90$, $P < 0.05$). A sample of 182 adult Richardson's ground squirrels collected near Regina, Saskatchewan (Sheppard 1972) included 100 yearlings, and this age ratio also differs significantly from that of the burrow mound remains ($\chi^2 = 10.04$, $P < 0.01$).

Unfortunately, our results are based on small samples which it will not now be possible to supplement. They do suggest, however, that some form of underground mortality removes disproportionate numbers of young Richardson's ground squirrels. It is possible that the hibernacula of young ground squirrels are less suitable that those of adults. Shaw (1926) excavated 136 dens of the Columbian ground squirrel (*Spermophilus columbianus*) and observed that the hibernacula of adults were at greater depth and had better drainage, on average, than the hibernacula of young.

Carl (1971) reported almost total overwinter mortality in "refugee populations" of Arctic ground squirrels (*S. parryi*). These populations consisted mainly of young ground squirrels that had dispersed from their natal burrows before hibernation. In contrast, young that hibernated in or near the natal burrow survived the winter. Thus, under certain conditions, inadequately constructed or poorly situated hibernacula can cause disproportionately high mortality of young ground squirrels during hibernation. Disease (Holdenreid et al. 1951; Lechleitner et al. 1968) and cannibalism (Musacchia 1954) are other possible causes of underground mortality.

The interyear residency of young Richardson's ground squirrels is less than that of adults. Michener and Michener (1971) reported interyear residency figures of 12% (1969–70) and 28% (1970–71) for young, compared with 42% and 45% for adults. Differential predation and dispersal may account for some of this difference, but overwinter mortality also seems to be important.

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Literature Cited

Carl, E. A. 1971. Population control in Arctic ground squirrels. Ecology 52: 395–413.

Dunmire, W. W. 1955. Sex dimorphism in the pelvis of rodents. Journal of Mammalogy 36: 356–361.

Holdenreid, R., F. C. Evans, and **D. S. Longanecker.** 1951. Host–parasite disease relationships in a mammalian community in the central Coast Range of California. Ecological Monographs 21: 1–18.

Lechleitner, R. R., L. Kartman, M. I. Goldenbert, and **B. W. Hudson.** 1968. An epizootic of plague in Gunnison's prairie dogs (*Cynomys gunnisoni*) in south-central Colorado. Ecology 49: 734–743.

Luttich, S., D. H. Rusch, E. C. Meslow, and **L. B. Keith.** 1970. Ecology of Red-tailed Hawk predation in Alberta.

Ecology 51: 190–203.
Michener, D. R. 1972. Population dynamics of Richardson's ground squirrels. Ph.D. thesis, University of Regina, Regina, Saskatchewan. 116 pp.
Michener, D. R. and **G. R. Michener.** 1971. Sex ratio and interyear residence in a population of *Spermophilus richardsonii.* Journal of Mammalogy 52: 853.
Michener, G. R. 1973a. Field observations on the social relationships between adult female and juvenile Richardson's ground squirrels. Canadian Journal of Zoology 51: 33–38.
Michener, G. R. 1973b. Climatic conditions and breeding in Richardson's ground squirrel. Journal of Mammalogy 54: 499–503.
Michener, G. R. and **D. R. Michener.** 1973. Spatial distribution of yearlings in a Richardson's ground squirrel population. Ecology 54: 1138–1142.
Musacchia, X. J. 1954. Cannibalism and other observations of captive ground squirrels. Journal of Mammalogy 35: 445–447.
Nellis, C. H. 1969. Productivity of Richardson's ground squirrels near Rochester, Alberta. Canadian Field-Naturalist 83: 246–249.
Shaw, W. T. 1926. Age of the animal and slope of the ground surface, factors modifying the structure of hibernation dens of ground squirrels. Journal of Mammalogy 7: 91–96.
Sheppard, D. H. 1972. Reproduction of Richardson's ground squirrel (*Spermophilus richardsonii*) in southern Saskatchewan. Canadian Journal of Zoology 50: 1577–1581.

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First Quebec Record of *Quiscalus quiscula stonei*, the "Purple" Race of the Common Grackle

On 26 April 1973, while experimenting with the use of baits treated with alpha-chloralose for the control of harmful birds at Sainte-Scholastique, Deux-Montagnes, Quebec, the first author caught and collected two birds which appeared to be typical of the purple race of the Common Grackle (*Quiscalus quiscula stonei* Chapman).

Both specimens, deposited in the ornithological collection of the Department of Biological Sciences of the University of Montreal, were males with fully ossified skulls. They had numerous intramuscular parasites and no body fat. The weights and measurements for the first (UM 03241) and second (UM 03242) specimens were, respectively, weight 104 and 124.8 g, total length 323 and 322 mm, wing 139 and 145 mm, tail 144 and 140 mm, culmen 29 and 33 mm, tarsus 34 and 36 mm, and testes 11 × 6 and 15 × 8 (right 11 × 9) mm. The plumage of both birds conforms with the descriptions of *Q. q. stonei* of Chapman (1935) and Bent (1958). Our identification was subsequently confirmed by Henri Ouellet of the National Museum of Natural Sciences of Canada.

The breeding range of *Q. q. stonei* covers the eastern United States from southeastern New York to northern Georgia (AOU 1957). The only previous record for Canada was reported from Kent Island, New Brunswick, on 20 November 1931 (Godfrey 1966). Since only two of 900 Common Grackles handled in 1972 and 1973 in the Mirabel Montreal II International Airport area appeared to be *Q. q. stonei*, the purple race of the Common Grackle must be considered accidental in southern Quebec.

Literature Cited

American Ornithologists' Union. 1957. Check-list of North American birds. 5th edition. Baltimore, Maryland. 691 pp.
Bent, A. C. 1958. Life histories of North American blackbirds, orioles, tanagers, and allies. United States National Museum Bulletin 211.
Chapman, F. M. 1935. Further remarks on the relationships of the grackles of the subgenus *Quiscalus.* Auk 52: 21–29.
Godfrey, W. E. 1966. The birds of Canada. National Museum of Canada Bulletin 203. 428 pp.

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Distribution of the Southern Flying Squirrel (*Glaucomys volans*) in Maine

Hall and Kelson (1959) give Hancock, Hillsboro County, New Hampshire, as the most northeasterly marginal record site for the southern flying squirrel (*Glaucomys volans*). These authors imply a range which encompasses southwestern Quebec, all but the northeastern corner of Vermont, the southern two-thirds of New Hampshire, and a portion of southern Maine. The implied range in Maine is indicated by a line which curves from the area of Stow, Oxford County, Maine, near the New Hampshire border, southeasterly to the area of Freeport, Cumberland County, Maine; however, no collection sites are listed from Maine (Hall and Kelson 1959).

Youngman and Gill (1968) reported this species from southwestern Quebec, and, more dramatically, Wood and Tessier (1974) found this species in southern Nova Scotia. The Nova Scotia sites suggest that this species may well be in Maine and New Brunswick.

On 12 and 13 July 1967, I collected two southern flying squirrels (*Glaucomys volans volans* Linnaeus) in North Anson, Franklin County, Maine (44° 51′ N; 60° 54′ W). Both were females which had recently ceased lactating. They are now in the Royal Ontario Museum (No. 62168), and in my personal collection at York University (DMC-214).

The specimens were collected from a mature mixed hardwood stand approximately 1 ha (2.5 acres) in size. Ten randomly located 0.04-ha (0.1-acre) sample plots provided cover and frequency values, respectively, for the four major component tree species as follows: red oak (*Quercus rubra*) 21%, 60%; sugar maple (*Acer saccharum*) 20%, 100%; beech (*Fagus grandifolia*) 32%, 80%; yellow birch (*Betula alleghaniensis*) 6.5%, 50%. Other tree species present were white birch (*Betula papyrifera*), white ash (*Fraxinus americana*), butternut (*Juglans cinerea*), trembling aspen (*Populus tremuloides*), and eastern hemlock (*Tsuga canadensis*). There were a number of dead sugar maples with nest holes 3–4.5 m (10–15 ft) high in this stand.

In a search of the literature, collections from eastern Canadian and United States museums, and from state and unversity collections, I found specimens taken from three other sites in Maine. These four sites in Maine, including North Anson, are beyond the implied range of Hall and Kelson (1959) (Table 1). I have examined all of the specimens listed in Table 1; they are definitely *G. volans*.

Muul (1968), in his study of physiological influences on *G. volans*, was perplexed that this species had not been collected in Maine; however, in a footnote to his text it was noted that he later found that two specimens of *G. volans* from Dryden, Franklin County, Maine, existed in the American Museum of Natural History. Dryden is 42 km (30 mi) southeast of North Anson. Further, he indicated that the northern boundary of this species in areas other than Maine

TABLE 1—Specimens of *Glaucomys volans* from Maine

Capture site	Date of capture	Collector	Site of specimen[1]	Museum number	Sex
North Anson	12 Jul. 1967	D. Cameron	ROM	62168	Female
North Anson	13 Jul. 1967	D. Cameron	York U.	DMC-214	Female
Dryden	13 Nov. 1951	G. Heinrich	AMNH	166835	Male
Dryden	16 Nov. 1951	G. Heinrich	AMNH	166836	Male
Norway	Feb. 1860[2]	Unknown	MCZ	943	Unknown
Eastport	Mar. 1860	U.S. Treat	MCZ[3]	941	Unknown

[1] Museums with specimens are ROM (Royal Ontario Museum), York U. (private collection of the author at York University), AMNH (American Museum of Natural History), and MCZ (Museum of Comparative Zoology, Harvard University).
[2] Date received.
[3] Skull only.

appeared to be delineated by several temperature measures. The average January, –9.4° C ± 2.8° C (15° F ± 5° F), and the average July, 20° C ± 1° C (68° F ± 2° F) isotherms in Maine encompass the collection sites of all the known Maine and Nova Scotia specimens, with North Anson being at the extreme limits of these two parameters.

The presence of *G. volans* in Maine (especially Eastport) and Nova Scotia, along with the existence of comparable vegetation and climate, suggests that this species is likely to be found in New Brunswick as well.

I thank the numerous persons who responded to my inquiries and who allowed me access to musuem specimens from the geographic area of concern. Special gratitude is extended to Charles O. Mack of the Museum of Comparative Zoology, Harvard University for his assistance regarding the MCZ specimens, and to E. O. Judkins, my father-in-law and owner of the woodlot where the North Anson collections were made, for gathering the phytosociological data.

Literature Cited

Hall, E. R. and **K. R. Kelson.** 1959. The mammals of North America. Volume I. Ronald Press, New York. xxx + 546 + 79 pp.

Muul, I. 1968. Behavioral and physiological influences on the distribution of the flying squirrel, *Glaucomys volans*. Museum of Zoology, University of Michigan, Miscellaneous Publications Number 134. iii + 66 pp.

Wood, T. J. and **G. D. Tessier.** 1974. First records of eastern flying squirrel (*Glaucomys volans*) from Nova Scotia. Canadian Field-Naturalist 88: 83–84.

Youngman, P. M. and **D. A Gill.** 1968. First record of the southern flying squirrel, *G. volans volans* from Quebec. Canadian Field-Naturalist 82: 227–228.

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Mourning Doves Wintering in Ontario

In recent years, reports indicating substantial numbers of wintering Mourning Doves (*Zenaida macroura*) in southern Ontario have increased. Winter flocks, sometimes consisting of up to 250 individuals, frequently occur around feeding stations in urban areas. In rural Ontario, they frequent corn cribs and fields from which grain has been incompletely harvested. I have observed them in granaries inside farm buildings, and associating with Rock Doves (*Columba livia*) in cattle enclosures.

Breeding and Winter Range

The species apparently occurred regularly in most of southwestern Ontario, and bred irregularly as far as Hamilton in 1886 but did not winter in the province (McIlwraith 1894). By 1907 the bird had extended its breeding range to Toronto (Fleming 1907) and, in 1910 the first breeding record for the Ottawa vicinity was reported (Eifrig 1911).

Baillie and Harrington (1936) reported that by 1936 the northern limits of the breeding range had extended to Simcoe and Carleton Counties, with individuals seen as far north as James Bay. They bred commonly as far north as King Township (Snyder 1930). The species had also penetrated into the Rainy River District but may not have bred there (Snyder 1938).

By 1960 the breeding range had been further extended to Algoma District and Renfrew County and to the Rainy River and Kenora Districts (MacLulich 1938; Ricker and Clarke 1939; Snyder 1957). Since 1960 the northern limit of breeding has probably been extended (W. E. Godfrey, personal communication), but relatively few birds breed north of latitude 46° N.

A Mourning Dove collected on 6 January 1877 near London (Morden and Saunders 1882) is the first winter record of the species in Ontario. The species, however, rarely wintered in Ontario until about 1940. It was first recorded wintering at Long Point in 1909 (Saunders 1909), at Kenora in 1930 (Baillie 1931), at Toronto in 1935 (unpublished Royal Ontario Museum record and ROM specimen 36.1.13.1), at Thunder Bay in 1938 (ROM specimen 31939), at Midhurst in 1939 (Devitt 1943), and at Cobourg in 1940 (ROM 33398). By 1940 the winter range had expanded to include Barrie (Devitt 1943) and Prince Edward County (Snyder et al. 1941). Between 1940 and 1945, the number of wintering individuals increased but they still were not common anywhere in the province (Snyder 1951).

Since 1945 the number of Mourning Doves wintering in Ontario has increased significantly

(Figure 1), particularly since about 1960, according to Christmas bird count data. By 1966 the winter range included "southern Ontario," north and east rarely to Ottawa (Godfrey 1966). Record numbers were observed at Long Point (353), Point Pelee (141), and St. Thomas (322) during the winters of 1967–1969.

Since 1968 the winter range has expanded further and the birds winter regularly in Kenora District and at Thunder Bay (unpublished ROM records). They occur in November as far north as New Liskeard (P. Richter, personal communication) but apparently do not winter north of Gravenhurst (H. Brown, personal communication). The present winter range includes virtually all of Ontario south of the −10°C mean minimum January isotherm.

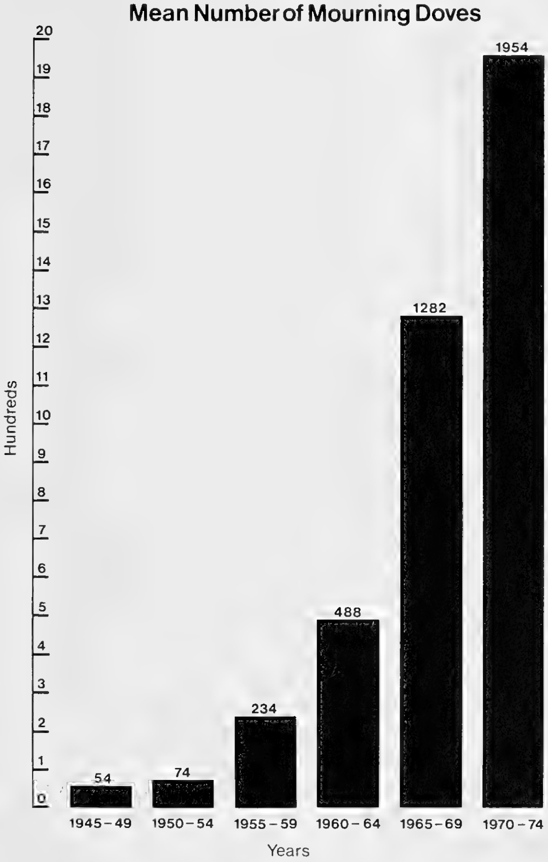

FIGURE 1. Numbers of Mourning Doves observed during Christmas counts (5-year means) at Barrie, Blenheim, Hamilton, Kettle Point, Kingston, London, Toronto, Pickering, and St. Thomas, 1945–1974. Data have been adjusted for annual variations in survey areas (i.e., birds per party hour). The Barrie count began in 1952 but was discontinuous after 1955; the Kettle Point count began in 1954. In both instances, count values in missing years were assumed to be zero, based upon ROM records, the opinions of local ornithologists, and the years for which counts were available. The remainder of the counts were conducted annually throughout the period.

Within this area, local populations have continued to increase. Unusually large winter counts have been made at Barrie (145), Blenheim (926), Kettle Point (255), London (460), Long Point (152), Napanee (69), Peel and Halton Counties (402), Pickering (520), Port Hope (242), and Toronto (111) since 1972 (Christmas counts, ROM records).

Despite available food, severely cold weather occasionally causes mortality among wintering Mourning Doves. In February 1967, 3 km north of Uxbridge, I found an individual weakened and unable to fly. All the toes of this bird were frozen and swollen and, as a result, it was unable to walk or stand. On 9 February 1975, 3 km south of Orillia, I found a dead adult male, with similarly frozen toes. In both instances, very cold temperatures had occurred during the previous week. Of 17 apparently healthy birds which I captured near Orillia on 8 February 1975, the toes of 14 individuals appeared to have been previously frozen. In all instances, nails were absent, toes were yellow and enlarged in appearance. The three individuals which had normal toes were possibly subadults, and the absence of deformities was probably due to the lack of very cold temperatures in the vicinity during the winter of 1974–75. Apparently this phenomenon is restricted to the extreme northern United States (K. Gamble, United States Fish and Wildlife Service, personal communication) and southern Ontario.

The Ontario wintering population appears to decline in late January and during February. The decline could be a result of emigration or mortality.

Taxonomic Considerations

There are only 14 Ontario winter specimens of this species in the Royal Ontario Museum. Twelve of these, all of which were obtained east of Sault Ste. Marie, are *Z. m. carolinensis*, the eastern race of the Mourning Dove. Recoveries of breeding individuals banded in that part of Ontario have been from South Carolina (one individual), Georgia (three), Louisiana (three), and Florida (one). Furthermore, Ontario recoveries of doves banded elsewhere include individuals from Louisiana (three), Michigan (two), Ohio (two), Virginia (two), Mississippi (one), New York (one), and North Carolina (one), suggesting that the birds which do not winter in southern Ontario are associated with wintering areas in the southeastern United States.

Two winter specimens from the vicinity of Thunder Bay have been identified by ROM staff as *Z. m.*

marginella, a race which breeds commonly in southern Manitoba. There are no banding data from western Ontario, and no substantial numbers of Mourning Doves winter north of 45° in Wisconsin and Minnesota (Christmas bird count data), the states immediately to the south of this region.

The proportion of the southern Ontario breeding population which remains within the province throughout the winter is probably very small. It is likely that few individuals from other breeding areas winter in Ontario and that the recent increases in wintering population are due to availability of food and increases in local breeding populations. Should the wintering tradition continue, it is possible that local physiological races may be developed. This behavior might be merely a tradition, however, with no genetic basis.

Literature Cited

Baillie, J. L. 1931. Mourning Dove in Kenora District, Ontario. Canadian Field-Naturalist 45: 180.

Baillie, J. L. and **P. Harrington.** 1936. The distribution of breeding birds in Ontario. Transactions of the Royal Canadian Institute 21: 43.

Devitt, O. E. 1943. The birds of Simcoe County, Ontario. Part I. Transactions of the Royal Canadian Institute 24: 306–307.

Eifrig, C. W. 1911. The birds of Ottawa. Ottawa Naturalist 24: 180.

Fleming, J. H. 1907. Birds of Toronto, Canada. Part 2. Land birds. Auk 24: 71–89.

Godrey, W. E. 1966. Birds of Canada. National Museum of Canada Bulletin 203: 208.

MacLulich, D.A. 1938. Birds of Algonquin Provincial Park, Ontario. Royal Ontario Museum of Zoology Contribution 13: 16.

McIlwraith, T. 1894. The birds of Ontario. 2nd Edition. Wm. Briggs Company, Toronto. 186 pp.

Morden, J. A. and **W. E. Saunders.** 1882. List of the birds of western Ontario. Canadian Sportsman and Naturalist 11: 193.

Ricker, W. E. and **C. H. D. Clarke.** 1939. The birds of the vicinity of Lake Nipissing, Ontario. Royal Ontario Museum of Zoology Contribution 16: 11.

Saunders, W. E. 1909. Winter birds at Point Pelee. Ottawa Naturalist 23: 48.

Snyder, L. L. 1930. A faunal investigation of King Township. Transactions of the Royal Canadian Institute 17: 187.

Snyder, L. L. 1938. A faunal investigation of western Rainy River District, Ontario. Transactions of the Royal Canadian Institute 22: 189.

Snyder, L. L. 1951. Ontario birds. Clarke, Irwin and Company, Toronto. p. 114.

Snyder, L. L. 1957. Changes in the avifauna of Ontario. *In* Changes in the fauna of Ontario. *Edited by* F. A. Urquhart. University of Toronto Press, Toronto. p. 132.

Snyder, L. L., E. B. S. Logier, T. B. Kurata, F. A. Urquhart, and **J. F. Brimley.** 1941. A faunal investigation of Prince Edward County, Ontario. University of Toronto Studies, Biological Series 48: 49.

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A Comparison of the Dispersal and Seedling Establishment of *Vaccinium angustifolium* (the Lowbush Blueberry) in Leeds County, Ontario and Pictou County, Nova Scotia

Introduction

While accumulating field data on the North American blueberries (*Vaccinium* section *Cyanococcus*) during the past five years, I observed that seedlings of *Vaccinium angustifolium* were very rare in eastern Ontario but common in Nova Scotia. Nevertheless colonies are abundant on acidic soils in both regions. The purpose of this paper is to describe quantitatively the reproductive mechanism of *V. angustifolium* in both these areas and to show through field germination trials that seedling establishment in eastern Ontario is rare unless the time of dispersal is significantly delayed. In Leeds County, Ontario seed dispersal begins as early as 11 June (1970) or as late as 20 June (1974), peaks in early July, and finishes in early September, at which time the Pictou County, Nova Scotia blueberries are at their peak.

The dispersal agents are similar for both regions: robins, bears, and small mammals eat most of the berries under natural conditions. In Pictou County, however, it is the migrating robins which are the most active dispersal agents. Eaton (1957) has reported a similar observation for New Brunswick. In Leeds County where dispersal occurs in early July robins are in the territorial phase of their annual life cycle; a high density of birds has not been observed.

Seedling establishment, however, seems to differ significantly in the two areas; in six summers (1969–1974) of careful observations not only in Leeds County, but also in adjacent counties, seedlings have been found only once (voucher specimens in ACAD) in a moss depression on Hump Island in Lake Opinicon, Leeds County, whereas in Pictou County any abandoned pasture, exposed ridge, or cut-over forest contains a large number of seedlings. This difference in seedling establishment is reflected in both the age structure of the colonies (Table 1) and in the density of seedlings in the two localities.

Table 2 shows the results of randomly throwing a 1-m square frame 10 times per ha in areas which had less than 0.1% shrub cover, and of counting the number of woody plant seedlings in each square metre. Not only do the number of seedlings for the two localities differ but also the species composition: *Acer rubrum* is the only common seedling species the two localities share. *Vaccinium angustifolium* seedlings were absent from the sandstone pavements and the adjacent granite-gneiss outcroppings near Elgin in Leeds County.

Although both areas are in the same plant hardiness zone (Thomas 1953), Rowe (1972) has placed the respective areas into two different forest regions: Leeds County falls within the Huron-Ontario section of the Great Lakes – St. Lawrence Region but Pictou County falls within the Cobequid section of the Acadian Forest Region.

These differences in vegetation may result from small but cumulative climatic differences: Pictou County receives 100 cm precipitation annually, Leeds County 83 cm (Climate of Canada 1962). The amount of summer rainfall is similar for both counties. On the average, the growing season in Pictou County begins on 24 April, 10 days later than in Leeds County; this delay may result from the prevalence of fogs which are at peak frequency in late spring in Pictou County. Although the average daily maximum temperature is similar in both areas during the early summer months, the mean daily minimum in Pictou County is consistently 2.3°C below that of Leeds County. Yet, as Geiger (1966, p. 439) has reported, blueberry growth and development shows a close relationship to night temperature and although this might account for the later dispersal period of *V. angustifolium* in Pictou County, it cannot account for the prevalence of seedlings in Pictou County and their absence from Leeds County. To clarify this aspect, field germination trials were established in Leeds and Pictou Counties.

Description of Sites

The Leeds County site is a granite-gneiss outcrop (0.1 ha) on the south shore of Lake Opinicon 1.7 km SW of Chaffey's Locks and is part of Queen's University Biological Station. Twenty percent of this outcrop is bare rock. It is fringed by extensive mats of *Polytrichum piliferum* which in turn merge into a *Poa compressa* – *Danthonia spicata* meadow at whose margin lies a *Quercus alba* – *Ostrya virginiana* parkland. *Vaccinium angustifolium* is present along chinks in the granite.

The Pictou County site is a 2-ha gravel hill 3.8 km SW of West Branch; its vegetation is primarily *Danthonia spicata, Hieracium pilosella, Myrica pen-*

TABLE 1—Differences in the frequency of *Vaccinium angustifolium* age classes in an old field near Elgin, Ontario and an old field near West Branch, Nova Scotia

Age classes* (years)	Colony size classed by diameter in cm	Frequency of occurrence	
		West Branch, N.S.	Elgin, Ontario
1–10	0.1 – 10	13	—
11 – 20	11 – 60	69	—
21 – 40	61 – 100	16	—
41 – 60	101 – 200	15	2
61 – 80	210 – 300	2	9
>80	>300	1	7

*Conversion of colony diameters to age class is based on growth rates of rhizomes as suggested by Eaton and Hall (1961).

TABLE 2—Comparison of woody plant seedling density/m² in abandoned fields near West Branch, Nova Scotia and near Elgin, Ontario

Species	West Branch, Pictou County (28-m² quadrats)	Elgin, Leeds County (34-m² quadrats)
Vaccinium angustifolium	33	—
Vaccinium macrocarpon	4	—
Rhododendron canadense	8	—
Alnus crispa	44	—
Myrica pensylvanica	5	—
Rubus allegheniensis	—	7
Spiraea latifolia	2	—
Viburnum cassinoides	—	1
Betula populifolia	11	—
Populus tremuloides	1	—
Acer rubrum	10	10
Juniperus communis	1	2
Picea glauca	32	—
Tsuga canadensis	1	—
Pinus strobus	—	1
Prunus serotina	—	1
Quercus alba	—	3
Quercus borealis	—	5
Ostrya virginiana	—	3
Rhus typhina	—	2
Amelanchier spp.	3	1
Crataegus spp.	4	—
Salix spp.	3	—

sylvanica, Vaccinium angustifolium, and *Populus tremuloides.*

Methods

At each site, a rain gauge and temperature sensing equipment were installed to measure precipitation patterns during the dispersal period and daily temperature fluctuations at ground level in order to correlate microclimatic data with seedling establishment.

Next, 10 seed beds, each with a diameter of 7 cm, were selected at random and prepared at each location. At the beginning of each week during the dispersal period, one of these beds had 75 seeds from berries harvested in the immediate area planted on its surface and covered with freshly dried and ground sphagnum. Each bed was labelled and the number of blueberry seeds which germinated was recorded.

In addition, at the Leeds County site, a field control was added. Ten 10-cm plastic pots filled with a sieved outcrop soil were set into refillable water wells, so that the soil in the pot could be kept constantly moist. Pots were buried in the sod with only the rim above ground. These pots were seeded in the same manner as described above. The addition of water to the wells was stopped on 5 September.

Finally, for control, fresh seeds were planted on top of a 1:1 peat-sand mixture, covered with a few millimetres of freshly dried and ground sphagnum and placed in a misting chamber. (See Hall et al. (1970) for details of technique.)

Results

Each berry contained 56 ± 12 seeds; of that number 30–50% are light brown seeds (33 mg/100 seeds); the remainder are pale and imperfect *sensu* Bell (1957), do not germinate, and weigh 17 mg/100 seeds.

In the misting chamber, the large seeds from both localities germinated readily after 20 days but the field controls planted in June and early July had no germination (Table 3). This lack of success in the early controls may be attributed to the desiccation of the surface: a direct consequence of the severe diurnal temperature fluctuations at ground level during this period when maximum ground temperatures of 46–61°C and minimum temperatures of 9–15°C were recorded on 26 June and 8 July respectively.

The same severe diurnal temperature fluctuations apply to field conditions. At Leeds, however, the rainfall was limited to light showers (Table 4) and probably accounted for the lack of germination during the summer. Not until 20 October were the first field seedlings observed in Leeds, an event which coincided with Indian summer when several of the control plants were already 4–5 cm tall. None of these field seedlings survived the winter. The control seedlings had severe winter kill and a late spring

TABLE 3—Field germination trials and seedling establishment of *Vaccinium angustifolium* in Leeds County, Ontario and Pictou County, Nova Scotia

		Leeds County, Ontario	Pictou County, Nova Scotia	Field control (Leeds County)	Control (misting chamber)
Dispersal dates (1974)	beginning	20 June	17 July	—	—
	maximum	10–20 July	20 Aug.–5 Sept.	—	—
	finish	15 Sept.	27 Oct.	—	—
Date of first planting		24 June	20 July	27 June	27 June
Date of last planting		4 Sept.	28 Sept.	4 Sept.	1 July
Date of first observed seedling		20 Oct.	21 Sept.	4 Aug.	18 July
Number of seedlings 5 Sept. 1974		0	0	111 (15%)	159 (53%)
25 Oct. 1974		2 (0.3%)	4 (0.5%)	225 (30%)	—
30 April 1975		0	Snow	128 (17%)	—
15 June 1975		0	1 (0.1%)	6 (0.8%)	—

drought killed 122 seedlings. But the six remaining seedlings were vigorous, 6–10 cm high with three lateral shoots within 9 months.

In conclusion, seedling establishment in Leeds County, while possible, is unlikely except when the following sequence of events occurs: (*i*) a cool spring which delays the dispersal period, (*ii*) a wet August and September, (*iii*) a mild winter or a winter with good snow cover, and (*iv*) a wet spring. That this sequence has probably not occurred in the last 40 years is supported by the lack of seedlings and the absence of small colonies from the sandstone pavements near Elgin. Only on the slow-weathering outcrops scattered throughout this region are the

TABLE 4—Precipitation pattern during the blueberry dispersal period in Leeds, Ontario and Pictou County, Nova Scotia in 1974

	Days with precipitation	Total precipitation	Mean daily precipitation	Variation in daily precipitation
Lake Opinicon, Leeds County (20 June – 4 Sept.)	27	154 mm	5.7 ± 6.9 mm	0.2 – 21 mm
West Branch, Pictou County (20 July – 13 Oct.)	13	236 mm	18.2 ± 8.9 mm	3 – 39 mm

colonies abundant but again no seedlings have been observed; this species is thus perpetuated only by its underground root system. Therefore, a decrease in the population of *Vaccinium angustifolium*, due to natural attrition and succession, is predicted for eastern Ontario.

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Literature Cited

Bell, H. P. 1957. The development of the blueberry seed. Canadian Journal of Botany 35: 139–149.

The Climate of Canada. 1962. *Reprinted from* The Canada year book 1959, 1960. Meteorological Branch, Canada Department of Transport, Toronto. 74 pp.

Eaton, E. L. 1957. The spread of blueberry seed through manure and by migrating robins. Proceedings of the American Society for Horticultural Science 69: 293–295.

Eaton, E. L. and **I. V. Hall.** 1961. The blueberry in the Atlantic Provinces. Research Branch, Canada Department of Agriculture, Publication 754. 35 pp.

Geiger, R. 1966. The climate near the ground. (*Translated by* Scripta Technica from the 4th German edition.) Harvard University Press, Cambridge, Massachusetts. 611 pp.

Hall, I. V., F. R. Forsyth, L. E. Aalders, and **L. P. Jackson.** 1970. Physiology of the lowbush blueberry. Economic Botany 26: 68–73.

Rowe, J. S. 1972. Forest regions of Canada. Canadian Forestry Service Publication 1300. 172 pp.

Thomas, M. K. 1953. Climatological atlas of Canada. National Research Council of Canada Bulletin 3151.

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Carex praegracilis W. Boott, Recently Adventive in Southern Ontario

Abstract. A widespread western species, *Carex praegracilis* W. Boott is only recently adventive in southern Ontario. It was first noticed in the southern part of the province in 1973. A map indicating its present distribution shows 28 locations representing 14 counties. Illustrations, a key, and a comparison table are provided to facilitate the separations of *C. praegracilis* from similar species of *Carex* in the northeast. With one exception the stations in southern Ontario are along major roadways. Dispersal of seeds and rhizomes has been augmented by highway traffic, especially by the activity of highway construction and maintenance equipment. Colonization by *C. praegracilis* has also been favored by its tolerance of extreme environmental conditions, including high NaCl levels resulting from the use of "de-icing" salt. The species may prove useful in maintaining an effective roadside cover. It is anticipated that *C. praegracilis* will become increasingly abundant and widespread in the northeast.

Carex praegracilis W. Boott is one of the most widespread species of *Carex* in western North America ranging from the Yukon to Central Mexico and east to Manitoba and Texas (Mackenzie 1931; Hermann 1974). It has also been reported from South America (Mackenzie 1931). Both Hermann (1974) and Mackenzie (1931) note that it is adventive eastward.

It was collected in northwestern Ontario along the CNR tracks 1 mi (1.6 km) west of Rainy River town in Atwood Township, Rainy River District by C. E. Garton (8534) in 1961 (TRT 133029). Voss (1972) reported this species from two localities in Michigan as well. But *C. praegracilis* was not known in southern Ontario prior to 1973 when a few colonies were discovered by the authors on highway verges. Subsequent surveys disclosed it to be frequent along highways 400 and 401 and present along a number of other major roadways. It now appears to be quite widespread in the southern part of the province (Figure 1). As some of the roads along which it occurs are less than 20 years old, the species is presumably a very recent introduction. One locality in Simcoe County is along a railway but all others are roadside sites. Surveys in eastern Ontario are very incomplete and the absence of stations from that area may be due entirely to this factor. Specimens substantiating these southern Ontario records are deposited in CAN, DAO, TRT, and TRTE.

In Ontario, *C. praegracilis* is the only member of the series *Divisae*. It is distinctive in the flora in having a stout rhizome with black fibrous sheaths, a hyaline

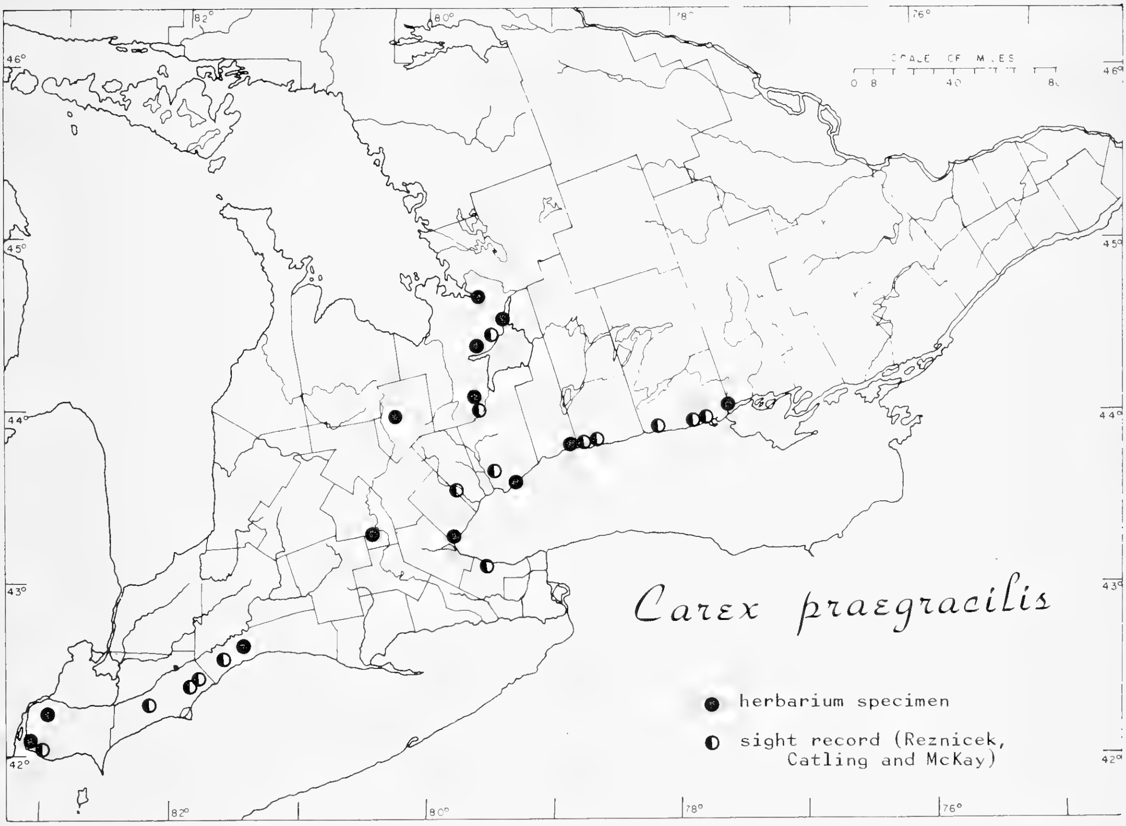

FIGURE 1. The distribution of *Carex praegracilis* W. Boott in southern Ontario, based on specimens at CAN, DAO, TRTE, and TRT, and on the sight records of A. A. Reznicek, P. M. Catling, and S. M. McKay.

inner band to the leaf sheaths and stipitate plano-convex, two-edged but not winged perigynia. The spikes are essentially similar. The habit of the plant and its distinguishing features are illustrated in Figure 2. Similar species in our flora are *C. sartwellii* and *C. foenea*. From the former, it is distinguished by the narrower leaves, hyaline inner band of the sheath, and the nerveless inner face of the perigynia, and from the latter by its thick dark rhizome and wingless, shorter perigynia. In addition, *C. sartwellii* is a species of fens, wet meadows, and openings in conifer swamps while *C. foenea* is a plant of dry sandy prairies and prairie-like situations in open dry oak or pine forests. The following key is adapted from the comparisons in Table 1.

Inner band of leaf sheaths hyaline, widest leaves usually 1.4–3.0 (3.5) mm
  Perigynia 2.2–3.7 mm long, blunt-margined *C. praegracilis*
  Perigynia 3.8–6.8 mm long ± wing-margined *C. foenea*
Inner band of leaf sheaths green and striate, widest leaves usually 2.8–4.8 mm *C. sartwellii*

From mid- to late May, *C. praegracilis* is very apparent along some southern Ontario highways, growing in the median strips, ditches, and even extending onto the gravel shoulders (Figure 3). It mostly occurs in large, often more or less circular clonal patches. These patches are usually either mostly pistillate with only a few staminate flowers in the inflorescences, or mostly staminate with only a few pistillate flowers. The flowers of the less frequent sex may be distributed anywhere in the inflorescences but are more frequent at the bases of the spikes. This dimorphism has been noted by Mackenzie (1931). The plants are frequently taller than the surrounding vegetation during the flowering period in late May and the "male" clones with their conspicuous straw-colored spikes (due to the exerted anthers) are very prominent. The "female" clones are more inconspicuous at anthesis, having thinner greenish-brown spikes.

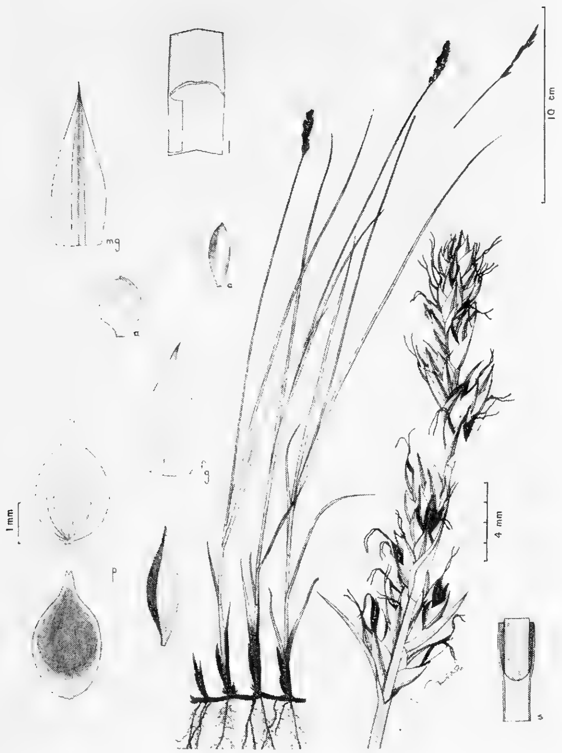

FIGURE 2. *Carex praegracilis*, based on TRT 183213. a, achene; fg, female glume; l, ligule; mg, male glume; p, perigynia; s, sheath. Drawing by Audra Geras.

Mature plants of *C. praegracilis* present an aspect markedly different from flowering specimens since the culms elongate considerably as maturity is reached. In southern Ontario the fruit matures and maximum height is attained in early July but frequently the highway verges have been mowed by this time, so specimens with mature perigynia may be difficult to obtain. Some patches occasionally remain uncut or a few culms are merely knocked down by the mowers. During the course of this study, however, plants from several localities were transplanted to allow for the collection of enough perigynia to ascertain the range of variation. In addition to their variation in size (Table 1), the perigynia were found to vary considerably in shape. The body ranged from suborbicular to ovate-lanceolate and tapered from abruptly to gradually, to a beak one-third to two-thirds as long as the body. The perigynia of *C. foenea* and *C. sartwelli* were observed to vary in parallel fashion.

Highway verges are among the habitats most frequently neglected by botanists, yet these areas are most interesting with respect to introduced and adventive species. They provide essentially uninterrupted corridors for long-distance dispersal and represent new habitats affording easy colonization with a minimum of competition. Dispersal may be rapidly accomplished, the seed being spread by mowers and highway traffic, and the sod and roots spread during grading of highway shoulders and by highway construction. Those species resistant to the extreme conditions of road verges, such as summer drought and high NaCl levels, would be favored.

Carex praegracilis is said to be alkali-tolerant

TABLE 1—A comparison of *C. praegracilis*, *C. foenea*, and *C. sartwellii* with respect to characters of the perigynia, leaves, and rhizomes. This table is based on measurements of specimens in CAN, DAO, TRT, and TRTE, and not on previously published descriptions

Species	Leaves		Perigynia			Rhizomes	
	Maximum width (mm)	Inner band of sheath	Length (mm)	Winged	Nerves on ventral face	Widest diameter (sheath incl.) (mm)	Sheath color
C. praegracilis	1.4–3.0	Hyaline	2.2–3.7	—	—	2.6–4.5	Black
C. foenea	1.8–2.9 (3.5)	Hyaline	3.8–6.8	+	±	1.5–3.0 (4.1)	Chestnut-brown
C. sartwellii	2.8–4.8	Green and striate	2.4–4.2	Thin-margined	+	3.0–5.2	Black

FIGURE 3. *Carex praegracilis* extending onto the gravel shoulders of highway 401 near Whitby, Ontario. Photographed June 1975 by P. M. Catling.

(Hitchcock and Cronquist 1973), and we have found pH values from 7.5 to 8.1, and sodium levels ranging from 200 to 1500 ppm in soil collected from about the roots of plants growing in several widely separated locations. These abnormally high sodium levels (for southern Ontario) result from the use of "de-icing" salt (NaCl—95%, $\mathrm{CaCl_2}$—5%) in winter. In the more saline, periodically moist sites *Carex praegracilis* associates with other plants tolerant of more or less saline conditions, such as *Puccinellia distans, Juncus compressus, Juncus balticus, Triglochin maritimum, Atriplex patula* var. *hastata,* and *Chenopodium rubrum*. But the sedge also grows in somewhat drier, less saline sites with *Festuca arundinacea, Festuca rubra,* and *Agropyron repens*. The two former species are used in establishing turf along southern Ontario highways and both are relatively salt-tolerant.

Although "de-icing" salt tends to destroy roadside vegetation, resulting in dieback and subsequent erosion problems, there seems to be no alternative to its use in clearing the highways in winter. The use of tolerant vegetation would seem to be an efficient and inexpensive means of maintaining vegetation cover. *Carex praegracilis* offers some interesting possibilities in this regard. In addition it appears to be able to colonize recently disturbed sites where all topsoil has been removed, and this situation is evident along all new highways. Finally, *Carex praegracilis* has become widespread in southern Ontario without any conscious intervention on man's part, and it seems likely that with some intentional stimulation through seeding and/or spreading of rhizomes and roots it could be very effective in maintaining cover and preventing erosion.

If the use of "de-icing" salt continues, we expect that there will be yet further development of salt-tolerant vegetation along highways and that *Carex praegracilis* and other species with a similar ecology will spread farther and become more frequent along major highways in eastern North America.

Literature Cited

Hermann, F. J. 1974. Manual of the genus *Carex* in Mexico and Central America. United States Department of Agriculture, Agriculture Handbook 467. 219 pp.

Hitchcock, C. L. and **A. Cronquist.** 1973. Flora of the Pacific Northwest, an illustrated manual. University of Washington Press, Seattle. 730 pp.

Mackenzie, K. K. 1931. Cyperaceae, Tribe 1, Cariceae. North American Flora (Jena) 18: 1–60.

Voss, E. G. 1972. Michigan flora. Part 1, Gymnosperms and monocots. Cranbrook Institute of Science and University of Michigan Herbarium. Bloomfield Hills, Michigan. 488 pp.

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A Dwarf Tree Swallow Egg

Recent documentation of unusually small eggs found in some passerines (Rothstein 1973; Seymour 1975) suggests that this occurrence is a rarity. The present note reports this phenomenon for the Tree Swallow, *Iridoprocne bicolor* (Vieillot), in Fredericton, New Brunswick.

The dwarf egg was found on 10 June 1975 in a nest box, one of a number put up for use by a small local swallow colony. The egg was laid between 7 and 9 June and represented one of the last three eggs deposited in a clutch of six by an adult female. The egg measured 13.1 × 9.2 mm compared to 17.7 × 14.3 mm for a randomly chosen normal one in the clutch. Sixteen other Tree Swallow eggs of five clutches on the same area averaged 18.7 × 13.2 mm, the smallest ones being 17.7 mm long and 12.6 mm wide. The egg did not hatch but on 23 June the rest of the clutch produced five young that all fledged on 12 July.

This unusually small egg represents the only one of its kind that I have found in examining 570 Tree Swallow eggs (119 clutches) in recent years. In addition, there is no mention of eggs of unusual size in 234 Tree Swallow clutches (1195 eggs) reported in the Maritimes Nest Records Scheme. Bent (1942) does not refer to dwarf eggs for any of the swallow species.

Literature Cited

Bent, A. C. 1942. Life histories of North American flycatchers, swallows, larks, and their allies. United States National Museum Bulletin 179. 555 pp.

Rothstein, S. I. 1973. The occurrence of unusually small eggs in three species of songbirds. Wilson Bulletin 85(3): 340–342.

Seymour, Norman R. 1975. An unusually small hermit thrush egg. Canadian Field-Naturalist 89: 188.

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Editor's note: The occurrence of dwarf eggs is probably not as rare as some authors have considered it to be. Probably, however, aberrant eggs are noted mainly by persons examining large numbers of eggs. As *The Canadian Field-Naturalist* does not wish to be inundated with these reports nor does it wish to clutter the literature with many individual reports, we suggest that similar data should be filed with nest records schemes. Thus when a comprehensive publication is planned, the data can be compiled both from nest records files—and we urge nest records schemes to keep such records on file—and from museum collections of eggs.

Twig Abscission in Maples (Section *Rubra: Acer rubrum* and *A. saccharinum*) as a Defence Reaction against Water Stress

Twig and branch abscission is well known in various trees, notably poplars (*Populus*) and oaks (*Quercus*). Until recently I have seen no discussion of its occurrence in maples (*Acer*). It is briefly mentioned for *Acer rubrum* and *A. saccharinum* by W. F. Millington and W. R. Chaney (1973. *In* Shedding of plant parts. *Edited by* T. T. Kozlowski. Academic Press, New York) and stated to be unusual in occurring during spring and early summer; but they do not mention the circumstances of its occurrence. I here present evidence that it counteracts water deficiency, which might otherwise induce severe leaf scorch.

Each spring from 1942 to 1949 a young red maple (*A. rubrum*) (ca. 20 cm diameter at breast height), growing close to a street intersection in front of my home at Ottawa, shed twigs so abundantly as to interfere with mowing the lawn. A 1-year count of raked up twigs between 2 cm and 28 cm long, exceeded 1200, but doubtless excluded many small ones that remained unobserved in the grass. The period of shedding ranged generally from soon after bud-break to early June, but was usually most abundant in mid- to late May approximately when the leaves became fully expanded. Actual abscission may appreciably precede twig fall in windless weather, but this aspect was not studied.

Frequent observations, in the same period, of red maples growing in parks and gardens without adjacent paved areas showed at most only slight abscission. A red maple in front of the house to which I moved in 1949 generally shed few twigs despite proximity to the sidewalk, perhaps because the lawn, on the north side of the house, was heavily shaded and the soil was a heavy clay loam that seldom dried out seriously. But in the year after I regraded the lawn and replaced the front path, inevitably cutting many roots, abscission was moderately heavy.

In 1974 and 1975 I had under observation a garden with four large silver maples (*A. saccharinum*): two in front of the house, each bordered on three sides by a paved driveway, a wide concrete path, and paved street and sidewalk; and two behind the house, far from any paved surfaces. In 1974 the weather from late April through May at Ottawa was cool and

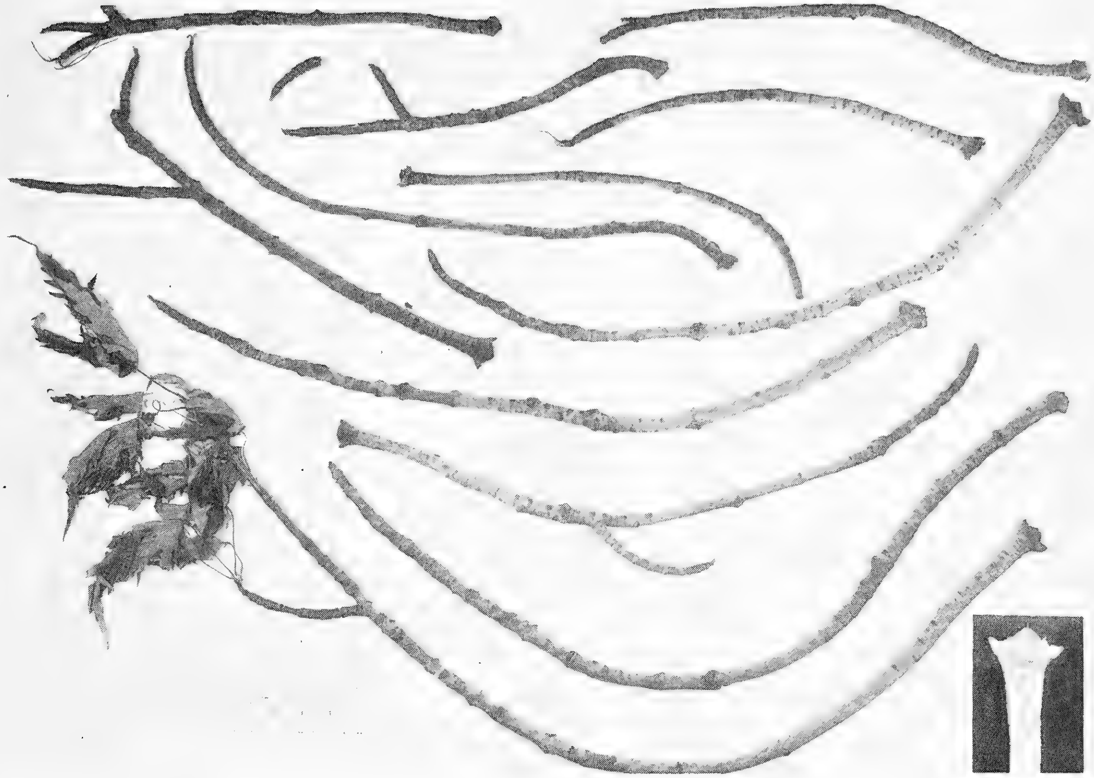

FIGURE 1. Selection of abscissed twigs of *Acer saccharinum*, collected from trees adjoining pavement, Ottawa, Ontario, 31 May 1975 (*Savile 5141*); photographed by Ken W. Spicer. Inset: detail of twig base; photographed by Modra Kaufert.

abnormally wet; and no twig abscission was noticed in any of these trees. In 1975 the weather was exceptionally warm and dry from late April to late May. Again no significant abscission occurred in the trees behind the house; but the trees in front of the house shed many twigs up to at least 35 cm long, mainly in the last half of May.

Figure 1 shows that the twigs of *Acer saccharinum* are cut off by a typical conical corky abscission layer, such as Millington and Chaney (*loc. cit.*) illustrate for *Populus* and *Quercus*. Abscissed twigs of *A. rubrum* are generally somewhat smaller but otherwise identical in form.

Water supply to the twigs seems generally to be cut off before the buds burst; but, as the lowest twig in Figure 1 shows, the vessels may remain intact until just before the twig falls, allowing partial expansion of the leaves.

Acer rubrum ranges in habitat from swamps and lake shores to arid south-facing rocky hillsides. Twig abscission in this species seems to be an adaptive device, whereby shedding of a proportion of twigs saves the tree from developing an interveinal scorch of all its leaves, such as is often seen in sugar maple (*A. saccharum*) under conditions of stress. *Acer saccharinum*, which is closely related to *A. rubrum*, grows most commonly on moist bottom land exposed to prolonged spring flooding. E. Jorgensen suggests that this flooding causes a physiological drought and twig abscission. The abscission habit is perhaps general in section *Rubra* Pax. and may indicate an ancestral species that evolved under conditions of frequent water stress.

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Local Denudation of the Sublittoral Fringe by the Green Sea Urchin, *Strongylocentrotus drobachiensis* (O.F. Müller)

Since 1968 regular visits have been paid to Pea Point, the site of a lighthouse near Black's Harbour, New Brunswick, for collection of study specimens in research and teaching programs. The lighthouse is on a small island separated from the mainland by a narrow channel, drained at mid-tide. The western end of the channel opens on Black's Harbour and is relatively sheltered. There is a coarse sandy beach and a number of stony runs between massive rock outcrops. The eastern end of the channel is much more exposed, opening onto the waters at the mouth of the Bay of Fundy. This part of the shore is relatively level, composed of bedrock largely covered by fucoids. Near the end of the channel, however, the rock drops steeply as a small cliff to another flat area at approximately the level of chart datum, bounded on either side by the higher and equally steep cliffs of the island and mainland. This lower flat is accessible at low water of large tides (in this region reaching chart datum), but not at low water of mean tides (1.1m above chart datum). Up to 1973 this lower flat was the site of a small *Laminaria* bed consisting of well-grown, closely-set plants with a quite rich associated flora and fauna. There were growths of *Lithothamnium* and other Rhodophyceae, sponges (mainly *Halichondria* sp.), various hydroids and bryozoans, small anemones (*Metridium senile*), mussels (mainly large dense-packed *Mytilus edulis*, particularly along the upper edge of the flat on large rounded blocks beneath the cliff leading to the upper shore, but also including small *Modiolus modiolus*), chitons, littorinids and other gastropods, small sea-cucumbers, and starfish. The green sea urchin, *Strongylocentrotus drobachiensis*, was common, but occurred mainly in gulleys and between the larger blocks when the tide was out.

This pattern began to change during 1974 and by the end of July had undergone considerable alteration. At that time only a few *Laminaria* plants did not show signs of damage and about a third were chewed to a lattice-work of holes. There were many naked stipes and decapitated holdfasts. Other species, however, were little affected and the rock surface retained the naturally dark coloration of weathered and encrusted ground. Urchins were in greater abundance than previously and no longer confined to the more sheltered spots while the tide was out. A number were found on *Laminaria* plants. Elsewhere on the island urchins were abundant in gullies on the lower shore and in places could be seen to be grinding the rock surface, exposing much paler patches on the flatter areas. By October 1975 the former *Laminaria* bed had entirely disappeared. The shore was visited at a time of unusually low tides when the entire surface of the lower flat was uncovered and it could be seen that not even holdfasts were left. Neither *Lithothamnium* nor encrusting animals were found on this part of the shore. *Mytilus* was confined to large blocks at the upper part of the flat and the population consisted largely of small individuals (spat-of-the-year) surrounding occasional large individuals. *Modiolus, Cucumaria, Asterias* were not seen, though littorinids, *Thais*, and a few young *Buccinum undatum* were still present in the area occupied by *Mytilus*. Chitons and other more delicate forms were not found.

Urchins were still one of the more abundant species, but were not nearly so common as in the previous year and were once again strictly confined to the more sheltered crevices during low water. Elsewhere on Pea Point urchins were very abundant near extreme low water, in many places forming a solid and uniform band along the rocks, unmixed with other species except for occasional large starfish at the upper boundary of their occupation. Fucoids and *Mytilus* were common higher on the shore, but did not reach nearly to the urchin zone, as they did in earlier years. The floors of stony runs at the Black's Harbour end of the channel contained considerable organic debris and were occupied by a uniform pavement of urchins so closely packed that it was impossible to pick up individuals without actually prising them loose from their neighbors. A count showed 400 or more full-grown individuals per square metre. On the seaward side of the island the few flat areas near low water were equally heavily occupied by urchins.

The most striking change, however, has been in the bedrock itself. In the former *Laminaria* bed the entire surface is pale, with the pinkish tinge of the unweathered rock apparent across the entire area contrasting strongly with the darker color of rock even a little higher up the shore. Examination of flat areas occupied by urchins on the seaward side of the island revealed similar conditions underneath the animals, and the conclusion that where *Laminaria* had once grown the urchins have now devoured everything, down to the organically-rich surface of the rock itself, seems inescapable. The impact upon the urchins themselves is clearly great. Not only is there no food left in this particular area, but there is no weathered surface left on which recolonization could start, nor shelter from wave action, freezing, or desiccation during the spring tide period. Comparison with normal rock surfaces at the edge of the area suggests that the amount of rock removed is probably of the order of 2–3 mm, but it may well be greater in some places.

Urchins, particularly the shallow-water forms *Arbacia* and *Strongylocentrotus*, are generally considered to be herbivores (Gosner 1971). But personal observation on *Arbacia* in the Naples Aquarium showed that if plant material were absent it regularly trapped small fish against the sides of the tank or other objects and would then devour the whole body. Similar observations in the Aquarium of the Huntsman Marine Laboratory at St. Andrews, New Brunswick, showed that *Strongylocentrotus* would eat *Mytilus* without difficulty and this has also been observed upon the shores of Passamaquoddy Bay. Physical damage to rocky shores (and especially to coral reefs) has been widely reported, though only to the limited extent of deepening existing gullies and depressions in which the urchins lodge as part of their normal rather secretive behavior. MacGinitie and MacGinitie (1968) doubt the claim that this is due to the abrasive action of spines, but consider that it is a very slow process brought about by gradual solution of clean rock by sea-water over a period of years.

Various studies have shown that lobsters are a major predator upon sea urchins (Mann and Breen 1972) and that their declining abundance is thus a key factor in encouraging the grazing of urchins upon *Laminaria* and other algae. This, however, appears to be the first case where complete denudation of the sublittoral fringe has been observed. It will be a matter of concern to see whether the area described remains barren in future years.

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Literature Cited

Gosner, K. L. 1971. Guide to identification of marine and estuarine invertebrates. Wiley Interscience, New York. 693 pp.

MacGinitie, G. E. and **N. MacGinitie.** 1968. Natural history of marine animals. 2nd edition. McGraw-Hill, New York. 523 pp.

Mann, K. H. and **P. A. Breen.** 1972. The relation between lobster abundance, sea urchins and kelp beds. Journal of the Fisheries Research Board of Canada 29: 603–605.

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Sight Record of Laughing Gulls (*Larus atricilla*) in Saskatchewan

On 9 July 1975, while driving west on the Trans-Canada Highway between Moosejaw and Swift Current, Saskatchewan, we saw numerous Franklin's Gulls (*Larus pipixcan*). A fresh breeze caused them to soar and wheel actively, especially over rolling ground just east of Lake Chaplin. In this area, between the northeast corner of the lake and the Trans-Canada picnic site a few miles farther east, two adult Laughing Gulls (*L. atricilla*) crossed the road in front of us. Both birds banked steeply after crossing to the north side of the highway, giving us excellent views of the deep gray mantle blending into the solidly black wing-tips. The appreciably larger size and the markedly different mantle emphatically distinguished the two birds from the accompanying Franklin's Gulls. Traffic conditions did not permit an immediate stop to search for possible additional birds. A few stops made later along Lake Chaplin and Reed Lake yielded no more birds; and a check of various flocks of Franklin's Gulls in the same area on 17 August was also negative.

W. E. Godfrey (1966. The birds of Canada. National Museum of Canada Bulletin 203) does not record the Laughing Gull in Canada west of Lake Erie. Godfrey tells us that he has no more recent records west of Lake Erie in Canada, or of occurrences in the northerly United States. It thus seems likely that these birds, rather than straying from the Atlantic Coast, came north in spring from the Gulf Coast with the Franklin's Gulls with which we saw them associated. Lake Chaplin is extremely saline, which might conceivably attract this typically maritime species.

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Fathead Minnows (*Pimephales promelas* Rafinesque) in Northeastern British Columbia

Fathead minnows (*Pimephales promelas*) are known throughout central North America from Chihuahua, Mexico to the Northwest Territories. Maine is the eastern limit of their range and the western limit was thought to be in the Alberta portion of the Peace River (Scott and Crossman 1973).

We have identified as fathead minnows fish collected on 8 September 1973 at One Island Lake, British Columbia (55°19′ N, 120°18′ W) by Vancouver Public Aquarium staff, including the junior author. One Island Lake is located south of Tupper, British Columbia about 10 mi (17 km) inside the British Columbia – Alberta border. It drains into the Kiskatinaw River which joins the Peace River a few miles upstream from the Alberta border.

McPhail and Lindsey (1970) indicate that fatheads are present in the Alberta portion of the Peace system although they are not recorded there by Paetz and Nelson (1970). Scott and Crossman (1973, p. 481) state that there are no records of fatheads in British Columbia. Fatheads were not reported in British Columbia by Carl et al. (1967).

The One Island Lake fatheads probably colonized the lake by moving upstream from the Alberta portion of the Peace River. G. R. Chislett, Regional Fisheries Biologist, states (personal communication) that he knows of no minnow introductions to the lake, although unauthorized introductions may have occurred. One Island Lake was surveyed by the Fish and Wildlife Branch of the British Columbia Department of Recreation and Conservation in 1968 (R. C. Thomas, personal communication). The species reported for the lake were finescale dace (*Chrosomus neogaeus*), brook stickleback (*Culaea inconstans*), and the introduced rainbow trout (*Salmo gairdneri*).

Nine of the One Island Lake fathead minnows were examined in detail. These fish had been held in captivity for over a year, first at the Vancouver Public Aquarium and later at the Pacific Environment Institute in West Vancouver. They have now been deposited in the National Museum of Natural Sciences (NMC 75-1521). Although body length and other body proportions may have been affected by this period of captivity, characters such as the number of scales and fin rays should be permanent. The ray counts of the dorsal (8 or 9), anal (7), and pelvic (8 or 9) fins were typical for the species as reported by McPhail and Lindsey (1970) and Scott and Crossman (1973). The pharyngeal teeth of two individuals were examined and found to be typical of the species in number (0,4–4,0) and shape. McPhail and Lindsey (1970) report 39–51 scales in the lateral line, 11–38 pored scales, and 14–18 pectoral rays. The nine One Island Lake fish had 42–51 lateral line scales, 20–50 pored scales, and 13–16 pectoral rays. Two individuals in the One Island Lake group are unusual: one fish with a complete lateral line and another with 13 pectoral fin rays. Fatheads are particularly variable in their meristic characters (Marcus and Vandermeer 1966; Vandermeer 1966). Scott and Crossman (1973) state that other populations such as those in the Thunder Bay region, may have complete lateral lines.

The presence of fathead minnows in One Island Lake in 1973 and their reported absence in the surveys of 1968 and earlier seem to indicate recent establishment of the population. It is quite possible, however, that a population might have escaped detection in earlier surveys.

We acknowledge the assistance of Mrs. V. E. McMillan in following up the initial observation which led to this publication.

Literature Cited

Carl, G. C., W. A. Clemens, and **C. C. Lindsey.** 1967. The fresh-water fishes of British Columbia. British Columbia Provincial Museum Handbook 5. 192 pp.

Marcus, L. F. and **J. H. Vandermeer.** 1966. Regional trends in geographic variation. Systematic Zoology 15: 1–13.

McPhail, J. D. and **C. C. Lindsey.** 1970. Freshwater fishes of northwestern Canada and Alaska. Fisheries Research Board of Canada Bulletin 173. 381 pp.

Paetz, M. J. and **J. S. Nelson.** 1970. The fishes of Alberta. Government of Alberta. Distributed by Queen's Printer, Edmonton, Alberta. 281 pp.

Scott, W. B. and **E. J. Crossman.** 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada Bulletin 184. 966 pp.

Vandermeer, J. H. 1966. Statistical analysis of geographic variation of the fathead minnow, *Pimephales promelas*. Copeia 1966: 457–466.

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Sight Record of a Shark in the Bay of Fundy

On 4 August 1975 while fishing from a 12-ft dory equipped with an outboard, about 2.2 km off Point Lepreau (45°2′ N, 66°31′ W) Wayne Kaye, Murray Rector, and Donald Urquhart sighted a shark. The sea had been calm all day and later as dusk approached a fog began to settle in. The fishing had been poor and about 2100 hours the fishermen began tossing their bait, mackerel, 3.9–4.7 cm, overboard, curious to see what it might attract. About 20 min later a large shark appeared. Kaye reported that it knocked against the side of the boat and slapped the boat a number of times with its tail. The shark swam under the boat and circled about close to the surface. It was clearly observed for about 1 min, after which the outboard was started and the shark moved off but remained in sight for about 5 min more. The shark, approximately 3 m long, was grayish-brown in color, had a rather flat head markedly broader than deep, possessed dark spots on its upper sides and back, and a single spot on its dorsal fin. This description most closely resembles the shovelnose or sand shark, *Odontaspis taurus*. The only other species in the area that could be considered spotted is the spiny dogfish, *Squalus acanthias*. Its spots are small and it reaches a maximum length of 1.2 m (Leim, A. H. and W. B. Scott. 1966. Fishes of the Atlantic Coast of Canada. Fisheries Research Board of Canada Bulletin 155).

The sand shark has been reported from Canadian waters in the past only once (Huntsman, A. G. 1922. The fishes of the Bay of Fundy. Contributions to Canadian Biology 3, 1921, pp. 49–72). That specimen was taken in a weir in Passamaquoddy Bay near St. Andrews, New Brunswick in 1913. Leim and Scott (*op. cit.*) make mention of the record in *Fishes of the Atlantic Coast of Canada.* This sighting is about 15.5 km farther up the Bay of Fundy than the previous sand shark record.

Kaye has done considerable salt-water fishing both in Canadian and in particular English waters, has caught a variety of fishes, including sharks, and is familiar with the porbeagle, *Lamna nasus*, the commonest (five records) shark in the area over 1.5 m in length.

I thank Stanley W. Gorham and David S. Christie for reading the manuscript.

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Parasites of Woodland Caribou in Tweedsmuir Provincial Park, British Columbia

A study of distribution and numbers of woodland caribou (*Rangifer tarandus caribou*) in the northern portion of Tweedsmuir Provincial Park in north-central British Columbia (Low 1964) provided the opportunity for limited investigation of parasite prevalence in that population. Two female caribou, a 2-year-old (Specimen I) and a yearling (II) were shot in July and August respectively, and two females 2½ (III) and 5½ (V) years old, and a male over 6½ years (IV) were shot in October 1963 near Fenton and Goodrich Lakes. All animals were in fair to good condition.

The specimens were necropsied in the field using the methods of Peters and King (1959). Organs and areas examined included nasopharynx, trachea, bronchi, bronchioles, alveoli, heart, oesophagus, all parts of stomach, small and large intestine, liver, diaphragm, pleural cavity, abdominal mesenteries, sections through muscles of shoulder, rib cage, and hind leg, subcutaneous fascia (particularly of hind leg), skin, and pelage. All parasites were preserved in 10% formalin. Parasites were identified by the authorities acknowledged.

Table 1 lists the parasites collected from the five caribou. The yearling female had moderate to heavy infections of lice (*Damalinia tarandi*), stomach worms (*Ostertagia* spp.), and fresh scars of warble grubs (*Oedemagena tarandi*). This specimen was the only one showing swollen greenish lymph nodes particularly in the inguinal regions. The 2-year-old female had a moderately heavy infection of lungworm (*Dictyocaulus* sp.), the 2½-year-old female had a

TABLE 1—Parasites of five woodland caribou (*Rangifer tarandus caribou*) from Tweedsmuir Provincial Park, British Columbia. Specimens were collected between July and October 1963

Parasite	Infection site	Incidence and prevalence	
Protoza			
Amoebae	Encysted in feces	Light infection in all specimens	
Helminths			
Tapeworms			
Moniezia (Moniezia) sp. (probably *expansa*)	Lower small intestine and upper colon	Moderately heavy in Specimen V	
Strongyles			
Nematodirella longissimespiculata (= *N.l. longispiculata)*	Small intestine	Light infection in Specimens II, V	
Nematodirus sp.	Small intestine	Light infection in Specimen V	
Ostertagia circumcincta and *O. trifurcata*	Abomasum and small intestine	Moderately heavy in Specimen II, about 4/cm^2 over ¼ of abomasum	
Lungworm			
Dictyocaulus sp. probably *D. viviparus*	Lung alveoli and bronchioles	Moderately heavy in Specimen I and light in other four	
Legworm			
Wehrdikmansia sp.	Over calcaneum subdermal	1 nodule in Specimen I	
Arthropods			
Lice			
Damalinia (Bovicola) tarandi	Over whole body	Very heavy in Specimen II, 4–5/cm^2 over much of body	
Warble grubs			
Oedemagena tarandi	Subcutaneous in dorsal area	Heavy in Specimens II, IV (estimated 800 and 1000 larvae), light in other three specimens	
Biting flies, mosquitoes, and biting midges			
Simulium spp.		Few	from Specimens I, II, collected in the summer
Tabanus spp.		Few	
Aedes pionips		Many	
Other mosquitoes		Moderate	
Ceratopogniod		Few	

moderately heavy infection of tapeworm (*Moniezia* sp.), and the prime adult male had a heavy infection of warble grubs (*Oedemagena tarandi*). Only lungworms and warble grubs were present in all specimens.

Hordes of biting insects were observed harassing the caribou from June to mid-August and some were collected from caribou being necropsied (Table 1). Caribou were frequently found in exposed windy areas and on snow patches during the summer, presumably escaping from the insects. Although adult *Cephenemyia* sp. were seen harassing caribou on four occasions and one adult fly was collected from a snow patch, no nose bots were found in the caribou examined.

Cowan (1951) reported bots, warbles, *Skrjabinema ovis, Ostertagia* sp., and cysticerci of *Taenia* spp. from woodland caribou in the Rocky Mountain National Parks. The apparent absence of hydatids and cysticerci in the Tweedsmuir caribou may be related to the virtual elimination of their definitive host, the wolf (*Canis lupus*), from the area for at least the last 10 years. Erikson and Highby (1942) reported *Dictyocaulus, Setaria, T. Krabbei* cysticerci, and nose bots from three Saskatchewan woodland caribou, and *Moniezia* and possibly *Fascioloides* from one in Minnesota. The present study makes the list of parasites known from woodland caribou more comprehensive.

Six months observation from June 1963 to February 1964 and discussion with local guides and hunters in the region (Low 1964) indicated that the caribou herd in the northern portion of Tweedsmuir Provincial Park was not seriously affected by parasitism.

For identifying the parasites, I thank the late G. J. Spencer, University of British Columbia (Mallophaga); the late W. W. Becklund, Beltsville Laboratory (helminths); C. Curtis, the late G. Rich, Kamloops Entomology Laboratory; and the late J. Chilcott, Ottawa (Arthropods). I. McT. Cowan and J. R. Adams of the University of British Columbia gave helpful advice on the project; I. McT. Cowan, through an NRCC grant, and the British Columbia Fish and Wildlife Branch gave financial assistance and moral support; and several residents of the Burns Lake region provided welcome assistance. I thank I. McT. Cowan, J. P. Kelsall, Canadian Wildlife Service, W. M. Samuel, University of Alberta, Edmonton, and two anomymous persons for helpful criticism of the manuscript.

Literature Cited

Cowan, I. M. 1951. The diseases and parasites of big game animals of western Canada. Proceedings of the 5th Annual Game Convention, Victoria, B.C. pp. 37–64.

Erikson, A. B. and **P. R. Highby.** 1942. Parasites of woodland caribou. Journal of Parasitology 28(5): 423.

Low, W. A. 1964. A general ecological study of mountain caribou in Tweedsmuir Provincial Park, B.C. Report of Game Management Research Division for 1963. British Columbia Fish and Wildlife Branch, Victoria, British Columbia. Multilith. (Final report for 1964 filed with Fish and Wildlife Branch, Wildlife Research Section, 1964). 4 pp.

Peters, S. S. and **J. M. King.** 1959. Newfoundland caribou disease investigation, 1958. Newfoundland Department of Mines and Resources Wildlife Division, 811-03 Progress Report Technical 1.

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Peculiar Damage to Mature Spruce Trees

On 23 June 1970 I was surprised, on returning to my bird study area west of Duparquet, Abitibi County, Quebec (at 48°31′ N, 79°30′ W), to find many mature black spruces (*Picea mariana*) damaged in a peculiar fashion (Figure 1). The bark of the larger spruces for about 2 m up from the base was split, with strips hanging down along the trunk and others peeled down to the flare of the roots. This damage was widespread through the 16.5-ha plot, and involved at least half of the spruces of 25 cm or more in diameter. Some spruces had the bark split around the trunk, but others were less injured. No fresh damage had been apparent on previous visits, the last 10 days previously, but I noted a few spruces with similar damage from some past time, now largely healed.

The forest stand in this area was heterogeneous, broken by the valleys of small creeks and by openings—possibly old cut-over areas—densely grown with speckled alders (*Alnus rugosa*). Balsam fir (*Abies balsamea*) dominated the stand, with black spruce second in importance, but the latter became relatively more important in the larger size-classes. Smaller numbers of paper birch (*Betula papyrifera*), balsam poplar (*Populus balsamifera*), trembling aspen (*P. tremuloides*), and jack pine (*Pinus banksiana*) comprised the tallest trees at 11 of 28 sampling stations, as most trees of these species were large (Table 1) (cf. Erskine, A. J. 1970. Disturbed fir-spruce forest with alder openings. Audubon Field Notes 24: 752–753). I saw no damage to trees other than spruces, although these made up only about one-fifth of the stand.

FIGURE 1. Base of mature spruce tree with bark damage, west of Duparquet, Quebec, 23 June 1970.

TABLE 1—Species composition of forest stand with tree damage, Abitibi County, Quebec, 1970

Species	Relative frequency (%) of all trees			
	≥7.5 cm dbh[1]		≥22.5 cm dbh	
Balsam fir	64		48	
Black spruce	19		21	
Paper birch	5	17	12	31
Balsam poplar	5		6	
Trembling aspen	2		8	
Others	5		5	

[1] d.b.h. = diameter breast height.

My first thought was of vandalism by humans, but the extent of damage that emerged made this explanation highly improbable. Black bears (*Ursus americanus*) are known to cause damage to conifers on a scale comparable to that found (cf. Poelker, R. J. and H. D. Hartwell. 1973. Black bear of Washington. Washington State Game Department, Biological Bulletin 14. 180 pp.). But photographs in that publication and others by Bob Hatcher (of Centre de récherches forestières des Laurentides, Québec, Québec) show a different pattern to that found, with the tree trunks usually completely stripped of bark for 1 to 2 m above the base, and with the cambium layer under the bark sometimes chewed or clawed. Reports of bear damage to conifers may be widespread as a result of continued activity over an extended period. The damage I found apparently had occurred entirely within the 10 days since my last visit to the plot. While bear damage might be thus concentrated, at the time of a major sap flow, for example, I believe that the evidence available points to a violent wind storm as a more plausible explanation.

It seems possible that the bark of the large spruces burst when the trees were bent or twisted by a sudden squall, as a fat man might burst his suspenders by bending over too abruptly. Only the largest trees (diameter > 25 cm) were damaged, and these taller veterans would have been most exposed to the full force of a squall. Additional evidence for damage by a wind storm included a few large trees fallen since my visit on 13 June, and areas of alders beaten down and tangled wherever there was space for them to fall, much as one sees grain fields "lodged" by heavy rain.

Published weather data for nearby stations (Monthly Record of Meteorological Observations in Canada, June 1970, Canada Department of Transport) give no indication of a major wind storm at the time, but violent winds of short duration could have occurred during a thunder storm. Between 13 and 23 June, rainfall in the area was heavy only on 18–19 June, when over 5 cm fell at Poularies, Quebec, the nearest weather station, about 22 km to the northeast. The minimum temperature recorded at Poularies on 18–19 June was +1°C, so wet snow or freezing rain (which might better explain the "lodging" of the alders than merely rain and wind) may also have fallen. On 18 June, I witnessed a prolonged thunder storm in La Vérendrye Park, Quebec, 220 km southeast, and on the following day, near Senneterre, Quebec, 165 km to the east, I found telephone poles that had been struck by lightning, so 18 June is the most likely date for the storm.

I saw evidence on the same plot of similar damage in earlier years. But I have never noticed anything comparable, either on other plots in the same region or elsewhere across the boreal forests of Canada. Of course, trees whose bark was broken all the way round would be killed, and subsequent loss of bark would obscure the pattern of damage within a couple of years. This may be a normal if hardly frequent cause of damage to mature spruces in areas where severe thunderstorms occur frequently.

Yorke Edwards, Edmund Telfer, Peter Pearce, and John M. McLeod read the manuscript and offered helpful suggestions. The final interpretation, however, is mine. Two of three journal reviewers considered it plausible, while the third was convinced that bears were responsible. The phenomenon thus remains open to clarification by more observations in greater detail, a challenge to field naturalists.

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Aquatic Invertebrates Inhabiting Agricultural Drainage Tile Systems in Southern Ontario

In June 1972, a section of field drainage tile on a farm near St. Agatha, Ontario (43°30′ N, 80°30′ W) broke and had to be replaced. These tiles, 15 cm inside diameter and made of baked clay, are used extensively for draining wet soils and are laid out in herringbone patterns buried to a depth of 1.5 to 2 m. When the tile was exposed, water moving at about 15 cm/sec was seen. A drift net (mesh size 135 μm) placed to intercept this flow yielded the following animals: rhabdocoeles, tubificids, and the crustaceans *Cyclops vernalis* (including females with eggs), *Attheyella nordenskioldii*, and *Crangonyx minor*. At its downstream end, 250 m further on, water from this tile flowed over a small waterfall into a tributary of the Nith River. This waterfall probably prevented entry of these animals into the tile. Moreover, most of the species found did not occur in the tributary.

A similar tile system was tapped in May 1974 in this same region. In this case, exposure resulted from the excavation of a surface drainage ditch which cut across the path of the tile (see Figure 1). This time a more quantitative study was made. All the water, which was being discharged at a rage of 10 *l*/min, was diverted through a 135 μm drift net for 24 h. The following animals were obtained.

Turbellaria:	
Fonticola velata (Stringer)	8
Oligochaeta:	
Tubificidae (unidentified)	1
Ostracoda:	
Candona stagnalis Sars	3 (immature)
Copepoda:	
Cyclops vernalis Fischer	21 (adults and small copepodites)
Amphipoda:	
Crangonyx minor Bousfield	498 (mixed adults of both sexes, with some immature)
C. setodactylus Bousfield	
Collembola:	
Isotomurus sp.	8
Coleoptera:	
Helophorus sp.	1 (larva)
Cyphon ?variabilis (Thunb.)	3 (larvae)
Staphylinidae (unidentified)	2 (adults)
Diptera:	
Orthocladius sp.	1 (third instar larva)
Diplopoda:	
(unidentified)	1 (adult)
Total	547

All these animals must have come from within the tile system, as contamination of the net was impossible because of its position (see Figure 1). But they are all species normally taken in surface waters and which, apart from some reduced pigmentation in the amphipods, exhibited none of the highly specialized morphological and physiological characters associated with true interstitial or troglobitic faunas (see Angelier, E. 1953. Recherches écologiques et biogéographiques sur la faune des sables submergés. Archives de Zoologie Expérimentale et Générale 90: 37–162). The numbers collected probably did not reflect the normal drift density within the tile, but rather an overestimate due to the increased discharge caused by the tile rupture.

At first this habitat would seem rather inhospitable but certain features of its design and function ensure reasonable conditions for its inhabitants. The way in which the tiles are laid is important; they are nestled

FIGURE 1. Recently exposed end of drainage tile (marked by arrow) located in the side of the newly excavated ditch. The collecting net is also visible.

into coarse gravel with a small gap left between them. This means that the animals need not stay in the pipe, where they may not find a foot-hold on the glazed surface, but can move about freely in a large-pored interstitial medium. Tiles may form a drainage network covering many acres but movement within this habitat is easily and quickly effected by entering the flow of water within the tile. The habitat is undoubtedly heterotrophic, with energy being based on detritus carried through the soil by rain. Comparison with local faunas suggested that colonization of these tiles was probably initially from Moser Creek, a nearby temporary stream (see Williams, D. D., N. E. Williams, and H. B. N. Hynes. 1974. Observations on the life history and burrow construction of the crayfish *Cambarus fodiens* (Cottle) in a temporary stream in Southern Ontario. Canadian Journal of Zoology 52(3): 365–370). Once established many of the species may breed within the system, as immature copepods and amphipods were collected. Occurrence of the few insects is puzzling though, as most would have to come aboveground in order to complete their life cycles. They most likely represent accidental introductions and have little or no chance of completing their life cycles.

Although these observations were made on only two drainage tile systems, it is likely that the occurrence of such underground aquatic faunas is as widespread as the drainage systems themselves. The lack of any specialized species, however, is probably a reflection of the comparatively recent formation of these particular habitats.

I thank the Department of Agriculture's Biosytematics Research Institute, Ottawa and the Canadian Oceanographic Identification Centre of the National Museum, Ottawa for identifying the Helodidae and Copepoda, respectively. H. B. N. Hynes of the University of Waterloo kindly supplied necessary materials.

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Snow Geese, Disturbed by Aircraft, Crash into Power Lines

During the spring migration, the eastern populations of the smaller race of the Snow Goose, *Chen c. caerulescens*, have major staging areas on the prairies of southern Manitoba where they feed and rest (Blokpoel 1974).

On 8 May 1974 several thousand Snow and Blue Geese were feeding on a stubble field near Pilot Mound, about 145 km southwest of Winnipeg. The birds covered almost the whole field and some were feeding very close to a power line that bordered one side of the field. A light aircraft flying at an estimated height of 100 to 200 ft (30 to 60 m) approached the field and caused panic amongst the geese. They took wing and in a chaotic mass rushed off the field on the side of the transmission lines. Many geese were injured or killed because they struck the wires, with the total number of birds involved varying from 25 to 75 depending on the person reporting the incident. It is unknown whether the birds were killed by the impact or from electrocution. The geese broke the wires and caused a local power failure.

Collisions with wires as a source of anatid mortality have been reported by Harrison (1963) and Cornwell and Hochbaum (1971).

There are several reports of Snow Goose disturbance in southern Manitoba by light aircraft. Some of those cases probably involved curious and ill-informed pilots but on other occasions there was deliberate harassment. Apart from disturbing the birds, low-flying pilots run the risk of colliding with one or more geese which could easily break the wind-shield or damage the rest of the aircraft and engines. When making aerial censuses, waterfowl biologists should be aware of the possibility that panicked birds may crash into structures in their attempt to avoid the aircraft.

We are thankful to A. Collins, L. Hazelwood, and S. Tole for bringing this incident to our attention.

Literature Cited

Blokpoel, H. 1974. Migration of Lesser Snow and Blue Geese in spring across southern Manitoba. Part 1. Distribution, chronology, directions, numbers, heights and speeds. Canadian Wildlife Service Report Series Number 28. 29 pp.

Cornwell, G. and **H. A. Hochbaum**. 1971. Collisions with wires—a source of anatid mortality. Wilson Bulletin 83: 305–306.

Harrison, J. G. 1963. Heavy mortality of Mute Swans from electrocution. Wildfowl Trust Annual Report 14: 164–165.

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Observations on the Spring Migration of Snow Geese from Southern Manitoba to James and Hudson Bays

In spring the eastern populations of the smaller race of the Snow Goose, *Chen caerulescens caerulescens* (Lesser Snow Goose and Blue Goose), follow the Mississippi Flyway, stopping at traditional staging areas along the way (Bellrose 1968). Having reached the plains of southern Manitoba, the geese are widely distributed along the international border with major concentrations in the Pilot Mound — Crystal City — Snowflake area (about 115 km southwest of Winnipeg) and in the Boissevain–Souris–Hartney area (about 230 km WSW of Winnipeg) (Blokpoel 1974). On departing the plains, the geese migrate in northeasterly directions to the coasts of James and Hudson Bays.

The Canadian Wildlife Service has studied the distribution and migration of Snow Geese in southern Manitoba in connection with air traffic control and flight safety (Blokpoel 1974; Blokpoel and Gauthier 1975). The distribution of Snow Geese along the coasts of James and Hudson Bays has been observed during population counts from the air (Curtis and Lumsden, unpublished data). Very little is known, however, of their distribution in the interior of northern Manitoba and northwestern Ontario. Because there is probably no suitable habitat, it is unlikely that there are major Snow Goose staging areas between the plains and the coasts of James and Hudson Bays. Thus most flights from the plains to the coasts (a distance of over 1000 km) are presumably non-stop. Blokpoel (1974) presented evidence for a through-flight in spring 1971 and this note provides further evidence for such direct flights.

Methods

In 1972, 1973, and 1974, records of Snow Goose sightings were obtained from volunteers in Manitoba and Ontario who were provided with reporting forms in advance of each migration season. Data were requested on dates, directions, heights, and magnitudes of migratory flights, and on presence of staging geese. The volunteers included wildlife biologists, conservation officers, bird watchers, native hunters, and personnel of weather stations, RCMP detachments, and the Hudson's Bay Company. Lists of those records are retained by the library of the head office of the Canadian Wildlife Service, Environment Canada, Ottawa K1A 0H3.

In the springs of 1972 and 1974, 16-mm time-lapse films were made of the master scope of the AASR-1 surveillance radar at Winnipeg International Airport. The film technique has been described by Solman (1969) and technical information on the radar has been presented by Canada Department of Transport (1967). Flocks of geese migrating within radar range (110 km) and flying at sufficient altitude produced distinctive "goose echoes" on the radar screen. The radar films provided a continuous record of the times, numbers, directions, and speeds of flocks of geese migrating across the Winnipeg area (Blokpoel 1974).

When examining the data for evidence of direct flights, we assumed that the geese travelled at ground speeds of about 70 km/h (Blokpoel 1974).

Results

Reports of Snow Geese in 1972, 1973, and 1974 showed that in some years a few hundred Snow Geese were seen as far west as The Pas, Manitoba, and as far east as Cochrane, Ontario. Much larger numbers (up to 6000 birds) were reported from the area between Lake Manitoba and Lake Winnipeg, the weather offices at Big Trout Lake, Ontario, and Island Lake, Manitoba, and from Gillam, Manitoba (see Figure 1). A few reports involving small numbers of geese came from Lake-of-the-Woods, Ontario, and the northern shore of Lake Superior.

Because of the small number of volunteer reporters and the vastness of the area between southern Manitoba and the coasts of James and Hudson Bays, the distribution of the Snow Goose sightings likely reflects the distribution of the observers rather than that of the geese.

Sightings that support the idea of direct flights were obtained for 4–5 May 1972, 12–13 May 1974, and 14–15 May 1974. The most pertinent of those observations are listed in Table 1 and plotted in Figure 1. Reported directions of the migrating geese usually varied between east and north. The arrows in Figure 1 show the weighted-average flight directions.

In 1972 the first major flight over the Winnipeg area, as seen on radar, began on the morning of 4 May and lasted until 2300 hours of that day. On the afternoon of 4 May, 200 Snow Geese were observed migrating near Red Lake, Ontario. Throughout the night of 4–5 May, Snow Geese were heard flying over Attawapiskat, on the James Bay coast. On 5 May, H. Lumsden and S. G. Curtis conducted an air survey of 77 km of coast south of Attawapiskat and found an estimated 68 000 Snow Geese where, the previous afternoon, there had been only 337 birds. Few geese were observed along the 129 km of largely frozen coastline surveyed north of Attawapiskat.

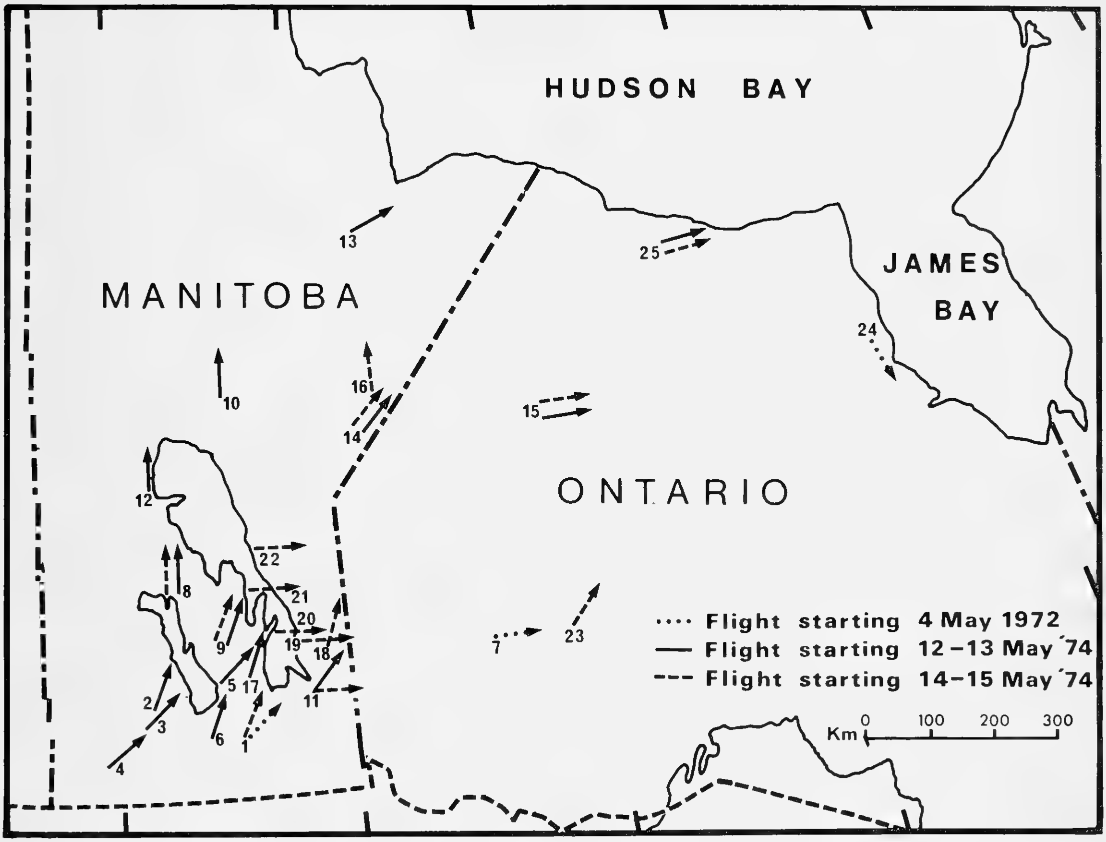

FIGURE 1. Observations of migrating Lesser Snow and Blue Geese (details of sightings and locations are given in Table 1.)

Evidence for the two other direct flights was obtained in 1974. A major departure from the Hartney–Souris staging area began on the afternoon of 12 May, continued through the evening (and probably the night), peaked in the early morning of 13 May, and subsided by late morning of that day. Several sightings of migrating geese were made further to the north and east. On 13 and 14 May several flocks were seen flying over Winisk.

The next major departure occurred from the Pilot Mound staging grounds beginning on the evening of 14 May and continuing through the late evening of 15 May. The departure and flight across southern Manitoba was observed both on the Winnipeg radar and by many volunteers. Sightings were again reported further en route and on the coast of Hudson Bay. On 16 May some 300 flocks, flying mostly from west to east, were observed at Winisk.

Although the three cases just presented were by far the most obvious, the data also suggested other possible incidences of through-flights. On the other hand, scattered sightings of migrating Snow Geese were reported that did not appear to constitute major direct flights.

Discussion

The observations in Table 1 are evidence of through-flights from southern Manitoba to the coasts of James and Hudson Bays. Although they do not prove direct non-stop flights, they indicate that the geese did not spend several days in the interior, making the presence of major staging areas unlikely. Suitable staging habitat providing food, water, and safe roosting places probably does not occur in the boreal forest of northern Manitoba and northwestern Ontario in early spring.

Most of the reports that we received pertained to "migrating birds," i.e., birds involved in a migratory flight, but some records mentioned that the birds were "sitting," "circling," or making a "local flight." The

TABLE 1—Representative observations of migrating Lesser Snow and Blue Geese which indicate three probable direct flights from the southern Manitoba staging grounds, through central and northern Manitoba and northwestern Ontario, to the coasts of James and Hudson Bays during the springs of 1972 and 1974

Southern Manitoba

Date	Time	Location or area	Fig. 1 reference	Estimated number
May 1972 (First flight)				
4	0800–2300	Winnipeg (radar)	1	166,600 (833 flocks)
May 1974 (Second flight)				
12	Morning	Minnedosa	2	Several 1000s
12	1400	Brandon	3	4000
12	Afternoon	Souris	4	Major flight
13	0600–0800	Oak Point	5	25000
13	0700–1100	Delta	6	32800
13	0800–0900	Lundar	5	10000
13	Morning	Souris	4	>62000
13	Morning	Brandon	3	Massive flights
13	1120–2030	Delta	6	5150
May 1974 (Third flight)				
14 15	1900–2400 0000–2200	Winnipeg (radar)	1	402800 (2014 flocks)

Hudson and James Bay coasts

Date	Time	Location or area	Fig. 1 reference	Estimated number
May 1972 (First flight)				
4–5	Night	Attawapiskat	24	Many flocks heard
May 1974 (Second flight)				
13	Day	Winisk	25	1070
14	Day	Winisk	25	>5000
May 1974 (Third flight)				
15	Day	Winisk	25	15 flocks
16	Day	Winisk	25	300 flocks

Central and northern Manitoba and northwestern Ontario

Date	Time	Location or area	Fig. 1 reference	Estimated number
May 1972 (First flight)				
4	1300	Red Lake	7	200
May 1974 (Second flight)				
12	Afternoon & evening	Gypsumville	8	2000
13	0600–1400	Fisher Branch	9	7675
13	0900	Cross Lake	10	200
13	1000	Pine Falls	11	3500
13	1030	Grand Rapids	12	120
13	1100	Gillam	13	150
13	1400	Grand Rapids	12	70
13	1530	Island Lake	14	65
13	1530	Big Trout Lake	15	180
13	Afternoon	Gods Lake Narrows	16	150
13	Afternoon & evening	Gypsumville	8	Heavy
13	Day	Riverton	17	30000
May 1974 (Third flight)				
14	Evening	Gypsumville	8	Heavy
15	0500–1700	Fisher Branch	9	37140
15	0600–1200	Bissett	18	450
15	0600–1400	Island Lake	14	5600
15	0820	Pine Falls*	11	51600
15	0835	Black River*	19	2200
15	0845	Manigotayan*	20	600
15	0855	Black Island*	20	500
15	0910	Punk Island*	20	1200
15	0925	Lake Winnipeg Narrows*	21	1800
15	0935	Pigeon River*	22	1100
15	0955	Berens River*	22	800
15	1400–1800	Big Trout Lake	15	1595
15	1900	Pickle Lake	23	150

*observation from light aircraft

latter observations, which usually involved fewer than 100 birds, indicate that some birds did not make a nonstop flight. However, we received no records of large numbers of geese remaining in an area for several days. Such observations would have indicated the presence of staging grounds. Thirst, fatigue, or adverse weather conditions may cause interrupted migratory flights. Perhaps migrating geese take brief rests, lasting only a few hours, when suitable resting areas are available.

The migration routes and staging areas in Canada's hinterland are not well known for several waterfowl species. Planned and on-going large-scale hydro developments in those remote areas make it necessary to obtain information on the use of those regions by migrating waterfowl. Studies of the routes of migrating waterfowl species would require a vast network of observers rather than the few scattered volunteers who provided the data for this note. Detailed information for those sparsely populated areas could be obtained using such techniques as radar surveillance, air surveys, and radiotelemetry.

Acknowledgments

We thank the many volunteers who reported their sightings of Snow Geese; unfortunately, space does not permit mention of all names. The following provided observations used in this note: M. G. Anderson, N. Bates, R. Blanchard, D. Busch, W. Cable, G. E. Clark, L. Foldy, W. D. Harrington, D. R. M. Hatch, A. W. Hochbaum, J. M. Hunter, Sr., D. Koostachin, D. Petznick, E. Ponchon, K. J. Sauerbrei, K. Stewart, R. W. Storer, and personnel of the weather station at Island Lake, Manitoba, and the conservation offices at Gypsumville, Manitoba, and Sioux Lookout District, Ontario. P. L. Madore prepared the figure. R. I. G. Morrison critically read the manuscript.

Literature Cited

Bellrose, F. C. 1968. Waterfowl migration corridors east of the Rocky Mountains in the United States. Illinois Natural History Survey, Biological Notes 61. 24 pp.

Blokpoel, H. 1974. Migration of Lesser Snow and Blue Geese in spring across southern Manitoba. Part 1. Distribution, chronology, directions, numbers, heights and speeds. Canadian Wildlife Service Report Series Number 28. 30 pp.

Blokpoel, H. and **M. C. Gauthier.** 1975. Migration of Lesser Snow and Blue Geese in spring across southern Manitoba. Part 2. Influence of the weather and prediction of major flights. Canadian Wildlife Service Report Series Number 32. 30 pp.

Canada Department of Transport. 1967. Air traffic control manual of equipment. Part 1, Radar. 254 pp.

Solman, V. E. F. 1969. Photography in bird control for air safety. Journal of the Biological Photographic Association 37: 150–155.

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Breeding Status of the Common Redpoll in Alberta and Saskatchewan

The breeding range of the Common Redpoll (*Acanthis flammea*) in North America has been thought to be confined mostly to arctic and subarctic parts of the continent (American Ornithologists' Union 1957).

When Lahrman and Nero (1961) published a record of the nesting of this species at Mortlach, *southern* Saskatchewan, this seemed amazing and extralimital. Scarcely less surprising was Blokpoel's (1970) description of a nest containing three young and an infertile egg at Saskatoon, Saskatchewan. Lister (1975) recorded no less than four nests located in Alberta in 1974, three in Edmonton, and one at Devon, 15 mi (24.1 km) southwest of Edmonton. He stated that redpolls were unusually numerous in the winter of 1973–74 in Edmonton.

The story does not stop there. Although the winter of 1974–75 was a poor one for redpolls in Edmonton, Robert Lister (letter dated 24 June 1975) informs me that the species nested there again in 1975. On 17 May, Edgar T. Jones received a report of two adults and four fledglings in the Edmonton garden of Mrs. W.

Hatch. By the time Jones had a chance to investigate the report, both adults and two of the young had disappeared, apparently victims of a cat. The two still-living young were turned over to the SPCA. One died and was acquired by Lister who donated it to the National Museum of Natural Sciences (No. 62526, bird research collection). It is a short-tailed juvenal barely capable of flight, obviously just out of the nest.

The question arises as to whether the nesting of the Common Redpoll in these southern localities is of recent origin or is a situation of long standing, heretofore overlooked. The latter seems more probable.

The Mortlach, Saskatchewan nesting goes back to 1945 (Lahrman and Nero 1961) although it was not published until 1961. Further evidence that the species has not suddenly begun nesting in these southern localities is furnished by Roy C. Anderson, University of Guelph. In 1942 or 1943, he (letter dated 28 July 1975) discovered a redpoll nest near Stony Creek, about 1 mi (1.6 km) south of Camrose, Alberta. The nest was 4 or 5 ft (1.2-1.5 m) up in a poplar stand and he was able easily to observe the incubating female. Young as he was at the time, Anderson realized the significance of the record and reported it locally, but as such a record was unheard of at that time no one took the trouble to check it.

The breeding range of the Common Redpoll is thus shown to extend southward into central Alberta (Edmonton, Camrose) and southern Saskatchewan (Saskatoon, Mortlach).

Literature Cited

American Ornithologists' Union. 1957. Check-list of North American birds. 5th edition Baltimore, Maryland.

Blokpoel, Hans. 1970. Redpoll nesting at Saskatoon, Saskatchewan. Canadian Field-Naturalist 84(4): 394-396.

Lahrman, Fred W. and **Robert W. Nero.** 1961. A Common Redpoll nest record for southern Saskatchewan. Blue Jay 19(3): 113-114.

Lister, Robert. 1975. Common Redpolls nesting at Edmonton, Alberta. Canadian Field-Naturalist 89(1): 64-65.

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The First Nest Record of the Greater Yellowlegs (*Tringa melanoleuca*) in Nova Scotia

The Greater Yellowlegs (*Tringa melanoleuca*) has long been thought to breed on the plateaus of northern Cape Breton Island, Nova Scotia. Tufts (1962) relates the reports of A. W. Cameron on 12 July 1945 and of Erskine on 23 July 1952, who were both subjected to persistent scolding in such a way as to indicate that young or a nest were present. Godfrey (1966) lists Cape Breton as a breeding area. Wayne Neily, former park naturalist at Cape Breton Highlands National Park, observed young Greater Yellowlegs.

The authors were at Cheticamp Lake, in the central plateau of Cape Breton, from 24 to 27 June 1974 and during this period of time observed several Greater Yellowlegs displaying breeding behavior. The birds would hover or swoop towards our heads while continually giving an alarm call. The nature of the vegetation prevented us from ascertaining whether in fact eggs or young were present.

The forest around Cheticamp Lake is composed largely of black spruce (*Picea mariana*), balsam fir (*Abies balsamea*), and red maple (*Acer rubrum*), which grow in a very tangled manner. Also near the lake are large open hummocky barrens thickly covered by ericaceous plants. In the barrens are many boggy lakes.

On 27 June 1974 in an open barren 2/3 mi east of Cheticamp Lake and slightly southwest of Two Islands Lake we flushed a Greater Yellowlegs and after considerable searching discovered its nest. It was an inconspicuous shallow depression lined with dead leaves of sheep laurel (*Kalmia angustifolia*), and with bits of lichen of the genus *Cladonia*. Inside were four extremely pale green eggs with many irregular brown spots. The nest was photographed and a copy of the photograph will be deposited with the Maritimes Nest Records Scheme. During the period of examination the bird was continually diving at our heads.

Bent (1927) says the following about the nesting of the Greater Yellowlegs: "Considering the fact that the Greater Yellowlegs is such a common and widely distributed bird, remarkably little has been published on its nesting habits, and comparatively few nests have been found, in spite of the fact that it does not go very far north to breed and its breeding grounds are fairly accessible. I know from personal experience with it that its nest is very hard to find."

He also cites the observations of Brewster (1883), Nelson (1877), and Norman (1915), who had similar difficulties in finding Greater Yellowlegs nests. Thus the long interval required to establish definitely the breeding of this species in Cape Breton is not an atypical situation.

We thank the Canadian Wildlife Service for its support in this work.

Literature Cited

Bent, A. C. 1927. Life histories of North American shorebirds. Part 1. United States National Museum Bulletin 142. 420 pp.

Brewster, W. 1883. Notes on the birds observed during a summer cruise in the Gulf of St. Lawrence. Proceedings of the Boston Society of Natural History 22: 364.

Godfrey, W. E. 1966. The birds of Canada. National Museum of Canada Bulletin 203. 428 pp.

Nelson, E. W. 1877. Birds of northeastern Illinois. Essex Institute Bulletin 8: 90–155.

Norman, E. S. 1915. The nesting of the Greater Yellowlegs in Manitoba. Ecologist 32: 126–127.

Tufts, R. 1962. The birds of Nova Scotia. Nova Scotia Museum, Halifax. 481 pp.

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News and Comment

Editor's Report

Large and increasing numbers of manuscripts covering a broad range of topics in the natural sciences continue to be offered for possible publication in *The Canadian Field-Naturalist.* A summary of the number of manuscripts received and accepted since I became Editor follows.

	Number of Manuscripts	
Year	Received	Accepted
1972	119	95
1973	153	117
1974	152	112
1975	167	—

The review and acceptance of a considerable number of 1975 manuscripts were unfortunately delayed because of the 43-day Canadian postal strike that ended on 2 December 1975.

The current circulation of *The Canadian Field-Naturalist* is about 2000. In 1975 it was sent to 1371 members of The Ottawa Field-Naturalists' Club (665 in Canada, 130 in the United States, and 12 overseas). Moreover the number of institutions and libraries that subscribe to the journal continues to increase. Of the 619 subscribers in this category in 1975, 310 were in Canada, 269 in the United States, and 40 were overseas.

As the present Editor, in addition to evaluating scientific merit of submitted manuscripts, I have been particularly interested in improving the standards of scientific writing so that it is clear, well organized, concise, simple, logical, and perhaps what is most important of all, interesting. To provide continuity throughout each issue of the journal, each manuscript is checked for the technical aspects of good writing, typographical conventions, and style (following the CBE Style Manual as a guide). Changes to improve the format and style of the journal are, however, always under consideration. For example, we have only recently adopted the use of SI symbols for units of measure. Starting in 1974, as a convenience to readers, the Table of Contents was moved to the back cover.

The cost of publishing the journal continues to escalate. We now request that, when grant or institutional funds are available, authors help defray a higher proportion of the cost of publishing their manuscripts. Although some of us would like to see the journal with a permanent office and a paid staff rather than volunteer workers as at present, the attainment of these objectives seems to be far in the future. The increasing number of manuscripts submitted to the journal as well as the additional time devoted to ensuring that they conform to journal style, however, continue to increase the work load. I hope that our authors and readers feel that the results are worth the considerable amount of effort and time expended.

Basically *The Canadian Field-Naturalist* is a medium for publication of research papers and notes in all fields of natural history that have relevance to Canada. Nevertheless, an increasing number of well-written and biologically important papers outside, or borderline to, the field of natural history, or ones without relation to Canada are now being submitted to our journal. Unfortunately, most of these are not within the scope of the journal and authors are encouraged to seek a more appropriate journal for their manuscripts. Peripheral to the fields covered by *The Canadian Field-Naturalist* are papers that deal mainly with statistics and computer science; highly technical methodologies, particularly if they are more laboratory studies than field studies, and studies designed particularly for the management of wildlife (unfortunately there is, at present, no Canadian wildlife management journal).

The main strength of the journal continues to lie in the reviewing of manuscripts by qualified and *willing* referees. A note published in most issues of the journal explaining the reviewing policy of *The Canadian Field-Naturalist* was recently up-dated and expanded.

It is my fervent intention and hope that *The Canadian Field-Naturalist* will continue in the future to fulfill its present important role as a journal devoted to the recording, interpreting, and communicating of information on Canadian natural history phenomena.

LORRAINE C. SMITH

IUCN Resolutions*

Resolutions of the 12th General Assembly of IUCN (International Union for Conservation of Nature and Natural Resources) are 1. Charter for Nature, 2. Marine Parks, 3. Conservation of Critical Coastal Marine Habitats, 4. Conservation of Mangroves, Salt Marshes, and Related Habitats, 5. Protection of Traditional Ways of Life, 6. Conservation of Tropical Rain Forests, 7. Restoration of Semi-arid Environments and Wildlife, 8. Principles Replacing Maximum Sustainable Yield as Basis for Management of Wildlife Resources, 9. The Lion Marmosets of Brazil, 10. Convention of Trade in Endangered Species, 11. Zoological and Botanical Gardens, and 12. Energy and Conservation.

Two resolutions are particularly pertinent.

1. Charter for Nature

Realizing that the problems of conservation of nature and natural resources are of concern to all mankind; Being aware that these problems must be dealt with in a holistic manner; Realizing that in dealing with such problems special consideration must be given to the situation existing in each country concerned; Recalling the proposal made by the President of the Republic of Zaire during the opening ceremony of this General Assembly of IUCN that a Charter for Nature be prepared which would set down the basic principles and concerns for the care of nature throughout the world, for which he offered the assistance and support of his Government; The 12th General Assembly of IUCN meeting in Kinshasa, Zaire, in September 1975: Recommends to governments and international organizations that a Charter for Nature be drafted, with the least possible delay, through cooperation between the various international and national institutions concerned.

5. Protection of Traditional Ways of Life

Recognizing the value and importance of traditional ways of life and the skills of the people which enable them to live in harmony with their environment; Recognizing also the vulnerability of indigenous people and the great significance they attach to land ownership; The 12th General Assembly of IUCN meeting in Kinshasa, Zaire, in September 1975: Recommends (1) That governments maintain and encourage traditional methods of living and customs which enable communities, both rural and urban, to live in harmony with their environment; (2) That educational systems be oriented to emphasize environmental and ecological principles and conservation objectives derived from local cultures and traditions, and that these principles and objectives be given wide publicity; (3) That governments devise means by which indigenous people may bring their lands into conservation areas without relinquishing their ownership, use or tenure rights; (4) That the governments of countries still inhabited by people belonging to separate indigenous culture recognize the rights of these people to live on the lands they have traditionally occupied, and take account of their viewpoints; (5) That in the creation of national parks or reserves indigenous peoples should not normally be displaced from their traditional lands, nor should such reserves anywhere be proclaimed without adequate consultation with the indigenous peoples most likely to be directly affected by such proclamation; and (6) That existing natural values be respected and integrated in the early planning stage of every urban or industrial development scheme, this requiring that ecological principles be taken as the basis for all planning.

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*From Special Supplement to IUCN Bulletin 6(11), November 1975.

Wanted—Information on Interspecific Aggression Behavior in Deer

There is a paucity of published information on interspecific aggression between mule deer (*Odocoileus hemionus*) and white-tailed deer (*Odocoileus virginianus*). Yet these two species have been studied more than any other member of the deer family (Cervidae). The majority of observations on this subject must therefore exist in hidden-away fieldnotes. Recently I observed an adult doe white-tailed deer pursue an adult buck mule deer for a distance of 360–460 m. Although rare, this has been observed before but with a much smaller chase distance involved (V. Geist, personal communication, 1976). With so few observations, the significance of this kind of observation is very limited in regard to furthering the understanding of "dominance" between the two deer species (A. Kramer, V. Geist, personal communication, 1976). But as a compilation of more observations would be useful in assessing how often certain aggression behaviors might occur I am requesting detailed observations of interspecific aggression between white-tailed deer and mule deer. Please contact Bob M. Fisher, 425-22 Ave. N.E., Calgary, Alberta, Canada T2E 1T8.

Request for Participants—International Shorebird Surveys

A cooperative International Shorebird Survey was started in 1975 to obtain information on shorebird migration and to identify and document areas of major importance. This scheme has been highly successful, with much very valuable information on shorebird distribution and migration coming from contributors throughout eastern Canada and the United States, the Caribbean Islands, and Central and South America. In 1976 we are anxious to continue and extend the scheme in as many areas as possible. Any observer who may be able to participate in regular survey counts of shorebirds during spring and autumn migration periods, as well as during the winter in shorebird wintering areas, is asked to contact one of the undersigned. Occasional counts from observers visiting shorebird areas on an irregular basis would also be most welcome.

For areas in Canada: *Dr. R. I. G. Morrison, Canadian Wildlife Service, 2721 Highway 31, Ottawa, Ontario, Canada K1A 0H3.*

For areas in the United States, Caribbean Islands, Central, and South America: *Brian A. Harrington, Manomet Bird Observatory, Manomet, Massachusetts USA 02345.*

Request for Information—Shorebird Color-marking

In 1976 the Canadian Wildlife Service will again be carrying out extensive banding and color-marking of shorebirds in James Bay. Last year a highly successful program resulted in over 70 reports of color-marked birds in eastern North America and South America from amongst about 4000 banded in southern James Bay. Much valuable information on migration routes is being obtained and observers were again asked to look out for and report any color-dyed or color-banded shorebirds that they may see. Reports should include details of species, place, date, color-marks, and if possible, notes on the numbers of other shorebirds present. For color-dyed birds, please record the color and area of the bird that was dyed. For color-bands and standard metal leg bands, please record which leg the bands were on, the colors involved, and the relative position of the bands if more than one was on a leg (e.g., right leg, blue over metal, etc.). All reports will be acknowledged and should be sent to *Dr. R. I. G. Morrison, Canadian Wildlife Service, 2721 Highway 31, Ottawa, Ontario Canada K1A 0H3.*

Request for Information—Color-marked Semipalmated and Least Sandpipers

In 1976 and 1977 the Surinam Forest Service plans to color-band large numbers of Semipalmated and Least Sandpipers along the Surinam coast, northeastern South America. The objective of this study is to obtain more information about the origin of the birds visiting Surinam and about their migration routes to and from this country. All birds will be banded *above* the tarsus ("knee") with one standard aluminum Fish and Wildlife Service band and two *orange* color-bands of about the same size as the aluminum band. If you see any of these birds, please write to *Arie L. Spaans, Surinam Forest Service, P.O. Box 436, Paramaribo, Surinam, South America,* mentioning species, location and date of observation, the position of the aluminum and color-bands (left or right, and, if more than one band is on a leg, which band is above and which below), and the number of color-banded birds involved.

Great Gray Owls—Information Wanted

A study is currently in progress to determine the historical and present status of the Great Gray Owl (*Strix nebulosa*) in North America. Any information regarding sight records of possible breeding occurrences of the Great Gray Owl is urgently required. Your cooperation will be gratefully acknowledged. Please write to Michael Collins, Department of Zoology, University of Manitoba, Winnipeg, Manitoba R3T 2N2.

La Fondation Marie-Victorin Décerne Quatre Médailles

La Fondation Marie-Victorin, établie en 1944, peu après le décès du fondateur du Jardin botanique de Montréal, avait pour premier but d'ériger un monument à la mémoire du célèbre botaniste—projet que fut réalisé en 1954—et secondairement d'octroyer périodiquement une médaille à un botaniste ayant oeuvré pour l'avancement de la botanique systématique au Québec. En reconnaissance de l'oeuvre accomplie dans le champ de la botanique québécoise, un comité composé des anciens médaillés, a proposé que les prochains médaillés soient: pour 1972, Ernest Rouleau (Montréal); pour 1973, Bernard Boivin (Ottawa); pour 1974, Ernest Lepage (Rimouski); pour 1975, Henry Teuscher (Montréal).

Un des principales publications d'Ernest Rouleau est la deuxième édition (révisée) de la *Flore laurentienne* du Frère Marie-Victorin (1964). Il a rendu de grands services à la communauté scientifique en compilant les index généraux de plusieurs périodiques et ouvrages importants.

Bernard Boivin est un membre depuis longtemps de l'Ottawa Field-Naturalists' Club et depuis 1969, il est membre de la Société Royale du Canada. Parmi ses publications scientifiques sont *Quelques noms vernaculaires de plantes du Quebec* (1942–1943); *Enumération des plantes du Canada,* 404 pages (1966–1968); et *Flora of the Prairie Provinces,* 3 volumes (1967–1972).

C'est en qualité de botaniste-explorateur qu'Ernest Lepage visite la côte entière de la baie James de 1953 à 1955, et accomplie la traversée de l'Ungava en trois directions, en 1945, 1961 et 1963. De si nombreuses expéditions dans des régions si mal connues ont naturellement été l'occasion de publications nombreuses sur la flore du Québec et de l'Ontario.

Henry Tuescher a publié plusieurs articles de horticulteur dans 72 périodiques canadiens, américains, allemands, français et anglais, ainsi que deux volumes: *The Soil and its Fertility* (1960) suivi d'une édition espagnole en 1965, et *Windowbox Gardening* (1956 et 1959).

Environmental Contaminants Act Stresses Prevention

Canadian legislators have broken new ground in the protection of man and his environment by enacting Bill C-25, *An Act to protect human health and the environment from substances that contaminate the environment.*

Until now the tendency has been to take remedial action to correct environmental damage that has already occurred. The new Act, however, attempts to anticipate potential problems, insofar as this is possible, and to institute a continuing risk evaluation system, at the national level, to monitor old and new chemicals, and adapt control methods to specific cases.

Bill C-25 is comprehensive; it attempts to deal with the total problem posed by chemical products. In the words of one of its authors, it is an "umbrella-law" and aims to provide protection against the danger of identifiable harmful substances being dispersed from many sources into the environment.

The Act provides that new chemicals that are expected to be dispersed widely in the environment will be tested and evaluated and that existing chemicals already on the market will be subject to restrictions, if necessary, and to periodic impact reassessment.

The Act, to be administered by the Ministers of Environment and of National Health and Welfare, is designed to supplement existing laws, not replace them.

Environment Canada experts will generally base their assessment on the extent to which the substance (1) persists in the environment (i.e., is not biodegradable); (2) combines with biological tissues and passes through the food chain; (3) spreads widely through air and water by natural transfer mechanisms; (4) can be retrieved, once dispersed in the environment; and (5) can induce biological changes, even though present in trace quantities.

The Act was enacted on 2 December 1975 and provides for fines of up to $100 000 or imprisonment for up to 2 years for persons or companies found guilty of not meeting the standards.

Book Reviews

ZOOLOGY

Bees and Beekeeping

By Roger A. Morse. 1975. Cornell University Press. 295 pp. $13.50.

This is a very readable book, presented in an interesting manner. The title may be somewhat misleading, as less than half the content is related to actual beekeeping. This is just as well since too many books have already been written on this subject, each repetitious of the other. The book starts off with a very good introduction of the honeybees and their various relatives, particularly relating to some of those found in countries other than America. This is followed by the life cycle which leads directly into the various senses of the honeybee including the senses of communication, sound, taste, color, etc., followed by a section on the pheromones and their relationship to the social insects. In each case a very good reference is made back to the effect of these various characteristics on commercial beekeeping. The information is quite up-to-date and supported by a reasonable list of references. The scientific material is presented in such a manner that the layman can readily understand and enjoy reading it, thus learning why the bees do certain things.

It might have been better if Part 2 of the contents had been considerably reduced with respect to management, and the elementary biology part expanded. Much of the information in Part 2 is readily available elsewhere in free government circulars and other books, although it is covered in a very acceptable free-flowing manner, again with readily understandable scientific background information.

The text is written as though it were taken from a set of notes for a course in introductory apiculture. If some of the author's personal views, which in some cases have very little support but are good for classroom discussion, were removed, it could very well have made a text which might have had wide use as a reference for an introductory course in apiculture at university level.

For the beekeeping enthusiast or commercial beekeeper who wants to delve into the scientific approach to modern beekeeping methods, this is the most up-to-date, easily-read book yet published.

G. F. TOWNSEND

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Porpoise, Dolphin and Small Whale Fisheries of the World: Status and Problems

By Edward Mitchell. 1975. IUCN Monograph Number 3, Morges, Switzerland. 129 pp. $3.50.

The 1970s have seen growth of unprecedented public awareness concerning commercial over-exploitation of the large cetaceans, and the blue whale in particular has become a *cause célèbre*. With the exception of the large catches of dolphins made incidentally by the tropical Pacific tuna industry of the United States, the plight of smaller cetaceans attracts much less attention.

In this singularly useful monograph Dr. Mitchell has attempted to bring together the voluminous (although often inadequate) information on the sixty-eight species which can be categorized as "small cetaceans," and has provided an excellent bibliography which will prove valuable to those interested in this field.

He has erected four practical categories for consideration: A, those species which are currently heavily fished, or have been significantly exploited in the recent past (13 species); B, species taken in small or moderate numbers which might significantly affect local populations, but not global stocks as a whole (16 species); C, those exploited at low levels (18 species); D, species rarely taken, or those which are rare or otherwise distributed so that they are not available to fisheries (21 species).

Since research funds are always totally inadequate for cetaceans studies—ocean-going research being one of the most expensive pastimes of the biologist—Dr. Mitchell's classification will assist agencies to direct such research monies as are available into studies of those species which present us with the most urgent problems. Five of those in category A are already giving cause for concern.

With the greatly reduced availability of large baleen whales, commercial whaling interest has switched quite rapidly to the minke whale, and there is danger that exploitation in some regions is already outstripping research on the species. Other cetaceans at risk include Dall's porpoise, of which coastal Japanese fisheries may take up to ten thousand a year; and those dolphins of the genus *Stenella* which are taken during seining operations for tuna in the tropical

Pacific. Estimates of the number of *Stenella* killed each year range from one hundred thousand to a quarter of a million, and authorities warn that the age structure in the populations now resembles that which characterized the Black Sea dolphin fishery shortly before its collapse as a result of over-fishing. Research is in progress with the hope of modifying tuna gear in such a way that dolphins can be released from the seines unharmed, without releasing the tuna at the same time. Naturally the industry is dragging its feet since it feels any such measures will increase costs; yet at the same time it is alarmed by the growing hostile pressure from environmental lobbies.

Dr. Mitchell concludes his discussion with a list of concrete recommendations concerning the data required, and the need for much more international cooperation in the collation of information, and the necessity for nations taking large numbers of small cetaceans to assume responsibility for the consequences of their actions.

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Mites of Moths and Butterflies

By Asher E. Treat. 1975. Cornell University Press, New York. 362 pp. $35.00 (20% discount on prepaid individual orders).

This excellent book is of unique importance to the developing study of mite–insect associations. In it the author summarizes the available information about the mites associated with Lepidoptera. This represents the first modern attempt at comprehensive treatment of the interactions of mites with insects of an entire order, and, as such, is of value not only to students of Acari or Lepidoptera, but also to all interested in the ecology of mites and insects.

The book begins with a concise and thorough historical review of the subject from 1759 to the present. This is followed by exceptionally effective chapters describing equipment and methods, and introducing acarology to the non-specialist. These three opening chapters should serve to orient lepidopterologists regardless of their previous familiarity with mites.

Chapters 4 through 8 deal with the mesostigmatic mites. The author has chosen to subdivide his account of the phoretic and facultatively parasitic species according to the nature of the host relationship rather than taxonomic boundaries. The allocation of these mites to his three categories is necessarily arbitrary, and initially unfamiliar. By presenting these chapters in order of increasing intimacy of the relationship, however, he is able to bring attention to possible evolutionary patterns.

Chapter 7 deserves special consideration. Here the author discusses his own research specialty, the parasites of the noctuid auditory organs, the mite genus *Dicrocheles*. Extensive original observations and inferences on the biology of these mites are presented with an attitude of infective enthusiasm tempered by rigorous attention to factual detail. This chapter represents the high point of the volume, and fully justifies its size and format.

The tempo of presentation is maintained through Chapter 8 which deals with the recent discoveries in the systematics and ecology of the Otopheidomenidae, or "ear-sparing" mites, parasites primarily of tropical sphingid moths.

In Chapters 9 through 12, Dr. Treat admirably rounds out his account with the acariform mites of the suborders Prostigmata and Astigmata. Throughout this part, he brings a refreshingly cautious approach to what is essentially a critical commentary on previous literature, supplemented by his own observations. The author properly emphasizes the fragmentary state of knowledge of the parasitengones, whose larvae are parasitic, and clearly identifies the problems encountered in studying these mites. The chapters dealing with adult prostigmates (phoretic or parasitic), and astigmates (phoretic hypopodial deutonymphs or scavenging adults) are comprehensive, and successfully set the stage for future research on these species.

Useful appendices are included providing keys to mites both in life and after slide-mounting, and tables summarizing known associations both by host species and by mite species.

The author's expertise with both Lepidoptera and their mite associates is reflected clearly throughout this fine volume. The book will be an essential reference for all serious students of mite–insect ecology. At the same time, it should encourage lepidopterologists to discover and report new data on the subject, regardless of the taxonomic or geographic scope of their interests. For these reasons, it is hoped that the considerable price will not restrict its availability to potential investigators.

IAN M. SMITH

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Wolves and Wilderness

By John B. Theberge. 1975. Dent, Toronto.

John Theberge has become well known as a leading advocate for the preservation of Canadian wilderness parkland. This intriguing book describes the people and wilderness experiences that influenced his early years of research centered on wolf behavior in Algonquin Park. This gives us an excellent insight into how a naturalist is made.

The first seven chapters center mainly on the wilderness experience, with the search for wolves providing a skeleton to hold together the descriptive essays of adventures and scenery in the back-country wilderness regions of Algonquin that few tourists ever see. Theberge weaves lessons on ecology and scientific information with nature lore and the tales of his experienced woodsman companion and mentor, Lawrence, in a flowing manner which compels the reader's interest and envy.

Periodically he interrupts with the rude reality of man's intervention into the wilds: the cruelty of bounty hunters, the destruction of the stately white pines by cutting them for ships' masts and by a fungus introduced from Europe, logging practices, and the waters of the Petawawa which in Algonquin taste of "solitude and rocky shores and pine needles" but downstream, through Ottawa, Montreal, and Quebec, become "a liquid whose complexity baffles the biochemists."

He gives us hope though with several illustrations of nature conquering in the end: lumber camps and roads which disappear to leave little trace, and the types of "natural" disasters which do occur when man develops nature with little forethought for the consequences.

Concerning the wolves, Theberge counters legends of bestial brutality with scientific observations, and narratives of the encounters between wolves and himself, his wife, and six-month-old child, camped in the wilderness, walking backwoods trails after dark, and even trading howls with a pack which had completely encircled him. Descriptions of long nights of fruitless searching, cold or rainy days in the field, and having to boil and clean thousands of skulls from bounty wolves illustrate that research is not all fun.

His chronicles on wolf behavior and wilderness ecology along with profound philosophy on man's relationship to nature and the value of wilderness present scientific facts in a compelling manner which will hold the interest of the least scientific reader.

Mary Theberge's illustrations are also highly commendable. They complement her husband's writing in a manner that only one who has shared the same experiences and love of wilderness could accomplish.

This book is highly recommended to all who enjoy wilderness or wish to learn more of its intrigues.

WILSON EEDY

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Handbuch der Vögel Mitteleuropas. Band 5. Galliformes und Gruiformes

[Handbook of the birds of Central Europe. Volume 5. Galliformes and Gruiformes]

Edited by U. N. Glutz von Blotzheim. 1973. Akademische Verlaggesellschaft, Frankfurt am Main. 700 pp., 5 color plates, 100 illustrations. DM 112.

The "Handbuch" series is the most important reference work for the birds of Central Europe. The first four volumes dealt with loons through flamingos (Volume 1), waterfowl (Volumes 2 and 3), and raptors (Volume 4). The present volume deals with all species belonging to the order of the Galliformes (e.g., grouse, partridge, and pheasant) and the Gruiformes (e.g., rails, coots, cranes, and bustards).

An enormous volume of published material is dealt with for each species and presented under the following headings: distribution of the species; classification of races; field marks; description; molt; vocalizations; breeding range; distribution in Central Europe; numbers and trends; migrations; biotope; density; reproduction; breeding success, mortality, age; behavior; food; and literature.

The book is a storehouse of information for both amateur and professional ornithologists. It is the most complete and most up-to-date synthesis of published information on the avifauna of Central Europe. The thorough scientific style, the logical division of the material, the large number of references in many languages, the high quality of the illustrations, and the pleasant layout and format (15 × 23 cm) all contribute to making the "Handbuch" series a unique and invaluable reference source.

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The Seabirds of Britain and Ireland

By Stanley Cramp, W. R. P. Bourne, and David Saunders. 1974. Collins, London. 287 pp., 4 pp. color plates, 8 pp. black-and-white photographs, 32 pp. maps. £3.50.

Canadians interested in Atlantic seabirds have to envy the British. To see anything more than gulls or cormorants we have to visit the less accessible parts of the Maritimes, go out to the Grand Banks, or at the very least take the Yarmouth – Bar Harbor ferry. In Britain most seabirds breed more or less on one's doorstep, and the rest can usually be seen close inshore from any prominent headland. There is also a large body of amateur ornithologists eager to organize population surveys of the kind we usually leave to government agencies. Moreover, they have been doing this systematically for several decades (Canadian surveys only seriously started in 1969 and are still incomplete), and the continuity of the records is invaluable in monitoring natural and man-induced population changes.

"Operation Seafarer" in 1969–70 is the most recent of these surveys. Its aim was to locate and count every coastal seabird colony in Britain and Ireland. The results of this monumental project are summarized in this book, along with notes on species identification, various aspects of breeding biology, and census methods and their limitations. There are, it appears, 24 species of seabird which regularly breed in Britain and Ireland, against only 15 in Atlantic Canada. In both areas Common Murre, Black-legged Kittiwake, Atlantic Puffin, and Herring Gull are the commonest species. But in Britain four other seabirds top the 100 000-pair mark, whereas Leach's Storm-Petrel, whose Atlantic breeding center is in Newfoundland, is the only other of our birds to do so. Our Gannets probably once did, but the population has yet to recover from the persecutions of a century ago. Anyone who wants to make more detailed comparisons may like to compare this book with the *Atlas of eastern Canadian seabirds*, shortly to be published by the Canadian Wildlife Service.

So far, so good. One wants to go further and speculate on the reasons for these differences, at a level a little more profound than saying that we have the Labrador Current but they have the Gulf Stream. Here, I think, the book fails. It is too insular. In Canada, the sheer size of the country forces us to take into account complete species ranges. But this book covers only Britain and Ireland. A wider geographical scope would of course have been even more of a monumental undertaking; a comparable survey in the eastern Atlantic would have to extend from Spitsbergen to Portugal. But it would have been useful to have more detailed statements of world distribution than the ones provided. Without them, a more detailed interpretation is scarcely possible. The only exception to this is the treatment of the Gannet, admittedly an easy species to count.

The book is also too land-orientated. There is almost no mention of pelagic species which visit but do not breed—not even in the illustrations as an identification guide. This too frustrates comparisons. I would guess that a substantially greater proportion of the eastern Canadian seabird biomass is made up of non-breeding pelagic species, but that at present is as far as one can go. W. R. P. Bourne partly makes up for this by a lucid chapter on the biology of seabirds which supplies the broad oceanographic background to their distributions. But I would have liked more details on why many of the colonies are where they are. The importance of tide races as feeding areas for Shetland seabirds, for example, could have been given more prominence. For this and because of its general interest to seabird workers, I recommend Bourne and Dixon's paper "The seabirds of the Shetlands" in the British Seabird Group's Report #4 (1974).

Stanley Cramp has contributed a useful chapter on the threats to seabirds, which summarizes the history of human persecution and of the increasing effects of oil and other pollutants on British seabirds. This is balanced by another chapter on changing seabird numbers, summarizing the increases in species such as large gulls and Northern Fulmars which exploit our various effluents, and the decreases in such groups as the alcids, which are overwhelmed by them. I only wish we could match the British (or for the matter the New England) data on seabird population trends.

Robert Gillmor's illustrations are up to his usual standard, though I prefer his line drawings to the identification guide style of the color plates. To my eye, however, his flying Fulmar's wings are too angled and gull-like, and the forked tail of his Leach's Storm-Petrel is not the useful field character that his (and for that matter Peterson's and Singer's) illustrations suggest. The colony symbols on Crispin Fisher's maps tend to run together in the more densely populated areas. The situation might perhaps be clearer if one used a standard-sized circle, varying the proportion of filling it in to indicate colony size, rather than varying the size of a solid circle as has been done here.

All in all, this is an important contribution to the seabird literature. Although it may in some ways not say enough about the seabirds of Britain and Ireland, it tells us a great deal more about them than we knew before.

R. G. B. BROWN

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BOTANY

Genera of the Eastern Plants

By Wade T. Batson. 1975. W. T. Batson, 1120 Blake Drive, Cayce, South Carolina. 204 pp. $4.50.

Seldom has a book come across my desk which so obviously fills a need felt among botanists, students of plant taxonomy, and naturalists as does this little volume. Anyone possessed of an urge to know at least the surnames of the plants they find in nature or in gardens will rapidly become enthusiastic over the facility which Professor Batson has now given us in identifying to genus most plants which occur naturally or are most commonly planted in Eastern North America, from south Florida to the Arctic.

The convenient format of the book (18 × 11 × making it a convenient pocket companion for field forays, is made possible by the author's acceptance of the genus as the logical taxonomic unit at which such an overall work should end. The only mention of species within each genus is a numerical estimate of the number likely to be found within the range of this half-continent.

The book is supplied with a brief and helpful explanation of the format adopted, figures to illustrate such features as leaf variation, inflorescence types, floral types (including specialized ones found in legumes, composites, and grasses), a list of abbreviations, and a two-page glossary of terms.

Keys to the major groups of vascular plants, to the families and to genera are constructed in easy-to-follow dichotomous arrangement and introduce a minimum of botanical jargon. For each genus entry, the authority for the genus and its common name(s) follow on line one; synonyms (if pertinent) on line two, followed by brief description of habit, distinctive features, ecology and distribution (if restricted). Finally, opposite the last entry line, a bar line identifies a finely executed line-drawing of pertinent diagnostic feature(s) at one end and the estimated number of species to be anticipated in the range at the other.

While a number of typographical errors have not been eliminated from this second edition they are, for the most part, likely to prove annoying rather than misleading to the critical user of the volume; on page 21, *Andropogon* is substituted for the obviously required *Arundinaria* in the key. The latter genus is correctly given, immediately following, in the listing of the four genera of the tribe Bambuseae commonly seen in our range.

In all, not since Père Louis-Marie published his little book *Flore manuel de la Province de Québec* dedicated "à la jeunesse de mon pays" has there been anything, to my knowledge, which so well fills the requirement of a field guide to eastern Canadian plants in one of Canada's official languages. Here we have a paperback (complete with a decimetre rule subdivided into centimetres and millimetres on the title page) which points the way to the genus we should consult, back home or in the laboratory, in detecting the specific identity of a given unknown plant.

WILLIAM I. ILLMAN

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Sedum of North America North of the Mexican Plateau

By Robert T. Clausen. 1975. Cornell University Press, Ithaca, New York. 742 pp., illus. $65.

This monograph is not written solely for the taxonomist, but also for the horticulturalist as well. The treatment is by a man who has spent a large part of his life studying *Sedum* and the related genera of the family Crassulaceae. In addition to extensive field surveys in many parts of North America and studying dried specimens in herbaria, he has grown and studied most of the taxa either in the greenhouses at Cornell University or in his garden at Ithaca, New York. Thus the book contains not just the descriptions of plants and their taxonomy, but a wealth of statistical data, habitat information, and many other interesting details as well, through which considerable insight to relationships of species and evolution can be gained. It is a companion to *Sedum of the Trans-Mexican volcanic belt: an exposition of taxonomic methods,* written by the same author and published in 1959 by Cornell University Press.

Thirty native species of *Sedum* are known to occur in North America north of the Mexican Plateau. Three species are found to be naturalized quite frequently in this area, and an additional ten have been reported as naturalized. Descriptions are given for 53 species of *Sedum* which are commonly cultivated, and references are given for an additional 55 species which have been grown occasionally. Three keys are presented: the first two are to 49 native species of *Sedum, Lenophyllum, Parvisedum,* and *Diamorpha,* and also five other genera, for plants in flowering and fruiting condition respectively, and the third is to the 53 species commonly in cultivation. Herbarium botanists may find some difficulty with these keys because they are designed for use with fresh material.

Several new taxa are described, and a number of transfers are made for subgenera, sections, and subspecies. To be specially noted is the transfer, *Acer nigrum* ssp. *saccharophorum* (Koch) R. T. Clausen, a transfer which would never be expected to be found in a monograph on *Sedum*!

Chapters on the history of the genus *Sedum* in North America, sampling techniques, the geology of North America, geography of *Sedum* in North America, relationships of species, conclusions, a gazetteer, a bibliography, and an index round out the volume.

Dr. Clausen is to be commended for bringing together this tremendous volume on *Sedum* and Crassulaceae. It will serve as an example to students in any taxonomic study, irrespective of their interest in these succulent plants.

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Flore du Canada

By Anonymous. 1974. Canada Secrétariat d'Etat, Bureau des Traductions, Bulletin de terminologie no. 156 (anglais-latin-français). 634 pp. Available from Information Canada, Ottawa, Catalogue No. S52-2/156F. $7.75 (softbound).

Botanists and naturalists in Canada will be disappointed in this book because it is not, as the title indicates, a flora of Canada. A modern comprehensive flora of Canada still remains to be published although there is hope that Homer Scoggan's flora will be available in the forseeable future.

The book is in fact a dictionary. It is a compilation from a number of books dealing with various sectors of the Canadian flora, which list common as well as Latin names of plants. The book is designed primarily for the translator who wishes to learn the French common name of a plant when given an English common name. It is possible too, however, by using an index, to learn the English and Latin names if the French is given, or English and French if the Latin is given, but the user should be cautioned that only those Canadian plants which have French common names are treated, and that there are many plant species found in Canada which have neither an English or French common name.

The main text is arranged alphabetically by English name in three columns: English-Latin-French. A plant which has more than one English name will appear as many times as there are English names for that plant, with the alternate English names following. The Latin and French text remains in the same order for each entry. The Latin names given are not necessarily synonomy, but may be different species or varieties for which there is the same common name. In the French column, the name used by Frère Marie-Victorin in his *Flore laurentienne* appears first where there is more than one French name, except in the case of trees, where the name employed in *Arbres indigènes du Canada* (1972 edition) is listed first.

This book will be a most useful tool for anyone wishing to learn the equivalent names, English-Latin-French, of Canadian plant species. Librarians will mourn the fact that the book has no author by which to classify it, and it is indeed unfortunate that there is no author to whom credit can be given for the careful compilation. There are a few typographical errors and the bibliographic references are not all complete, but this does not detract from the usefulness of the book.

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ENVIRONMENT

To the Wild Country

By John and Janet Foster. 1975. Van Nostrand Reinhold, Toronto. $19.95.

A series of nature films that John and Janet Foster prepared for the CBC inspired the book, *To the Wild Country*. The Fosters guide us through six of their favorite locations in the Canadian wilderness: Kluane, the Pacific shore, short grass country, Algonquin Park, the St. Lawrence, and Baffin Island. Their book is a very personal armchair tour which captures the essence of each region.

The text of *To the Wild Country* is a first-person narrative which relates details of the filming for the television serial and recounts intimate details of a particular terrain. For example, the reader learns that on Baffin Island a lemming rummaged through the Fosters' packs one night and escaped with a feast of freeze-dried vegetables. One can read about the film crew's quest for remote Triangle Island near Pacific Rim National Park. They spent several days trying to get to the bird-infested "miserable pile of rocks," even attempting to hitch a ride on a destroyer that the Lieutenant-Governor of British Columbia was using to visit remote ports.

Interspersed with the text are many well-documented black-and-white photos, visual essays which complement the narrative. Excellent colored photos appear at the end of each chapter. My personal favorites are the fantastic bleak landscapes of Baffin Island. Unfortunately, the descriptions for the colored pictures are grouped together at the end of the book, a feature which necessitates excessive page-flipping. The legends, however, are certainly worth reading, particularly by nature-photography buffs, because they include such information as the type of lens used for a particular shot.

Perhaps the mood of this book can best be expressed by J. B. Harkin's words, the closing quotation of *To the Wild Country*: "To go into the quiet woods or mountains produces a feeling of perfect rest and liberation—a true re-creation. . . .A person finds pleasure in the absolute stillness, in primitive and wild sounds such as the wind in the trees, the falling of water, the wide expanse of landscape or sky, and he renews again his ancient relationship with wild animals, a relationship as old as man himself."

John and Janet Foster have told us of their re-creation. Their book compels each reader to go and seek his/her own perfect rest and liberation.

GAIL BEBEE

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Fire and Ecosystems

By T. T. Kozlowski and C. E. Ahlgren (*Editors*). 1974. Academic Press, New York, 542 pp. $39.50.

The use of fire as a resource management tool has been abused by managers having incomplete knowledge of its results and by a public unjustifiably fearful of its effects. "Because of growing interest, pressures exerted by public and conservation groups, and conflicting schools of thought among biologists regarding the role of fire, the editors decided that the time was appropriate to bring together in one volume a summary of available information on the role of fire in the ecosystems of the modern world." In the fourteen chapters of *Fire and Ecosystems*, international fire ecologists have reviewed the effects of fire on whole ecosystems as well as ecosystems components.

In itself each paper is excellent. And there is remarkably little repetition for a text which has restricted itself to a narrow topic, has attempted to review distinct aspects of a subject, and has had numerous contributors.

The editors feel that ". . . the new philosophy of almost complete condemnation of all fire reflected rather wholesale rejection of the historically demonstrated beneficial effects of fire." But this discrepancy between modern theory and empirical fact does not appear to be a problem in Australia. "In Australia, a good public understanding has been one of the contributing factors to widespread success of the hazard reduction control burning program, which utilizes low intensity fires to remove fuel accumulation and facilitate wildfire control." The omission of Australian material in *Fire and Ecosystems* is one of the book's few weaknesses.

Papers by J. F. Bendell and R. J. Vogl are representative of the thoughtful scientific quality found in the other contributions to *Fire and Ecosystems*. Bendell's paper (Chapter 4) on the effects of fire on birds and mammals is an excellent review. Included are approximately 300 references indicating a rather comprehensive search of the literature. It is his feeling that "the remarkable stability of populations within a rapidly changing environment strongly suggests that birds and mammals control their own populations more or less independently of it." Each ecologist could probably cite papers not included in Bendell's review; however, most would acknowledge his treatment as quite comprehensive.

Vogl's paper (Chapter 5), the effects of fire on grassland, is acknowledged by the authors as an extension of Daubenmire's (1968) paper (Ecology of fire in grasslands. Advances in Ecological Research 5: 209–266). Judging from the number of post-1968 references, a reasonable effort has been made in updating Daubenmire's paper.

Fire and Ecosystems is an expensive text. Only someone sincerely interested in fire ecology should consider purchasing it. Others are advised to borrow a copy from their local library.

PETER CROSKERY

Ontario Ministry of Natural Resources, Ignace, Ontario

OTHER BOOKS

Survival 2001. Scenario from the future

By Henry E. Voegeli and John J. Tarrant. 1975. Van Nostrand Reinhold, New York. 115 pp., illus. $6.95.

Fact or fiction? A rather novel approach presents the views of a technological historian looking back from the year 2001 and describing how man survived the present energy crisis. Although none of the solutions presented are particularly startling or original, the brief descriptions and simplified technical sketches summarize the many possible technical methods by which man might survive in an almost *Whole Earth* manner. An engineer might feel the whole approach is grossly oversimplified, but the average field-naturalist can probably learn a great deal about the alternate solutions to the energy problems which face us today.

The first pages present some of the less mechanical methods of conserving energy and natural resources. These include discussions of how a heat-pump works, relying on the constant temperature at a depth of 50 feet to help conserve heat in the winter and coolness in the summer. Surrounding this are various ideal solutions to the insolation problem, most of which are beyond the present-day technical capabilities of the average home-owner, but worthy of future consideration. Water is conserved by segregation of potable and untreated supplies—maybe a future necessity, but I'm sure a municipal nightmare. Maybe if we 'smarten up' and pollute less it won't be required. Solid wastes are of course recycled or composted.

A substantial portion of the book is devoted to wind and solar power. The major problem seems to be storage. Many variations of the windmill or solar collector are presented. Again the value of the book is in the summarization of potential technology, giving the layman an insight into the solutions. No technical comparisons are made and the engineering details are very superficial.

Water power also receives considerable attention. The bobbing, oscillating or rocking buoys with complex systems of levers or internal chambers translating the eternal motion of the sea into electrical impulses are described. Facinating, until you begin to think of the thousands of acres of ocean necessary to fill with these in order to send a significant supply through the network of electrical cables across the ocean floor. Likewise, the thought of an immense dam stretched across the Bay of Fundy, Cape Code Bay, Long Island Sound, or the Bering Strait is somehow frightening. Even the assurance that 2½ times more water could be exploited at Niagara Falls "without losing much of the scenic attraction" seems quite naïve, even if the authors snidely assure us that off-season manipulation would "satisfy the environmentalists" as well as being "good common sense," as if the two could not be equal. This section ends with a vista of floating super-mines, powered by the sun and waves as they exploit the last refuge of the ocean's depths.

Next we briefly touch on geothermal power. The feasibility of sinking pipes 750 to 1000 miles into the earth and of boilers built right into the sides of volcanos is assumed. None of the solutions to technical (nor gaseous) problems are detailed. Transportation, with electric cars, power gliders, and weirdly shaped monorail trains closes the chapter with ideas almost more of the past than of the future technology.

This book is an interesting, intriguing, easily read, and informative treatment of future alternatives to energy problems, for the average layman with a passing interest in mechanics or engineering technicalities. The value lies in the great variety of solutions presented, not in the precise details. For the naturalist, perhaps the true value lies in giving us an insight into some of the technicalities of these future dreams. We might just begin to contemplate what the absolute results of some of these "solutions" might encompass. Some of the ideas presented in this book can raise our hopes for the future while others should open our eyes to very real and frightening aspects.

WILSON EEDY

Beak Consultants Ltd., Mississauga, Ontario M9W 1R6

A Guide to the Queen Charlotte Islands

By Neil G. Carey. 1975. Alaska Northwest Publishing Co., Anchorage, Alaska. 71 pp. $2.95.

This booklet gives practical information on how to travel throught the islands—by boat, plane, and road (including plenty of maps), notes on weather and on suitable clothing.

From this point of view the book will prove very useful. Getting to the Queen Charlotte Islands has been easy for many years; the problem is getting around them.

To the naturalist and anthropologist the Peale's race of the Peregrine Falcon, seabird and sealion colonies, the endemic forms of birds and mammals and plants, and the mossy remains of Haida totem poles offer a great attraction. These subjects, however, are only mentioned in passing in this book and the inquisitive visitor will have to search out some of the excellent specialized sources of information such as *The Flora of the Queen Charlotte Islands* (J. A. Calder and R. L. Taylor. 1968. Resources Branch, Canada Department of Agriculture, Queen's Printer, Ottawa).

While the maps are clear, it is unfortunate that many roads are omitted. The maps are often shown on their side with north to the left which is needlessly disturbing. St. James is listed as one of the five major islands comprising the Charlottes, which it is not. Sandspit Airport is not the only port of entry for aircraft. Rose Spit is not a Provincial Park (it is an Ecological Reserve). When eating molluscs the booklet instructs the reader to "be alert for signs of red tide" to avoid paralytic shellfish poisoning, without indicating what the signs are (the signs are often misleading anyway).

In spite of these minor drawbacks, the newcomer to the Charlottes is sure to benefit from Neil and Betty's twenty years of intimate association with the islands.

J. B. FOSTER

Ecological Reserves, Department of Environment, Victoria, British Columbia V8V 1X5

NEW TITLES

Zoology

Animal invaders. 1976. By Clive Roots. Douglas, David, and Charles, Vancouver. $19.25.

***Atlas of eastern Canadian seabirds.** 1975. By. R. G. B Brown, D. N. Nettleship, P. Germain, C. E. Tull, and T. Davis. Canadian Wildlife Service, Ottawa. Information Canada Catalogue Number CW66-44/1975. 220 pp., illus. $6.75 in Canada, $8.10 elsewhere.

Avian biology. 1975. Edited by Donald S. Farner, James R. King, and Kenneth C. Parkes. Academic, New York. Volume 5. xxiv, 524 pp., illus. $49.50.

***Behaviour of ungulates and its relation to management.** 1974. Edited by V. Geist and F. Walther. IUCN, Morges, Switzerland. IUCN Publications New Series No. 24. Two Volumes. (Papers of an international symposium held at the University of Calgary, 2–5 November, 1971). 940 pp. $15.

A bibliography of the fossil mammals of Africa, 1950—1972. 1975. By Margaret W. Cross and Vincent J. Maglio. Princeton University Department of Geological and Geophysical Sciences, Princeton, N.J. ii, 292 pp. Paper $3.

The biology of sea snakes. 1975. Edited by William A. Dunson. University Park Press, Baltimore. xii, 530 pp., illus. $34.50.

Birds of North America. A personal selection. 1975. By Eliot Porter. A & W Visual Library, New York. 140 pp., illus. Paper $8.95.

The butterflies of North America. 1976. Edited by William H. Howe. Doubleday, Garden City, N.Y. $45.

Breeding endangered species in captivity. 1975. Edited by R. D. Martin. Academic, New York. 420 pp. $33.75.

Checklist of the butterflies and skippers of Canada. 1975. By anonymous. Macdonald College, Ste-Anne de Bellevue, PQ. Lyman Entomological Museum and Research Laboratory Memoir No. 3.

†**Conodont ultrastructure: the subfamily Acanthodontinae.** 1975. By C. R. Barnes and D. J. Slack. Royal Ontario Museum, Toronto. Life Sciences Contribution 106. 21 pp. $1.50.

The dictionary of butterflies and moths in colour. 1975. By Allan Watson and Paul E. S. Whalley. McGraw-Hill, New York. xiv, 296 pp. $29.95.

Fiddler crabs of the world, Ocypodidae: genus Uca. 1975. By Jocylyn Crane. Princeton University Press, Princeton, N.J. xxiii, 737 pp., illus. $75.

Fisheries resources of the sea and their management. 1975. By David Cushing. Oxford University Press, New York. vi, 88 pp., illus. $9.75.

†**Fishes of the National Capital Region.** 1974. By D. McAllister and B. Coad. National and Provincial Parks Association, Ottawa. 200 pp., illus. $4.

Hawks, falcons and falconry. 1976. By Frank Beebe. Hancock House, Saanichton, B.C. 224 pp., illus. $25.

Insect ecology. 1975. By Peter W. Price. Wiley, New York. xiv, 514 pp., illus. $15.95.

Lemur biology. 1975. Edited by Ian Tattersall and Robert W. Sussman. Plenum, New York. xiv, 366 pp., illus. $22.95.

***Mites of moths and butterflies.** 1975. By Asher E. Treat. Cornell University Press, Ithaca. 362 pp., illus. $35.

Neural and endocrinal aspects of behaviour in birds. 1975. Edited by Peter Wright, Peter G. Caryl, and David M. Vowles. Elsevier, New York. (Papers from a conference, Edinburgh, July 1974). x, 408 pp., illus. $40.95.

***The northern interior grizzly bear *Ursus arctos* L.** 1975. By Arthur M. Pearson. Canadian Wildlife Service, Ottawa. CWS Report Series No. 34. 86 pp. $4.50 in Canada, $5.40 elsewhere.

†**Owls.** 1976. By Clive Catchpole. Illustrated by David Nockels. Bodley Head, London. 48 pp. $5.95.

Parasites of forest Lepidoptera in Canada. Part I, subfamilies Metopiinae and Pimiplinae (Hymenoptera: Ichneumonidae). 1976. Compiled by G. A. Bradley. Information Canada, Ottawa. 99 pp. $2.50 in Canada, $3 elsewhere.

Portraits in the wild. Behavior studies of east African mammals. 1975. By Cynthia Moss. Houghton Mifflin, Boston. xviii, 364 pp. + plates. $12.50.

Progress in soil zoology. 1975. Edited by Jan Vanek. Junk, The Hague. (Proceedings of a colloquium, September 1973, Prague). 630 pp., illus. Dfl. 100.

†**The red colobus monkey.** 1975. By Thomas T. Struhsaker. University of Chicago Press, Chicago. 311 pp. $25.

To save a bird in peril. 1975. By David R. Zimmerman. Coward, McCann, and Geoghegan (Canadian distributer Longman, Don Mills, Ontario). 261 pp. $11.75.

†**Scales instead.** An introduction to fish and fisheries. 1975. By David C. Arnold. Department of Biology, Mount Allison University, Sackville, N.B. 40 pp. Paper $2.

***The secret life of animals.** 1975. By Lorus Milne, Margery Milne, and Franklin Russell. Dutton, New York. (Canadian Distributer Clarke Irwin,Toronto). 214 pp., 332 illus. $34.50.

Sleek and savage. North America's weasel family. 1975. By Delphine Haley. Pacific Search, Seattle. 128 pp., illus. $5.50.

Small mammals. Their productivity and population dynamics. 1975. Edited by F. B. Golley, K. Petrusewicz, and L. Ryszkowki. Cambridge University Press, New York. International Biological Programme 5, xxvi, 452 pp., illus. $32.50.

Botany

Aquatic plants. 1976. By Karel Rataj and Thomas Horeman. Clarke Irwin, Toronto. $19.25.

†**Common weeds of Canada/Les mauvaises herbes communes du Canada.** 1976. By Gerald A. Mulligan. McClelland and Stewart, Toronto. 140 pp., illus. $4.95.

Cytotaxonomical atlas of the arctic flora. 1975. By Askell and Doris Loeve. Cramer, Vaduz, Germany. 598 pp. DM200.

Flora of the Texas coastal bend. 1975. By Fred B. Jones. Drawings by Eveline Jackson. Mission Press, Corpus Christi, Texas. 262 pp., illus. $7.80.

The forests of Gatineau Park. 1975. By Environment Canada, Forestry Service. Forest Management Institute, Ottawa. Free.

The near woods. 1975. By M. C. Davis. Knopf, New York. $10.

Plant biology. 1976. By Knut Norstog and Robert W. Long. Saunders, Philadelphia. 450 pp., 360 illus.

Plants consumed by man. 1975. By B. Brouk. Academic, New York. 479 pp. $39.25.

***Sedum of North America north of the Mexican plateau.** 1975. By Robert T. Clausen. Drawings by Elfriede Abbe. Cornell University Press, Ithaca. 742 pp., illus. $65.

Seeds of woody plants in the United States. 1974. Coordinated by C. S. Schopmeyer. USDA Forest Service, Washington, Agriculture Handbook No. 450. 883 pp., illus. $13.60.

Shrubs and vines for northeastern wildlife. 1974. By Northeastern Experimental Station. USDA Forest Service, Upper Darby, Pennsylvania. General Technical Report NE-9. 180 pp.

Environment

Background to environmental planning. 1975. By R. Fraser Reekie. Arnold, London. viii, 136 pp., illus. $16.

Biology: food and people. The economic importance of biology. 1975. By Robert Barrass. St. Martin, New York. x, 246 pp., illus. $13.95.

Do you know your birds and trees? A nature quiz for fun and painless learning. 1976. By Victoria and William McMillan. Douglas, David, and Charles, Vancouver. 120 pp. Paper $3.95.

†**The economy of nature.** A textbook in basic ecology. 1976. By Robert E. Ricklets. Chiron, Portland, Oregon. v, 455 pp. $13.95.

Elements of oceanography. 1976. By J. Michael McCormick and John V. Thiruvanthukal. Saunders, Philadelphia. 350 pp.

The Forest Service. A study in public land management. By Glen O. Robinson. Johns Hopkins University Press, Baltimore. Resources for the Future. xviii, 338 pp. Cloth $16.95; paper $4.95.

The legal status of ecological reserve creation and management in Canada. 1976. By Robert T. Franson. IUCN, Morges, Switzerland. IUCN Environmental Policy and Law Paper No. 9. 108 pp. $16.

The life-giving sea. 1975. By David Bellamy. Crown, New York. 320 pp., illus. $15.95.

Man-environment interactions. Evaluations and applications. Edited by Daniel H. Carson. Dowden, Hutchinson, and Ross, Stroudsburg, Pennsylvania. (Distributor Halsted New York.) 3 volumes, illus. $50.

Human ecology and susceptibility to the chemical environment. 1976. By Theron G. Randolph. Thomas, Springfield, Illinois. 160 pp. $8.50.

Natural resources measurements. 1975. By T. E. Avery. McGraw-Hill, New York. xiii, 339 pp. $12.95.

Physiological limnology. An approach to the physiology of lake ecosystems. 1975. By H. L. Golterman with the assistance of K. E. Clymo and R. S. Clymo. Elsevier, New York. Developments in Water Science, 2. xiv, 490 pp., illus. $51.95.

†**Sea attraction.** 1975. By David C. Arnold. Huntsman Marine Laboratory, St. Andrews, N.B. 32 pp. Paper $1.50.

Seasons of the salt marsh. 1975. By David A. Gates. Illustrated by Edward and Marcia Norman. Chatham, Old Greenwich, Connecticut. 128 pp. $8.95.

Miscellaneous

†**Canadian conservation directory 1975/1976.** 1976. Edited by Theodore Mosquin and Sandra MacDougall. Canadian Nature Federation, Ottawa. 58 pp. $2.

†**Elements of physical geology.** 1976. By James H. Zumberge and Clemens A. Nelson. Wiley, New York. xvi, 409 pp., illus. $13.50.

***Environmental change in the maritimes.** 1975. Edited by J. G. Ogden III and M. J. Harvey. Nova Scotia Institute of Science, Halifax. (Proceedings of a symposium held at Dalhousie University, Halifax, 22–23 October 1971, sponsored by the NRC Association Committee for Quaternary Research.) 109 pp., illus. Paper $5.

Geology of the Sierra Nevada. 1975. By Mary Hill. Maps by Adrienne E. Morgan. Drawings by Alex Eng and others. University of California Press, Berkeley. California Natural History Guides, 37. viii, 232 pp. + plates. Paper $3.25.

†**International stratigraphic guide.** A guide to stratigraphic classification, terminology, and procedure. 1976. Edited by Hollis D. Hedberg. Wiley, New York. 200 pp. $9.50.

Nahanni. 1975. By Dick Turner. Hancock House, Saanichton, B.C. (previously titled Headless valley). $9.95.

†**An outline of structural geology.** 1976. By Bruce E. Hobbs, Winthrop D. Means, and Paul F. Williams. Wiley, New York. 571 pp., illus. $16.95.

Peace country heritage. 1974. By E. C. Stacey. Western Producer, Saskatoon. 182 pp. $8.95.

Superior: the haunted shore. 1975. By Bruce Littlejohn and Wayland Drew. Gage, Agincourt, Ontario. 176 pp., illus. $35.

*Assigned for review
†Available for review

The Ottawa Field-Naturalists' Club

Minutes of the Ninety-sixth Annual Business Meeting of The Ottawa Field-Naturalists' Club

The 96th Annual Business Meeting of The Ottawa Field-Naturalists' Club was held in the auditorium of the National Research Council on Sussex Drive, Monday, 20 January 1975. The President E. C. D. Todd, called the meeting to order at 8:13 p.m., with 38 persons present (late arrivals increased this to 45). He requested approval of the agenda, since this departed somewhat from the conventional form, and this was done on motion (by M. Brigham, 2nd H. Thomson).

The minutes of the 95th Annual Meeting were read by the Recording Secretary, and accepted on motion (by A. Erskine, 2nd A. Sheppard), with one small correction.

The Treasurer's report of the financial standing of the Club was available for examination. The Treasurer pointed out the more significant items, including the selling of the Club's holdings of stock in Bell Canada and Microsystems International. Other items were the increased cost of publishing *Trail & Landscape* ($500 more than last year); the purchase of a slide projector and screen; increased revenue from subscriptions to *The Canadian Field-Naturalist* (up by $1000); the larger grant from the National Research Council ($1500 more); the very low income shown from charges for plates and tables resulting from balancing out a gross overestimate of such income in the previous year. Discussion followed a motion for adoption (by C. Gruchy, 2nd E. Dickson). L. C. Smith queried inclusion of a new filing cabinet under editing expenses rather than as a capital cost, and M. Brigham noted that this also applied to the new slide projector. Gruchy agreed that this change could be made in the statement with little difficulty. With these provisos, the financial statement was approved.

Copies of the annual reports of the Committees of the Council were available, and the President reviewed highlights of each report. These included an increase in the membership, regaining the numbers lost last year after the membership fee had been raised; the active program of excursions and lectures, including regular monthly meetings except in summer; the results of a questionnaire on the reasons members belonged to the Club, and improvements suggested by these results; addition of a Production Manager for *The Canadian Field-Naturalist*; the separation of the funds of the Club from those of the journal; the Club's suggestions to the Ottawa-Carleton Regional Plan, which were all accepted except for the Region's retention of the option to build the Britannia Arterial road; the exploration of the Carp Hills; problems with snowmobiles on the Mer Bleue and with traffic at the Ramsayville marsh; the meagre response to the natural areas inventory; examination of bird records, and the successful bird counts at various seasons; the provision of displays advertizing the Club at naturalists' conferences, and of participation in radio interviews on natural history subjects; the securing of judges for nature exhibits at the Ottawa Science Fair, and of speakers and trip leaders for outside groups; liaison with the Federation of Ontario Naturalists; support of the public bird feeders in the Greenbelt in winter; and encouragement of the Macoun Field Club for younger naturalists. Adoption of the report was moved (by W. Cody, 2nd H. MacKenzie). D. A. Smith remarked on the failure to mention *Trail & Landscape* in the Publication Committee report; C. Gruchy acknowledged that this had been an oversight, and agreed to prepare, with A. Hanes (*T & L* Editor) a brief addition to remedy this lack. G. Neville commended the idea of radio interviews. The report was then approved.

The Chairman then proceeded to consideration of the Amendments to the Constitution, proposed at the last meeting by D. A. Smith and subsequently published in *The Canadian Field-Naturalist*. The first, dealing with the procedure for amending the Constitution, aroused considerable discussion in relation to the clause permitting further amendment of the amending motion from the floor of the meeting at which it was to be voted on. D. A. Smith emphasized his view that the initial motion of amendment and its subsequent publication merely opened the way for consideration of a given Article of the Constitution, after which amendment of desirable but imperfect proposals was as valid as rejection of undesirable ones. G. Neville queried whether a minimum of one month's notice was enough advance warning, in view of the present slow delivery of mail; it was agreed that this could, if necessary be amended once the motion was passed. The motion was passed, 30 to 2, with 2 abstentions stated (presumably there were others).

The other seven motions all passed with little discussion, and without dissent (except one opposed vote on motion 3). In discussion, W. Cody pointed out that the deletion of Article 5 might be considered to change the numbers of all succeeding articles, some of which were mentioned in amending motions, but this could be dealt with simply by applying to all such cases the numbering existing when the amending motion was made.

C. Gruchy then introduced a motion (2nd L. C. Smith) to amend the Constitution by adding to Article 1 the following sentences: "All assets and other accretions of the Club shall be used in promoting the Objectives of the Club and in no way shall be used for the purposes of financial gain for its members. In the event of dissolution of the Club, all remaining assets, after payment of liabilities, shall be distributed to one or more recognized charitable organizations in Canada." These provisions are required by law if the Club is to be registered as a charitable organization for purposes of receiving tax-free donations. This motion will be published in *The Canadian Field-Naturalist*, and voted on at the next Annual Meeting.

The President then asked J. Reddoch, for the Nominating Committee, to present the slate of Officers and other Council members for the Club in 1975. The following were approved on motion (by J. Reddoch, 2nd A. Hanes): President, Ewen Todd; Vice-President, Roger Foxall; Treasurer, Pamela Sims; Recording Secretary, Tony Erskine; Corresponding Secretary, Chuck Gruchy. The following additional members of Council were then approved on motion (by J. Reddoch, 2nd M. Stuart): Bill Cody, Joe Dafoe, Albert Dugal, Erich Haber, Don Lafontaine, Hue MacKenzie, Pat Narraway, Gerald Oyen, Loren Padelford, Allan Reddoch, Joyce Reddoch, Arnet Sheppard, Roger Taylor, Stan van Zyll de Jong, Florence Weekes, and Harry Williamson. The Chairman introduced new Council members present to the membership, and also paid tribute to Council members then retiring or having resigned during the year: Ernie Brodo, Loney Dickson, Jim Ginns, Wayne Grimm, Vi Humphreys, Aileen Merriam, Lorraine Smith, and Geoffrey Wasteneys, as well as the Auditors, Monty Brigham and Harry Williamson, and the refreshments organizer, Catherine O'Keefe. Auditors for 1975 were then approved on motion (by W. Cody, 2nd R. Foxall), as follows: G. D. Tippett, C. A. and G. J. Wasteneys.

Under "New Business," the President then called on H. MacKenzie, chairman of the Centennial Planning Group, to speak on plans for the Club's Centennial in 1979. MacKenzie noted the call for suggestions published in *Trail & Landscape*, and mentioned some of those received to date: a cumulative index to *The Canadian Field-Naturalist* and earlier publications in the same series; a reprinting of the address of Dr. Fletcher at the Club's first evening meeting; publication of a series of drawings by Mrs. White, wife of the Club's first president; the flora and fauna of Parliament Hill; a history of the Club; an anniversary volume of *The Canadian Field-Naturalist*; a publication based on the Club's orchid survey; a request for a special commemorative stamp; and a special Club banquet *without* after-dinner speeches. G. Neville suggested that the Club might also consider buying a piece of land as a nature preserve, possibly in the Carp Hills.

E.Todd extended an invitation to Club members to attend Council meetings, to improve communications between Council and the membership. It was agreed that Council meetings could be publicized at the monthly meetings of the Club in the preceding week. Stuart Hamill also suggested publicizing the monthly meetings of the Club at the two local universities, and this was approved.

E. Dickson asked if the slate of officers and Council members could be circulated before nominations were closed. Todd read the new draft By-law on Nominations, to show that the matter was under study. Further discussion pointed up the problem of making adequate provision for nominations by the general membership when currently existing provisions were virtually never taken advantage of.

Adjournment was moved (by J. Reddoch, 2nd G. Wasteneys) at 10:35 p.m., after which refreshments were served, and then A. J. Erskine introduced and commented on a silent film on "Trumpeter Swans" from the Canadian Wildlife Service files.

A.J. ERSKINE, Recording Secretary

Report of Council to The Ottawa Field-Naturalists' Club

A study of "Club Policies and Management Practices," carried out by H. N. MacKenzie at the request of Council in the latter part of 1974, was reported in April 1975. Among its recommendations were the combining or re-organizing of some committees, the setting up of clearer terms of reference for committees and Club officers, and more systematic planning of Club policies. These are being implemented gradually. The change in format of this report reflects some of these recommendations, as well as considerable condensation in response to increased printing costs. Omission of reports from the Bird Records and Bird Feeders Committees recognizes that these groups deal directly with "nature" rather than with Council "business"; they are active Club operations as before. Committee reports follow, with names of chairpersons in parentheses.

Finance Committee. Early in the year, the budget for 1975 was prepared and adopted by Council. A new system of accounts was established for funds both of the Club and *The Canadian Field-Naturalist*, whereby interest can be accumulated on the funds held from the beginning of the year to the time of disbursement. A bequest of $500.00 was received from the estate of the late Rowley Frith, longtime member and Honorary Member of the Club. (R. A. Foxall)

Membership Committee. In 1975 there was again a slight increase in the total membership. Numbers of members in the various categories in 1974 and 1975 are compared below. The Committee thanks all the members who responded to various appeals for assistance during the past year (P. J. Narraway)

Publications Committee. Since the last Annual Meeting, four numbers of *The Canadian Field-Naturalist* were published, including Volume 88, number 4, and Volume 89, Numbers 1 to 3, in all 514 pages. The 90 articles and notes published included 39 in ornithology, 22 in mammalogy, 13 in botany, and the remaining 16 in herpetology, ichthyology, entomology, malacology, pollution, and pesticides. The number of manuscripts submitted remained high, 167 for 1975. The Committee considered bids from several printers, and selected Mail-O-Matic Printing (now M.O.M. Printing) to publish Volume 90 of the journal. A generous grant of $8500 from the National Research Council enabled the continued publication of the journal in its present form during a time of rapidly rising costs. Five numbers of *Trail & Landscape* totalling 152 pages were published during the year. The articles published covered the usual broad range of subjects, dealing with flora and fauna, ecology and landscape of the National Capital area, as well as general conservation topics and Club activities. (C. G. van Zyll de Jong)

Excursions and Lectures Committee. During 1975, the Committee organized 53 events. The 41 local excursions included 15 of general interest, 18 relating to ornithology, 4 to botany, and 1 each to herpetology, ichthyology, entomology, and nature photography. Photography also occupied one evening meeting and a workshop. The excursions were highlighted by a special trip, on Thanksgiving weekend, by 45 people to the St. Lawrence estuary; minke and beluga whales and a variety of seabirds were seen from a chartered boat between Rivière-du-Loup and Tadoussac, and thousands of migrating Snow Geese at Montmagny and Cap Tourmente. The nine lectures covered birds in arctic Quebec, population studies of chipmunks, mushrooms, recording natural history sounds, natural history in Sweden, outback Australia, birding in Alaska, bogs, and British orchids. The lecture program attracted about 70 persons per meeting. The annual dinner, on 15 April at the Talisman Motor Inn, featured Bill Mason, who spoke on his experiences during the making of his wolf films, and showed the latest film "Wolf Pack." The

Membership of The Ottawa Field-Naturalists' Club

Category	Canadian				Foreign				Totals	
	Local		Other		USA		Other			
	1974	1975	1975	1974	1974	1975	1974	1975	1974	1975
Individual	411	451	503	542	106	127	11	9	1031	1129
Family	200	198	16	16	2	2	2	0	220	216
Sustaining	5	5	0	1	0	0	1	1	6	7
Life	5	6	1	1	1	1	2	2	9	10
Honorary	5	5	4	4	0	0	0	0	9	9
Totals	626	665	524	564	109	130	16	12	1275	1371
Changes	+39		+40		+21		-4		+96	

Committee expresses its sincere appreciation to all speakers and leaders and to those who helped with refreshments at meetings. (J. D. Lafontaine)

Conservation Committee. Conservation action in 1975 included (1) input at each of three stages of public participation on the route of the Outer Ring Road; (2) further field studies of the Carp Hills, with a report for the Ottawa-Carleton Region's planning staff; (3) an oral presentation to the Regional Planning Committee opposing an application for residential development in Niven's Woods, designated a Conservation Area in the Region's Official Plan; (4) a brief to the National Capital Commission opposing a suggested routing of Hwy A-5 through Gatineau Park; (5) a brief to the National Capital Commission pointing out small, botanically significant areas in the Greenbelt not already designated for protection; (6) a brief to the Region's planners opposing proposed routes for the Outer Ring Road which would cut through Conservation Areas designated in the Official Plan; (7) a brief to the Ontario Minister of Housing opposing inclusion of the Britannia arterial highway in the Region's Official Plan. The effort required adequately to face the conservation problems of the Ottawa-Hull region is far greater than the time, talent, and information which have been offered by Club members to date; more effective action will require more effort by more people. (A. H. Reddoch)

Macoun Field Club Committee. The highlight of the past year was the return of the Club to the National Museum of Natural Sciences where, on 31 October, its new clubroom in the activities center was first occupied. The Junior, Intermediate, and Senior Sections continued with their usual activities, with an Awards Meeting in June marking the end of the 1974–75 program. At that time, E. Haber stepped down as Chairman of the Club, with L. Marhue taking over for the rest of the year. No official canoe trip was sponsored during the summer, owing to problems in maintaining supervision and safety for the group. (E. Haber)

Education and Publicity Committee. Displays were prepared for the Federation of Ontario Naturalists' meeting in Peterborough and for the CUSO/Pollution Probe-sponsored "Week for the World" in Ottawa. Field-trip leaders and speakers were found for a number of outside groups (churches, cubs, scouts, high schools). Judges were found for the environmental section in the Ottawa Science Fair. The Committee took part in the Ottawa Duck Club meeting at Shirley's Bay. (A. Sheppard)

A new committee was established to assemble and collate proposals of projects and activities to mark the centennial of the Club in 1979. A special meeting of Council on 3 November considered 19 proposals received to date, with special emphasis on their appropriateness and feasibility. More information is being sought on favored proposals, some of which will require efforts by a number of people over two years. Additional proposals involving less outlay of time or money may still be considered in future.

An important decision was taken by Council when it was agreed that, starting in 1976, members should be offered the choice of remaining members or becoming subscribers to *The Canadian Field-Naturalist* with no membership privileges.

As in recent years, Council met regularly on the third Monday of each month (except July and August), with an average attendance of 12 (out of 20) Council members.

Compiled from committee reports
and Council minutes
A.J. ERSKINE, Recording Secretary

The Ottawa Field-Naturalists' Club Balance Sheet

as at December 31, 1975

Assets			
Current			
Cash in Bank—OF-NC	$ 1,893.38		
Cash in Bank—CF-N	18,567.75	$20,461.13	
Bills Receivable		4,519.59	
Accrued Interest Receivable		6,439.31	$31,420.03
Fixed (at cost)			
Furniture, Fixtures and Equipment		529.50	
Less: Accumulated Depreciation		356.00	173.50
Investments and Securities			
Canada Savings Bonds			10,700.00
			$42,293.53
Liabilities and Equity of Surplus			
Current Liabilities			
Income Received in Advance		$ 8,211.80	
Accounts Payable		7,334.00	$15,545.80
Equity of Surplus			
Balance January 1, 1975		$23,766.60	
Add: Net Income for the Year		2,981.13	26,747.73
			$42,293.53

(Signed) G.D. Tippett, Auditor
G.J. Wasteneys, Auditor
Pamela J. Sims, Treasurer

The Ottawa Field-Naturalists' Club Statement of Profit and Loss — The Canadian Field-Naturalist

for the year ending December 31, 1975

Revenue			
Membership Income		$ 4,520.13	
Subscription Income		7,197.45	
Grants—National Research Council of Canada	$ 8,500.00		
Grants—Cornell University	75.00	8,575.00	
Reprints		4,512.10	
Plates and Tab Settings		2,049.51	
Extra Pages and Authors' Costs		5,792.09	
Back Numbers		2,295.82	
Special Publications		8.50	
Interest Income		613.90	$ 35,564.50
Less: Cost of Publications			
Volume 89 (No's 1,2,3,4)		25,088.94	
Plates and Tab Setting		884.00	
Reprints		2,673.80	28,646.74
Gross Profit on Operations			6,917.76
Less: Operating Expenses			
Bank Charges and Interest		1.79	
Circulation		1,015.15	
Office Assistant		1,390.00	
Postage		687.31	
Printing and Stationery		376.32	
Editing—Contracts		800.00	
Editing—General Expenses		867.91	
Honoraria		1,365.00	
Miscellaneous		38.20	6,541.68
Net Income			$ 376.08

The Ottawa Field-Naturalists' Club Statement of Profit and Loss

for the year ending December 31, 1975

Net Income from *The Canadian Field-Naturalist*		$ 376.08
Other Income		
Membership Income	$ 4,520.12	
Donations	558.84	
Sale Income	16.00	
Special Activities	259.91	
Subscriptions—*Trail & Landscape*	431.25	
Interest Income and Dividends	1,273.44	7,059.56
		7,435.64
Less: Cost of Publications		
Trail & Landscape Volume 9	2,113.30	
Circulation	101.38	
Office and Editorial	5.55	
Honoraria	400.00	2,620.23
Gross Profit on Operations		4,815.41
Less: Operating Expenses		
Council Expenses	481.92	
Printing and Stationery	8.00	
Committee Expenses–Membership	473.07	
–Excursions and Lectures	39.84	
–Publication	17.35	
–Bird Records	20.39	
–Bird Feeder	278.85	
Conservation	22.81	
–Education	31.86	
Macoun Club	146.24	
Orchid Survey	25.57	
Baldwin Scholarship	45.00	
Depreciation Expense	43.38	
Accounting Services	200.00	1,834.28
Net Income		$ 2,981.13

Instructions to Contributors

Manuscripts

Authors should submit three complete manuscripts with two copies of figures (in addition to the originals) for use by referees. Manuscripts are accepted in either English or French. They should be typewritten on paper measuring 8½ × 11 inches, and if possible, the paper should have numbered lines. Margins should be 1 to 1½ inches wide to allow for copy marking. All text matter, including quotations, footnotes, tables, literature citations, and captions for figures should be double-spaced. Only words meant to appear in italics should be underlined. Every sheet of the manuscript should be numbered. Generally words should not be abbreviated; this includes references to tables and figures as well as literature citations. Authors are requested, however, to use SI symbols for units of measure.

Authors are expected to have complied with all pertinent legislation regarding the study, disturbance, or collection of animals, plants, and minerals. It is strongly recommended that, before submitting a paper, authors ask qualified persons to appraise it.

An abstract is required for all Articles but is optional for Notes. Authors are requested to use at least one given name. Literature cited should be listed alphabetically according to author and should be placed immediately after the main body of the text, except in Letters to the Editor. If only one or two references are cited, they should be inserted in the text. The tables should be titled and numbered consecutively in arabic numerals, and each should be placed on a separate page after the Literature Cited. Captions for figures should be typed together on one page. The places in the text for tables and figures should be marked in the margin.

Extensive tabular or other supplementary material not essential to the text should be submitted on letter size paper (8½ × 11") for the Editor to place in the Depository of Unpublished Data, National Science Library, National Research Council of Canada, Ottawa, Canada K1A 0S2. A notation in the published text should state that the material is available, at a nominal charge, from the Depository. Two copies are required for the Depository.

The **CBE Style Manual,** third edition (1972), published for the Council of Biology Editors, Committee on Form and Style, by the American Institute of Biological Sciences, is recommended as a guide to contributors.

Webster's New International Dictionary is the authority for spelling. In a case, however, of difference in the spelling of a common name, and in the use of a variant name, a decision of a learned society is preferred.

The order in which papers are published will be determined by the Editor.

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All illustrations should be numbered consecutively in arabic numerals. The author's name, title of the paper, and figure number should be written in the lower left corner of the sheet on which each illustration appears. The caption should **not** appear on the illustration.

Line drawings should be made with India Ink on good quality material: white drawing paper; tracing paper, film, or cloth; or blue-lined co-ordinate paper. Co-ordinate lines that are to appear on the reproduction should be ruled in black ink. Descriptive matter should be lettered, not typewritten, and all parts of the drawing should permit easy legibility even if a reduction is made. Photographic reproductions of line drawings are acceptable in lieu of large originals.

Photographs should have a glossy finish and show sharp contrasts. For reproduction as a complete plate they should be mounted with minimal space between prints.

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Mailing date of previous issue 19 March 1976

Errata

1975. Canadian Field-Naturalist 89(4). *Fish distribution in Gatineau Park, Quebec, in relation to post-glacial dispersal, man's influence, and eutrophication* by Peter J. Rubec. The captions for Figures 2 and 3 are reversed on pages 392 and 393.

1976. Canadian Field-Naturalist 90(1). *Range extension of the Ribbon Snake in eastern Ontario* by John G. Woods and Francis R. Cook. The address of John G. Woods on page 70 is incomplete and should read Glacier and Mount Revelstoke National Parks, Mount Revelstoke, British Columbia.

1976. Canadian Field-Naturalist 90(1). *Red squirrel introduction to Newfoundland* by Neil F. Payne. Figure 1 and 2 are reversed on pages 61 and 63.

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The CANADIAN FIELD-NATURALIST

Published by THE OTTAWA FIELD-NATURALISTS' CLUB, Ottawa, Canada

Special Issue

dedicated to raptors—especially the Peregrine Falcon

Volume 90, Number 3

July-September 1976

The Ottawa Field-Naturalists' Club

FOUNDED IN 1879

Patrons

Their Excellencies the Governor General and Madame Jules Léger

The objectives of this Club shall be to promote the appreciation, preservation, and conservation of Canada's natural heritage; to encourage investigation and publish the results of research in all fields of natural history and to diffuse information on these fields as widely as possible; to support and co-operate with organizations engaged in preserving, maintaining, or restoring environments of high quality for living things.

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* This Council is in office until the Annual Business Meeting in January 1977.

Correspondence: Address to The Ottawa Field-Naturalists' Club, Box 3264, Postal Station C, Ottawa, Canada K1Y 4J5

The Canadian Field-Naturalist

The Canadian Field-Naturalist is published quarterly by The Ottawa Field-Naturalists' Club with the assistance of contributions from the National Research Council of Canada and The Canadian National Sportsmen's Show. Opinions and ideas expressed in this journal are private and do not necessarily reflect those of The Ottawa Field-Naturalists' Club or any other agency.

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All material intended for publication should be addressed to the Editor:

Dr. Lorraine C. Smith, Department of Biology, Carleton University, Ottawa, Ontario, Canada K1S 5B6

Cover: Female Peregrine Falcon (*anatum* race) with a blackbird at a nest site in southern Alberta in 1972. This is the last breeding record for the *anatum* race south of the boreal forest and east of the Rocky Mountains in North America. Photo by Richard Fyfe. See the North American Peregrine Falcon survey, 1975 on page 228.

The Canadian Field-Naturalist

Volume 90, Number 3 July-September 1976

Raptor Research and Conservation during the Last Five Years

This is the second issue of *The Canadian Field-Naturalist* to be devoted primarily to studies of raptors. As in the first, most of the research described herein was stimulated by the widespread collapse of certain raptor populations, caused by use of DDT and other persistent organochlorine compounds. The Peregrine Falcon, *Falco peregrinus*, has again acted as a focus of these studies. Once the joy of kings and princes, this endangered species has now become for many people a symbol of concern for environmental degradation and the embodiment of hope for its cure. It has assumed a new role of "ecological barometer" of importance to everyone.

By 1970, the time of the first North American Peregrine Falcon survey, the widespread decline of the peregrine had become apparent throughout North America and Europe. The decline had been linked with poor breeding, and especially with eggshell thinning, itself caused by DDE, the main metabolite of DDT. It was known also that many other species had been affected similarly, especially the bird-eating species such as the Merlin, *F. columbarius,* and certain accipiters, and the fish-eaters, such as Osprey, *Pandion haliaetus,* and Bald Eagle, *Haliaeetus leucocephalus.* A great deal happened in the next five years: to the environment, to the birds, and to our understanding of the problems.

Perhaps the most significant event was the almost complete banning of DDT usage in the United States, after prolonged court hearings, in June 1972 (registrations were cancelled, effective January 1973). This was followed in 1974 by the suspension of all registrations for aldrin and dieldrin. In Canada the use of DDT was severely restricted in late 1969; however, dieldrin is not restricted. Already the downward trend in the numbers of certain species in the eastern United States has stopped, as these species have begun to breed more successfully. The peregrine, however, seems not yet to have begun to respond. The main paper in this issue draws together the results of a survey in 1975 of the status of the Peregrine Falcon in North America and Greenland. Covering almost the whole of the known range of the species in these areas, this is an impressive survey, and we owe a considerable debt to the participants, and to the authors for drawing the results together. They show a further decline in the North American Peregrine Falcon populations since the previous survey of 1970. The eastern *F. p. anatum* population had disappeared altogether in the 1960s, while the western one has continued to decline. Only parts of the comparatively small Pacific maritime population (*F. p. pealei*) have remained more or less stable in recent years. Perhaps the most striking find, however, is that the entire *F. p. tundrius* population is now well into decline, from Alaska across northern Canada. This will undoubtedly come as a shock to many readers: that peregrines breeding in this, the last major wilderness in North America, should be as contaminated as those elsewhere. The reason has apparently to be sought in Central and South America, where these peregrines and their arctic prey species winter, and pick up sub-lethal loads of pesticides. It highlights one of the most insidious effects of DDT and other organochlorines, that at sub-lethal level they can cause the steady decline of populations that breed in areas hundreds of miles distant from where these chemicals have been applied.

In Europe the situation seems a little brighter, as different countries have since the early 1960s brought in progressive restrictions in the use of DDT and other organochlorines. Between 1962 and

1970, the British peregrine population showed a marked recovery in both numbers and nesting success, and more recently, increases have been noted in several areas of central Europe. On the other hand, the previously healthy population of Spain has now begun to show some decline, shell-thinning, and other symptoms of DDE contamination, following an increase in the usage of DDT in that country. There have been some remarkable parallels on the two continents, for example the decline of the northern populations due mainly to pesticide use further south, and the fact that the only populations that have remained stable are those which are resident in areas of no pesticide usage, and which feed on prey species which are themselves resident. In North America these conditions apply to the Pacific maritimes, and in Europe to the Scottish Highlands and a few other restricted areas.

Another welcome development of the last five years has been the successful breeding of peregrines in captivity, not just a few birds, but on a scale sufficient for release projects. For this we owe a great debt to Tom Cade and colleagues at Cornell, to Richard Fyfe and colleagues at Edmonton, and to other dedicated workers scattered over North America and Europe. Through their efforts, more than a hundred fledged peregrines have now been produced in North America, and in Europe about another fifty. Thus it seems that the survival of endangered genotypes is ensured, at least in captivity, and that the production of enough birds for reintroduction is a practical proposition. The main problems now center on how to release these birds into the wild with the maximum chance of success. In populations which are still extant, one obvious way is to use the eggs or young from captive birds to supplement the depleted broods of remnant wild stock. On declining populations this is at best a stop-gap measure, aimed at slowing or stopping the decline, in the hope that one day the environment will become clean enough to enable the birds to make it on their own. Where wild populations have become totally extinct, the only method is to introduce birds into the wild, using one of the established falconry techniques. Both methods were used with success in 1975 using birds from Cornell, and it is likely that the next five years will see some exciting developments in this field. Whether peregrines can yet survive and maintain themselves in the vacated eastern range remains to be seen. In this kind of project, ultimate success occurs only when the released birds themselves produce young in the wild. But in fairness, such projects should be judged stage by stage, first the production of young, then their establishment in the wild, and finally their eventual successful breeding. So far the first two stages have been accomplished successfully, and we wish the breeders concerned an equal success with the third. After the banning of DDT, captive propagation has become for many people the main hope of saving the peregrine.

Research has also made great strides in the last few years. Not only has the peregrine received more concentrated attention than any other bird in the world, but there has also been an enormous increase in the research effort devoted to raptors in general. Although the precise mechanism of action of DDE still remains largely unknown, the case against it is probably as well substantiated as it ever will be. It is based on a mass of detailed circumstantial field evidence from many species in several parts of the world, and also on much carefully planned experimental work in the laboratory. But there are still some who claim to be unconvinced, so strong is their motivation for wishing to believe otherwise.

Increasingly, attention has been directed in recent years to the other organochlorines, such as dieldrin and PCBs, and also to other problems of land-use as they affect raptors. The scientists who have worked on the raptor–pesticide problem have shown a degree of dedication, and of cooperation and integration of effort seldom met in ecological research, a trend started perhaps by the 1965 Peregrine Conference at Madison, and helped subsequently in North America by the setting up of the Raptor Research Foundation. This has also brought about new standards in field work: for living at low densities and nesting in mainly inaccessible places, raptors are not the easiest birds to study.

The fate of the Peregrine Falcon has also served to focus the attention of conservationists on raptors in a way that could not have been imagined only ten years ago. The idea of management for conservation is catching on in a big way, even in parts of Europe where, for several hundred years, the only management directed at raptors was aimed at total eradication. The United States Bureau of Land Management project at Snake River in Idaho could be singled out as a supreme example of the controlled development of wilderness, with the conservation of raptors in mind. The efforts of power companies to reduce eagle deaths through electrocution, and to provide nest sites in areas lacking them, is another example.

In his introduction to the previous issue of *The Canadian Field-Naturalist* (84(3), 1970) devoted to raptors, J. J. Hickey drew attention to the three-step idea-acceptance syndrome of C. L. Huskins; he predicted that agriculturalists would react in this way to the findings of ecologists on the problems that certain pesticides have created. The steps included the initial response, "we do not believe it", followed by the second step, "it is of no importance anyways", and finally "we knew it all the time." Five years later, we still seem to be stuck on the second stage, as the industry and other vested interests do their best to convince us that human life, as we know it, would be impossible without such pesticides. Witness for example an article by Jack Redden in a recent issue of *Cooperation Canada* (May/June 1975), a publication of the Canadian International Development Agency: "no matter what the drawbacks, known and unknown, of widespread pesticide use, our style and standard of life requires them. They are a crucial factor in balancing life for mankind. Man has become dependent on pesticides."

Whether you are against all pesticides, or just against the persistent ones that have done most damage, the problems are not over with the introduction of restrictive legislation. Almost without exception in the countries involved, vested-interest pressure groups have continually pushed for the reintroduction of DDT or dieldrin for some purpose or other; they have based their case, not on the extra private profit they stand to gain, but on the loss to society as a whole that will result (they claim) from withholding these compounds. Implicitly or explicitly, ecologists with a concern for the environment are thus being increasingly held up as obstacles to human progress.

The fate of birds like the Peregrine Falcon is the proper concern of ecologists, but its indication of an important new environmental problem is of general concern. The argument is not, as some have put it, whether one prefers birds to men, but whether men should take serious heed of what has happened to some birds as a result of using substances which are useful in controlling insects, but at the same time highly dangerous to a wide range of other organisms. Recent research has amply confirmed earlier suspicions that persistent organochlorine pesticides are *(a)* biologically active at levels far lower than those that are lethal; (*b*) affecting populations far removed from areas of application; (*c*) able to cause extinctions, at least of certain predatory birds; and (*d*) now widely distributed in soils, water, and organisms throughout the world. The extent to which any country can limit the use of organochlorines will presumably depend largely on local conditions. Thus a case might be made for their use in some tropical areas where human health is otherwise at stake, or where development is otherwise impossible, but over the rest of the world their withdrawal seems a wise precaution to protect natural resources. Perhaps the greatest service we can perform in the immediate future is to disseminate knowledge in the developing countries of the problems created by persistent pesticides elsewhere. For it is to these areas that much of the continuing organochlorine production of the developed world is now going.

I. NEWTON

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The 1975 North American Peregrine Falcon Survey

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Fyfe, Richard W., Stanley A. Temple, and Tom J. Cade. 1976. The 1975 North American Peregrine Falcon survey. Canadian Field-Naturalist 90(3): 228–273.

Abstract. In 1975 a large-scale survey of breeding populations of the Peregrine Falcon (*Falco peregrinus*) was made throughout the known range of this falcon in North America and Greenland. This continued and extended the surveys begun in 1970 and scheduled to be repeated at 5-year intervals. The results of the survey show that almost all North American populations have declined further in numbers since 1970. In the arctic tundra region in 1975, 60 nesting sites are known to have been occupied by peregrines (*F. p. tundrius*), and at least 34 pairs fledged young. By 1975 most arctic populations investigated had declined to approximately 50% or less of their maximum recorded size. In the boreal forest regions, the 1975 survey recorded at least 97 sites occupied by peregrines, and at least 36 of these fledged young. All boreal forest populations investigated had declined in numbers from their historical maximum size. The Pacific maritime peregrines (*F. p. pealei*) are the only major population that has remained largely stable in recent years. Estimates placed the total population in the Queen Charlotte and Aleutian Islands at over 475 pairs. In the regions south of the boreal forest, populations of *F. p. anatum* have declined drastically so that in many regions the species is extinct as a breeding bird. At least 62 nesting sites were occupied in 1975, most of these being resident birds in the southwestern United States and in Mexico, and at least 18 pairs fledged young. Nowhere in North America have peregrine populations started to recover their numbers since the reduction of DDT usage. The official declaration of the Peregrine Falcon as an endangered species has focused much interest and activity on its ecological problems and its conservation.

Introduction

Since the first North American peregrine survey (Cade and Fyfe 1970), many things have happened to the Peregrine Falcon (*Falco peregrinus*), both in the field and in the human arena of politics related to its survival. Most of the breeding populations have continued to decline, as detailed in the following regional reports; but encouragingly, some populations have remained stable, and the rate of decline seems to have lessened in others. Unfortunately, there is no clear evidence that a recovery has begun anywhere in North America, as is now the case in Great Britain (Ratcliffe 1973).

In the area of man's relations with peregrines, there have been several important developments in the last five years. Of greatest significance has been the acceptance by governmental authorities of the conclusion that DDT has had a wide range of adverse effects on wildlife, including sublethal effects influencing the productivity of raptorial birds, and the subsequent banning of DDT use for almost all purposes in the United States and Canada since the early 1970s. Another United States government action has been the inclusion of the arctic Peregrine Falcon (*F. p. tundrius*) on the official list of "endangered species" along with *F. p. anatum*. These governmental actions have not gone uncriticized (see Beebe 1974, for example), but they have been accepted as wise and prudent by most knowledgeable people.

Certainly the "endangered" status of the Peregrine Falcon has served to focus public and governmental attention on the needs of the species (Cade 1974). Increasingly, planners at all levels of government, local, state, provincial, and federal, take the peregrine into consideration before any irreversible actions affecting its welfare are approved.

The United States Endangered Species Act of 1973 has important provisions not only for protecting species but also for protecting and securing the essential habitat required for endangered species. Many federal and state agencies are currently assessing the lands under their jurisdiction to identify "critical habitat" for the peregrine. Recovery teams for the eastern and western *anatum* and arctic peregrine populations were also established by the director of the Fish and Wildlife Service in 1975 under the authority of this act.

Environmental impact statements and assessments for major developments in both Canada and the United States characteristically give consideration to possible impacts on peregrines and other sensitive species. For example, the peregrine has figured importantly in several decisions having to do with the construction of the Trans-Alaska oil pipeline as well as in the environmental considerations relative to the Mackenzie Valley Pipeline.

Major captive breeding facilities and programs for the peregrine got underway in both Canada and the United States in 1970 and 1971. One was established by the Canadian Wildlife Service in Alberta, and another was started at Cornell University in New York State (Cade 1974). More than 85 young peregrines have been produced by the two programs in the last 3 years, and experiments on the release and reintroduction of domestically propagated falcons to nature are well advanced and show encouraging results (Zimmerman 1975a).

As a consequence of this great interest now focused on the peregrine, it has been possible to mount a much more thorough inventory of nesting peregrines in North America in 1975 than in 1970. We are now able to provide some information on virtually every region of North America where peregrines still breed or did breed in some numbers in historical times (Figure 1), including Greenland and Mexico, for which virtually no information existed in 1970 (Table 1). Obviously some regions and some populations are much more thoroughly known than others, but we believe it is now possible to provide a reasonably clear picture of the current status of the Peregrine Falcon in North America. For comparison with the 1970 survey results, Table 1a provides a direct comparison of occupancy of sites investigated in Canada in both the 1970 and 1975 surveys.

Regional Summaries

The regional reports that follow can best be summarized with reference to four major breeding zones for peregrines in North America: (1) the arctic tundra regions of Alaska, Canada, and Greenland, (2) the boreal forest or taiga zones of Alaska and Canada, (3) the Pacific Northwest maritime regions of British Columbia and Alaska, and (4) the range of the *anatum* peregrine south of the boreal forests.

1. *The Arctic Region*

In northern Alaska along the Colville River, the decline in numbers that first became evident in 1969 and 1970 as a reduction in the percentage of reproductively successful pairs and in lowered output of fledged young (Cade and Fyfe 1970; Cade et al. 1971) continued at least through 1973. In the last 3 years the population has consisted of about 12 to 14 occupied territories with 6 or 7 productive pairs raising 9 or 10 young per year (Cade and White, and Haugh, this compilation), compared to earlier years when 32 to 36 pairs occupied cliffs and 20 or more productive pairs raised 45 to 50 young (Peakall et al. 1975). A similar downward trend appears to have occurred along the Sagavanirktok River, where five pairs nesting in the Franklin Bluffs area in the late 1950s have been reduced to two pairs (Roseneau et al., this compilation).

Data for good historical comparisons are lacking for the rest of Arctic Alaska. Only a total of about 28 sites are known for the Arctic Slope east of the Colville (Roseneau et al., this compilation), and it is doubtful whether as many as half of them are currently occupied by breeding pairs. Even less is known for the western arctic regions of Alaska. Formerly, some peregrines are known to have nested on the Utukok and Kukpowruk Rivers (Cade 1960), on the Pitmegea River (Childs 1969), and in the Cape Thompson area (Swartz 1966); but the total number of known breeding territories in this region is less than 15, and most have not been checked recently. In July 1953, however, W. J. Maher accompanied a geological survey party down the Utukok River from just below Driftwood Creek to a point about 67 km below Carbon Creek. He found five nests, and adult peregrines present at three other cliffs; four of these nests were between Driftwood Creek and Disappointment Creek. In 1971 Cade, Temple, and Weaver checked this stretch of the upper Utukok in early July and found only one pair of peregrines with young. These limited data suggest that the now well-documented decline along the Colville has also occurred in other parts of arctic Alaska.

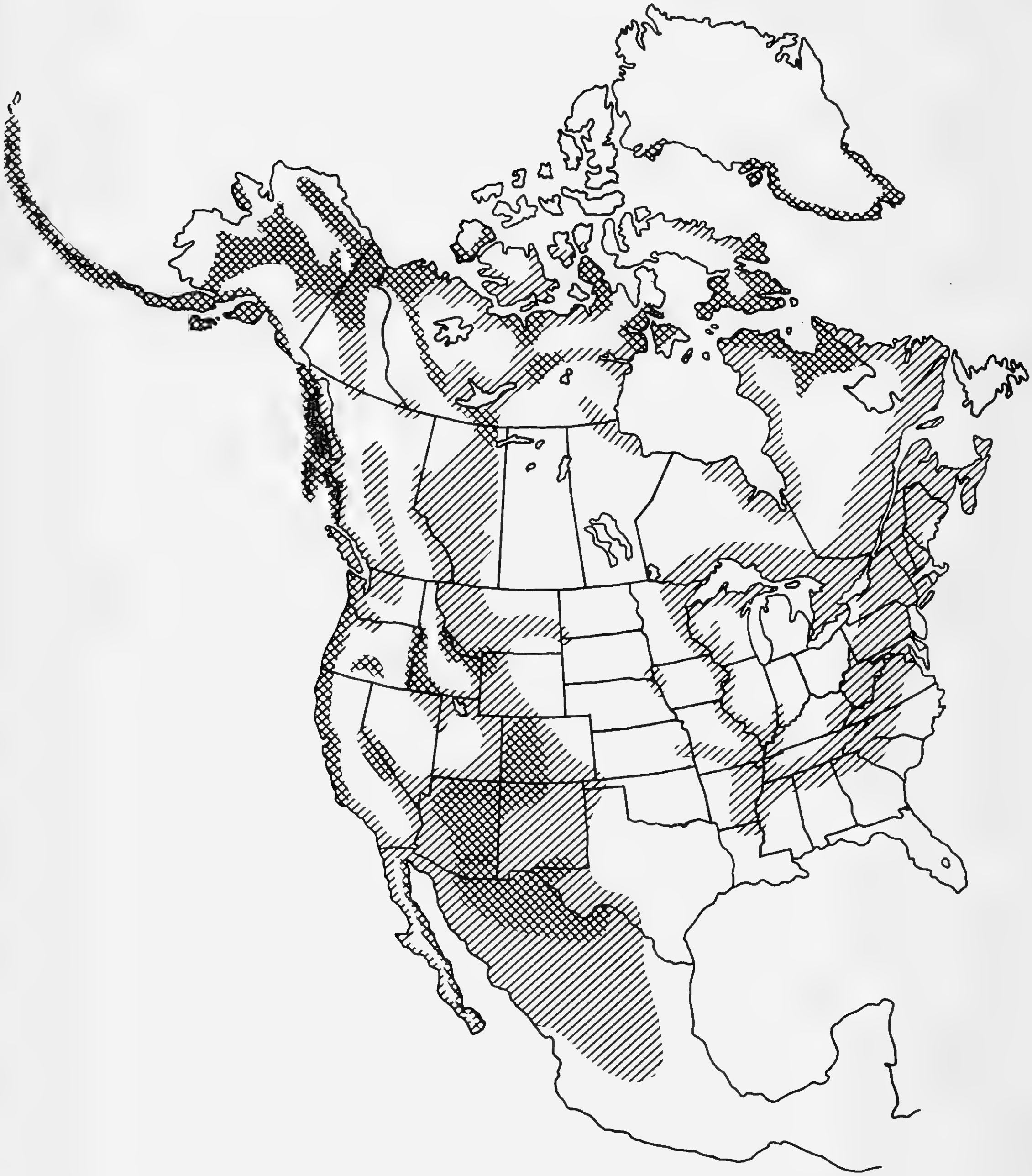

FIGURE 1. The breeding range of *Falco peregrinus* in North America. Hatching indicates approximate known historical range, and crosshatching indicates approximate known range from 1970 to 1975. *Falco p. anatum* breeds south of the tree line; *F. p. tundrius* breeds north of the tree line, and *F. p. pealei* breeds on Pacific coastal islands and the Aleutians.

TABLE 1—Summary of past and present Peregrine Falcon occupancy in the specific regions covered by the 1975 survey

Region surveyed	Total known sites	Number of sites		
		Known occupied in 1975	Suspected occupied in 1975	Producing young
(a) Arctic tundra regions				
Western Greenland	9	8	0	5
Ungava Bay	27	11	0	9
East Coast, Hudson Bay	5	0	0	0
Interior Barrens, Canada	16	1	0	1
Central Arctic Coast, Canada	27	13	0	11
Banks Island	14	7	0	6
North Slope, Canada	12	5	0	?
Northeastern Alaska	28	3	8	2+
Colville River	46	12	1	?
Totals	184	60	9	34+
(b) Taiga regions				
Maritime Provinces	15	0	0	0
Southern Labrador	2	0	0	0
Ontario	29	0	0	0
Alberta	48	4	0	0
Mackenzie District	68	35	0	19
Yukon Territory	37	17	0	6
Fortymile River, Alaska	1	1	0	0
Central Yukon River, Alaska	31	16	0	9
Charley River, Alaska	5	5	0	1
Tanana River, Alaska	19	2	1	0
Noatak River, Alaska	2	0	0	0
Western Coast of Alaska	79	11	12+	?
Gulf of Alaska	81	6	37+	?
Totals	349	97	50+	35+
(c) Pacific maritime regions				
Queen Charlotte Islands	103	60	0	?
Aleutian Islands	59+	45+	375+	?
Totals	162+	105+	375+	?
(d) Regions south of the Taiga				
Eastern United States	212	0	0	0
Michigan	9	0	0	0
Mississippi River and Lake Superior	30	0	0	0
Northwestern United States	60	4	18	?
Rocky Mountains, United States	35	8	3	2
Utah and Eastern Nevada	42	1	1	1
New Mexico	10	5	1	3
Arizona	35	6	8	?
California	91	8	1	6
Western Texas and adjacent Mexico	14	11	0	6
Gulf of California, Mexico	19	19	7	?
Totals	557	62	39	18+

TABLE 1a—Comparison of Canadian nesting sites checked for Peregrine Falcons in 1970 and 1975

Region	1970			1975		
	Total sites checked	Total sites occupied	% occupancy	Total sites checked	Total sites occupied	% occupancy
Falco peregrinus anatum						
Maritime Provinces	15	0	0	14	0	0
Labrador	2	2	100	2	0	0
Ontario	29	0	0	8	0	0
Alberta and Saskatchewan	33	3	9	29	1	3
Mackenzie District	16	9	56	15	5	33
Yukon River	10	6	60	10	5	50
Totals	105	20	19	78	11	14
Falco peregrinus tundrius						
Interior barrens	11	4	36	10	1	10
Ungava	15	12	80	15	7	47
Totals	26	16	62	25	8	32
Falco peregrinus pealei						
Queen Charlotte Islands	6	6	100	6	6	100

It is doubtful whether as many as 50 pairs of peregrines are still producing young in northern Alaska, where Cade (1960) estimated the breeding population at 200 to 300 pairs in the late 1950s.

The situation in the Canadian Arctic is very much like that in northern Alaska. Most populations have declined to 50% or less of their historically known size. In five areas, ie., Ungava Bay, the Interior Barrens, Central Arctic Coast, Banks Island, and the North Slope, where we have some historical records upon which to base comparisons, only 41% of the historically known sites were occupied in 1975. Of the 86 known sites in these regions, only 30 were occupied by adult pairs in 1975.

In addition to these historical comparisons, there are also some more recent data that indicate the decline in occupancy is proceeding at a rapid rate. In 1973 as a result of environmental impact surveys and the continuing peregrine monitoring program in the Canadian Arctic and subarctic, data were collected on several new populations of peregrines for which previous records were unavailable. A comparison of occupancy of territories newly found in 1973 with occupancy of the sites in 1975 indicates a 60% decline from 20 occupied sites in 1973 to 8 in 1975. These data clearly suggest an accelerated decline in arctic populations of *F. p. tundrius* since 1973.

Comparative data for Greenland are available only since 1972 (Burnham and Mattox, this compilation). Observations in an approximate 1800-km^2 area of western Greenland have revealed a substantial density of peregrines (1 pair per 200 km^2) with productivity averaging nearly 2.5 young per pair over a 4-year period. DDE residues in addled eggs and eggshell thickness indicate incipient problems for this population, which needs careful watching over the next years.

2. *The Boreal Forest Region*

In the forested regions of interior Alaska peregrines have apparently survived better than in the tundra, with the notable exception of the Tanana River population, which has declined from 16 observed nesting pairs (three not on the main river) in 1967 to one apparently unproductive pair and one single adult in 1975 (Haugh, this compilation). Along the Yukon River, however, where there is a history of information going back to 1951 and even to 1899 for some sites, the number of occupied cliffs has been reduced by only about 25% (15 versus 20) since 1969, and the number of productive pairs has fallen from about 16 or 17 to 9 or 10.

The Porcupine River is the other area of interior Alaska that has historically supported a substantial breeding population of peregrines (Cade 1960). In 1967 Enderson et al. (1968) recorded several peregrine sites on the Porcupine River below Old Crow. There certainly appear to have been no noticeable changes in the population along the Porcupine River in these years. Unfortunately, no one seems to have made a search on the Alaskan portion of this river in the 1970s, but judging from the findings in the Yukon Territory, there must be some falcons still breeding on Alaska's stretch. It is perhaps not unreasonable to speculate that any reduction in numbers there has been no more severe than along the Yukon River.

Not much is known about the rest of the boreal forest zone between the Brooks and Alaska Ranges. J. Haugh has surveyed some of the rivers draining the south slope of the Brooks Range for the Alaska Department of Fish and Game and found no peregrines nesting along the Kobuk, Alatna, Wild, John or North Fork, and main Koyukuk Rivers in 1971. The Kuskokwim River had peregrines nesting along it in former times (Cade 1960), but no recent observations are known to us.

Few peregrines nest in the forested region south of the Alaska Range (Cade 1960). In 1975, C. M. White and T. J. Cade conducted aerial surveys along the Susitna, Chulitna, Matanuska, and portions of the Copper Rivers and found no peregrines. Nor have the numerous inventories and surveys carried out along the Trans-Alaska pipeline route produced nesting peregrines south of the Alaska Range (White and Streater, *in* Cade and Fyfe 1970).

For mainland Alaska we doubt that there could be more than 200 pairs of peregrines still nesting or attempting to nest. The number is probably less than that.

The situation in the boreal forest regions of Canada is once again similar to that in Alaska. In most forested areas in eastern Canada, the peregrine is now extinct, and as of 1975, we know of no active sites in the boreal forest region east of the Alberta-Saskatchewan border. In the western boreal forest region, the situation is somewhat better but still not good. The well-studied Mackenzie River population has declined to 33% of its former size, but successful breeding does still occur. Most other western boreal forest populations have shown similar declines of 50% or more. There are, however, several localized populations that have remained remarkedly stable in numbers of breeding pairs.

A good example of an apparently healthy boreal forest peregrine population is the well publicized population in the Campbell Hills of the Mackenzie District, Northwest Territories. The population was first recorded in 1964, at which time five breeding pairs were located. Although the area has since been intensively surveyed, a statement on the status of this specific population was not publicized until 1974 (Beebe 1974). This statement indicated that a survey party visited the area in 1972, found the original five territories still occupied and located one additional breeding pair. Largely on the strength of the report that this population remained intact, it has been suggested that the entire arctic subspecies was, in fact, holding its own (Beebe 1974). Unfortunately those data did not give an accurate picture of even the Campbell Hills population and certainly cannot be extrapolated to any other area, as illustrated by the fact that in the same year less than 80 km from the above mentioned birds, only one pair of peregrines remained in an area where eight pairs formerly nested.

Regretfully, even such apparently healthy populations are not immune from those factors that are detrimental to the species. In the Campbell Hills area, we have received reports of adults being shot, of nests being robbed, and even more disturbing in 1974, an egg sample (from one pair in this population which failed to produce young) had the highest residue values for any Canadian peregrine egg samples to date (Fyfe, unpublished). Earlier residue data from this population were among the lowest levels recorded for North America (Fyfe, unpublished). In 1975, the peregrine survey recorded a 60% occupancy of the previously known territories in the Campbell Hills population.

3. *Pacific Northwest Maritime Region*

The only really encouraging findings in Alaska since 1970 relate to the peregrines nesting in the Aleutian Islands (White, this compilation). The Aleutains have long been known as a center of abundance for peregrines (Cade 1960), but only since the biological studies carried out in connection with the Atomic Energy Commission's project on Amchitka have we begun to realize just how many peregrines there really are. In 1937, O. J. Murie found peregrine nests on 14 of the Aleutian Islands — Unimak, Amak, Chuginadak, Carlise, Gareloi, Sequam, Kasatochi, Salt, Kiska, Buldir, Chuqul, Amchitka, Semisopochnoc, and Anamaliak — and he remarks in his notes that some of the larger islands had two to three pairs. He saw peregrines on 22 other islands. On the basis of his findings, Cade (1960) gave a minimum estimate of 100 pairs for the Aleutians. White's (1975) studies on Amchitka and several other islands since 1969 now allow us to revise this figure upward to between 375 and 580 pairs. Similar densities may well exist on most of the islands lying along the base of the Alaska Peninsula as well, so that it appears that a truly impressive population of maritime peregrines still thrives on these fog-bound islands of the Aleutian Chain and around the southern perimeter of the Alaska Peninsula.

Peregrines appear to be much less common along the northern and eastern coastlines of the Gulf of Alaska. Isleib and Kessel (1973) have estimated 12 to 20 pairs nesting along the north coast in the Prince William Sound region. White (this compilation) has summarized the information for this region and for southwestern Alaska. With the possible exception of the one island in Cook Inlet, there is no evidence to suggest that peregrine numbers have declined in any part of southern Alaska in the last 30 years.

The populations of *F. p. pealei* that nest on the Queen Charlotte Islands off the British Columbia coast continue to be the only relatively stable peregrine populations in Canada. For the same reasons that the Peale's race of the falcon thrives in the Aleutian Islands, the Queen Charlotte population of peregrines has managed to maintain its numbers and to produce enough offspring to replace adult losses. On Langara Island, where our records are most complete, the total number of occupied sites has remained constant at six or seven ever since 1968 following a decline in numbers. Furthermore, the reproductive performance of these pairs has consistently been within the range expected for a normal, healthy population. In fact, during 1975 a total of 13 young was produced on Langara, the highest total since 1968.

4. *Regions South of the Boreal Forests*

In the continental United States, the populations of *F. p. anatum* are either extinct or numerically depleted and declining. In the region east of the Mississippi River, the peregrine no longer occurs as a breeding bird and, as far as we know, has not since 1961. Presumably, there are no representatives of the eastern *anatum* population surviving today, as the last verified observation of a wild adult occupying a nesting cliff was made in 1970. There have been rumored accounts of peregrines occupying eastern breeding sites more recently, but the 1975 survey of eastern nest sites, which made a point of checking these rumors, failed to reveal any signs of recent peregrine occupancy within the region.

Despite the fact that the eastern *anatum* population is now extinct, it still figures prominently in many of the more controversial aspects of current peregrine ecology and politics. The eastern peregrine is thought to be the only major bird population that has been extirpated as a consequence of the lethal and sublethal effects of pesticides on the species. Hence, the demise of the eastern *anatum* peregrine was an important piece of evidence in the proceedings that ultimately led to the banning of DDT in North America (Zimmerman 1975b).

Even though the temporal relationship between the advent of DDT usage and the decline of the eastern peregrine population has been quite well documented (Hickey 1969; Peakall, this issue), there are persistent critics who maintain that factors other than pesticides were responsible for the decline. Surprisingly, some of the very data that convinced most concerned scientists that DDT was involved in the decline have been used as evidence that the relationship was not valid. Hickey (1942) carried out the original study of the population biology of the *anatum* peregrine in the region east of the Rocky Mountains prior to the DDT era, and our knowledge of the population is based primarily on his compiled records. Up to 1941, Hickey managed to obtain valid evidence of 275 sites being occupied at one time or another in the eastern United States. He does not indicate that all of these sites were active in any given year nor does he imply that this sample included all or even most of the sites in the study region. From his compiled records of these 275 known sites, he concluded that from the time of the earliest historical records up to 1941 "eighteen percent represent[ed] a maximum decrease in the peregrine population and ten percent a minimum decrease within recorded times." Hickey further stated that as of 1941 "a tentative estimate would place the breeding peregrines in the eastern States at perhaps 350 pairs."

Several critics have apparently misinterpreted these seemingly clearcut findings. For example, Beebe (1974) has implied incorrectly that Hickey found a 50% decline in the population prior to 1941. Furthermore, Beebe implies that Hickey "considered the extinction of this falcon in the area of his study to be a predictable probability." Quite to the contrary, in 1941 Hickey was impressed by the fact that "the number of pairs on territory at the start of each breeding season is remarkedly constant from one year to another."

The decline of a population that had shown remarkable historical stability from an estimated 350 breeding pairs in 1941 to none in 1964 is a startling statistic that implies a sudden and catastrophic change in some aspect of the peregrine's biology. The now well-documented relationship between sublethal levels of DDT and impaired reproduction provides us with evidence of exactly such a catastrophic change (Peakall, this issue).

Outside of the eastern United States, we have very few historical records on peregrine populations; this is especially true in western regions (see Bond 1946; Hickey 1969). Even at the time of the 1970 North American Peregrine Survey, few systematic surveys or population estimates had been made in the west. Since 1970, however, this situation has changed as can be seen in the eight regional reports from the west included in this paper.

In 1975 we have reports of at least 62 occupied sites in the western United States and adjacent Mexico. While this represents a small number of birds scattered over a vast area, it at least indicates that a viable population still survives in the region. Furthermore, most investigators feel that their surveys were incomplete and imply that they located only a portion of the occupied sites.

Of the 37 pairs of *anatum* peregrines in the west for which we have complete reproductive data, 22 (59%) apparently fledged young in 1975. This figure is consistent with findings of studies of northern populations that are also affected by sublethal concentrations of chemical poisons. With most regions of the western United States where historical records are available showing continuing declines, the only hope seems to be that this population will be able to recover, as the British populations did in the decade following the ban on DDT usage.

In the regions of Canada south of the boreal forest, peregrine populations are either extinct or on the verge of extinction. In 1970, despite intensive surveys of suitable habitat in southern Quebec and Newfoundland, no evidence was found in either region of recent peregrine occupancy. Investigations that year also included visits to all known nesting territories in southern Ontario, southern Quebec, and the Gaspé, but results were the same: no peregrines were observed, and no evidence of recent occupancy was found. More recently, in 1972, Cade and Temple investigated the north and south shores of the St. Lawrence River but found only a single first-year female at one site and no evidence of breeding. On the strength of those findings, we focused our energies and resources elsewhere during 1975, and consequently, Newfoundland, southern Quebec, and much of southern Ontario were not included in the current surveys.

In southern Alberta, where there were formerly some 12 nest sites, the peregrine has all but disappeared. In 1975 only a single adult male was found occupying historical sites. In northern Alberta of 36 known sites, 3 were occupied. One of these pairs hatched three young which were subsequently exchanged for six young captive-produced peregrines. These young falcons, produced by the breeding program of the Canadian Wildlife Service, were all fledged successfully by their wild foster parents. Experiments such as this give some small hope that we can maintain this remnant population of Alberta peregrines.

Validity of Population Estimates

Some individuals have found it difficult to accept the population declines recorded in the 1970 Peregrine Survey (Beebe 1970). In justifying this position, the most frequent disagreements appear to center around either the acceptance of the evidence implicating pesticides (Beebe 1974) or in accepting the extent of the declines (Beebe 1970; Oliphant et al. 1975). Peakall (this issue) has dealt at some length with pesticide involvement in the decline, but some clarification is desirable relative to the extent of survey coverage and the declines in site occupancy.

There have been various suggestions that substantial numbers of breeding peregrines exist in remote areas in the mountains, boreal forests, or tundra of Canada and Alaska (Beebe 1972; Oliphant et al. 1975), but extensive field work since 1970 has revealed no evidence of such populations. Indeed, most areas of suitable habitat identified in Hickey (Fyfe, *in* Hickey 1969) have been surveyed or visited by biologists since 1970, and no extensive new populations of *F.p. anatum* or *F.p. tundrius* have been found. Although a few remaining pairs are undoubtedly present in areas that have not been investigated, no major population units have been encountered to support theories of large, undiscovered, uncontaminated populations of *anatum* or *tundrius* peregrines. We do not deny the possible existence of peregrines in areas which have not been investigated, but where no supporting data are presented, such speculations must be classed as conjectural. Indeed, in 1975, a preliminary survey of historical nest sites in suitable accessible habitat in the interior of British Columbia yielded no current breeding pairs of peregrines (I. Smith, personal communication). Although the survey was preliminary, it does indicate that peregrines are not abundant in the more accessible areas of the British Columbia interior.

A frequent theory to explain the absence of birds from historical territories is the suggestion that the birds have simply moved to more remote areas. There are no data to support this supposition, and where birds remain, their very presence at historical nest sites refutes this theory. Also, in many areas as in the barrens, there are simply no areas of suitable nesting habitat into which the birds could move. Even in areas where good alternative nesting habitat is available, site tenacity is the rule, as is illustrated in the case of the readily identifiable lone male which has been maintaining his traditional territory each year for the past 5 years in southern Alberta.

Band recoveries for western Canadian Prairie Falcons (*Falco mexicanus*) and Peregrine Falcons strongly suggest that, whenever possible, breeding adults return to the same territory used the previous nesting season. At the same time, we have no data which would suggest a shifting of Peregrine or Prairie Falcon territories to more remote areas owing to frequent human disturbance. Although new breeding pairs of peregrines have been found adjacent to existing pairs and in newly investigated areas, there is no evidence that would suggest this represents a shift to new territories or to remote areas. New pairs adjacent to existing pairs presumably are the young of the remaining adults, which have reached breeding age and are forced to seek new territories. Where historical nest sites are left unoccupied, we suggest that the reason is because the tradition has been lost owing to death of the adults and a lack of replacement by any offspring produced in the territory. In this way, any traditional site may well remain unoccupied, unless the tradition is re-established by a new pair of birds.

Not to be confused with a shift of territory is the fact that frequently within an established nesting territory a pair may have several alternate nest sites. Such alternate nest sites, though most frequently found on the same cliff, in some instances have been recorded as far as 1.6 km from a previously used nest scrape.

One criticism of the 1970 surveys was that in many instances the comparisons were of occupancy of the total known territories which included territories found in different years. Also it has been argued that any increase in the number of known territories or breeding pairs must surely be interpreted as a population increase. These criticisms could only be valid if the theory of a shifting population is accepted and if it were shown that these birds move about extensively. We do not accept this and can find no data to support this theory. Any increases in known territories or in the number of breeding pairs recorded in any area result solely from new data, more intensive surveys, or surveys into new areas not previously investigated.

Because of the extent of the surveys and the limits of funding and manpower, the entire area included in the North American Peregrine Falcon Survey is investigated only during the specific year of the larger survey. Consequently, except during the larger surveys, all areas are not investigated in any one year. Extensions of the surveys are normally carried out, whenever possible, as small independent surveys in the intervening years. It is possible, however, to compare directly the current survey data, territory to territory, for any area to show a comparison of present occupancy with the data on an earlier survey. For example in 1966, 16 territories were located and were occupied along the Mackenzie System whereas in 1975 only five of these same territories were occupied. A comparison of these data appear in Table 2 where it is clear that such a comparison shows similar population trends.

Recent papers (Campbell and Davies 1973; Oliphant et al. 1975) discussing current Canadian peregrine populations have made reference to prior estimates for northern peregrine populations (Fyfe, *in* Hickey 1969). These original estimates made in 1965 were based on the best available data at that time; however, on the basis of more recent surveys of extensive areas of the Arctic and additional data on available nesting habitat and prey populations, it is obvious that these figures were too high. Although it was stated that these estimates were in fact extrapolations from known population units, the figures have frequently been used to support the notion that large peregrine populations remain in arctic Canada.

Yet another line of evidence that has been presented as proof that arctic peregrine populations have not declined is the number of migrant peregrines counted on their southern passage each fall. Indeed, there has been no decrease and perhaps even a slight increase in the number of falcons caught and banded each year. But this encouraging result is not a valid indication that the number of migrant falcons has remained constant. Rather it represents a

TABLE 2—Occupancy in 1975 of initially documented nesting territories

Region	Occupied territories		
	Initial[1] number	1975[2] number	% Occupancy in 1975
Boreal			
Mackenzie (1966)	16	5	31[4]
S. Yukon (1967)	8	4	50
N. Alberta (1971)	6	3	50
Delta (1973)	14	9	64
N. Yukon (1973)	14	8	57
Total	58	29	50
Tundra			
Perry River (1965)	3	0	0
Ungava and Barrens (1967)	20	6	30[4]
Horton River (1968)	10	0[3]	0
Arctic Coast and N. Yukon (1973)	29	14	48
Total	62	20	32

[1] The total number of occupied territories located on the first intensive survey of the areas identified; this was taken as 100% occupancy.

[2] The number of the same territories occupied in 1975.

[3] The 1975 survey was an intensive survey of the same stretch of river. The specific 1968 territories had not been identified.

[4] One site not checked.

tremendous increase in the number and efficiency of observers and trappers. The same bias enters into estimates of numbers based on sightings.

Some figures from the 1975 migration season are revealing. On Assateague Island, a total of 40 peregrines was banded, the second highest seasonal total to date, but at the same time the trappers had 41 recaptures of falcons they had banded earlier the same season (F. P. Ward, personal communication). Ward estimated that about 100 falcons passed Assateague Island this season so that the trapping efficiency approached 50%. Ward and Berry (1972) have previously indicated that they trap a large proportion of all falcons migrating by Assateague. Other trapping sites along the Atlantic coast reported similar statistics, and the total number of falcons caught along this important peregrine migration route was 97. If the nearly 50% trapping efficiency recorded on Assateague Island applied all along the coast, the total passage may have been only several hundred birds, a number that is not at odds with the size of the known breeding population in the eastern Canadian Arctic and Greenland.

Although there has been no statistical analysis of these migration data, we fail to find any evidence that they suggest an arctic peregrine population much larger than estimated on the basis of breeding surveys. Rather it appears that they may offer evidence that the surveys of breeding falcons have covered nearly all the major populations.

Regional Reports

Greenland

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Research on the Peregrine Falcon (*F.p. tundrius*) population on Greenland was initiated during the summer of 1972. Before that time only scattered observations had been made on Greenland peregrines, and almost nothing was known of the peregrine's ecology or biology on the island. During the summers of 1972–1975, we visited five separate geographical areas on the island in an attempt to gain an accurate picture of the falcon's status. The most detailed and complete work was conducted in one inland area located on the western coast some 100 km above the Arctic Circle. This report is based on studies in this area unless otherwise indicated. Detailed results of the research can be found in Mattox et al. (1972), Burnham et al. (1974), and Burnham (1975).

All observed peregrine nest sites were located on rocky cliffs varying in height from 25–120 m. Falcons were not found nesting on dirt banks or on the ground as has been described in some North American arctic locations. The falcons usually located their nest on a ledge with little overhead protection and in the upper half of the cliff. All sites had a commanding view of the surrounding landscape, and adult peregrines were observed hunting from the nesting cliffs. Over 90% of the falcon's diet in Greenland is comprised of the four small passerine species which occur on the island.

The density of nesting populations of Peregrine Falcons in Greenland varies greatly as one moves inland from the coast. The Greenland Ice Cap and cold Atlantic Ocean currents are important factors influencing the island's climate. The Ice Cap makes up most of the island's central mass, and only narrow strips of land skirt the ice sheet. Cool wet weather prevails during the summer months in coastal areas, with the result that only sparse prey populations are available for the falcons. Nesting peregrines are very scattered in these coastal areas and, based on our present information, the distances between occupied sites range from 60–199 km. In the inland areas near the central Ice Cap, where the climate is more moderate and dry, warm springs and summers favor increased prey population densities. In these warmer inland areas, the peregrine population reaches its maximum nesting density; distances between occupied sites were less than 6.5 km (approximately 1 occupied site/200 km^2).

During 1972, nine inland peregrine nests were located. These sites have been rechecked in subsequent years and are probably the best available indicators of reproductive performance in the Greenland population (Table 3). The thickness of eggshell fragments collected from these nests was compared to the thickness of Greenland peregrine eggshells collected prior to 1940, and a 14% reduction in thickness was noted. Two addled eggs were collected from these nests, and they contained an average of 332 parts per million of DDE in the lipid fraction (Walker et al. 1973). The percentage of eggshell thinning and DDE levels are near those of other peregrine populations which have experienced declines. At this time, it is difficult to draw conclusions on the status of the Greenland Peregrine Falcon population. In coastal regions, however, a high percentage of previously reported nesting sites is now unoccupied. The pesticide levels, degree of eggshell thinning, reduction in

TABLE 3—Occupancy and reproductive performance by peregrines at inland sites in western Greenland

(a) Data on occupancy

Year	Total known sites	Number checked	Occupancy: Unoccupied	Occupancy: Lone adult	Occupancy: Pair	Percentage occupancy
1972	9	9	0	1	8	100
1973	9	9	0	0	9	100
1974	9	9	1	3	5	88
1975	9	9	1	2	6	88

(b) Data on reproduction

Year	Pairs with young	Percent of total pairs	Total young	Young per pair	Young per successful pair
1972	7	88	18	2.3	2.6
1973	9	100	24	2.6	2.7
1974	5	100	15	3.0	3.0
1975	5	83	12	2.0	2.4

reproductive success, and abandonment of formerly occupied sites are all indications that the inland peregrine population is also experiencing a decline.

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Ungava Bay

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During the summer of 1975, Peregrine Falcon nest sites in the Ungava Bay region of Quebec were surveyed to determine and monitor the status of the species. The last such survey was made by Weaver in 1972. Based on information gathered since 1967, there are 27 peregrine nesting territories known in the Ungava Bay region. Of the 25 sites visited in 1975, which included all 15 sites checked in 1970, only 11 were occupied, and nine pairs produced 16 young or 1.8 young per successful nest (Table 4). The pesticide problems and population declines of this peregrine population have been described previously (Berger et al. 1970).

East Coast of Hudson Bay, Quebec

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The Richmond Gulf and the offshore islands along the Quebec coast of Hudson Bay, north of the settlement of Great Whale River, reportedly held a good breeding population of peregrines in the 1940s and 1950s. Although these reports could not be substantiated, breeding peregrines were documented on the nearby Belcher Island to the west (M. Freeman, personal communication), the Great Whale River to the south, and Christie Island (Manning 1946) to the north.

Cliffs along the coast of Hudson Bay from Great Whale River (55° 16′ N, 77° 45′ W), including the Manitounuk Islands, to the entrance of Richmond Gulf, and then along the west side of Richmond Gulf, including Castle Peninsula, to its north end (56° 30′ N, 76° 22′ W) were surveyed by canoe from July 19 to 23, 1975. The cliffs were scanned using binoculars and a 20-power spotting telescope. Rifle shots were fired into areas offering good nesting potential in attempts to flush birds. During the entire survey, no Peregrine Falcons or signs of their nest sites were observed.

Habitat in Richmond Gulf appeared to offer potential for falcons, with cliff heights ranging from

TABLE 4—Occupancy and reproductive performance by peregrines in the Ungava Bay Region

(a) Data on occupancy

Year	Total known sites	Number checked	Occupancy Unoccupied	Occupancy Lone adult	Occupancy Pair	Percentage occupancy
1970	15	15	3	3	9	80
1975	27	25	14	2	9	44

(b) Data on reproduction

Year	Pairs with young	Percent of total pairs	Total young	Young per pair	Young per successful pair
1970	7	78	12	1.33	1.71
1975	9	100	16	1.78	1.78

73 to 504 m. There were numerous ledges and cavities and potential prey in the form of waterfowl; Black Guillemots (*Cepphus grylle*) and Ptarmigan (*Lagopus* spp.) were abundantly available. Large expanses of inaccessible cliffs precluded detailed examination allowing the possibility that peregrines existing there were not seen.

Potential raptor cliffs were explored by helicopter along Hudson Bay on 11 and 13 July, yielding only Raven (*Corvus corax*) nests and one pair of Rough-legged Hawks (*Buteo lagopus*).

Thelon River and Interior Barrens, Northwest Territories

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The area of the Northwest Territories specifically included in the Thelon River survey extends from the western edge of the barrenlands near Artillery Lake, east to Baker Lake. Current investigations have included previously known nesting territories and recently reported nest sites along the Thelon River, its tributaries and those lakes which combine to form the Thelon River system. Three sites were not checked in 1975 because of the difficulty in making on-site verification of any breeding attempt.

The actual survey was carried out by fixed-wing aircraft from 15 to 17 July. Since this survey was carried out under optimum weather conditions, it was possible to visit and check each nesting territory on the ground for any evidence of occupancy. During the current survey, 13 out of a total of 16 known nesting territories were investigated with but one site occupied (Table 5). This site is also the last remaining occupied territory of the original 11 historical territories surveyed in 1970. Since available nesting habitat is limited and since we have good long-term data for the area, we are satisfied that the surveys give an accurate indication of the population trends of *F. p. tundrius* for the interior barrens. Total occupancy along this river system has now declined to about 8% of the historical figure. Regrettably, the decline has continued since the 1960s, and one can now only speculate as to when this population will be totally extirpated.

Central Arctic Coast, Northwest Territories

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Following the initial publication of breeding records of peregrines in Bathurst Inlet in 1957 (McEwen 1957), several surveys have been conducted for breeding birds of prey. These surveys have been carried out by fixed-wing aircraft, by boat, and on foot and have included areas of suitable habitat on the coastal areas and islands of the Coronation Gulf, Bathurst Inlet, and Melville Sound. Additional

TABLE 5—Occupancy and reproductive performance by peregrines on the Thelon River and Interior Barrens, Northwest Territories

(a) Data on occupancy

Year	Total known sites	Number checked	Occupancy: Unoccupied	Occupancy: Lone adult	Occupancy: Pair	Percentage occupancy
1970	11	11	7	0	4	36
1975	16	13	9	0	1	8

(b) Data on reproduction

Year	Pairs with young	Percent of total pairs	Total young	Young per pair	Young per successful pair
1970	3	75	8+	2.00	2.67
1975	1	100	3	3.00	3.00

information on breeding birds of prey has been provided by G. Warner who operates a naturalist lodge on Bathurst Inlet. This population represents one of the more remote and inaccessible populations covered in the current survey.

In the 1975 survey, all 24 previously recorded nest sites were checked, and three new nest sites were found as a result of intensive surveys carried out in new areas of suitable habitat (Table 6). Of the 27 known territories, 13 sites were occupied, 12 by pairs and one by a lone adult bird for a total of 48% occupancy. It should be noted, however, that since all of the territories have been located since 1968, we have actually recorded a decline over the interval between the 1968 and the 1975 surveys. For the most part, the area investigated is prime peregrine habitat with virtually unlimited nest ledges, an abundance of available prey, and minimal human interference.

Banks Island

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Banks Island, the westernmost island of the arctic archipelago, comprises an area of approximately 71 703 km^2. Physiographically, most of Banks Island is either lowland tundra or coastal moraine, but extensive cliffs occupy much of the north and extreme south coasts of the island. Unlike most of the other regions examined in the North American Peregrine Falcon Survey, the past history of the peregrines on Banks Island is poorly known. Any observations of peregrines on the island were strictly incidental to other studies, and information on specific nest locations and reproductive success is lacking. The only references to the peregrine's relative abundance

TABLE 6—Occupancy and reproductive performance by peregrines on the central arctic coast of the Northwest Territories

(a) Data on occupancy

Year	Total known sites	Number checked	Occupancy: Unoccupied	Occupancy: Lone adult	Occupancy: Pair	Percentage occupancy
1975	27	27	14	1	12	48

(b) Data on reproduction

Year	Pairs with young	Percent of total pairs	Total young	Young per pair	Young per successful pair
1975	11	92	21	1.75	1.91

are found in two sources and are markedly general: Porsild (1951) considered the peregrine to be common and breeding wherever suitable nesting sites were found, while Manning et al. (1956) estimated the total population to be 600 birds. This estimate, combined with the extent of the cliffs on Banks Island, prompted the present survey.

Preliminary aerial reconnaisance was conducted from fixed-wing aircraft flown at approximately 600 m (2000 ft) over the entire island, and habitat considered as optimum from these flights was later surveyed either on foot or from a helicopter, flown at slow speeds adjacent to cliff faces. Where either birds or signs of current occupancy were observed, a thorough ground search of the area was made in an effort to locate active nests. Surveys were conducted from 11 to 28 July, and from 4 to 10 August.

The results for 1975 were disappointing as only six active nest sites were located with a single adult occupying another cliff. The six breeding pairs had excellent production as the nests contained a total of 18 young, or 3.00 young per pair (Table 7). Whether the present population represents a recent decline can not be determined as a result of the lack of earlier more comprehensive population information. Porsild (1951) and Manning et al. (1956) mention a total of 10 known falcon nesting territories, comprised of eight peregrine sites and two gyrfalcon sites. Only one of these sites, previously known only as a gyrfalcon nest site, was occupied by peregrines in 1975. With the exception of the 300-m-high cliffs at Nelson Head and Cape Lambton, which could not be surveyed adequately, the remaining seven sites were checked and found to be lacking peregrines. Thus, six new nest sites were found in 1975.

While present numbers are not indicative of a large population, it is nevertheless encouraging that the peregrines which bred in 1975 appeared healthy, as evidenced by strong nest defense and good productivity. Additional years of observations with visits to nest sites, first during early incubation and later when young are almost fledged, would provide important data concerning peregrine population dynamics.

Horton River, Northwest Territories

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After an overview of the Horton River area was obtained by flying along the river valley, an intensive survey was carried out by boat, floating downriver from a point roughly 306 km upstream from the river's mouth. This river was first investigated for falcons by H. Kendall in the mid-1960s and later by F. Beebe and R. Upton in 1968. The river was not surveyed again for raptors until 1973, when an intensive raptor survey was carried out as part of an environmental impact assessment by K. Hodson and J. Campbell (unpublished report). The 1975 Peregrine Falcon Survey covered the same extent of the river valley as the 1973 investigation and included approximately an additional 129 km of the river not checked by Beebe in 1968. The current survey data are compared to both Beebe's reported results (Beebe, personal communication) and the 1973 survey (Table 8).

It is worth noting that although peregrines have declined in the area reported by Beebe, the number of breeding pairs of Gyrfalcons in the same area has remained stable. The Gyrfalcon, being a resident arctic species which feeds largely on resident prey, has not shown high levels of chlorinated hydrocarbon residues and fits the pattern of the more successful

TABLE 7—Occupancy and reproductive performance by peregrines on Banks Island

(a) Data on occupancy

Year	Total known sites	Number checked	Occupancy: Unoccupied	Occupancy: Lone adult	Occupancy: Pair	Percentage occupancy
1975	14	14	7	1	6	50

(b) Data on reproduction

Year	Pairs with young	Percent of total pairs	Total young	Young per pair	Young per successful pair
1975	6	100	18	3.00	3.00

TABLE 8—Occupancy and reproductive performance by peregrines on the Horton River, Northwest Territories

(a) Data on occupancy

Year	Total known sites	Number checked	Occupancy: Unoccupied	Occupancy: Lone adult	Occupancy: Pair	Percentage occupancy
1968[1]	10	10	0	0	10	100
1973	13	13	8	0	5	38
1975	15	15	10	0	5	33

(b) Data on reproduction

Year	Pairs with young	Percent of total pairs	Total young	Young per pair	Young per successful pair
1973	2	40	3	0.6	1.33
1975	3	60	9	1.8	3.00

[1] Data from F. Beebe (personal communication).

resident European and North American Peregrine and Prairie Falcon populations.

North Slope, Yukon Territory

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Approximately 19 500 km^2 of the Yukon Territory's North Slope were searched for gyrfalcons from mid-March through June by helicopter (see Platt, this issue, for a description of the area). Eleven locations listed as Peregrine Falcon nest sites by the Canadian Wildlife Service were visited. Four of the 11 were occupied and a peregrine was found incubating at a fifth site that had previously been used by gyrfalcons. None of these sites was checked after hatching.

Because of the extensive survey work conducted in the study area, I believe few nesting peregrines have gone undetected.

Northeastern Alaska

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Prior to 1972, little was known about the Peregrine Falcon populations that breed in northeastern Alaska. The following is a report of peregrine surveys made in northeastern Alaska between 1972 and 1975. The regions we surveyed can be generally described as the Sagavanirktok River drainage, the Arctic Slope between the Sagavanirktok River and the Canadian border, the eastern Brooks Range, and the Yukon Flats — Porcupine Plateau region north of the Porcupine and Chandalar Rivers. This region covers some 91 000 km^2 of Alaska. Aerial and/or ground survey techniques were employed in searching for peregrine nests in this vast region.

The Sagavanirktok River drainage on the study area's western boundary supports the largest number of nesting peregrines in northeastern Alaska. Table 9 presents the data obtained from the Sagavanirktok River during 1972–1975 as well as data gathered in 1970 by White and Streater (*in* Cade and Fyfe 1970), data obtained in 1958 and 1973 by J. Koranda (personal communication), and data obtained in 1963 by M. D. Mangus (personal communication). Two nesting sites in the northern section and two sites in the southern section of the river appear to be the most consistently utilized and favored sites, though data are lacking for many of the other sites prior to 1974. Just west of the Sagavanirktok River drainage Koranda (personal communication) found two pairs of nesting peregrines in the White Hills on the Toolik River in 1958 and only one pair in 1973.

In recent years fledging success has been very low in the Sagavanirktok River population. In 1974 four pairs attempted to breed along the river. They produced a total of 11 eggs for an average clutch size of 2.8 eggs per pair. Eight eggs hatched successfully producing an average of 2.0 young per nesting site.

TABLE 9—Occupancy and reproductive performance by Peregrine Falcons on the Sagavanirktok River, Alaska

(a) Data on occupancy

Year	Total known sites	Number checked	Occupancy: Unoccupied	Occupancy: Lone adult	Occupancy: Pair	Percentage occupancy
1958	11	5	0	0	5	100
1963	11	6	2	0	4	66
1970	11	8	5	0	3	38
1972	11	10	5	0	5	50
1973	11	4	2	0	2	50
1974	11	10	5	0	5	50
1975	11	10	7	0	3	30

(b) Data on reproduction

Year	Pairs with young	Percent of total pairs	Total young	Young per pair	Young per successful pair
1958	nd[1]	nd	nd	nd	nd
1963	nd	nd	nd	nd	nd
1970	2	66	5	1.6	2.5
1972	2	40	5	1.0	2.5
1973	nd	—	—	?	?
1974	3	60	8	1.6	2.7
1975	2	66	5	1.6	2.5

[1] nd = no data on reproduction that year

Only three of these nestlings fledged from the four nesting sites so that the overall production averaged only 0.8 per pair. In 1975 only three pairs nested, producing 10 eggs for an average clutch size of 3.3 eggs per pair. Only five of these eggs successfully hatched, producing an average of 1.7 young per nesting site. Three of these young were found dead, however, and one young was missing from another site. The overall average production was only 0.3 young per pair.

We conclude that the peregrine population nesting on the Sagavanirktok River is declining in numbers of nesting pairs, at least in the northern section of the river (see Table 9). Productivity has been poor along the entire river. Our data indicate that an increased frequency of total nesting failures (i.e., desertion or full clutches failing to hatch) is an important factor in the population's decline along this river, a finding consistent with that of Cade and Fyfe (1970) for northern peregrines. Recent heavy mortality of nestlings has also reduced the reproductive success of this population.

The section of the Arctic Slope between the Sagavanirktok River and the Canadian border contains several river systems and mountains that appear to have suitable nesting habitats for peregrines. Bailey (1948), summarizing his data for this northern region, reported that a peregrine was collected at Brownlow Point near the mouth of the Canning River on 16 May 1944. Bailey also reported an observation made by Brooks of a flying peregrine near Demarcation Point on 10 June 1914, as well as his own observation of a peregrine flying over his ship in the same vicinity on 13 August 1921. This last observation is suspect, however, because Bailey (1933) apparently referring to this same incident, had previously identified this bird as a Gyrfalcon (*Falco rusticolus*). Peregrines have also been reported " . . . on the Hulahula River . . ." by Anderson (1913).

The earliest report of a nesting in the region appears to be that of a pair of adults and a clutch of five eggs collected in June 1929 in the Romanzof Mountains (Bailey 1948; Gabrielson and Lincoln 1959). J. Drew reported two pairs of peregrines nesting on the Jago River (T. J. Cade, personal communication) near where we have found Rough-legged Hawks (*Buteo lagopus*) nesting. On 4 June 1959, Cade (1960) discovered a nesting pair of peregrines in the upper Sadlerochit River drainage. In 1971, C. White and W. Spofford surveyed the Canning River between a point about 8 km upriver of the Marsh Fork confluence and the Red Hill area and found no nesting peregrines. W. Troyer (personal communication) had reported peregrines near the confluence of Eagle Creek and the Canning River during the late 1960s or early 1970s. M. Mangus found peregrines nesting at three places on the Canning River and Kavik River in 1947. He found one pair on the Katakturuk in 1963 and 1966, two pairs on the Aichilik river in 1966 and 1969, and three pairs on the Kongokut River in 1966.

During 1972–1975 we found only three active peregrine nests in the region; all three sites were located in the Canning River drainage. All three sites were occupied in 1972 and two successfully fledged young. Only two sites were occupied in 1973, and we have no data on their reproductive success. In 1974 all three sites were unoccupied. Only one of the three sites was checked by us in 1975, and it was not active.

South of the Brooks Range we surveyed the area lying north of the Porcupine River and east of the Chandalar River. Historical data from this region appear to be even fewer than those from the area to the north. To our knowledge, prior to 1972 only a single peregrine nest site, located in the headwaters of the Firth River, had been noted. Troyer (personal communication) reported a pair present at this site during 1970 or 1971. R. Fyfe (personal communication) reported that this site was occupied by peregrines during 1971. We found the site unoccupied in 1972 and in following years it was occupied by either Golden Eagles (*Aquila chrysaetos*) or Gyrfalcons. During 1972–1975 we located only one additional peregrine nesting site south of the Brooks Range. This site in the Sheenjek River drainage, was active in 1972 and 1973 and fledged young both years. We did not check this site in 1974 or 1975.

Throughout the course of the 1972–1975 work, northeastern Alaska east of the Sagavanirktok River drainage was tentatively mapped in terms of poor, fair, and good to excellent nesting habitat for cliff-nesting raptors. Twenty-one north-slope and five south-slope river drainages were evaluated within this broad region. Of these, only sections of the Canning River, Sadlerochit River, and Kongakut River appear to offer good habitat. In areas other than these rivers suitable nesting habitat is limited to sites which could probably support no more than single pairs. The scarcity of large dirt bluffs and rock cliffs, the scarcity of river canyons and the large amount of terrain above 760-m elevation combine to produce unfavorable nesting habitat for peregrines. The paucity of peregrines in northeastern Alaska, therefore, attaches an increased importance to the populations west of the Sagavanirktok River, especially in the Colville River drainage of northwestern Alaska.

Large areas within the study area do, however, contain habitat well suited to nesting pairs of Gyrfalcons, Rough-legged Hawks, and Golden Eagles. These species are, in fact, generally numerous, nest successfully throughout the region, and appear to be the dominant large cliff-nesters.

Most of the data for northeastern Alaska were acquired during an extensive series of aerial wildlife surveys conducted by Renewable Resources Consulting Services Ltd. under contract to and supported by Alaskan Arctic Gas Study Company. The Alaska Department of Fish and Game participated cooperatively during 1973–1974. W. R. Spofford helped us obtain data for a portion of the Canning River drainage during a survey conducted in 1971. Most of the Sagavanirktok River data were obtained during surveys sponsored by United States Fish and Wildlife Service in 1970, 1972, 1974, and 1975. Additional data for this river were provided by J. Koranda, M. D. Mangus, and the Alaska Department of Fish and Game.

Colville River Watershed, Alaska

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The Colville River is the major drainage system on the Arctic Slope of Alaska with a watershed of about 60 000 km^2 and cliff-lined watercourses totalling more than 3000 km. The riverine bluffs and cliffs of the main Colville and its tributaries have been known as prime nesting habitat for peregrines since the early 1950s (Kessel and Cade 1958; Cade 1960; White 1964; White and Cade 1971).

We carried out our 1975 surveys by air, either from a fixed-wing Helio Courier or from helicopters.

For the purpose of making comparisons with previous studies, we concentrated on the main river from the mouth of the Etivluk to Ocean Point, where there is a history of information going back to 1952 (Cade 1960); we got down on the ground as much as possible in this area, at a total of 20 locations where peregrines are known to have nested in the past. At no place where we made ground observations did we find peregrines where they had not first been seen from the air. Most of our observations in other parts of the watershed were from the air, with occasional landings where possible to check on peregrines.

Table 10 summarizes our coverage of the watercourses. In addition, we flew across the middle and upper reaches of all the tributaries from Thunder Creek to the Killik and checked likely-looking cliffs along the routes. The only portion of the watershed that did not receive attention was along the middle and lower reaches of the Itkillik, where we knew from previous flights that suitable bluffs and cliffs do not occur, and the headwaters of tributaries in the Brooks Range, where again peregrines are not known to nest

TABLE 10—Kilometres of river covered by aerial surveys in the Colville region, 1975

Locations	Kilometres of river	Number sites occupied	
		Peregrines	Gyrfalcons
Main Colville, Etivluk to Ocean Point	302	12(+1?)	13
Upper Colville above the Etivluk	238	3	3
Upper Itkillik River	69	0	0
Anaktuvuk and Nanushak Rivers	391	2	9
Chandler and Siksikpuk Rivers	199	1	5
Killik River and tributaries	399	0	2
Oolamnagavik and tributaries	115	0	3
Kurupa and tributaries	191	0	1
Etivluk and tributaries	230	1	3
Lower Ipnavik River	32	0	0
Lower Kuna River	25	0	1
Lower Awuna River	48	0	0
Lower Kogosukruk River	65	0	0
Lower Kikiakrorak River	53	0	0
Totals	2357	19 or 20	40

and where flying this kind of survey becomes extremely hazardous.

We carried out our surveys between 22 June and 1 July, during the latter part of egg incubation and, therefore, can report nothing definite on the final productivity of this population in 1975. We found peregrines at 12, possibly 13, sites on the Colville River from the Etivluk to Ocean Point. Only three of these sites were located upriver from Umiat. Eggs were found at nine sites and were possibly present at one other. Of the 34 eggs found, we know that seven were bad or abandoned during our period of observation, leaving a total of 27 possibly viable eggs. If half of these eggs resulted in fledged young—about the most optimistic expectation one could have—then 13 to 14 young could have been produced by this population in 1975. If survival of these eggs and young followed the pattern observed by Haugh (this compilation) in 1973, a more likely prospect, then fewer than 10 young fledged this year.

In 1973, Haugh (this compilation) made a complete on-the-ground survey of the Colville peregrines for the Alaska Department of Fish and Game. In June he found 14 pairs and a single adult between the Etivluk and Ocean Point; 11 pairs had 32 eggs. In late July only four of these pairs had a total of nine advanced nestlings. As in our 1975 survey, he found only three pairs at cliffs upriver from Umiat, but they were on three different cliffs than the ones occupied this year (Table 11). Formerly, about 18 to 20 pairs nested

TABLE 11—Occupancy by Peregrine Falcons along the Colville River, Alaska

(a) Data on occupancy

Year	Total known sites	Number checked	Occupancy			Percentage occupancy
			Unoccupied	Lone adult	Pair	
1952-1959[1]	51	51	10	5	36	80
1964	51	14	3	0	11	78
1967	51	46	17	5	29	66
1968	51	51	19	1	31	62
1969	51	51	18	0	33	64
1970	51	27	16	0	11	40
1971	51	51	20	6	25	60
1973	51	51	36	1	14	29
1974	51	26	18	0	8	30
1975	51	51	38	3	10	25

[1] Year of maximum numbers

upriver from Umiat, while 15 to 18 pairs nested below. (A total of 25 nesting places is known upriver, and 26 downriver, Table 11.)

In 1974, C. M. White made a quick helicopter survey from Ocean Point to Umiat on 8 July at hatching time. He found peregrines at eight places, including five pairs with a total of 11 eggs or newly hatched young. The other three pairs acted as though they had no occupied nests. White felt that he might have missed one or two pairs, as the survey was done hurriedly. Two of the cliffs where he found peregrines in 1974 were not occupied in 1975, and we found falcons at three cliffs where he saw none in 1974.

When the information for 1974 and 1975 is compared with the earlier data summarized in Table 11 it appears that the decline that began in the Colville population in 1969 may have bottomed out in 1973, or at least that the rate of decline has lessened, for our figures on number of pairs and reproductive performance in 1974 and 1975 do not differ markedly from Haugh's findings in 1973. Although one could be encouraged to hope that the main Colville population has now leveled off at about 35% of its former breeding numbers, caution must be exercized, because the low reproductive yield of less than one young per pair is not sufficient to maintain breeding numbers without recruitment from outside sources.

Throughout the rest of the Colville watershed in 1975 we were able to find peregrines at only seven places. Four certain nests yielded 14 to 16 eggs, and a fifth probable nest could have raised the total to 18 or 20 eggs. Only single adults were seen at the other two sites. Since we were working mostly over unfamiliar ground in these areas, where we had little prior knowledge of exact nesting locations, and especially since we conducted these surveys near the end of the incubation period for peregrines when the birds sit tightly on their nests, we feel there is a greater chance that we missed more peregrines in these areas than on the main Colville, where we could pinpoint exact locations on which to concentrate our attention. Even so, we doubt that we could have missed more than half of the pairs actually present on the tributaries and upper Colville.

Seven to fourteen pairs widely scattered along more than 1900 km of watercourses in an area of some 50 000 km^2 make up a very sparse population, indeed, and lead to speculation about changes in numbers in these parts of the Colville watershed. Fortunately there is a little historical information on some of these areas that provides us with insight. In 1952, T. J. Cade and G. B. Schaller found eight pairs of peregrines during the late nestling and early fledgling period at the end of July and in early August along 135 km of the Colville upriver from the mouth of the Etivluk (Kessel and Cade 1958). In 1975 we could find only two pairs along the same stretch of river, and Haugh and Conner found none during a flight on 22 July 1971. In 1956 along 55 km of the Oolamnagavik River, T. J. Cade and H. M. Webster, Jr. found five pairs of peregrines during the hatching period between 30 June and 6 July (Kessel and Cade 1958), where we could find none present in 1975. In 1968, L. L. Boyd and E. Stauber found two pairs of peregrines nesting on the middle reach of the Killik River, and C. M. White found two pairs on the lower Killik in 1964. J. Haugh could find none along the entire Killik in 1971, nor could we in 1975. In 1971, J. R. Haugh carried out aerial surveys for the Alaska Department of Fish and Game along the Chandler and Siksikpuk Rivers and along the Anaktuvuk and Nanushak Rivers, where we also worked in 1975. He found six pairs of peregrines (also two along the Chandler in 1972), where we found birds at only three places, single adults at two, and a pair with eggs at a third. Two of our locations were ones at which Haugh had found peregrines. Haugh also surveyed the Killik and Okpikruak Rivers in 1971 and reported one pair of peregrines on the latter at its confluence with Verdant Creek and the Middle Fork. We found none there or elsewhere on these or other tributaries of the Killik system in 1975.

All this information indicates that (*a*) peregrines were formerly widely distributed and common on the upper Colville and on the tributaries, and (*b*) that the breeding populations are now greatly reduced along these watercourses. Cade (1960) estimated that the breeding peregrine population of the Colville drainage in the 1950s was between 60 and 150 pairs, with 100 pairs being the best estimate of the real population. At that time he had detailed, on-the-ground knowledge only of the main Colville, one late summer run on the upper Colville, and one mid-season run on the Oolamnagavik, although he had made flights over most of the watershed at one time or another and had a good concept of the overall topography and general ecological conditions of the entire region. The more recent surveys of the late 1960s and 1970s confirm the existence of suitable nesting cliffs and breeding habitat for peregrines along all the major tributaries except the Itkillik, and we still feel that 100 to 120 pairs is a good conservative estimate of the breeding population that existed in the 1950s and earlier. Conceivably it could have been even larger—around 200 pairs—as an average of one pair per 15 km of river is not unreasonable based on data for the Colville and Oolmanagavik Rivers (45 pairs along about 500 km of river, or about 11 km per pair). Also, in the 1950s peregrines outnumbered Gyrfalcons about three or four to one. In 1975 we located 40 pairs of Gyrfalcons in the Colville watershed, a number which again fits a concept of 120 to 160 former pairs of peregrines, assuming that Gyrfalcons have not substantially increased or decreased in numbers region-wide since the 1950s.

If these speculations are approximately correct, it would appear that the reduction in numbers has been greatest for nesting peregrines on the tributaries, next most telling on the upper Colville, and least on the lower Colville, for an overall reduction to about 25% of the breeding population present in the 1950s.

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The Maritime Provinces

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The Peregrine Falcon Survey in the Maritimes centered around the Bay of Fundy in New Brunswick and Nova Scotia. There is no definite evidence of peregrines ever having nested on Prince Edward Island. The last report of nesting activity in New Brunswick was in 1948 on Grand Manan Island and near Matthew Head, Albert County. The last young produced in Nova Scotia appears to have been in 1955 near Advocate, Cumberland County. The scarcity of these birds in the Maritimes during the summer months is reflected in the number of reported sightings, only 12 since 1963. Considerably more were reported during spring and fall migrations.

Approximately 253 km of potential nesting habitat (mostly coastal cliffs) were investigated in 1975 using low-flying fixed-wing aircraft. This included 14 known nest sites used in the past (six in Nova Scotia, eight in New Brunswick), one of which was an inland site in York County, New Brunswick. The survey covered part of the southern coast of New Brunswick from Pecks Cove to Johnson Mills, from Mountville to Tynemouth Creek, and also included Grand Manan Island. In Nova Scotia, the coastal areas searched were along the Minas Basin and Channel, Upper Economy to Pinnacle Island, Partridge Island, Cape Split, Cape Chignecto to Cape Spencer and Île Haute. In addition to this, surface investigation of coastal cliffs was carried out in Cape Breton Highlands National Park.

No peregrines were seen during the survey, nor was there any evidence of occupancy at any of the sites investigated. The results reaffirm the conclusion reached in the 1970 Peregrine Falcon Survey: these birds are no longer breeding in the Maritimes.

Southern Labrador

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In 1970 two active peregrine nest sites were discovered along the Labrador coast (Gibbon et al., *in* Cade and Fyfe 1970). During 1975 a brief survey was made in the Hamilton Inlet and Grosswater Bay regions of Labrador. No peregrines were found at either of the two sites occupied in 1970, nor were peregrines located in the region.

Southern Ontario

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In 1970 an intensive investigation was carried out throughout southern Ontario with no evidence of recent occupancy at any of the recorded peregrine nest sites (Gibbon et al., *in* Cade and Fyfe 1970). In 1975 it was agreed that no attempt should be made to carry out as intensive a survey as that of 1970. Instead, a selection was made of those sites which had been the most recently occupied or which were judged to have the best potential for occupancy. As a result, in 1975 eight of the previously known breeding territories were surveyed. As in the 1970 survey, no birds were seen, and there was no evidence of recent occupancy.

Alberta

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Forty-eight historical peregrine breeding territories are recorded in Alberta. Available records indicate that many of these sites were last occupied in the 1950s, with a few isolated pairs breeding into the late 1960s (Enderson 1964).

In 1975 44 former nesting territories were investigated in Alberta. In northern Alberta three pairs of peregrines were found occupying territories, one of which adopted and fledged the six captive-bred *anatum* young. No new breeding pairs of peregrines have been located in this area since 1972.

As in previous years, a few additional sightings were reported in southern Alberta, but as in northern Alberta, no new breeding pairs were found in 1975 (see Table 12). The one territory reported in southern Alberta in the 1970 survey (Cade and Fyfe 1970) last held a breeding pair in 1972 (Figure 2). Although this pair fledged two young that year, the female has failed to return in the following or subsequent years, and the territory has since remained occupied by the lone male. This male is readily identifiable, and each year has occupied the territory throughout the breeding

FIGURE 2. One of the last known Peregrine Falcons of the *anatum* race south of the boreal forest and east of the Rocky Mountains in North America. This male bird is shown feeding young in 1972 in its last breeding attempt. Photograph by Richard Fyfe.

TABLE 12—Occupancy and reproductive performance by peregrines in Alberta

(a) Data on occupancy

Year	Total known sites	Number checked	Occupancy Unoccupied	Lone adult	Pair	Percentage occupancy
1970	48	33	30	1	2	9
1975	48	44	40	1	3	9

(b) Data on reproduction

Year	Pairs with young	Percent of total pairs	Total young	Young per pair	Young per successful pair
1970	1	50	3	1.50	3.00
1975	0	0	0	0	0

season, arriving within a few days of the same date each spring, defending the territory against intruding raptors, and unsuccessfully courting migrant female peregrines which pass within a few miles of the territory.

Unfortunately the results of the 1975 survey suggest almost complete extermination of breeding *F. p. anatum* in its former range south of the boreal forest and east of the Rocky Mountains.

Mackenzie Valley, Northwest Territories

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Portions of the Mackenzie Valley and adjacent mountain ranges have been intensively surveyed by several investigators each year since 1970. Because additional occupied territories were found on subsequent surveys, the most extensive coverage occurred in 1975 when 44 recorded nest sites were checked with aircraft and later visited on foot.

Of the 24 sites which were occupied in 1975, 14 produced young, and the reproductive status of two could not be determined.

Comparing the 1970 and 1975 surveys results (Table 13) may lead one to an unwarranted state of optimism. In both years approximately 50% of the breeding territories checked were occupied; 50% of the occupied sites produced young in 1970, and approximately 65% produced young in 1975. The increase in productive sites can probably be attributed to the discovery of several new nest sites (See Tables 1a and 2) that have since begun to show signs of regression.

When each of the 44 previously known nest sites of the Mackenzie Valley are analyzed on a year-to-year

TABLE 13—Occupancy and reproductive performance by peregrines in the Mackenzie Valley, Northwest Territories

(a) Data on occupancy

Year	Total known sites	Number checked	Occupancy Unoccupied	Lone adult	Pair	Percentage occupancy
1970	16	16	7	3	6	56
1975	44	44	20	3	21	55

(b) Data on reproduction

Year	Pairs with young	Percent of total pairs	Total young	Young per pair	Young per successful pair
1970	3	50	6	1.20	2.00
1975	14	65	18+	0.85+	1.29+

basis, it appears that an overall trend of diminishing reproductive success is being followed by territory abandonment. Fortunately some of the sites are successfully raising young year after year, and it is on these few individuals that the future population of the Mackenzie Valley depends.

Old Crow and Porcupine River, Yukon Territory

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Olaus J. Murie had seen the falcons along the Porcupine River in 1926 on a round-trip by boat between Fort Yukon and Old Crow, and his field notes, which he kindly abstracted for T. Cade in 1952, indicate that he found peregrines at eight places below Old Crow. He also found several falcon nests on the Old Crow River. It should be pointed out that his observations were incidental to travel and that he was not engaged in a thorough search for peregrines. In 1954, J. W. Buckley and W. L. Libby made a trip up and down the river between Shuman House and the Bluefish River, about 255 km, in late August in the post-fledging period. They saw 31 peregrines at approximately 12 nest sites (minimum of 10 positive locations). Again, they were not specifically looking for falcons.

The current survey consisted of visits to all known nest sites on the Old Crow River from the Alaska border to the town of Old Crow and on the Porcupine River from the Alaska border to a point approximately 100 km upstream. A search of the same areas for new sites was also made. The rivers were travelled twice; an early check was made from 25 June to 1 July, and a later check from 27 to 31 July.

In general, occupancy by Peregrine Falcons was poor on the Old Crow River. Of nine previously known sites, only one was occupied. Two new sites, however, were located, making the overall occupancy 3 of 11 sites. On the Porcupine River, occupancy was better; of 10 sites previously known, 7 were occupied. One new site was also located making the occupancy 8 of 11 sites.

Of the three occupied nest sites on the Old Crow River, two are known to have raised young. Of the eight occupied sites on the Porcupine River, only three were later checked for productivity; one was successful. It seems likely that three of the remaining sites raised young, so that probably four out of the eight occupied sites were successful.

The Yukon River Valley, Yukon Territory

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The 1970 survey of the Yukon River included data for known peregrine territories on several inland lakes as well as those along the Yukon River. Since we are unaware of recent occupancy at any of the former territories on the inland lakes, the 1975 investigations were restricted to the Yukon River. Surveys by boat were followed up by extensive ground searches of each nesting territory.

The river was surveyed between Dawson, Yukon Territory and the boundary from Alaska from 7 to 9 July, during which time we found 6 of 12 territories occupied. Five pairs and one single bird were present for 50% occupancy; however, only two of the five pairs were productive, each with a single nestling. In comparison with earlier years, production by successful pairs is greatly reduced, as four pairs in 1967 produced 10 young, and three pairs in 1970 produced a total of six young (Table 14).

Only one of the two successful pairs showed typical nest defense behavior when we approached their nesting territory. The second pair did not show normal aggression, and what was apparently aberrant behavior was noted in the form of aggression between the members of the pair. Similar behavior was observed at one of the unsuccessful nest sites. This aggression was repeated several times at both nest sites although at no time was physical contact observed. The remainder of the unsuccessful pairs displayed normal behavior with no aggression towards us or to one another and with little or no screaming.

The Central Yukon River, Alaska

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The area under consideration here consists of the main Yukon River from Fortymile, Yukon Territory to Circle, Alaska. The river bluffs of the main Yukon have been known as prime falcon habitat since the Gold Rush Days of the late 1890s (Osgood and Bishop 1900). The nesting peregrines were first examined in detail in 1951 (Cade 1953, 1960) and have received increasing attention by a number of investigators since 1966 (Cade et al. 1968; Enderson et al. 1968; 1972; Temple et al., *in* Cade and Fyfe 1970).

In 1975 one team, consisting of Cade and White, surveyed the river in a fixed-wing Helio Courier and in a Bell Jet Ranger II helicopter. There were two or three observers in addition to the pilot on these flights, and our method was to fly along the river and pass as close as possible to cliffs where falcons might be

TABLE 14—Occupancy and reproductive performance by peregrines on the Yukon River, Yukon Territory

(a) Data on occupancy

Year	Total known sites	Number checked	Occupancy			Percentage occupancy
			Unoccupied	Lone adult	Pair	
1970	15	15	9	1	5	40
1975	15	12	6	1	5	50

(b) Data on reproduction

Year	Pairs with young	Percent of total pairs	Total young	Young per pair	Young per successful pair
1970	3	60	6	2.00	2.00
1975	2	40	2	0.40	1.00

nesting. We made repeated passes by the cliffs, until we were sure we had seen as much as could be seen. Another team, consisting of Ambrose and Ritchie, made boat trips on the river between Eagle and Circle later in July and August and checked all known nesting localities on the ground. Also, J. Haugh and J. Campbell independently traveled downriver by boat from Fortymile in the same time period, and they have made their observations available to us. Thus, we are able to compare the results of an aerial survey with on-the-ground studies at approximately the same time.

From the air, we found evidence of falcons present in 1975 at nine cliffs, although one of them appeared to have been abandoned by the time of our observations. We counted a total of 10 to 12 young at five nests and suspected from the behavior of the adults that young were also present at one other. The ground teams were able to account for a total of 15 cliffs where peregrines were seen or heard, at which 10 held breeding pairs that produced 16 young. Thus our aerial survey failed to locate all pairs or all young, even though it was conducted at about the optimum time for finding the nests, that is, when there were large downy young present. There is no question that the forested aspect of the Yukon region and the complex rocky structure of these cliffs make accurate counts from the air very difficult, far more so than is the case in the Colville River region of the Arctic Slope.

In addition, we flew past "Twelvemile Bluff" downriver from Circle, on two different days. This cliff is an old historical site and D. G. Roseneau found an adult female peregrine with three fledged young at this location in September 1974, the first time it has been used in recent years to our knowledge. We saw no sign of use in 1975.

Table 15 summarizes the information we have on the occupancy of cliffs by peregrines between Fortymile and Circle for 8 years between 1951 and 1975. On compiling this list, we were surprised to discover that no less than 31 different localities have been used by peregrines one or more times, although 20 is the maximum number known to have been occupied in any one year (1951).

There are more than 40 potentially usable cliffs between Fortymile and Circle, a distance of about 325 km. Only nine cliffs have been used in most years (in all, or all but one, of the recorded years), although 10 have been used only once or twice. Three cliffs known to have been used in 1951 have not been occupied since, although two of them were said by the local Indians to have been occupied "for many years" prior to 1951.

In 1951 Cade recorded peregrines at 20 locations between Fortymile and Circle, and 16 of these sites had productive pairs that fledged at least 20 young. Because this was the first time Cade had been on the Yukon and because his single season survey was carried out late in the season at or just after fledging time, these figures must be considered minimal reflections of the actual numbers present. With the data for more recent years to provide a perspective, it seems likely that pairs were missed in 1951 between Fortymile and the Yukon–Alaska border and at two or three places between Eagle and Circle, Alaska. Probably there were between 20 and 23 pairs of peregrines nesting along the main Yukon in the 1950s, producing about 30 young per year.

The data for 1966, derived from four trips up and down the river, do not differ significantly from this revised estimate for the decade of the 1950s (Cade et al. 1968). Seventeen pairs nesting between "Castle

TABLE 15—Yukon River cliffs used by peregrines, Fortymile to Circle. + = Site occupied by a single bird or a pair; - = site unoccupied; ? = site probably occupied; nc = site not checked

Cliff Number	Years								Total occupancy	Class "A" nest sites[1]
	1951	1966	1967	1968	1970	1971	1973	1975		
Fortymile River, Yukon Territory										
1	+	nc	+	-	+	+	+	+	6/7	X
2	-	nc	-	+	+	-	-	+	2/7	
3	?	nc	?	+	+	+	+	-	4/7	
4	-	nc	+	+	-	-	-	-	2/7	
5	+	+	+	+	+	+	+	+	8/8	X
6	+	-	-	-	-	-	-	-	1/8	
7	+	-	?	+	+	+	+	+	6/8	
8	-	+	-	-	-	-	-	-	1/8	
9	+	-	-	-	-	-	-	-	1/8	
Eagle, Alaska										
10	+	+	-	+	+	-	+	-	5/8	X
11	+	-	-	-	-	-	-	-	1/8	
12	?	+	+	+	+	+	+	+	7/8	X
13	+	-	-	-	-	-	-	-	1/8	
14	-	-	+	-	-	+	-	-	2/8	
15	+	+	+	-	+	-	+	+	5/8	
16	+	+	+	+	+	+	+	+	8/8	X
17	+	+	+	+	+	+	+	+	8/8	X
Nation River										
18	-	-	-	-	-	+	-	+	2/8	
19	+	+	+	+	+	+	+	+	8/8	X
20	-	-	-	-	-	+	-	-	1/8	
21	+	-	-	+	-	-	-	-	2/8	
22	+	+	+	+	-	-	+	-	5/8	
23	-	+	-	-	-	-	-	-	1/8	
24	?	-	+	+	+	+	+	+	6/8	X
25	+	+	+	+	+	+	+	+	8/8	X
26	?	+	?	+	+	-	+	+	5/8	
27	+	+	+	-	-	-	-	+	4/8	
28	+	+	+	+	+	+	-	-	5/8	
29	+	+	+	+	+	+	-	-	6/8	
30	+	+	+	+	+	+	+	+	8/8	X
31	+	+	+	+	-	-	-	-	4/8	
Circle, Alaska										

NOTE: 1951 data from Cade (1960); 1966 data from Cade et al. (1968); 1967 data from D. G. Roseneau, L. G. Swartz, J. H. Enderson, and J. Campbell; 1968 data from T. J. Cade, C. M. White, and J. H. Enderson; 1970 data from J. H. Enderson, S. A. Temple, and J. Campbell; 1971 data from T. J. Cade and L. G. Swartz; 1973 data from C. M. White, S. Ambrose and R. Ritchie.

[1] Based on Hickey's (1942) classification of nest site quality.

Rock" (St. Peter's Dome) and Circle fledged 30 young, and it is probable that two or more pairs resided on cliffs upriver between the Dome and Fortymile that year, although we made no observations on that stretch. The year 1968 was also similar: 19 cliffs were occupied between Fortymile and Circle, at least 17 pairs attempted to nest, and a minimum of 12 and probably as many as 16 young fledged from the sites downriver from Eagle; the number fledged upriver from Eagle was not determined that year. The first year to show a reduced number of occupied cliffs was 1970, when seven productive pairs raised 18 young (Temple et al., *in* Cade and Fyfe 1970). The population appears to have remained essentially unchanged since then. For example, L. G. Swartz and Cade found nine productive pairs with 17 young at the end of the nesting season in 1971, and S. Ambrose and R. Ritchie found six productive pairs with 16 young in the nests between Eagle and Circle in 1973. These figures compare closely with our 1975 findings.

Of the 10 cliffs judged to be most superior nesting habitat for peregrines (based on physical characteristics and regularity of occupancy) only one, Eagle Bluff, has become unproductive since 1970. Five cliffs that were used fairly regularly from Takoma Bluff downriver to Circle have been largely unproductive since 1970, and only the one "superior" cliff on this stretch remains active. The number of productive pairs has declined from 16 or 17 in the years before 1970 to 9 or 10 since then.

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The Charley River, Alaska

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Of all the tributaries draining into the Yukon River between Dawson and Circle, the Charley River shows the most promise as a region with significant nesting habitat for peregrines. I surveyed the Charley River drainage in a helicopter with W. Brown of the National Park Service on 9 and 10 July 1975. Running for approximately 125 km from its mouth up through steep-walled valleys and canyons to its eastern headwater branch, the Charley River has no fewer than 49 major cliffs, any one of which could house a pair of falcons. In fact, from the first cliff about 2.5 km up from its mouth to the division into east and west headwater forks, one is never out of sight of a major rock formation.

The only way this river can be surveyed adequately for peregrines is on the ground. Even with a helicopter, it would be necessary to stop at each cliff and climb up and down for an hour to several hours at each place, in order to be certain whether falcons are present. In the short time we had for our survey, no precise information on the number of breeding pairs could be obtained.

Even so, we saw peregrines at four, and probably five, widely spaced cliffs, and we saw clear signs that falcons had been present within the last year or two at two other cliffs, which were marked with droppings and had green grassy ledges on them. We found an adult female feeding one 3-week-old chick at a cliff on the right limit above Highland Creek; and a pair of adults at a cliff on the left limit below Crescent Creek certainly acted as though a nest with young were present, but we could not find it. The other sightings were of single adults at cliffs.

The work on the Charley River was supported by the National Park Service and the Bureau of Land Management, United States Department of the Interior. I also thank the Arctic Institute of North America and the Chapman Fund of the American Museum of Natural History for grants-in-aid.

The Fortymile River, Alaska

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The Fortymile River is a tributary of the upper Yukon flowing northeastward through eastern Alaska and the western Yukon Territory. Since a substantial population of falcons is known to exist in the Yukon Valley (Cade 1960), and since numerous cliffs along the Fortymile appear favorable as nesting sites for peregrines, it seemed worthwhile to see whether a significant number of peregrines nest on the cliffs along this river.

In mid-July 1975, a brief aerial survey was conducted in the drainage of the Fortymile, followed by a boat trip on the South Fork of the Fortymile and on the Fortymile from the confluence of the North and South Fork to the Yukon River. One cliff was found occupied by a pair of peregrines, but no evidence of successful nesting was found on this cliff at the time of the survey. There are also extensive cliffs on the North and Middle Forks that need to be checked.

The reason for the apparent paucity of peregrines in the area is unknown, but the lack of available prey and hunting territory may be factors of importance. This mountainous, well-drained, forested valley is lacking in marsh and lake habitat and, except for the Spotted Sandpiper (*Actitis macularia*), is nearly devoid of shorebirds and waterfowl. The narrow canyon also lacks the extensive gravel bars and exposed areas, common along larger Alaskan rivers, which provide good hunting habitat for the peregrine. Alternatively, falcons may formerly have been more common along the Fortymile but may have disappeared as part of the general decline witnessed in other areas of Alaska, such as along the Tanana River (Haugh, this compilation), in recent years.

Tanana River of Alaska

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In 1970 an organized effort was made to survey as many breeding populations as possible to determine the status of the Peregrine Falcon in North America (Cade and Fyfe 1970). As part of this effort, I conducted a survey on the Tanana River (Haugh, *in* Cade and Fyfe 1970).

This paper reports the results of a 5-year study, from 1970 to 1975, on changes in the population of Peregrine Falcons along the Tanana River in interior Alaska. Data were collected on the physical features of nest sites, site occupancy, reproductive success, and the effects of man, in an attempt to determine some of the factors influencing the population dynamics of the falcons.

The Tanana River is one of the largest Alaskan rivers. From its origin at the confluence of the Nabesna and Chisana Rivers in eastern Alaska, it flows over 650 km through the taiga of interior Alaska before emptying into the Yukon River near the village of Tanana. There are at least 45 major cliffs between Tetlin Junction and Nenana.

In each of the 5 years of my investigation, a survey was made from Tetlin Junction to Nenana, a distance of approximately 480 km. The trips were made during the month of July at a time when viable eggs had hatched and young falcons were in the nest. The observations in 1970 and 1973 were made during the first half of July when downy young were in the nests. In 1971, 1972, and 1974, studies were conducted during the last two weeks of July when the young birds were within a few days of fledging.

A total of 16 sites was examined each year from 1970 through 1975. Information for the years prior to 1970 were obtained from L. Swartz, B. Kessel, and D. Grisco (personal communications). T. Cade and C. White surveyed the Tanana River in 1975 and have allowed me to include their observations here. Table 16 summarizes the available data on occupancy and reproduction for the Tanana River peregrines through 1975.

Nine of the 16 sites checked along the Tanana River in 1970 were unoccupied, and no evidence of reoccupancy was found in subsequent years. At the seven occupied sites, adult falcons fledged 20 young in 1970 (Haugh, *in* Cade and Fyfe 1970). In 1971 three additional sites were unoccupied, and no evidence was round to indicate that falcons returned to the cliffs or attemped to nest in any year after 1971. From 1971 to 1973 seven to nine young were produced at the four remaining active cliffs, but in 1974 only one cliff was occupied in July by adult falcons, and only a single young was fledged at this site. Peregrines were observed in early June at another cliff by an Alaska Department of Fish and Game research biologist (T. Smith, personal communication), but this pair either failed to lay or had early nesting failure, for they were not present in July

In 1975, T. Cade and C. White found a pair of

TABLE 16—Site occupancy and reproduction by peregrines along the Tanana River. x = Site occupied, no data on reproduction; - = site unoccupied; nc = site not checked; numerals indicate the number of young produced at site.

Site number	Cliff description[1]	Years								
		Pre-1963[2]	1963[2]	1868[2]	1970	1971	1972	1973	1974	1975[3]
1	BB	x	nc	1	-	-	-	-	-	-
2	AA	x	nc	3	3	0	2	1	1	0
3	AA	x	nc	1	3	3	2	1	-	0
4	AA	x	nc	1	3	3	0	3	-	-
5	BB	x	nc	x	-	-	-	-	-	-
6	AC	x	x	2	1	-	-	-	-	-
7	BB	x	nc	3	-	-	-	-	-	-
8		x	nc	1	x	nc	-	nc	-	nc
9	AC	x	nc	3	4	3	3	3	-	-
10	CA	x	x	3	-	-	-	-	-	-
11	CB	x	x	0	2	-	-	-	-	-
12		nc	3	nc	nc	nc	nc	nc	nc	nc
13	CB	x	nc	4	-	-	-	-	-	-
14	CB	x	nc	1	-	-	-	-	-	-
15		x	nc	x	nc	nc	nc	nc	nc	nc
16	CC	x	nc	x	-	-	-	-	-	-
17	BB	x	x	x	4	-	-	-	-	-
18	CB	x	x	nc	-	-	-	-	-	-
19	BB	x	x	nc	-	-	-	-	-	-

[1] Cliff description key: The first letter indicates the likelihood of human activity or disturbance at the cliff (A = disturbance unlikely, B = disturbance possible, C = disturbance likely). The second letter indicates the degree of protection afforded nesting falcons by the size and structure of cliff (A = maximum protection, B = moderate protection, C =little protection).

[2] Data from D. Grisco, Brina Kessel, or L. Swartz (personal communications).

[3] Data from T. Cade and C. White (personal communications).

peregrines at only one site but were unable to find any evidence of successful nesting. They observed a single adult near another site, and an abandoned egg but no birds was found at a third cliff. Thus, it appears that in 1975, for the first time during this study, no falcons were fledged from the Tanana nest sites.

Cade et al. (1968, p. 177) judged that in 1966 interior Alaskan falcons along the upper Yukon were "perilously balanced near the threshold level of organochlorine residues that initiated dysgenic reproductive behavior and eventual population decline." Since the Tanana peregrines are part of the same interior Alaskan population, it is possible that residue levels in these birds would be similar to those of the Yukon falcons in 1966. Since the late 1960s, the species has been considered too rare for specimens to be collected solely for analysis, but three addled eggs were obtained in 1969, and three more were obtained in 1973 from nest sites along the Tanana River. The analysis of these eggs has provided evidence that eggshell thinning and organochlorine levels are similar to those normally expected to prevent adequate reproduction for population maintenance (Peakall et al. 1975) and suggests that organochlorine contamination is a factor of major importance in the decline of the Tanana falcons. Nevertheless, the fact that peregrines along the Tanana disappeared during a time when birds continued to occupy cliffs along the Yukon indicates that other factors could have contributed to the disappearance of the Tanana falcons.

The decline along the Tanana is in agreement with other reported studies showing that nest sites isolated from human activity are occupied longer than other nests (Rice, *in* Hickey 1969), and sites located on the largest cliffs are preferentially occupied (Hickey 1942, 1969). The last sites to be occupied are located on the largest cliffs on the river and are the most isolated from man's influence (see Table 15), whereas sites where birds first disappeared are located on accessible cliffs, poorly isolated from disturbing activities of man. This pattern of occupation suggests that man has played a role in the decline of the peregrine along the Tanana, perhaps by shooting adults or otherwise disturbing nesting birds.

In light of the ability of healthy peregrine populations to acclimate to man's presence and recover from heavy predation (Ratcliffe 1963), the pattern or abandonment and decline observed in the Tanana Valley suggests that the direct interference of man has hastened (rather than caused) the decline of a population already weakened by other detrimental factors. This view is reinforced by the decline of other more isolated populations, such as the Arctic Peregrines (*Falco peregrinus tundrius*) along the Colville River in northern Alaska. A high probability exists that organochlorine pesticides, a primary factor in the drastic decline of the British peregrines (Ratcliffe 1963, 1972), have influenced the birds along the Tanana.

The decline of the peregrine population in North America and Europe has generally been associated with peculiar reproductive failures, followed after a time by the disappearance of adults from their nesting cliffs (see Hickey 1969). The decline in the number of fledged young from 26 in 1967 to none in 1975, and the reduction of adult pairs, indicate that the Tanana falcons are exhibiting a similar pattern. Without observations at the nest sites in June, it is impossible to state with certainty, however, that only one or perhaps two pairs of falcons attempted to nest in 1974 and 1975. Nevertheless, the failure to locate any sign of birds (i.e., prey remains, excreta, non-breeding adults) at previously occupied sites does strongly suggest this. Moreover, the failure of any site along the Tanana to be reoccupied once abandoned lends support to the idea that what is involved is not a temporary nesting failure but a permanent loss of breeding pairs. Whether this is the result of reproductive failure and failure of fledglings to survive to enter the breeding population, increased adult mortality, or a combination of these factors is unclear. It is clear, however, that without a dramatic reversal in the present population trend, the extinction of the Tanana River peregrines is likely in the near future.

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Noatak River Valley and Iliamna Lake Regions of Alaska

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In an attempt to determine the status of the Peregrine Falcon in the Noatak River Valley of northwestern Alaska and the Iliamna Lake area of south central Alaska, I spent a month in 1971 and three weeks in 1975 surveying the Noatak River and its tributaries, and in 1975 I conducted a 10-day investigation of the Iliamna Lake area. In both of these regions, a fixed-wing aircraft was used to make an aerial survey, and in both 1971 and 1975 I travelled by boat on the Noatak River to make a closer study of nesting raptors along the river.

In an early survey of the avifauna of the Noatak River, McLenegan (1887) failed to mention the

Peregrine Falcon as occuring in the valley. E. S. Hall (personal communication), an anthropologist working in the valley during the early 1960s, identified one pair of nesting falcons as peregrines and believed that a second pair he observed was also of this species. Manuwal (1974) considers the peregrine to be a resident bird in the area. A careful perusal of these papers, however, reveals that no actual nests were found during the collection of field data, and the peregrine is listed as a member of the avifauna only through observations of flying birds (Dean and Chesemore 1974).

During my investigations, I found no evidence of peregrines nesting along the Noatak, although Gyrfalcons (*Falco rusticolus*) were found nesting on cliffs at several locations. It is possible that the peregrines noted in the above reports may have been falcons from the Colville River drainage that were wandering or migrating south after having had a nesting failure farther north. Another possibility is that Gyrfalcons may have been misidentified as peregrines in some instances.

Hall's observations suggest a small number of peregrines may have nested along the Noatak in the past. The peregrine may also have been present at the time of McLenegan's survey, since he failed to report a number of species subsequently found along the Noatak. Evidence indicates, however, that the Noatak was at best a marginal area for peregrines and that, if birds did nest there, they disappeared before the present decade, perhaps as part of the general decline observed over widespread areas of North America during the 1960s (see Cade and Fyfe 1970). The species is not now a part of the nesting avifauna of the Noatak Valley.

The Peregrine Falcon may have a similar history in the Iliamna Lake – Lake Clark area. S. Hornberger (personal communication) of Port Allsworth, Alaska reported a peregrine occupying a cliff on Lake Clark in 1975, but she found no nest. I believe her identification of the bird to be correct, but I was unable to locate the falcon in late July. I was unable to find any other conclusive evidence that peregrines nested in the Iliamna Lake – Lake Clark area in 1975 or in the recent past (Williamson and Peyton, 1962). If the species did nest in this region in former times, I believe it unlikely that any sizeable breeding population existed.

The Western Coast of Alaska

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Based on limited data, it seems that the western coast of Alaska differs from portions of the Aleutian Islands, the upper Yukon and Tanana River valleys, and the Colville River in that it apparently has no history of having supported more than widely scattered pairs of peregrines. Cade (1960) previously noted the apparent paucity of breeding pairs along the coast. Our observations in this area and all information we have received to date support this conclusion. The distant offshore islands of the Bering Sea also have little apparent history of occupancy. The personal communications we have received have not reported the presence of peregrines on Little Diomede Island (S. Stoker), King Island (Stoker and R. Pegau), St. Lawrence Island (S. Johnson, Stoker, Pegau), Nunivak Island (E. Knoder), and St. Paul Island (M. Thompson). Bailey (1956) reported a specimen of an immature male identified as *F. p. anatum* collected on St. Lawrence Island on 15 September 1950. Sealy et al. (1971) found a feather near Gambel, St. Lawrence Island on 21 July 1967 that was identified as a rectrix from a first year peregrine. A female, identified as *F. p. pealei*, was collected on St. George Island 12–14 March 1914 (Gabrielson and Lincoln 1959). Peregrines have also been reported breeding on St. George Island, but this is an error (Cade 1960).

On the mainland coast of Alaska, nesting habitat is virtually absent from Point Barrow southwest to Cape Lisburne, a distance of about 500 km, although Childs (1969) did report two pairs nesting inland along the Pitmegea River in the late 1950s. Cliffs at Cape Lisburne and along the coastline both east and south support large numbers of nesting seabirds, and it is probable that breeding peregrines occur in this region. Peregrines have nested to the south on the sea cliffs at Cape Thompson, which is only separated from the Cape Lisburne cliff system by about 52 km (Swartz 1966). In 1959 two pairs nested on the Cape Thompson cliffs and fledged at least two young. At least one pair nested in 1960 and 1961; two young were fledged in 1960 and three in 1961.

No suitable nesting habitat exists south from Cape Thompson to Chamisso and Puffin Islands in Kotzebue Sound. Aerial reconnaissance by Roseneau in 1969 suggested that at least Chamisso Island might support peregrines. A specimen of an adult female from Chamisso, undated and with no collector named, exists in the American Museum of Natural History, New York. This specimen could represent either a resident breeder or a migrant.

Alaska Department of Fish and Game research and University of Alaska raptor programs during 1968–1972 produced good information for virtually all of the Seward Peninsula including its inland areas. Potential nesting habitat for peregrines was found to exist primarily along the peninsula's coast in the vicinities of Deering – Goodhope River. Wales Mountain, Cape York, Tuksuk Channel, Cape Riley, the southern and western portion of Sledge Island, Topkok Head, Bluff, Rocky Point, Cape Darby, Portage Roadhouse, Mount Kwiniuk, and Bald Head.

A small seabird colony west of Deering along the southern edge of Kotzebue Sound has supported breeding peregrines. Roseneau and W. Walker observed a defending pair there in 1970. Prior to 1970 the only recorded nesting of peregrines on the Seward Peninsula occurred in 1935 at Wales Mountain (Hanna 1940), where we failed to locate this species during 1968–1972. Hanna (1940) also reported the collection of a peregrine on Wales Mountain on 25 May 1939. G. Divoky (personal communication) saw a single peregrine near Wales Mountain on 11 September 1973.

Eastward from the Wales Mountain – Cape York region, potential peregrine habitat is next encountered along the southern coastline of the Seward Peninsula at Tuksuk Channel where Cade (1960) reported Gyrfalcons, and Roseneau, Walker, and Springer found Gyrfalcons and Rough-legged Hawks nesting during 1968–1972. South of the Tuksuk Channel area a small sea-cliff and seabird colony at Cape Riley has supported a nesting pair of Gyrfalcons, but peregrines were not encountered here during 1968–1972.

Between Cape Riley and Topkok Head, little coastal habitat is available; however, one notable situation does exist. Sledge Island lies approximately 9.5 km offshore and 35 km west of Nome. It supports a colony of seabirds at its southern end and has good escarpments along its western side. Cade (1952) did not find peregrines nesting there in 1950, but a pair of Rough-legged Hawks was present. During 1969–1972 no raptors nested there, although Gyrfalcons probably occasionally have in the past. Between 25–28 July 1975, however, W. H. Drury (personal communication) observed a pair of adult peregrines on the southwest section of Sledge Island. A nest was not located, although a female was observed on several occasions carrying prey, which was brought in by the male, to the same area of the cliff face. It is presumed that she was feeding young.

Topkok Head was found to support both Gyrfalcons and Rough-legged Hawks during 1968–1972, but peregrines were never observed in the vicinity. Drury (personal communication) reported individual peregrines at Topkok once in early July and twice during late July and early August 1975; no nest was found.

Excellent coastal habitat, similar to that of the Topkok area, is also found at Bluff. In 1968–1972 Gyrfalcons and Rough-legged Hawks were found nesting here, but no peregrines were observed. Again, Drury (personal communication) reported a pair of adult peregrines with one fledged young between Bluff and Square Rock during 15–20 August 1975. Because of the late date, it is possible that this pair could have nested elsewhere. The fledgling, however, frequented the same site on the cliff face, suggesting that the nest was there.

Peregrines have not been observed by us at the remaining coastal areas that offer potential nesting habitat, although Gyrfalcons were found nesting near Rocky Point in 1969.

The next potential peregrine nesting habitat south of the Seward Peninsula lies at the head of Norton Sound. Cade (1960) reported one nesting at Cape Denbigh. Peregrines were not located in this locality or along the sea cliffs north to Point Dexter in 1969. Besboro Island at the head of Norton Sound also appears to offer some potential nesting habitat, although no information is available for this area.

Between Norton Sound and Cape Pierce, far to the south, little nesting habitat for peregrines is available. Much of this extensive coastline consists of the broad, flat Yukon–Kuskokwim River delta with only a few major series of sea cliffs. The first cliffs that may offer potential nesting habitat are Cape Romanzof and Cape Vancouver, but data are lacking for these areas. At Goodnews Bay one nesting peregrine was reported to Roseneau by local residents in 1962. The site was located at Beluga Hill on the north side of Goodnews Bay, and nesting was said to have occurred in the late 1940s. This report must be considered suspect because of possible confusion with Gyrfalcons. The site was visited in 1962, and, although not occupied, it bore some evidence (molted feathers) of having been used by Gyrfalcons in the past. It was definitely used by Gyrfalcons in the 1930s and in 1949 (T. J. Cade, personal communication).

Peregrines have also been reported from Cape Newenham though Cade (1960) clarifies the suspect nature of the historical observations at this locality, and again W. E. Griffee reported Gyrfalcons nesting on the sea cliffs there. Peregrines, however, have been observed in this area in recent years. M. Dick and L. Dick (1971. Natural history of Cape Pierce and Nanook Bay. United States Fish and Wildlife Service, unpublished report. Washington, D.C.) reported observations of single peregrines, thought to be juveniles, at Cape Pierce on 21, 23, and 24 August 1970. On 25 August 1970 they observed two peregrines thought to be adults. Because of the late date and the fact that nests were not observed earlier, these birds were considered to be migrants. On 8 May 1973, again during migration, three peregrines, thought to be adults, were observed passing through this same area (L. Schandelmeier, personal communication), and on 7 June, M. Dick watched an adult pursue a sparrow.

The last potential nesting habitat for peregrines along the Bering Sea coast north of the Alaska Peninsula and the Aleutian Islands appears to be on Hagemeister Island and the Walrus Islands. D. Weir (personal communication) did not observe peregrines on the islands during avian reconnaissance there in 1952 and 1962.

The reasons for the apparent low numbers of breeding peregrines along the western coast of Alaska are not clear, nor are the reasons for the apparent lack of breeding peregrines on the islands of the Bering Sea. In all, we can find valid records of no more than 10 pairs of peregrines ever nesting in the region. Unfortunately, we do not have enough data from earlier times either to confirm or reject the possibility that the numbers found recently reflect declines during the past few years, but the bulk of what we do have suggests sporadic occupancy over a very long period. Further complicating any efforts to rationalize what we find is the fact that we do not know from which migratory population or populations the birds under consideration are derived. It seems possible that the birds on the northern section of the coast are a part of the North American *tundrius* population and that the birds in the central region might be derived from the *anatum* race. We doubt that climatic limitations and competition with Gyrfalcons, both posed by Cade (1960) as possible factors limiting peregrines in some areas, are important here, but have only one additional speculation to add for future evaluation. The 25 relatively small stretches of coast including the near islands, within which suitable nesting habitat occurs, as outlined above, are widely scattered along approximately 3500 km of coastline (Cape Lisburne to the Walrus Islands). The distant offshore islands in the Bering Sea are also widely scattered, and suitable nesting habitat occurs along only certain portions of their shorelines. The one factor in this region that is different from areas such as the Aleutian Islands, Yukon River, and the Colville River is this wide separation of relatively limited breeding sites. It is possible that this may account for the apparent sporadic occupation of sites, perhaps owing to a lack of consistent recruitment.

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Gulf of Alaska Coast and Southeastern Alaska

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This report reviews data through 1975, mainly from unpublished material, for the coastal portion of Alaska between about 162° W and 134° W, including Kodiak Island. The region considered starts more or less where information on the Aleutian Islands leaves off (White, this compilation, 1975) and extends some 2880 km from the end of the Alaska Peninsula to Prince William Sound and south along the Alexander Archipelago to Forrester Island. The entire area has not been previously reviewed, other than the brief statements made by Cade (1960), and information is sketchy because there have been no specific studies on the peregrine.

A feature of this region is that good sea-cliff structure is frequent and either scattered or, in some cases, more or less continuous throughout a major portion of the coastline, and to attempt to outline discrete areas of peregrine habitat is futile. Also, prime peregrine prey species (alcids, small gulls, and petrels) are widespread and generally common to abundant. Yet the records suggest spotty, low to sparse falcon densities compared to adjacent regions with similar conditions on either side of this area. Near the end of the Alaska Peninsula, M. Hehnke (personal communication) surveyed in some depth an area extending over about 864 km from Chiqnik Bay to Samalga Pass plus some large island groups, during the summers of 1968–1970. A total of 61 nest sites was found, 35 between Chignik Bay and False Pass, 22 in the eastern Aleutians and 4 elsewhere. Nearly all nest sites were on islands rather than cliffs on the mainland. Areas with numbers of pairs were Chignik Bay to False Pass (5 on mainland), Nakchamik Island (1), Chankliut Island (1), Chiachi Islands (4), Shumagin Islands (12)). (W. Troyer found one additional nest on Simeonof in the Shumagins not found by Hehnke), Pavlof Islands (6), Deer Islands (2) and Sanak Islands (4). There is a general lack of information from the entire coast east of Kulukta Bay to Katmai Bay, a distance of some 320 km.

In May 1972, W. Troyer surveyed the Semidi Islands for wilderness status. He (personal communication) only located one definite nest site, although alcids and kittiwakes are common, but he really covered only one island thoroughly.

During the "summer" of 1962, C. Yamata (personal communication) found one nest site on the mainland "in the general Katmai Bay region" after reaching land on a boat trip heading almost directly north from Karluk, Kodiak Island. Cahalane (1944) does not report any breeding peregrines along the coastal Katmai region. D. Gibson (personal communication) worked the entire coastal area around Kukak, Katmai region in 1967 where peregrine habitat is "good." He saw only one immature on 4 July. None was seen in 1966 or 1968. Data are not available east of Katmai from Hallo Bay until Cook Inlet, some 220 km.

From the Kodiak Island region, we were unable to find data for Chirikof, Shuyak, Afognak, and the Trinity Islands. Data for Kodiak, though perhaps inconsistent, may suggest the nature of the density for the entire region. From the extensive review Cade (1960) made on Alaskan breeding records, he points out that despite statements that peregrines are common residents and breed there, he could not locate a definitely recorded breeding record for Kodiak. Friedmann (1935) doubted they were common. M. Dick (personal communication) spent the entire summer of 1975 finding and examining seabird colonies for the United States Fish and Wildlife Service. He surveyed the total northwest coast but failed to find a breeding peregrine. R. MacIntosh (personal communication) has numerous sightings in the Chiniak Bay region during the winter of 1974–75, but remarked that they were "last seen on April 25 despite 14 trips into good Peregrine habitat between April 26 and May 15, 1975." For Kodiak, we have learned of only four definite sites, two on the mainland on the eastern side of the main island (1968–1970), one on an offshore islet, and one in Uganik Bay (1973) (M. Heiner, M. Hehnke, personal communication).

Barren Island has had two recorded sites, on different islands, one on East Amatuli Island in 1965 (D. Roseneau) and one on Sud Island in 1975 (E. Bailey, personal communication). The earlier site was not active in 1975.

Within Cook Inlet, Kalgin Island was reported to have "a pair" and Chisik Island to have five or six pairs prior to 1960 (R. Graham and V. Siefert, personal communication). Only one pair was found on the latter island during studies on kittiwakes in the early 1970s (D. Snarski, personal communication), and J. Haugh (personal communication) saw only one there in 1975. A portion of the western coastline of Cook Inlet was also reported to have had several nesting pairs present prior to about 1960 (V. Siefert, personal communication).

Along the northwest coast of Kenai Peninsula only one site was documented at Kachemak Bay in the early 1960s (F. S. L. Williamson, personal communication), and a second was found in 1970 (M. Hehnke, personal communication) also in Kachemak Bay.

For the Gulf of Alaska from Cape Elizabeth east through Prince William Sound to Icy Cape, well over 480 km and including such large islands as Montague, Knight, Kayak, and Hichinbrook, Isleib and Kessel (1973) documented only 12 different nest sites (Isleib, personal communication) after some 10 years' study. They judge the peregrine to be a rare resident with nests generally associated with seabird nesting colonies or waterfowl breeding areas, and they estimate that perhaps 20 pairs may exist in the entire region. Roseneau found a nest site on Tanker Island in 1967 that was unknown to them, and White (*in* Hickey 1969) reported one not included among their 12.

Shortt (1939) noted several falcons in Yakutat Bay during the summer and indicated there were many suitable nesting situations, but failed to obtain evidence of actual breeding. M. Heiner and F. Robards (personal communication) have independently looked at Yakutat, and both agree that not more than two to three pairs can be expected there.

Most of the Malaspina Coastal Plain, except for Yakutat Bay, which extends for about 280 km, has essentially no peregrine habitat and may act as something of a barrier between populations south through the Alexander Archipelago and beyond and those north through the Gulf of Alaska and the Peninsula.

The panhandle of Alaska south of Cape Fairweather extends over a distance of 520 km and has more than 19 200 km of shoreline. For this region, excluding Forrester Island, fewer than 20 sites are documented despite active searching by several independent parties since 1965.

Other than the cited literature, the following data came from A. R. Weisbrod, M. Heiner, F. Robards, and D. Spencer (personal communications). The numbers of known nest sites in each region are as follows: Glacier Bay Area (3), mainland between Juneau and Berners Bay (1), mainland between Juneau and Petersburg (3), mainland between Petersburg and Portland Canal (1), Chichagof Island (4), Admiralty Island (1), Barnof Island (2), and Sitka Sound (1).

Cade (1960) earlier called attention to this region as one of low density, and this is supported by a rather extensive survey in 1975. D. Gibson (personal communication) surveyed the southern portion over about 320 km between 17 and 27 July while cataloguing seabird colonies for the Unites States Forest Service. The ship started at the northern tip of Forrester Island, and the seaward side of Dall, Suemez, Baker, Noyes, Heceta, Coronation, and Spanish Islands, plus scores of small ones, were surveyed. The only peregrines observed were on Forrester Island.

Lastly, Forrester Island has been visited frequently. Willett (1915) found six nests. L. Crowley (personal communication) found three on the east side in 1969, and seven were reported for the entire island that year (F. Robards). Three were found on the east side in 1970 (T. Ray, personal communication), and between 6–7 July 1973, D. Houseworth (personal communication) found one young in one nest, two young in another, 10 flying young, and what they judged to be 10 pairs of adults during a helicopter flight of the entire island.

Certainly the entire region we have considered has not had good in-depth studies, but most information supports the idea of a sparse peregrine population with one or two local concentrations.

Queen Charlotte Islands, British Columbia

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An intensive inventory of all likely nesting habitat in the Queen Charlotte Islands for the Peale's race of the Peregrine Falcon was conducted by personnel of the British Columbia Fish and Wildlife Branch during the period 21 May to 2 June 1975. Although results of surveys by Branch personnel and others (Beebe 1960; Blood 1969; Nelson, *in* Cade and Fyfe 1970) have published for portions of these islands, the current inventory represented the first attempt to survey intensively all likely nesting habitat. Since previous Fish and Wildlife Branch inventories (I. Smith, unpublished) had indicated that the Peale's race utilizes only cliffs immediately adjacent to exposed marine areas, no attempt was made to inventory inland cliffs or those along inlets or other inland waterways.

The inventory technique consisted of firing a shot from a boat in the vicinity of all cliffs. Although a normal shotgun shell was usually utilized, where it was impossible to approach sufficiently close to a cliff for a shotgun blast to be heard above the roar of the surf, use was made of either tele-shot or rifle shells. In this manner it was possible to check satisfactorily the great majority of possible nesting areas. Although adverse weather conditions resulted in only marginally satisfactory checks of some limited stretches of coastline, we believe that insignificant numbers of birds were missed.

Because it was not possible to climb to all the suspected nest sites to confirm nesting activities, a nesting attempt was considered to have occurred if a site was occupied by two birds. If only one bird was seen, a nest was judged to be present unless the behavior of the bird suggested that this was not the case.

We located 56 sites that we believe were occupied by pairs of birds, plus an additional four sites at which we suspected there were only single tiercels. At two sites, three peregrines were noted. The total number of successful nests was probably less than 56, but it is also likely that the number of sites at which two birds were actually present was greater than 56. One such instance occurred on Langara Island where an independent survey by W. Nelson (this compilation) located a pair of peregrines where we concluded that only a tiercel was present. Nelson, however, found no evidence of a nest, thus confirming our conclusion that the site was not productive.

Comparisons of this inventory with published results of former inventories are difficult because Blood (1968) did not note specific nest locations, and because Beebe (1960) and Nelson (1970b) utilized different inventory methods. As indicated above, our method did not attempt to determine the actual number of nests, but rather attempted only to determine the number of pairs. Beebe and Nelson attempted to determine the number of nests, climbing to them in most instances. It is of interest to note, however, that of 12 sites identified as occupied in 1952 by Beebe, only three were occupied by a pair of birds in 1970 and 1975. The Langara population appears to have remained stable since 1970, with six pairs in both years. The population on the east side of Moresby Island has declined from 19 to 28 pairs in 1965 through 1967 (Blood 1968) to a maximum of 14 pairs in 1975.

Langara Island, Queen Charlotte Islands

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From 11 to 18 June 1975, all of the potential falcon nesting areas on Langara Island were examined, the occupied sites were watched at length, and the nestlings counted, aged, and sexed.

Six sites were occupied, all by adult pairs. One pair failed earlier in the season. Five pairs had 12 young (about 25 days old to just flying). If all of these did fledge successfully (which could be expected, although a few late nestling losses have occurred in other years), the 1975 productivity was as good as, if not slightly better than, the best previous year I have observed (Table 17).

One territory that held a single male from 1970 to 1973 was vacant in 1974. The neighboring female had been occupying the territories of her mate plus that of a single male. Apparently one of the males died during the past year, and the remaining pair now occupies the original two territories (this was the failing pair in

TABLE 17—Occupancy and reproductive performance of peregrines on Langara Island, British Columbia[1]

(a) Data on occupancy

Year	Total known sites	Number checked	Occupancy: Unoccupied	Occupancy: Lone adult	Occupancy: Pair	Percentage occupancy
1968	5	5	0	0	5	100
1969	6	6	0	0	6	100
1970	6	6	0	1	5	100
1971	7	7	0	1	6	100
1972	7	7	0	2	5	100
1973	7	7	0	1	6	100
1974	7	7	0	1	6	100
1975	7	6	0	0	6	100

(b) Data on reproduction

Year	Pairs with young	Percent of total pairs	Total young	Young per pair	Young per successful pair
1968	4	80	9	1.80	2.25
1969	3	50	5	0.83	1.67
1970	5	100	11	2.20	2.20
1971	4	67	11	1.83	2.75
1972	4	80	10	2.00	2.50
1973	5	83	11	1.83	2.20
1974	4	67	9	1.50	2.25
1975	5	83	13	2.17	2.60

[1] Data from Nelson and Myres (1976).

1975). This and other observations show that the present falcon population is a saturated one in terms of its food supply.

The very large numbers of several small seabirds at Langara Island described in the late 1940s and 1950s are now much reduced, apparently as a result of a decline in available zooplankton. The peregrines also have declined from an estimated 21–23 pairs breeding in the early 1950s to 6 pairs in 1975 (Beebe 1960; Nelson and Myres 1976). The falcons now defend large territories, apparently in response to the reduced seabird food base.

Samples collected from 1968 to 1972 showed that falcons and seabirds contained significant amounts of the pollutants DDE and PCB. Falcon eggshells averaged 12–13% thinner than pre-DDT eggshells from the same area, and some eggs and nestlings were lost, apparently because of effects of pollutants. But contamination has not quite reached critical proportions for egg breakage and population decline (Nelson and Myres 1976).

Production and survival of these falcons in recent years has been adequate to sustain their present breeding and "floating" or non-breeding populations. The future of the Langara peregrines is very closely tied to whatever changes occur in their seabird food supply.

Aleutian Islands

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At the time of the first North American Peregrine Survey (Cade and Fyfe 1970), studies on the Aleutian Islands had just begun, and the available data were limited. In this report I present information on Amchitka Island for the past seven successive years and data on population densities on several islands of the central and western Aleutian Islands spanning a linear distance of about 448 km.

Many aspects of the study through 1972 have been reported elsewhere (White 1975). The general status of the populations as reported in 1970 (Cade and Fyfe 1970) has not changed during the past five years, but some fluctuation in breeding success has occurred, apparently in response to climatic vagaries. Climatic factors may explain the poor reproduction noted in 1973. Chemical contaminants are low in egg contents when compared to other populations, and eggshells show only about 8% thinning (White et al. 1973; Peakall et al. 1975).

Reproductive performances and population densities for Amchitka peregrines are given in Table 18. In some years, such as 1968 and 1974, the data are incomplete because only a brief survey could be made or because different survey techniques were employed. One important point that can be extracted from Table 18 is that only about 12 (41%) of the sites that have been occupied are producing most of the young annually. The actual percentage is probably a bit higher, however, since some of the sites are occupied by single adults in some years. For Amchitka, this value has varied from about 0.9 to 1.7 young. If only nests which produced young are considered, the value has varied from about 2.3 to 2.9 young per site. Production rates for other islands in the archipelago that have been visited appear to be similar to those of Amchitka.

The density of peregrines within the Aleutian Islands has been discussed elsewhere (White 1975). Based on the estimated population density of one pair or a single defending adult per 16 km of shoreline (a conservative estimate) or of one pair per 10 km of shoreline as it is on Amchitka, the total population of the Aleutian Islands appears to be between 375 and 580 breeding pairs (White 1975). Population densities for specific islands are given in Table 19.

In summary, the peregrine population on the Aleutian Islands, as indicated by the sample studied on Amchitka, is apparently reproductively and demographically healthy.

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Eastern United States

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During 1975 we conducted a survey of most of the formerly occupied peregrine nesting sites known in the eastern United States. This survey was undertaken in order to determine whether any breeding peregrines still existed in the region and to assess the present habitability of the peregrine's former nesting sites with a view to selecting areas for the release of captive-produced falcons.

The region we surveyed included the following states: Maine, New Hampshire, Vermont, New York, Massachusetts, Connecticut, New Jersey, Pennsylvania, Maryland, Virginia, West Virginia, North

TABLE 18—Occupancy and reproductive performance by Peregrine Falcons on Amchitka Island, Alaska

(a) Data on occupancy

Year	Total known sites	Number checked	Occupancy			Percentage occupancy
			Unoccupied	Lone adult	Pair	
1968	29	7	0	0	7	100
1969	29	20	3	1	16	85
1970	29	23	2	2	19	91
1971	29	28	5	2	21	82
1972	29	28	9	1	18	68
1973	29	29	13	0	16	55
1974	29	29	14	0	15	51

(b) Data on reproduction

Year	Pairs with young[1]	Percent of total pairs	Total young	Young per pair	Young per successful pair
1968	4	57	11	1.57	2.75
1969	7	44	18	1.13	2.57
1970	10	53	29	1.53	2.90
1971	14	66	37	1.76	2.64
1972	12	66	30	1.66	2.33
1973	6	37	14	0.88	2.33
1974	5	33	10	0.66	2.00

[1] Although additional pairs of Peregrine Falcons were present, evidence of breeding was not established.

TABLE 19—Islands surveyed in the western and west-central Aleutian Islands

Island, year of survey	Shoreline surveyed, km	Mean number of pairs on island	Mean kilometres of shoreline occupied per pair
Amchitka 1969–1973	193	18.6	10.1
Semisipochnoi 1970	64	8	8.0
Rat 1971	34	4	8.5
Buldir 1972, 1974	19	4	4.8
Little Sitkin 1974	35	3	11.7
Segula 1974	26	2	13.0
Davidof and Khvostov combined, 1974	18	2	9.0
Agattu 1974	85	7	12.1

Carolina, South Carolina, Kentucky, and Tennessee. Within these states, we checked all or most of the historically known peregrine sites that were included in the inventory compiled by J. J. Hickey in 1941 (Hickey, unpublished). In all we checked 149 formerly occupied sites as well as an additional 32 sites that seemed suitable for peregrines but for which there was no history of occupancy. This accounted for 70% of the 212 known sites Hickey listed for the surveyed states.

None of the sites we checked were occupied by peregrines. In fact, only three sites held any visible evidence that falcons had ever been there. The absence of peregrines was not surprising, however, since Berger et al. (*in* Hickey 1969) had previously conducted a similar survey in 1964 and discovered no birds. The last known record of an adult peregrine occupying a nesting site in the East was in 1970 when Spofford observed a lone male at a site in Vermont. The decline and demise of the peregrine in this well known region has been documented by Hickey (1969). In conclusion, we found no evidence to suggest that the extinction of the peregrine in the eastern United States was not as complete as Hickey (1969) had concluded.

Our surveys did reveal a surprising diversity of other cliff-nesting raptors occupying the abandoned peregrine sites. Turkey Vultures (*Cathartes aura*), Black Vultures (*Coragyps atratus*), Red-tailed Hawks (*Buteo jamaicensis*), Golden Eagles (*Aquila chrysaetos*), Kestrels (*Falco sparverius*), Great Horned Owls (*Bubo virginianus*), or Ravens (*Corvus corax*) occupied 27 of the cliffs we checked.

Our surveys were supported by the United States Fish and Wildlife Service and the United States Forest Service through contracts to the National Audubon Society. Mrs. S. Spofford, Mrs. B. Temple, A. G. Nye, and S. K. Sherrod assisted us with parts of this survey.

Upper Peninsula of Michigan

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During the summer of 1975, a survey of historical Peregrine Falcon (*Falco peregrinus anatum*) nesting sites was conducted in three areas of the Upper Peninsula of Michigan: Isle Royale National Park, Pictured Rocks National Lakeshore, and the lands owned by the Huron Mountain Club. The history of the population that once nested in this region is poorly documented, but there are indications that the peregrine was once a breeding resident. Wood (1951, p. 127) lists it as a "... rare local summer resident in northern counties along the Great Lakes," Dodge (1961, p. 29) as a rare summer resident, and Zimmerman and Van Tyne (1959, p. 14) as having bred in Marquette, Alger, Delta, and Mackinac Counties. These published records formed the basis for the 1975 survey.

Isle Royale National Park has three areas of suitable peregrine habitat: Passage Island, the Pallisades, and Feldtman Ridge. The cliffs on Passage Island, because of interference from the Coast Guard station located adjacent to the cliff, are no longer suitable for falcons. The Pallisades, an area of basalt cliffs on the northeast end of the island, is reported by Stauber (1963) to have been used by peregrines at one time. I could find no evidence of past nesting. The Feldtman Ridge area appears suitable for peregrines, but no evidence of recent occupancy was found.

A preliminary survey of the Huron Mountain Club lands produced no evidence of peregrine activity. The sandstone cliffs on which Dodge (1961, p. 10) reported birds breeding appear too rotten for present peregrine use. An extended survey on the club lands may disclose other more suitable nesting cliffs.

Perhaps the best peregrine nesting cliffs in the study area were located in the Pictured Rocks area. Peregrine nests with young were reported by Barrows and Bradford (1912, p. 290) and Wood (1951, p. 128). W. Taylor (personal communication) reported that peregrines were present as recently as 1961 or 1962 and that young of that year were taken by falconers. I was able to locate this site by boat and found that ledge intact. Located at the 40-m level on a 65-m sheer rock face, the ledge overlooks Lake Superior to the northwest, has an extensive protective overhang, and is inaccessible to predators.

In summary, none of the former nesting sites of the Peregrine Falcon in the Upper Peninsula of Michigan were occupied in 1975 although most sites still appear suitable for nesting.

Upper Mississippi River and Lake Superior Regions

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During 1975 I conducted a survey of the historical nesting areas of the Peregrine Falcon along the north shore of Lake Superior in Minnesota and along the upper Mississippi River in Minnesota, Wisconsin, and northern Iowa. These areas once supported a nesting population of at least 30 pairs of peregrines, but since the mid-1960s, there has been no nesting activity in the region. The last reported nesting of peregrines in the Midwest was in the Boundary Waters Canoe Area in 1964 (Green and Janssen 1975, p. 69). Berger and Mueller (*in* Hickey 1969) found young in two nests along the upper Mississippi River in 1962 but observed adult birds only at one location for the next two years. Green and Janssen (1975, p. 69) include a sighting of adults near a site on the north shore of Lake Superior in 1964, but they have no summer reports of peregrines from 1965 to 1969. They do, however, report observations of single birds in two localities in the Twin Cities area in 1970 and 1971. Also, D Behrens (personal communication) observed a single peregrine near Red Wing, Minnesota during the summers of 1972 and 1973.

No extensive studies of the peregrine population in this region have ever been undertaken. Roberts (1932, p. 353–359) summarized the observations on peregrines up to 1932. He provided a few data on nesting chronology, clutch size, number of young, and migration dates. In the 1920s W. J. Breckenridge supplied more detailed reports of a few nests along the north shore of Lake Superior. From the 1930s to the 1950s the only "regular" observations on peregrines came from D. S. and J. A. Struthers (1940, 1941, 1942). Berger and Mueller (*in* Hickey 1969) conducted surveys of peregrine nest sites in Wisconsin and adjacent areas from 1952 until 1965. Based on these observations and occasional reports from other observations, it appears that this region supported a substantial, stable peregrine population.

During 1975 I visited six known sites along the north shore of Lake Superior, an area where Breckenridge found six pairs in 1927 and four pairs in 1928. Similar breeding densities are also reported by D. S. and J. A. Struthers (1940, 1941, 1942) for the immediate pre- and post-World War II period. Although few reports of nesting peregrines exist for the Boundary Waters Canoe Area or lakes on the Canadian border (Roberts 1932; Olson 1946), there are many apparently suitable cliffs and surrounding habitats in this region, and Indian names for many of the lakes indicate peregrines were frequently observed there.

Nest sites have also been reported on the St. Croix River north of Stillwater, Minnesota (Roberts 1932; Engstrom 1940; Plattes and Woolsey 1941). We know the exact location of only two of these nest sites, and it is doubtful if more than two or three pairs nested here simultaneously.

During 1975 I visited 27 known nest sites along the Mississippi River between Diamond Bluff, Wisconsin and Marquette, Iowa. It is likely that as many as 10–20 pairs nested simultaneously along the river in this 300 km stretch. Although we have only two verified reports (Huber 1962; Grewe, personal communication), some peregrines also nested a few kilometres "inland" from the Mississippi River along some of its tributaries (i.e., Whitewater, Cannon, Zumbro, and Root Rivers).

My 1975 surveys failed to reveal any resident peregrines at formerly occupied sites in the Midwest. Furthermore, none of the sites held any evidence of recent occupancy.

The United States Forest Service, North Central Forest Experiment Station funded my survey work during 1975. I am extremely grateful to W. J. Breckenridge and D. S. and J. A. Struthers for the valuable information they provided on the peregrines that formerly nested in the region. D. S. Struthers and P. T. Redig assisted me during the survey work.

Northwestern United States

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(Prepared by Stanley A. Temple)

This report summarizes what is known of the Peregrine Falcon populations in the northwestern United States (Washington, Oregon, Idaho, and western Montana). Our information on current nesting activity in the region is limited because no concerted effort has been made to locate active nests or even to check all the formerly occupied sites. As a result, our coverage of the region is very scattered, and much of our data is second-hand in nature. We believe, however, that even this less-than-complete information gives a general picture of the status of the peregrine in the region.

In the past, we know that the Northwest supported a sizeable population of peregrines. Nelson (*in* Hickey 1969) summarized most of the historical records of peregrines in the region. In brief, the population probably numbered over 150 pairs of birds, although there are definite records for only some 50–60 pairs. These birds were largely concentrated in several areas: coastal cliffs (6–10 pairs), the Columbia River (13 pairs), Okanogan River (10 pairs), Salmon River (4 pairs), Malheur Lake region (5 pairs), Crater Lake region (4 pairs), and the Cascade Range (6–10 pairs).

The following information on the current status of the peregrine is based primarily on a 1973 survey of 18 known sites by Craighead and reports by falconers and other observers during 1974 and 1975. Along the Oregon coast, we have reports of four or five pairs of nesting peregrines in both 1974 and 1975. We can confirm that at least one of these pairs produced young in 1975. In eastern Oregon, we have reports of three nesting pairs in both 1974 and 1975. We have no information about the reproductive performance of these birds.

In Washington we have received reports of at least nine occupied sites, but we feel that the actual number is not this great. We have been able to confirm only that birds nested at two of these sites. One pair may have fledged young in 1975, as immature birds were seen near a nesting cliff in late summer.

In Idaho our data are more reliable, and over the period 1973–1975, we know of four occupied sites each year. In 1973 one pair fledged young, but during the following years, we have no definite reports of young being fledged in the state.

In Montana, Craighead checked 13 formerly used sites in 1973 but found none occupied. In 1974 a single pair of nesting falcons was located, but it is not known whether they successfully reared young.

Our information suggests that perhaps as many as 13 sites in the Northwest have been occupied by peregrines during the past three years. We should point out, however, that there are vast areas of suitable peregrine habitat in the region that are very difficult to check thoroughly. As is true in most western states, the task of tracking down all, or even most, of the widely scattered pairs of peregrines is enormous. At least we can say that nesting peregrines still occur throughout the Northwestern States, even if their numbers are very much reduced and their reproductive success is poor.

Rocky Mountain Region of the United States

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Since 1973 we have surveyed Peregrine Falcon nesting sites in the region from southeastern Arizona to southern Montana. Our methods and 1973 results have already been reported (Enderson and Craig 1974), and this account summarizes our data from 1973 to 1975.

In 1973 we found 14 of 35 well-authenticated historical sites in the region occupied by pairs, but only three young were fledged. Eggshell thickness, determined from fragments and addled eggs, was about 20% less than pre-1947 levels. This thinning was accompanied by DDE in egg contents averaging 33 parts per million (wet weight). In 1974 only 10 pairs could be found, but 1.4 young fledged per pair, near normal for the species. Eggshells from five nests were as thin as in 1973, and the contents of two addled eggs from different nests averaged 14 and 15 parts per million DDE (wet weight).

We visited 25 former nests in 1975, plus a newly discovered site, and obtained information on two former sites known to us but visited by other observers. We also learned of three other apparently active nests, seen by competent observers, but did not verify them. Excluding these last three sites and the new one we found, 27 formerly used cliffs had seven pairs of adult peregrines. Hence, we could find 14, 10, and 7 adult pairs in 1973, 1974, and 1975, respectively, when newly reported or discovered sites are not included.

We have records on 19 sites among those considered above where the site has been visited in each of several years dating back, in nearly every case, to the 1960s. Table 20 shows the occupancy record for these best known sites in recent years.

Of the nine pairs seen in the 1975 survey, one included a yearling female which made no nesting attempt. At another site, the adult female suddenly disappeared while she was still caring for young in the nest.

Of the eight adult pairs, including the new one we found, five pairs are known to have laid eggs, and one pair, probably two, laid second clutches. In all, two young certainly fledged; three others, seen as large downy young, probably fledged, and three more might have fledged, but neither they nor the adult female was present on the cliff about two weeks after the likely fledging time, even though the male was present continually. If five young did fledge, the productivity averaged about 0.7 young per adult pair.

Broken eggs were found in both clutches of one pair that ultimately failed, and another had a clutch of addled eggs. Three half-grown young died at one site where the female disappeared, but the male successfully reared the remaining two young.

TABLE 20—Occupancy history of 19 Rocky Mountain peregrine nests

(a) Data on occupancy

Year	Total known sites	Number checked	Occupancy: Unoccupied	Occupancy: Lone adult	Occupancy: Pair	Percentage occupancy
1972	19	15	4	2	9	73
1973	19	19	6	3	10	68
1974	19	17	7	2	8	59
1975	19	18	11	1	6	38

The years 1973 to 1975 have seen a continuing decline in the use of formerly known sites and a rate of reproduction in that averaged only 0.7 young per pair for the nesting attempts we saw in those years. The fact that new sites are reported or found occasionally suggests that there may be many unknown sites still to be found in the region. But, if the entire population is experiencing the downward trend seen for the historical sites, it cannot be too many years until a known active peregrine nest will be very hard to find in the Rocky Mountain region.

We thank Daniel D. Berger, David Ponton, Tom Smylie, and Marcy Cotrell for helping with this work. This project was supported by a United States Fish and Wildlife Service contract through the World Wildlife Fund.

Utah and Eastern Nevada

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By 1972 the presence of 30 known and 12 suspected (based on pairs of adults at cliffs) peregrine nesting sites had been documented for Utah (Porter and White 1973; White and Porter 1972). This was a rather surprising finding in view of the climate and topography of the state. Utah, with an area of 219 000 km^2 is essentially a desert state with an annual precipitation of between 10 and 25 cm. In spite of the seemingly marginal peregrine habitat in Utah, a density of about one pair per 5490 km^2 was achieved, assuming that all localities with peregrines were active simultaneously. The greatest density occurred along the Wasatch Mountains fronting the extensive marshland produced by the Utah and Great Salt Lakes. The average distance between sites there was 16 km for 13 nests, but all the habitat is not suitable for peregrines. If one considers only areas with cliffs, the distance is reduced, on average, to 3 km of suitable habitat between sites. The size of the population then was significant when one considers the known or suspected peregrine density for some of the neighboring areas of the West. At the time of the report by Porter and White (1973), none of the known sites was positively known to be active, although a few pairs still were suspected to occur in the state.

In 1973 we checked eight formerly occupied sites, eight areas where peregrines might be suspected to occur, and one area where a peregrine was reported to be. No peregrines were found. In 1974, 37 areas were checked, four of these being in Nevada. Seventeen areas had formerly been used by peregrines. Seventeen areas were newly checked with the majority being areas of likely peregrine occupancy. Three areas were reported to have nesting peregrines. No peregrines were found in 1974. We later, however, received reports of peregrines being seen in August at one well known site. The tally of areas examined does not convey the nature or the extent of the survey. For example, one area was checked along the Colorado River where peregrines were known to nest at least through 1958, and in addition, some 48 km^2 surrounding that precise site were also checked. This was recorded as checking only one area, however.

In 1974 and 1975 two individuals working on other projects reported peregrines. In northern Utah an adult was repeatedly seen, and although two specific nest sites were thought to have been found, one pair proved to be a Prairie Falcon (*Falco mexicanus*). In 1975, P. Scott and K. Kertell (personal communication) watched a site in southern Utah that fledged at least two young. Upon investigation, they were able to determine that three peregrines were seen there in 1974, and an immature was seen near there in 1973. Both observations suggest breeding in those years. This is an area where peregrines bred in the past.

In summary, a total of 82 different cliff areas were checked at 55 different localities in the states of Utah and Nevada, and flights with a fixed-wing aircraft were made along two areas during the summers of 1973 and 1974. Some of the localities consisted of 32 km stretches of cliffs. No nesting peregrines were located. Only one nest is currently known to be active, and one other area at the opposite end of the state may have an additional nest. The extent and nature of the habitat at these two localities suggests that another three to four occupied sites could be there. Additionally, vast areas along three river systems may contain another half dozen nest sites; this is speculative and needs serious investigation. Of the 42 formerly known or suspected sites, only two definitely remain active as of 1975, and only one produced young.

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New Mexico

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This report summarizes the results of our 1975 survey of Peregrine Falcon nesting sites in New Mexico, a state in which known breeding pairs of peregrines formerly occurred no less than 10 different sites. It is important to note, however, that there has never been a thorough survey of all the suitable peregrine nesting habitat in the state. As is true in most western states, the area's mountainous terrain affords many potential nesting sites, making a complete survey a formidable task.

In 1975 we checked only five well-known historical nesting sites and one new site. All these sites were in the north-central mountain region or in the southwestern corner of the state. We found four sites occupied by breeding pairs and one site occupied by a lone adult.

We have some data on the reproductive performance of these four pairs of peregrines. Three of the pairs fledged to a total of at least five young, but the fourth pair failed in its nesting attempt. Apparently one other breeding pair, unknown to us, also fledged young. We saw an immature peregrine on 18 July 1975 in an area of southwestern New Mexico where we know of no active nests.

From our experience with peregrines in New Mexico, we would estimate that the total breeding population of the state is probably on the order of 15 pairs. It is difficult to assess the status of the peregrine population in New Mexico on the basis of our incomplete data. An encouraging indication of the population's stability, however, is the fact that peregrines have occupied four well known sites continuously for at least the past 10 years.

Arizona

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Although many observers have reported peregrines summering and breeding in Arizona, 1975 was the first year that an organized effort was made to determine the bird's status in the state. Information has been compiled for 33 historical sites where reliable observers have reported peregrines breeding or probably breeding in the past.

The historical records that formed the basis of the 1975 summary were varied. Five sites had well authenticated histories of peregrines breeding, and fledged young had been seen with adults at three other sites. Defensive adults had been observed at eight locations, and adults had merely been seen during the breeding season at an additional 13 sites. There were also reports of breeding, without evidence, at four localities.

The distribution of these historical sites within Arizona is uneven. If Arizona is roughly divided into four quarters, 15 historical sites are located in the northwest sector, three in the northeast sector, six in the southwest sector, and nine in the southeast sector. These previously occupied sites occur in all the region's plant communities from desert through the montane coniferous forest.

During 1975, 20 of the 33 historical sites were visited. Peregrines were found at six of the sites. Three sites were occupied by single adults, and the remaining three were occupied by adult pairs. In addition to these findings at historical sites, I obtained information on two new sites during 1975. One of these was occupied by a single adult, and at the second site an immature peregrine was seen. In all, the 1975 survey located eight sites that were occupied by pairs of peregrines or single birds. I did not climb to any of the nests, and no attempt was made to determine their productivity. It is difficult to assess the status of the peregrine in Arizona from the incomplete 1975 survey. It does, however, seem likely that more extensive surveys in the coming years will result in more birds being located.

California

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Herman et al. (1970) reviewed the status of the Peregrine Falcon (*F. p. anatum*) in California. Earlier Bond (1946) had compiled extensive nest records for California and gave no indication of a population decline in progress. With these records and more recent data from several cooperators, Herman et al. (1970) concluded that approximately 100 pairs of peregrines produced young annually in California prior to the mid-1940s. Fewer nesting pairs and poor reproductive success characterized the two decades subsequent to 1945. A survey during 1969–1970 showed that less than 5% of the historical peregrine nesting sites were still active (Herman 1971).

During 1975 we attempted to determine the current status of the peregrine in California. The sample of nesting sites visited consisted of previously unreported and historical nest sites. Eight pairs of peregrines were observed, and a ninth nest was suspected active. At a tenth site, a single adult peregrine foraged on several occasions near a series of cliffs where peregrines nested historically.

Nesting peregrines are widely distributed geographically and utilize several habitat types in California. Three nests in oak-woodland vegetation and two nests in chaparral vegetation were active in the Coast Ranges. One nest was on a coastal cliff. In the Cascade Range, a pair nested on a cliff adjacent to a river. One nest reported active from 1969–1974 was not visited in 1975. It is in pinyon-juniper vegetation adjacent to a river in the southern Sierra Nevada.

Six of the eight pairs observed fledged a minimum of 14 young for a reproductive rate of 1.75 young per nesting pair. Five sites each fledged two young, and one site fledged four young. One pair incubated three eggs but failed to produce young, possibly because of direct human disturbance. Another pair consisted of an adult male and an immature female. These two peregrines were observed together on two occasions, once at a cliff, but no breeding activity was observed.

Each of the eight nesting pairs was at cliffs known to be used by nesting peregrines prior to 1975. Five of the pairs we observed in 1975 had nested yearly during the past five years. The most recently discovered site, first visited in 1973, was probably active in earlier years, but no data are available.

Approximately 70% of the known historical sites were on coastal cliffs or less than 125 km inland. By contrast, in 1975 only one of eight pairs nested on a coastal cliff. At this particular nest site, an adult female died in 1969. A lone male occupied the nesting territory in 1970. Since 1971, a pair has produced young annually at this nest. There have been no other pairs reported nesting at coastal nest sites since the late 1960s. A parallel situation exists in Britain where coastal pairs still fail to produce though inland pairs do better (Ratcliffe 1973).

In California it appears that no expansion of the peregrine breeding population has occurred since the 1969–1970 survey, but rather we have increased our knowledge of the locations of the few remaining pairs. Data on the nesting pairs presented here are primarily the result of intensified searching and increased cooperation. Fledging success for this remnant population is encouraging. We will be able to detect a recovery in the California peregrine population only if we continue yearly surveys of the presently unoccupied historical nest sites.

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Western Texas and Northeastern Mexico

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Although we have relatively good historical information on Peregrine Falcon populations in most regions of North America, the populations in the extreme southern United States and Mexico have never been adequately studied. This report summarizes the results of a survey carried out in the ecological region known as the Chihuahuan Desert. Geographically this region encompasses part of southern New Mexico, most of western Texas, and most of northeastern Mexico east of the Sierra Madre Occidental and north of the State of Zacatecas. Six field workers searched for peregrines in this area for 4 months during 1975, and sporadic visits were made into the region in previous years. Because there was little existing information on where peregrines nested in the region, locating nests involved searching vast numbers of likely-looking cliffs by foot or by canoe. Most of the previously known sites had been located by R. H. Wauer of the United States National Park Service, and his knowledge of the region proved valuable, if not essential, to the survey.

Ten territories were found where pairs were present in 1975. One nest was active in 1974 but could not be located in 1975. Another nest reported active in 1969 could not be found in 1974 or 1975. In neither of these cases were the many nearby cliffs sufficiently examined to conclude that the territories had been abandoned. At another possible nesting cliff, a single adult was observed during a brief visit. Lastly, two sites were found late in the 1975 season which appeared to have been recently occupied by peregrines. In all, 11 occupied sites were discovered during 1974 and 1975; six of these are in Mexico and the remaining five are in Texas.

In the Chihuahuan Desert region, peregrines nest on cliffs along rivers and in mountains. Four of the 11 territories observed in 1974 or 1975 were located on rivers, and none of these produced young. Furthermore, I am unaware of any young being fledged along any of the Chihuahuan Desert rivers. In contrast, I either observed or received valid reports that six of the seven mountain sites fledged young in 1975.

The reason for the disparity of success between mountain and river sites is not certain, but, as I have reported elsewhere (Hunt, *in press*), the prey of the peregrine may differ to some extent in the two habitats. Bats and Cliff Swallows (*Petrochelidon pyrrhonota*), both insectivorous and migratory, must figure more heavily in the diet of the river peregrines, along with waterfowl and shorebirds. Woodland birds, whose diets are likely free of contamination, are both available and vulnerable at the mountain nesting sites.

The survival of peregrines in the Chihuahuan Desert, as in Spain, has probably resulted from the region's pastoral economy and because of the southern latitude where neither the peregrine nor much of its prey need migrate to areas of heavy pesticide use.

We are just beginning to understand the ecology of the peregrine in this region, and it is not possible to estimate the size of the total peregrine population from this year's data. The results of this year's survey have been most encouraging, and pending the results of more extensive surveys in coming years, it is possible that the density of nesting peregrines in the Chihuahuan Desert region may exceed that of any other region in North America south of the boreal forests.

Other members of the 1975 survey team include Mariel Brockway, Nick Dunlop, Frank Erhard, Fred Fridrikksson, and Mark Hitchcock. I also thank Lloyd Logan, Joan Fryxell, and Curt Griffin for their help with the survey. The work was supported by a grant from the United States National Park Service and conducted under the auspices of the Chihuahuan Desert Research Institute.

The Gulf of California, Mexico

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Little is known of the status and ecology of most species of birds in the Gulf of California, and this is perhaps especially true for the Peregrine Falcon (*F. p. anatum*). Banks (*in* Hickey 1969) made the first detailed report on peregrines in the Baja California region, although he relied primarily on published and unpublished records of other observers, especially those of the late L. W. Walker.

My observations were made primarily in the Gulf of California between latitudes 27° and 30°N. Most observations were made between the months of February and July from 1971 through 1975. With other biologists, I located nest sites incidentally to other research activities. In addition, M. N. Kirven directed me to nine nests in 1971. I attempted to keep yearly observations on as many nests as possible. Sites were seldom climbed, and my limited productivity estimates were based almost entirely on the number of fledged young seen near nests. Since my productivity estimates are based solely on situations where young were seen, they can only represent young per successful pair. On the other hand, they represent a minimal estimate because it is not likely that all young were always seen.

I believe that not enough information exists to estimate adequately the size of historical populations of Peregrine Falcons in the Gulf of California. The west coast of Baja California is better known, and Banks (*in* Hickey 1969) believed that peregrines in this region had declined by the 1960s. During the 4 years that I surveyed the west coast of Baja California, I found no peregrines, and I suspect that this population has either declined drastically or disappeared as have peregrines and other raptors in the Channel Islands area of California (Lynch and Johnson 1974).

Most of my current information is on the Peregrine Falcon in the Gulf of California rather than on the west coast of Baja California. Using Banks' (*in* Hickey 1969) estimates along with mine on a portion of the Gulf, I was able to make a projected estimate for the entire Gulf region. Considering that we did not search out all potential peregrine nesting habitat, I believe that 35 to 50 active nests in 30 to 35 local areas is a reasonable estimate for the Gulf of California. In 40 checks for seasonal occupancy during the breeding season, involving 12 nests over a period of 5 years (potential of 60 occupancy checks), I found 77% to be occupied. In all I know of 19 nests that were active between 1971 and 1975, plus another seven sites that were suspected to have been active.

Although my productivity data are limited, in six known successful nesting attempts, I observed 13 flying young, or a minimum of about 2.2 young per successful nesting attempt. This is an encouraging figure when compared to those given by Hickey (1969).

It is possible that pollution from increasing agriculture in Baja California and Sonora will ultimately affect peregrines and other birds in the Gulf of California; but at present, judging from my data on other resident species, the problem is not an acute one. But Risebrough et al. (1968) reported about 102 parts per million DDE (wet weight basis) in one unhatched peregrine egg collected in the Gulf of California in 1967, a level that would normally be expected to accompany reproductive failure.

From my observations, I believe that peregrines in the Gulf feed mainly on the following birds: Black Petrels (*Loomelania melania*), Least Petrels (*Halocyptena microsoma*), Craveri's Murrelet (*Endomychura craveri*), Eared Grebes (*Podiceps caspicus*), Heermann's Gulls (*Larus heermanni*), Elegant Terns (*Thalasseus elegans*), Northern Phalaropes (*Lobipes lobatus*), and other shorebirds and waterfowl. Many of these are the types of birds one would expect to be carrying high concentrations of chemical pollutants.

Data obtained for this report were acquired during studies funded by the United States Fish and Wildlife Service, Denver Wildlife Research Center, Denver, Colorado. M. N. Kirven suggested that I monitor peregrines on my research in the Gulf of California, and he directed me to many of the nest sites. L. R. DeWeese, J. O. Keith, K. A. King, and J. E. Mendoza were with me at one time or another during all of my activities in Mexico.

Conclusion

Currently there is much concern for the Peregrine Falcon as an "endangered species" and in developing policies that will assure its survival and, if possible, its restoration in areas where it no longer breeds. Effective restrictions on the use of DDT and other organochlorine pesticides were the first order of business, and after many hearings and arguments constraints had been obtained in the United States, as well as in Canada. Unfortunately, as Peakall (*this issue*) points out, while residue levels of DDE have greatly decreased in many parts of North America since the 1960s, our migrant peregrines are still heavily burdened with DDE, they are still laying thin-shelled eggs, and as the foregoing reports show, they are still delcining locally and regionally. Apparently the problem now lies in Latin America, where most of these falcons sojourn during the non-breeding season and where DDT is still being used in large quantities. There is not much that can be done to help these migrant peregrines on their breeding grounds in North America as long as DDT continues to be used south of our borders.

The Endangered Species Act of 1973 has some provisions that are beginning to be put into effect for the peregrine in the United States. One of these provisions has to do with designating areas of "critical habitat" that will receive special protective status. Irrespective of their current use or non-use by peregrines, any cliffs that have a known history of occupancy by nesting peregrines should be given careful consideration by land-use planners and agencies as "critical habitat" for this species. The reason is that any future recovery of the peregrine, either by natural or managed means, will depend upon the existence of nesting habitat that the peregrines—not humans—consider essential. For example, although to our human eyes there may be 40 cliffs on the Yukon River in Alaska that look suitable for nesting peregrines, the actual behavior of the birds through time has shown that only 31 of them have ever been selected by pairs, and of these only 16 have been used more than half of the recorded times between 1951 and 1975. Furthermore, in Great Britain where a slow recovery of the peregrine population has been under way since the low point reached in 1962–1963, field naturalists have observed that precisely the same cliffs that once were used are the ones that are attracting new pairs in the recovery phase (Ratcliffe 1973). No completely new nesting places have been used since 1963, and in many territories not only the same cliffs but the same nest ledges that were favored before desertion are the ones now being taken over by new birds. Although the modification of the behavior of captive-produced and released falcons to accept man-made or other unnatural nesting sites remains problematical (Cade 1974), these striking results in Great Britain indicate that any future recovery of our North American peregrines will depend upon the continued natural integrity of these historical nesting cliffs and that they should all be designated as critical habitat. Every time one of these historical sites is destroyed by quarrying, road construction, or any other of the limitless forms of environmental deterioration that go with man's development of the land and its resources, there is one opportunity fewer for a breeding pair of Peregrine Falcons.

Literature Cited

Anderson, R. M. 1913. Report of the natural history collections. *In* My life with the Eskimo. *By* V. Stefannson. McMillan Company, New York.

Bailey, A. M. 1933. A cruise of the *Bear*. Natural History 33: 497–510.

Bailey, A. M. 1948. Birds of Arctic Alaska. Colorado Museum of Natural History, Popular Series, Number 8. 317 pp.

Bailey, A. M. 1956. The bean goose and other birds from St. Lawrence Island, Alaska. Auk 73: 560.

Barrows, W. and **S. B. Bradford.** 1912. Michigan bird life. Special Bulletin of the Department of Zoology and Physiology of the Michigan Agricultural College. 822 pp.

Beebe, F. L. 1960. The marine peregrine of the northwest Pacific coast. Condor 62(3): 154–189.

Beebe, F. L. 1970. The myth of the vanishing peregrine; a study in the manipulation of public and official attitudes. Victoria, British Columbia. 31 pp.

Beebe, F. L. 1972. From a Canadian point of view. Canadian Raptor Society Newsletter 2.

Beebe, F. L. 1974. Field studies of the Falconiformes of British Columbia. British Columbia Provincial Museum, Occasional Paper Number 17. 163 pp.

Berger, D. D., D. W. Anderson, J. D. Weaver, R. W. Risebrough, and **J. A. Keith.** 1970. Shell thinning in eggs of Ungava peregrines. Canadian Field-Naturalist 84: 256–267.

Blood, D. A. 1968. Population status of peregrine falcons in the Queen Charlotte Islands, British Columbia. Canadian Field-Naturalist 82: 169–176.

Blood, D. A. 1969. Peregrine Falcon surveys in coastal British Columbia. Biological Conservation 1: 250–251.

Bond, R. M. 1946. The peregrine population of western North America. Condor 48(3): 101–116.

Burnham, W. A. 1975. Breeding biology and ecology of the Peregrine Falcon in west Greenland. M.Sc. thesis, Brigham Young University, Provo, Utah. 59 pp.

Burnham, W. A., M. A. Jenkins, F. P. Ward, W. G. Mattox, D. M. Clement, and **J. T. Harris.** 1974. Falcon research in Greenland, 1973. Arctic 27(1): 71–74.

Cade, T. J. 1952. Notes on the birds of Sledge Island, Bering Sea. Condor 54: 360.

Cade, T. J. 1953. The Peregrine Falcon in the Yukon valley. Proceedings of the Second Alaska Science Conference 1951: 330–334.

Cade, T. J. 1960. Ecology of peregrine and gyrfalcon populations in Alaska. Univeristy of California Publications in Zoology 63(3): 151–290.

Cade, T. J. 1974. Breeding falcons in captivity. Animal Kingdom 78: 2–9.

Cade, T. J. and **R. Fyfe.** 1970. The North American peregrine survey, 1970. Canadian Field-Naturalist 84(3): 231–245.

Cade, T. J., J. L. Lincer, C. M. White, D. G. Roseneau, and **L. G. Swartz.** 1971. DDE residues and eggshell changes in Alaskan falcons and hawks. Science (Washington) 172: 955–957.

Cade, T. J., C. M. White, and **J. R. Haugh.** 1968. Peregrines and pesticides in Alaska. Condor 70(2): 170–178.

Cahalane, V. H. 1944. Birds of the Katmai region, Alaska. Auk 61: 351–375.

Campbell, R. W. and **B. Davies.** 1973. Nesting raptor survey in the western Canadian arctic. Environmental Protection Board Report, 1973, Section 1.

Childs, H. E. 1969. Birds and mammals of the Pitmegea River region, Cape Sabine, north Alaska. Biological Papers of the University of Alaska, Number 10.

Dean, F. C. and **D. L. Chesemore.** 1974. Studies of birds and mammals in the Baird and Schwatka mountains, Alaska. Biological Papers of the University of Alaska Number 15.

Dodge, P. 1961. Birds of the Huron Mountains, Marquette County, Michigan. Jack-Pine Warbler 39(1): 1–33.

Enderson, J. H. 1964. A study of the prairie falcon in the central Rocky Mountain region. Auk 81: 332–352.

Enderson, J. H., D. G. Roseneau, and **L. G. Swartz.** 1968. Nesting performance and pesticide residues in Alaskan and Yukon peregrines in 1967. Auk 85: 683.

Enderson, J. H. and **J. Craig.** 1974. Status of the Peregrine Falcon in the Rocky Mountains in 1973. Auk 91: 727–736.

Enderson, J. H., S. A. Temple, and **L. G. Swartz.** 1972. Time-lapse photographic records of nesting Peregrine Flacons. Living Bird 11: 113–128.

Engstrom, H. R. 1940. Minnesota nesting records. Flicker 12(1): 1–15.

Friedmann, H. 1935. The birds of Kodiak Island, Alaska. Bulletin of the Chicago Academy of Science 5(3): 13–54.

Gabrielson, I. N. and **F. C. Lincoln.** 1959. The birds of Alaska. Stackpole Company, Harrisburg, Pennsylvania. 932 pp.

Green, J. C. and **R. B. Janssen.** 1975. Minnesota birds. University of Minnesota Press, Minneapolis. 217 pp.

Herman, S. G. 1971. The Peregrine Falcon decline in California (Peregrine Falcon nesting study II-3). California Department of Fish and Game, Special Wildlife Investigations, Sacramento.

Herman, S. G., M. N. Kirven, and **R. W. Risebrough.** 1970. The Peregrine Falcon decline in California. Audubon Field-Notes 24(3): 609–613.

Hickey, J. J. 1942. Eastern population of the Duck Hawk. Auk 59(3): 176–204.

Hickey, J. J. (*Editor*). 1969. Peregrine Falcon populations: their biology and decline. University of Wisconsin Press, Madison. 596 pp.

Huber, R. L. 1962. The summer season. Loon 34(3): 80–85.

Hunt, W. G. 1976. The significance of wilderness ecosystems in the ecology of the Peregrine Falcon in west Texas and adjacent regions. *In* Symposium on the biological resources of the Chihuahuan desert. United States National Park Services. *In press.*

Isleib, M. E. and **B. Kessel.** 1973. Birds of the north Gulf Coast-Prince William Sound region, Alaska. Biological Papers of the University of Alaska, Number 14.

Kessel, B. and **T. J. Cade.** 1958. Birds of the Colville River, northern Alaska. Biological Papers of the University of Alaska, Number 2.

Lynch, J. F. and **N. K. Johnson.** 1974. Turnover and equilibria in insular avifaunas with special reference to the California Channel Islands. Condor 76: 370–384.

Manning, T. H. 1946. Bird and mammal notes from the east side of Hudson Bay. Canadian Field-Naturalist 60(4): 71–85.

Manning, T. H., E. O. Hohn, and **A. M. MacPherson.** 1956. The birds of Banks Island. National Museum of Canada, Bulletin Number 143.

Manuwal, D. A. 1974. Avifaunal investigations in the Noatak River Valley. *In* The environment of the Noatak River Basin, Alaska. *Edited by* S. B. Young. Center for Northern Studies, Wolcott, Vermont.

Mattox, W. G., R. A. Graham, W. A. Burnham, D. M. Clement, and **J. T. Harris.** 1972. Peregrine Falcon survey, west Greenland, 1972. Arctic 25(4): 308–311.

McEwen, E. H. 1957. Birds observed at Bathurst Inlet, Northwest Territories. Canadian Field-Naturalist 71: 109–115.

McLenegan, S. B. 1887. Exploration of the Noatak River, Alaska. *In* Report of the cruise of the revenue steamer *Corwin* in the Arctic Ocean, 1885. United States Government Printing Office, Washington, D.C.

Nelson, R. W. 1970. Some aspects of the breeding behavior of Peregrine Falcons on Langara Island, British Columbia. M.Sc. thesis, University of Calgary, Alberta. 306 pp.

Nelson, R. W. and **M. T. Myres.** 1976. The populations of Peregrine Falcons and their seabird prey at Langara Island, British Columbia, and possible causes for their decline. Condor. *In press.*

Oliphant, L. W., R. Rafuse, and **T. Donald.** 1975. The Peregrine Falcon: past, present and future. Blue Jay 33(1): 43–50.

Olson, R. 1946. Nesting birds of prey. Flicker 18(1): 16–17.

Osgood, W. H. and **L. B. Bishop.** 1900. Results of a biological reconnaissance of the Yukon River region. North American Fauna 19: 1–100.

Peakall, D. B. 1976. The Peregrine Falcon (*Falco peregrinus*) and pesticides. Canadian Field-Naturalist 90(3). (*This issue.*)

Peakall, D. B., T. J. Cade, C. M. White, and **J. R. Haugh.** 1975. Organochlorine residues in Alaskan peregrines. Pesticide Monitoring Journal 8: 255–260.

Plattes, C. W. and **R. A. Woolsey.** 1941. Adventure with the Duck Hawk. Flicker 13(2): 13–14.

Porsild, A. E. 1951. Bird notes from Banks and Victoria Islands. Canadian Field-Naturalist 65: 41.

Porter, R. D. and **C. M. White.** 1973. The Peregrine Falcon in Utah, emphasizing ecology and competition with the Prairie Falcon. Brigham Young University Science Bulletin, Biological Series, Number 18.

Ratcliffe, D. A. 1963. The status of the peregrine in Great Britain. Bird Study 10(2): 56–90.

Ratcliffe, D. A. 1972. The peregrine population of Great Britain in 1971. Bird Study 19(3): 117–156.

Ratcliffe, D. A. 1973. Studies of the recent breeding success of the peregrine, *Falco peregrinus*. Journal of Reproduction and Fertility (Supplement) 19: 377–389.

Risebrough, R. W., P. Reiche, D. B. Peakall, S. G. Herman, and **M. N. Kirven.** 1968. Polychlorinated biphenyls in the global ecosystem. Nature (London) 220: 1098–1102.

Roberts, T. S. 1932. The birds of Minnesota. University of Minnesota Press, Minneapolis. 691 pp.

Sealey, S. G., J. Bédard, M. D. F. Udvardy, and **F. H. Fay.** 1971. New records and zoogeographical notes on the birds of St. Lawrence Island, Bering Sea. Condor 73: 322–336.

Shortt, T. M. 1939. Summer birds of Yakutat Bay, Alaska. Contributions of the Royal Ontario Museum of Zoology, Number 17.

Stauber, E. 1963. The birds of prey of Isle Royale. Department of Forestry and Conservation, Purdue University, Special Report. 29 pp.

Struthers, D. S. and **J. A. Struthers.** 1942. Duck Hawks of the Mississippi and north shore. Flicker 4(2–3): 32.

Struthers, J. A. and **D. S. Struthers.** 1940. Duck Hawks of the Mississippi River bluffs. Flicker 12(3): 32–33.

Struthers, J. A. and **D. S. Struthers.** 1941. Further notes on Duck Hawks. Flicker 13(3–4): 38.

Swartz, L. G. 1966. Sea cliff birds. *In* Environment of the Cape Thompson Region. Alaska. *Edited by* N. J. Wilimovsky and J. N. Wolfe. U.S. Atomic Energy Commission, Springfield, Virginia.

Walker, W., W. G. Mattox, and **R. W. Risebrough.** 1973. Pollutant and shell thickness determinations of peregrine eggs from west Greenland. Arctic 26(3): 256–258.

Ward, F. P. and **R. B. Berry.** 1972. Autumn migrations of peregrine falcons on Assateague Island, 1970–71. Journal of Wildlife Management 36: 484–492.

White, C. M. 1964. Comments concerning Alaskan peregrines and gyrfalcon populations. Journal of the North American Falconry Association 3(1): 9–11.

White, C. M. 1975. Studies on Peregrine Falcons in the Aleutian Islands. *In* Population studies of raptors. *Edited by* J. R. Murphy and C. M. White. Raptor Research Report Number 3, Raptor Research Foundation, Vermillion, South Dakota. *In press.*

White, C.M. and **R. D. Porter.** 1972. The Peregrine Falcon in Utah and its decline. Proceedings of the Utah Academy of Sciences, Arts and Letters 49(1): 59–60.

White, C. M. and **T. J. Cade.** 1971. Cliff-nesting raptors and ravens along the Colville River in Arctic Alaska. Living Bird 10: 107–150.

White, C. M., W. B. Emison, and **F. S. L. Williamson.** 1973. DDE in a resident Aleutian Island peregrine population. Condor 75: 306–311.

Willett, G. 1915. Summer birds of Forrester Island, Alaska. Auk 32: 295–305.

Williamson, F. L. and **L. J. Peyton.** 1962. Faunal relationships of birds in the Iliamna Lake area, Alaska. Biological Papers of the University of Alaska, Number 5.

Wood, N. A. 1951. The birds of Michigan. Museum of Zoology, University of Michigan, Miscellaneous Publications, Number 75. 559 pp.

Zimmerman, D. A. and **J. Van Tyne.** 1959. A distributional checklist of the birds of Michigan. University of Michigan, Museum of Zoology, Occasional Papers Number 608. 63 pp.

Zimmerman, D. R. 1975a. That the peregrine shall live. Audubon Magazine 77(6): 38–49.

Zimmerman, D. R. 1975b. To save a bird in peril. Coward, McCann and Geoghegan, New York.

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Population Limitation in Diurnal Raptors

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Abstract. Raptors are usually monogamous, but several species (especially *Circus*) are often polygynous, and at least two are often polyandrous. Most species defend strongly only a small area around the nest, and obtain much of their food elsewhere. The term 'nest site' is used for the situation of the nest, 'nesting territory' for the area around the nest that is defended, and 'home range' for the area containing the nesting territory and hunting places of a pair. Except in some *Buteo* and *Aquila* populations, home ranges usually overlap widely among pairs. Normally nest sites and food govern the distribution of breeding raptors. Where nest sites are widespread, many species nest solitarily in contiguous or overlapping home ranges; but where sites are concentrated in relation to feeding areas, nesting territories may be grouped and hunting areas largely communal on land nearby. Given widespread nest sites, exclusive or partly exclusive home ranges are also associated with fairly even and stable food sources, whereas gregariousness (communal breeding, roosting, or hunting) is associated with abundant yet widely spaced and transient food sources. The latter include rodent plagues (exploited by kites and harriers), insect swarms (utilized by small falcons and some eagles), various aquatic foods (snails by the kite *Rhostramus*, frogs by the kite *Elanoides*), and large carcasses (utilized by vultures). Particular species show different dispersion patterns according to how food is distributed.

For many solitary species, the idea that breeding density is limited is based on (*a*) their stability in numbers and distribution over many years, (*b*) the existence of surplus birds, which try to nest when a territory is made available through death of an occupant, but otherwise do not, (*c*) the re-establishment, after removal by man, of a population showing roughly the same size and distribution as its predecessor on the same ground, and (*d*) in areas where nest sites are not restricted, a regular spacing of breeding pairs.

Given enough nest sites, breeding density is regulated in relation to food: (*a*) species which live on fairly stable (often varied) food sources show fairly stable densities which, however, differ between regions where prey abundance differs (e.g., *Falco peregrinus, Buteo buteo*); (*b*) species which live on fluctuating (often restricted) food supplies show fluctuating densities (e.g., *B. lagopus* and *Accipiter gentilis* in northern regions); (*c*) unusual concentrations of raptors are associated with unusual food abundances, either natural (e.g., seabird colonies) or artificial (e.g., garbage in cities). Spacing behavior acts as an intermediate (proximate) mechanism, adjusting density to food supply.

That breeding density is in some areas limited by shortage of nest sites can be inferred from (*a*) the absence of breeding pairs in terrain lacking nest sites but otherwise suitable, and (*b*) the fact that, when extra nest sites are provided artificially, breeding density sometimes increases. Where nest sites are scarce, the presence of one species may restrict the numbers and distribution of another. What forms an acceptable nest site varies between regions, according partly to pressure from human and natural enemies. Several species which usually nest on cliffs nest on the ground on islands devoid of mammal predators. Also, some species show local traditions, using nest sites in some regions that they ignore in others, with effects on their distribution (e.g., localized tree-nesting by *F. peregrinus*).

Introduction

Although many birds of prey have been much reduced in range and numbers by various human activities, enough studies have been made of intact populations to suggest how their densities are limited. This paper reviews published work on the influence of food and other natural factors on the dispersion and densities of raptors. It does not discuss the effects of pesticides and persecution, except incidentally, and thus complements the reviews of Ratcliffe (1970), Cooke (1973), Biljeveld (1974) and others.

The problems of studying raptors are great. The general low densities of these birds, their nesting in remote and inaccessible places, and their proneness to human interference (often undetected by the observer) make for samples that are small and hard to evaluate. In this review I shall attempt to organize the available information, point out deficiencies, and suggest lines of further study. I cannot hope to cover the whole of the relevant literature, which is vast and scattered, so for general points I have selected examples from the most thorough studies known to me. The term 'nest-site' is used for the situation of the nest, 'nesting territory' for the area around the nest that is defended, and 'home range' for the area that includes the nesting territory and the hunting places of the pair. Nomenclature and taxonomy follow Brown and Amadon (1968).

Mating Systems

Monogamy is apparently usual in raptors, and the pair remain together at least for the duration of breeding. As a rule, the male obtains most of the food and hunts away from the nest, while the female undertakes most incubation and parental care. As the young grow, they are brooded less, but the female remains near the nest and may hunt in the vicinity. When the nestlings are feathered, both parents may range further afield, and each may hunt a separate area. These general statements are based on all the papers mentioned in this review that cover breeding biology.

In at least nine species in five genera, occasional males have been found with more than one female at the same time (Table 1). In polygyny type A, the females used the same nest, in type B they used separate nests close together in an area that would normally hold one pair, and in type C they used separate nests far apart in areas that would normally hold separate pairs. More than one type has been found in the same species. Polygyny is especially prevalent in harrier *Circus* species, and in *C. cyaneus* was noted in widely separated areas in North America (Hecht 1951; Hamerstrom, *in* Hickey 1969), the Netherlands (van der Kraan and van Strien 1969), north-east Scotland (N. Picozzi, unpublished) and Orkney (Balfour 1962). In this last area, the overall sex ratio among breeders was one male to two females, but individual males had up to six females at one time (Balfour and Cadbury 1974). Polygyny was much more common among older males than among yearlings, and was especially prevalent during two periods of high population. In *B. buteo* bigamy was recorded in only one of several studies, but occurred in four territories and in different years involved at least 14 different females (Picozzi and Weir 1974). In all territories in which it was recorded twice, one or both females were different in the second year, implying that bigamy was regulated, depending on some aspect of territory or male.

Polyandry, involving one female and more than one male, has been noted as widespread in Harris's Hawk, *Parabuteo unicinctus* (two males per female) (Mader 1975), and the Galapagos Hawk, *Buteo galapagoensis* (two or three males per female) (de Vries 1973). In both species such relationships held for more than one year, and in each case the two or three different males all copulated, shared in incubation, and provided food for the female and young. In other species, three adults have been known to occupy a territory together, but the third bird was neither sexed nor known to participate in breeding (Bataleur, *Terathopius ecaudatus* (Brown 1952–1953), Red Kite, *Milvus milvus* (Davies and Davis 1973), Bald Eagle, *H. leucocephalus*, (Sherrod et al., *in press*)). In the last species one trio remained together for at least four years.

Space Requirements While Breeding

Certain generalizations can be made from studies of nest-spacing and home range, chiefly on species of *Haliaeetus* (Wilgohs 1961; Brown 1960; Brown and Hopcraft 1973; Eltringham 1975; Postupalsky 1974), *Circus* (Weiss 1923; Hall 1947; Hecht 1951; Balfour 1962; Neufeldt 1964), *Accipiter* (Sulkava 1964; Pielowski 1968; Kramer 1973; Newton 1972, 1973; Platt 1973; McGowan 1975), *Buteo* (Dare 1961; Mebs 1964; Tubbs 1974), *Aquila* (Brown 1955a, b; Lockie 1964; Brown and Watson 1964; Gargett 1970, 1971, 1975), and *Falco* (Rowan 1921–22; Schuyl et al. 1936; Webster 1944; Beebe 1960; Cade 1960; Ratcliffe 1962; Cavé 1968; Hickey 1969; White and Cade 1971):

(1) The focal point of the range is the nesting territory itself. As well as the nest in use, this area usually contains old nests from previous years, together with roosting and feeding perches. It is where the pair most often advertize themselves by display. Whether based on a crag, an isolated tree, a grove, or a patch of thick ground cover—according to species—it tends to be in the same location from year to year, occupied by a succession of breeding birds.

(2) The vicinity of the occupied nest is defended against conspecifics and against mammal and avian predators, including corvids. But the distance from the nest at which intruders are attacked varies greatly among species: from 15–30 m in the Kestrel (*F. tinnunculus*))Petersen 1956; Cavé 1968) to 200 m or more in the

TABLE 1—Instances of polygny in raptors

Species	Nests used by females			Reference
	Same nest (Type A)*	Separate nests close together in an area that would normally be occupied by one pair (Type B)*	Separate nests far apart in areas that would normally be occupied by separate pairs (Type C)*	
Osprey *Pandion haliaetus*		+		D.N. Weir, personal communication
Marsh Harrier *Circus aeruginosus*		+	+	Hosking 1943; Dementiev and Gladkov 1954; Bengston 1967
Hen Harrier *Circus cyaneus*		+	+	Hecht 1951; Balfour 1962; Hammerstrom *in* Hickey 1969; van der Kraan and van Strien 1969
Montagu's Harrier *Circus pygargus*		+	+	Dent 1939; Hosking 1943
Sparrowhawk *Accipiter nisus*	+		+	Jourdain 1928; Newton 1973
Red-tailed Hawk *Buteo jamaicensis***	+			Wiley 1975
Buzzard *Buteo buteo*		+		Picozzi and Weir 1974
Kestrel *Falco tinnunculus*	+	+		Mathew 1882; Witherby et al. 1938; Petersen 1956
Peregrine*** *Falco peregrinus*	+	+		Spofford, *in* Hickey 1969; D.N. Weir, unpublished

* In Type A, the evidence consisted of two females seen or shot together at a nest containing a double clutch, and at which only one male was known. A double clutch alone is insufficient, because one female might have replaced another, or the same female might have laid both clutches (Balfour 1962). In Types B and C, the evidence is based on one male consistently visiting more than one nest, at which no other male was seen.

** Both females were fed by the male, brooded and fed the young, but only one laid.

***Only the larger of two females was fed by the male and laid, and the smaller female sat on the nest only when the larger one was absent. In the other case, the two females used alternative cliffs in the same home range and both laid.

Peregrine (*F. peregrinus*) (Cade 1960). It also varies with stage of breeding cycle, mood of occupant, identity and behavior of intruder, local topography, and so on (Cade 1960). Colonial species generally attack conspecifics at less distance than do solitary species, and in both groups the area defended is usually much smaller than that used for hunting. Defence is also limited vertically and, on a high tiered cliff, one pair can nest above another without friction

(Craighead and Craighead 1956). In fact, in sea-cliff nesting falcons, territory expressed by aggression takes the form of a quarter sphere in front of and below the eyrie but extends little above it, and not at all behind (Beebe 1960). Pairs thus nest closer if their eyries do not face one another than if they do. Likewise, pairs of tree-nesting species are often closer together on a slope, where they occupy different levels, than on the flat (Craighead and Craighead 1956), and ground nesters are often closer when they are separated by a ridge than when they are in the same valley (Balfour 1962).

(3) Although birds often nest year after year in the same site, or alternate between different sites in the same restricted nesting territory, sometimes they use alternative nesting territories in the same home range, and defend vigorously only the one in use. This is usual in crag-nesting species where crags are superabundant, and alternative nesting areas may be up to several kilometres apart. They are judged to alternatives in the same home range because only one is occupied in any one year (Lockie 1964; Ratcliffe 1962).

(4) The location of the nesting territory seems to be determined primarily by the need for safety. Nest sites are either difficult of access to human and other predators, easily defended, remote, or well hidden. The distribution of other pairs is also important, acting to produce 'over dispersion' in solitary nesting species and clumped dispersion in colonial ones (see pp. 278). If prey happens to be abundant near the nest, the female may take advantage of it (Craighead and Craighead 1956; Schnell 1958).

(5) Other hunting areas may lie at varying distance and direction from the nest, may be separated from the nest by country in which hunting is impossible (as in some Ospreys, *Pandion haliaetus,* and some town-nesting kestrels), and may also be used by other pairs. Individual *Accipiter nisus* have been found to fly up to 9 km from the nest to hunt (Newton and Marquis *in press*), *Circus melanoleucos* up to 5 km (Neufeldt 1964), *C. aeruginosus* and *C. cyaneus* up to 3 km, and *C. pygargus* up to 12 km (Schipper 1973), *Pandion* up to 11 km (D.N. Weir, personal communication), Kites, *M. milvus*, up to 15 km (Davies and Davis 1973), Saker Falcons, *Falco cherrug*, up to 20 km (Dementiev and Gladkov 1954), *F. peregrinus* up to 20 and 27 km in different areas (Kumari 1974; Porter and White 1973), Verreaux Eagles, *Aquila verreauxi*, up to 27 km (Brown 1955b), and *Gyps* vultures up to 150 km (Houston 1974). Such distant hunting (usually by males) has been proved by observation of marked birds or by radio telemetry, or has been inferred from prey species found at nests.

(6) When the nesting and hunting areas of birds are mapped, it has become customary to draw a line around them and call the area enclosed the home range. But most food might be secured in only a small part of this range, and over other parts the birds might seldom even fly (Craighead and Craighead 1956; Platt 1973; Newton and Marquiss, *in press*). Generally the range is small where prey is abundant near the nest, and large where prey is either generally scarce or local, but far distant. The occupants then spend much time travelling back and forth, and may even have to cross the nesting territories of other pairs (Neufeldt 1964; Newton and Marquiss, *in press*). The choice of hunting areas, and hence the extent and shape of the home range, may also change during the season, and may come to embrace ground previously defended by other pairs that have since failed and moved away (Craighead and Craighead 1956; R. Fyfe, personal communication). The whole home range is not normally defended, but conflicts may occur over the most used parts, such as favored perches and other hunting places, if two birds happen to be there at the same time.

In conclusion, although nesting territories are defended and consistent in location from year to year, home ranges often vary in size and shape during the season, and may overlap with those of neighbors.

The amount of ground that is actively defended seems to depend largely on what is feasible, and some species may behave differently in different environments. Where birds can get most of their needs in a small area, they tend to defend it all, but where they range over a larger area, this tends to be less exclusive, with poorly defined boundaries. Exclusive ranges are often held by *Buteo* species, as by the *B. buteo* studied by Picozzi and Weir (1974), the Red-shouldered Hawks (*B. lineatus*) studied by

Craighead and Craighead (1956), and the Red-tailed Hawks (*B. jamaicensis*) studied by Fitch et al. (1946). Boundaries between such home ranges were often stable from year to year. Similar exclusive ranges were found in *Aquila verreauxi* in a high density area (Gargett 1975). On the other hand, widely overlapping ranges were shown by the *B. buteo* studied by Joensen (1968), the *M. milvus* studied by Davies and Davis (1973), the *Circus* species studied by Balfour (1962) and Neufeldt (1964), the *Accipiter nisus* studied by Newton and Marquiss (*in press*), the Prairie Falcons, *F. mexicanus*, studied by R. Fyfe (personal communication), and also by various colonial raptors. On such communal hunting areas, there is often some temporal segregation, with no more than one bird in a given sector at one time. Individuals keep their distances, but change their respective positions with time, so that the expected chance accumulations at particular points seldom occur.

Dispersion Systems

Relation to Food Supplies

Raptors show the same broad relationships between dispersion patterns and food supplies as other birds (Crook 1965; Lack 1968; Ward and Zahavi 1973). Given widespread nest sites, the three major known systems of dispersion are based on the following:

(*a*) *Exclusive, or partly exclusive, home ranges,* in which the pair nest solitarily and hunt and roost together or alone. This is the usual system in about 75% of the 81 raptor genera listed by Brown and Amadon (1968), including *Accipiter, Buteo, Aquila,* and most *Falco*. Most such species live on relatively large vertebrate prey, and show considerable stability in numbers and distribution from year to year (exceptions discussed pp. 286–287.

(*b*) *Loose nesting assemblages, localized and communal hunting areas.* Individuals keep apart when hunting (presumably to avoid mutual interference), but their hunting areas are often grouped or communal and continually changing in location. This system is commonly shown by various kites, *Elanus* and *Milvus*, harriers, *Circus*, and others when exploiting rodent plagues (Pickwell 1930; Breckenridge 1935; Hecht 1951). Much nomadism occurs, and individuals concentrate to breed wherever food is temporarily plentiful, so that local populations fluctuate substantially from year to year (Galushin 1974).

(*c*) *Nesting colonies and foraging flocks.* This system is shown by species which exploit sporadic food sources, including the snail-eating Everglades Kite, *Rostrhamus*, the insect-eating kites, *Elanoides, Gamponix, Elanus, Chelictinia,* and *Ictinia*, the insect-eating falcons, *Falco naumanni, F. vespertinus, F. amurensis,* and *F. eleonorae* (which also feeds migrant birds to its young), and various carrion-eating raptors (Lynes 1925; Ali and Ripley 1968; Brown and Amadon 1968; Lack 1968; Snyder 1975). Among the Old World vultures, colonial nesting is usual and colonies often large in the seven *Gyps* species, which feed entirely on large carcasses. The remaining Old World vultures, *Gypaetus, Necrosyrtes, Torgos, Sarcogyps, Aegypius*, and *Trigonoceps* and the New World vultures, Cathartidae, usually nest solitarily, but some roost communally and also group around large carcasses. Their diet, unlike that of *Gyps*, includes many smaller items, including living prey (Brown and Amadon 1968).

The above division into three categories is somewhat arbitrary, and in practice gradations exist between, on the one hand, exclusive highly defended home ranges spread evenly through the habitat, and on the other, breeding colonies and feeding flocks occupying only a fraction of the habitat at any one time. The former is associated with fairly uniform, stable, and predictable food supplies and the latter with sporadic superabundances. Rodent plagues, insect swarms, temporary pools of frogs and snails, or large carcasses are all food sources which are irregular and continually changing in distribution, but on which, once located, many birds can feed together. Feeding close together (in flocks) occurs in situations where mutual interference is not important in influencing hunting success. Moreover, particular dispersion patterns cannot necessarily be considered species characteristics: various kestrels (Bolam 1912; Bent 1938; Piechocki 1968), harriers (Hall 1947; von Blotzheim et al. 1971; N. Picozzi, unpublished), and kites (Davies and Davis 1973; Snyder and Snyder 1970) all show different dispersion patterns in different food situations.

Relation to Nest Sites

The dispersion of a species can also vary among localities according to the relative distribution of nesting and hunting areas. Where nesting places are widespread, many species, as mentioned, nest solitarily in contiguous or overlapping home ranges; on a map their nests appear widely, but regularly, spaced. But where potential nesting places are concentrated in relation to potential feeding areas, nesting territories of these same species may be grouped and hunting areas largely communal on land nearby. Examples of such nesting concentrations among species that are usually more dispersed include these: (*a*) the 211 pairs of 11 species, including 117 pairs of *F. mexicanus,* which bred in 60 km of canyon in Idaho (Olendorff and Kochert, *in press*); (*b*) the 124 pairs of five species which bred in a 13000-ha 'island' of forest in East Germany (Wuhtky 1963); (*c*) various 'colonies' of *F. tinnunculus* (Bolam 1912; Piechocki 1968), including those produced artificially in nest boxes (Cavé 1968); (*d*) groups of *M. migrans* in the same isolated tree; and (*e*) single pairs of *M. migrans, F. tinnunculus,* and *F. subbuteo* nesting together in the same isolated tree (Dementiev and Gladkov 1954). In all these instances, involving pairs of the same and different species, the birds spread out to forage over a wide area devoid or almost devoid of nest sites. The huge concentrations mentioned above were also associated with exceptionally abundant food.

Close Nesting by Fish-eating Species

In the "loose colonies" in which *Pandion* and some sea eagles, *Haliaeetus* spp., sometimes nest (see Baker 1932–1935 for *H. leucogaster;* Bent 1938; Broley 1947 for *H. leucocephalus*; Wilgohs 1961 for *H. albicilla*), two dispersion systems are apparently represented: one results from nesting sites being concentrated among widespread feeding areas, and the other from individual pairs holding extremely small home ranges. The first system occurs, for example, where several hundred *Pandion* pairs nest within a few square kilometres on the same island, with nests as close as 50 m, but hunt over communal feeding areas in nearby extensive coastal bays and marshes (Abbott 1911; Tyrrell 1936; Bent 1938). The second system is shown by the African Fish eagles, *H. vocifer*, found by Brown (1960) to have small but overlapping home ranges, each containing a nest, good perches to watch for fish, and shallow water to catch them in. Probably small home ranges are possible in such situations (shallow water around islands), because of a constant through-movement of fish produced over a larger area. Similar close nesting by *F. eleonorae* and *F. concolor* on islands (Vaughan 1961; Clapham 1964) may depend on the continual passage of prey past the nests, in this case mainly migrant birds. They are thus not dependent solely on prey produced within their small home ranges.

Limitation of Breeding Density

Most information on breeding density refers to populations of solitary-nesters, so this section is concerned with these, unless stated otherwise. For some species, the idea of limitation is based on (1) stability of breeding population, in both size and distribution, over periods of many years; (2) existence in the population of 'surplus' birds, encouraged to breed only when a site becomes available through loss of the previous occupant, but otherwise shown to be present without attempting to nest; (3) the re-establishment, after removal by man, of a population showing roughly the same size and distribution as the previous one on the same ground; and (4) in areas where nest sites are not restricted, a consistent and regular spacing of breeding pairs. Stability would of course be expected only from populations in stable environments (including food), and not from populations permanently depressed or changing because of some major human pressure, such as pesticide use, habitat change, or persecution. Many recent studies have inevitably referred to reduced populations, so much of the evidence discussed here comes from earlier studies, and from well documented anecdote.

Stability of Breeding Population

Usually taken for granted, this remarkable fact can be documented to some extent from particular long-term studies in stable environments (Table 2). Evidence involving at least 10 pairs over at least 10 years is available for *B. buteo* in at least two areas (Wendland 1952; Tubbs 1974), *Aquila chrysaetos* in at least four

TABLE 2—Stability of numbers in breeding raptors, taken from populations free from serious human influence

Honey Buzzard, *Pernis apivorus*
(1) 5–6 pairs in 1938–42, no record 1939, Denmark (Holstein 1944).
(2) 4, 4, 4, 4 and 3 pairs in 1940–44, 3 pairs in 1948, and 2 pairs in 1950 and 1951, Germany (Wendland 1953).

Black Kite, *Milvus migrans*
(1) 7, 8, 8, 8 and 7 pairs in 1940–44, and 7 pairs in 1950 and 1951, Germany (Wendland 1953).

Red Kite, *Milvus milvus*
(1) 1, 1, 2, 3, 0 pairs in 1940–1944, 2 pairs in 1948, and 1 pair in 1950 and 1951, Germany (Wendland 1952–53).

African Fish Eagle, *Haliaeetus vocifer*
(1) 56 pairs in 1968–69 and again in 1970–71 on Lake Naivasha, Kenya, despite a marked increase in total population (Brown and Hopcraft 1973).

Goshawk, *Accipiter gentilis*
(1) 5 pairs in 10 successive years, 1956–1965, Poland (Pielowski 1968).

Sparrowhawk, *Accipiter nisus*
(1) 13 and 15 pairs in 1940–41, Germany (Wendland 1952).
(2) 6 pairs in 1941–1943, Netherlands (Tinbergen 1946).

Red-tailed Hawk, *Buteo jamaicensis*
(1) 23, 22, 21, 21 and 20 pairs in 1967–1971, Alberta (McInvaille and Keith 1974).
(2) 27, 33, 27 pairs in 1953–1955, Wisconsin (Orians and Kuhlman 1956).
(3) 64 and 73 pairs in 1971 and 1972, Montana (Johnson 1975).

Buzzard, *Buteo buteo*
(1) 28, 29, 30, and 29 pairs in 1941–1944, 29 and 30 pairs in 1950–51, Germany (Wendland 1952).
(2) 33–37 pairs in ten successive years in 1961–71, England (Tubbs 1974).
(3) 25 pairs in 1956 and 1958, 27 pairs in 1959, Germany (Mebs 1964).

Golden Eagle, *Aquila chrysaetos*
(1) 10–13 pairs in 26 successive years, Upper Deeside, Scotland, 1944–1969 (Watson 1970).
(2) Change by one pair more or less over 10 years in four Scottish areas holding 16, 13, 12, and 8 pairs (Brown and Watson 1964).
(3) 31 and 30 pairs in 1963 and 1964, Montana (McGahan 1968).
(4) 4 pairs 1947–1958, 3 pairs in 1959–1975, Rhum, Scotland (M. Ball, personal communication).

Verreaux Eagle, *A. verreauxi*
(1) 55 pairs in 1964–1973, Matopos Hills, Rhodesia (Gargett 1970, 1971, 1975).

Kestrel, *Falco tinnunculus*
(1) 11, 11, 10, 12 pairs in 1941–1944, 11 pairs in 1950, 13 pairs in 1951, Germany (Wendland 1953).
(2) 52, 48, 50 pairs in 1964–1966, England (Taylor 1967).

Merlin, *Falco columbarius*
(1) 3–4 pairs for about 19 successive years from 1898, England (Rowan 1921–22).

Hobby, *Falco subbuteo*
(1) 10, 9, 9, 10 pairs in 1941–1944, 12 pairs in 1950–51, Germany (Wendland 1953).

Peregrine, *Falcon peregrinus*
(1) Four populations of up to 6, 12, 18, and 25 pairs fluctuated by no more than 8% of mean, 1945–1960, Britain (Ratcliffe 1962).
(2) 10–13 pairs in 1935–1942 and 1947, Massachusetts (Hagar, *in* Hickey 1969).
(3) 17–20 pairs in 1954–1961, East Germany (Kleinstauber, *in* Hickey 1969).
(4) 10, 8, 11, and 9 pairs in 1956–1959, Colville River, Alaska; on a larger stretch of river 32 pairs in 1952, 36 in 1959 plus 5 unmated adults (Cade 1960), 34, 32, 33, and 31 pairs in 1967–1969 and 1971, after which population declined from pesticides (White and Cade 1976).
(5) 18 pairs + 1 unmated bird in 1939, 19 pairs in 1940, around New York (Hickey 1942).
(6) 1 pair per 10 miles of Yukon River, Alaska, in 1899, 1 pair per 9.3 miles in 1951, and 1 pair per 10.5 miles in 1966 (Cade et al. 1968).
(7) 3 pairs in 1940–1944, after which declined from pesticides, Germany (Wendland 1953).

areas (Watson 1957, 1970; Brown and Watson 1964), *Aquila verreauxi* in at least one area (Gargett 1975), and *F. peregrinus* in at least seven areas (Hagar *in* Hickey 1969; Ratcliffe 1962; Cade et al. 1968; White and Cade 1976). Evidence involving fewer pairs or fewer years is available for other populations of these same species, and also for *Pernis apivorus, Milvus milvus, M. migrans, Haliaeetus vocifer, Accipiter gentilis, Accipiter nisus, B. jamaicensis, F. tinnunculus, F. columbarius,* and *F. subbuteo* (Table 2). In all studies involving 10 or more pairs, breeding numbers remained either absolutely constant, or changed by less than 15% of the mean over the period involved. This in some cases occurred despite great annual fluctuations in the production of young (Wendland 1952–1953; Mebs 1964), and in others despite prolonged depressed production (Ratcliffe 1972; Tubbs 1974), which further strengthens the case for density limitation.

Evidence for stability of numbers is also available for the composite raptor population over large areas. In one area of 96 km^2 in Michigan, the total number of raptor pairs was 43 in 1942, 44 in 1948, and 41 in 1949, even though in this period one *Buteo* species partly replaced another through habitat change (Craighead and Craighead 1956). Likewise, near Berlin, Wendland (1952–1953) found constancy in both individual species over several years (Table 2), and of the raptor population as a whole.

Evidence for stability of distribution comes from the fact, already noted, that pairs usually occupy the same nesting places year after year, or move among a few alternatives. Periods of longest use have been recorded from species that nest on crags, perhaps because crags are among the most permanent features in any environment. More or less continuous occupancy, spanning periods of 70–100 years, has been noted in *Pandion* (Verner 1909), *H. albicilla* (Wilgohs 1961), *Aquila chrysaetos* (Watson 1957; Gordon 1955), *F. rusticolus* (Dementiev and Gladkov 1954), and *F. peregrinus*. Also, out of 49 *F. peregrinus* eyries known to falconers between the 16th and 19th centuries, 42 were still occupied in 1930–1939 (Ratcliffe 1972). Continued occupancy could thus have held at many cliffs for hundreds of years, long before ornithologists could record it. In trees, too, certain eagle nests have been in use for longer than the lifetime of a man and, added to year after year, often reached enormous proportions (Herrick 1924; Brown 1955b; Gordon 1955; Wilgohs 1961). One historic Bald Eagle (*H. leucocephalus*) nest measured 4 x 2 m on top, and contained two wagonloads of material, and another was 5 m high and 3 across (Bent 1938). Among other tree nesters, particular *Pandion* nests were in continued use for 41, 44, and 45 years, and Red-shouldered Hawk (*B. lineatus*) nests for 37 and 47 years (Bent 1938). Certain groups of trees or patches of forest were used for long periods by other species (Verner 1909; Newton and Marquiss, *in press*), and even particular patches of ground cover that remained intact were used by *C. cyaneus* for more than 50 years (Balfour 1962).

Hickey (1942) thought that the continued use of particular sites depended on their superiority in relation to local alternatives; Tinbergen (1946) and Cade (1960) that it depended on one bird, after the death of its mate, attracting a new partner to the same site; and Ferguson-Lees (1951) on the young returning to their birthplace*; while White (*in* Hickey 1969) proposed "genetic continuity" in the birds using particular *F. peregrinus* haunts. Perhaps all these factors are involved but, from experience in Britain, even when both occupants are killed every year, the same sites remain used. At one *F. peregrinus* eyrie, both occupants were shot in 13 years out of 23, the hen alone in another 5, and eggs or young were destroyed every year, yet the cliff remained tenanted (Ferguson-Lees 1951). This could of course occur only where enough new recruits were available to fill the gaps.

Surplus Birds

Evidence for the existence of surplus birds, which breed only when a site becomes available, is chiefly that lost mates are often replaced the same season by other birds, which then breed successfully. The speed with which this sometimes happens has long aroused comment among ornithologists. Specific instances involve at least 17 species in nine genera (Table 3), whereas general statements that replacement of shot birds occurred in *B. buteo* (both sexes), Shikra *A. badius, F. peregrinus, F. cherrug, F.*

columbarius (male), and *F. subbuteo* were made by Dementiev and Gladkov (1954). Bent (1938) cites an instance in *Pandion* where both partners were shot at the same time, and replaced byn a fresh pair.

Most replacements referred to hens, perhaps because these were most easily shot and, where shooting was continued, three hens were obtained at the same site in a short time in *H. albicilla* (Saxby 1874), *Accipiter nisus* (Owen 1936–1937), *F. columbarius* (Seebohm 1883), and *F. peregrinus* (Weir, *in* Ratcliffe 1972). Moreover, the newcomer often carried on where the previous bird left off. Thus two female *Accipiter cooperi* which successively replaced another, each incubated the clutch of the first till they were shot, and a male *Accipiter gentilis,* which replaced another in the nestling period, helped to rear the brood (Holstein 1942); likewise at one *F. peregrinus* site in Canada, the adults were replaced so quickly that two birds eventually raised a brood that neither had parented (Taverner, *in* Hickey 1942). Evidently the behavior of the incomer is influenced by what the nest contains, and females have laid in empty nests, incubated an existing clutch, or brooded and fed young, as the case may be.

There is thus no doubt that, in many species in many areas, vacancies at nesting territories have often been quickly filled. But controlled experimentation is badly needed. At the start of a season, replacement could sometimes have been by birds that might otherwise have bred elsewhere, whereas later, replacement could have been by birds that had failed or lost a mate at another site. Also, a loss followed by a replacement is more likely to have been documented than a loss followed by no replacement, so more information is needed on the frequency with which replacement occurs. In the *B. buteo* studied by Dare (1961), most vacancies were filled not in the breeding season, but at periods of local movement (autumn and late winter), and 6 weeks was the shortest period between a loss and replacement. The inference was that replacement depended not only on the existence but also on the proximity of suitable recruits.

Among raptors in general, potential breeding pairs are found only in association with nesting territories, and other (unpaired) birds may include not only adults unable to acquire a mate or nesting territory but also individuals too young to breed. Unpaired birds of both groups have been found to live (*a*) on nesting territories not occupied by a pair, as in *Aquila chrysaetos* (Sandeman 1957), *F. mexicanus* (Fyfe, personal communication), and *F. peregrinus* (Hagar, *in* Hickey 1969); (*b*) in the interstices between the territories of breeding pairs, as in *B. buteo* (Tubbs 1974; Weir and Picozzi, unpublished), *B. jamaicensis* (Fitch et al. 1946), *Aquila verreauxi* (Gargett 1975), *F. mexicanus* (Fyfe, personal communication), and *F. peregrinus* (D.N. Weir, personal communication); (*c*) in other habitats in the same locality that are unsuitable for breeding, as in *B. lineatus* (Henny et al. 1973) and *Aquila chrysaetos* (A. Watson, personal communication); (*d*) unobtrusively within the home ranges of established pairs, at least for short periods, as in *Aquila chrysaetos* (Brown and Watson 1964) and *F. mexicanus* (Fyfe, personal communication); or (*e*) mainly in different geographical areas (e.g., "winter quarters") from breeding birds, at least for much of the season, as in *Pandion* (Osterlof 1951; Henny and Wight 1969), Montagu's Harrier, *Circus pygargus* (Mead 1973), and in northern (*B. b. vulpinus*) but not southern (*B. b. buteo*) Buzzards in Sweden (Olsson 1958). These are not mutually exclusive alternatives, and more than one system has occurred in the same population. Depending on food supply, such birds live solitarily or gregariously (non-breeding *M. migrans* have been found in flocks of more than 100 individuals in summer (Dementiev and Gladkov 1954)). Their overall numbers are presumably influenced partly by rates of production and recruitment into breeding populations. They have been found to vary between areas and years, and to fluctuate considerably above the level at which breeding density was affected. Thus on Lake Naivasha, Kenya, adult *H. vocifer* increased by 40% and immatures by 11% between 1968 and 1971, but breeding numbers remained constant at 56 pairs (Brown and Hopcraft 1973). Because they are not tied to a nest, non-breeders have greater freedom of movement than breeders, and more often exploit temporary abundances of food (for *H. leucocephalus*, see Sherrod et al. 1976; for *Aquila audax*, see Leopold and Wolfe 1970).

TABLE 3—Instances of replacement of lost mates in the same season

Osprey	Sex replaced	Time period	References
Osprey *Pandion haliaetus*	Both	?	St. John 1884; Bent 1938
White-tailed Eagle *Haliaeetus albicilla*	Female	Within 1 week	Saxby 1874
White-backed Vulture *Gyps bengalensis*	?	Within 5 days	Ali and Ripley 1968
Bataleur *Terathopius ecaudatus*	Female	?	Brown 1952–1953
Montagu's Harrier *Circus pygargus*	Both	?	Mayr 1938
Goshawk *Accipiter gentilis*	Male	Within 2 weeks	Holstein 1942
Sparrowhawk *A. nisus*	Both	Within 1 week	Owen 1936–1937; Nethersole-Thompson 1951
Cooper's Hawk *A. cooperi*	Female	Within 'some days'	Bent 1938; Schriver, *in* Hickey 1969
Red-shouldered Hawk *Buteo lineatus*	?	'Promptly'	Bent 1938
African Red-tailed Buzzard *B. auguralis*	Female	The next day	Brown and Amadon 1968
Imperial Eagle *Aquila heliaca*	Both	?	Valverde 1960
Golden Eagle *Aquila chrysaetos*	Female	Within 10 weeks	Dixon 1937
Verreaux Eagle *A. verreauxi*	Female	Within 3 weeks	Visser 1963
American Kestrel *Falco sparverius*	Both	One female within 5 days	Mayr 1938; Enderson 1960
Merlin *F. columbarius*	Female	?	Seebohm 1883
Gyrfalcon *F. rusticolus*	Female	?	Bent 1938
Peregrine *F. peregrinus*	Both	One female within 15 days	Walpole-Bond 1938; Witherington 1910; Hickey 1942; Ferguson-Lees 1951; Hall 1955; Hagar, *in* Hickey 1969; Ratcliffe, *in* Hickey 1969; Kumari 1974

These various observations show the existance of unpaired birds in raptor populations. Admittedly, many referred to birds in immature or sub-adult plumage, which when paired were perhaps less likely to nest than were older birds. But successful breeding in sub-adult plumaged birds has been noted in at least six major genera (*Haliaeetus* by Hoxie 1910; Herrick 1924; *Circus* by Lundevall and Rosenberg 1955; Schmutz and Schmutz 1975; *Accipiter* by Hoglund 1964; Newton, *in press* H. Snyder, personal communication; *Buteo* by Luttich et al. 1971; Henny et al. 1973; *Aquila* by Valverde 1960; A. Watson, personal communication; and *Falco* by Temple 1972; Hickey and Anderson, *in* Hickey 1969).

Establishment of New Populations to the Same Level as Previous Ones

Areas from which populations have been removed by man have often been recolonized to about the same level as before, with the same nesting territories occupied. In parts of Britain, *F. peregrinus* was nearly exterminated during the last war, and recolonized afterwards (Ratcliffe, *in* Hickey 1969). Not only did the newcomers use the same restricted areas as their predecessors, but also used the same nest ledges (Ratcliffe 1972). Recolonization of some areas occurred within a few years, but in other areas was still going on when numbers were again reduced by pesticides; in no area did numbers increase above the pre-war level. *Accipiter nisus* has likewise re-occupied former nest areas to the same density in regions where it has recently recovered (Newton, unpublished). Rowan (1921–1922) wrote how the Merlins, *F. columbarius*, in two neighbouring territories were shot every year for 19 years, and produced not a single young, yet every year without fail new pairs settled on the same ground. In one territory the same heather patch was used for all 19 years, and in another area for 12 years, until destroyed by fire. Seebohm (1883) gave similar information for another area.

Regular Spacing of Breeding Pairs

Through continuously suitable habitat, regular spacing has been documented in *Accipiter nisus* (Newton et al., *in press*), *B. buteo* (Tubbs 1974; Weir and Picozzi, unpublished), *B. lineatus* (Stewart 1949; Henny et al. 1973), *B. jamaicensis* (Hagar 1957; McInvaille and Keith 1974), *Aquila chrysaetos* (Lockie 1964; Brown and Watson 1964), Wedge-tailed Eagle, *Aquila audax* (Leopold and Wolfe 1970), Wahlberg's Eagle, *A. wahlbergi*, and Martial Eagle, *Polemaetus bellicosus* (Brown 1970; Smeenk 1974), *F. tinnunculus* (Taylor 1967), *F. columbarius* (Newton, unpublished), *F. mexicanus* (Fyfe, personal communication), and *F. peregrinus* (Cade 1960; Ratcliffe 1962). In general, nests were more evenly spaced in tree- than in crag-nesting species, presumably because the former had more choice of nest area, or less widely spaced alternatives in their home range. Uniform spacing is consistent with the idea of density limitation but does not alone prove it, because of the alternative interpretation that pairs, already limited by some other factor, then divide an area equally between them.

The four arguments taken together, however, provide strong circumstantial evidence (*a*) that breeding density is limited, (*b*) that the limitation is through intraspecific competition for nesting territories, and (*c*) that stability is helped by the existence of surplus birds, able to breed only when an existing territory becomes vacant. This is not to imply that surplus birds are available at all times in all populations and, as mentioned, the phenomena discussed here would not apply to many modern populations reduced by pesticide poisoning. A curious feature was that in well studied populations it was rare for all nesting territories to be occupied at once, despite the existence of "surplus" birds which replaced shot breeders and nested themselves. The usual occupany of British *F. peregrinus* territories until 1939 was 85% (Ratcliffe 1972), and in New Forest *B. buteo* territories over 10 years, it was 79–86% (Tubbs 1974). Certain territories were vacant much oftener than others, and were probably inferior or suitable only in certain years. This impinges on the problem of territory quality, discussed later. (Reliable figures on occupancy can of course be obtained only at the start of the season, for later it is not always possible to distinguish 'unoccupied' from 'failed at an early stage and left'.)

Breeding Density in Relation to Food Supplies

Regional Variations in Breeding Density

Some species nest at different densities in different regions, even in suitable habitat where not restricted by shortage of nest sites or by persecution. On circumstantial evidence for a few species, such density differences are probably related to food availability.

(*a*) *Accipiter nisus.* In 12 well wooded districts in Britain, nesting territories were evenly spaced, but at distances varying from 0.5 to 2.1

km apart, according to district. These differences in density were related to soil productivity and, in at least three areas where counts were made, to the abundance of small bird prey. In one 100-km valley, Sparrowhawks nested most densely on the richest ground near the coast, at an intermediate density part way up and at lowest density on poor ground near the top (Newton et al. 1976).

(*b*) *Falco peregrinus*. Ratcliffe (*in* Hickey 1969) gave the following mean distances between pairs in different parts of Britain: 2.6 km on sea-cliffs in southeast England and some Scottish islands with numerous seabirds; 4.8 km over much of England, Wales, and southern Scotland; 5.5–6.4 km in the southern Highlands and northern coasts; 7.2 km in the central Highlands; 8.3 km on north-eastern coasts and 10.3 km in the western and north-west Highlands. The average area per pair for three inland populations not limited by shortage of nest sites, and covering the full range of variation, were Wales 52 km^2, east-central Highlands 96 km^2, and western Highlands 220 km^2. These differences were broadly correlated with food. The south coast was backed by rich farmland, offering a variety of abundant prey, but in Wales and southern Scotland the country was less rich, but near to fertile lowlands. With distance northwards, the country became more barren, and high peregrine densities were found only near those coasts where seabirds were plentiful. The populations of most regions remained stable for as far back as records go, but a one-fifth decline in the number of breeding pairs occurred in the western Highlands between 1890 and 1950, which Ratcliffe (*in* Hickey 1969) attributed to a long-term decline in prey caused by extractive land management. He thus argued for a relationship between density and food supply both on a geographical parallel, and on a local long-term change in density, associated with long-term change in food.

Higher densities than any in Britain were found on the Queen Charlotte Islands, off western Canada, where the mean distance between about 20 pairs was 1.6 km (Beebe 1960), linked with massive concentrations of seabirds. This population has recently also declined to about six pairs, following a decline in prey (Nelson and Myres 1975). Lower densities than any in Britain were found along the Colville River in Alaska, where 8 to 11 pairs were separated by 11.2–15.4 km (Cade 1960). In other regions pairs were found at exceedingly low density, say one pair per 50000 km^2 (Bond 1946; Hickey and Anderson, *in* Hickey 1969); they were usually isolated near local oases of food in otherwise sterile terrain.

(*c*) *Buteo buteo*. In general, high densities were again found on fertile soils, and in Britain in areas with most rabbits, *Oryctolagus cuniculus*, as prey. In Moore's (1957) survey, high densities occurred more often in farmland, or mixed moorland and farmland, than in moorland or forest alone. On Skomer Island (Wales), seven pairs nested in 3.1 km^2, feeding from the masses of rabbits and seabirds. Elsewhere in western Britain, densities of 0.4 to 1.5 pairs per square kilometre were found in six good rabbit districts, and in three other districts 0.1 to 0.2 pairs per square kilometre. Buzzard densities were thus 15 times greater in the best rabbit areas than in the worst (and 22 times greater if Skomer was included). Furthermore, when rabbit numbers in Britain crashed from disease in 1954–1956, Buzzard densities also fell (Dare 1961).

On the continent, in nine districts where rabbits were unimportant, Buzzard densities were generally higher in deciduous woods on rich humus soil than in pine woods on poor sandy soil, and higher in lowlands than in mountains, again linked with prey (Mebs 1964). Not all home ranges in the areas involved were contiguous but, where their sizes were calculated, they varied more or less inversely with density. Home-range size also varied within each population and, where studied, was related to local food supply or quality of feeding area (Dare 1961; Mebs 1964; Picozzi and Weir 1974).

(*d*) *Aquila verreauxi*. In some regions, this species had home ranges covering 210–260 km^2 (Rowe 1947; Brown 1955b). But in the Matopos Hills in southern Rhodesia, 55 pairs lived in 570 km^2, an average of one pair per 10 km^2, associated with an exceptional abundance of two hyrax species, the main prey (Gargett 1975). In the low density areas the rocky hills where hyrax lived were sparser and further apart than in the high density area.

(*e*) *Unusual Concentrations*. Vultures and kites live at extremely high density in some eastern cities. In Delhi in 1968–1969, 715 nesting territories including 679 occupied nests, were found in 37 km² of sample areas, a mean of 19.3 pairs/km². As the city covered 150 km², its total raptor population was estimated at 2900 pairs. Black Kites, *Milvus migrans*, formed 83%, at 16.1 pairs/km², or about 2400 pairs in all; the rest consisted mainly of large vultures (such as *Gyps bengalensis*), with 2.7 pairs/km², or 400 pairs in all, and *Neophron* at 0.5 pairs/km², or 100 pairs in all (Galushin 1971). This remarkable concentration was attributed primarily to the huge amount of food within the city: garbage, carcasses of animals on roads and rubbish dumps, small birds and mammals; but also to an abundance of nest sites, and to "the traditional good-will of Indians to all living beings." As noted earlier, the high densities of *Pandion* and *Haliaeetus* eagles in some shallow coastal areas. and of *F. eleonorae* and *F. concolor* on bird migration routes, arise where there is a continual passage of prey.

In all these raptors, breeding density was broadly related to food supply, and unusual concentrations were associated with unusual food abundances, occurring either naturally (e.g., seabird colonies) or as a result of human activity. The implication is that raptor pairs respond to the food situation, and space themselves more widely where food is scarce. *Aquila chrysaetos* in Scotland has been quoted as a possible exception. Brown and Watson (1964) counted both carrion (dead sheep and dead deer) and live prey in four areas, and found no consistent relationship between overall food abundance and eagle density. If living prey alone were considered, however, eagle density (and brood sizes) were higher in the best (eastern) area than in three poorer (western) ones.

Annual Variations in Breeding Density

Although for some species the evidence for regulation in relation to food supplies rests largely on long-term stability in breeding density, but at different levels in different regions, that for other species rests on local fluctuations in breeding density, which parallel changes in food. Most such species in the regions concerned have restricted diets based on cyclic prey (Formosov 1934; Elton 1942; Hagen 1969). Two main cycles are involved: (*a*) an approximately 4-year cycle of rodents and other animals, including the lemmings *Lemmus* and *Dicrostonyx* on the northern tundras, and various *Microtus* voles in the open forests and grasslands further south; and (*b*) an approximately 10-year cycle of snowshoe hares (*Lepus americanus*) in the boreal forests of North America (Lack 1954; Keith 1963). Gallinaceous birds are also involved, but whereas in Europe numbers of Willow Ptarmigan (*Lagopus lagopus*) follow the 4-year rodent cycle, with peaks in the same years, in North America the Willow Ptarmigan, Ruffed Grouse (*Bonasa umbellus*), and Sharp-tailed Grouse (*Pedioecetes phasianellus*) follow the 10-year hare cycle. The populations of these various animals do not reach a peak simultaneously over their whole range, but rodent cycles may be synchronized over tens or many thousands of square kilometres. The main raptor species involved in rodent cycles include the Rough-legged Hawk (*B. lagopus*) of northern tundras (Finnila 1916; Shelford 1943; Hagen 1969), various kestrels, harriers and kites of more southern grasslands and semi-deserts (Snow 1968; Hamerstrom, *in* Hickey 1969; Galushin 1974), and some similar species on the African plains (Brown 1970). All such species tend to nest more densely and produce more young per pair when rodents are plentiful than when they are scarce (Table 4). The increase in density from one year to the next is often so great that it cannot be due merely to the high survival of adults and young from the previous year, but must be due primarily to immigration. To judge from ringing recoveries, the immigration is mainly of birds nesting for the first time (Galushin 1974).

If we turn now to the species dependant on gallinaceous birds (and rabbits), the Goshawk (*Accipiter gentilis*) follows the 4-year cycle in Europe and the 10-year one in North America, which is strong circumstantial evidence of a link with food (Lack 1954; Keith 1963; Sulkava 1964). Over 7 consecutive years in part of Norway, Goshawk breeding density was one pair per 22–100 km² (Hoglund 1964), according to prey abundance, and over 4 years in part of Alaska it was one pair per 41–372 km² (McGowan 1975). The breeding density of Gyr Falcons (*F. rusticolus*) on tundras also fluctuates in relation to Ptarmigan numbers (Cade

TABLE 4—Varification in breeding populations of raptors that exploit greatly fluctuating food supplies

A. Species that eat rodents (3- to 5-year cycles)	
Rough-legged Buzzard, *B. lagopus*	(1) 0–9 pairs in nine years, 1938–1946, Dovre, Norway (Hagen 1969) (2) 51, 46, and 61 nests in 1967–1969, Colville River, Alaska (White and Cade 1971)
Hen Harrier, *C. cyaneus*	(1) 10–24 females in 33 km^2 over 22 years, 1944–1965, Orkney, Scotland (Balfour from Hamerstrom, *in* Hickey 1969) *(2) 13–25 females in 160 km^2 over five years, 1960–1964, Wisconsin (Hamerstrom *in* Hickey 1969)** *(3) 0–9 pairs in six years between 1938 and 1946 (Hagen 1969)
Kestrel, *F. tinnunculus*	*(1) 35–109 clutches in four years, 1969–1963; 109 clutches at vole density index 24, 97 at index 13, 35 at index 9, 50 at index 4, Netherlands (Cavé 1968) *(2) Approximately 20-fold fluctuation in index of number of broods ringed in Britain, 1925–1966, with peaks every 4–5 years (Snow 1968) *(3) 1–14 pairs in five years, 1942–1946, Dovre, Norway (Hagen 1969)
B. Species that eat gallinaceous birds and rabbits (4-year or 10-year cycles)	
Goshawk, *Accipiter gentilis*	(1) 0–4 nests in 100 km^2 over 13 years, 1942–1954; 2–9 nests in 200 km^2 over seven years, 1954–1960, in two areas of Norway (Hoglund (1964) (2) 1–9 nests in 372 km^2 over four years, 1971–1974, Alaska (McGowan 1975)

*Prey population also assessed and related to raptor numbers.
**Excluding one year when population dropped from DDT poisoning.

1960; White and Cade 1971), but the whole cycle has apparently not been followed. For all these raptors, more information is needed on nest spacing at different prey densities, whether home ranges are larger when prey is scarce or just have fewer nests occupied, and for the falcon whether the fluctuations are more in proportions of pairs breeding than in numbers of pairs present.

The raptor species involved in such fluctuations remain much more stable in environments where their food is more stable (often through being more varied). Compare, for example, *Accipiter gentilis* in boreal Europe (Hoglund 1964) and temperate Europe (Pielowski 1968), *F. tinnunculus* in southern and northern Britain (Taylor 1967a; Snow 1968), or *C. cyaneus* in Wisconsin (Hamerstrom, *in* Hickey 1969) and eastern Scotland (N. Picozzi, unpublished). A wide food spectrum seems to have the general effect of damping down density variations in time, presumably because the chances of total food supply fluctuating violently decrease with the increase in number of prey species involved.

Breeding Density in Relation to Nest Sites

Shortage of Nest Sites

In some open landscapes, potential nesting places are scarce and widely scattered. These may be trees or crags, according to species, but the effect is the same, with pairs further apart and at lower density than where sites are more plentiful. Such restriction can be inferred from how a species is distributed in relation to nest sites. Where sites are freely available, the density of pairs is relatively high, spacing between them is regular, and some potential sites remain untenanted; but in similar habitat with sparser sites, density is lower, spacing of pairs is irregular, according to nest sites, and all (or nearly all) potential sites are occupied. If nest sites are far apart, home ranges of neighboring pairs may be completely separated (for *Accipiter* and *B. lineatus* see Craighead and Craighead 1956). In some regions, such depressed density was apparent in *Accipiter nisus* (Tinbergen 1946), *Aquila chrysaetos* (Brown and Watson 1964; Boeker and Ray 1972), *Aquila verreauxi* (Brown 1966), *Polemaetus bellicosus* (Smeenk 1974), and many other species.

Further evidence comes when the provision of extra nest sites by man is followed by an increase in raptor breeding density. Cavé (1968) put suitable boxes on a new Dutch polder, previously almost devoid of nest sites and breeding *F. tinnunculus*, and from the next year on more than 100 pairs nested; others obtained similar

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*R. Fyfe has seen yearling *F. mexicanus* and *F. peregrinus* returning in spring to the nest-sites where they were raised, but these birds were deterred from staying by the pairs in occupation.

results on a smaller scale elsewhere, and Hamerstrom et al. (1973) did the same with the American Kestrel, *F. sparverius*. Likewise, after suitable holes had been dug in earth-banks, *F. mexicanus* increased in one area from 7 to 11 pairs (R. Fyfe, *in* Cade 1974), while the erection of nest platforms in coastal areas was followed immediately by increases in the density of breeding *Pandion* (Reese 1970; Rhodes 1972). Nesting in disused quarries has sometimes allowed *F. peregrinus* to occupy areas devoid of natural cliffs (Herbert and Herbert; Mebs; Ratcliffe all *in* Hickey 1969) as has its use of buildings in several towns in North America, Britain, and Europe (Hickey 1969; Mebs 1964), Africa (Cade, *in* Hickey 1969), and Australia (S. Davies, personal communication). On the other hand, removal of nest sites has also led to a reduction in density: in *F. peregrinus* when cliffs were destroyed by mining (Porter and White 1973), and in *Aquila heliaca* when large free-standing trees were felled (Paspaleva, *in* Biljeveld 1974). There is thus abundant evidence that the breeding density of certain species is in some regions limited by shortage of nesting places.

Interspecific Competition for Nesting Places

Where crags or nest trees are scarce, the presence of one species may influence the numbers and distribution of another. This is hard to establish where the local raptor population is stable, but becomes apparent where a change in the status of one species caused by human action is accompanied by a corresponding change in another. *Aquila chrysaetos* was eliminated from southern Scotland by human persecution. Immediately after four eagle pairs had re-occupied an area, two peregrine pairs shifted to alternative crags in the same home range, and two other pairs disappeared altogether (D.A. Ratcliffe, personal communication). Dixon (1937) also recorded an eagle pair supplanting a peregrine pair in California. Likewise, where the eagle *H. albicilla* was exterminated in northwest Scotland, both the original nest sites and the food niche were largely taken over by *Aquila chrysaetos*, implying that the latter was formerly restricted by competition.

The outcome of competition for nest sites sometimes varies with circumstance. Verner (1909) noted that *Aquila chrysaetos* and Griffons (*Gyps fulvus*) in Spain would not tolerate one another on the same cliffs, but they used the same cliffs in different years, and eagles drove away single pairs, but not groups, of Griffons. The scarcity of eagles in one region was associated with all the best sandstone cliffs being occupied by Griffon colonies. As another example, *F. mexicanus* in western Canada could displace the Canada Goose (*Branta canadensis*) from ledges on earthbanks but not from potholes (R. Fyfe, personal communication).

Where nest sites are plentiful, such competition may result merely in the displacement of one species to another site in the same home range, with no reduction in breeding density. Great Horned Owls (*Bubo virginianus*) often pre-empt the tree nests of raptors, especially *Buteo jamaicensis* (Orians and Kuhlman 1956), but alternative nests are nearly always available. Nonetheless the two species prefer to avoid one another: in an Alberta area, distances between all active nests and their nearest neighbors (either hawk or owl) differed significantly from the distances expected on a random distribution ($P < 0.01$). The nearest neighbor distances between owl-owl nests (mean 2.1 km), owl-hawk nests (mean 1.9 km), and hawk-hawk nests (mean 2.5 km) reflected this interaction (McInvaille and Keith 1974).

In many mountain areas, two or more raptor species may alternate with one another and with Ravens (*Corvus corax*) at the same crags but, if crags are plentiful, no species suffers reduction in breeding numbers (Verner 1909; Ratcliffe 1962; White and Cade 1971). Some species get along better than others, and most tolerate other species closer than their own. On the Colville River, Alaska, various raptors usually placed their nests out of view of one another and, given appropriate conditions, even *F. peregrinus* and *F. rusticolus* bred successfully on the same cliff, and neither forced Rough-legged Hawks (*B. lagopus*) to shift more than about 50 m. Yet the minimum distance between different pairs of these same species was 0.6, 3.0, and 0.4 km respectively (White and Cade 1971).

Another type of displacement sometimes occurs among species in the same genus which show partial overlap in nesting habitat. *Buteo jamaicensis* and *B. lineatus* occupy mainly different habitats but, where they overlap, they also fight and hold mutually exclusive ranges (Bent 1938; Craighead and Craighead 1956). In similar conditions, *F. peregrinus* has thrice been seen to displace previously settled *F. mexicanus* pairs (Fyfe, personal communication). Likewise, the various *Accipiter* species in Europe and North America breed mainly in woods of different structure but, where they overlap, they do not share nesting places (Newton, unpublished; H. Snyder, personal communication). In all these instances the larger species dominates and occasionally replaces the smaller, and hence presumably restricts its distribution. The competition is for nesting territories, and only to a small extent for food, but in the accipiters the larger species also eat the smaller.

Traditions in Nest Sites

Species differ in the amount of building they do, and in the range of sites they use for nesting. The falcons and cathartids do no building except for scraping out a hollow and arranging debris around the edge. But most species build large stick nests on cliffs, trees, or ground, some using only one of these situations and others two or three. Both the amount of building possible and the range of sites acceptable are presumably inherent in each species, evolved partly through predation pressures and through competition for sites with other species. But within these limits, regional variations occur. In any one area, a species normally prefers the best out of a range of sites available, and if good sites are superabundant poorer ones are ignored. More importantly, however, regional differences occur in the minimum standard of site acceptable and in the type of site used; they apparently depend on learning, and can influence the density and distribution of breeding pairs, as discussed below.

(*a*) *Standard of Site Acceptable.* Over most of its range, *F. peregrinus* nests only in places that give good security against human and other mammal predators: on high cliffs or on islets surrounded by water or bog. But on tundra and other areas where people and other predators are few, it will accept lesser crags, earth slopes, or even flat ground, on low mounds or boulders less than 1 m above surrounding terrain (Hickey 1969); Kumari 1974). "Generally speaking, the minimal height (of cliff) acceptable to the birds varies inversely with the degree of wilderness ..." (Hickey 1942). Where good sites are in short supply, the breeding density is thus lower in populated than in remote areas. The abandonment of some accessible sites with increasing human population in the Canadian Arctic was noted by Fyfe (*in* Hickey 1969), and the same evidently happened in Britain before 1860 (Ratcliffe, *in* Hickey 1969), and also in eastern North America following settlement by Europeans (Hickey 1942). In recent years, peregrines in Britain have occasionally nested on the ground on slopes, but the habit has not persisted, presumably because such attempts generally fail. Acceptance of less safe sites in areas undisturbed by people was also noted in *Neophron* in Spain (Verner 1909), and in *Pandion* on islands off eastern North America (Abbott 1911; Bent 1938); on the other hand increased human presence around some American lakes was followed by their abandonment by *H. leucocephalus* (Sprunt, *in* Hickey 1969).

In the species mentioned, site acceptance was linked with human disturbance, but the same response to natural predators probably occurs in these and other species. In the Aleutians, *H. leucocephalus* used accessible nest sites only on islands lacking arctic foxes, *Alopex lagopus* (Sherrod et al. 1976). Likewise the nesting of *F. tinnunculus* on the ground in Orkney, and of *B. buteo* on the ground in Uist (Newton, unpublished), is linked with the absence on these Scottish islands of wild mammal predators. In Orkney ground nesting by *F. tinnunculus* is recent. The first ground nest was found around 1945, but the habit grew rapidly and once a site was established, it remained in continuous occupation, so that by 1955 nineteen such sites were known, all in long heather, in cracks in banks or rabbit holes (Balfour 1955). Its development enabled Kestrels to occupy areas not otherwise available, and thereby to increase their numbers. Conversely, ground-nesting *Pandion* disappeared from an island off California, following its colonization by coyotes (*Canis latrans*) (Kenyon 1947).

There is thus evidence that (*a*) some geographical differences in the types of sites acceptable are linked with differences in local predation and disturbance pressures (e.g., *F.*

peregrinus, F. tinnunculus, B. buteo, H. leucocephalus), (*b*) minimal requirements have changed with time as disturbance and predation have changed (e.g., *F. peregrinus, H. leucocephalus, Pandion*), (*c*) individuals occasionally attempt to nest in less safe sites and, although these usually fail (e.g., *F. peregrinus*), they occasionally succeed, and (*d*) the habit may then spread, leading to local expansion in distribution and density (e.g., *F. tinnunculus*). The minimum level of security any local population accepts in nest sites may thus be in continual process of adjustment to predation pressures. Where good nest sites are superabundant, population density need not suffer, but where good sites are scarce, the population could be lower than if it accepted less safe sites.

(*b*) *Nature of Site Acceptable.* Other local traditions concerning nest sites are apparently not connected with predation. Although over most of its range *F. peregrinus* nests only on crags or earth banks, in the Mississippi drainage system in North America and in Australia it uses cavities in giant trees, and in parts of Europe, Asia, Alaska, Virginia, and Australia, it uses old tree-nests of other species (Jones 1946; papers *in* Hickey 1969; White and Roseneau 1970), and can thus breed in areas devoid of cliffs. These local traditions no doubt arose independently in each area. They are probably not genetically controlled, because in middle Europe tree- and crag-nesting populations are contiguous (Mebs, *in* Hickey 1969), and in several areas around the Baltic, crag, ground, and tree nests are interspersed in the same geographical areas (Thomasson 1947; Kumari 1974). The problem is why the habit is localized when, by nesting in trees, the species could spread over huge areas otherwise not available. Competition for tree nests can scarcely be involved, because the peregrine nests fairly early, can hold its own against most other birds, and some of the commonest sites (heron colonies) are extremely widespread. Unfortunately, most populations concerned have been exterminated in recent years through use of DDT (Hickey 1969).

Most other large falcons nest in trees, at least in part of their range, and again traditions are probably involved. *Falco rusticolus* uses trees regularly in much of its Asiatic range, but extremely rarely in Europe and North America except perhaps for the Anderson River area (Dementiev and Gladkov 1954; Bent 1938; Kuyt 1962; R. Fyfe, personal communication). *Falco cherrug* uses trees mainly in the west of the range and cliffs mainly in the east (Dementiev and Gladkov 1954). For *F. mexicanus* I can find only one good record of tree nesting, probably involving a repeat after a failure of a cliff nest (Porter and White 1973), but again the range could probably be greatly expanded if the habit caught on. Another striking instance of range restriction by nest site is in the Pygmy Falcon (*Polihierax semitorquatus*), which in southern Africa breeds in the nest-masses of the Sociable Weaver (*Philetairus socius*), and is not found outside the range of this species despite wide areas of otherwise suitable habitat (MacLean 1970).

Another problem concerns nesting on man-made structures, which would be expected in species which normally nest on cliffs. Among small falcons only the kestrels have taken up this opportunity, and several species over their whole range use anything from isolated ruins to churches and public buildings in city centers. (Witness the German name Turmfalke (tower falcon) for the European Kestrel). Among the larger falcons, nesting on man-made structures is far from widespread. The Lanner (*F. biarmicus*) has nested on the Egyptian pyramids (Meinertzhagen 1954), and both it and the Laggar (*F. jugger*) have used monuments and tall buildings in India (Vaurie 1965); the Orange-breasted Falcon (*F. deiroleucos*) has used churches and ruins in central America (Brown and Amadon 1968); *F. rusticolus* has occasionally used raven nests on disused gold dredges and other structures in Alaska (White and Roseneau 1970); but *F. mexicanus* has only once been known to attempt to breed on a building (Nelson 1974). On the other hand, *F. peregrinus* has used old buildings to a considerable extent, either isolated or in small towns (Hickey 1969). But it has nested in only a few modern cities (though on four continents), despite the high inaccessible nest sites and superabundant pigeons. Perhaps cities are acceptable to only a small fraction of the population, mass human presence deterring the rest.

Among other raptors, *Neophron* uses old buildings in India, including some in towns, and various *Buteo* species and the eagles *Aquila chrysaetos* and *A. rapax* have used isolated ruins, power poles, and other structures away from habitation (Dementiev and Gladkov 1954; White and Roseneau 1970; Olendorff and Stoddart 1974). The Osprey has long used artificial structures, including cliff substitutes such as ruins, tree substitutes such as telegraph poles, and in recent years special platforms (Reese 1970; Rhodes 1972; Garver et al. 1974; Postupalsky and Stackpole 1974). During aerial surveys along the Atlantic coast of North America, platforms for nesting Ospreys were noted in every state from South Carolina to New York, many in use. Around parts of Chesapeake Bay, it seems to have become a status symbol to have a pair of Ospreys on a platform near your home. In 1973, only 31% of the 1500 pairs in Chesapeake Bay were found nesting on trees, the remainder using duck blinds (29%), channel markers (22%), and other man-made structures, including platforms (18%) (Henny et al. 1974).

Use of man-made structures enabled all such species to increase their density and extend their range in places where natural sites were scarce or non-existent. In some instances acceptance of such structures was immediate, but in others it occurred only after many years or only in particular areas. All local traditions probably depend to some extent on young 'imprinting' to particular site-types and preferring these in adult life, but research is badly needed. The fact that use by raptors of man-made structures can be listed so briefly is an indication of the limited extent to which such opportunities have been exploited by the group as a whole. No doubt persecution has been partly responsible for deterring the larger species.

Territory Quality, Occupancy, and Success

That quality of territory influences occupancy and nesting success is evident in several species. Quality can be assessed in terms of security of nest site against predators and in terms of local food-supply, which are two major factors influencing the chance of raising young.

Security against Predation

For *F. peregrinus* in Massachusetts, Hagar (*in* Hickey 1969) graded cliffs according to height, disturbance by people, and suitability of ledges. In the years 1935–1942 and 1947, the six best cliffs were occupied by pairs every year, but of eight poorer cliffs, four to seven were occupied in different years, though sometimes by single males or by pairs in which the female was in immature plumage. Surplus non-breeding females were also present because female vacancies on good cliffs were promptly filled, and extra females repeatedly visited such cliffs where pairs were established. This occurred even though males held some poorer cliffs alone, the implication being that not all females found inferior sites acceptable. Breeding success was also better on good cliffs, but it is not certain whether this was owing entirely to the cliff itself, or to its being occupied by older (or superior) birds. Pairs on good cliffs more often laid eggs, and hatched and raised more young than did pairs on poor cliffs, the mean production on good and poor cliffs being respectively 1.6 young and 0.5 young per pair per year. In other regions, too, good cliffs were more consistently tenanted than lesser ones (Hickey 1942; Ratcliffe 1972) and, as populations declined in recent years (through pesticide poisoning), the poorer cliffs were generally deserted first (Rice, *in* Hickey 1969; Porter and White 1973). These observations could be interpreted in two ways: either the adults which held the best cliffs survived longest, or any birds that wished to nest consistently chose the best of the various unoccupied cliffs available.

For *Pandion* in Connecticut, raised nests (on trees or platforms) were more successful than ground ones (Ames and Mersereau 1964), mainly because of differences in accessibility to human and natural predators. The birds also shifted from the ground when such raised sites were made available artificially (see also Reese 1970). Likewise among *F. columbarius* in Britain, nests in trees were more successful than those on low crags accessible to foxes, and the latter were more successful than those on the ground (Newton, unpublished). Other significant differences in success between territories, dependent on remoteness and inaccessibility to people, were noted in *Aquila chrysaetos* (Brown 1969), *B. jamaicensis*, and *B. lineatus* (Wiley 1975a).

Local Food-supply

In part of southern Scotland, 150 *Accipiter nisus* territories were occupied at least once in a 5-year period, with 82–110 occupied in individual years (Newton and Marquiss, *in press*). Particular birds often occupied different territories in different years. Many more territories were occupied in only one year and in all five years than was expected on a chance basis ($P<0.001$), indicating that birds avoided certain territories and favored others. The most popular territories were those in which nesting attempts were most often successful ($P<0.001$), partly because they were nearest to good food sources. Most good territories were in small woods in low farmland and most poor ones were in large forests in neighboring hills (Newton, *in press*). Predation and human interference were negligible. Likewise in *B. buteo*, the number of young in successful nests was significantly correlated with the amount of farmland in each of 22 home ranges. Farmland was again richer in prey than the other habitats in the area (Picozzi and Weir 1974). Among 56 *H. vocifer* pairs on Lake Naivasha, Kenya, those with access to lagoons in papyrus swamp had consistently better success than those with access to open water, probably because of a difference in food availability (Brown and Hopcraft 1973).

There are thus indications from several species that not all territories and nest sites in a region are equally good, that birds appreciate these differences and, in at least two species, that they compete more strongly and stick more tenaciously to the good ones. For female peregrines in Massachusetts, a good-quality site was apparently more important than the presence of a potential mate on a poor site in leading to pair formation. So far no data show that individuals which start in poor territories eventually move to good ones. But this might be expected from the facts that (*a*) after death of its mate, *F. peregrinus* is more likely to desert a poor territory than a good one (Hickey 1942), and (*b*) individuals of some species are more likely to desert their breeding place after a failure than after a success (for *B. buteo* see Dare 1961; for *C. cyaneus* see Hamerstrom 1969; and for *Accipiter nisus* see Newton and Marquiss, *in press*).

Winter Populations

Dispersion in Winter

What little is known of raptors in winter suggests that their dispersion and density are no less related to food supply then than while breeding. Nesting sites are irrelevant and roosting sites are likely to be important only in open country, devoid of trees and crags. (Harriers are unusual in roosting on the ground). The three main systems of winter dispersion are based on the following:

(a) Exclusive, or partly exclusive, home ranges, which in resident species may cover much the same ground as in summer, and support either the pair together or one member alone (Craighead and Craighead 1956). In resident *Buteo* and *Aquila* species the pair usually stay together on the range (Brown 1955b; Dare 1961; Gargett 1971), and may even feed together on the same carcasses (Kellomaki and Sulkava 1974). Adults that have left their breeding areas hold individual winter ranges, as do immatures. Such winter ranges are commonly held, among others, by *Aquila, Buteo, Accipiter,* and *Falco* species. Birds may roost within their hunting areas or, if a suitable place is not available, may fly elsewhere. As such species roost solitarily, the actual sites are presumably defended, as seen in *F. peregrinus* (Herbert and Herbert 1965) and *F. tinnunculus* (Newton, unpublished).

(b) Communal roosts, localized and often communal hunting areas. Individuals keep apart when hunting, but their hunting areas are often grouped or communal, as in summer, and from time to time change in location. This system is shown by species that exploit sporadic food supplies, including *B. lagopus* (Schnell 1969), various *Milvus* kites (Davies and Davis 1973; Ward and Zahavi 1973), and *Circus* harriers (Weiss 1923; Gurr 1968; Watson and Dickson 1972; Renssen 1973). Two or more *Circus* species often use the same roost (Moreau 1972), and in one place, *C. cyaneus* regularly flew up to 36 km from roost to feeding area (Craighead and Craighead 1956). In North America, *H. leucocephalus* roosts and feeds communally where fish are temporarily plentiful, with up to 3000 birds in one place (McClelland 1973).

(c) Huge communal roosts, flock-feeding, and itinerancy in relation to local flushes of food, such as termites and locusts. The roosts break up into smaller flocks by day. This system is shown mainly by the insectivorous falcons, namely *F. amurensis, F. eleonorae, F. naumanni,* and *F. vespertinus.* Roosts often number thousands of individuals of several species, and at least one contained 50 000–100 000 birds, mainly *F. amurensis* (Benson 1951; Moreau 1972). They may be used year after year (Benson 1951). *Milvus* and *Elanus* kites, harriers, buzzards, eagles, Lanner Falcons (*F. biarmicus*) and other species also congregate around colonies of Quelea finches, termite and locust swarms (Jensen 1972; Brooke et al. 1972). In Rhodesia, Steyn (*in* Moreau 1972) saw 'groups of *A. rapax* and *A. pomarina* wandering on the ground like so many chickens capturing termites as they emerged for nuptial flight.' On one occasion he estimated 150–200 of these large eagles in less than one hectare. Elsewhere in Africa, Spotted Eagles (*Aquila clanga*) and Hobbies (*F. subbuteo*) also feed in flocks on insect concentrations, and in equivalent habitat in South America Swainson's Hawks (*Buteo swainsoni*) and to a lesser extent Broad-winged Hawks (*B. platypterus*), vultures, and harriers do the same (Bent 1938). Moreover, they may be in single species or multi-species flocks. Vultures that depend on large carcasses behave similarly, but generally roost in smaller concentrations and are less nomadic than the insectivores.

To conclude, the same broad relationships between dispersion patterns and food supplies hold in winter as in summer, more or less exclusive home ranges being associated with fairly regular even food supplies, and some form of gregariousness with abundant yet sporadic and unpredictable ones. Again flock-feeding occurs when mutual interference on abundant supplies is not important, and particular species show different dispersion patterns according to diet. They may also change for short periods, as when many birds leave their regular ranges to feed together on a large carcass (for *H. leucocephalus* see Sherrod et al. 1976).

Density Regulation

On 96 km^2 of farmland, with scattered woods and marshes, in southern Michigan, *B. jamaicensis, B. lineatus, B. lagopus, F. sparverius*, and *C. cyaneus* fed chiefly on *Microtus* voles, and *Accipiter cooperi* on birds (Craighead and Craighead 1956). The whole raptor population became stabilized after autumn migration, in home ranges which varied in size according to species and food supply. In general, ranges were smaller and density higher in a winter when mice were plentiful than in a second winter when mice were scarce. Some 96 hawks of six species remained the first winter, but only 27 of four species the second, with juveniles relatively fewer, *C. cyaneus* present for only a short time, and *B. lagopus* absent altogether. It was not clear how the birds adjusted to food supply, but they continually responded to one another, often in subtle ways, and a short flight by one bird was followed by similar flights by its neighbors, leading to continual spatial adjustment. Nor was it clear whether the failure of two species to remain through the second winter was the result of such interactions, or because they needed higher prey densities than other species to maintain themselves. But *C. cyaneus* when present consistently hunted those parts of the *Buteo* ranges which were not in use at the time.

In *F. tinnunculus*, aggressive and spacing behavior in winter was also related to food (Cavé 1968). In one winter when voles were numerous, the birds concentrated at suitable areas and showed no obvious territorial behavior; but in another winter when voles were scarce, they defended individual hunting ranges. This was established by observation and by use of stuffed birds, a method previously used by Cade (1955) on *F. sparverius.* These various observations give some idea of how populations settle on winter quarters and, if home ranges vary with food supplies, of how densities are determined. They also indicate how some species come to spread further south than usual in years when food is scarce. Such 'invasion' movements are especially marked in *B. lagopus* (Schüz 1945) and *Accipiter gentilis*, in both of which young birds move further than old ones, as might be expected from their lower social status (Mueller and Berger 1967, 1968).

To conclude, both dispersion and the density of birds of prey in winter can be related to the distribution and abundance of food, and changes in density of birds may be mediated through social interactions, as in spring. This holds within species, and to some extent between species that are sharing the same resources. Besides food, most raptors need hunting and roosting perches in winter, and the extent to which lack of such perches restricts winter density in open country needs investigating. The birds are quick to use power poles and other structures for this purpose.

Discussion

The natural distribution of breeding raptors can be explained largely in terms of two major resources, food and nest sites. Predators seem to be important only indirectly in influencing the types of nest sites accepted by a species, and thus in some areas its breeding density. In winter, nesting sites are irrelevant, and for most species roosting sites are likely to be limiting only in open landscapes devoid of trees and crags. The sections below consider the adaptive significance of various behavior patterns.

Mating Systems

In raptors, the pairs stay together at least for the duration of breeding, presumably because both partners are necessary for rearing the young. Work is divided, the female being responsible for most defence and parental care, and the male for most hunting. One might therefore expect that polygyny would arise in good food conditions, when a male could feed more than one female at the same time (presumably at the time of settling), and polyandry in the opposite conditions, when one male alone was unable to feed a female properly. Three lines of evidence suggest a link between polygyny and ease of foraging: (*a*) polygyny (as in other birds, Lack 1968; Orians 1971), occurs mainly among raptor species found in two-dimensional habitats, such as marsh or prairie, where biological production is concentrated at one level; (*b*) in any one species, it is most prevalent in areas or in years which on other evidence are considered rich in food (see Balfour 1962 for *C. cyaneus*; Picozzi and Weir 1974 for *B. buteo*); and (*c*) in *C. cyaneus* it is more prevalent among older, more experienced males than among young ones (Balfour and Cadbury 1974). The proposed link between polyandry and difficulty in foraging is less firm, but *P. unicinctus* practises group hunting, so a pair of males may be disproportionately more successful at obtaining food than one alone (Mader 1975). In several species which showed an unusual mating system, groups persisted for more than one year, despite the occasional replacement of a group member. This implies some regulation in composition of mating groups and, to judge from findings on other birds, neither polygyny nor polyandry is likely to result merely from uneven sex ratio. Study of their incidence in the same species in different environments, together with the experimental removal of selected individuals, perhaps offer the best lines of investigation.

Spacing Systems

In raptors, as in other birds (Crook 1965; Lack 1968), exclusive or partly exclusive home ranges are associated with fairly even and stable food supplies, and gregariousness (communal nesting, roosting, and feeding) with sporadic food supplies. Particular dispersion patterns are not necessarily characteristic of species, moreover, and various eagles, buzzards, harriers, kites, and falcons adopt different systems according to how their food is distributed. Thus statements in the literature, for example that a certain species holds feeding territories, may mean no more than that the species has so far been studied only in environments where such behavior is advantageous. Nonetheless, many species show only one dispersion pattern over most of their range, or for most of the time.

The transition from exclusive home ranges, through overlapping home ranges, to communal but continually changing feeding areas, gives the birds progressively greater freedom to adjust to changes in available food sources. In an exclusive range, the individual (or pair) gets sole use of food sources; in an overlapping range, each pair holds an exclusive area around the nest, but has shared access to the food sources of a wider area; and in a nesting colony, each pair has exclusive use of a small nesting area, but can forage with others over a very wide area, wherever food happens to be plentiful at the time. The three systems may thus be regarded as progressive adjustments to increasingly widely spaced and sporadic food sources. An even more flexible system is possible in winter, when the birds no longer need to return frequently to a fixed point (the nest) and can become nomadic over huge areas, which is apparently the strategy adopted by insectivorous falcons in Africa. In any one area, moreover, different segments of a population may forage differently, nonbreeders having greater freedom of movement than resident pairs.

The behavior of a bird in any one situation may depend on how resources are distributed relative to its foraging range. It may be economical for it to defend predictable and abundant food supplies, but not unpredictable or sparse ones. Thus Snyder and Snyder (1970) have described territorial and communal feeding in *Rhostramus* kites under abundant and sparse food supplies respectively. With widely spaced sporadic food sources, gregariousness may also be advantageous because individuals can quickly learn from one another the locations of temporary feeding areas (Ward and Zahavi 1973). No one who has seen vultures home in to a carcass can doubt the effectiveness of such social facilitation.

How far apart birds hunt also depends on resources. Flock-feeding occurs when food is locally so concentrated that many individuals can feed in a small area without interfering with one another. Feeding in multi-species flocks on the same food is also associated with sporadic super abundances. The latter thus lead to relaxation both in the usual spacing within species and in the usual food differences between species.

Spacing in Solitary Nesters

The spacing-out of nesting territories seems to serve at least two purposes, first to adjust breeding density to correspond with the resources available in particular landscapes; and second, to achieve some regularity in distribution. The advantage of regularity is that individual pairs are as far apart as possible under any given density, thus reducing the chances of mutual interference in breeding and hunting. Also, if the nest is near the middle of the hunting area, the time spent travelling back and forth is minimal.

Some form of aggressive behavior is probably involved as a proximate factor in achieving spacing, and hence in limiting density. This is shown by the existence of "surplus birds," which attempt to nest when a territory is made available through death of an occupant, but otherwise do not. But how does density come to be limited at different levels in areas with different prey abundance? A suitable hypothesis would be that differences in feeding conditions produce differences in the behavior of the birds, which in turn leads to differences in density. Obviously aggressive behavior is seen mainly around the nest and, in many solitary nesters, the distance at which breeding pairs space themselves is much greater than the distance at which they attack intruders. Hence, other interactions (perhaps involving advertizement and avoidance) may be involved in spacing out pairs to the extent observed. The alternative view, that a tendency to nest at high or low density is genetically fixed in each bird, is untenable because of the short-term temporal and spatial variations which occur in the same population, and the fact that appropriate behavioral changes have been seen in birds under changing food conditions (Cavé (1968), Craighead and Craighead (1956), Snyder and Snyder (1970)).

Future Work

This paper has attempted to organize the types of information at present available on spacing and density limitation in raptors, so as to provide a basis for further work and experiment. More information is particularly needed on (*a*) the extent to which individual birds return to the same nesting territories in successive years, or move to other territories, (*b*) the use of home ranges, local movements and interactions of neighboring pairs, (*c*) the conditions under which polygyny and polyandry develop, (*d*) the role of social behavior in density regulation, especially the relation between food supplies on the one hand and aggressive and spacing behavior on the other, (*e*) variations in the quality of home ranges, and of the individuals occupying them. Experimentation could usefully include artificial nest sites, stuffed or captive birds, temporary removal of territory owners, and provision of extra food. As it is, most of our understanding of population control in raptors is based on associations.

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Literature Cited

Abbott, C. G. 1911. The home-life of the Osprey. Witherby, London. 54 pp.

Ali, S. and **S. D. Ripley.** 1968. Handbook of the birds of India and Pakistan. Volume 1. Oxford University Press, London. 380 pp.

Ames, P. L. and **G. S. Mersereau.** 1964. Some factors in the decline of the Osprey in Connecticut. Auk 81: 173-185.

Baker, S. 1932-1935. The nidification of birds of the Indian Empire. Volume 4. Taylor & Francis, London. 546 pp.

Balfour, E. 1955. Kestrels nesting on the ground in Orkney. Bird Notes 26: 245-253.

Balfour, E. 1962. The nest and eggs of the Hen Harrier in Orkney. Bird Notes 30: 69-73, 145-52.

Balfour, E. and **J. Cadbury.** 1974. A population study of the Hen Harrier, *Circus cyaneus*, in Orkney. *In* The natural environment of Orkney. *Edited by* R. Goodier. Nature Conservancy Council, Edinburgh. pp. 122-128.

Beebe, F. C. 1960. The marine Peregrines of the northwest Pacific coast. Condor 62: 145-189.

Bengston, S. A. 1967. Observations of the reproductive success in 26 nests of the Marsh Harrier *Circus aeruginosus* in Skane Province, Sweden. Oologists' Record 41: 23-28.

Benson, C. W. 1951. A roosting site of the eastern Red-footed Falcon *F. amurensis*. Ibis 93: 467-468.

Bent, A. C. 1937-1938. Life histories of North American birds of prey. Volume 1 and 2. Dover, New York. 409 and 482 pp., respectively.

Biljeveld, M. 1974. Birds of prey in Europe. MacMillan Press, London. 263 pp.

Boeker, E. L. and **T. D. Ray.** 1972. Golden Eagle population studies in the southwest. Condor 73: 463-467.

Bolam, G. 1912. Birds of Northumberland and the Eastern Borders. Privately published, Alnwick. 726 pp.

Bond, R. M. 1946. The Peregrine population of western North America. Condor 48: 101-116.

Breckenridge, W. J. 1935. An ecological study of some Minnesota Marsh Hawks. Condor 37: 268-276.

Broley, C. L. 1947. Migration and nesting of Florida Bald Eagles. Wilson Bulletin 59: 3-20.

Brooke, R. K., J. H. Grobler, and **M. P. S. Irwin.** 1972. A study of the migratory eagles *Aquila nipalensis* and *A. pomarina* (Aves: Accipitridae) in Southern Africa, with comparative notes on other large raptors. Occasional Papers of the National Museums of Rhodesia 1972, B5(2): 61-114.

Brown, L. H. 1952-1953. On the biology of the large birds of prey of Embu District, Kenya Colony. Ibis 94: 577-620; 95: 74-114.

Brown, L. H. 1955a. Supplementary notes on the biology of the large birds of prey of Embu District, Kenya Colony. Ibis 97: 38-64.

Brown, L. H. 1955b. Eagles. Michael Joseph, London, 274 pp.

Brown, L. H. 1960. The African Fish eagle *Haliaëtus vocifer*, especially in the Kavirondo Gulf. Ibis 102: 285-297.

Brown, L. H. 1966. Observations on some Kenya eagles. Ibis 108: 531-572.

Brown, L. H. 1969. Status and breeding success of Golden Eagles in north-west Sutherland in 1967. British Birds 62: 345-363.

Brown, L. H. 1970. African birds of prey. Collins, London. 320 pp.

Brown, L. H. and **D. Amadon.** 1968. Eagles, hawks and falcons of the world. Country Life Books, London. 945 pp.

Brown, L. H. and **J. B. D. Hopcraft.** 1973. Population structure and dynamics in the African Fish Eagle *Haliaëtus vocifer* (Daudin) at Lake Naivasha, Kenya. East Africa Wildlife Journal 11: 255-269.

Brown, L. H. and **A. Watson.** 1964. The Golden Eagle in relation to its food supply. Ibis 106: 78-100.

Cade, T. J. 1955. Experiments on winter territoriality of the American Kestrel, *Falco sparverius*. Wilson Bulletin 67: 5-17.

Cade, T. J. 1960. Ecology of the Peregrine and Gyrfalcon population in Alaska. University of California Publications in Zoology 63: 151-290.

Cade, T. J. 1974. Plans for managing the survival of the Peregrine Falcon. Management of Raptors, Raptor Research Foundation, Raptor Research Report 2: 89-104.

Cade, T. J., C. M. White, and **J. R. Haugh.** 1968. Peregrines and pesticides in Alaska. Condor 70: 170-178.

Cavé, A. J. 1968. The breeding of the Kestrel, *Falco tinnunculus* L., in the reclaimed area Ostelijk Flevoland. Netherlands Journal of Zoology 18: 313-407.

Clapham, C. S. 1964. The birds of the Dahlac Archipelago. Ibis 106: 376-388.

Cooke, A. S. 1973. Shell thinning in avian eggs by environmental pollutants. Environmental Pollution 4: 85-152.

Craighead, J. J. and **F. C. Craighead.** 1956. Hawks, owls and wildlife. Stackpole, Pennsylvania. 443 pp.

Crook, J. H. 1965. The adaptive significance of avian social organisations. Symposium of the Zoological Society of London 14: 181-218.

Dare, P. 1961. Ecological observations on a breeding population of the Common Buzzard *Buteo buteo*. Ph.D. thesis, Exeter University.

Davies, P. W. and **P. E. Davis.** 1973. The ecology and conservation of the Red Kite in Wales. British Birds 66: 183-324, 241-270.

Dementiev, G. P. and **N. A. Gladkov.** 1954. Birds of the Soviet Union. Volume 1. Publishing House, Moscow. (*In Russian.*) 704 pp.

Dent, G. 1939. A case of bigamy in Montagu's Harrier. British Birds 33: 51-52.

Dixon, J. B. 1937. The Golden Eagle in San Diego County, California. Condor 39: 49-56.

Elton, C. S. 1942. Voles, mice and lemmings. University Press, Oxford. 496 pp.

Eltringham, S. K. 1975. Territory size and distribution in the African Fish Eagle. Journal of Zoology (London) 175: 1-13.

Enderson, J. H. 1960. A population study of the Sparrow Hawk in east and central Illinois. Wilson Bulletin 72:222-231.

Ferguson-Lees, J. L. 1951. The Peregrine population of Britain. Bird Notes 24: 200–205, 309–314.

Finnilä, C. 1916. Studier öfver Fjällvraken (*Archibuteo lagopus*) i Finska lappland. Fauna och Flora 11: 165–172.

Fitch, H. S., F. Swenson, and **D. F. Tillotson.** 1946. Behavior and food habits of the Red-tailed Hawk. Condor 48: 205–237.

Formosov, A. N. 1934. Raptors and rodents. Zoologicheskii Zhurnal 13: 664–700. (*In Russian.*)

Galushin, V. M. 1971. A huge urban population of birds of prey in Delhi, India. (*Preliminary note.*) Ibis 113: 522.

Galushin, V. M. 1974. Synchronous fluctuations in populations of some raptors and their prey. Ibis 116: 127–134.

Gargett, V. 1970. Black Eagle Survey, Rhodes Matopos National Park. A population study 1964–1969. Ostrich Supplement 8: 397–414.

Gargett, V. 1971. Some observations on Black Eagles in the Matopos, Rhodesia. Ostrich Supplement 9: 91–124.

Gargett, V. 1975. The spacing of Black Eagles in the Matopos, Rhodesia. Ostrich 46: 1–44.

Garver, D. P., J. R. Koplin, and **J. R. Karl.** 1974. Osprey management on the Lassen National Forest, California. Management of Raptors, Raptor Research Foundation, Raptor Research Report 2: 119–122.

Gordon, S. 1955. The Golden Eagle, king of birds. Collins, London. 246 pp.

Gurr, L. 1968. Communal roosting behavior of the Australasian Harrier in New Zealand. Ibis 110: 332–337.

Hagar, D. C. 1957. Nesting populations of Red-tailed Hawks and Horned Owls in central New York State. Wilson Bulletin 69: 263–272.

Hagen, Y. 1969. Norwegian studies on the reproduction of birds of prey and owls in relation to micro-rodent population fluctuations. Fauna 22: 73–126. (*Norwegian, with English summary.*)

Hall, E. M. 1947. Concentrated nesting of Marsh Hawks. Condor 49: 211–212.

Hall, G. H. 1955. Great moments in action, the story of the Sun Life falcons. Mercury Press, Montreal. (Also reprinted 1970, Canadian Field-Naturalist 84: 211–230.)

Hamerstrom, F., F. N. Hamerstrom, and **J. Hart.** 1973. Nest boxes: an effective management tool for Kestrels. Journal of Wildlife Management 37: 400–403.

Hecht, W. R. 1951. Nesting of the Marsh Hawk at Delta, Manitoba. Wilson Bulletin 63: 167–176.

Henny, C. J., F. C. Schmid, E. L. Martin, and **L. L. Hood.** 1973. Territorial behavior, pesticides, and the population ecology of Red-shouldered Hawks in central Maryland, 1943–1971. Ecology 54: 543–554.

Henny, C. J., M. M. Smith, and **V. D. Stotts.** 1974. The 1973 distribution and abundance of breeding Ospreys in the Chesapeake Bay. Chesapeake Science 15: 125–233.

Henny, C. J. and **H. M. Wight.** 1969. An endangered osprey population: estimates of mortality and production. Auk 86: 188–198.

Herbert, R. A. and **K. G. S. Herbert.** 1965. Behavior of Peregrine Falcons in the New York City Region. Auk 82: 62–94.

Herrick, F. R. 1924. Nests and nesting habits of the American Eagle. Auk 41: 213–231.

Hickey, J. J. 1942. Eastern populations of the Duck Hawk. Auk 59: 176–204.

Hickey, J. J. (*Editor*). 1969. Peregrine Falcon populations, their biology and decline. University of Wisconsin Press, Madison. 596 pp.

Höglund, N. 1964. Der Habicht *Accipiter gentilis* Linné in Fennoscandia. Viltrevy 2: 195–328.

Holstein, V. 1942. Duehogen *Astur gentilis dubius* (Sparrman). Forlag. Copenhagen. 155 pp.

Holstein, V. 1944. Hvepsevaagen *Pernis apivorus apivorus* (L.). Forlag, Copenhagen. 199 pp.

Hosking, E. 1943. Some observations on the Marsh Harrier. British Birds 37: 2–9.

Houston, D. C. 1974. The role of Griffon Vultures *Gyps africanus* and *Gyps ruppellii* as scavengers. Journal of Zoology (London) 172: 35–46.

Hoxie, W. J. 1910. Notes on the Bald Eagle in Georgia. Auk 27: 454.

Jensen, R. A. C. 1972. The Steppe Eagle *Aquila nipalensis* and other termite-eating raptors in South West Africa. Madaqua, Series 1(5): 73–76.

Joensen, A. 1968. An investigation on the breeding population of the Buzzard (*Buteo buteo*) on the Island Als in 1962 and 1963. Dansk Ornithologisk Forenings Tidsskrift 62: 17–31. (*Danish, with English summary*).

Johnson, S. J. 1975. Productivity of the Red-tailed Hawk in southwestern Montana. Auk 92: 732–736.

Jones, F. M. 1946. Duck hawks in eastern Virginia. Auk 63: 592.

Jourdain, F. C. R. 1928. Bigamy in the Sparrowhawk. British Birds 21: 200–202.

Keith, L. B. 1963. Wildlife's ten year cycle. University of Wisconsin Press, Madison. 201 pp.

Kellomaki, E. and **P. Sulkava.** 1974. Suomen kotkat v. 1973. Suomen Luonto 33: 90-93.

Kenyon, K. W. 1947. Breeding populations of the Osprey in lower California. Condor 49: 152–158.

Kraan, van der, C. and **N. Y. van Strien.** 1969. Polygamie bÿ de Blauwe Kiekendief (*Circus cyaneus*). Limosa 42: 34–35.

Kramer, K. 1973. Habicht und Sperber. Die Neue Brehm-Bucherei. Ziemsen Verlag, Wittenberg Lutherstadt. 103 pp.

Kumari, E. 1974. Past and present of the Peregrine Falcon in Estonia. *In* Estonian wetlands and their life. Valgus, Tallinn. pp. 230–253.

Kuyt, E. 1962. A record of a tree-nesting Gyrfalcon. Condor 64: 508–510.

Lack, D. 1954. The natural regulation of animal numbers. University Press, Oxford. 343 pp.

Lack, D. 1968. Ecological adaptations for breeding in birds. Methuen, London. 409 pp.

Leopold, A. S. and **T. O. Wolfe.** 1970. Food habits of nesting Wedge-tailed Eagles, *Aquila audax*, in southeastern Australia. CSIRO Wildlife Research 15: 1–17.

Lockie, J. D. 1964. The breeding density of the Golden Eagle and Fox in relation to food-supply in Wester Ross, Scotland. Scottish Naturalist 77: 67–77.

Lundevall, C. F. and **E. Rosenberg.** 1955. Some aspects of the behavior and breeding biology of the Pallid Harrier (*Circus macrourus*). Proceedings of the International Ornithological Congress 11: 599–603.

Luttich, S. N., L. B. Keith, and **J. D. Stephenson.** 1971. Population dynamics of the Red-tailed Hawk (*Buteo jamaicensis*) at Rochester, Alberta. Auk 88: 73–87.

Lynes, H. 1925. On the birds of North and Central Darfur. Ibis 1925: 344–416.

McClelland, B. R. 1973. Autumn concentrations of Bald Eagles in Glacier National Park. Condor 75: 121–123.

McGahan, J. 1968. Ecology of the Golden Eagle. Auk 85: 1–12.

McGowan, J. D. 1975. Distribution, density and productivity of Goshawks in interior Alaska. Report of the Alaska Department of Fish and Game. 32 pp.

McInvaille, W. B., Junior and **L. B. Keith.** 1974. Predator-prey relations and breeding biology of the Great Horned Owl and Red-tailed Hawk in central Alberta. Canadian Field-Naturalist 88: 1–20.

MacLean, G. L. 1970. The Pygmy Falcon *Polyhierax semitorquatus*. Koedoe 13: 1–21.

Mader, W. J. 1975. Extra adults at Harris' Hawk nests. Condor 77: 482–485.

Mathew, M. A. 1882. Two Kestrels laying in the same nest. Zoologist 6: 267–268.

Mayr, E. 1938. The proportion of sexes in hawks. Auk 55: 522–523.

Mead, C. J. 1973. Movements of British raptors. Bird Study 20: 259–286.

Mebs, Th. 1964. Zur Biologie und Populationsdynamik des Mausebussards (*Buteo buteo*). Journal für Ornithologie 104: 247–306.

Meinertzhagen, R. 1954. Birds of Arabia. Oliver and Boyd, London. 337 pp.

Moore, N. W. 1957. The past and present status of the Buzzard in the British Isles. British Birds 50: 173–197.

Moreau, R. 1972. The Palaearctic-African bird migration systems. Academic Press, London. 384 pp.

Mueller, H. C. and **D. D. Berger.** 1967. Some observations and comments on the periodic invasions of Goshawks. Auk 84: 183–191.

Mueller, H. C. and **D. Berger.** 1968. Sex ratios and measurements of migrant Goshawks. Auk 85: 431–436.

Nelson, R. W. 1974. Prairie Falcons: nesting attempt on a building, and effects of weather on courtship and incubation. Ethology Information Exchange, Raptor Research Foundation 1: 10–12.

Nelson, R. W. and **M. R. Myres.** 1975. Changes in the Peregrine population and its sea-bird prey at Langara Island, British Columbia. Raptor Research Report 3: 13–31.

Nethersole-Thompson, D. 1951. The Greenshank. Collins, London. 145 pp.

Neufeldt, I. A. 1964. Notes on the nidification of the Pied Harrier *Circus melanoleucos* (Pennant), in Amurland, U.S.S.R. Journal of the Bombay Natural History Society 64: 284–306.

Newton, I. 1972. Birds-of-prey in Scotland: some conservation problems. Scottish Birds 7: 5–23.

Newton, I. 1973. Studies of Sparrowhawks. British Birds 66: 271–278.

Newton, I. Breeding of Sparrowhawks (*Accipiter nisus*) in different environments. Journal of Animal Ecology. *In press.*

Newton, I. and **M. Marquiss.** Occupancy and success of territories in the European Sparrowhawk. Raptor Research. *In press.*

Newton, I., M. Marquiss, D. N. Weir, and **D. Moss.** The spacing of Sparrowhawk nesting territories. Journal of Animal Ecology. *In press.*

Olendorff, R. R. and **J. W. Stoddart.** 1974. The potential for management of raptor populations in western grasslands. Management of Raptors, Raptor Research Foundation, Raptor Research Report 2: 47–88.

Olendorff, R. R. and **M. N. Kochert.** Land management for the conservation of birds of prey. Proceedings of ICBP Conference, Vienna. *In press.*

Olson, V. 1958. Dispersal, migration and death causes of *Strix aluco, Buteo buteo, Ardea cinerea* and *Larus argentatus*. Acta Vertebratica 1: 95–189.

Orians, G. 1971. Ecological aspects of behavior. *In* Avian biology. Volume 1. *Edited by* D. S. Farner and J. R. King. Academic Press, New York and London. pp. 513–546.

Orians, G. and **F. Kuhlman.** 1956. The Red-tailed Hawk and Great Horned Owl populations in Wisconsin. Condor 58: 371–385.

Osterlof, S. 1951. Fiskgjusens, *Pandion haliaetus* (L.) flyttning. Var Fagelvärld 10: 1-15.

Owen, J. H. 1936–1937. Further notes on the Sparrowhawk. British Birds 30: 22–26.

Petersen, C. M. 1956. Studies of the breeding-biology of the Kestrel *Falco tinnunculus* L. in Copenhagen. Dansk Ornithologisk Forenings Tidsskrift 50: 134–159 (*Danish, with English summary*.)

Pickwell, G. 1930. The White-tailed Kite. Condor 32: 221–239.

Picozzi, N. and **D. Weir.** 1974. Breeding biology of the Buzzard in Speyside. British Birds 67: 199–210.

Piechocki, R. 1968. Der Turmfalke. Die Neue Brehm-Bucherei. Ziemsen Verlag, Wittenberg Lutherstadt. p. 50.

Pielowski, Z. 1968. Studien über die Beslandsverhaltnisse einer Habichtspopulation in Zentralpolen. Schriftenreihe der Landesstelle für Naturschutz und Landschaftspflege in Nordrhein-Westfalen 5: 125–136.

Platt, J. B. 1973. Habitat and time utilisation of a pair of nesting Sharp-shinned Hawks (*Accipiter striatus velox*) —a telemetry study. M.Sc. thesis. Brigham Young University, Utah.

Porter, R. D. and **C. M. White.** 1973. The Peregrine Falcon in Utah, emphasising ecology and competition with the Prairie Falcon. Brigham Young University Science Bulletin 18: 1–74.

Postupalsky, S. 1974. Raptor reproductive success: some problems with methods, criteria, and terminology. Management of Raptors, Raptor Research Foundation, Raptor Research Report 2: 21–31.

Postupalsky, S. and **S. M. Stackpole.** 1974. Artificial nesting platforms for Ospreys in Michigan. Management of Raptors, Raptor Research Foundation, Raptor Research Report 2: 105–117.

Ratcliffe, D. A. 1962. Breeding density in the Peregrine *Falco peregrinus* and Raven *Corvus corax*. Ibis 104: 13–39.

Ratcliffe, D. A. 1970. Changes attributable to pesticides in egg breakage frequency and eggshell thickness in some British birds. Journal of Applied Ecology 7: 67–107.

Ratcliffe, D. A. 1972. The Peregrine population of Great Britain in 1971. Bird Study 19: 117–156.

Reese, J. G. 1970. Reproduction in a Chesapeake Bay Osprey population. Auk 87: 747–759.

Renssen, Th. A. 1973. Social roosting of *Circus buffoni* in Surinam. Ardea 61: 188.

Rhodes, L. I. 1972. Success of Osprey nest structures at Martin National Wildlife Refuge. Journal of Wildlife Management 36: 1296–1299.

Rowan, W. 1921–1922. Observations on the breeding habits of the Merlin. British Birds 15: 122–129, 194–202, 222–231, 246–253.

Rowe, E. G. 1947. The breeding biology of *Aquila verreauxi* Lesson. Ibis 39: 347–410, 576–606.

St. John, C. 1884. A short tour in Sutherland. Volume 1. David Douglas, Edinburgh. pp. 296.

Sandeman, P. W. 1957. The breeding success of Golden Eagles in the southern Grampians. Scottish Naturalist 69: 148–152.

Saxby, H.L. 1874. The birds of Shetland. MacLachlan and Stewart, Edinburgh. p. 6.

Schipper, W. J. A. 1973. A comparison of prey selection in sympatric Harriers, *Circus* sp., in Western Europe. Gerfaut 63: 17–120.

Schmutz, J. K. and **S. M. Schmutz**. 1975 Primary molt in *Circus cyaneus* in relation to nest brood events. Auk 92: 105–110.

Schnell, G. D. 1969. Communal roosts of wintering Rough-legged Hawks (*Buteo lagopus*). Auk 86: 682–690.

Schnell, J. H. 1958. Nesting behaviour and food habits of Goshawks in the Sierra Nevada of California. Condor 60: 377–403.

Schuyl, G., L. Tinbergen, and **N. Tinbergen.** 1936. Ethologische Beobachtungen and Baumfalken (*Falco s. subbuteo* L.). Journal für Ornithologie R: 387–403.

Schuz, E. 1945. Der europaïsche Rauhfussbussard, *Buteo l. lagopus* (Brunn) als Invasionsvogel. Jahresbericht des Vereins für Vaterländische Naturkunde Württembert: 97–101, 125–150.

Seebohm, H. 1883. A history of British birds, with coloured illustrations of their eggs. Volume 1. Porter, London. pp. 34–41.

Shelford, V. E. 1943. The abundance of the Collared Lemming (*Dicrostonyx groenlandicus* (Tr.) var. *richardsoni* Mer) in the Churchill area, 1929 to 1940. Ecology 24: 472–484.

Sherrod, S. K., C. M. White, and **F. S. L. Williamson.** Biology of the Bald Eagle (*Haliaeetus leucocephalus alascanus*) on Amchitka Island, Alaska. Living Bird. *In press.*

Smeenk, C. 1974. Comparative ecological studies of some East African birds of prey. Ardea 62: 1–97.

Snow, D. W. 1968. Movements and mortality of British Kestrels *Falco tinnunculus*. Bird Study 15: 65–83.

Snyder, N. F. R. 1975. Breeding biology of Swallow-tailed Kites in Florida. Living Bird 13: 73–97.

Snyder, N. F. R. and **H. A. Snyder.** 1970. Feeding territories in the Everglade Kite. Condor 72: 492–493.

Stewart, R. E. 1949. Ecology of a nesting Red-shouldered Hawk population. Wilson Bulletin 61: 26–35.

Sulkava, S. 1964. Zur Hahrungsbiologie des Habichts. *Accipiter gentilis* (L.). Aquilo Ser Zoologica 3: 1–103.

Taylor, S. M. 1967. Breeding season status of the Kestrel. Proceedings of the Bristol Natural History Society 31: 293–296.

Temple, S. A. 1972. Sex and age characteristics of North American Merlins. Bird banding 43: 191–196.

Thomasson, L. 1947. On the nesting sites of the Peregrine Falcon in the countries around the Baltic. Var Fagelvärld 6: 72–81. (*Swedish, with English summary.*)

Tinbergen, L. 1946. Sperver als Roofvijand van Zangvogels. Ardea 34: 1–123.

Tubbs, C. R. 1974. The Buzzard. David & Charles, London. 199 pp.

Tyrrell, W. B. 1936. The Ospreys of Smith's Point, Virginia. Auk 53: 261–268.

Valverde, J. A. 1960. La population d'Aigles Impériaux (*Aquila heliaca adalberti*) des marismas du Guadalquivir; son évolution depuis un siècle. Alauda 28: 20–26.

Vaughan, R. 1961. *Falco eleonorae*. Ibis 103: 114–128.

Vaurie, C. 1965. The birds of the Palearctic fauna. Volume 2. Witherby, London. pp. 214–216.

Verner, W. 1909. My life among the wild birds in Spain. Bale, Sons and Danielsson, London. 468 pp.

Visser, J. 1963. The Black Eagles of Zuurhock, Jansenville. African Wildlife 17: 191–194.

Von Blotzheim, U. N. G., K. Bauer, and **E. Bezzel.** 1971. Handbüch der Vogels Mitteleuropas. Volume 4. Akademische Verlagsgesellschaft, Frankfurt am Main. 943 pp.

Vries, de T. 1973. The Galapagos Hawk. M.Sc. thesis, Free University of Amsterdam.

Walpole-Bond, J. 1938. A history of Sussex birds. Volume 2. Witherby, London. p. 255.

Ward, P. and **A. Zahavi.** 1973. The importance of certain assemblages of birds as "information-centres" for food-finding. Ibis 115: 517–534.

Watson, A. 1957. The breeding success of Golden Eagles in the Northeast Highlands. Scottish Naturalist 69: 153 169.

Watson, A. 1970. Work on Golden Eagles. *In* Research on vertebrate predators in Scotland. Nature Conservancy, Edinburgh. pp. 14–18.

Watson, A. D. and **R. C. Dickson.** 1972. Communal roosting of Hen Harriers in southwest Scotland. Scottish Birds 7; 24–49.

Webster, H. M. 1944. A survey of the Prairie Falcon in Colorado. Auk 61: 609–616.

Weiss, H. 1923. Life of the harrier in Denmark. Wheldon and Wesley, London. 80 pp.

Wendland, V. 1952-1953. Populationsstudien an Raubvogeln, I and II. Journal für Ornithologie 93: 144–153; 94: 103–113.

White, C. M. and **T. J. Cade.** 1971. Cliff-nesting raptors and ravens along the Colville River in arctic Alaska. Living Bird 10: 107–150.

White, C. M. and **T. J. Cade.** Long term trends of Peregrine populations in Alaska. Proceedings of ICBP Conference. Vienna. *In press.*

White, C. M. and **D. G. Roseneau.** 1970. Observations on food, nesting, and winter populations of large North American falcons. Condor 72: 113–115.

Wiley, J. M. 1975a. The nesting and reproductive success of Red-tailed Hawks and Red-shouldered Hawks in Orange County, California, 1973. Condor 77: 133–139.

Wiley, J. M. 1975b. Three adult Red-tailed Hawks tending a nest. Condor 77: 480–482.

Wilgohs, J. F. 1961. The White-tailed Eagle *Haliaeetus a. albicilla* (L.) in Norway. Arbok for Universitetet i Bergan, Matematisk-naturvitenskapelig, Serie 12. 212 pp.

Witherby, H. F., F. C. R. Jourdain, N. F. Ticehurst, and **B. W. Tucker.** 1938. The handbook of British birds.

Volume 3. Witherby, London. 387 pp.
Witherington, G. 1910. Rapid re-mating of the Peregrine Falcon. British Birds 3: 263–264.
Wuhtky, K. 1963. Beutetierfunde in Greifvogelhorsten des Hakel. Beiträge zur Vogelkunde 9: 140–171.

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The Peregrine Falcon (*Falco peregrinus*) and Pesticides

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Abstract. The evidence advanced to link the decline of the Peregrine Falcon to the use of certain persistent organochlorines is reviewed. Pesticides are considered to have been a major factor in the decline of the peregrine, and the level of DDE in the egg at which hatching failure occurs is 15–20 ppm. Levels of DDE and PCB in typical prey species in North America are reviewed and it is recommended that this factor be carefully considered before reintroduction attempts are undertaken. High buildings in big cities appear to be good sites for reintroduction.

Underlying our deliberations on the fate of the Peregrine Falcon (*Falco peregrinus*) is the assumption that the persistent organochlorines are the major causative agents in its decline. Therefore, it seems worthwhile to review the evidence. The idea that pesticides were the cause of this problem was first widely recognized at the Madison Conference in 1965 (Hickey 1969), although the hypothesis had been advanced earlier (Moore and Ratcliffe 1962). It was at this conference that it became apparent that an unprecedented decline of the peregrine was occurring throughout much of the north temperate zone. The data from the British Isles were the most detailed, showing that the decline had started in southern England in 1955 and had spread northwards, and showing a close correlation to the increasing use of certain agricultural chemicals (Ratcliffe, *in* Hickey 1969). Since that time, the evidence that pesticides are a major cause has been greatly strengthened, but the issue continues to be controversial in some circles.

Bioconcentration of organochlorines, leading to mortality and reproductive failure at the top of a food chain, was first demonstrated by the Clear Lake studies (Hunt and Bischoff 1960), although there was clear experimental evidence much earlier of accumulation of DDT in fat (Laug et al. 1950). Since the Clear Lake studies many detailed studies on bioaccumulation have been published (e.g., Hickey et al. 1966; Jensen et al. 1969). Nevertheless the occurrence of bioaccumulation has been doubted. Edwards (1975) cited five references in a letter to *Science* to point out the lack of food-chain magnification of DDT, especially in the marine environment. The only paper cited that contained original data was that of Hamelink et al. (1971), who showed concentration factors of 770 in algae, 18 000 in invertebrates, and 171 500 in fish, as neat a study of bioaccumulation as could be wished. Portmann (1975), surveying the evidence at a recent symposium of the Royal Society, concluded that there was a concentration of three orders of magnitude in the first step of the marine food chain, *viz.* water to phytoplankton, and after that two orders of magnitude concentration from plankton to top-predators on a lipid basis and five orders of magnitude on a wet-weight basis.

Reproductive Failure

The first hint of trouble for the peregrine was the finding that broken or missing eggs were much more common in the period 1949 to 1956 than had been the case in earlier years (Ratcliffe 1958). Subsequently Ratcliffe (1967) showed a significant decrease in the eggshell weight of the peregrine in Great Britain starting in 1947 or 1948. Subsequently the same finding was demonstrated in North America (Hickey and Anderson 1968) and has been extended to many other species (Anderson and Hickey 1972). The relationship of eggshell thickness to DDE residue levels was clearly established for the Alaskan peregrine by Cade et al. (1971) and recently extended to cover a wider series of eggs (Peakall et al. 1975).

The evidence that DDE and eggshell thinning are related has been disputed. Hazeltine (1972) argued that in the case of the Brown Pelican

(*Pelecanus occidentalis*) no such correlation existed. His case was based on an inadequate sample (nine eggs) and has been clearly refuted by the detailed studies of Risebrough (1971) and Blus et al. (1972, 1974). These studies involved a total of several hundred pelican eggs. A good deal of the argument on the Brown Pelican shell-thinning data and on eggshell thinning in general at the United States Environmental Protection Agency hearings that led to restrictions on DDT use, was on the validity of statistical analysis. Although one can argue about the exact statistical procedure that should be used, the data relating eggshell thickness to DDE levels in the peregrine are highly significant, using a variety of parametric and non-parametric methods. In addition to analysis of field data, eggshell thinning caused by DDE has been demonstrated in American Kestrels (*Falco sparverius*) in experimental studies (Wiemeyer and Porter 1970; Lincer 1972). Further, Lincer (1975) has shown close correlation between experimental DDE-induced eggshell thinning and field data for American Kestrels.

Another criticism that has been raised is that the onset of eggshell thinning in the peregrine occurred soon after the first small-scale use of DDT and before the maximum usage of this insecticide. In his presidential address to the Association of Applied Biologists, Gunn (1972) concluded "the thinning must have some other cause, for an effect occurring before its cause is utterly unacceptable." Recent studies have shown the presence of DDE in the membranes of eggs collected in 1948–1950 in California (Peakall 1974) and in 1947–1952 in Great Britain (Peakall et al., *in press*). The levels in the membranes have been related to levels in the contents for a series of eggs collected in Alaska in 1967. The amounts found in membranes of eggs collected in 1947–1952 were sufficient to account for the degree of thinning.

A further criticism on the timing of the decline (Gunn 1972) was that the population crash did not occur in Great Britain until 1955 whereas eggshell thinning was demonstrated to have started in 1947. This delay is, in fact, what one would expect in a long-lived bird that is failing to reproduce. The adults continue to occupy nesting sites for several years without reproducing and the sites become vacant on their death.

Involvement of Pesticides

Strong evidence for pesticides being the major cause of the decline of the peregrine comes from the recovery of the species in the British Isles following the restrictions on most of the uses of DDT and other organochlorine pesticides. The peregrine is largely a resident species in the British Isles and thus does not have the problem of migrating into highly contaminated areas. In recent years the residue levels in the eggs have decreased and productivity increased (Ratcliffe 1972). Both the decline and the recovery follow the usage pattern of the persistent organochlorine pesticides and this analysis holds up both temporally and geographically. In Scandinavia very marked declines have been noted and are still continuing (Linberg 1975). The Swedish population was only 9 pairs in 1974 and in Finland 11 pairs were located in 1973, with a total population estimated at 20–25 pairs. In Denmark the last pair bred in 1972. The northern Scandinavian population is migratory, but southern populations are more sedentary. No detailed residue data are available. Recent measurements of peregrine eggs collected in Siberia in the mid-1960s show 25% thinning compared to pre-1940 eggs (Peakall and Kiff, unpublished data). Although no detailed surveys have been made, marked decreases of the breeding populations have been noted in those areas which have been studied (Flint, personal communication). The position in the USSR thus appears to parallel that which has been found in arctic North America. It seems likely that the entire arctic population of peregrines is in danger of extinction.

DDE- and DDT-induced eggshell thinning has been demonstrated experimentally in a variety of species (Cooke 1973; Peakall et al. 1973) and no other organochlorine has been consistently shown to cause eggshell thinning except at high dosages not likely to occur in nature. There is a wide range of sensitivity of different avian species to DDE-induced eggshell thinning. Peakall (1975a) arbitrarily divided the orders studies into three major groups: highly sensitive, moderately sensitive, and low sensitivity. This analysis was based on 30 published reports. The orders placed in the first group are the Pelicaniformes, Ciconiiformes, Falconiformes, and Strigiformes; in the second, Anseriformes, Charadriiformes, and Columbiformes; and the last group, the Galliformes and Passeriformes. As examples, 10 ppm DDE in the diet of American Kestrels causes nearly 30% thinning (Peakall et al. 1973), 10 ppm DDE causes 10% thinning in the Mallard (*Anas platyrhynchos*) (Heath et al. 1969), whereas 300 ppm failed to cause significant thinning in the chicken (*Gallus gallus*) (Cecil et al. 1972). The fact that DDE does not cause eggshell thinning in the chicken has caused those who consider "The Chicken" as "The Bird" to doubt that the phenomenon of eggshell thinning in wild species is caused by DDE. Nevertheless it is hard to see what additional evidence is needed to complete the case that DDE is the major, possibly the sole, causative agent of eggshell thinning, where this occurs.

Egg breakage caused by egghsell thinning is not the sole effect of organochlorines on avian reproduction. Failure of contaminated eggs to hatch has been noted in several species of raptors, *viz.* Peregrine Falcon (Cade et al. 1971; Ratcliffe 1970; Peakall et al. 1975), Prairie Falcon (*Falco mexicanus*) (Enderson and Berger 1970; Fyfe et al. 1976b); Osprey (*Pandion haliaetus*) (Wiemeyer et al. 1975), Merlin (*Falco columbarius*) (Newton 1973b), European Sparrow-hawk (*Accipiter nisus*) (Newton 1973a), and White-tailed Eagle (*Haliaeetus albicilla*) (Koeman et al. 1972). Evidence indicates that dieldrin (Brown et al. 1965) and the polychlorinated biphenyls (Peakall 1975b) are more embryotoxic than DDE. Dieldrin has been considered as an important factor in the decline of the peregrine in the British Isles (Ratcliffe 1970) and as the major causative agent in the decline of the Golden Eagle (*Aquila chrysaetos*) (Lockie et al. 1969). Jefferies and Prestt (1966) and Bogan and Mitchell (1973) found adult falcons with levels of dieldrin in the brain above those considered lethal (Stickel et al. 1969). Examination of levels of dieldrin in peregrine eggs in northern England and Scotland (Ratcliffe 1972), however, shows that levels are low and thus not a widespread problem over the period 1962–1971. Egg exchange experiments with the Osprey between areas of high and low contamination suggest that the cause of reproductive failure lies within the egg itself (Wiemeyer et al. 1975). Similar studies were carried out on the Herring Gull (*Larus argentatus*) involving a larger number of eggs (Fox et al. 1975). A high failure rate was associated with high egg-residue levels even when the eggs were placed under "clean" adults or were artificially incubated. When "clean" gull eggs, however, were placed under "dirty" adults the reproductive success was poor. These experiments indicate the presence of a behavioral component in addition to embryotoxic effects. Newton and Bogan (1974) calculated that failure of peregrines to lay after a nest was built accounted for 43% of all failures in the European Sparrowhawk, with egg breakage accounting for 31% of all failures. Both of these classes of failure were associated with egg organochlorine levels significantly higher than those showing normal success. A correlation between lack of defence of nest site and high organochlorine residues has been found in the Merlin by Fyfe et al. (1976b) and is a feature of the failing Herring Gull colonies on Lake Ontario. Decreased nest attentiveness caused by PCBs has been found in one experimental study (Peakall and Peakall 1973).

Peakall et al. (1975), reviewing the data for the peregrine, tentatively concluded that 15–20 ppm DDE (wet weight) was the critical level in the egg for causing hatching failure in this species. Fyfe et al. (1976b) came up with a minimum effect value of 2 ppm DDE (wet weight) for the Prairie Falcon with reproductive failure occurring at 12.5 ppm DDE. Although these values should be viewed with caution, they can be used to help evaluate the significance of residue levels found in raptor eggs. The levels of 20–70 ppm DDE (wet weight) found in peregrine eggs from Alaska over the period 1968–1973 are well above this level (Peakall et al. 1975). The failure of federal and state authorities to allow addled eggs to be collected in Alaska in the last two field seasons has caused a serious gap in our knowledge. In addition to aiding in the calculation of a critical level in eggs it may be of interest to compare egg levels with tissue levels of apparently healthy adults collected during the breeding season. The ratios (based on wet weight values) for the peregrine are, egg : brain : muscle :

fat 1 : 0.15–0.4 : 1–2 : 16–40 (Enderson and Berger 1968; Cade et al. 1968; Lincer et al. 1970) and the corresponding values for two species of gull are 1 : 0.15–0.17 : 0.7–0.8 : 18–20 (Hickey et al. 1966; Keith 1966; Vermeer and Reynolds 1970). Again these values should be used with caution but they allow some assessment of body burden of adults in relation to breeding success.

The survey results detailed elsewhere in this issue suggest that the northern race of the peregrine (*Falco peregrinus tundrius*) is passing into extinction in the wild. Fortunately, the peregrine is now being bred successfully in captivity and efforts to reintroduce the species are already underway. For these efforts to be successful a careful consideration of the current levels of contamination will be required.

Races of the Peregrine

Two declining races of the peregrine are under consideration here. These are *F. p. tundrius*, which breeds in the Arctic and migrates south to Central and South America, and *F. p. anatum*, which originally bred from the tree-line south to northern Mexico. The latter race moves south from the more northern parts of its range but is resident over much of its range. *Falco p. anatum* has completely gone from the eastern United States and southeastern Canada (Berger et al. *in* Hickey 1969), and only remnant populations remain in the Rocky Mountains (Enderson and Craig 1974; Fyfe et al. 1976a) and in California (Herman 1971) although more substantial populations occur in Mexico and in parts of the boreal forest. The third North American race of the peregrine, *F. p. pealei*, is resident in the Aleutian and Queen Charlotte Islands. It is still reproducing well in the Aleutians and DDE residue levels of 3–5 ppm are well below the calculated critical level (White et al. 1973). Population decreases have been noted in the Queen Charlotte Islands and a mean value of 17 ppm in peregrine eggs from there (Nelson and Myres 1973) is close to the calculated critical level.

The problems confronting the two declining races are quite different. The residue levels in the eggs of *tundrius* are still too high for successful reproduction despite the banning of most usages of DDT and aldrin-dieldrin in the United States and Canada. One can only assume that these peregrines obtain their residue levels from south of the United States border where they and much of their prey winter. Goldberg (1975) has shown that the area of heavy DDT usage has moved from the north temperate zone to the tropics. The problem of *tundrius* lies not in the Arctic but in Central and South America. The solution may be difficult to find — a good biological control for cotton boll weevil, for example. Eventually pest resistance to DDT may cause its usage to decline. The indications are that global usage of DDT is not declining, but merely shifting southwards, although firm figures are not available. Current knowledge suggests that releasing *tundrius* back into the Arctic will be futile until the usage of DDT decreases in the southern hemisphere. The best that we can do for this race is to keep a pure gene pool in captivity for release some time in the future. The release of *tundrius* into areas formerly inhabited by *anatum* poses additional problems. The minimum physiological adaptations for success would be that these birds act as short-distance migrants and be capable of reproduction at a substantially reduced day-length.

Reintroduction of the Peregrine

The reintroduction of *F. p. anatum* into temperate North America is more hopeful. There are clear indications that the levels of organochlorine pesticides are declining in the fauna of North America. Nickerson and Barbehann (1975) showed that the levels of total DDT and dieldrin have declined significantly in Starlings (*Sturnus vulgaris*) from 1967 to 1972. Further, these authors predict that the level of total DDT in Starlings in the United States should fall below a mean of 0.1 ppm by 1974. Despite the fact that the mean level in 1972 was 0.44 ppm (wet weight), Starlings from Rapids, Louisiana had 11.7 ppm DDE and those from Aiken, South Carolina 5.0 ppm, so that local conditions have to be carefully considered. Johnston (1974) noted a marked decline in total DDT levels in songbirds over the period 1969–1973 with the mean level decreasing from 17.8 ppm to 2.1 ppm (lipid weight basis). Bulter (1973), considering the levels in molluscs from 1965 to 1972, found a definite trend toward decreased total DDT residues beginning in 1969–1970.

TABLE 1—Residue levels in possible prey species of the Peregrine Falcon, given as geometric means in parts per million (wet weight)

Species	Area	Year	Tissue	Sample size	DDE	PCB
Charadriiformes						
Ancient Murrelet (*Synthliboramphus antiquum*)	British Columbia	1971	Whole body	2 (adults) 2 (immatures)	2.78 16.8	2.78 2.70
Cassin's Auklet (*Ptychoramphus aleutica*)	British Columbia	1971	Whole body	2	1.45	1.18
Common Puffin (*Fratercula arctica*)	Newfoundland	1973	Whole body	5	0.73	1.14
American Woodcock (*Philohela minor*)	Ontario	1973	Muscle	15	0.96	0.44
Long-billed Curlew (*Numenius americanus*)	Alberta	1969	Whole body	1	14.0	0.05
Spotted Sandpiper (*Actitis macularia*)	New Brunswick	1971 1972	Whole body	24 14	1.96 2.04	1.29 1.30
Willet (*Catoptrophorus semipalmatus*)	Alberta	1970	Whole body	1	1.13	0.03
Dunlin (*Calidris alpina*)	British Columbia	1970	Muscle	11	0.32	1.01
Columbiformes						
Rock Dove (*Columba livia*)	Alberta, Saskatchewan	1971 1971	Whole body	3 1	0.03 0.01	no data 0.01
Passeriformes						
Cliff Swallow (*Petrochelidon pyrrhonota*)	Mackenzie	1967–68	Whole body	7	0.82	no data
Starling (*Sturnus vulgaris*)	Prince Edward Island	1973	Muscle	17	0.06	trace
	Ontario,	1973		23	1.57	0.04
	Alberta	1973		20	0.01	0.02

NOTE: All data from Canadian National Pesticide Register.

TABLE 2—Possible reintroduction sites for the Peregrine Falcon

Site		Risks	
Type	Specific example	Predation	Pesticides
Sea cliffs	Bonaventure Island, Quebec	Expensive to provide adequate protection against humans	Levels fairly low in alcids but movement south and migratory shorebirds could be a problem
Inland cliffs	Taughannock Falls, N.Y.	Predation from Great Horned Owls was a problem in 1975	Levels probably low
High buildings	Montreal, Quebec New York City, New York	Predation risk could be held down with suitable selection	Levels in pigeons low, but high levels could occur with feeding in such areas as Jamaica Bay, New York
Other man-made objects	High tower on military reserve	Predation risk could be held to a low level	Risk would be high if overlooking coastal mudflat. Much lower if inland

The ideal reintroduction site for the peregrine would have adequate security and a good supply of clean food. Adequate security is needed to protect the young falcons from pigeon fanciers, falconers, and casual gunners. Levels of organochlorine residues in some prey items are given in Table 1. Levels of organochlorines above a few hundredths of a part per million (ppm) are found only for DDT and its metabolites and polychlorinated biphenyls (PCBs) except in rare instances. The levels in some species of shorebirds remain high and are similar to the levels found in shorebirds along the Colville River in 1967 (Cade et al. 1968). Some possible reintroduction sites are considered in terms of risks in Table 2. Cities would appear to be the best choice for release sites provided that extensive mud-flats for migratory shorebirds are not nearby. It would be advisable to check, ahead of release, the actual residue levels in likely prey. As an example, Ring-billed Gulls (*Larus delawarensis*) are present in Ottawa in the fall and it would make a great deal of difference if these birds had wandered north from the Great Lakes or had moved south from more northern populations. Successful reintroduction of the Peregrine Falcon will require the talents of both biologists and analytical chemists.

Literature Cited

Anderson, D. W. and **J. J. Hickey.** 1972. Eggshell changes in certain North American birds. Proceeding of the 15th International Ornithological Congress. pp. 514–540.

Blus, L. J., C. D. Gish, A. A. Belisle, and **R. M. Prouty.** 1972. Logarithmic relationship of DDE residues to eggshell thinning, Nature (London) 235: 376–377.

Blus, L. J., A. A. Belisle, and **R. M. Prouty.** 1974. Relations of the Brown Pelican to certain environmental pollutants. Pesticides Monitoring Journal 7: 181–194.

Bogan, J. A. and **J. Mitchell.** 1973. Continuing dangers to Peregrines from dieldrin. British Birds 66: 437–439.

Brown, V. K., A. Richardson, J. Robinson, and **D. E. Stevenson.** 1965. The effects of aldrin and dieldrin on birds. Food and Cosmetic Toxicology 3: 675–679.

Butler, P. A. 1973. Organochlorine residues in estuarine mollusks, 1965–72 — National Pesticide Monitoring Program. Pesticides Monitoring Journal 6: 238–362.

Cade, T. J., J. L. Lincer, C. M. White, D. G. Roseneau, and **L. G. Swartz.** 1971. DDE residues and eggshell changes in Alaskan falcons and hawks. Science (Washington) 172: 955–957.

Cade, T. J., C. M. White, and **J. R. Haugh.** 1968. Peregrines and pesticides in Alaska. Condor 70: 170–178.

Cecil, H. C., G. F. Fries, J. Bitman, S. J. Harris, R. J. Lillie, and **C. A. Denton.** 1972. Dietary p,p'-DDT, o,p'-DDT, or p,p'-DDE and changes in eggshell characteristics and pesticides accumulation in egg contents and body fat of caged White Leghorns. Poultry Science 51: 130–138.

Cooke, A. S. 1973. Shell thinning in avian eggs by environmental pollutants. Environmental Pollution 4: 85–152.

Edward, J. G. 1975. Vinyl chloride and DDT: Environmental effects. Science (Washington) 189: 174.

Enderson, J. H. and **D. D. Berger.** 1968. Chlorinated hydrocarbon residues in peregrines and their prey species from northern Canada. Condor 70: 149–153.

Enderson, J. H. and **D. D. Berger.** 1970. Pesticides: eggshell thinning and lowered production of young in prairie falcons. Bioscience 20: 355–356.

Enderson, J. H. and **J. Craig.** 1974. Status of the Peregrine Falcon in the Rocky Mountains in 1973. Auk 91: 727–736.

Fox, G., A. Gilman, D. Hallett, R. Norstrom, F. Onuska, and **D. B. Peakall.** 1975. Herring Gull productivity and toxic chemicals in the Great Lakes in 1975. Canadian Wildlife Service Manuscript Report 34.

Fyfe, R. W., S. A. Temple, and **T. J. Cade.** 1976a. The North American Peregrine Falcon Survey, 1975. Canadian Field-Naturalist 90(3). *This issue.*

Fyfe, R. W., R. W. Risebrough, and **W. Walker, II.** 1976b. Pollutant effects on the reproduction of the Prairie Falcons and Merlins of the Canadian prairies. Canadian Field-Naturalist 90(3). *This issue.*

Goldberg, E. D. 1975. Synthetic organohalides in the sea. Proceeding of the Royal Society, Series B, Biological Sciences 189: 277–289.

Gunn, D. L. 1972. Dilemmas in conservation for applied biologists. Annals of Applied Biology 72: 105–127.

Hamelink, J. L., R. C. Waybrant, and **R. C. Ball.** 1971. A proposal: Exchange equilibria control the degree chlorinated hydrocarbons are biologically magnified in lentic environments. Transactions of the American Fisheries Society 100: 207–214.

Hazeltine, W. 1972. Disagreements on why Brown Pelican eggs are thin. Nature (London) 239: 410–411.

Heath, R. G., J. W. Spann, and **J. F. Kreitzer.** 1969. Marked DDE impairment of mallard reproduction in controlled studies. Nature (London) 224: 47–48.

Herman, S. G. 1971. The Peregrine Falcon decline in California. 2. Breeding status in 1970. American Birds 25: 818–820.

Hickey, J. J. (*Editor*). 1969. Peregrine Falcon populations. Their biology and decline. University of Wisconsin Press, Madison. pp. 596.

Hickey, J. J. and **D. W. Anderson.** 1968. Chlorinated hydrocarbons and eggshell changes in raptorial and fish-eating birds. Science (Washington) 162: 271–273.

Hickey, J. J., J. A. Keith, and **F. B. Coon.** 1966. An exploration of pesticides in a Lake Michigan ecosystem. Journal of Applied Ecology 3 (Supplement): 141–154.

Hunt, E. G. and **A. I. Bischoff.** 1960. Inimical effects on wildlife of periodic DDD applications to Clear Lake. California Fish and Game 46: 91–106.

Jefferies, D. J. and **I. Prestt.** 1966. Post-mortems of Peregrines and Lanners with particular reference to organochlorine residues. British Birds 59: 49–64.

Jensen, S., A. G. Johnels, M. Olsson, and **G. Otterlind.** 1969. DDT and PCB in marine animals from Swedish waters. Nature (London) 224: 247–250.

Johnston, D. W. 1974. Decline of DDT residues in migratory songbirds. Science (Washington) 186: 841–842.

Keith, J. A. 1966. Reproduction in a population of Herring Gulls (*Larus argentatus*) contaminated by DDT. Journal of Applied Ecology 3(Supplement): 57–70.

Koeman, J. H., R. H. Hadderingh, and **M. F. I. J. Bijleveld.** 1972. Persistent pollutants in the White-tailed Eagle in the Federal Republic of Germany. Biological Conservation 4: 373–377.

Laug, E. P., A. A. Nelson, O. G. Fitzhugh, and **F. M. Hunze.** 1950. Liver cell alteration and DDT storage in the fat of the rat induced by dietary levels of 1 to 50 ppm DDT. Journal of Pharmacology and Experimental Therapeutics 98: 268–273.

Linberg, P. 1975. Peregrine Falcon in Sweden. Svenska Naturskyddksö Reningen, Stockholm. pp. 2–94.

Lincer, J. L. 1972. The effects of organochlorines on the American Kestrel (*Falco sparverius* Linn). Ph.D. thesis, Cornell University.

Lincer, J. L. 1975. DDE-induced eggshell thinning in the American Kestrel (*Falco sparverius* Linn.). Ph.D. thesis, and laboratory results. Journal of Applied Ecology 12: 781–794.

Lincer, J. L., T. J. Cade, and **J. M. Devine.** 1970. Organochlorine residues in Alaskan Peregrine Falcons (*Falco peregrinus* Tunstall), Rough-legged Hawks (*Buteo lagopus* Pontoppidan) and their prey. Canadian Field-Naturalist 84: 255–263.

Lockie, J. D., D. A. Ratcliffe, and **R. Balharry.** 1969. Breeding success and organochlorine residues in Golden Eagles in West Scotland. Journal of Applied Ecology 6: 381–389.

Moore, N. W. and **D. A. Ratcliffe.** 1962. Chlorinated hyrdocarbon residues in the egg of a Peregrine Falcon (*Falco peregrinus*) from Perthshire. Bird Study 9: 242–244.

Nelson, R. W. and **M. T. Myres.** Changes in the Peregrine population and its seabird prey at Langara Island, B.C. 1973 Conference on Raptor Conservation Technique.

Newton, I. 1973a. Success of Sparrowhawks in an area of pesticide usage. Bird Study 20: 1–8.

Newton, I. 1973b. Egg breakage and breeding failure in British Merlins. Bird Study 20: 241–244.

Newton, I. and **J. Bogan.** 1974. Organochlorine residues, eggshell thinning and hatching success in British Sparrowhawks. Nature (London) 249: 582–583.

Nickerson, P. R. and **K. R. Barbehann.** 1975. Organochlorine residues in Starlings, 1972. Pesticides Monitoring Journal 8: 247–254.

Peakall, D. B. 1974. DDE: its presence in Peregrine eggs in 1948. Science (Washington) 183: 673–674.

Peakall, D. B. 1975a. Physiological effects of chlorinated hydrocarbons on avian species. *In* Environmental dynamics of pesticides. *Edited by* R. Haque and V. H. Freed. Plenum Publishing Company, New York.

Peakall, D. B. 1975b. PCBs and their environmental effects. Critical Reviews of Environmental Controls 5: 469–509.

Peakall, D. B., T. J. Cade, C. M. White, and **J. R. Haugh.** 1975. Organochlorine residues in Alaskan Peregrines. Pesticide Monitoring Journal 8: 255–260.

Peakall, D. B., J. L. Lincer, R. W. Risebrough, J. B. Pritchard, and **W. B. Kinter.** 1973. DDE-induced eggshell thinning: structural and physiological effects in three species. Comparative and General Pharmacology 4: 303–311.

Peakall, D. B. and **M. L. Peakall.** 1973. Effect of a polychlorinated biphenyl on the reproduction of artificially and naturally incubated dove eggs. Journal of Applied Ecology 10: 863–868.

Peakall, D. B., L. M. Reynolds, and **M. C. French.** 1976. DDE in British Peregrine eggs, 1946–1952. Bird Study.

Portmann, J. E. 1975. The bioaccumulation and effects of organochlorine pesticides in marine animals. Proceeding of the Royal Society, Series B, Biological Sciences 189: 291–304.

Ratcliffe, D. A. 1958. Broken eggs in Peregrine eyries. British Birds 51: 23–26.

Ratcliffe, D. A. 1967. Decrease in eggshell weight in certain birds of prey. Nature (London) 215: 208–210.

Ratcliffe, D. A. 1970. Changes attributable to pesticides in egg breakage frequency and egg shell thickness in some birds. Journal of Applied Ecology 7: 67–116.

Ratcliffe, D. A. 1972. The Peregrine population of Great Britain in 1971. Bird Study 19: 117–156.

Risebrough, R. W. 1971. Effects of environmental pollutants upon animals other than man. Sixth Berkeley Symposium on Mathematical Statistics and Probability, University of California, Berkeley.

Stickel, W. H., L. F. Stickel, and **J. W. Spann.** 1969. Tissue residues of dieldrin in relation to mortality in birds and mammals. *In* Chemical fallout: current research on persistent pesticides. Proceeding of the First Rochester Conference on Toxicity. pp. 174–204.

Vermeer, K. and **L. M. Reynolds.** 1970. Organochlorine residues in aquatic birds in the Canadian prairie provinces. Canadian Field-Naturalist 84: 117–130.

White, C. M., W. B. Emison, and **F. S. L. Williamson.** 1973. DDE in a resident Aleutian Island peregrine population. Condor 75: 306–311.

Wiemeyer, S. E. and **R. D. Porter.** 1970. DDE thins eggshells of captive American kestrels. Nature (London) 227: 737.

Wiemeyer, S. N., P. R. Spitzer, W. C. Krantz, T. G. Lamont, and **E. Cromartie.** 1975. Effects of environmental pollutants on Connecticut and Maryland Ospreys. Journal of Wildlife Management 39: 124–139.

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Rationale and Success of the Canadian Wildlife Service Peregrine Breeding Project

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Abstract. The Canadian Wildlife Service Peregrine Falcon (*Falco peregrinus*) breeding project is a positive attempt to maintain gene pools of this species for future reintroduction into its former range. The project originated directly from the response by the 34th Federal-Provincial Wildlife Conference to the decline of *F. p. anatum* and *F. p. tundrius* that was recorded in the 1970 North American Peregrine Survey. Other species have been included in the project for experimental problem-solving. Research has been necessary relative to pair formation, imprinting, artificial incubation, and reintroduction. The project has been successful in captive breeding of four falcon species and in experimental releases utilizing fostering and cross-fostering techniques. Considerable refinement is necessary in both breeding and release techniques.

Captive breeding is often considered to be a last resort in the preservation of a species. To many, it is extremely unpalatable; some would sooner see a species left to its fate rather than see any of the remaining animals in captivity. The choice is never an easy one but it must be made if a species or race has been extirpated over much of its range and continues to decline, as in the case of the Peregrine Falcon (*Falco peregrinus anatum*).

Captive breeding of birds of prey has received a great deal of attention in recent years as a result of this and other attempts to breed endangered forms. In contrast to the nocturnal raptors which have bred fairly consistently in captivity, the diurnal raptors have been difficult to maintain and breed in confinement. Until recently, few of the large falcons or eagles had been bred with any consistency. The difficulties apparently centered around incompatibility of pairs, imprinting, artificial incubation and brooding, photoperiod, and nutrition. As the solutions to these problems are germane to the captive breeding of peregrines, each will be discussed briefly in the following sections. Our approach to experimental problem-solving has been to utilize primarily species other than the peregrine.

When the severity of the peregrine decline was fully recognized (Cade and Fyfe 1970), the question of what should be done was put to delegates at the 1970 Federal-Provincial Wildlife Conference. It appeared that the prime decimating factors were problems associated with pesticide contamination in the normal diet of these birds. Even with the phasing out of contributing chemicals, the residues would remain for many years, and wild falcons would continue to be exposed. Throughout the general decline, individuals, pairs, and small population units have persisted in certain localities. The most plausible explanation for their survival is that they have not been contaminated to the same extent because of either food preference or availability of alternate food on the breeding or wintering grounds. As a consequence, the alternatives presented were (1) to leave the species to its fate, or (2) to take a limited number into captivity for captive breeding.

The decision by the federal and provincial delegates was that the Canadian Wildlife Service should take a limited number of the *anatum* race into captivity for captive breeding. This held much promise, as captive breeding of both the Peregrine Falcon and Prairie Falcon had already been pioneered by several falconers, notably Waller (1968), Beebe (1967), Schram (*in* Peterson 1968), and Kendall (1968). The Canadian Wildlife Service Peregrine Breeding Project was therefore initiated with two primary objectives: (*a*) to establish a captive breeding flock of Peregrine Falcons, and (*b*) to reintroduce them into their former range when and where pesticide contamination of their prey falls below danger levels.

The Canadian Wildlife Service Peregrine Breeding Project

It was decided that, for genetic diversity, we should obtain suitably-aged birds from different geographic units, and that a minimum of three pairs from each unit would be desirable. Unfortunately, scarcity has not always permitted such a selection.

In 1970, 12 *anatum* birds were collected, representing four geographic units, from the range of this race of peregrines. Additional birds have since been added to the project and several others have been donated by falconers and provincial wildlife agencies. These included Merlins (*Falco columbarius*), Prairie Falcons (*F. mexicanus*), Gyrfalcons (*F. rusticolus*), and Peregrine Falcons (*F. p. anatum* and *F. p. tundrius*). We also receive annually a variety of injured, orphaned, or illegally held owls and hawks, most of which are rehabilitated and released to the wild.

For the project to succeed, the birds required a relatively clean diet, adequate housing (until a breeding facility could be established), and a technician with specific knowledge and expertise in caring for birds of prey.

Analysis of potential food items indicated that domestic fowl and game birds would provide a relatively pesticide-free diet. The primary diet of the falcons has consisted of quail and pheasant raised by the pheasant hatchery of the Alberta Fish and Wildlife Division on a co-operative cost-sharing basis. Since these birds are fed a diet of clean grains, they are relatively free from organochlorine pesticide or mercury residues. Chicken necks and heads have been fed as an alternate when fresh or frozen game birds were not available.

Since falcons are predatory by nature and could not all be held in a single pen, housing initially presented a major difficulty. The problem was overcome by establishing a series of temporary pens in an existing barn and other buildings on my farm near Edmonton. It was here in 1971 that the project had its initial breeding success with Prairie Falcons (Fyfe 1975; Figure 1).

The manpower requirement, also difficult, was eventually met by hiring a young falconer under contract. His being a falconer provoked some criticism from conservationists, but then and now the most important qualification of a technician must be a demonstrated knowledge and interest in working with these birds. The only persons known to us with these qualifications were falconers who had chosen the sport because of their interest in the birds.

Since Peregrine Falcons normally mature at 2 or 3 years of age (Fischer 1968; Fyfe, inpublished data), the first 2 years of the project were primarily devoted to the care and management of the birds. During this period the sexes were separated and regular observations on all birds were made through one-way mirrors. Specific attention was paid to signs of aberrant behavior or aggression.

Concurrently, we sought a suitable location for a breeding facility. This was difficult as it had to be remote enough to avoid excessive human activity and at the same time had to provide electricity and water for the facility. The final site selected was adjacent to Betty Lake in a restricted area of the military base at Camp Wainwright, Alberta. Construction began during the winter of 1972 and was completed the following spring. Although the time was the worst possible, our existing space was so crowded that we had to separate and move the birds into their new quarters during the last phase of construction, at about the time of normal courtship activity. Despite the timing, the birds settled in very well and we obtained our first fertile peregrine eggs for the project that spring.

The Breeding Facility

The breeding facility constructed at Wainwright includes a series of 12 large outdoor pens, a heated research and maintenance building, and a two-bedroom trailer which doubles as office and living quarters for staff and visitors to the facility (Figure 2).

The outdoor pens are 15 x 10 x 5 m high. Nine are subdivided into three equal-sized pens, each to be used for one pair of peregrines. The three remaining units house larger numbers of birds, or pairs of any of the larger raptorial species. Each pen is equipped with a bath, a nest ledge, a

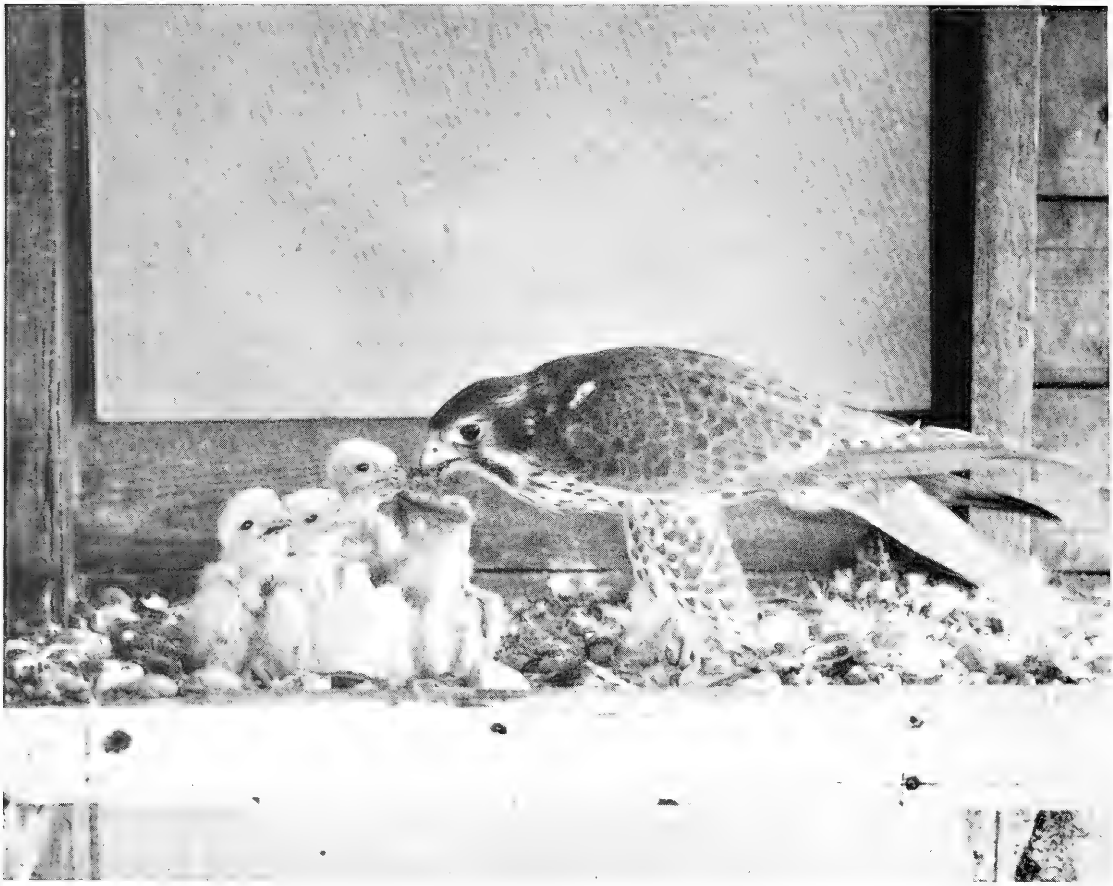

FIGURE 1. Adult female and four young captive bred Prairie Falcons in the initial renovated barn facility.

heated and an unheated feeding shelf, plus a series of branch perches and sheltered roosts placed to permit observation of specific courtship patterns (Figure 3). Observation blinds and servicing areas are built into each pen so that the birds need never see people during the breeding period. Feeding, watering, and egg removal are carried out through trap doors behind the feeding and nest ledges.

The heated research and maintenance building is a two-storey frame structure. It contains six breeding pens and four rooms set aside for incubation and brooding, food storage, and maintenance. The breeding pens in this building permit continuous observation and allow control of both lighting and heating. The incubation and brooding room has six incubators and a series of brooders for maintaining newly-hatched and developing young birds. During the breeding season, the temperature and humidity of the incubators are remotely monitored. The food storage areas provide space for holding both fresh and frozen goods. The general work area provides some space for routine work, carpentry, etc., as required.

The audio-video monitoring center for the entire facility is the office-living trailer. Up to 24 pens can be monitored at once through a closed-circuit sound and video system covering all breeding and potential breeding pairs (Figure 4). This permits detailed behavioral observations, essential to establishing and maintaining compatible breeding pairs.

Problems in Breeding

Pair Formation

FIGURE 2. Outdoor pens at Canadian Wildlife Service raptor breeding facility at Wainwright.

Problems in pair formation have been difficult to understand and overcome. Although it was realized in the late 1960s (Fyfe 1967; Olendorff 1967) that the mere placement of an adult male and female in the same pen did not always result in the formation of a pair bond, the reasons behind non-compatibility and non-breeding were not obvious. We had first to establish criteria to evaluate behavioral problems. Behavioral studies carried out by R. Wayne Nelson and myself (Nelson 1971; Fyfe 1972) provided guidelines for comparison.

Each new pairing must be kept under continuous observation to determine compatibility and normal sequential courtship behavior patterns. Where incompatibility is obvious, individuals can be exchanged, but again must be followed by intensive observations. Where a well-established pair is compatible but not productive, exchanges can be particularly difficult as pair bonds are very strong. The introduction of a new mate frequently elicits serious antagonism which could even result in the death of one of the birds.

Many of these problems can be overcome if identified in time. Expansion from two to five breeding pairs of peregrines at Wainwright in 1975 resulted in large part from our detailed behavioral observations and pair manipulation.

Imprinting

Many of the behavioral problems associated with captive breeding have been attributed to imprinting. Imprinting is described as a rapid and abrupt form of learning in young birds which is a behavioral effect of experience. The

FIGURE 3. View of inside of large outdoor pen at Wainwright; a female peregrine is on the perch.

capacity for imprinting appears to be limited to a brief critical period of the animal's life and typically is a young-to-parent relation (Etkin 1969). But only specific reactions become imprinted to a particular object. For example, a bird may imprint to a human as a parent and sexual companion but it will accept other birds as companions (Eibl-Eibesfeldt 1970). Unfortunately, imprinting tends to be largely a gray area in our knowledge because so many interrelated factors influence the degree of the "imprinting" and the eventual behavioral response of the individual affected (Nelson 1972).

In order to minimize the influence of imprinting, the project birds were collected as close to fledging as possible and we have since attempted to keep the birds isolated from contact with humans and other species. Although, in retrospect, we were apparently successful in minimizing the effect of imprinting on our initial breeding flock, we are still acutely aware of problems associated with this phenomenon. Since we are raising some of the young birds in isolation from their parents or in some cases under foster parents, the potential for undesirable imprinting exists. Specific attention is paid to the duration of artificial care by ourselves and to the timing of introduction under foster parents. Individual histories are kept of each bird, to seek insight into the influence of imprinting and the origin of any behavioral problems that appear.

In addition, specific experiments will be carried out to clarify such aspects as the critical timing of imprinting as it applies to the falcons and the role of imprinting in mate and nest-site

FIGURE 4. Closed circuit television and audio monitoring system for 24 pens, Wainwright.

selection.

Incubation and Brooding

Falcons in general are steady and reliable incubators, but artificial incubation is necessary with any increase of egg production, whether by single egg removal or "double-clutching." Since full clutches and the onset of incubation terminate egg-laying, to maximize egg production, the eggs of fertile pairs must be removed sequentially and put under other birds or artificially incubated. As most of the birds come into laying during roughly the same time interval, artificial incubation is usually required.

Available information on specific temperature and humidity requirements for incubation of eggs of poultry, gallinaceous birds, and waterfowl does not apply to the large falcons. We have had to begin at the beginning: experimenting with different regimes of temperature, humidity, turning and cooling, utilizing the eggs and young of our captive Prairie Falcons. Our work and that of others (Olendorff 1972; Weaver and Cade 1974) has established parameters for incubation and brooding of peregrines.

Provided the eggs are left under the birds for 7 to 10 days, we can hatch about 70% of the fertile eggs in incubators (Figure 5). There is still very poor hatching success, however, with eggs incubated entirely in incubators. Obviously additional research is required to understand the regime necessary for the first week to 10 days.

As with artificial incubation, the requirements for artificial brooding and feeding of newly-hatched young were not known. Fortunately

FIGURE 5. Incubator and brooder at Wainwright.

some expertise had been developed by falconers in the rearing of older young and this has provided a base from which to start (Figure 6). As with incubation, regimes of temperature and humidity had to be established. For brooding, these parameters must be altered as the young develop to accommodate development of down and the changing physiology of the developing chicks. It must be indicated that the project has not been without losses. In addition to hatching failures, we have lost birds of four species through cannibalism and predation.

Photoperiod

It was recognized as early as 1967 that pairs of *F. p. tundrius* that were set aside for breeding were not coming into full breeding condition at the lower latitudes (Fyfe 1967). One of the reasons for these early breeding failures was incorrect photoperiod or day-length. Several unsuccessful attempts were made at modifying photoperiods by extending day-length only during the breeding season (Fyfe 1967). The first successes came when Cade placed tundra birds on an artificial regime that matched all phases of the natural photoperiod regime on the breeding grounds, during migration and on the wintering grounds (Weaver and Cade 1974). Cornell has had continued success with this regime, but with the establishment of the pair bond and the continuous presence of the mates, the birds appear to be modifying their photoperiod requirements (Cade, personal communication).

Since a variety of stimuli interact in bringing the birds into breeding condition (Welty 1968) (i.e., a minimum light stimulus, the presence of a

FIGURE 6. Technician feeding captive bred peregrine chicks at Wainwright facility.

mate, the presence of a suitable nest ledge, and suitable weather conditions) it is difficult to know to what extent another natural set of stimuli would affect these birds or their progeny. This is one of the reasons why care must be exercised in releases of a subspecies into any new geographic area.

Our approach has been somewhat different. We have been working primarily with *F. p. anatum* and have allowed our breeding pairs to come into breeding condition under natural light in the outdoor pens. We have also attempted to duplicate the natural regime to the extent that birds are separated when out of the breeding season and are paired during the same time span as the wild birds and are therefore under the same light and weather conditions.

These different approaches to the problem are desirable, as many of our successes to date have resulted directly from the sharing of knowledge gained through a diversity of approaches.

Nutrition

The nutritional requirements of the young appear to have been satisfactorily met with the diet of freshly-ground whole quail. But as nutritional, physiological, and temperature requirements are interrelated, additional study is required to ensure that we are providing the necessary requirements for the young bird. The occurrence among captive birds of occasional problems in skin condition, rickets, and "stargazing," which apparently are related to vitamin or mineral deficiencies (Graham 1972), suggests the need for additional research in these areas.

Reintroduction Program

We have been successful in breeding Peregrine Falcons, Gyrfalcons, Prairie Falcons, Richardson's Merlins and Sharp-shinned Hawks (*Accipiter striatus*) at the Wainwright facility (Table 1), and have started experimental reintroduction.

TABLE 1—Summary of breeding success of captive falcons at Wainwright in 1975

Taxa	Laying pairs	Copulating pairs	Fertile eggs	Young fledged
Falco peregrinus anatum	6	5	26[1]	17
Falco peregrinus pealei	1	-	2[1]	1
Falco mexicanus	3	3	16[2]	5
Falco rusticolus	3	2	6	3
Falco columbarius richardsoni	3	3	12[3]	3

[1] *F. p. anatum* and two *F. p. pealei* eggs fertilized through artificial insemination.

[2] Prairie Falcon eggs were used for artificial incubation experiments necessary to determine temperature and humidity requirements.

[3] Most of these eggs did not hatch, presumably as a result of incorrect artificial incubation parameters.

Since 1970 we have experimentally introduced Prairie Falcons through hacking, cross-fostering, and fostering (Table 2). In 1975 six peregrines were introduced through fostering (Figure 7) and in 1970 and 1974 we were successful in apparently doubling production of three pairs of peregrines in Alberta through "double clutching."

To meet requirements for breeding and reintroduction, we set a limit for the Canadian Wildlife Service facility of 15 breeding pairs of the threatened races. Once this limit is reached, surplus birds will either be used for experimental reintroduction and releases to the wild or they will go to other breeding projects to serve as breeding stock.

At present our policies relative to the utilization of captive-reared birds are (1) to cooperate with other breeding projects in disseminating captive birds so that not all of the birds of any gene pool are in one location, so as to avoid catastrophic losses in the event of fire, disease, or other disaster; (2) to supplement production of remnant groups of wild peregrines so as to assist in the maintenance of such reservoirs of the species within their original range in the wild; whatever the reason, these birds have remained, and we contend that their young have the best possible chance for survival under present environmental conditions. We are therefore supplementing their production through "double clutching" and the fostering of captive-raised young with the intention of maintaining these reservoirs of wild breeding stock; and (3) to reintroduce experimentally captive-raised young throughout their former range. It is emphasized that the first releases will be experimental and will be carried out expressly to develop acceptable methods of release for future larger-scale reintroductions of peregrines.

TABLE 2—Sucess of Canadian Wildlife Service captive breeding project, 1971–1976

Taxa	Young produced	Young released
Falco peregrinus	63	47
Falco mexicanus	42	19
Falco rusticolus	10	—
Falco columbarius richardsoni	6	—
Accipiter striatus	1	—

As with the development of a breeding flock, reintroductions present many problems, including the development of suitable methods of assessing habitat and prey abundance; the role of imprinting in mate selection, territoriality, and nest site selection; and the development of suitable methods of reintroduction and inducement of territory occupancy.

Most of these problems and their solutions are interrelated, and we believe experimental releases can be designed to provide many of the answers. Fortunately, several methods of reintroduction are available to us. In particular, hacking is an old and proven method developed by falconers for releasing trained birds to the wild. It is basically a release method that allows a

FIGURE 7. Captive-raised peregrines fostered to wild adults in northern Alberta in 1975.

bird to enter the wild at its own rate. Many variations to hacking exist but all are based on a gradual independence from a food source supplied by man. A variation of this technique has been used successfully by Cornell in their releases this year (Weaver, personal communication).

The most straightforward method of reintroduction is probably that of fostering, or adding eggs or young to the nests of wild peregrines to be raised and fledged as their own. We have encountered no problems in utilizing this method to introduce Prairie Falcons (between 1970–1974) and peregrines (in 1975). This was also the method used by Cornell in their releases in Colorado in 1974 (Cade, personal communication).

Another technique is that of "double clutching." This is not so much a method of reintroduction as a means of increasing productivity of pairs that have low production (Lejeune 1972). This technique is simply the taking of the first clutch of eggs from the parents (preferably after 7 to 10 days of incubation) and incubating them either artificially or under other birds. The falcons are then allowed to recycle and the second clutch is left with them until hatched or replaced by the young hatched from the first clutch. This technique works best when two or more pairs are involved, as the young can then be used to build up each brood in turn.

In 1974 we applied this technique successfully to two pairs of peregrines in northern Alberta. Of the first clutch of eggs collected, five were fertile and three were hatched successfully. Subsequently the two pairs hatched a further total of three in their second clutch. When the three young hatched at Wainwright were about 3 weeks old, we returned them to one of the nest sites and put the three newly hatched young into the second nest. The result was six young fledged by the two pairs.

This technique is not without risk, however, as many of the wild reproductive peregrines are heavily pesticide-contaminated and frequently show aberrant behavior. Problems include the desertion of eggs or young, failure to renest, and (as we found in 1975) the failure of fertile eggs to hatch, apparently because of residue levels. Fortunately in this instance, no production was lost as we were able to place captive-raised young in the nests. These young were adopted immediately by the adults and six young were fledged in 1975.

Fostering and double clutching can be used in those areas where there are remnant groups of peregrines. North America, south of the taiga and east of the Rocky Mountains, however, has no known breeding peregrines (Fyfe et al., this issue), which leaves only the techniques of hacking or cross-fostering.

Cross-fostering refers to the placing of young of one species (e.g., Prairie Falcons) in the care of another species. One of the primary advantages of both fostering and cross-fostering lies in the fact that the young are raised with no dependence on, and little association with, man. The major disadvantage lies in the potential of unknown problems associated with imprinting. Do young falcons imprint to the parent birds or siblings as the pattern they will later seek for a mate (Immelmann 1972); and to what extent is the choice of a nest site influenced by imprinting?

We have carried out initial field experiments with captive-raised young Prairie Falcons and three species of buteos. In 1972, young Prairie Falcons were placed in two nests of Ferruginous Hawks (*Buteo regalis*). No problems were encountered in the care of the young falcons as the Ferruginous Hawks adopted and raised four of the five young. As far as we were able to ascertain, all of the young fledged and one young male was subsequently observed at a nest cliff for about 6 weeks. One of these young was taken into captivity at fledging and in 1974 this bird, a female, mated with her own kind and laid fertile eggs.

In 1974 we placed small Prairie Falcon young in three nests of Red-tailed Hawsk (*B. jamaicensis*) and one of Swainson's Hawk (*B. swainsoni*). All but two of the young fledged and observations were then carried out at two of the sites, where the young falcons remained for several weeks. During this period, they tended to associate with their nest mates and the only observations of association with the foster parents were of the young feeding near the adults. Throughout this period, however, at our approach, the young were defended by the foster parents.

Because of the many questions relating to imprinting, homing, and nest-site selection, this experiment was initiated in an area 130 km north of the normal range of the Prairie Falcons. Site selection was based on the presence of the normal prey base of the Prairie Falcons and the nests chosen were in isolated clumps of trees which will allow good visibility when the young return. We have reason to believe some will return as we have had a band return (which indicates that at least one of the young survived the critical period after dispersal from the nest area) and five separate observations of large falcons in the release area in 1975. If the young do return to nest, it is hoped that this experiment will provide some of the answers, as this technique for release could have very wide application to other endangered species.

Summary and Conclusions

Captive breeding of peregrines has had, and will continue to have, both opponents and supporters. Controversy will continue relative to different aspects of the program. Initially many people believed that the birds could not be bred in captivity. Once this was accomplished some people still felt that the birds could not be successfully released to the wild. Now that this has also been done, the most recent criticism is that the birds will not reestablish and breed in the wild.

Such criticism has about 3 years to develop as each step takes about that long. The majority of the birds do not breed until they are 2 or 3 years of age and as might be expected, our birds did not breed until they were 3 years of age. Similarly, we have had to wait for the production of young to begin releases. Now we have at least another 2 or 3 years before released young return to establish and breed.

The 1970 and 1975 Peregrine Falcon surveys clearly indicate that this species is in serious trouble. Fortunately we have a choice: we could leave it to its fate as was done in eastern Canada, the eastern United States, and southern Alberta, or we can do something positive. Captive breeding of peregrines is a reality and as of 1976 we are now releasing *anatum* birds to the wild. We will need all the cooperation we can get from government agencies, falconers, and naturalists in locating suitable release sites, releasing birds, and in carrying out observations to record the results.

Many problems were faced and overcome in bringing success to the breeding of the peregrine in captivity. This is not a simple success story but is the result of cooperative effort and sharing of data by many dedicated individuals. Research scientists, biologists, falconers, and interested aviculturists have met once a year since the late 1960s to discuss problems in relation to captive breeding of raptors and have shared data of both successes and failures. The credit for these successes in breeding raptors in captivity belongs to everyone who has contributed.

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Literature Cited

Beebe, F. L. 1967. Experiments in the husbandry of the peregrine. Raptor Research News 1(4): 61–86.

Cade, T. and **R. Fyfe.** 1970. The North American Peregrine Survey, 1970. Canadian Field-Naturalist 84(3): 231–245.

Etkin, W. 1969. Social behavior from fish to man. University of Chicago Press. 188 pp.

Eibl-Eibesfeldt, I. 1970. Ethology—the biology of behavior. Holt, Rinehart and Winston. 464 pp.

Fischer, W. 1968. Der Wanderfalk. Die Neue Brehm Bucherei. Berliner Tierpark. Buch 13.

Fyfe, R. 1967. BPIE 4. Breeding Project Information Exchange #4. Raptor Research Foundation.

Fyfe, R. 1972. Breeding behavior of captive and wild Prairie and Peregrine Falcons. Proceedings of the Raptor Research Special Conference on Captive Breeding of Raptors. Volume 6, Supplement C. C43-52.

Fyfe, R. 1975. Breeding Peregrine and Prairie Falcons in captivity. Breeding endangered species in captivity. *Edited by* R. D. Martin. Academic Press, London.

Fyfe, R. W., S. Temple, and **T. J. Cade.** 1976. North American Peregrine Falcon Survey, 1975. Canadian Field-Naturalist 90(2). (*This issue.*)

Graham, D. 1972. Raptor Research Conference Proceedings, 1972.

Immelmann, K. 1972. The influence of early experience upon the development of social behavior in estriline finches. Proceedings of the 15th International Ornithological Congress. pp. 316–330.

Kendall, H. 1968. Breeding Prairie Falcons in captivity. Journal of the North American Falconers' Association 7: 57–64.

Lejeune, J. 1972. A pilot project to increase the reproduction of Peregrine Falcons in the wild by artificial means. Raptor Research News 5(5 and 6).

Nelson, R. W. 1971. Captive breeding of peregrines. Suggestions from their behavior in the wild. Raptor Research News 5(2): 54–85.

Nelson, R. W. 1972. Imprinting and other behavioral considerations. Proceedings of the Raptor Research Special Conference on Captive Breeding of Raptors. Volume 6, Supplement C. C52-64.

Olendorff, R. 1967. Breeding project information exchange. Raptor Research Foundation 1: 5.

Olendorff, R. 1972. Incubation, natural and artificial. Proceedings of the Raptor Research Special Conference on Captive Breeding of Raptors. Volume 6, Supplement B. B7-34.

Peterson, R. 1968. The domestic raising of the Peale's Peregrine Falcon. Journal of the North American Falconers' Association 7: 64–67.

Waller, R. 1968. A report of the first successful breeding of Peregrine Falcons in captivity. Journal of the North American Falconers' Association 7: 45–57.

Weaver, J. D. and **T. J. Cade.** 1974. Special report on the falcon breeding program at Cornell University. Raptor Research BPIE 90.

Welty, C. J. 1968. The life of birds. Alfred A. Knopf, New York. 546 pp.

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Behavioral Aspects of Egg Breakage in Peregrine Falcons

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Abstract. Egg breakage by Peregrine Falcons is considered in terms of (*a*) accidental breakage or (DDE-induced) thin-shelled eggs, and (*b*) destruction of the eggs accidentally or deliberately by abnormal parental behavior. Interspecific diffferences exist in the behavioral responses to elevated DDE levels in the body, broken eggs in the nest, and normally hatched eggshells. Although behavioral abnormalities have been observed in some other species, little evidence is available to implicate aberrant behavior as a cause of egg breakage in peregrines. Normal peregrine incubation behavior is quite adequate to account for accidental breakage of thinner-than-normal eggshells.

The discovery that Peregrine Falcons (*Falco peregrinus*) and some other predatory birds began laying thin-shelled eggs in 1946–1950 in Great Britain (Ratcliffe 1967) and North America (Hickey and Anderson 1968) was a major step in linking the persistent chlorinated hydrocarbon biocides with the widespread post-1945 population declines of peregrines and some other species. Field and laboratory studies have correlated the decrease in eggshell thickness with the concentration of DDE (the principal breakdown product of DDT) found in the egg (e.g., in American Kestrels, *Falco sparverius*, by Wiemeyer and Porter 1970; Prairie Falcons, *F. mexicanus*, by Fyfe et al. 1969, and Enderson and Berger 1970; Peregrine Falcons by Cade et al. 1971; see Cooke 1973 for review). The DDE within an egg is an indicator of the concentration within the female that laid the egg (see Enderson and Berger 1968). Presumably it is the DDE concentration within the female which influences the thickness of the shell deposited on the egg, and the DDE concentration in the male or female which might be responsible for aberrant (egg-breaking) behavior which bears some relationship to thinning of eggshells.

This paper considers the relative contribution of eggshell thinning and aberrant parental behavior to the destruction of peregrine eggs.

Aberrant Behavior as a Cause of Egg Breakage

Ratcliffe (1972, p. 132) suggested that in peregrines the contribution of eggshell thinning to egg breakage "... may be less important than that of direct behavioral disturbances ..." in which deliberate (biocide-induced) parental destruction of the eggs might occur. He implied (1972, 1973) that a close parallel may exist between losses of eggs in falcons and in herons. Milstein et al. (1970), studying behavior of Grey Herons (*Ardea cinerea*), observed one male in 13 pairs stabbing and flicking eggs out of its nest.

Peakall and Peakall (1973), with Ring Doves (*Streptopelia risoria*), found that dietary PCB caused slightly lower and more variable incubation temperatures and poorer hatch under natural incubation (versus controls and artificial incubation), and attributed this to poorer nest attentiveness by PCB-fed doves—that is, an organochlorine biocide did cause measurable changes in incubation behavior.

Some caged Mallards (*Anas platyrhynchos*), fed DDE and/or PCB, broke eggs (Risebrough and Anderson, 1975). Although unable to observe a complete sequence, these authors believed that at least some of the breakage represented the non-accidental breaking of intact eggs.

The report of the egg-destroying male heron by Milstein et al. (1970) and that of a European Sparrowhawk (*Accipiter nisus*) "... seen to hole one of its eggs with its bill and then to tip the damaged egg out of the nest ..." by M. E. Greenhalgh (Ratcliffe 1970, p. 73) appear to be the only observations that have been made of the actual act of egg destruction by birds in biocide-contaminated populations.

In the Cooper's Hawk (*Accipiter cooperii*), Snyder et al. (1973, p. 302) found breakage in 11 of 60 clutches and stated that " . . . not all of the punctured eggs . . . were exceptionally thin shelled, but all were relatively high in DDE. This fact suggests that DDE contamination may contribute to egg destruction in ways additional to eggshell thinning. Perhaps care of eggs is equally important." Nest desertion in Cooper's Hawks was associated with egg breakage in 10 of 11 cases, and Snyder (1974, p. 442) remarked that "Cooper's hawks usually desert their nest if just one egg of a clutch breaks." Three pairs showed abnormal behavior: two built frail nests and one female had difficulties in accepting food from her mate and in feeding her nestlings. These three females laid eggs with relatively high DDE levels.

Enderson et al. (1972), by means of time-lapse photography, observed the behavior of peregrines during the last half of incubation at seven Yukon River eyries. Five of 24 eggs were broken either before or during filming; shell fragments from two unsuccessful nests were thinner than shell fragments from successful nests. The films showed the male of one of the unsuccessful pairs to be at its nest very infrequently; otherwise none of the seven pairs showed any abnormalities in parental behaviour.

I studied peregrine incubation behavior from egg-laying to hatching on Langara Island, British Columbia in 1968–69 and 1971–72, with more than 300 h of observations from blinds. Eight eggs (two fresh-laid, six infertile or dead) had an average shell-thickness index (Ratcliffe 1967) of 1.67; this is 12–13% less than the average of 1.91 for 91 pre-DDT eggshells from the same population (pre-DDT data of Anderson and Hickey 1972; and D. W. Anderson, personal communication). Of 12 clutches followed for all or part of the incubation phase, four clutches (33%) lost single eggs, apparently by breakage (Nelson and Myres, 1976). In contrast, only about 4% of pre-DDT British peregrine clutches lost one or more eggs during incubation (Ratcliffe 1970). I saw no behavior which could be construed as being aimed destructively at the eggs nor any abnormal behavior (e.g., unusual clumsiness) which might have damaged eggs. A number of near-accidents were, however, observed (see next section).

Accidental Breakage of Thin-shelled Eggs

The following points (*a*) illustrate some interspecific similarities and differences seen in egg treatment and breakage, (*b*) offer evidence for accidental breakage as being a major cause of peregrine egg loss, and (*c*) indicate ways in which peregrines (and some other species) can accidentally break weakened eggshells.

Overall, the behavioral information and circumstantial evidence strongly support Anderson's (1970, p. 89) statement: "The critical level of thinning seems logically associated with the behavioral traits of nest and incubation behavior characteristic of various groups of birds."

1. Treatment of Eggshells at Hatching

In the several wild pairs and one captive pair of peregrines I have observed on the day of hatching, occasionally the female would reach beneath, pull out a large piece of shell, pick it up and drop it a number of times and nibble it, all the while remaining low on the nestlings and/or eggs. Similarly the male picked up and dropped and nibbled bits of shell that remained when he was at the scrape. Some small fragments of shell fell on the ledge, some may have been eaten. I have seen no suggestion that peregrines carry eggshells from the nest. For British peregrines the Nethersole-Thompsons (1942, p. 218) noted ". . . an eggshell found below one eyrie, but strong evidence for supposing that shells sometimes eaten . . . ."

Captive Merlins (*F. columbarius richardsonii*) similarly nibble eggshells shortly after hatching (Campbell and Nelson 1975). Sparrowhawks sometimes drop shells over the edge of the nest, sometimes carry them away, but nibbling and eating the shells seems more usual (Newton 1973; Nethersole-Thompson and Nethersole-Thompson 1942). Grey Heron eggshells usually are dropped over the edge of the nest or broken up in the nest, and there is no evidence of carrying (Nethersole-Thompson and Nethersole-Thompson 1942). Milstein et al. (1970, p. 212) observed that " . . . the eggshell is gently lifted between the mandible tips and simply dropped over the side." This behavior does not appear closely related to the stabbing and flicking of freshly-laid eggs from the heron nest mentioned earlier. The Nethersole-Thompsons (1942) point out that there can be considerable variation in the manner of eggshell disposal both within a species and in an individual from one egg to the next.

2. *Treatment of Broken Eggs*

The Nethersole-Thompsons (1942) reported that P. M. Meeson saw a female peregrine (pre-DDT) eating an egg damaged by a falling rock. These authors note that several species are known to eat a damaged egg in their nest. This behavior appears to be a means of cleaning up the nest and preventing soiling of feathers after a natural accident has occurred.

Ratcliffe (1970) found peregrine shell remains at a distance from eyries, but, without knowing the time of their discoveries in relation to the nest histories, it is difficult to know whether falcons removed them from the nests or a nest predator removed them after the falcons abandoned the clutches or parts of them. Beebe (1967) observed a captive female peregrine carrying in its beak a half-shell containing a recently dead, partly-hatched young. This could suggest a different response to a solidly-filled shell (carrying) than a partially incubated but broken egg or an empty eggshell (eating and nibbling) (e.g., see Tinbergen et al. 1962*a, b*).

Ratcliffe (1970) and Newton (1973) reported that Sparrowhawk eggs which were broken have been found below nests, in nests, and occasionally at a distance. The remains may consist of small fragments of shells, of partial shells, or of intact but punctured eggs.

The Nethersole-Thompsons (1942, p. 190) found that damaged eggs, especially if broken during laying or early incubation, " . . . with many species, not infrequently caused nest desertion." The close association between breakage of their eggs and desertion in Cooper's Hawks (see above) may be related to this general tendency. In the related Sparrowhawk, however, desertion usually does not occur until the clutch is depleted to one egg (Newton 1973).

Milstein et al. (1970) reported that the egg-destroying heron did not eat the shells or much of the contents before flinging them out of the nest, and commented that the heron's type of bill probably would have made eating of the contents difficult.

3. *Timing of Breakage*

In apparent contrast to herons, in which most egg losses seem to occur during laying or early in incubation, peregrine egg losses appear to occur at any time between laying and hatching. Ratcliffe (1970, p. 71) indicates that in peregrines ". . . a higher proportion of losses occurs when the incubation period is well advanced. . . ." Possibly the few percent thinning of eggshells that occurs due to the normal extraction of eggshell material by the developing embryo (e.g., see Vanderstoep and Richards 1971; Kreitzer 1972) causes some eggshells to reach a critical level of thinning late in incubation and to be broken at that stage. Sparrowhawk egg losses similarly occur at any time from laying onward (Newton 1973).

Figure 1b shows an egg in which the young died during hatching. This egg, once it was pipped, had much of the shell fracture and flake off. Then the embryo had nothing solid (i.e., no shell) against which to cut the shell membrane, and the shell membrane could quickly dry and toughen. When a rescue attempt was made, the embryo was already dead, its beak still by the original single pip hole.

This peregrine egg bore a remarkable resemblance to eggs of a Michigan Osprey (*Pandion haliaetus*) (figure in Conway et al. 1969), a Michigan Bald Eagle (*Haliaeetus leucocephalus*) (Harrington 1969), and Great Lakes Herring Gulls (*Larus argentatus*) (Figure 5D in Anderson 1970; Figure 4 in Gilbertson 1974), all of which no doubt failed to hatch. The last was from a colony averaging 16% thinning of eggshells (Gilbertson 1974) (see also Keith 1966 concerning flaking of gull eggs).

Apparently a thinned (physically weakened) shell will be further (structurally) weakened as soon as the embryo begins pipping. Shuffling by the parent (see below) could then chip back the weak edges of the shell, imprisoning the embryo permanently. This form of mortality apparently has not been observed before in peregrines, but this may not be surprising for, in order to observe this, the observer might have to be present at the nest within a day before or after the expected hatching date (e.g., see Beebe's (1967) observation above). The time-lapse films of Enderson et al. (1972) and the DDE and eggshell thinning data from that part of Alaska (about 17% thinning) (Cade et al. 1971) suggest that this is not a common form of mortality for peregrines, however, even in a population experiencing related difficulties.

4. *Relation of Thinness to Breakage*

Nesting success and egg breakage of British peregrines are closely related to the eggshell thickness index of their eggs; for eggs collected during 1963–1968, mean thickness indices were as follows:

(*a*) 1.67 in eggs from nests where no breakage was found, but 1.42 in eggs from clutches which were depleted by breakage;

(*b*) 1.60 in eggs from nests which produced fledged young, but 1.46 in eggs from clutches which failed to fledge young.

These differences were statistically significant (t-test, $P < 0.001$) (Ratcliffe 1970). Apparently, when the shell thickness index reaches 1.6—1.5 (a reduction of about 15–17%) in peregrine eggs, likelihood of the egg's surviving is much reduced.

Ratcliffe (1970) has observed dented peregrine eggs, one of which was measured; its thickness index was 1.25. Berger et al. (1970) found many broken and cracked eggs in Ungava, and these averaged 21% thinner than shells from 1900–1940 from the eastern Canadian Arctic.

5. *Loss of Single Eggs*

If eggs are broken by means of aberrant behavior of biocide-laden parent falcons, then it is unclear why, if one egg is broken, all are not treated in the same way. The loss of single eggs and survival of the remainder suggest accidental breakage. Dented or cracked eggs found in eyries also suggest accidental breakage of thin-shelled eggs. Presumably a full or reduced clutch of three or two eggs could be expected to survive with fewer losses owing to breakage than a clutch of four or five eggs, simply by occupying less space beneath the incubating bird (see *Behavior Patterns*, next section).

Of the eight Langara Island eggshells collected in 1968–1972, one had a 19.9% reduction in thickness index compared to the pre-1947 mean for this population. This egg was the only one in a clutch of four that did not hatch. The pair of falcons producing this 1972 clutch lost single eggs from their 1969 (three-egg) and 1971 (four-egg) clutches (unknown if any loss in 1970). DDE levels in eggs from 1969, 1971, and 1972 showed a slight increase in these years. With the same or increased DDE levels in eggs—and, presumably, in brains—the falcons might have been expected to break some eggs deliberately or accidentally in 1972 as well, and the thinner 1972 eggshells would simply add to this likelihood. Yet all four of their 1972 eggs survived incubation, suggesting that accidental breakage was responsible for the losses in previous years.

Ratcliffe (1970) found that at least 44 of 61 depleted clutches fledged no young at all, and suggested that once one egg was broken, all in the clutch were likely to disappear. It is not clear, however, what the levels of contamination in these 61 clutches were. If most or all contained high levels of DDE and were greatly thinned, then it is understandable why the loss of one egg might signify the (accidental) destruction of the whole clutch eventually.

Of the 61 depleted clutches Ratcliffe reported, four were known to fledge young (13 unchecked for hatching success), indicating that some depleted clutches can yield young. Hall (1955, 1970) reported that some depleted clutches fledged young, and Enderson et al. (1972) found that one of three depleted clutches fledged young. Berger et al. (1970, p. 267) reported that in their survey area "The eight eggs that were broken or cracked were collected at five eyries, four of which had one downy young and the fifth had two." All four of the Langara Island eyries experiencing egg loss fledged young. It appears, then, that breakage of eggs by peregrines bears a relationship to the degree of contamination and thinning, and that there may be a gradient in susceptibility to accidental breakage ranging from single eggs lost through to whole clutches being lost.

6. *Behavior Patterns Threatening Thin-shelled Eggs*

The following descriptions of incubation behavior patterns of peregrines are summarized from Nelson (1970) and from very close observations of one pair of peregrines breeding in captivity. The captive peregrines contained very low levels of biocides (J. A. Campbell, Sr., and R. W. Fyfe, personal communication). Quantitatively and qualitatively these behavior patterns appear to be identical in the wild (moderately contaminated) and captive (slightly contaminated) falcons I have observed. Behavioral descriptions of captive Merlins are from observations of Campbell and Nelson (1975).

a. Approaching the nest scrape. Peregrines usually land ½ m or more away, and walk the remaining distance to the scrape. At 20–30 cm from the scrape all the toes on each foot are held close together and point forward (Figure 1a). The last steps to, and the movements in, the scrape are with the feet held in this manner. The weight of the bird is supported in a small area and all of the talons are in a small area, apparently to limit the threat to the eggs posed by the strong feet and sharply pointed talons. Despite this adaptation, near-accidents do occur when the bird puts a substantial portion of its weight onto an egg (Figure 1b).

In captive Merlins and wild and captive Peregrine Falcons I have not made observations of the type of arrival described by Rowan (1922, p. 196) at a British Merlin nest, in which the female landed in the middle of the clutch.

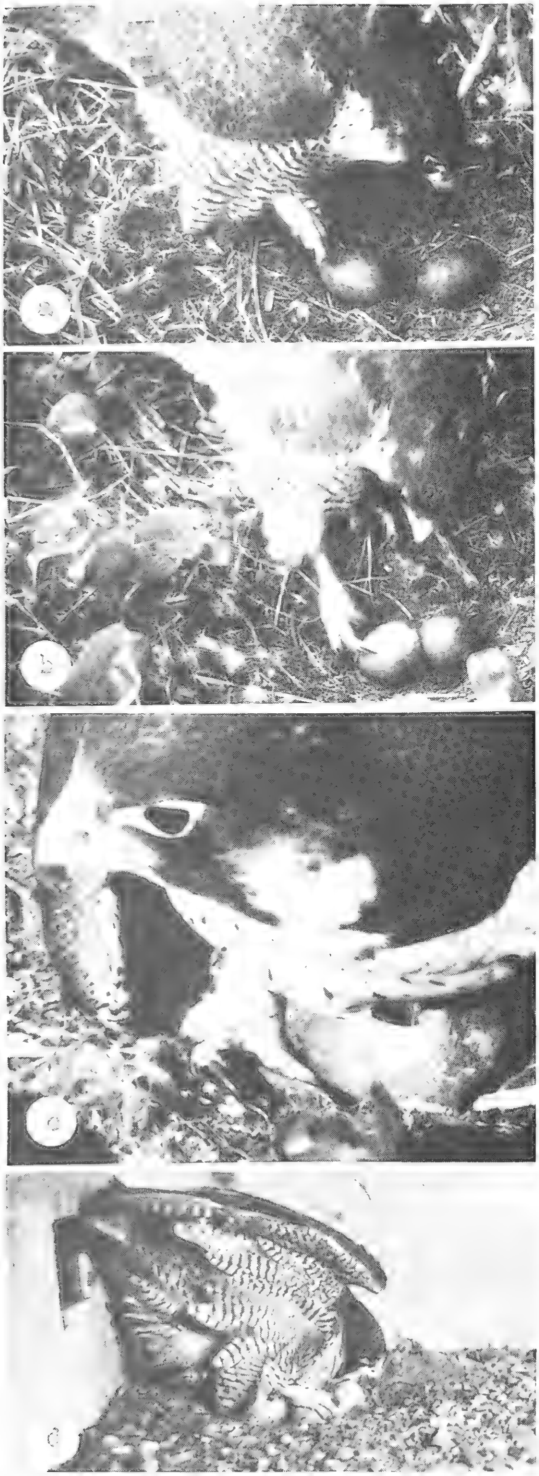

FIGURE 1. Some behavior patterns posing threats to Peregrine Falcon eggs. (a) Normal approach to the eggs. Note how the foot appears to be limp, with toes occupying a very small area. A third egg disappeared from this nest at mid-incubation.
(b) A near-accident upon arrival at the scrape. The female accidentally steps on one end of an egg. The egg moved and her talon slipped off without puncturing the shell. The white membrane on this egg resulted from the unsuccessful hatching attempt of that embryo (see text). The second egg hatched that night.
(c) During incubation the falcon occasionally turns to a new position. If it turns while remaining low on the eggs, the eggs are rolled, slid, and bounced toward the new position, between the feet and tarso-metatarsi and between them and the wings.
(d) The positioning of the scrape close to an obstruction sometimes causes the incubating falcon to stumble or otherwise move clumsily in the scrape. The captive female stands on an egg as she attempts to complete a turn (counter-clockwise) to a new incubation position.

b. Settling on the eggs. Among the many settling movements, shuffling may pose the greatest threat. In shuffling, the falcon briskly slides its feet back and forth a number of times between or beneath the eggs. Near to hatching time the shuffling can be very vigorous, and it often occurs also while the bird incubates. Shuffling can be extremely vigorous if the incubating falcon is showing signs of heat stress. The shuffling feet sometimes punch eggs that happen to lie in their way. In captive Merlins with eggs near hatching, both sexes shuffled in such a way that the eggs could be heard knocking together from a distance of over 1 m away. It sounded like someone rattling a loose handful of walnuts (J. A. Campbell, Sr. and Jr., personal observations).

c. Turning on the scrape. To change to a new position on the eggs, the falcon may stand up or it may rise up almost imperceptibly, then step or shuffle to face in a different direction. If done while remaining relatively low on the scrape, the actions of the wings, feet, and tarso-metatarsi tend to jostle the eggs along with the bird to its new position (Figure 1c).

d. Shifting the eggs. The 'turning,' shifting, or tucking of the eggs beneath the body is done with the beak opened slightly, perhaps as a means of partially removing the point of the upper mandible from the vicinity of the egg. The underside of the lower mandible is pushed against the egg, and the point of the upper mandible also may contact the lower part of the egg. In wild and captive peregrines the egg sometimes will not move back farther beneath the bird, and the falcon applies so much force that the egg rides up on the egg(s) behind it, right off the ground, and then falls back when the falcon ceases pushing it.

Rowan (1922, p. 196), studying British Merlins, noted that the eggs ". . . were invariably turned with the help of talon and gaping beak ([Rowan's] Fig. 4). The effect of this rough method of handling became more and more apparent as time went on, as minute bits of the outer pigmented shell got chipped off, finally producing eggs very freely sprinkled with small white specks." This incredible manner of moving the eggs was not evident in the one pair of captive North American Merlins, nor in the peregrines I have observed. Whether it was (is) typical of British Merlins is unknown.

e. Leaving the scrape. During incubation the eggs lie between or beside the toes and tarso-metatarsi, and occasionally upon partially buried toes. Sometimes the eggs are jostled within the scrape as the undisturbed bird carefully rises and steps away. When moderately alarmed, the falcon usually steps away from the scrape in an unhurried manner, but in cases of a very sudden fright, the falcon may launch itself directly from the nest scrape. If suddenly frightened, peregrines sometimes knock an egg out of the scrape (Cade 1960, p. 188). Clearly, thin-shelled eggs are greatly at risk when sudden disturbances occur.

f. Position of the nest scrape. At many nest sites, and even when indoors in captivity, peregrines place their scrapes close to a wall at the back or side of the ledge, even when the ledge substrate and the sheltering overhang permit the scrape to be located at some distance from an obstruction (e.g., see plates in Hickey 1969). As a result, frequently the incubating falcon, in trying to turn to a new position over the eggs, catches its wing tips and/or tail on the obstruction and then stumbles, or shifts its footing quickly in order to maintain its balance while completing the turn, creating considerable hazard for the eggs beneath (Figure 1d).

7. *Ability of Egg-breakers to Incubate Successfully*

Ratcliffe (1962, 1963, 1973) reported three remarkable instances in which European Common Kestrel (*F. tinnunculus*) clutches on cliff ledges were commandeered by Peregrine Falcon pairs which apparently had broken their own clutches just previously. That the peregrines in one of these cases were known to have fledged the young kestrels suggests that the peregrines accidentally broke their own eggs rather than deliberately destroyed them. If the peregrines had lost their own eggs owing to behavioral abnormalities, they could be expected to have destroyed the kestrel eggs in like manner. Ratcliffe (1970) noted that the same female which fledged the brood of kestrels in 1963 lost her eggs again in 1964 but reared two peregrines in 1965. Hall (1955, 1970), similarly with a recognizable female, reported clutch loss in one year and fledging of young the next. These observations, and those noted under *Loss of Single Eggs*, above, in which depleted clutches fledged young, argue against the "egg-eating habit" developing in this species once one or a few eggs have been broken, and support the contention that accidental breakage of weakened eggs is the cause of egg loss in peregrines.

Discussion

I am aware of only one observation of apparently aberrant behavior concerning the parent–egg relationship in peregrines, and it merits consideration in some depth. G. Carse (*in* Ratcliffe 1970) reported on a previously known female engaged in scrape-making behavior, the 'digging' action that forms the nest scrape, and which usually occurs pre-laying. She was seen to kick an egg out of the scrape, a second egg was found below the ledge, and previously four eggs had been seen in the nest.

In 1974 I observed somewhat similar behavior in a wild, yearling female Prairie Falcon which laid four eggs and which, during the laying interval, scattered them about her ledge. Shortly after the first egg was laid she and the ledge were soaked by a late spring blizzard and then her mate resumed winter (non-courtship, non-incubation) behavior. Thus it was unclear what factor(s) caused her to mistreat the eggs. Neither the Prairie nor the Peregrine Falcon (apparently) provided any biocide samples.

Both the male and the female of the captive pair of peregrines I have observed carried out scraping behavior *during* the laying period in their second successful breeding season. The wild peregrine which knocked an egg out of the scrape may actually have been involved in a 'natural' accident if she earlier lost her clutch of four eggs, and was observed by Carse at the start of the laying of the second clutch.

If the poor egg-tending behavior in the wild Prairie and Peregrine Falcons was biocide-induced, rather than weather- or mate-induced (or a 'natural' accident in the case of the peregrine), then it is reminiscent of the aberrant behavior of the egg-stabbing, improperly incubating male heron (above) which may not have progressed from courtship into incubation behavior. This would be suggestive of hormone abnormalities (see Jefferies 1973).

It is interesting that from three separate *pre*-1947 peregrine populations in Alaska, Cade et al. (1971) found thickness indices to have the extreme lower range values of 14.4%, 10.1%, and 8.6% less than their respective population means. The lowest thickness index in pre-1947 eggs from the Queen Charlotte Islands (Anderson and Hickey, personal communication) was only 13.6% less than that population's mean. For 509 pre-1947 British peregrine eggs, Ratcliffe's (1970, p. 76) data show only about 24 eggs with thickness indices more than 13% below the mean, and only about eight with indices more than 18% below the mean. Apparently extremely few pre-DDT eggs were produced with thickness indices as low as 1.6–1.5 (a reduction of about 15–17%), which recently are associated with considerable breakage. In this regard, Risebrough's (1971, p. 279) comment is most appropriate: "The optimum thickness of an egg shell has been determined in countless evolutionary processes. Any deviation might be considered a selective disadvantage."

Very few *post*-1947 peregrine eggs have been collected with shells more than 30% thinner (thickness index < 1.25) than pre-1947 averages (see figures in Ratcliffe 1970, Cade et al. 1971), implying that there comes a limit to the thinness of an eggshell that can survive long enough under the incubating falcon to be found by a human observer (Anderson and Hickey 1974).

The data of Hickey and Anderson (1968) and Cade et al. (1971) indicate that peregrine populations which had (have) average eggshell thickness indices of 18% or more below pre-1947 averages are either extirpated or declining. At this degree of thinning, and even with lesser amounts of thinning, peregrines are known to break unusual numbers of eggs. If biocide-induced aberrant (egg-breaking) behavior of peregrines is important as a cause of the population declines, such behavior must manifest itself in critical proportions at exactly the same level of DDE contamination as causes the critical levels of shell-thinning. Such a relationship between aberrant behavior and shell-thinning seems too coincidental to invoke at this time.

Ratcliffe (1958, 1970) and others have observed peregrines in the process of eating their own eggs in the post-1947 era, during which so many clutches have had eggs disappear. The event which now needs to be recorded is *the actual breakage of an egg.*

Because the laying of a clutch of four eggs takes slightly longer than 6 days, and the incubation period (from laying of the last egg until its hatching) takes about 33 days (Nelson 1972), to monitor one nest, waiting for the observation of the brief instant in which an egg is broken (which may not occur!), would require immense manpower and/or elaborate technological aids. The likelihood is much less that casual observations will provide information on exactly what occurred when eggs were broken.

Further indications of the role of aberrant behavior and shell-thinning in egg breakage might be found by transplanting clutches between wild and/or captive breeding peregrines. The *beta*-backscatter device would be useful as it provides a portable, rapid, non-destructive means of measuring in the field the quality of eggshells (thickness and thickness index; see Fox 1974). Wiemeyer et al. (1975) switched a number of Osprey clutches between a suffering Connecticut population and a sound Maryland population. The contaminated Connecticut Ospreys did hatch a normal number of Maryland eggs, and the relatively unpolluted Maryland Ospreys hatched only a few of the Connecticut eggs. Aberrant incubation behavior did not appear to be a cause of poor production.

From the observations provided above, I would expect very similar results from such experiments involving Peregrine Falcons.

Conclusions and Summary

While DDE-induced thin eggshells are closely associated with abnormally high losses of eggs, the exact manner in which Peregrine Falcon eggs are broken is still unknown. It may result from (*a*) biocide-induced, deliberate parental destruction of the eggs, (*b*) biocide-induced, accidental destruction of eggs (e.g., by overly clumsy behavior), and/or (*c*) strictly accidental breakage of eggs because the shells are too weak to withstand normal incubation. Other factors also may operate.

Although there appears to be little evidence pointing to aberrant behavior as a cause of egg loss in peregrines, it is important to bear in mind Ratcliffe's suggestion that this mechanism also may be present and should be looked for.

The available evidence suggests that there are considerable interspecific differences in the response to DDE levels, thin eggshells, broken eggs, hatched shells, and intact shells.

In Peregrine Falcons, the DDE-induced thinning of the eggshells appears to be the major factor responsible for the widespread breakage of eggs that has been reported in recent decades.

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Literature Cited

Anderson, D. W. 1970. Chlorinated hydrocarbons; their dynamics and eggshell effects in Herring Gulls and other species. Ph.D. thesis, University of Wisconsin, Madison. 207 pp.

Anderson, D. W. and **J. J. Hickey.** 1972. Eggshell changes in certain North American birds. *In* Proceedings of the XVth International Ornithological Congress.

Edited by K. H. Voous. E. J. Brill, Leiden. pp. 514–540.

Anderson, D. W. and **J. J. Hickey.** 1974. Eggshell changes in raptors from the Baltic region. Oikos 25: 395–401.

Beebe, F. L. 1967. Experiments in the husbandry of the peregrine. Raptor Research News 1(4): 61–86.

Berger, D. D., D. W. Anderson, J. D. Weaver, and **R. W. Risebrough.** 1970. Shell thinning in eggs of Ungava Peregrines. Canadian Field-Naturalist 84(3): 265–267.

Cade, T. J. 1960. Ecology of the Peregrine and Gyrfalcon populations in Alaska. University of California Publications in Zoology 63(3): 151–290.

Cade, T. J., J. L. Lincer, C. M. White, D. G. Roseneau, and **L. G. Swartz.** 1971. DDE residues and eggshell changes in Alaskan falcons and hawks. Science (Washington) 172: 955–957.

Campbell, J. A. and **R. W. Nelson.** 1975. Captive breeding and behavior of Richardson's Merlins, 1974. Journal of the North American Falconers' Association 14. 24–31.

Conway, G., et al. (14 authors). 1969. DDT on balance. Environment 11(7): 3–5.

Cooke, A. S. 1973. Shell thinning in avian eggs by environmental pollutants. Environmental Pollution 4: 85–152.

Enderson, J. H. and **D. D. Berger.** 1968. Chlorinated hydrocarbon residues in Peregrines and their prey species from northern Canada. Condor 70(2): 149–153.

Enderson, J. H. and **D. D. Berger.** 1970. Pesticides: eggshell thinning and lowered production of young in Prairie Falcons. BioScience 20(6): 355–356.

Enderson, J. H., S. A. Temple, and **L. G. Swartz.** 1972. Time-lapse photographic records of nesting Peregrine Falcons. Living Bird 11: 113–128.

Fox, G. A. 1974. Eggshell quality and DDE: correlation with reproductive success in the common tern. M.Sc. thesis, University of Alberta, Edmonton. 80 pp.

Fyfe, R. W., J. Campbell, B. Hayson, and **K. Hodson.** 1969. Regional population declines and organochlorine insecticides in Canadian Prairie Falcons. Canadian Field-Naturalist 83(3): 191–200.

Gilbertson, M. 1974. Pollutants in breeding Herring Gulls in the lower Great Lakes. Canadian Field-Naturalist 88(3): 273–280.

Hall, G. H. 1955. Great moments in action; the story of the Sun Life falcons. Mercury Press, Montreal. 37 pp. Reprinted 1970 *in* Canadian Field-Naturalist 84(3): 209–230.

Harrington, R. 1969. Eaglet and an egg . . . (*Cover photograph*). Science (Washington) 163(3867).

Hickey, J. J. (*Editor*). 1969. Peregrine Falcon populations: their biology and decline. University of Wisconsin Press, Madison. 596 pp.

Hickey, J. J. and **D. W. Anderson.** 1968. Chlorinated hydrocarbons and eggshell changes in raptorial and fish-eating birds. Science (Washington) 162: 271–273.

Jefferies, D. J. 1973 The effects of organochlorine insecticides and their metabolites on breeding birds. Journal of Reproduction and Fertility, Supplement 19: 337–352.

Keith, J. A. 1966. Reproduction in a population of Herring Gulls (*Larus argentatus*) contaminated by DDT. Journal of Applied Ecology (Supplement) 3: 57–70.

Kreitzer, J. F. 1972. The effect of embryonic development on the thickness of the eggshells of Coturnix Quail. Poultry Science 51: 1764–1765.

Milstein, P. le S., I. Prestt, and **A. A. Bell.** 1970. The breeding cycle of the Grey Heron. Ardea 58(3–4): 171–257.

Nelson, R. W. 1970. Some aspects of the breeding behaviour of Peregrine Falcons on Langara Island, B.C. M.Sc. thesis, University of Calgary, Calgary, Alberta. 306 pp.

Nelson, R. W. 1972. The incubation period in Peale's Falcons. Raptor Research 6(1): 11–15.

Nelson, R. W. and **M. T. Myres.** 1976. The populations of Peregrine Falcons and their seabird prey at Langara Island, British Columbia, and possible causes of their declines. Condor. *In press.*

Nethersole-Thompson, C. and **D. Nethersole-Thompson.** 1942. Egg-shell disposal by birds. British Birds 35(8): 162–169, (9): 190–200, (10): 214–223, (11): 241–250.

Newton, I. 1973. Success of Sparrowhawks in an area of pesticide usage. Bird Study 20(1): 1–8.

Peakall, D. B. and **M. L. Peakall.** 1973. Effect of a polychlorinated biphenyl on the reproduction of artificially and naturally incubated dove eggs. Journal of Applied Ecology 10: 863–868.

Ratcliffe, D. A. 1958. Broken eggs in Peregrine eyries. British Birds 51(1): 23–26.

Ratcliffe, D. A. 1962. Peregrine incubating kestrel's eggs. British Birds 55: 131–132.

Ratcliffe, D. A. 1963. Peregrines rearing young kestrels. British Birds 56: 457–460.

Ratcliffe, D. A. 1967. Decrease in eggshell weight in certain birds of prey. Nature (London) 215: 208–210.

Ratcliffe, D. A. 1970. Changes attributable to pesticides in egg breakage frequency and eggshell thickness in some British birds. Journal of Applied Ecology 7: 67–115.

Ratcliffe, D. A. 1972. The Peregrine population of Great Britain in 1971. Bird Study 19(3): 117–156.

Ratcliffe, D. A. 1973. Studies of the recent breeding success of the Peregrine, *Falco peregrinus.* Journal of Reproduction and Fertility, Supplement 19: 377–389.

Risebrough, R. W. 1971. Chlorinated hydrocarbons. *In* Impingement of man on the oceans. *Edited by* D. W. Hood. Wiley-Interscience, New York. pp. 259–286.

Risebrough, R. W. and **D. W. Anderson.** 1975. Some effects of DDE and PCB on Mallards and their eggs. Journal of Wildlife Management 39: 508–513.

Rowan, W. 1922. Observations on the breeding-habits of the Merlin. II. Incubation. British Birds 15: 194–202.

Snyder, N. 1974. Can the Cooper's Hawk survive? National Geographic 145(3): 432–442.

Synder, N. F. R., H. A. Snyder, J. L. Lincer, and **R. T. Reynolds.** 1973. Organochlorines, heavy metals, and the biology of North American accipiters. BioScience 23(5): 300–305.

Tinbergen, N., G. J. Broekhuysen, F. Feekes, J. C. W. Houghton, H. Kruuk, and **E. Szulc.** 1962a. Egg shell removal by the Black-headed Gull, *Larus ridibundus* L.; a behaviour component of camouflage. Behaviour 19: 74–117.

Tinbergen, N., H. Kruuk, M. Paillette, and **R. Stamm.** 1962b. How do Black-headed Gulls distinguish between eggs and egg-shells? British Birds 55: 120–129.

Vanderstoep, J. and **J. F. Richards.** 1971. The changes in egg shell strength during incubation. Poultry Science 49: 276–285.

Wiemeyer, S. N. and **R. D. Porter.** 1970. DDE thins eggshells of captive American Kestrels. Nature (London) 227: 737–738.

Wiemeyer, S. N., P. R. Spitzer, W. C. Krantz, T. G. Lamont, and **E. Cromartie.** 1975. Effects of environmental pollutants on Connecticut and Maryland Ospreys. Journal of Wildlife Management 39(1): 124–139.

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Osprey and Bald Eagle Populations in Labrador and Northeastern Quebec, 1969–1973

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Abstract. Osprey (*Pandion haliaetus*) and Bald Eagle (*Haliaeetus leucocephalus*) populations were studied over extensive areas of Labrador and northeastern Quebec. Census estimates of 1.0 and 1.2 Osprey nesting territories per 100 mi^2 (259 km^2) were obtained in western Labrador and northeastern Quebec, respectively. Known densities of up to 3.8 territories per 100 mi^2 (259 km^2) were observed in east-central Labrador. Osprey populations in western and east-central Labrador appeared to be declining annually during the study at rates of 8–9% and 3–4%, respectively. We speculate that Osprey population dynamics in northeastern Quebec are similar to those in western Labrador. Eagle numbers were low with an estimated 0.2 nesting territories per 100 mi^2 (259 km^2) in western Labrador. Eagle productivity approaches that which is necessary for the maintenance of a stable population. A significant correlation was observed between Osprey productivity and the date water bodies became clear of ice in the spring.

Declines in Osprey and Bald Eagle populations have been well documented in the eastern and midwestern United States (Henny and Ogden 1970; Sprunt et al. 1973). While many populations have been declining there has been an increase of Osprey migration past the Hawk Mountain Sanctuary and Bake Oven Knob Ridge in Pennsylvania (Brett and Nagy 1973; D. S. Heintzelman, personal communication). These birds are believed to be from eastern Canada, Maine, and the Adirondack Mountains (Spofford 1969).

From 1969 through 1973 the Newfoundland and Labrador Wildlife Division and the Canadian Wildlife Service studied Osprey and Bald Eagle populations on the northeastern edge of their range in Labrador and northeastern Quebec. This work was done as an adjunct to work on waterfowl and caribou (*Rangifer tarandus*) populations.

Study Areas

Osprey and Bald Eagle population data were collected in three study areas: western Labrador, northeastern Quebec, and east-central Labrador (Figure 1). The western Labrador study area (21 700 mi^2 or 56 200 km^2) was of interest because it supported relatively large numbers of waterfowl (Gillespie and Wetmore 1974) and caribou. This area is the site of flooding for the Churchill Falls hydroelectric development. The area is low lying and drift-filled with slight relief ranging from 1500 to 2000 ft (478 to 610 m). Prior to flooding, the area displayed a vast number of shallow water bodies separated by bogs, string bogs, marshes, fens, lichen-spruce woodland, and close-crowned spruce forest. Now with the reservoir filled, approximately 3400 mi^2 (8800 km^2) of marsh, bog, and lakes are flooded, thus destroying large areas of waterfowl nesting and caribou calving grounds. Only in the extreme south of the study area will low-lying areas remain in their natural state.

Osprey are found nesting throughout the western Labrador study area. Nests are typically built on the tops of the taller (50 to 60 ft, 15 to 18 m) spruce (*Picea mariana* and *P. glauca*) or balsam fir (*Abies balsamea*) in the denser woodlands that border streams draining hillsides overlooking shallow lakes or rivers. Nests were also found along rivers, again in tall trees at the edges of dense riparian forests. Eagle nests were found in a variety of habitats but most frequently were in tamarack (*Larix laricina*) at the edge of large shallow lakes or in large bogs.

The northeastern Quebec study area (52 700 mi^2, 136 500 km^2) included those areas generally

FIGURE 1. Western Labrador, northeastern Quebec, and east-central Labrador study areas.

south of the tree-line, and west of the tundra of the eastern Labrador plateau (Figure 1). In the center of the study area the Whale River Basin and headwaters of the Kaniapiskau River are predominantly drift-filled areas. Here vegetation is similar to that in western Labrador. The other dominant geological feature of the study area is the Labrador Trough which runs between Leaf Basin and Schefferville. Here and in the far western, northern, and eastern segments of the study area, lichen woodlands occupy the valleys and hillsides. On the tops of the hills between water courses, lichen–heath plant communities are found.

In northeastern Quebec Osprey nests are found in similar habitat types to those in western Labrador. We did not locate any Bald Eagle nests in the area during our study. We have seen eagles in the southeastern portion of the study area, however, and eagles are known to nest in the northern portions of the western Labrador study area.

The east-central Labrador study area (18 000 mi², 46 600 km²) contains a variety of geological features and habitat types (Figure 1). In the north, Lake Melville, Double Mer, and Grand Lake are conspicuous features. Close-crowned spruce-fir forest is the dominant cover type. Bogs, marshes, and small lakes are scattered throughout the area. Osprey nests are generally located in the taller trees along hillside streams overlooking the shallow north shores of Lake Melville and Double Mer. A unique concentration of nests is found along the hills on the west side of The Narrows between Rigolet and Lake Melville. Here the water is deep, but strong tidal action produces upwelling and the area is rich in marine life.

In the middle of the east-central study area the Mealy Mountains rise abruptly from Lake Melville to elevations of between 2000 and 4000 ft (610 and 1220 m). The foothills and valleys of the mountains are mostly open-crowned spruce forest while on top, lichen–heath plant communities are found. Osprey nests are found primarily in the foothills west of the Kenamu River.

South of the Mealy Mountains is a large drift-filled area with bogs, string bogs, lakes, open-crowned and close-crowned spruce-fir woodlands. The headwaters of the Eagle River rise here. Osprey nests are found in tall spruce and fir trees of the denser forest types along the large lakes and rivers and along hillside tributaries overlooking lakes and bogs. The only eagle nests known in the study area are found in this section near Park Lake. To the east of the headwaters of the Eagle River, the forests become denser and the terrain more rugged. Osprey nests are found primarily on hillsides along rivers and streams.

In the southwest portion of the east-central study area at the headwaters of the Minipi, Kenamu, and Traverspine Rivers, bogs, close-crowned forests, and large lakes are found. Osprey nests are observed in typical locations in this area.

Methods

Productivity

Osprey and eagle nests were initially located in a variety of ways: (1) during air and ground wildlife management and enforcement work throughout Labrador and northeastern Quebec; (2) by questioning residents and bush pilots; and (3) during nest productivity checks and censuses.

In order to determine Osprey and Bald Eagle productivity, nests were checked twice during the nesting season in western and east-central Labrador. The initial check of nests generally lasted from the last two days of May through the middle of June. The presence or absence of adults and the number of eggs were recorded. Follow-up checks of nests with an adult bird or eggs were carried out from late July through mid-August, depending upon nest phenology and coordination with other projects. On the second check the presence of adults and the number of young and/or eggs were noted. Occupied nests that did not undergo both checks were excluded from productivity estimates. The large majority of nests were checked using helicopters (Bell G-2, Bell 206A, and Hiller 12E), although in 1969 and 1972 several were checked in July using a deHavilland Beaver and deHavilland Turbo-Beaver.

Nests were classified as occupied-productive, occupied-nonproductive, occupied-unknown outcome, alternate, unoccupied, blown down, or occupied by other species. Alternate Osprey nests were defined by measuring the map distance between the two closest occupied nests over the 5-year study. Nests closer together than 0.9 mi (1.5 km) in the western and 0.7 mi (1.1 km) in the east-central study areas were considered to be in the same nesting territory. Nests without birds or eggs observed during the first check were classified as unoccupied. Because of the conspicuousness of Osprey nests and the aggressive nature of the adults we feel that all nesting territories located could be classified as occupied or unoccupied. Because of the large distances between the known eagle nests and the lack of knowledge about eagle nesting territory size each nest was considered to be a separate territory.

Nest Censuses

From 25 July to 1 August 1971 we conducted a waterfowl brood, Osprey and Bald Eagle nest census of the western Labrador study area using a Hiller 12E helicopter. The study area was divided into seven unequally sized blocks according to watershed and the flooding plans of the Churchill Falls project. Sampling intensity varied among blocks according to the requirements of the waterfowl work. Since neither the blocks nor sampling intensity bore any relationship to Osprey or eagle nest distribution, data were combined. Eighty-one 9.3 mi^2 (24.1 km^2) replicates 1.5 x 6.2 mi (2.4 x 10 km) were sampled by making three passes through each at an altitude of approximately 200 ft (61 m). This gave 3.5% coverage of the study area. Because of the conspicuous nature of Osprey and eagle nests we believe we saw all nests within each replicate.

From 25 July to 3 August 1972 we conducted a waterfowl brood and Osprey nest census of the northeastern Quebec study area using a deHavilland Beaver (3.1% coverage). North–south lines were flown at 12-mi (19.3-km) intervals at an altitude of 200 ft (61 m) using a strip width of 1/6 mi (270 m) on either side of the aircraft.

Because of funding limitations we were unable to census the east-central Labrador study area. Unlike the western study area, however, most of the nests were concentrated in three areas in east-central Labrador (Figure 1). We give data on the total number of known nesting territories in 1973 for those concentrations.

Break-up Data

Data on spring ice break-up in Wabush Lake near Labrador City – Wabush (1750 ft or 534 m elevation) and Terrington Basin near Goose Bay (sea-level) were gathered (Allen and Cudbird 1971; J. R. H. Noble, Atmospheric Environment Service, personal communication). The dates for "water clear of ice" were used as an indication of the progress of spring break-up. Date for "water clear of ice" is defined by Allen and Cudbird (1971, p. vi) as being "the earliest date on which the water was reported to be completely free of all floating ice and remained so until the following freeze-up." Winter temperature, spring temperature, freeze-up date, and snow fall influence the date when the water is clear of ice in Terrington Basin (Cooper 1972). Of weather factors tested, Cooper found the highest correlation between March–April temperature and the date for water clear of ice.

Results

Osprey

In western Labrador the percentage of productive nests and the number of young per occupied nest with known outcome fluctuated over the four years 1970–1973. During the same time there was little variation in the number of young raised per productive nest (Table 1). The percentage of nesting territories classified as occupied from 1970 to 1973 was 54, 41, 36, and 54.

During the 1971 census of western Labrador we observed 11 nests in sample replicates. From this we calculated that there were 0.14 ± 0.11 nest per replicate, or approximately 317 nests (including alternates) in the entire 21 700 mi^2 (56 200 km^2) study area. Calculating from the total estimated nests and the June 1971 nest classification data we estimated approximately 1.0 nesting territory (occupied and unoccupied) per 100 mi^2 (259 km^2). From nest success data (Table 1) we can estimate that there were 194 nesting adults which produced 103 young in western Labrador in 1971 (Table 2).

In 1972, 28 nests were observed on 1613 mi^2 (4178 km^2) during the strip census of northeastern Quebec. Assuming that suitable nesting habitat distribution was random we estimated 916 nests in the 52 700 mi^2 (136 500 km^2) area. Applying the 1971 nest classification data from western Labrador (Table 2) to the sample data from northeastern Quebec we estimated that there were approximately 1.2 nesting territories (occupied or unoccupied) per 100 mi^2 (259 km^2) in the study area. The 1971 nest classification was used because it was our largest and most representative sample. Of the 28 nests observed in northeastern Quebec, eight were occupied (38%). This was similar to the percentage of total nests (including alternates) observed occupied in the western (33%) and east-central (36%) Labrador study areas in 1972.

In east-central Labrador the percentage of productive nests and the number of young per occupied nest with known outcome varied greatly between the five breeding seasons (Table 1). As in western Labrador the number of young

TABLE 1—Reproductive success of Osprey populations in western and east-central Labrador study areas

	1969	1970	1971	1972	1973	Total
Western Labrador						
Occupied nests		15	26	20	42	103
Occupied nest-known outcome		12	25	18	29	84
Productive nests		4	19	4	10	37
Percent productive		33	76	22	34	44
Young raised		6	27	4	15	52
Young/productive nest		1.5	1.4	1.0	1.5	1.4
Young/occupied nest-known outcome		0.5	1.1	0.2	0.5	0.6
East-central Labrador						
Occupied nests	10	35	50	60	83	238
Occupied nests-known outcome	8	27	39	56	74	204
Productive nests	2	4	30	26	54	116
Percent productive	25	15	77	46	73	57
Young raised	4	5	52	41	94	196
Young/productive nest	2.0	1.2	1.7	1.6	1.7	1.7
Young/occupied nest-known outcome	0.5	0.2	1.3	0.7	1.3	1.0

TABLE 2—Estimated Osprey production, western Labrador study area 1971

Nest class	Number observed[1]	Percent	Number in study area (projected)	Nesting adults (projected)	Young produced (projected)
Occupied-productive	19	22.4	71	142	99
Occupied-nonproductive	6	7.1	22	44	0
Occupied-unknown outcome	1	1.2	4	8	4
Alternate	25	29.1	93	0	0
Unoccupied	34	40.0	127	0	0
Total	85	99.8	317[2]	194	103

[1] 1971 nest classification conducted during productivity surveys (Table 1).
[2] Total estimated from 1971 census.

per productive nest did not vary as much. The percentage of nesting territories classified as occupied from 1969 to 1973 was 77, 54, 54, 45, and 60. This indicates a higher percentage of occupied territories in east-central than in western Labrador.

Unlike those in western Labrador, most nests in the east-central study area were concentrated in three areas (Figure 1). In 1973 we observed 3.8 territories/100 mi^2 (259 km^2) in a portion of the headwaters of the Eagle River (1780 mi^2, 4610 km^2). We know of no nests in an area of about equal size to the north in the vicinity of the Mealy Mountains. Another area of nest concentration includes 860 mi² (2230 km²) southwest of Goose Bay. Here the density of known territories in 1973 was 2.8/100 mi² (259 km²). Again in similar-sized areas, west, east, and south we knew of few nests. The third area of nest concentration in the east-central study area stretched along the north side of Lake Melville. This area is about 820 mi² (2120 km²) and in 1973 we knew of 2.7 territories/100 mi² (259 km²).

Bald Eagle

During the five-year study we located 18 eagle nests. Thirteen of these were in the western study area while the remainder were in the headwaters of the Eagle River in east-central Labrador. Productivity data for the two study areas were combined (Table 3). As with Osprey, the percentage of productive nests and the number of young per occupied nest with known outcome fluctuated over four breeding seasons. Also the number of young per productive nest was relatively constant. The percentage of nests checked and classified occupied from 1970 to 1973 were 75, 80, 46, and 57.

Using the ratio of known to total estimated Osprey nests, we estimated eagle nest density in western Labrador from the number of known eagle nests. Thus, assuming that eagle nests were as easily located as Osprey nests we estimate 0.2 eagle nests/100 mi² (259 km²) in western Labrador. Comparable estimates are not available for the other study areas, though we believe this to be the highest density of the three areas.

Reproductive Success and Spring Break-up

Young per occupied nests with known outcome fluctuated in the western and east-central study areas (Table 1). In an attempt to find a possible cause for these fluctuations we investigated weather phenomena.

Osprey usually arrive in east-central Labrador in early May. Birds were first seen at North West River on 5 May 1970, 9 May 1971, 29 April 1972, and 12 May 1973. At this time most lakes and ponds are still ice-covered and birds are limited to fishing in open sections of streams and rivers. We hypothesized that should spring break-up be delayed, causing access to food to be limited, it might have a negative effect on nesting success.

We found a significant correlation ($P < 0.05$) between young per occupied nest with known outcome and the date for "water clear of ice" (Figure 2). Data from the western Labrador study area were plotted against break-up dates

TABLE 3—Reproductive success of Bald Eagle populations in Labrador

	1970	1971	1972	1973	Total
Occupied nests	2	8	6	8	24
Occupied nests-known outcome	2	8	5	7	22
Productive nests	2	3	0	5	10
Percent productive	100	37.5	0	71.4	45.4
Young raised	2	4	0	6	12
Young/productive nest	1	1.3	—	1.2	1.2
Young/occupied nest-known outcome	1	0.5	0	0.9	0.6

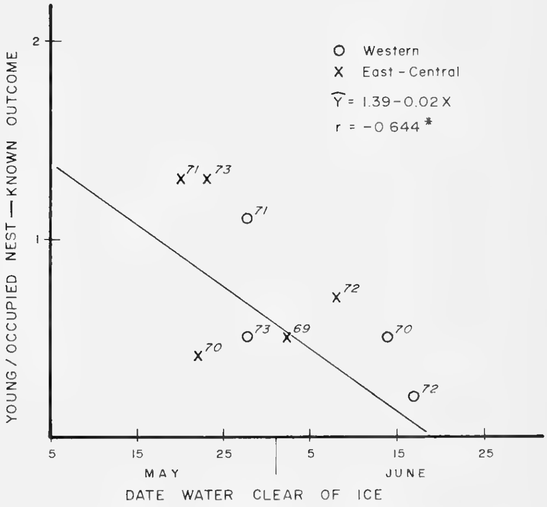

FIGURE 2. Young per occupied nest with known outcome correlated with date for "water clear of ice" in spring, for western and east-central Labrador study areas (*indicates $P < 0.05$). The linear regression equation was used to draw the line of best fit.

for Wabush Lake and those from the east-central area were plotted against dates for Terrington Basin.

In 1970 a larger than usual discrepancy was noted between break-up in Terrington Basin and that of the surrounding upland ponds at elevations averaging 1300 ft (400 m). Consequently, in 1970 only productivity data gathered from nests near sea-level were used in the correlation. This points out the need in future studies for recording break-up dates in several locations within study areas rather than relying on Atmospheric Environment Service data.

Discussion

Osprey

Our survey method did not permit us to follow uninterrupted a large number of nesting territories over a number of years. Therefore, following the population model developed by Henny and Wight (1969), we used weighed mean productivity data to calculate the rates of population change. Unless compensated for by ingress from other areas the populations in western and east-central Labrador appeared to be declining at annual rates of 8 to 9% and 3 to 4% respectively. The lower percentage of productive nests combined with the lower number of young per productive nest resulted in a greater rate of decline in western Labrador (Table 1). Because of the similar percentage of occupied nests observed in 1972 we speculate that populations in northeastern Quebec may be declining at a rate similar to that of western Labrador.

The number of eggs observed during the first nest check in occupied-successful versus occupied-unsuccessful nests differed significantly in both western and east-central study areas (2.35 ± 0.30 vs. 1.03 ± 0.43 and 2.68 ± 0.14 vs. 1.42 ± 0.32, respectively). This could indicate fewer territorial pairs laying eggs, fewer eggs per laying pair, and/or more egg breakage in unsuccessful nests.

In western Labrador 2.35 ± 0.30 eggs yielded 1.41 ± 0.17 young while in the east-central study area 2.68 ± 0.14 eggs averaged 1.69 ± 0.13 young. The number of young per productive nest did not change significantly between years through the study.

Thus it appears that low numbers of young per occupied nest is caused by limited egg-laying or poor hatching success. This poor success is accentuated in years of later break-up (Figure 2).

Henny and Wight (1969), using combined recoveries from birds shot and found dead, calculated that a New York – New Jersey Osprey population would require production of 1.22–1.30 young per female of breeding age to maintain a stable population. Labrador populations were below this level of production; however, in the east-central study area adequate production was achieved in 1971 and 1973 (Table 1). If because of higher nest success, higher production is achieved in years of early break-up then during a series of years with mild springs the population in east-central Labrador could be expected to sustain its numbers. Populations in more southern areas of eastern Canada with limited ice cover, earlier break-up, and longer summers may be expected to produce stable or perhaps increasing populations, thus possibly contributing to increases observed at Hawk Mountain and Bake Oven Knob Ridge. Unfortunately, at this time there are no population data to substantiate this hypothesis.

Chlorinated hydrocarbon contamination has been suggested as a cause for the decline of Osprey populations (Ames 1966; Postupalsky 1969). If pesticides are a problem for Labrador and northeastern Quebec populations, most residues are probably accumulated in wintering areas since there is only localized use of insecticides in a few communities in Labrador.

The possibility of synergism between late spring break-up and residue contamination deserves further study. Also the effects of large northern reservoirs (e.g., at Churchill Falls and James Bay) on local climate and break-up should be investigated as it relates to nesting success.

Bald Eagles

Eagle populations are small in Labrador and we did not locate any nests in northeastern Quebec. Sprunt et al. (1973) indicate that in order to maintain stability at least 50% of the breeding pairs must be productive and produce at least 0.7 young per occupied nest. Although our sample size is quite small it appears that eagle populations in Labrador approach this level of production (Table 3). In 1972 none of the five nests observed produced young; 1972 had the latest spring break-up ever recorded in Labrador (Noble, Atmospheric Environment Service, personal communication).

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Literature Cited

Allen, W. T. R. and **B. S. V. Cudbird.** 1971. Freeze-up and break-up dates of water bodies in Canada. Canadian Meteorological Service, Toronto. 144 pp.

Ames, P. L. 1966. DDT residues in the eggs of the Osprey in the northeastern United States and their relation to nesting success. Journal of Applied Ecology 3 (Supplement): 87–97.

Brett, J J. and **A. C. Nagy**. 1973. Feathers in the wind. The mountain and the migration. Hawk Mountain Sanctuary, Hawk Mountain Sanctuary Association, Pennsylvania. 70 pp.

Cooper, J. E. 1972. The forest industry of Labrador. Synoptic conditions affecting forest fire hazards in Labrador and forecast of spring break-up of Terrington Basin. Environment Canada, Atmospheric Environment Service, Goose Bay, Labrador. 35 pp. (Mimeo.)

Gillespie, D. I. and **S. P. Wetmore**. 1974. Waterfowl surveys in Labrador–Ungava, 1970, 1971, 1972. *In* Waterfowl studies. Canadian Wildlife Service Report Series 29: 8–17.

Henny, C. J. and **H. M. Wight.** 1969. An endangered Osprey population: estimates of mortality and production. Auk 86(2): 188–198.

Henny, C. J. and **J. C. Ogden.** 1970. Estimated status of Osprey populations in the United States. Journal of Wildlife Management 34(1): 214–217.

Postupalsky, S. 1969. The status of the Osprey in Michigan in 1965. *In* Peregrine Falcon populations; their biology and decline. *Edited by* J. J. Hickey. University of Wisconsin Press, Madison. pp. 338–340.

Spofford, W. R. 1969. Hawk Mountain counts as population indices in northeastern America. *In* Peregrine Falcon populations; their biology and decline. *Edited by* J. J. Hickey. University of Wisconsin Press, Madison. pp. 323–332.

Sprunt, A., IV, W. B. Robertson, Jr., S. Postupalsky, R. J. Hensel, C. E. Knoder, and **F. J. Ligas.** 1973. Comparative productivity of six Bald Eagle populations. Transactions of the North American Wildlife and Natural Resources Conference 38: 96–106.

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Gyrfalcon Nest Site Selection and Winter Activity in the Western Canadian Arctic

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Abstract. During the latter halves of January and of February 1975, 31 Gyrfalcon (*Falco rusticolus*) nest sites were examined in the Yukon Territory north of 68° 00′ N. Half of these nest sites were observed to be frequented by Gyrfalcons during each survey and pairs of falcons were found in February, about 60 days before egg-laying. The presence of snow on the nest ledge did not appear to affect whether a site was frequented but did appear to influence its use as a nest site. No juvenile Gyrfalcons were identified in the study area during the winter. Evidence is presented that the young leave the breeding range during the winter while adults remain. Willow Ptarmigan (*Lagopus lagopus*) was the main prey although microtine rodents were also utilized.

The Gyrfalcon (*Falco rusticolus*) is a true arctic species, with a circumpolar nesting distribution. The breeding distribution for North America and Greenland extends in Greenland from 82° N south to 60° N (Salomonsen 1951); in North America nests occur from 79° N on Ellesmere Island south to about 60° N across Canada (Godfrey 1966). Local populations occur south to 57° N in western Alaska and Quebec.

Of all North American diurnal raptors, the ecology of the Gyrfalcon is perhaps the least studied. Cade (1960), White and Cade (1971), Roseneau (1972), and Platt (1975, unpublished data) have made many year nesting studies of local populations. With the exception of the last, these studies restricted their investigation to the period from late incubation through fledging.

Reports of Gyrfalcon activity during the non-breeding season consist of sightings in southern Canada and the northern United States. The majority of Gyrfalcons seen in winter, however, are of non-breeding age (see below). Cade (1960) found apparent winter perches near Gyrfalcon nest cliffs on the Colville River in Alaska and suggested that Gyrfalcons probably winter on the breeding grounds. Irving (1960) reported sighting Gyrfalcons in Anaktuvuk Pass in central Alaska throughout the winter, and Sheldon (1909) reported seeing a single Gyrfalcon in the Mount McKinley region in winter. Sutton (1960), however, discounted Cade's idea that Gyrfalcons could winter at Colville River latitudes (68° N) and stated that there were few if any valid records of high-latitude Gyrfalcons in the dead of winter. Beebe (1974) maintained that only a few Gyrfalcons remained north of the tree-line during the winter and that they survived only by feeding on sea ducks.

The purpose of this investigation was to perform the first systematic examination of Gyrfalcon breeding territories during January and February. If the Gyrfalcons were present, I wanted to determine (1) what habitats in the study area are used by Gyrfalcons during this period, (2) whether Gyrfalcons visit nest sites during this period, (3) what prey sources are available to Gyrfalcons in the winter, and (4) whether there is a relationship between winter occupancy and later breeding activity.

Study Area

The study area is approximately 19 500 km^2 in area. It is approximately 150 km east to west, being between 136° 00′ W, and 140° 11′ W. To the north lies the Beaufort Sea (68° 50′ N to 69° 40′ N); the southern boundary is an arbitrary line parallel to the coast and approximately 100 km inland.

The study area contains the following physical divisions.

1. The coastal plain which varies between 8 and 30 km in width. The plain is bordered on the north by the Beaufort Sea and on the south by the foothills.
2. The north slope foothills, which are

tundra-covered and less than 300 m above sea-level. The foothills rise gradually from the coastal plain to the mountains to the south.

3. The British and Richardson Mountains, which form the divide between the Beaufort Sea drainage and the Yukon River drainage. The mountains are mostly barren and less than 1370 m above sea-level.

4. A section of south slope, which is tundra-covered and similar to the foothills but with less relief. The section within the study area extends south 15 km from the divide between the north and south slopes.

More than a dozen river systems originate in the mountains. The river valleys are generally below 600 m elevation. They are, to a large extent, tundra-covered, but extensive patches of willow occur along the water courses. These patches of willow occur in small but frequent clumps in higher parts of the valleys and in much larger areas along the water courses in the foothills and on the coastal plain.

The banks and cliffs along the river systems provide most of the nest sites for diurnal raptors. Knolls and outcroppings on the coastal plain also provide nest sites. The study area contained 31 territories in which Gyrfalcons produced young during either 1973 or 1974 (28 of these sites were used in 1973). It also contained cliff nest sites of Golden Eagles (*Aquila chrysaetos*), Rough-legged Hawks (*Buteo lagopus*), Peregrine Falcons (*Falco peregrinus*), and Common Ravens (*Corvus corax*).

Temperatures during the period December 1974 to February 1975 ranged from −48°C to −9°C near sea-level. Warmer temperatures were generally accompanied by strong winds and blowing snow. The amount of daylight ranged from 3 h in mid-January to 7 h in late February.

Methods

During the last two weeks of January and the last two weeks of February investigators worked from Shingle Point DEW-line site using a Bell 206 turbine-powered helicopter. All known Gyrfalcon nest cliffs in the study area were searched from the air and on foot for evidence of Gyrfalcon presence during the winter. Whether the eyrie (nest ledge) was snow-filled was also noted.

Surveys in search of Gyrfalcons away from known nest sites were flown along the length of all major water courses and along the coastal cliffs. The flights were made at 140 km/h and 30 m above the ground.

Surveys in search of prey species were flown each day of the winter investigations at 70 km/h and 5 m above the ground cover. Sample areas of all major habitat types in the study area were examined as well as habitats in nearby areas not represented on the study area (Herschel Island, the Old Crow Flats, and the Mackenzie Delta).

The number of ptarmigan in each of six plots was estimated. The plots were selected from about 500 m above ground according to the following criteria: each plot was a stand of willow surrounded by a willow-free area; the willow was dense enough that more area was covered by willow than by snow; and the plot had to be larger than 0.5 ha. The helicopter flew back and forth across the plot about 5 m above the ground cover, driving any ptarmigan present to one end of the plot where they gathered, being reluctant to enter the open area surrounding the plot. The number of ptarmigan gathered at the end of the drive and seen to escape was estimated by the pilot and the two observers in the helicopter. The three estimates were averaged.

Results

Evidence and Sightings of Gyrfalcons

Twenty-eight gyrfalcon nest sites used in either 1973 or 1974 were visited during January 1975. In February these sites were again examined at least once and three additional sites were visited. Fourteen of the 28 nest cliffs visited in January showed sign (described below) of Gyrfalcon winter activity. Thirteen of these 14 continued to show evidence of recent Gyrfalcon activity when revisited in February. Two nests showing no sign of being frequented in January showed abundant sign at the February examination. Of the three nest sites visited only in February, one was being frequented by Gyrfalcons. Thus, 16 of the 31 sites examined in February were being frequented; a total of 17 were being used in either January or February. Frequented nest sites were located throughout the study area; nest cliffs at the highest and lowest elevations showed activity as did sites near all four borders of the study area.

Two types of perches were in use at the

frequented nest cliffs. One type was situated in an open location, often commanding a view in every direction and always of more than 180°. Scattered excrement and foot tracks but only occasional pellets marked these sites. The only prey remains (see below) recovered during the winter were found at three of these perch points. Active perch points were found at every frequented cliff and occasionally occurred at more than one location on a cliff.

The other perch type was located on the face of the nest cliff, either in a crevice or under a large overhang. The field of vision from these perches was estimated to be between 90° and 130° in all cases. Present at these perches (hereafter called roosts) were pellets and dozens or, in some cases, hundreds of individual excretions on top of the snow. A roost was found at 13 of the 17 frequented nest cliffs.

The eyrie was examined at 29 of the 31 nest sites (eyries at two cliffs had disappeared). Table 1 shows that the falcons did not preferentially frequent cliffs with snow-free eyries ($\chi^2 = 0.049$; $P > 0.8$).

Gyrfalcons had walked into three of the eyries that were open in January. In late February these eyries continued to show evidence of falcon visitations, and a fourth showed evidence of visitations for the first time. None of the eyries showed evidence in either month of the falcons making the nest cup (scrape), which is formed during the early stages of falcon courtship.

At least 18 sightings of Gyrfalcons were made during the winter study. At least seven individual falcons were seen in January; six of these were males and one was a female. During February, at least 11 falcons were observed; six of these were males and five were females. It is assumed that some of the January falcons were again seen during February. One Gyrfalcon was seen from the ground under poor light conditions and its age could not, therefore, be determined. But all of the other Gyrfalcons were examined at close range from the helicopter and had yellow feet and a light breast, which indicate that they were over 1 year old.

TABLE 1—Snow condition versus winter utilization of 29 Gyrfalcon eyries

Utilization in winter	Snow condition		Total
	Snow-free	Snow-filled	
Eyrie frequented	8	9	17
Eyrie not frequented	6	6	12
Total	14	15	29

Eight of the 18 Gyrfalcon sightings made during the winter were at nest sites. Three of the eight were lone birds seen in January, and a lone falcon and two pairs were seen at nest sites in February.

Ten of the 18 Gyrfalcon sightings were of birds distant from known nests. Four were seen in January during 12 h of Gyrfalcon surveys and six in February during 28 h of Gyrfalcon surveys. All of these falcons were near willow patches; one was flying above coastal cliffs, and the nine others were either perched or flying along the river valleys. One bird was observed flying slowly around scattered willow bushes, almost hovering above each bush.

Results of Surveys and Plot Counts for Prey Items

Of primary interest was whether a sufficient prey base was available to Gyrfalcons that wintered in the study area; 5 h of surveys for prey species were flown in January and 8 h in February.

Most birds leave the Arctic in winter; only three species were recorded on the north slope besides the Gyrfalcon—the Snowy Owl (*Nyctea scandiaca*), the Common Raven, and the Willow Ptarmigan (*Lagopus lagopus*). A Gray Jay (*Perisoreus canadensis*) was seen in the Mackenzie Delta and another in the Old Crow Flats.

Single Snowy Owls were seen three times in January and twice in February. Although generally confined to the lower portions of river valleys, one was seen perched on the sea ice 2 km from land. Because of its size and its scarcity, the Snowy Owl is unlikely to be a potential prey item.

Ravens were seen in groups as well as singly. The aggregations occurred at the Shingle Point and Komakuk Beach DEW-line stations where the Ravens scavenged for food. The single

Ravens were seen in the river valleys 4 times in January and 7 times in February. As in the case of the Snowy Owl, this large uncommon winter resident is probably not a significant prey item.

Willow Ptarmigan were the most abundant animals observed on the north slope in winter. They were found from the sea coast to 60 km inland and from sea-level to nearly 600 m above sea-level. All of those seen were in flocks numbering between 13 and 400 birds. The mean flock size was estimated to be 60 birds. All ptarmigan flocks were found in close association with willow communities. Willow patches throughout the study area contained abundant sign of ptarmigan feeding and roost sites and densities in such habitat were high (Table 2). Herschel Island, the Mackenzie Delta, and Old Crow Flats also contained large numbers of ptarmigan. Both male and female Willow Ptarmigan were collected in the study area during winter. Although Rock Ptarmigan (*Lagopus mutus*) are present during the summer, none was identified in the winter flocks or prey remains. Because ptarmigan are known to be the primary prey of Gyrfalcons on the Yukon North Slope during the breeding season (Platt 1975) and because ptarmigan remains were found at three winter perch points, this abundant winter resident is considered the primary prey item for winter Gyrfalcons.

TABLE 2—Results of ptarmigan census by helicopter of six willow plots on the Yukon Territory North Slope, February 1975*

Area of plot (ha)	Number of ptarmigan flushed	Ptarmigan per ha
3.0	350	117
2.0	80	40
1.0	150	150
0.7	400	571
0.7	125	179
0.7	90	129

* Two smaller plots of 0.5 ha each were also censused but contained only signs of recent ptarmigan activity.

The winter surveys revealed the presence of at least nine mammalian species on the north slope: caribou (*Rangifer tarandus*), moose (*Alces alces*), Dall sheep (*Ovis dalli*), wolf (*Canis lupus*), wolverine (*Gulo gulo*), red fox (*Vulpes vulpes*), snowshoe hare (*Lepus americanus*), weasel (*Mustela* sp.), and a microtine rodent. Those species larger than the hare are not considered prey items and their use as carrion has not been reported.

Snowshoe hare sign was common in the spruce communities of the Old Crow Flats and the Mackenzie Delta. Small numbers were also seen in the upper portions of some of the rivers that have stands of spruce. Hares were also found in lower sections of the river valleys in those few areas with willow stands 2 to 3 m in height. Although a Gyrfalcon is capable of catching and subduing snowshoe hares, their sparse distribution outside forested areas makes it unlikely that they are an important prey item. Weasels spend much of their winter beneath the snow feeding on microtines. Because of this and their relative rareness they are unlikely prey.

The availability of the microtine population was not determined. Tracks were occasionally seen during the ground searches in the foothills. The microtines were generally scarce during the summers before and after the winter surveys, but were locally common on the coastal plain. Arctic microtines are active in the winter and would be highly vulnerable when not under the snow cover. Because microtine tracks were found on top of the snow cover and because microtines do occur in the summer diet of nesting Gyrfalcons, they are considered a potential food item for winter Gyrfalcons.

Twenty-six winter pellets were gathered at nest sites throughout the study area. Sixteen contained ptarmigan remains, four contained only microtine hair, and six contained both microtine and ptarmigan remains.

Relationships between Winter and Spring Activity

Table 3 shows the relationship between presence or absence of Gyrfalcons at nest cliffs in winter and usage during the subsequent 1975 breeding season. Significantly more of the sites that were frequented in winter than of those that were not frequented were occupied in the

TABLE 3—1975 nesting results at 31 Gyrfalcon nest sites examined in January and February 1975

Nesting results	Sites frequented in January or February	Sites not frequented in January or February
Produced eggs or young	9	1
Site defended in June but had no eggs or young	3	1
No activity	5	12
Total	17	14

subsequent season (x^2 = 9.82; $P<.005$). The nine sites that were used during the winter and summer of 1975 have not been occupied year round, year after year. Only five of them produced young in 1974.

Besides the nests examined in both winter and spring (Table 3), three additional Gyrfalcon nests were found on the study area in the spring of 1975. Hence there were 13 nesting pairs in the study area in 1975, the same number as in 1974; these 26 nestings occurred at 20 nest sites. These were not alternate nest sites within the same territories but rather widely separated, different sites. Fourteen nest sites were used once in two years. Although the breeding density remained constant from 1974 to 1975, one half (7 of 13) of the 1975 pairs bred at sites not used in 1975.

Discussion

The winter surveys found Gyrfalcons at their nest sites during January and pairs present in February. The primary prey item was found to be Willow Ptarmigan, with microtine rodents also being eaten. The Gyrfalcons concentrated their activity in the river valleys of the foothills; these areas contained their nest sites and ptarmigan habitat. Eggs or young were produced in the spring of 1975 at 53% of the nests frequented during the winter of 1974–75, but only 7% of the nests not frequented in winter later produced eggs or young.

The presence of roosts at nearly two-thirds of the nests frequented in winter indicates that nest-site selection may occur as early as January and certainly by February (when pairs were present). The prey base present during January was not similar to that present in spring; besides the total unavailability of migratory and hibernating species in winter, ptarmigan present in winter were in flocks but those present in summer were territorial.

If an improved prey base is not the reason for these yearly shifts in nest sites, perhaps it has to do with the acceptability of the nest structure. Although nest cliffs with snow-free eyries were frequented at the same rate as they occurred in the study area (Table 1), snow-free eyries were selected for egg-laying more than twice as many times as snow-filled eyries (Table 4). Although these data suggest that nest sites which are open in the winter are preferentially used for egg-laying, the tendency in this sample is not significant (χ^2 = 1.71; $0.2 > P > 0.1$).

Gyrfalcon eyries with the prominent overhang mentioned by Cade (1960) were not the rule on the Yukon North Slope; over two-thirds of the sites were without a well developed projection over the nest. Consequently, whether a nest was drifted in was dependent on the prevailing winds and storms of a given winter. Gyrfalcons may visit several nest sites, but select only those open enough to allow the courtship displays that occur on the nest ledge.

What are the advantages to Gyrfalcons of remaining on the breeding grounds for an arctic winter? By being first at the nest site in the spring, Gyrfalcons have an advantage over the

TABLE 4—Nesting results from 29 Gyrfalcon eyries examined during January and February

Status in breeding season	Snow condition in winter		Total
	Snow-free	Snow-filled	
Produced eggs or young	7	3	10
No activity	7	12	19
Total	14	15	29

four other cliff-nesting raptors in nest-site selection. The existence of competition for nest sites is demonstrated by the facts that Gyrfalcons generally use nests constructed by the other cliff-nesting raptors and ravens, and that sites known to have been used by Gyrfalcons have later been used by Peregrine Falcons, Ravens, and Rough-legged Hawks (Platt 1975).

Another advantage enjoyed by Gyrfalcons, and apparently not by migratory raptors, is the availability of sufficient time for renesting if eggs are lost in the early stages of incubation. Such Gyrfalcon renesting is known to have occurred twice on the study area.

The survival of any raptor wintering on the study area would be dependent on its ability to kill ptarmigan consistently. Gyrfalcons are well adapted to this prey, but young Gyrfalcons may lack the hunting efficiency required for winter conditions. Bird and Bird (1941) and Manniche (1910) report that lemmings made up the vast majority of stomach contents found in juvenile Gyrfalcons in Greenland. The observed presence of adults and absence of juveniles is probably in response to there being a benefit for the adults to remain (nest-site selection and early breeding) and a cost to the young to remain (more difficulty in obtaining food in the less diverse arctic environment).

Each winter Gyrfalcons are recorded throughout southern Canada and the northern tier of the United States. These birds are seldom aged or sexed; for example, Buckley (1972) lists 59 sightings of which only two were aged and none were sexed. Competent falconers and hawk banders, however, often age and sex observed Gyrfalcons. Table 5 lists 31 sightings which have been aged. Twenty-four were juveniles and seven were adults. One of the 'adults' was trapped and found to be in its second year (Burr 1975) and, therefore, at least two years away from breeding age (from my personal observations of captive breeding pairs). This sample suggests that most Gyrfalcons moving south are non-breeders—juveniles and sub-adults.

Of the 26 birds listed in Table 5 that were sexed, 20 were females and 6 were males. Identification as to sex is based on size and wing-beat rate. I believe that observers are likely to sex incorrectly more males than females; such a bias could produce the reported sex-ratio imbalance. But evidence supporting the existence of sex-ratio imbalance in migrant Gyrfalcons comes from examination of the sex ratio of the falcons trapped (Ligon 1968; Sutton 1974; Burr 1975); five were females and only one was a male. Also, unequal sex ratios in the American Kestrel (*Falco sparverius*) on wintering grounds have been documented by Platt (1971), Mills (1975), and others.

Figure 1 attempts to put the winter data into a 12-month perspective, based on nesting data for three years. Egg-laying requires 8 days and occurs between 5 and 30 April; hatching takes place 35 days later, i.e., from late May to early June. After fledging, which occurs between mid-July and early August, the young remain as a family group into September. T. W. Barry (personal communication) has repeatedly sighted groups of two and three juvenile Gyrfalcons at his station on the Anderson River, Northwest Territories (69° N) in early September. Three juvenile Gyrfalcons were seen at Komakuk Beach, Yukon Territory (69° 35′ N) on 10 September 1973 (A. N. Wiseley, personal communication), and two lone juveniles, as well as adults, were seen in my study area in late October 1975 (W. R. Koski, personal communication).

As the weather worsens and the diversity of prey lessens, I believe that the juvenile falcons move south, but that the adults, both male and female, remain in the nesting area. The January investigations revealed large amounts of excrement at roost sites, which suggests that falcons were present at nest cliffs in December.

The surveys recorded an apparent change in the sex ratios during the winter—females were less numerous than males in January, but almost as common in February. It is known that males are more involved than females in territorial defence (Platt 1975) and one would expect males to have a greater affinity to nest sites than females. The appearance of females corresponded to the discovery of paired Gyrfalcons; this suggests that females may not attend (or be tolerated at) nest sites until the onset of courtship. I suggest that the females winter in arctic regions but may avoid competition by localizing away from nest sites.

February observations found pairs at nest cliffs. The forming of a scrape at the eyrie probably precedes copulation, as in other fal-

TABLE 5—Ages of Gyrfalcons sighted in winter (Oct.–Mar.) in southern Canada and the United States. Sources listed without dates are personal communications

Age	Sex	Date	Location	Source
Juvenile	Female	3 Nov. 1971	N.W. Illinois	Burr 1975
Juvenile	Female	4 Oct. 1966	N.E. Illinois	Burr 1975
2nd year	Female	7 Jan. 1973	Central Illinois	Burr 1975
Juvenile	Male	12 Oct. 1973	N. Illinois	Burr 1975
Juvenile	Male	6 Nov. 1973	N.W. Minnesota	D. Evans
Juvenile	Female	2 Nov. 1974	N.W. Minnesota	D. Evans
Juvenile	Female	26 Feb. 1968	Southern Idaho	Ligon 1968
Juvenile	Female	Dec. 1973	Western Idaho	M. Nelson
Juvenile	Female	Winter 1974	Western Idaho	M. Nelson
Juvenile	Female	15 Oct. 1970	Southern Idaho	T. N. Smith
Juvenile	Male	25 Oct. 1970	Southern Idaho	T. N. Smith
Juvenile	?	25 Oct. 1970	Southern Idaho	T. N. Smith
Juvenile	?	Oct. 1970	Southern Idaho	T. N. Smith
Juvenile	Male	Feb. 1972	S.E. Idaho	T. N. Smith
Juvenile	Female	Nov. 1974	S.W. Idaho	T. N. Smith
Juvenile	Female	Mar. 1975	S.E. Idaho	T. N. Smith
Juvenile	Female	Winter 1972	New Jersey	American Birds 1972
Juvenile	?	9 Dec. 1967	Southern Alberta	CFNS*
Juvenile	?	22 Feb. 1968	Southern Alberta	CFNS*
Juvenile	Female	Dec. 1969	Southern Alberta	R. Rafuse
Juvenile	Female	Feb. 1970	Central Alberta	R. Rafuse
Juvenile	Male	Dec. 1971	Central Saskatchewan	R. Rafuse
Juvenile	Female	Dec. 1971	Central Saskatchewan	R. Rafuse
Juvenile	Male	Nov. 1972	E.Central Saskatchewan	R. Rafuse
Juvenile	Female	12 Jan. 1974	Oklahoma	Sutton 1974
Adult	Female	5 Nov. 1967	Southern Alberta	J. Campbell
Adult	Female	Sept. 1972	Southern Alberta	R. Rafuse
Adult	Female	Mar. 1973	Central Alberta	R. Rafuse
Adult	Female	Mar. 1974	Central Saskatchewan	R. Rafuse
Adult	Female	Mar. 1974	S.E. Idaho	T. N. Smith
Adult	?	Feb. 1972	New Jersey	American Birds 1972

* Calgary Field Naturalist's Society.

cons. No scrapes were found in late February, but copulation and scrape formation were observed in late March.

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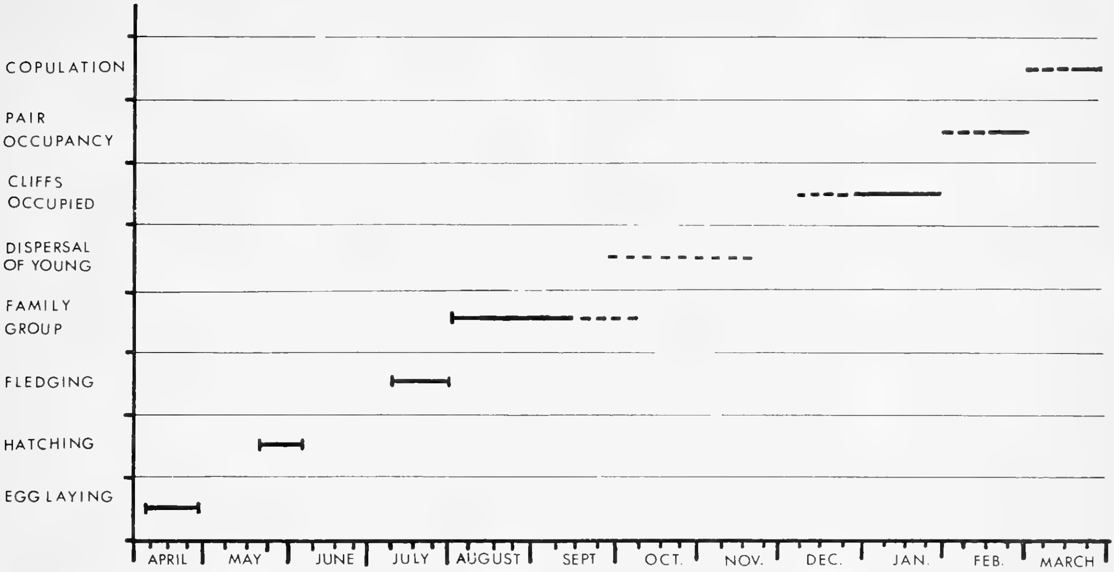

FIGURE 1. A proposed activity pattern for breeding Gyrfalcons on the Yukon Territory North Slope.

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Literature Cited

Beebe, F. L. 1974. Field studies of the Falconiformes of British Columbia, British Columbia Provincial Museum, Occasional Papers Series, Number 17. 163 pp.

Bird, G. G. and **E. G. Bird.** 1941. Birds of northeast Greenland. Ibis 83: 118–161.

Buckley, P.A. 1972. The changing seasons. American Birds 26: 568–574.

Burr, B. M. 1975. Status of the Gyrfalcon in Illinois. Wilson Bulletin 87: 280–281.

Cade, T. J. 1960. The ecology of the Peregrine and Gyrfalcon populations in Alaska. University of California Publications in Zoology 63: 151–290.

Godfrey, W. E. 1966. The birds of Canada. National Museum of Canada Bulletin 203. 428 pp.

Irving, L. 1960. Birds of Anaktuvuk Pass, Kobuk, and Old Crow. United States National Museum Bulletin 217. 409 pp.

Ligon, J. D. 1968. First record of the Gyrfalcon in Idaho. Condor 70: 397.

Manniche, A. L. V. 1910. The terrestrial mammals and birds of northeast Greenland. Meddelelser om Grönland 45: 1–100.

Mills, G. S. 1975. A winter population study of the American Kestrel in central Ohio. Wilson Bulletin 87: 241–247.

Platt, J. B. 1971. A survey of nesting hawks, eagles, falcons and owls in Curlew Valley, Utah. Great Basin Naturalist 21: 51–65.

Platt, J.B. 1975. A study of diurnal raptors that nest on the Yukon North Slope with special emphasis on the behaviour of Gyrfalcons during experimental overflights by aircraft. Volume 30. Chapter II. Arctic Gas Biological Report Series.

Roseneau, D. B. 1972. Summer distribution, numbers and food habits of the Gyrfalcon on the Seward Peninsula, Alaska. M.Sc. thesis, University of Alaska, Fairbanks. 124 pp.

Sheldon, C. 1909. List of birds observed on the upper Toklat River near Mt. McKinley, Alaska 1907–1908. Auk 26: 66–70.

Salomonsen, F. 1951. Gronlands Fugle. Volume 3. Copenhagen.

Sutton, G. M. 1960. Review of ecology of the peregrine and gyrfalcon populations in Alaska. Science (Washington) 132: 1832–1833.

Sutton, G. M. 1974. A check-list of Oklahoma birds. Stovall Museum of Science and History, University of Oklahoma, Norman. p. 11.

White, C. M. and **T. J. Cade.** 1971. Cliff nesting raptors and ravens along the Colville River in arctic Alaska. Living Bird 10: 107–150.

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Pollutant Effects on the Reproduction of the Prairie Falcons and Merlins of the Canadian Prairies

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Abstract. Studies of the pollution ecology of the Prairie Falcon (*Falco mexicanus*) and the Richardson's Merlin (*Falco columbarius richardsonii*) carried out by the Canadian Wildlife Service in Alberta and adjacent regions of western Canada have shown that both species have been stressed by residues of *p,p′*-DDE accumulated from food webs. Reproduction of the more contaminated members of both populations was significantly decreased. Changes in nest defense behavior of Merlins were significantly associated with decreasing shell-thickness index and increasing levels of DDE and possibly of PCB; more contaminated individuals were less aggressive in defending territories. DDE levels in the eggs associated with decreases in productivity were approximately 10 ppm dry weight (2 ppm wet weight) in Prairie Falcon eggs and 30 ppm dry weight (6 ppm wet weight) in Merlin eggs. Effects of current levels of PCB, dieldrin, heptachlor epoxide, and mercury on the reproduction of these populations could not be demonstrated; mean concentrations of these pollutants in eggs appeared to be below threshold levels. Pollutant levels in addled eggs and in eggs containing dead embryos were not significantly different from those in viable eggs.

Over the past three decades a wide variety of chemical biocides has been applied to agricultural lands of the prairie provinces to control insect pests, to inhibit the growth of fungi attacking cereals, flax seed and seedlings, and to kill plants along right-of-ways and weeds on range and croplands. Simultaneously, changes in land use practices have reduced habitat available for wildlife. Among the species affected by such changes in agricultural practice are the raptorial birds. In 1966 the Canadian Wildlife Service undertook a study of the population biology of Prairie Falcons, *Falco mexicanus* (Figure 1). Of territories known to have been occupied, 34% no longer contained breeding birds in 1968. Changes in the shell-thickness index (Ratcliffe 1967: weight of the dry shell/(length × breadth)) indicated a physiological abnormality in breeding females (Fyfe et al. 1969). In 1969 the study was expanded to include the Richardson's Merlin (*Falco columbarius richardsonii*) which breeds on the northern prairie, frequently occupying old nests of other birds in isolated clumps of trees. This paper reports on investigations carried out through 1973 of pollutant effects on the reproduction of these species in the Canadian prairies. The five pollutants examined, *p,p′*-DDE (DDE), dieldrin, heptachlor epoxide, polychlorinated biphenyls (PCB), and mercury, have become widespread environmental contaminants, not only in prairie ecosystems but elsewhere in the world.

Methods

Data recorded from each study site included number of eggs and/or young. Nest defense behavior of the adult was classified as "aggressive" if one or both adults made direct attacks on the intruding investigator, "moderate" if one or both adults were vocally aggressive, remaining in the immediate area but not attacking, "weak" if both adults left the immediate areas, and "absent" if both adults were absent at the time of the visit. Normally, one egg was collected from each clutch for shell-thickness index determination and for pollutant analysis. In cases of breeding failure, the remaining eggs were also collected. Egg contents were placed in aluminum foil containers, frozen, and shipped to the Ontario Research Foundation, Sheridan Park, Ontario, for analysis by L.M. Reynolds. Methods of analysis have been described elsewhere (Reynolds 1969; Vermeer and Reynolds 1970; Reynolds and Cooper 1975). The egg contents were classified according to the following categories: (1) fresh: no visible embryonic development, yolk intact, egg apparently not incubated; (2) live embryo: the approximate state of development to the nearest quarter was noted;

FIGURE 1. An adult Prairie Falcon banded as a nestling and photographed as a breeding adult in 1971 at a nesting cliff in southern Alberta. Photo by Richard Fyfe.

(3) dead embryo: age not determined; (4) dead embryo: the approximate stage of development by quarters; (5) addled: no apparent development, yolk usually not intact, egg usually had been incubated.

Data were analyzed by the one-way analysis of variance program of the Statistical Package for the Social Sciences (Nie et al. 1970) and by the nonparametric Kruskall-Wallis test (Sokal and Rohlf 1969; Siegel 1956; Conover 1971). A discussion of the parametric and nonparametric analysis of these data has been presented elsewhere (Jacobs, *in press*).

Among these data, the majority of the pollutant distributions could not be distinguished from lognormality; very few were normally distributed (Risebrough and Walker, *in press*). Geometric mean pollutant concentrations are therefore presented in the tables. The clutch rather than the individual egg was the sampling unit; when data from more than one egg per clutch were available, arithmetic means of thickness index and pollutant concentrations were calculated for the clutch values. Arithmetic means were calculated for thickness indices, since these data were normally distributed (Risebrough and Walker, *in press*). Ninety-five percent confidence intervals about the geometric means were calculated from the log-transformed data.

Results and Discussion

Productivity

A subsample of the data for each species was selected, derived from those nests from which one egg only had been collected, and which were subsequently visited to determine the number of young at times of fledging (Prairie Falcon, $N = 161$; Merlin, $N = 128$). These data were analyzed to determine whether the number of young successfully fledged was related to thickness index or to the concentrations of particular pollutants. The results are presented in Tables 1 and 2. The productivity of Prairie Falcons was found to be related to thickness index: the mean shell-thickness index of clutches that produced no young Prairie Falcons ($\bar{x} = 1.67 \pm 0.06$, $N = 43$) is lower than the mean of the clutches that produced four young ($\bar{x} = 1.78 \pm 0.04$, $N = 50$). Productivity decreases with thickness index; both analysis of variance (Anova) ($P = 0.007$) and the Kruskall-Wallis ($P = 0.02$) tests indicate that significant differences exist among the mean thickness indices of the productivity groups. The productivity of Merlins also varied with shell-thickness index; both Anova and the Kruskall-Wallis tests provide a probability of 0.04 for accepting the null hypothesis that the mean thickness indices are equivalent. The mean shell-thickness indices increase from clutches that produced no young ($\bar{x} = 1.05$) to mean values of 1.10, 1.12, 1.11, and 1.16 for clutches that produced two, three, four, and five young, respectively. Previous studies of Prairie Falcons (Fyfe et al. 1969; Enderson and Berger 1970) and Merlins (Fox 1971; Newton 1973) have also reported an association between lower productivity and decreases in shell-thickness index.

Elsewhere we have shown from these data that shell-thickness index is closely dependent upon DDE concentrations and that DDE explains most of the increase in variance of the shell-thickness index (Fyfe, Risebrough, and Walker, unpublished data). Among Prairie Falcon nestings grouped by productivity, the eggs of pairs producing no young had the highest mean DDE concentration ($N = 43$, $\bar{x} = 12.3$ ppm dry weight). Mean DDE concentrations decreased progressively from 11.4, 10.3, 8.3, to 7.2 ppm among the groups that produced one, two, three, and four young, respectively. The differences were found, however, not to be significant by either Anova ($P = 0.07$) or the Kruskall-Wallis test ($P = 0.14$), probably because of the large variation in DDE residue concentrations. Though the sample sizes are comparatively large, even larger samples might be necessary to demonstrate a statistical difference. Because of the significant relationships between thickness index and DDE concentrations, we consider that the changes in productivity associated with thickness index are caused ultimately by DDE.

DDE concentrations in the Merlin eggs were approximately four times as high as those in Prairie Falcon eggs. Merlin nests which were less productive were more contaminated by DDE than nests producing several young; the differences in mean DDE concentrations among the productivity groups are significant by both the Anova ($P = 0.003$) and the Kruskall-Wallis test ($P = 0.004$). Mean DDE concentrations in Merlin eggs from nests that produced three,

TABLE 1—Productivity of Prairie Falcons: dependence upon shell-thickness index and pollutant concentrations in eggs

			Pollutant concentrations, geometric means, ppm dry weight				
	Number in sample	Thickness index [a]	DDE [a]	PCB	Dieldrin	Heptachlor epoxide	Mercury
Numbers of young produced							
None	43	1.67 (1.61–1.73)	12.3 (9.2–16.3)	3.5	0.88	1.51	0.43
One	12	1.63 (1.50–1.76)	11.4 (5.7–23.1)	4.2	1.89	1.26	0.48
Two	15	1.65 (1.54–1.76)	10.3 (6.6–16.0)	3.3	0.76	1.06	0.28
Three	39	1.75 (1.70–1.81)	8.3 (6.3–11.0)	2.4	0.59	1.17	0.27
Four	50	1.78 (1.74–1.83)	7.2 (5.8–9.0)	2.5	0.81	1.29	0.37
Five	2	1.69 (0.22–3.15)	6.7 (0.9–54.1)	4.6	2.04	0.52	0.12
All clutches	161	1.72 (1.69–1.75)	9.2 (8.0-10.6)	2.9	0.82	1.27	0.35
F,		3.35	2.07	0.93	1.76	0.79	1.44
P		0.007	0.073	0.46	0.13	0.56	0.21
Kruskall-Wallis test, *P*		0.023	0.14	0.51	0.16	0.40	0.30

[a] 95% confidence intervals.

four, or five young are approximately twice as high as the mean DDE concentrations in Prairie Falcon eggs from nests that produced no young. These data suggest that productivity of Prairie Falcons is more sensitive to DDE than is the productivity of Merlins.

The mean level of DDE concentrations in eggs of this Prairie Falcon population, 9.2 ppm dry weight or approximately 2 ppm wet weight, is therefore associated with a decrease in productivity among the more severely contaminated members of the population. DDE levels at which productivity is affected are in the order of 10 ppm dry weight: nest sites producing three or more young had mean concentrations below this value and nest sites producing two or fewer had mean concentrations greater than 10 ppm. The corresponding value of shell-thickness index is approximately 1.72, which represents a reduction of 11% below the pre-1945 mean index.

No relationship was found between productivity of Prairie Falcons and concentrations of PCB; mean concentration was 2.9 ppm dry weight. Significant differences, however, were found among the Merlin productivity groups: clutches that produced three young had significantly less PCB than the clutches that produced none. Because of a high correlation between the concentrations of DDE and PCB in the Merlin smple (ln PCB vs. ln DDE, $r = 0.46$, $P<0.001$, $N = 167$) it is not possible to separate the effects of DDE and PCB upon productivity.

TABLE 2—Productivity of Merlins: dependence upon shell-thickness index and pollutant concentrations in eggs

			Pollutant concentrations, geometric means, ppm dry weight				
	Number in sample	Thickness index[a]	DDE[a]	PCB[a]	Dieldrin	Heptachlor epoxide	Mercury
Numbers of young produced							
None	46	1.05 (1.02–1.08)	55.5 (41.3–74.7)	6.9 (5.6–8.4)	2.12	1.66	0.64
One	8	1.06 (0.96–1.15)	57.3 (21.5–152.6)	6.2 (4.2–9.4)	1.83	1.09	0.87
Two	14	1.10 (1.04–1.15)	32.0 (21.0–48.9)	5.6 (4.1–7.7)	1.88	2.16	0.62
Three	22	1.12 (1.08–1.17)	24.2 (16.6–35.4)	3.7 (2.9–4.7)	1.48	1.87	0.71
Four	36	1.11 (1.08–1.15)	27.8 (20.4–37.8)	4.8 (4.0–6.0)	1.59	1.87	0.61
Five	2	1.16 (0.78–1.54)	25.9 (5.1–131.0)	3.6 (0.4–31.0)	0.52	0.86	0.86
All clutches	128	1.09 (1.07–1.11)	37.0 (31.2–43.6)	5.4 (4.8–6.0)	1.76	1.74	0.66
F,		2.47	3.81	3.51	1.0	1.0	0.23
P		0.036	0.003	0.005	0.42	0.42	0.95
Kruskall-Wallis test, *P*		0.039	0.004	0.003	0.404	0.285	0.97

[a] 95% confidence intervals.

Mean PCB concentration in clutches grouped by productivity was 5.4 ppm dry weight.

Geometric mean dieldrin level in the combined productivity groups of Prairie Falcon clutch samples was 0.82 ppm dry weight. In the Merlin eggs the mean concentration was 1.76 ppm dry weight. These values are below the level of 1 ppm wet weight, or approximately 5 ppm dry weight of dieldrin, which appears to be the threshold above which productivity was found to decline in Golden Eagles (*Aquila chrysaetos*) in west Scotland (Lockie et al. 1969).

Analysis of the brains of two young Prairie Falcons found dead in a nest in 1968 revealed concentrations of 5 ppm wet weight of heptachlor epoxide. This was considered to represent a lethal level (Fyfe et al. 1969). Concentrations of heptachlor epoxide of this magnitude were not found in the eggs sampled. Mean concentrations in the Prairie Falcon and Merlin eggs were 1.3 and 1.7 ppm, respectively; these levels do not appear to be associated with a decrease in productivity. The sample, however, is biased towards those birds that did breed and lay eggs and does not include non-breeding birds nor those which may have been directly poisoned by heptachlor or dieldrin, among the more acutely toxic of the organochlorine insecticides which have been used in the prairie provinces.

Mean concentrations of mercury expressed as total mercury, dry weight, were 0.35 and 0.66 ppm in the Prairie Falcon and Merlin eggs, respectively. These concentrations could not be associated with a decrease in productivity at the population level (Tables 1 and 2). Previous studies (Fimreite et al. 1970) have demonstrated that mercury residues incorporated into local food webs result from the use of mercury compounds in seed dressings in Alberta. In 1968 a pair of Prairie Falcons known to be feeding in part upon Ring-necked Pheasants (*Phasianus colchicus*) failed to hatch eggs with mercury levels ranging from 0.9 to 1.7 ppm wet weight. Concentrations of this magnitude have been shown to affect the hatchability of pheasant eggs (Borg et al. 1969; Fimreite 1971). Thus it is possible that the productivity of individual pairs was affected by mercury in agricultural areas where mercury compounds were used as seed dressing. Mercury levels in these populations of Prairie Falcons and Merlins have declined in recent years as a result of restrictions on this use of mercury (Fyfe, Risebrough, and Walker, unpublished data).

Territory Defense

Nest defense behavior at 136 of the Prairie Falcon nestings was recorded as weak ($N = 44$), moderate ($N = 27$), or aggressive ($N = 65$). Observations at the remaining nestings did not permit assignment of territory defense to any of these categories. No significant differences in mean thickness indices or pollutant concentrations were found among these classes ($P > 0.05$; Table 3).

Observations at 112 of the Merlin nestings permitted classification of territory defense into these categories: aggressive ($N = 55$), moderate ($N = 21$), weak ($N = 27$), and adults absent ($N = 9$) (Table 4). Mean shell-thickness index is highest in the "aggressive" category, lowest in the "adults absent" category; the differences among the four categories are significant ($P < 0.005$). Similarly, DDE conentrations are highest in the "adults absent" category, lowest in the "aggressive" category; differences among the means are also significant ($P = 0.05$).

A PCB-related effect upon nest defense behavior is also suggested among the Merlins (Anova, $P = 0.11$; Kruskall-Wallis, $P = 0.056$). This apparent effect may result, however, from the correlation between DDE and PCB concentrations, as discussed previously.

Merlin populations with mean DDE concentrations in eggs of approximately 40 ppm dry weight (approximately 8 ppm wet weight) can therefore be expected to show behavioral abnormalities among the more contaminated individuals. If the other pollutants examined affect this behavioral trait, the threshold levels would be higher than the mean concentrations found in this sample (Table 4).

The present samples of Prairie Falcon and Merlin eggs are biased in that they represent only those individuals which undertook courtship behavior, formed pair bonds, constructed nests, and laid eggs. Not included in the present sample would be those members of a population that did not breed because of behavioral abnormalities. A study of the Sparrowhawk (*Accipiter nisus*) in southern Scotland during 1971 through 1973, and from which data from 325 nests were obtained, showed that the principal cause of unsuccessful breeding was a failure to lay eggs by pairs that had built a nest. This was found to occur at 15% of the nests, and accounted for 43% of all complete failures (Newton and Bogan 1974). The arithmetic mean organochlorine concentrations in the lipid of 131 Sparrowhawk clutches were 148 ppm DDE, 66 ppm PCB, and 26 ppm dieldrin, lipid basis (approximately 43 ppm DDE, 19 ppm PCB, and 7.5 ppm dieldrin on a dry weight basis, assuming a mean lipid content of 6% and a mean moisture content of 80%). Examination of the Prairie Falcon and Merlin data indicated that arithmetic means of these data are higher than the geometric means by about 1.9 (DDE), 1.3 (PCB), and 1.7 (dieldrin). The Scottish Sparrowhawks appear, therefore, to be more contaminated with PCB and dieldrin than are the Canadian Merlins, but to have lower DDE levels. The failure to lay eggs was not associated with any of the pollutants detected.

Embryonic Mortality and Nonviable Eggs

The egg samples of each species were further examined by separation into four categories: (1)

TABLE 3—Territory defense by Prairie Falcons: association with shell-thickness index and pollutant concentration in eggs

			Pollutant concentrations, geometric means, ppm dry weight				
Defense	Number in sample	Thickness index[a]	DDE	PCB	Dieldrin	Heptachlor epoxide	Mercury
Weak	44	1.68	10.2	2.7	0.87	1.6	0.48
Moderate	27	1.73	9.0	3.5	0.75	1.5	0.42
Aggressive	65	1.72	10.0	2.8	0.78	1.7	0.46
All clutches	136	1.71	9.8	2.9	0.80	1.6	0.46
F,		0.97	0.16	0.50	0.17	0.26	0.11
P		0.38	0.85	0.61	0.84	0.77	0.90
Kruskall-Wallis test, *P*		0.38	0.83	0.26	0.97	0.82	0.75

[a] Arithmetic means.

TABLE 4—Territory defense by Merlins: association with shell-thickness index and pollutant concentrations in eggs

			Pollutant concentrations, geometric means, ppm dry weight				
Defense	Number in sample	Thickness index[a]	DDE[b]	PCB	Dieldrin	Heptachlor epoxide	Mercury
Adults absent	9	1.00 (0.92–1.08)	75.9 (25.0–230.2)	7.8	2.1	2.0	0.66
Weak	27	1.05 (1.01–1.10)	47.8 (33.2–68.9)	5.4	2.0	1.6	0.92
Moderate	21	1.04 (1.00–1.09)	46.2 (30.0–71.1)	6.6	1.8	1.6	0.98
Aggressive	55	1.12 (1.10–1.15)	30.6 (23.3–40.3)	4.8	1.3	1.6	0.79
Total	112	1.08 (1.06–1.10)	39.6 (23.6–48.2)	5.5	1.6	1.6	0.84
F,		7.15	2.85	2.05	1.15	0.20	0.74
P		0.005	0.041	0.11	0.33	0.90	0.53
Kruskall-Wallis test, *P*		0.001	0.048	0.056	0.26	0.98	0.56

[a] Arithmetic means and 95% confidence intervals.

[b] 95% confidence intervals.

eggs that were fresh when collected, with an intact yolk, no apparent embryonic development, and that apparently had not been incubated; (2) eggs that contained a living embryo; (3) eggs that contained a dead embryo; and (4) eggs that were addled, showing no apparent sign of development, and that had apparently been incubated. Some of the addled eggs, however, most likely contained small dead embryos which had decomposed so as to be no longer visible. Neither the parametric nor nonparametric tests showed any differences in thickness index or pollutant concentrations (Tables 5 and 6), except that the Anova test rejects the hypothesis of equivalent PCB distributions in the Prairie Falcon egg samples ($P = 0.004$). The respective variances, however, were not homogeneous (Jacobs, *in press*), and the nonparametric test does not reject the hypothesis ($P = 0.11$). Thus, the thickness indices and pollutant concentrations in addled eggs and eggs containing dead embryos could not be shown to be different from those in fresh eggs and in eggs containing live embryos.

Embryonic mortality has, however, been implicated in the reproductive failures of other species. Six eggs of the White-tailed Eagle (*Haliaeetus albicilla*) obtained in 1969, 1970, and 1971, in Schleswig-Holstein, West Germany, in which embryos had died, contained geometric mean values, wet weight, of 6.7 ppm DDE, 24 ppm PCB, 0.20 ppm dieldrin, and 0.33 ppm mercury (Koeman et al. 1972). The DDE values are comparable to those of the Merlins reported here; PCB concentrations, however, are considerably higher and may therefore be related to the observed mortality. Dieldrin concentrations in eggs of the White-tailed Eagles were slightly above those recorded in the Prairie Falcons but below those in the Merlins.

In the study of Scottish Sparrowhawks (Newton and Bogan 1974) embryonic death ac-

TABLE 5—Embryonic mortality and addled eggs of Prairie Falcons: association with shell-thickness index and pollutant concentrations in eggs

			Pollutant concentrations, geometric means, ppm dry weight				
Group	Number in sample	Thickness index[a]	DDE	PCB	Dieldrin	Heptachlor epoxide	Mercury
Addled	40	1.71	8.5	1.8	0.88	1.37	0.37
Fresh	19	1.77	12.3	4.6	0.96	0.97	0.26
Live embryo	96	1.72	9.4	3.4	0.79	1.53	0.44
Dead embryo	27	1.72	9.4	3.4	0.55	1.15	0.28
Total	182	1.72	9.4	3.0	0.78	1.36	0.38
F,		0.61	0.93	4.6	1.0	1.4	2.0
p		0.61	0.43	0.004	0.39	0.25	0.11
Kruskall-Wallis test, *p*		0.47	0.43	0.11	0.44	0.32	0.037

[a] Arithmetic mean.

TABLE 6—Embryonic mortality and addled eggs of Merlins: association with shell-thickness index and pollutant concentrations in eggs

			Pollutant concentrations, geometric means, ppm dry weight				
Group	Number in sample	Thickness index[a]	DDE	PCB	Dieldrin	Heptachlor epoxide	Mercury
Addled	20	1.06	54.6	5.8	1.8	1.4	0.46
Fresh	35	1.07	42.4	5.7	2.1	1.8	0.59
Live embryo	88	1.09	36.8	5.3	1.6	1.8	0.80
Dead embryo	7	1.17	25.7	5.1	1.3	1.7	0.62
Total	150	1.09	39.4	5.5	1.7	1.7	0.68
F,		2.3	1.2	0.16	0.82	0.49	2.1
P		0.08	0.31	0.92	0.48	0.69	0.11
Kruskall-Wallis test, *P*		0.06	0.27	0.69	0.44	0.59	0.09

[a] Arithmetic mean.

counted for 11% of all failures. This was less important than failure to lay (43% of all complete failures), egg breakage (31%), and nest desertion (15%). The clutches involved did not have the thinnest shells but had the highest organochlorine levels. As discussed above, DDE levels in the Sparrowhawk study were somewhat lower than those in the Merlins but levels of both PCB and dieldrin were higher.

In summary, the data indicate that the populations of both Prairie Falcons and Merlins on the Canadian prairies are stressed by DDE; the more contaminated clutches of both species produced fewer young. Critical levels appear to be approximately 10 ppm and 30 ppm, dry weight, in the Prairie Falcons and Merlins, respectively.

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Literature Cited

Borg, K., H. Wanntorp, K. Erne, and **E. Hanko.** 1969. Alkyl mercury poisoning in terrestrial Swedish wildlife. Viltrevy 6: 301–379.

Conover, W. J. 1971. Practical nonparametric statistics. John Wiley and Sons Inc., New York, 462 pp.

Enderson, J. H. and **D. D. Berger.** 1970. Pesticides: eggshell thinning and lowered production of young in Prairie Falcons. Bioscience 20: 355–356.

Fimreite, N. 1971. Effects of dietary methylmercury on Ringnecked Pheasants. Canadian Wildlife Service, Occasional Paper Number 9.

Fimreite, N., R. W. Fyfe, and **J. A. Keith.** 1970. Mercury contamination of Canadian prairie seed eaters and their avian predators. Canadian Field-Naturalist 84: 269–276.

Fox, G. 1971. Recent changes in the reproductive success of the pigeon hawk. Journal of Wildlife Management 35: 122–128.

Fyfe, R. W., J. Campbell, B. Hayson, and **K. Hodson.** 1969. Regional population declines and organochlorine insecticides in Canadian Prairie Falcons. Canadian Field-Naturalist 83(3): 191–200.

Jacobs, S. A. An application of the Kruskall-Wallis test to pollutant data. *In* The statistics of pollution biology. Canadian Wildlife Service. *In press.*

Koeman, J. H., R. H. Hadderingh, and **M. F. I. J. Bijleveld.** 1972. Persistent pollutants in the White-tailed Eagle (*Haliaeetus albicilla*) in the Federal Republic of Germany. Biological Conservation 4: 373–377.

Lockie, J. D., D. A. Ratcliffe, and **R. Balharry.** 1969. Breeding success and organochlorine residues in Golden Eagles in West Scotland. Journal of Applied Ecology 6(3): 381–389.

Newton, I. 1973. Egg breakage and breeding failure in British Merlins. Bird Study 20(4): 241–244.

Newton, I. and **J. Bogan.** 1974. Organochlorine residues, eggshell thinning and hatching success in British Sparrowhawks. Nature (London) 249: 582–583.

Nie, N. H., D. H. Bent, and **C. H. Hull.** 1970. Statistical package for the social sciences. McGraw-Hill, New York. 343 pp.

Ratcliffe, D. A. 1967. Decrease in eggshell weight in certain birds of prey. Nature (London) 215: 208–210.

Reynolds, L. M. 1969. Polychlorobiphenyls (PCB's) and their interference with pesticide residue analysis. Bulletin of Environmental Contamination and Toxiciology 4: 128.

Reynolds, L. M. and **T. Cooper.** 1975. The analysis of organochlorine residues in fish. *In* Water quality parameters. American Society for Testing and Materials, Philadelphia. pp. 196–205.

Risebrough, R. W. and **W. Walker II.** Mathematical models of pollutant distributions. *In* The statistics of pollution biology. Canadian Wildlife Service. *In press.*

Siegel, S. 1966. Nonparametric statistics for the behavioral sciences. McGraw-Hill, New York. 312 pp.

Sokal, R. R. and **F. J. Rohlf.** 1969. Biometry. W. H. Freeman and Co., San Francisco. 776 pp.

Vermeer, K. and **L. M. Reynolds.** 1970. Organochlorine residues in aquatic birds in the Canadian Prairie Provinces. Canadian Field-Naturalist 84: 117–130.

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Notes

Directional Exposure of Golden Eagle Nests

Abstract. Data from Golden Eagle (*Aquila chrysaetos*) nest sites (Alaska, Montana, Utah, and Texas) suggest that developing eagle chicks may be quite sensitive to thermal stress. For 166 nest sites we have recorded latitude, elevation, and direction of exposure. The Alaskan population shows a significant directional preference to the southeast, while the Utah population shows an equal preference to the northwest. Montana nest sites have a significant orientation to the south and Texas nests show no significant orientation. We hypothesize that these differences in directional orientation are explainable on the basis of temperature-dependent nest-site selection by cliff-nesting Golden Eagles.

Direction of nest-site exposure has been suggested as a factor in nest-site selection by cliff-nesting birds, but there are few data to support this hypothesis (Brown and Amadon 1968). In a discussion of climatological problems associated with raptor nestling survival, M. Nelson asserted that young raptors can be killed by less than ½ h exposure to the direct rays of the sun between 10:00 a.m. and 5:00 p.m. on days with the ambient temperature above 32°C (Nelson 1965, p. 66). D. Ellis (personal communication), however, has indicated that his data do not support this assertion. That exposure to direct insolation and extremes of temperature during the early period of development is extremely stressful to most young raptors, indeed to all young birds, is generally accepted by students of raptor ecology. It is not, however, a universal problem. The Ferruginous Hawk, *Buteo regalis*, successfully rears young in the hot arid southwest in nests that normally have no shade except that provided by the adults (N. Woffinden, personal communication).

This paper is intended to deal only with direction of exposure of nest sites selected by Golden Eagles, *Aquila chrysaetos*.

The data for Golden Eagle populations from Utah and Alaska were collected by the authors between 1970 and 1974. Analysis of our data led us to solicit similar data for other Golden Eagle breeding populations. We thank Michael Lockhart for the Texas data and John Baglien for the Montana data.

Methods

We recorded latitude, elevation, and direction of exposure for each eagle nest without separating active, inactive, or supernumerary nests, on the assumption that if selection is involved the building of each nest represents a specific site selection. Latitude and elevation were taken from topographic maps. Direction of exposure was recorded by shading in the ⅛-pie sectors included between imaginary lines extending from the center of the nest cup to the face of the cliff on each side of the nest (see Figure 1). Shaded sectors were totalled and Cochran's Q-test applied to determine if the shaded sectors deviated from random (Sokal and Rohlf 1969).

The Montana data were not divided by direction of exposure to as fine an extent as for other areas and a two-way *chi*-square test was used by J. Baglien (personal communication) to analyze them.

We examined for a relationship between exposure and elevation, by regression analysis, within each of the areas (except Montana). Temperature data were taken from the appropriate 1972 volumes of Climatological Data for a weather station near the center of the areas described by the eagle nest distribution for the four populations.

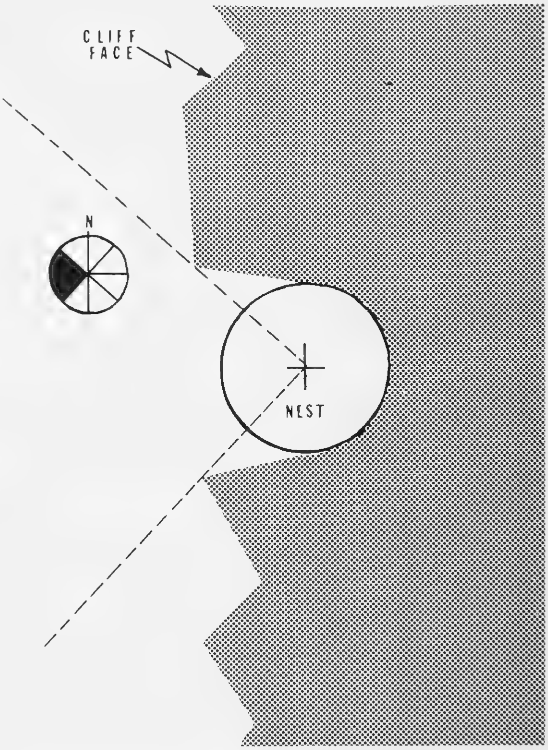

FIGURE 1. Diagram indicating the method to determine the direction of nest-site exposure.

Results and Discussion

The orientation of Golden Eagle nests in the four populations is shown in Figure 2. The Utah and Alaska data show statistically significant directional preferences ($\alpha = 0.01$). Utah nests are oriented NNW while Alaska nests are oriented SSE. Montana nests have a significant orientation to the south (J. Baglien, personal communication). McGahan (1968) reported 50% and 48% of occupied cliff nests that he checked in Montana were south-facing during 1963 and 1964, respectively. The Texas values suggest a slight northern preference but it is not significant. No statistically significant relationship was discerned between elevation and nest exposure within any of the localities.

Breeding season schedules and monthly temperature regimens are presented in Figure 3.

It appears that Golden Eagle young are susceptible to death by thermal stress during at least the first 6 weeks after hatching. It seems reasonable that nest sites which provide a microclimate within the range of temperature tolerance offer two distinct advantages. First, by avoiding extremes of temperature and insolation the young are protected from death caused by such exposure. Second, shading or brooding time required of the adults would be reduced, with a consequent increase in the time available for other

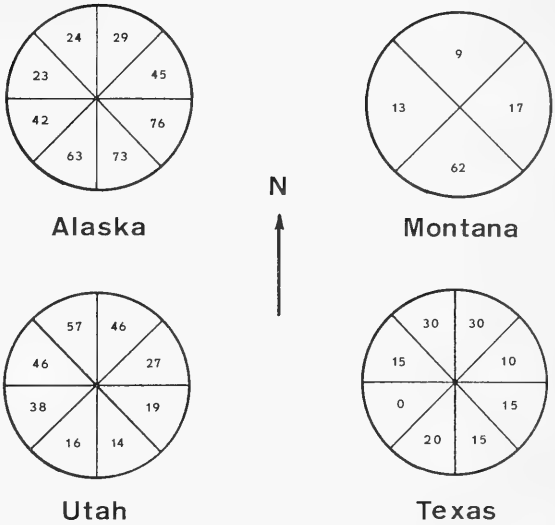

FIGURE 2. Orientation of Golden Eagle nests. Values are the percentage of nests which are exposed in each sector and (except for Montana) will total to more than 100%. Deviations from random are significant for Alaska, Montana, and Utah. Sample sizes are as follows: Alaska, 62; Montana, 47; Utah, 37; and Texas, 20.

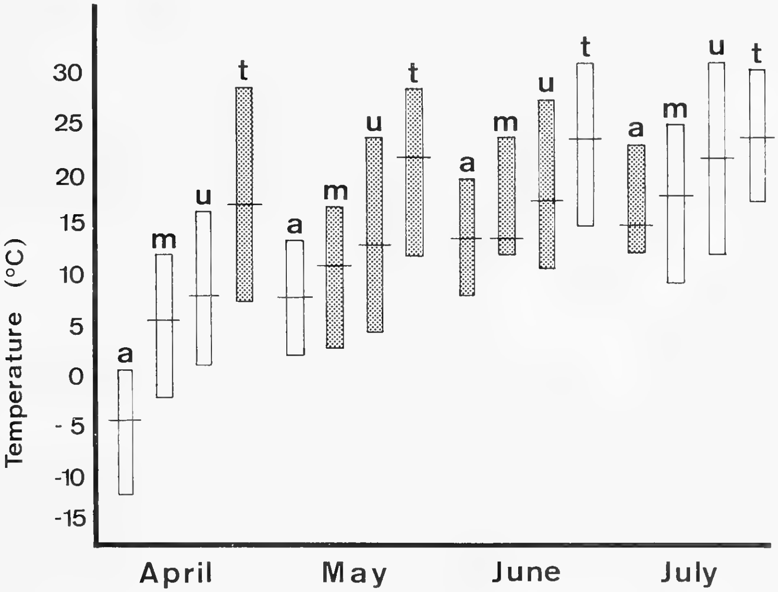

FIGURE 3. Monthly temperature regimes for four populations of nesting Golden Eagles as related to the thermoregulatory critical period for nestlings. Bars give monthly high and low averages for 1972. The cross line is the normal monthly average temperature. The shaded bars indicate the critical period for nestling eagles (3 to 6 weeks of age). Alaska, Montana, Utah, and Texas are designated by the appropriate initial.

activities critical to the successful rearing of young and for self-maintenance.

If this hypothesis is correct, we would expect to observe systematic changes in nest exposure correlated with changes in latitude and elevation which are both indicators of local temperature and insolation regimens. Our data, with some interpretation, support the hypothesis. Certainly the SSE exposure of the Alaskan nests suggests an avoidance of cold, while the reverse situation is demonstrated by the Utah data. The south-facing Montana nests may be accounted for by a combination of latitude and elevation (see Table 1). The Texas data appear to cloud the issue. M. Lockhart (personal communication), however, indicated two mitigating factors for Texas which may actually support our hypothesis. He noted that shading of young birds by the adults was very important to nest success and that suitable nesting sites were limited with respect to the prey base. Eagles seem to nest on any cliff in an area of prey abundance. It must also be noted that the sample size was small and there appeared to be a northward-facing tendency (non-significant) to the nest distribution.

TABLE 1—Nest elevations for four populations of Golden Eagles

Region (sample size)	Elevation (m) Range	Elevation (m) Average	Latitude[1]	Elevation adjusted to 65° N[2]
Alaska (62)	15–1342	827	65	827
Montana (47)	1678–2898		45	458–1678
Utah (37)	1495–2562	1891	40	366
Texas (20)	1403–2135	1638	35	192

[1] To the nearest 5°.
[2] On the basis of 1° latitude equals 61 m.

Figure 3 further demonstrates the importance of temperature regimen to nesting eagles. In a study of Montana eagles, D. Ellis (1973) observed that shading of the young was most important from about 3 to 6 weeks of age and that contour feathers begin to appear at about 2½ weeks of age. Based on these observations, we suggest that a thermoregulatory critical period for young eagles lies between 3 to 6 weeks of age. That is the period during which the young would be most susceptible to hyperthermia. The shaded bars of Figure 3 roughly indicate the time period for each of the four populations that encompass this critical period. Note especially the time shift in breeding season between Alaska and Texas and the similarity of temperatures during this critical period for all four areas. Breeding season dates were taken from Ellis (1973), Smith (1971), Bent (1937), and Mosher and White (unpublished data).

Eagles could also reduce the effects of warmer climates by building nests at higher elevations. Data in Table 1 suggest that this might happen. With the possible exception of Montana, however, the right-hand column of that table shows that compensation by movement to higher elevations is incomplete. Strict interpretation of such values is also confounded by the lack of data on available nest sites with respect to elevation.

A corollary hypothesis to our own is that in a given local population of nesting eagles, active nests with different exposure should require different amounts of brooding and/or shading by the adults. This could be field tested with relative ease. These data strongly indicate that more detailed and systematic work on nest-site selection by cliff-nesting birds would be valuable.

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Literature Cited

Bent, A. C. 1937. Life histories of North American birds of prey. Part 1. Smithsonian Institution, United States National Museum Bulletin 167. 409 pp.

Brown, L. H. and **D. Amadon.** 1968. Eagles, hawks and falcons of the world. McGraw-Hill Co., New York, New York.

Ellis, D. H. 1973. Behavior of the Golden Eagle: an ontogenic study. Ph.D. thesis, University of Montana, Missoula, Montana. 416 pp.

McGahan, J. 1968. Ecology of the Golden Eagle. Auk 85(1): 1–12.

Nelson, M. W. 1965. The status of the Peregrine Falcon in the Northwest. *In* Peregrine Falcon populations. *Edited by* J. J. Hickey. University of Wisconsin Press, Madison, Wisconsin. 596 pp.

Smith, D. G. 1971. Population dynamics, habitat selection, and partitioning of breeding raptors in the eastern Great Basin of Utah. Ph.D. thesis, Brigham Young University, Provo, Utah. 260 pp.

Sokal, R. R. and **F. J. Rohlf.** 1969. Biometry. W. H. Freeman and Co., San Francisco. 776 pp.

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Population and Reproductive Changes in Alaskan Arctic Peregrines

Abstract. During the summer of 1973, 14 pairs of Peregrine Falcons (*Falco peregrinus*) were located along the Colville River in northern Alaska. Nine young were fledged by four successful pairs, the poorest reproductive performance ever recorded for this population. If the present trends continue, the survival of the peregrine as a part of the North Slope avifauna appears unlikely.

Kessel and Cade (1958) and Cade (1960) first called attention to the widespread populations of Peregrine Falcons (*Falco peregrinus*) nesting along the Colville River in the northern foothills of the Brooks Range, Alaska. During the 1950s Cade counted as many as 36 pairs nesting along the Colville (White and Cade 1971). By 1971, however, the number of pairs had dropped to 25, the lowest number ever recorded for this population. Moreover, the reproductive success, which had reached new low values in 1969 and 1970, declined even further in 1971 (White and Cade 1971; Haugh 1970). A number of young were found dead, apparently from parental neglect, and addled eggs and eggshell fragments from 12 nests revealed a decrease in shell thickness of 31% below the pre-DDT era average (White and Cade 1971).

Alarmed by the decline of the peregrine in widespread areas of North America and Europe (Hickey 1969) and the rapid decline of the peregrine along the Tanana River in interior Alaska, I have attempted to continue monitoring changes in the peregrine population along the Colville and in other areas of Alaska to ascertain the status of this species. In 1973 I made two surveys of the Colville population along the same stretch of river surveyed by Cade in his previous investigations (White and Cade 1971).

Methods

The first of the 1973 surveys was conducted between 13 June and 3 July by floating down the Colville River in a rubber raft from the mouth of the Etivluk River to Ocean Point, a distance of 183 mi (295 km). (See White and Cade (1971) for a map of the area.) Active cliffs and nesting sites were located at this time, and the number of eggs was ascertained by climbing to the nest sites. The second survey was made between 22 and 25 July with the aid of an Alaska Department of Fish and Game pontoon-equipped aircraft. My method was to land the plane on the river near the active cliffs (located during the June survey) and then climb to the nest sites to determine reproductive success.

Results and Discussion

In the June survey 14 sites were found occupied by pairs of peregrines. In addition, one site was occupied and weakly defended by a single bird. Only 11 of 14 pairs had eggs at the time of my visit to the eyrie site; the other three pairs were either not nesting or had already failed in their nesting attempts. The 11 pairs of falcons produced a total of 32 eggs or 2.9 eggs per pair. At least five, and probably seven, pairs failed during the late incubation or early nesting period, and only four pairs are known to have produced young. The total of nine young produced on the river represents an average of only 0.64 young per starting pair.

Table 1 compares the 1973 nesting success of the Colville peregrines with nesting success along the same stretch of river in 1967, 1968, and 1971. The number of pairs occupying cliffs in 1973 represents a decline of approximately 50% since the late 1960s. Although the mean number of young per starting pair is slightly above that observed in 1971, the total number of young produced along the Colville River in 1973 represents the poorest reproductive performance recorded in this population in 12 years of observations over a 21-yr period. The mean of 2.91 eggs per active

TABLE 1—Nesting success of Colville Peregrine Falcons in 1967, 1968, 1971, and 1973. NA= Not available

Year	Number of starting pairs[1]	Number of active pairs[2]	Total eggs layed	Mean (± S.E.) number of eggs per active pair	Number of pairs with young	Total number of advanced young	Mean (± S.E.) number of advanced young per starting pair
1967[3]	27	24	54	2.28 (± 0.20)	18	34	1.26 (± 0.23)
1968[3]	32	23	63	2.74 (± 0.22)	15	34	1.06 (± 0.24)
1971[4]	25	19	57	3.0 (NA)	9	14	0.56 (NA)
1973	14	11	32	2.91 (± 0.33)	4	9	0.64 (± 0.32)

[1] Starting pairs = total number of pairs occupying territories at time of initial survey
[2] Active pairs = pairs still incubating eggs at time of initial survey
[3] Haugh, unpublished field notes
[4] Data from White and Cade 1971

pair in 1973 is somewhat greater than that observed in 1967 and 1968 but is similar to the values (approximately 2.9) reported by Cade for the 1950s (Cade 1960). The mean of 0.64 young per starting pair observed in 1973 is considerably less than the 1.4 young per pair in 25 nesting pairs examined by Cade during the 1950s. Since the falcons appear to be laying clutches of normal size, the poor reproductive performance apparently results from a decreased number of nesting pairs combined with a failure of eggs to hatch or young to survive to fledging. The post-laying failures may reflect abnormal behavior of the adult birds (see White and Cade 1971).

The rapid decline of adult birds in the early 1970s may result from the failure of young to replace adult mortality losses, perhaps because of the poor production of young in the population during the last several years. Cade et al. (1971) have shown that levels of organochlorine residues remain in Alaskan peregrines at levels known to have resulted in reproductive failure and population declines in other falcon populations (Peakall et al. 1975), and it seems likely that this could be an important factor in the poor reproductive performance among the Colville birds in recent years. Alternatively, the rapid decline observed during the early years of this decade may be partially a reflection of nesting failures and abandonment of cliffs early in the nesting period, prior to the surveys in June. If the latter is true, abnormal weather may have been an important factor. I observed in 1972 and 1973 that leafing out of vegetation along the middle Colville was approximately 3 weeks later than in 1967 and 1968. In 1972 and 1973 snow patches persisted on the cliffs well into early July, while in 1967 and 1968 snow disappeared from these areas by the middle of June.

Regardless of the cause, evidence is strong that the peregrine population along the Colville River has experienced a marked decline in recent years, both in reproductive success and number of breeding pairs. Moreover, surveys I have made during the last four years of 14 major rivers draining the Brooks Range area have indicated that no substantial number of peregrines nest in these drainages (Haugh, unpublished data). It appears as if Cade's earlier estimate of 200–250 pairs for the inland foothill tundra of the Arctic Slope of northern Alaska (Cade 1960) was much too high. I believe it unlikely that more than 100 pairs of peregrines have nested in the northern foothills of the Brooks Range in recent times, and with the current decline of the arctic peregrines, the number of pairs remaining in this region may be less than 50 and perhaps less than 25. The concern of White and Cade (1971) for the continued survival of the Peregrine Falcon as part of the North Slope avifauna would seem to be justified. The Colville peregrines should continue to be watched closely and all possible steps taken to avoid disturbance of the few remaining birds in this endangered population.

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Literature Cited

Cade, T. J. 1960. Ecology of the peregrine and gyrfalcon populations in Alaska. University of California Publications in Zoology 63(3): 151–290.

Cade, T. J., J. L. Lincer, C. M. White, D. G. Roseneau, and **L. G. Swartz.** 1971. DDE residues and eggshell changes in Alaskan falcons and hawks. Science (Washington) 172: 955–957.

Haugh, J. R. 1970. Northern Alaska. *In* The North American peregrine survey, 1970 *Edited by* T. J. Cade and R. Fyfe. Pp. 243–244. Canadian Field-Naturalist 84(3): 231–245.

Hickey, J. J., (*Editor*). 1969. Peregrine falcon populations: their biology and decline. University of Wisconsin Press, Madison.

Kessel, B. and **T. J. Cade.** 1958. Birds of the Colville River, Northern Alaska. University of Alaska, Biological Papers, Number 2. 83 pp.

Peakall, D. B., T. J. Cade, C. M. White, and **J. R. Haugh.** 1975. Organochlorine residues in Alaskan peregrines. Pesticides Monitoring Journal. (*In press.*)

White, C. M. and **T. J. Cade.** 1971. Cliff-nesting raptors and ravens along the Colville River in Arctic Alaska. Living Bird 10: 107–150.

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Elevated Heptachlor Epoxide and DDE Residues in a Merlin That Died after Migrating

Merlin (*Falco columbarius richardsonii*) population laying thin-shelled eggs, exhibiting below-normal productivity, and showing declines in numbers have been documented in recent years. Risebrough et al. (1970) reported that adult Merlins migrating through Wisconsin contained levels of DDE (139–704 ppm) in the lipid fraction of a fat sample (fat biopsy) that were comparable to those in several Peregrine Falcon (*Falco peregrinus*) populations. Fimreite et al. (1970) pointed out that bird-eating falcons (including the Merlin) and accipiters in the Canadian prairie provinces were also frequently found with elevated mercury levels in their eggs. The authors of both papers concluded that levels of contamination by both the organochlorines and mercury were such that reproductive abnormalities could be expected. Fox (1971) studied eggshell weight and reproductive success of the Merlin in the grasslands of the Great Plains and eastern Canada, and indeed found such abnormalities. Eggshells had decreased 23% in weight since 1950, and this was accompanied by decreases of 43 and 33% in hatching success, respectively, in the two areas; by decreases of 32 and 37% in young of any age per nest; and by decreases in numbers of Merlins observed at major fall-migration concentration points.

A banded adult male Merlin found dead (fresh) on 24 October 1974 at a ranch about 25 km southeast of Portales, New Mexico (34° 10′ N, 102° 50′ W) was immediately frozen and, with the above information in mind, stored for analysis at the Denver Wildlife Research Center. A subsequent band recovery report showed the Merlin was banded as an after-second-year (ASY) male on 25 June 1970 (by RWF) about 10 km southeast of Hanna, Alberta (51° 30′ N, 111° 40′ W) and, therefore, was at least 7 years old at the time of death.

Analysis Methodology

Samples of homogenized carcass, whole brain, and breast muscle section were extracted with 20% (v/v) acetone in iso-octane for residue and lipid measurements by the procedure of Peterson et al. (1976). An aliquot of the extraction solution was partitioned with water to remove the acetone. The isolated iso-octane layer was then placed over a pre-wet 5-g column of Florisil that had been activated at 130°C for 24 or more hours. To separate PCBs and DDE from other possible chlorinated hydrocarbons, two eluants were used. The first was 55 ml of *n*-hexane and the second was 100 ml of 6% (v/v) ethyl ether in *n*-hexane.

The eluates were separately collected in Kuderna-Danish flasks, then equipped with three-ball Snyder columns, and the solutions were concentrated over a steam bath. Residue measurements were made by electron-capture detection gas chromatographs employing two unlike columns (3% OV-1, 5% QF-1) for qualitative confirmation.

Recoveries of insecticides ranged from 60 to 90%, with lindane being the lowest, heptachlor epoxide, DDT, and metabolites 90%, while dieldrin and endrin averaged 80%. Polychlorinated biphenyl (Aroclors 1254, 1260) recoveries averaged 80%. No corrections for these recoveries was made for the reported residues.

Results and Discussion

The dead adult Merlin may have just completed a 2000-km fall migration, since Merlins from adjacent Arizona wintering areas are principally reported from late September through April (Phillips et al. 1964). No fat was observed on the emaciated carcass after it was skinned; possibly the fat reserves were used during migration. The lipid content of the skinned carcass was only 1.6%. We do not know the normal lipid content of the carcass of wild Merlins but data are available for wintering kestrels, which belong to the same genus. American Kestrels (*Falco sparverius*) trapped and killed on 10 January 1975 in Denver, Colorado contained 12.2% lipid (mean of three males) and 14.4% lipid (one female) (Henny, unpublished data). The residue levels (wet weight) of both DDE (178 ppm) and heptachlor epoxide (9.6 ppm) in the brain of the dead Merlin were high (Table 1).

DDE, dieldrin, and heptachlor epoxide have been identified in egg samples of Merlins and Prairie Falcons (*Falco mexicanus*) and in their principal prey species on the breeding grounds in Alberta (Fyfe et al. 1969). Since DDT has not been widely used in this region, it would appear that these residues originated in the prey species on the birds' wintering grounds or along their migration routes. In addition, Merlins may have obtained some DDT on their wintering areas. In contrast, dieldrin and heptachlor have a long history of use for seed treatment against wireworm (Coleoptera, Elateridae) in the Canadian prairie provinces where the Merlins breed. Field sampling of grassland birds in treated and untreated areas of Alberta and Saskatchewan has shown a direct correlation between seed treatment and elevated levels of heptachlor epoxide and dieldrin (Fyfe, unpublished data). Since Merlins feed largely on seed-eating grassland birds in the Canadian prairies, this would explain the elevated level of dieldrin and heptachlor epoxide in their eggs and tissues.

Stickel et al. (1970) reported residues of DDE (wet weight) in the brains of Brown-headed Cowbirds (*Molothrus ater*) that died in captivity. They found 314 ppm or higher in 95% of the brain samples. Porter and Wiemeyer (1972) reported two of 14 male American Kestrels died after 14 and 16 months on a diet containing 2.8 ppm wet weight *p,p'*-DDE. The brains of these two birds contained DDE residues (wet weight) of 213 and 301 ppm compared with 14.9 ppm (range, 4.47–26.6 ppm) for 11 of the adult males which were killed after 12 to 16 months on dosage. Two male American Kestrels died at the Denver Wildlife Research Center after they were fed a diet containing 250 ppm wet weight *p,p'*-DDE for 9 and 12 days (Henny, unpublished data). The brains of these two birds contained DDE residues of 223 and 280 ppm (wet weight). Both kestrels that died in the Porter and Wiemeyer (1972) study had grossly reduced pectoral muscles and badly depleted fat reserves. The same phenomenon was observed with the kestrels that died at Denver and the Merlin that died in New Mexico, but it is uncertain whether the 178 ppm DDE in the brain was sufficient to be the sole cause of death of the Merlin. It is noteworthy that this Merlin was found 2.5 years after the moratorium on DDT usage in the United States; however, the bird was hatched in 1967 (or earlier) at a time when DDT was still in use.

Oberheu (1971) reported residue levels of heptachlor epoxide in the brains of birds that died following a treatment of a citrus region in Florida with heptachlor. He found heptachlor epoxide residues (wet weight) in the brains of the dead birds as follows: House Sparrow (*Passer domesticus*) 13.5 ppm, Blue Jay (*Cyanocitta cristata*) 9.25 ppm, and two Northern Mockingbirds (*Mimus polyglottos*) 5.31 and 12.3 ppm. Residues of heptachlor epoxide in brains were diagnostic of death in a small experiment in which four species of blackbirds of different sexes and ages were given heptachlor in the feed. The break between dead and survivors came between 8 and

TABLE 1—Residue levels of chlorinated hydrocarbons in ppm wet weight found in a Merlin. Values in parentheses are ppm lipid weight

Category	DDE	Dieldrin	Heptachlor epoxide	PCB like	Hexachloro benzene
Muscle	33 (2540)	0.4 (31)	7.1 (550)	<0.5	nd[1]
Brain	178 (1800)	0.44 (4.4)	9.6 (96)	<0.5	nd
Carcass[2]	23 (1392)	nd (nd)	7.3 (205)	<0.5	0.38

[1] None detected

[2] Mean of two samples.

9 ppm, wet weight (W. H. Stickel, personal communication). We therefore strongly suspect that the Merlin died primarily of heptachlor epoxide poisoning.

Porter and Wiemeyer's (1972) two DDE-killed kestrels died at a time when the birds suffer a seasonal weight loss and depletion of fat reserves caused by stress associated with reproduction and molt. With loss of fat, stored toxicant is released into the blood for redeposition at other sites (Findlay and DeFreitas 1971). Bernard (1963, p. 190) first proposed the idea that some birds might retain sublethal amounts of pesticides in fat all summer and perish in winter or during migration when fats are utilized. Porter and Wiemeyer (1972) point out that raptorial birds are subjected to weight losses of considerable magnitude during their nesting activities and/or during their long-distance migrations and that extended periods of weight loss may be fatal for those birds whose tissues contain lethal amounts of pesticides or other pollutants. Laboratory studies with birds have shown lethal mobilization of pesticides at least 4 months after dosage ceased (VanVelzen et al. 1972). We hypothesize that the Merlin reported in this paper mobilized its fat reserves during its fall migration and died as a result.

Reichel et al. (1974) mentioned a Peregrine Falcon from North Carolina suspected to be dieldrin poisoned, and reviewed data for 17 of 153 Bald Eagles (*Haliaeetus leucocephalus*), analyzed between 1964 and 1970, that were considered likely to have died from pesticide poisoning, reporting 15 from dieldrin, 1 from DDT, and 1 from DDE. More recently, Cromartie et al. (1975) reported on 37 Bald Eagles analyzed between 1971 and 1972. Four eagles possibly contained lethal levels of dieldrin. This case adds to the records of accumulation of lethal residues of pesticides in wild birds of prey in North America.

We acknowledge the assistance of W. H. Stickel, Patuxent Wildlife Research Center, who provided unpublished laboratory data on heptachlor epoxide poisoning. R. E. White kindly assisted in preparing the section on chemical methodology and E. L. Boeker brought the Merlin carcass to our attention at the Denver Wildlife Research Center.

Literature Cited

Bernard, R. F. 1963. Studies of the effects of DDT on birds. Michigan State University, Museum Biological Series 2(3): 155–192.

Cromartie, E., W. L. Reichel, L. N. Locke, A. A. Belisle, T. E. Kaiser, T. G. Lamont, B. M. Mulhern, R. M. Prouty, and **D. M. Swineford.** 1975. Residues of organochlorine pesticides and polychlorinated biphenyls and autopsy data for Bald Eagles, 1971–72. Pesticide Monitoring Journal 9(1): 11–14.

Fimreite, N., R. W. Fyfe, and **J. A. Keith.** 1970. Mercury contamination of Canadian prairie seed eaters and their avian predators. Canadian Field-Naturalist 84(3): 269–276.

Findlay, G. M. and **A. S. W. DeFreitas.** 1971. DDT movement from adipocyte to muscle cell during lipid utilization. Nature (London) 229(5279): 63–65.

Fox, G. A. 1971. Recent changes in the reproductive success of the Pigeon Hawk. Journal of Wildlife Management 35(1): 122–128.

Fyfe, R. W., J. Campbell, B. Hanson, and **K. Hodson.** 1969. Regional population declines and organochlorine insecticides in Canadian Prairie Falcons. Canadian Field-Naturalist 83(3): 191–200.

Oberheu, J. C. 1971. Effects on fish and wildlife of heptachlor applied to eradicate the sugarcane root weevil in Apopka, Florida. Proceedings of the Southeastern Association of Game and Fish Commissioners 24: 194–200.

Peterson, J. E., K. M. Stahl, and **D. L. Meeker.** 1976. Simplified extraction and cleanup for determining organochlorine pesticides in small biological samples. Bulletin of Environmental Contamination and Toxicology 15(2): 135–139.

Phillips, A., J. Marshall, and **G. Monson.** 1964. The birds of Arizona. University of Arizona Press, Tucson. 212 pp.

Porter, R. D. and **S. N. Wiemeyer.** 1972. DDE at low dietary levels kills captive American Kestrels. Bulletin of Environmental Contamination and Toxicology 8(4): 193–199.

Reichel, W. L., L. N. Locke, and **R. M. Prouty.** 1974. Case report — Peregrine Falcon suspected of pesticide poisoning. Avian Diseases 18(3): 487–489.

Risebrough, R. W., G. L. Florant, and **D. D. Berger.** 1970. Organochlorine pollutants in Peregrines and Merlins migrating through Wisconsin. Canadian Field-Naturalist 84(3): 247–253.

Stickel, W. H., L. F. Stickel, and **F. B. Coon.** 1970. DDE and DDD residues correlated with mortality of experimental birds. *In* Pesticide symposia. *Edited by* W. B. Deichmann Halos and Associates, Miami. pp. 287–294.

VanVelzen, A. C., W. B. Stiles, and **L. F. Stickel.** 1972. Lethal mobilization of DDT by Cowbirds. Journal of Wildlife Management 36(3): 733–739.

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Food Caching Behavior in Richardson's Merlin

Food caching, the deliberate hiding or placement of food for later use, has been observed in several species of wild raptors including the Crowned Eagle, *Stephanoaetus coronatus* (Brown 1971), Goshawk, *Accipiter gentilis* (Schnell 1958), American Kestrel, *Falco sparverius* (Tordoff 1955; Stendell and Waian 1968), and Peregrine Falcon, *Falco peregrinus* (Nelson 1970). Brown and Amadon (1968, p. 78) consider it to be "well known" in the American Kestrel and "recorded" in the Peregrine, African Hobby, *Falco cuvieri*, and Goshawk. They have also observed caching by a Secretary Bird, *Sagittarius serpentarius*, and a Lizzard Buzzard, *Kaupifalco monogrammicus*.

Caching of excess food by captive raptors appears to be very common and we have observed it routinely in captive Prairie Falcons, *Falco mexicanus*. Recent studies utilizing captive American Kestrels indicate that caching is a strong, instinctive behavior and persists without reinforcement (Mueller 1974).

Initial observations on Richardson's Merlins, *Falco columbarius richardsonii* (subspecies confirmed by pattern on molted primaries, Temple 1972), nesting in the city of Saskatoon, Saskatchewan indicated that these birds may cache prey items (Oliphant 1974). Although no direct observations of caching were made, the male was observed on several occasions to fly out from the nest site toward a group of trees used for plucking prey and return almost immediately with a sparrow. On at least two occasions he appeared to have picked up a sparrow from the crotch of a tree. Hindquarters of birds and occasionally entire birds were found under trees near the nest site. Whether these were dropped by the birds or were cached in the trees and fell could not be determined.

In 1975 more intensive observations were made on two pairs of merlins nesting in the city. These birds were completely tolerant of human activities near the nest, allowing detailed observations. Many direct observations of food caching and retrieval were made at one of these sites and substantiated by observations at the second site.

Caching of entire birds or parts of birds by the male, who did nearly all of the hunting, was observed throughout the nesting period. The male cached food when the female refused to accept food he brought in for her. After making a kill, and often partially plucking and decapitating the bird, the male would fly to a perch in the immediate area of the nest. At this time the male would utter a call similar to, but less intense than, their normal aggression call or "ki-ki-ki-ki-keee." This is probably the vocalization termed "short chatter" by Campbell and Nelson (1975). If the female did not appear immediately, the male would then make a series of single "chips." If the female did not leave the nest after several minutes, the male would fly to a nearby tree and cache the prey. Caching of partially eaten birds also occurred. Usually the breast and internal organs except the gizzard were eaten first. The hindquarters were then cached if the male's appetite seemed satisfied.

The single observed incident of the female caching was during egg incubation. The unfinished remains of a bird were cached in a nearby spruce. Later the same day when the male failed to supply her with food immediately, she retrieved the remains of the bird.

Caching occurred throughout the day with the exception of the early morning. On the three occasions in which observations began at dawn, the male arrived just after the sun rose with a fresh bird which was immediately taken by the female. The male then resumed hunting and generally ate the next bird himself. Caching of part of the second kill or any other prey caught during the day might then occur.

The caches were always in a tree, although merlins nesting in southern Alberta have been observed to make caches on the ground (Tom Donald, personal communication). Very seldom was the same tree used on a regular basis. In American Kestrels it has been noted that one tree has been used for extended periods of time (Stendell and Waian 1968). Spruce were used by the merlins most frequently with elm also used on occasion. These were the most abundant trees nearby. In the spruce trees the prey was placed close to the trunk on a bough that was sheltered from above by other boughs. The remains put in elm trees were placed in a conspicuous crotch of the tree. As the elms leafed out they were used less. Spruce were used entirely after early June.

Prey retreived from a cache by the male was transferred to the female if she wanted food and the male was nearby without a fresh kill. The food transfers of one pair were made with both birds perched on a horizontal limb facing each other. The other pair commonly made aerial transfers. On one occasion the male was seen to retrieve a cached bird for his own consumption.

Retrieval most often occurred in the afternoon and evening. The earliest recorded retrieval was 1100 h and the latest 2035 h. Mueller (1974) has noted that the incidence of retrieving behavior in captive kestrels was considerably higher in the evening than at other times of the day. Consecutive days of observation indicated that caches were retrieved on the same day they were made. Caches from previous days were never seen to be utilized.

The male often did not appear to remember the exact location of the cache and had to search before finding it. This is contrary to findings with captive kestrels which appeared to be able to relocate accurately a previous cache (Mueller 1974).

Caching of prey items appears to be a consistent behavior of wild merlins at least during nesting. The frequency and persistence of this behavior without reinforcement in captive kestrels, as well as in larger falcons at all times of the year, suggest that it is a typical behavior of many members of the genus *Falco*.

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Literature Cited

Brown, L. H. 1971. The relations of the Crowned Eagle *Stephanoaetus coronatus* and some of its prey animals. Ibis 113: 240–243.

Brown, L. H. and **D. Amadon.** 1968. Eagles, hawks and falcons of the world. McGraw-Hill, New York.

Campbell, J. A. and **R. W. Nelson.** 1975. Captive breeding and behavior of Richardson's Merlins, 1974. Journal of the North American Falconers' Association 12. *In press.*

Mueller, H. C. 1974. Food caching behavior in the American Kestrel *(Falco sparverius).* Zeitschrift für Tierpsychologie 34: 105–114.

Nelson, R. W. 1970. Some aspects of the breeding behavior of Peregrine Falcons on Langara Island, B.C. M.Sc. thesis, University of Calgary, Alberta.

Oliphant, L. W. 1974. Merlins — the Saskatoon falcons. Blue Jay 32: 140–147.

Schnell, J. H. 1958. Nesting behavior of goshawks in the Sierra Nevada of California. Condor 60: 377–403.

Stendell, R. and **L. Waian.** 1968. Observations on food caching by an adult female Sparrow Hawk. Condor 70: 187.

Temple, S. A. 1972. Systematics and evolution of the North American merlins. Auk 89: 325–338.

Tordoff, H. B. 1955. Food storing in the Sparrow Hawk. Wilson Bulletin 67: 139–140.

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Present Status of the Prairie Falcon in Saskatchewan

Considerable attention has been focused on birds of prey during the last decade, especially those species that have undergone recent population declines (Hickey 1969). Stimulated by the hypothesis that pesticides are a major cause of these declines, the Toxic Chemical Division of the Canadian Wildlife Service began to monitor falcon populations in 1966. Data from field investigations in Alberta and Saskatchewan carried out between 1966 and 1968 were interpreted to indicate a 34% reduction in occupied territories of Prairie Falcon, *Falco mexicanus*, during the previous 10 years (Fyfe et al. 1969). A correlation was also shown between levels of insecticide residues in Prairie Falcon eggs and nestling production.

Subsequent studies (Fyfe 1972) have indicated an increase in the occupancy of eyries but no data on productivity were given. The present study reports the current levels of occupancy and productivity of Prairie Falcons in the two major Prairie Falcon nesting areas known in Saskatchewan (Areas A and B of Fyfe et al. 1969). In both of these areas the Prairie Falcons nest in holes or on ledges of cliffs along drainage systems.

Methods

In 1974 an extensive survey was made of the breeding population of Prairie Falcons along 130 mi of the South Saskatchewan River (Area B of Fyfe et al. 1969). All previously known nesting sites as well as other suitable habitat was checked. All occupied sites were revisited later in the season to band the young. In addition, 31 holes were dug in suitable cliff faces to provide artificial nesting sites; this continued a project initiated by the Canadian Wildlife Service to improve the nesting potential of this area.

In 1975 Area B was surveyed again. An initial visit was made during the first week in June to check all previously known sites as well as all man-made holes. An additional 5 days was spent on the south side of the river looking for new sites. None of the eyries were climbed at this time, and the time spent at eyries was kept at a minimum. A site was considered occupied if one or both adults were present and showed signs of aggression. A second visit to occupied sites was made during the first weekend in July to band the young.

Previously known sites in Area A (Fyfe et al. 1969) were surveyed on 14 and 15 June 1975. This area was not adequately studied in 1974. All active eyries were climbed and the young counted.

The term "eyrie" or "site" as used in this paper indicates a single ledge or hole used for breeding. One or more eyries may be defended by a pair of falcons, in which case the site being utilized plus the alternate sites are considered a "territory."

Observations

1974

A total of 12 pairs of Prairie Falcons was found in Area B in 1974. Of these, nine pairs successfully hatched eggs producing a total of 38 young (Table 1). Eight are known to have died prior to fledging and 30 are believed to have fledged.

One easily accessible eyrie contained five dead young. These were sent to G. Wobeser at the Western College of Veterinary Medicine for post-mortem examination. The necropsy report indicated that they had been killed by an unidentified predator. A second eyrie had one dead young and two live young. The cause of death was not determined.

On 23 June at a third eyrie, five nestlings (2 ♂♂ and 3 ♀♀) were found heavily infested with ticks (*Ornithodoros concanensis*). Six days later one young male appeared relatively normal but the other four were weak and emaciated, unable to stand properly or open their eyes. The single male was dusted with Diryl (insecticidal powder containing carbaryl, Pitman-Moore Inc.) and left in the eyrie. The remaining four young were taken for rehabilitation. Two of the females died within 24 h. Post-mortem examination at the Western College of Veterinary Medicine indicated the cause of death was general debilitation brought on by the massive tick infestation. The remaining female and male survived and several dustings with Diryl eliminatd the ticks. These two young falcons were later released with one other pair of young Prairies as part of an experimental release project under a permit issued by the Saskatchewan Department of Tourism and Renewable Resources.

Of the three unsuccessful pairs, one was present at a site that has had a history of intermittent occupancy by Great Horned Owls, *Bubo virginianus* (C.S. Houston and M. Gollop, personal communication). No alternate nest sites were found near this eyrie. The eyrie of the second pair had filled in with loose dirt making it unsuitable for nesting. Both of these eyries were cleaned out and enlarged. The third eyrie contained eggshell fragments in a scrape with no evidence of nestlings. All three pairs exhibited only moderate or no aggressive behavior.

1975

The initial 1975 survey of Area B (including an area on the south side of the river) revealed 12 pairs of Prairie Falcons (Table 1). One pair occupied an artificial hole dug in 1974. A single non-defending adult was present at a 13th eyrie. On the second visit eight pairs were found to be successful with a total of 31 young produced (Table 1). The young ranged in age from 1 week to near fledging. At the time of banding all young appeared healthy except for four young mildly infested with ticks at the same eyrie that was heavily infested in 1974. The 3½-week-old young did not seem weakened by the ticks, as they struggled fiercely when handled for banding.

Of the four unsuccessful pairs in Area B, two eyries were observed to have eggs on 13 June 1975 (H. Armbruster, personal communication). Five addled eggs were collected at one of these eyries for pesticide analysis by the Canadian Wildlife Service. The second eyrie, washed out by heavy rains, was abandoned by 5 July and no eggs were present. Nothing is known of the fate of the other two unsuccessful pairs.

In Area A, seven pairs of Prairie Falcons were found. Four of these were successful and the 19 young produced were 7 to 10 days old on 14 June. All young were accounted for and healthy when banded on 21 June by C. S. Houston.

Aggressive adults were present at all unsuccessful eyries in Area A. One eyrie had three adults near a nest hole which contained five broken eggs with signs of predation. Another eyrie, which has been consistently successful in the past, was found to contain only an addled Great Horned Owl egg half buried in the mud. The third unsuccessful eyrie had eggshell fragments in the scrape. A rancher in the area reported a heavy

TABLE 1—Prairie Falcon production in major nesting areas in Saskatchewan 1974, 1975

	1974		1975	
	Area A	Area B	Area A	Area B
Occupied territories	No data	12	7	12
Successful pairs	No data	9	4	8
Nestlings produced	No data	38[1]	19	31
Nestlings produced per occupied territory (N/O)	No data	3.2	2.7	2.6
Nestlings pro duced per successful pair (N/S)	No data	4.2	4.8	3.9

[1] Of the 38 nestlings produced only 30 fledged.

snowfall in May which may have been the cause of these failures, as was observed in 1965 and 1966.

Discussion

Prior to 1958 only two nestings of the Prairie Falcon in Saskatchewan had been reported (Potter 1937; Godfrey 1950). In 1958 members of the Saskatchewan Falconry Association discovered five nest sites of Prairie Falcons in two separate areas (Fyfe 1958a, b), which are the two Saskatchewan study areas at present. In 1959 nine new sites were discovered in addition to the previous five, making a total of 14 active sites that year (Fyfe 1959).

A decline in these two populations of Prairie Falcons in Saskatchewan and certain populations in Alberta, associated with pesticide residues, was postulated by Fyfe et al. (1969). In 1972 declines were reported to be continuing in those populations where avian species were a major food source, although those feeding on rodents were stable or increasing (Fyfe 1972). Prey remains collected in 1975 from successful eyries in Area B indicated a predominantly avian diet including ducks, Western Meadowlarks, blackbirds, Common Flickers, and Brown Thrashers. All indications are that this population is reproducing well at the present time.

The average number of nestlings produced in Saskatchewan per occupied territory (N/O) for 1974 and 1975 was 2.8 and the average number per successful pair (N/S) was 4.2. Most of these birds when banded were well developed and should have fledged successfully. This production is only slightly higher than the 2.5 N/O and 3.57 N/S found by Fyfe et al. (1969) for Alberta and Saskatchewan in 1968. It should be noted that the 1968 production figures do not take into account the effects of removing eggs for pesticide analysis. Enderson (1964) reported an average of 1.9 N/O for Prairie Falcons in Colorado and Wyoming. Parker (1973) reported 3.43 young per nest in Washington. It is not clear whether this represents the number per occupied territory or the number per successful pair, but presumably it is the latter.

The earlier data from Saskatchewan and Alberta were reported as a "34% reduction in occupancy of territories known in the previous ten years" (Fyfe et al. 1969). This was calculated by dividing the number of previously known territories not occupied in 1968 (18) by the total number of territories known over the previous 10 years (52). New territories discovered in 1968 (30) are not included in the calculation. With this method, the maximum occupancy that could have been recorded in 1968 is 100%, i.e., it was impossible to shown an increase in occupancy using this method. If the new territories were included, a 23% *increase* in occupied territories could have been postulated (64 occupied territories in 1968 as compared to 52 in the previous 10 years). Both of these conclusions are biased and point out one of the problems involved in using this method to evaluate the population status of the Prairie Falcon.

A reduction in occupancy of previously known territories does not necessarily imply a similar decline in the Prairie Falcon population. Parker (1973) found that 13% of the nest sites in Washington were unoccupied during his 2-year study. Enderson (1964), in a 3-year study of the Prairie Falcon in the Rocky Mountains, found 44% of the eyries were not utilized in at least 1 of the 3 years, although it is not clear what proportion of these were alternate nest sites within occupied territories. If our own data for Area B (presuming 1974 to be the first year) were analyzed as in Fyfe et al. (1969), a decrease in occupied territories of at least 33% could be shown for a single year. Only six of the eyries occupied in 1974 were occupied in 1975. An additional two eyries may have been alternate sites of 1974 territories, giving eight previously known occupied territories, four unoccupied territories, and four new sites. Another problem involved in assessing the population status in this manner is the loss of usable nest sites. At least three previously known sites had slumped away or were no longer suitable for use in 1975 in Area B.

Long-term studies such as those currently being carried out by the Canadian Wildlife Service should provide meaningful data on such things as territory and mate fidelity, territory size, and turnover rates of the population. At the present time, we feel that the best indication of the population status of the Prairie Falcon is the number of breeding pairs in a given area regardless of which territories are occupied or how many historic sites are known, plus a reasonable assessment of the breeding success.

Production of nestlings, both in 1968 (Fyfe et al. 1969) and in the past two years, certainly compare favorably with other known populations and suggest good reproduction. The 19 known occupied territories, although certainly not representing the total population of Saskatchewan Prairie Falcons, does represent the largest number of known occupied territories recorded in a single year.

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Literature Cited

Enderson, J. H. 1964. A study of the Prairie Falcon in the central Rocky Mountain region. Auk 81: 332-352.

Fyfe, R. W. 1958a. Prairie Falcon nesting records in Saskatchewan. Blue Jay 16(3): 115-116.

Fyfe, R. W. 1958b. Falconry in Saskatchewan. Blue Jay 16(3): 118-119.

Fyfe, R. W. 1959. The hawk men. Blue Jay 17(4): 152-154.

Fyfe, R. W. 1972. Canadian Wildlife Service involvement with birds of prey. 36th Federal-Provincial Wildlife Conference Transactions, Dartmouth, Nova Scotia. pp. 69-76.

Fyfe, R. W., J. Campbell, B. Hayson, and **K. Hodson.** 1969. Regional population declines and organochlorine insecticides in Canadian Prairie Falcons. Canadian Field-Naturalist 83(3): 191-200.

Godfrey, W. E. 1950. Birds of the Cypress Hills and Floten Lake Regions, Saskatchewan. Canada Department of Resources and Development, Bulletin Number 120.

Hickey, J. J. (*editor.*) 1969. Peregrine Falcon populations, their biology and decline. University of Wisconsin Press, Madison. 596 pp.

Parker, R. C. 1973. Prairies and people: A current look at Prairie Falcon management and status in Washington. Washington Wildlife 24(3): 18-23.

Potter, L. B. 1937. The Prairie Falcon nesting in Saskatchewan. Condor 39: 39-43.

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The Use of Osprey Nests by Great Horned Owls in Labrador

Osprey (*Pandion haliaetus*) and Bald Eagle (*Haliaeetus leucocephalus*) populations were investigated from 1969 to 1973 in western Labrador (west of 63° W) and east-central Labrador (between 52°30′W and 54°30′N and 57° W and 61°30′W) as described by Wetmore and Gillespie (1976). During the study Great Horned Owls (*Bubo virginianus*) were observed nesting in 35 out of 648 Osprey nests checked from aircraft between late May and 1 July. Great Horned Owls commonly use tree nests of other large birds for nesting (Bent 1938). In the forested regions of Labrador Osprey are common, building their nests in tops of large spruce (*Picea mariana* and *P. glauca*) or balsam fir (*Abies balsamea*) trees near streams, rivers, and lakes. Rough-legged Hawks (*Buteo lagopus*), Red-tailed Hawks (*B. jamaicensis*), Goshawks (*Accipiter gentilis*), Bald Eagles, and Ravens (*Corvus corax*) are also found nesting in trees in Labrador; however, we did not observe owls using their nests.

Of the 35 nests used by owls, 33 contained one or two chicks (mean 1.7), there being no significant difference between study areas or years. The other two nests contained adults but it was not determined if they were successful in nesting.

Owl nests contained downy young generally between late May and early June. Assuming a 28-day incubation period (Bent 1938), laying would take place in late April and early May. First arrival dates for Osprey in east-central Labrador ranged from 25 April to 12 May from 1970 to 1973. Egg-laying generally occurred from the last week of May through the first week of June. Therefore, owls had established nests and were incubating or brooding prior to the beginning of Osprey nesting.

Minimum distances between active Osprey nests were 1.5 km (0.9 mi) and 1.1 km (0.7 mi) in western and east-central Labrador respectively (Wetmore and Gillespie 1976). In six instances Osprey nested closer than these distances to Great Horned Owls with no obvious effect on the nesting success of either species. All of the owl nests produced young. Three Osprey nests were successful, one was unsuccessful, and in two, nesting success was not determined. Overall success rates for occupied Osprey nests were 44% and 57% in western and east-central Labrador respectively.

Great Horned Owls in Alberta increased in number and in rate of nesting in response to prey, particularly snowshoe hare (*Lepus americanus*) abundance (Rusch et al. 1972). As it grew, this same population usurped an increasing number of Red-tailed Hawk nests forcing hawks to build new nests (McInvaille and Keith 1974).

Data on prey abundance in Labrador was limited to

TABLE 1—Percentage of hunters who indicated more grouse and hares present than in the previous year on hunting license returns. Number of replies are given in parentheses.

Year	East-central Labrador		Western Labrador[1]
	Snowshoe hare	Grouse[2]	Grouse[2]
1968–69		54(43)	88(24)
1969–70	47(19)	73(26)	67(17)[3]
1970–71	80(20)	52(27)	0(12)
1971–72	88(17)[3]	57(21)[3]	15(13)
1972–73	40(10)	6(17)	0(6)

[1] Licence return data not available for snowshoe hares.

[2] Spruce Grouse and Willow Ptarmigan are by far the most abundant species but Ruffed Grouse (*Bonasa umbellus*) and Rock Ptarmigan (*Lagopus mutus*) are also present.

[3] Indicates peak year of abundance.

information from a small number of hunting license returns on snowshoe hare and grouse [primarily Spruce Grouse (*Canachites canadensis*) and Willow Ptarmigan (*Lagopus lagopus*)]; in these the hunter was asked his opinion on species abundance relative to the previous year (Table 1). Returns for hare were not available for western Labrador; however, hunters and trappers indicated, in conversation with the authors, that numbers peaked in 1971–72.

The use of Osprey nests by owls fluctuated during the study (Figure 1). Although we have no data on owl population size, nesting rates, or food habits our data suggest a relationship between the proportion of Osprey nests used by owls and larger prey abundance. In east-central Labrador use of Osprey nests peaked in 1972 coincident with hare and grouse population peaks in 1971–72. In western Labrador the relationship is not clear. Nest use peaked in 1971 while hare numbers were increasing and grouse populations were declining.

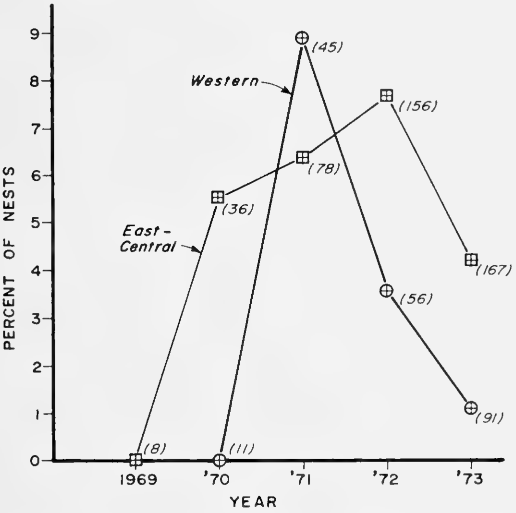

FIGURE 1. Percentage of Osprey nests checked between late May and 1 July in which Great Horned Owls were nesting in the western and east-central Labrador study areas, 1969–1973. Sample sizes are in parentheses.

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Literature Cited

Bent, A. C. 1938. Life histories of North American birds of prey. Part 2. United States National Museum Bulletin 170: 295–322.

McInvaille, W. B. and **L. B. Keith.** 1974. Predator-prey relations and breeding biology of the Great Horned Owl and Red-tailed Hawk in central Alberta. Canadian Field-Naturalist 88(1): 1–20.

Rusch, D. H., E. C. Meslow, P. D. Doerr, and **L. B. Keith.** 1972. Response of Great Horned Owl populations to changing prey densities. Journal of Wildlife Management. 36(2): 282–296.

Wetmore, S. P. and **D. I. Gillespie.** 1976. Osprey and Bald Eagle populations in Labrador and northeastern Quebec, 1969–1973. Canadian Field-Naturalist 90(3). *This issue.*

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News and Comment

The International Council for Bird Preservation (ICPB) Conference on Birds of Prey

The world conference on the conservation of birds of prey was held in Vienna, Austria from 1–3 October 1975. This meeting was organized by the ICBP world working group on birds of prey with the support of major national and international conservation and field sport organizations, and was attended by about 150 people active in raptor research from Africa, Europe, and North America.

The conference opened with a review of the global problems facing the birds of prey, followed by a series of reports on the current national and international status of populations of raptors. These reports provided the general background for much of the remainder of the conference.

Papers presented dealt with aspects of national and international legislation, research relevant to conservation of birds of prey, and the application of techniques for management. It was soon apparent that many of the problems influencing raptors were universal and the focus was directed towards problems associated with habitat loss and changing land-use patterns, toxic chemical contamination, and human interference. Throughout the conference, it was recognized that birds of prey are indicators of the delicate balance of the ecosystems in which they live and as such can serve as indicator species of environmental problems.

Following the paper and working sessions, the conference closed on a positive note with delegates adopting a series of resolutions pertinent to raptor conservation. These have since been submitted to government conservation agencies through the International Council for Bird Preservation.

RICHARD FYFE, chairman
ICBP World Working Group on Birds of Prey

Les Noms français des Oiseaux

Les noms en usage au Canada pour désigner les espèces d'oiseaux qui s'y rencontrent sont établis par le *Comité permanent des noms français des oiseaux du Canada.* Pour les noms anglais et latins, il utilise ceux déterminés par l'American Ornithologists' Union. En 1973, l'AOU a publié le trente-deux supplement de l'American Ornithologists' Union Check-list of North American birds (Auk 90: 411–419). Quant aux noms francais, il en a dressé une liste dont trois éditions ont paru jusqu'à maintenant. Le dernier edition du comité,"Noms des oiseaux du Canada; noms francais, anglais et scientifiques," (Service Canadien de la faune, Publication Hors Série #2), était publié en 1972. Jusqu'à nouvel ordre, c'est le seul organisme responsable de l'adoption des noms francais des oiseaux du Canada. Puis on espère que le comité publie bientôt une liste révisée des noms français des oiseaux en tenant compte des changements faits par l'AOU en 1973.

Status of Canadian Raptor Populations

Several factors that have had a direct bearing on raptor populations in Canada have been identified. Among these are changes in land use which has altered prey abundance and breeding habitat; human depredation in the form of shooting, egg collecting, and disturbance at nest sites; and most recently the harmful effects resulting from direct or indirect exposure to persistent toxic chemicals.

Disturbance at nest sites, changes in land use, and toxic chemical residues remain as serious problem

TABLE 1—Population status of raptors in the Maritime Provinces

Common name	Scientific name	Population trends	Relative abundance
Goshawk	*Accipiter gentilis*	stable	rare-medium
Cooper's Hawk	*Accipiter cooperii*	unknown	rare
Sharp-shinned Hawk	*Accipiter straiatus*	stable	uncommon-medium
Marsh Hawk	*Circus cyaneus*	decline	low
Rough-legged Hawk	*Buteo lagopus*		migrant
Red-tailed Hawk	*Buteo jamaicensis*	stable	medium
Red-shouldered Hawk	*Buteo lineatus*	unknown	uncommon
Broad-winged Hawk	*Buteo platypterus*	stable[1]	medium-heavy migration
Golden Eagle	*Aquila chrysaetos*	unknown	low
Bald Eagle	*Haliaeetus leucocephalus*	stable	medium
Osprey	*Pandion haliaetus*	stable	medium
Gyrfalcon	*Falco rusticolus*		rare migrant
Peregrine Falcon	*Falco peregrinus*		
	F. p. anatum	extinct	
	F. p. tundrius		rare migrant
Merlin	*Falco columbarius*		
	F. c. columbarius	stable	low
American Kestrel	*Falco sparverius*	stable[2]	high
Great Horned Owl	*Bubo virginianus*	stable	high
Long-eared Owl	*Asio otus*	fluctuating	low-medium
Short-eared Owl	*Asio flammeus*	fluctuating	rare-low
Snowy Owl	*Nyctea scandiaca*		migrant
Barred Owl	*Strix varia*	stable	medium
Great Grey Owl	*Strix nebulosa*	unknown	rare
Hawk Owl	*Surnia ulula*	unknown	rare
Boreal Owl	*Aegolius funereus*	fluctuating	low
Saw-whet Owl	*Aegolius acadicus*	stable	medium

[1] Absent in P.E.I.
[2] Slight decrease in Nova Scotia.

areas and are primary factors affecting these populations. Fortunately, the birds of prey are protected in Canada by legislation and as a result both shooting and egg collecting are no longer believed to be major influences on bird-of-prey populations.

Although it is recognized that several factors influence all populations, in most instances one or more factors can usually be identified as major contributors to major population change. This is particularly true in relation to the effects of toxic chemical residues on raptor populations. As elsewhere, field data from Canada suggest a direct correlation between elevated pesticide residues and the declines in some populations of birds of prey. In contrast, pesticide data from the eggs of those species that have maintained the most stable populations have shown correspondingly low residue levels. Although anomalies appear to be present, it has been shown that elevated residue levels result from the eating of contaminated prey and it now appears that a consistent pattern is emerging which more clearly explains variation in residue levels within and between species. Although it is always dangerous to generalize, I suggest that the following generalizations seem to hold in North America. The raptors most affected by pesticides and exhibiting the highest residues have been the migratory species or races feeding on contaminated prey which in turn frequently are migratory (i.e., those migratory raptors feeding heavily on contaminated migratory birds). Canadian examples would include the *anatum peregrine* (*Falco peregrinus anatum*), the tundra peregrine (*Falco peregrinus tundrius*), and the Richardson's merlin (*Falco columbarius richardsonii*).

TABLE 2—Population status of raptors in Ontario and southern Quebec

Common name	Scientific name	Population trends	Relative abundance
Goshawk	*Accipiter gentilis*	cyclic	medium-high
Cooper's Hawk	*Accipiter cooperii*	slight decline or stable	low-medium
Sharp-shinned Hawk	*Accipiter striatus*	slight decline or stable	low-high
Marsh Hawk	*Circus cyaneus*	stable[1]	low-medium
Rough-legged Hawk	*Buteo lagopus*		migrant
Red-tailed Hawk	*Buteo jamaicensis*	stable or increasing	high
Red-shouldered Hawk	*Buteo lineatus*	decline	low
Broad-winged Hawk	*Buteo platypterus*	stable	high
Golden Eagle	*Aquila chrysaetos*	unknown	rare
Bald Eagle	*Haliaeetus leucocephalus*	decline	low-medium
Osprey	*Pandion haliaetus*	stable	low-medium
Gyrfalcon	*Falco rusticolus*		rare migrant
Peregrine Falcon	*Falco peregrinus*		
	F. p. anatum	extinct	
	F. p. tundrius		rare migrant
Merlin	*Falco columbarius*		
	F. c. columbarius	decline or stable	rare-medium
American Kestrel	*Falco sparverius*	stable[2]	high
Screech Owl	*Otus asio*	stable[3]	rare-medium
Great Horned Owl	*Bubo virginianus*	stable or increasing	high
Long-eared Owl	*Asio otus*	fluctuating[3]	low-medium
Short-eared Owl	*Asio flammeus*	fluctuating[3]	low-high
Barn Owl	*Tyto alba*	unknown	low
Snowy Owl	*Nyctea scandiaca*		migrant low-high
Barred Owl	*Strix varia*	increasing	low-medium
Great Grey Owl	*Strix nebulosa*	fluctuating	rare
Hawk Owl	*Surnia ulula*	fluctuating	rare-low
Boreal Owl	*Aegolius funereus*	fluctuating[3]	rare-low
Saw-whet Owl	*Aegolius acadicus*	unknown	medium-high

[1] Marked decline in Ottawa area, slight decline in two other areas.
[2] Decreased in Ottawa area.
[3] Absent in Sault Ste. Marie area.

The next highest residue levels are usually found in those migratory or non-migratory raptors feeding locally on contaminated non-migratory prey. This would include fish-eaters feeding on prey from heavily polluted waters or raptors feeding on seed or insect-eating birds or mammals contaminated by treated seed, poisoned insects or bait. Examples in Canada would include the Prairie Falcon (*Falco mexicanus*), and eastern Bald Eagles (*Haliaeetus leucocephalus*).

Less predictable are those raptors which have a more varied diet and which feed on mammals and/or both migratory or non-migratory birds. Since residue levels are found to fluctuate widely with the prey eaten, individuals or groups of individuals could be either very clean or very heavily contaminated.

The lowest residue levels have usually been found in those raptor species, non-migratory in nature, that feed exclusively on resident prey species whether bird or mammal.

When toxic chemicals alone are considered those birds of prey whose eggs have exhibited high residue levels have shown eggshell thinning, poor overall production, and local or general population declines. In contrast, those raptors with eggs containing low residue levels have retained stable populations and reproduction has remained normal where other factors have remained relatively constant.

Perhaps of nearly equal importance in the long term are changes in land use and the consequent alteration of habitat which directly or indirectly affects raptor

TABLE 3—Population status of raptors in the Prairie Provinces

Common name	Scientific name	Population trends	Relative abundance
Goshawk	*Accipiter gentilis*	cyclic	medium-high
Cooper's Hawk	*Accipiter cooperii*	stable	medium
Sharp-shinned Hawk	*Accipiter striatus*	stable	medium
Marsh Hawk	*Circus cyaneus*	wide fluctuation	low-medium
Rough-legged Hawk	*Buteo lagopus*		migrant medium-high
Ferruginous Hawk	*Buteo regalis*	stable	rare-medium
Red-tailed Hawk	*Buteo jamaicensis*	stable[1]	high
Swainson's Hawk	*Buteo swainsoni*	decline or stable	medium-high
Broad-winged Hawk	*Buteo platypterus*	stable	high
Golden Eagle	*Aquila chrysaetos*	stable	rare-low
Bald Eagle	*Haliaeetus leucocephalus*	stable	low-medium
Osprey	*Pandion haliaetus*	stable	low-medium
Gyrfalcon	*Falco rusticolus*		rare migrant
Prairie Falcon	*Falco mexicanus*	stable or increasing	medium
Peregrine Falcon	*Falco peregrinus*		
	F. p. anatum	decline	rare
	F. p. tundrius		rare migrant
Merlin	*Falco columbarius*		
	F. c. richardsonii	increasing	low-medium
	F. c. columbarius	stable	medium
American Kestrel	*Falco sparverius*	stable	high
Great Horned Owl	*Bubo virginianus*	stable	high
Long-eared Owl	*Asio otus*	fluctuating	low-medium
Short-eared Owl	*Asio flammeus*	fluctuating	low-high
Snowy Owl	*Nyctea scandiaca*		migrant low-high
Barred Owl	*Strix varia*	unknown	low
Great Grey Owl	*Strix nebulosa*	fluctuating	rare-medium
Hawk Owl	*Surnia ulula*	fluctuating	low-medium
Burrowing Owl	*Speotyto cunicularia*	stable[2]	low-high
Boreal Owl	*Aegolius funereus*	fluctuating	low
Saw-whet Owl	*Aegolius acadicus*	stable	medium

[1] Marked decline recorded in one area of southern Saskatchewan.
[2] Declining in Manitoba.

species. In western Canada the more sensitive species such as the Golden Eagle (*Aquila chrysaetos*) or Ferruginous Hawk (*Buteo regalis*) appear to have declined in areas subject to increased cultivation and human activity. In contrast, current agricultural practises appear to have favored the Red-tailed Hawk (*Buteo jamaicensis*), Swainson's Hawk (*Buteo swainsoni*), and American Kestrel (*Falco sparverius*). Some of the owls, falcons as well as the harriers, Bald Eagle and Osprey live in wilderness areas but may also be found in close proximity to developed areas where depredation is no longer a serious threat. In Canada, however, it must be recognized that the early declines of the Peregrine Falcon and Bald Eagle began in areas of heavy population and intensive agriculture, probably in response to the combined pressures of habitat change and human depredation with the final blow in some areas apparently dealt by pesticide residues.

Although as stated it is dangerous to extrapolate and generalize, for the purpose of this report I believe it is desirable to do so. Whereas I believe it is important to indicte that many raptor populations are declining, I also believe it is equally important to indicate that many others are stable or expanding. Similarly, it is important to indicate our lack of knowledge and if in my generalizing others find

TABLE 4—Population status of raptors in British Columbia

Common name	Scientific name	Population trends	Relative abundance
Goshawk	*Accipiter gentilis*	stable	medium-high
Cooper's Hawk	*Accipiter cooperii*	stable[1]	medium
Sharp-shinned Hawk	*Accipiter striatus*	stable	high
Marsh Hawk	*Circus cyaneus*	fluctuating[2]	low-medium
Rough-legged Hawk	*Buteo lagopus*		migrant
Red-tailed Hawk	*Buteo jamaicensis*	stable	high
Swainson's Hawk	*Buteo swainsoni*	unknown	
Golden Eagle	*Aquila chryaetos*	stable	low-medium
Bald Eagle	*Haliaeetus leucocephalus*	stable	medium
Osprey	*Pandion haliaetus*	stable	medium
Gyrfalcon	*Falco rusticolus*		migrant
Prairie Falcon	*Falco mexicanus*	decline	low
Peregrine Falcon	*Falco peregrinus*		
	F. p. anatum	unknown	unknown
	F. p. pealei	slight decline	medium
Merlin	*Falco columbarius*		
	F. c. columbarius	stable	medium
	F. c. sucklei	unknown	low
American Kestrel	*Falco sparverius*	increasing	high
Screech Owl	*Otus asio*	stable	low-medium
Great Horned Owl	*Bubo virginianus*	stable	high
Long-eared Owl	*Asio otus*	unknown	low
Short-eared Owl	*Asio flammeus*	fluctuating	low-high
Barn Owl	*Tyto alba*	unknown[3]	low-medium
Snowy Owl	*Nyctea scandiaca*		migrant low-high
Barred Owl	*Strix varia*	unknown	medium
Spotted Owl	*Strix occidentalis*	declining	rare
Great Grey Owl	*Strix nebulosa*	fluctuating	rare-low
Hawk Owl	*Surnia ulula*	fluctuating	low-medium
Burrowing Owl	*Speotyto cunicularia*	declining	low
Boreal Owl	*Aegolius funereus*	unknown	low
Saw-whet Owl	*Aegolius acadicus*	stable	medium
Flammulated Owl	*Otus flameolus*	unknown	rare
Pygmy Owl	*Glaucidium gnoma*	stable	low

[1] Status unknown in the interior of the province.
[2] Common migrant in the interior of the province.
[3] May be expanding locally.

reason for disagreement, I hope it will stimulate controversy, a search for more and better information, and greater input by others.

Tables 1–5 are a compilation of information received as a result of a survey of some of the best bird observers in the different regions of Canada. Although I recognize the inadequacies of such a general survey, it is the best information I have been able to obtain. I would like to point out, however, that the general consistency of the response on most species leads me to believe this does give a reasonably accurate picture of the status of most bird-of-prey populations in Canada.

I gratefully acknowledge status information from the following contributors: Harry Armbruster, David Bird, Craig Campbell, Wayne Campbell, Keith Denis,

TABLE 5—Population status of raptors in the Northwest Territories and Yukon

Common name	Scientific name	Population trends	Relative abundance
Goshawk	*Accipiter gentilis*	fluctuating	medium-high
Sharp-shinned Hawk	*Accipiter striatus*	unknown	low
Marsh Hawk	*Circus cyaneus*	fluctuating	low-medium
Rough-legged Hawk	*Buteo lagopus*	fluctuating	medium-high
Red-tailed Hawk	*Buteo jamaicensis*	unknown	low-medium
Golden Eagle	*Aquila chrysaetos*	stable	low-medium
Bald Eagle	*Haliaeetus leucocephalus*	stable	low-medium
Osprey	*Pandion haliaetus*	stable	low
Gyrfalcon	*Falco rusticolus*	stable	low-medium
Peregrine Falcon	*Falco peregrinus*		
	F. p. anatum	declining	rare-low
	F. p. tundrius	declining	rare-low
Merlin	*Falco columbarius*		
	F. c. columbarius	unknown	low
American Kestrel	*Falco sparverius*	stable	low-medium
Great Horned Owl	*Bubo virginianus*	stable	high
Short-eared Owl	*Asio flammeus*	fluctuating	low
Snowy Owl	*Nyctea scandiaca*	fluctuating	low-high
Great Grey Owl	*Strix nebulosa*	unknown	rare-low
Hawk Owl	*Surnia ulula*	unknown	low-medium
Boreal Owl	*Aegolius funereus*	fluctuating	low

Russ Dennison, Marshall Field, Earl Godfrey, Clive Goodwin, David Hatler, Stewart Houston, Nelson Hurry, Fred Lahrman, Allan Madden, Ian McLaren, Wayne R. Nelson, Robert Nero, Lynn Oliphant, Peter Pearce, Spencer Sealy, Rudy Stocek, and Ron Weir.

RICHARD W. FYFE
Canadian Wildlife Service

Call for Nominations for OFNC Council

A Nominating Committee is being chosen to nominate persons for election to the various offices and membership of the Council as required by the Constitution.

Club members may also nominate candidates for officers and for 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, P.O. Box 3264, Postal Station C, Ottawa, Ontario, K1Y 4J5, to arrive before November 15, 1976.

The Committee will also consider any suggestions for nominees which members wish to submit to it by November 1, 1976. It would be helpful if some relevant background on the proposed nominees were provided with the suggestions.

M. W. NEY
Chairman, Nominating Committee

Book Reviews

ZOOLOGY

Golden Eagle Country

By Richard R. Olendorff. 1975. Alfred A. Knopf, New York. 202 pp. $12.95 (U.S.) hard cover.

The dust jacket tells us that this book is a celebration of North America's noblest winged predator. It is that and much more, for it is an optimistic, informative, literary, and elegant production.

This, for a change, is not a doom-and-gloom book; Olendorff is optimistic about the fate of most raptors and explains why. We learn much about the habits of the raptors, chiefly the Golden Eagle, Ferruginous Hawk, Prairie Falcon, and Swainson's Hawk, which live on the shortgrass prairie east of the Rockies; at the same time we are told about the geology, history, and land-use practices in the area. The prose is masterful; Olendorff is a scientist and yet his narrative and word pictures of his two summers of field study make the sights, sounds, and smells of grassland come to life in a manner reminiscent of Wallace Stegner. Olendorff explains the emotional impact of the open plains and the "charisma" of the Golden Eagle without being gushy or sentimental. The numerous attractive and accurate drawings by Robert Katona are the perfect complement to the text, and make this a beautiful production. The publishers are to be congratulated for the attractive layout, the absence of detectable errors, and the remarkably low price for a book of this quality.

Although I have read a number of Butch Olendorff's scientific accounts, I had no idea that he was such a superb storyteller. This book is recommended for reading to intelligent and interested children and for the bedside table; each of the 16 chapters is just the right length. It would make an ideal gift item for anyone who enjoys good nature writing, even if he is not specially interested in raptors.

C. STUART HOUSTON

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Field Studies of the Falconiformes of British Columbia. Vultures, Eagles, Hawks, Falcons

By Frank L. Beebe, 1974. British Columbia Provincial Museum, Victoria. Occasional Paper No. 17. 163 pp.

The contents of this book encompass much more than is indicated by the title. The scope of the topics far exceed the boundaries of British Columbia and often the limits of North America; however, this broad perspective permits extensive comparisons between and within species in analogous yet distant situations.

The first twenty pages of text deal with topics relating to raptors in general, although the species of British Columbia are the focal point of the discussions. Taxonomy, evolution, ethology, population ecology, and human propagation and attitudes are all discussed under various headings. Each topic is well documented and the ideas and theories put forth are thought-provoking.

The main body of the text consists of seventeen accounts for recorded British Columbia species. An additional four hypothetical species are briefly described. Each detailed account includes a section on species' description, sub-species, field recognition, range, migration, habitat, habits and food, reproduction, voice and calls, historical use, and additional comments. In essence the book discusses in detail all common Canadian species except the Broad-winged and Red-shouldered Hawks. Forty-four black-and-white illustrations throughout the publication duly exemplify the artistic talents of the author. A colored frontispiece of a black Merlin is particularly striking.

Mr. Beebe's experience both as a falconer and as a researcher provides an extensive foundation for the document. His association with falconry and falconers is clearly stated and at times defended. For example, in the latter paragraphs of the preface and the section relating to human attitudes, he outlines the contribution falconers have made to the understanding of raptors and the supposedly illogical bias that is often expressed against the practice. Accordingly, the trained hunting potential and utilization by man for falconry is documented in the historical use section of each species' account. Preferential overtones towards falconers are subtly apparent throughout. Although the inclusion of such may cause instinctive aggravation with some readers, it provides a perspective lacking in more classical scientific works. His intimate relationships with many raptorial species are stimulatingly conveyed in his writing style. As a result, the text is generally easy to read.

Some inconsistencies were noted, however, and cast doubt as to the rigor of some of the theories detailed by the author. For instance, on p. 25, describing general raptorial social behavior, he states the nests of osprey are "as close as 500 meters apart" but on p. 38, in the detailed species account for the osprey, he states they are "as close as 60 or 70 meters apart." Also, in the description of migration patterns he states "[nothing] resembling the large flocks characteristic of autumn migrations is known in the spring." This seems rather contradictory to the large annual spring migration observed at such locations as Derby Hill, New York. Although both may be relatively insignificant points, it is recommended the theories be carefully reviewed in more detail than has been undertaken herein, to ensure that the "Velikovsky Syndrome" of presenting only supportive information and deleting contradictory evidence has not been contracted. Similarly, although the majority of the species information appears reliable, much is supported only by anecdotal incidences and thus has not been substantiated by controlled scientific investigation. It should be noted, however, that by sharing his wealth of experience and his thoughts and theories, Mr. Beebe has provided a valuable reference for falconers, ornithologists, and naturalists alike.

J. E. HANNA

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NEW TITLES

The forest watchers

A new film produced by the National Film Board of Canada, P.O. Box 6100, Montreal, Quebec H3C 3H5; 35 mm and 16 mm color; screening time 25 min, 28 sec. Free on request through NFB offices.

This film, on remote forestry sensing, has something to do with just about every aspect of forestry in Canada and contains useful information on the significant benefits of remote sensing technology. In addition, the film tells us that the forests we take for granted are fast dwindling because of fires, spruce budworms, air pollution, and indiscriminate logging operations. But man now has impressive technological aids, high altitude photography, to help him identify problem areas.

A glimpse of wild nature. 1975

By Robert W. Nero. Manitoba Department of Renewable Resources and Transportation Services. 12 pp. A new pamphlet about hawks and owls.

Instructions to Contributors

Manuscripts

Authors should submit three complete manuscripts with two copies of figures (in addition to the originals) for use by referees. Manuscripts are accepted in either English or French. They should be typewritten on paper measuring 8½ × 11 inches, and if possible, the paper should have numbered lines. Margins should be 1 to 1½ inches wide to allow for copy marking. All text matter, including quotations, footnotes, tables, literature citations, and captions for figures should be double-spaced. Only words meant to appear in italics should be underlined. Every sheet of the manuscript should be numbered. Generally words should not be abbreviated; this includes references to tables and figures as well as literature citations. Authors are requested, however, to use SI symbols for units of measure.

Authors are expected to have complied with all pertinent legislation regarding the study, disturbance, or collection of animals, plants, and minerals. It is strongly recommended that, before submitting a paper, authors ask qualified persons to appraise it.

An abstract is required for all Articles but is optional for Notes. Authors are requested to use at least one given name. Literature cited should be listed alphabetically according to author and should be placed immediately after the main body of the text, except in Letters to the Editor. If only one or two references are cited, they should be inserted in the text. The tables should be titled and numbered consecutively in arabic numerals, and each should be placed on a separate page after the Literature Cited. Captions for figures should be typed together on one page. The places in the text for tables and figures should be marked in the margin.

Extensive tabular or other supplementary material not essential to the text should be submitted on letter size paper (8½ × 11") for the Editor to place in the Depository of Unpublished Data, National Science Library, National Research Council of Canada, Ottawa, Canada K1A 0S2. A notation in the published text should state that the material is available, at a nominal charge, from the Depository. Two copies are required for the Depository.

The **CBE Style Manual,** third edition (1972), published for the Council of Biology Editors, Committee on Form and Style, by the American Institute of Biological Sciences, is recommended as a guide to contributors.

Webster's New International Dictionary is the authority for spelling. In a case, however, of difference in the spelling of a common name, and in the use of a variant name, a decision of a learned society is preferred.

The order in which papers are published will be determined by the Editor.

Illustrations

All illustrations should be numbered consecutively in arabic numerals. The author's name, title of the paper, and figure number should be written in the lower left corner of the sheet on which each illustration appears. The caption should **not** appear on the illustration.

Line drawings should be made with India Ink on good quality material: white drawing paper; tracing paper, film, or cloth; or blue-lined co-ordinate paper. Co-ordinate lines that are to appear on the reproduction should be ruled in black ink. Descriptive matter should be lettered, not typewritten, and all parts of the drawing should permit easy legibility even if a reduction is made. Photographic reproductions of line drawings are acceptable in lieu of large originals.

Photographs should have a glossy finish and show sharp contrasts. For reproduction as a complete plate they should be mounted with minimal space between prints.

For large drawings and mounted photographs the ratio of height to width should conform to that of the printed journal page (ratio of 45 up to 35 across) or roughly 7½ × 5¾ inches, but the height should be adjusted to allow for the caption if the caption is to go on the same page.

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Limited journal funds are available to help offset publication charges to authors with minimal financial resources. Requests for financial assistance should be made to the Editor when the manuscript is submitted.

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Articles

The Canadian Field-Naturalist is a medium for publication of research papers in all fields of natural history. If possible, major articles should be illustrated.

Notes

Short notes on natural history and related topics written by naturalists and scientists are welcome. Range extensions, interesting behavior, pollution data, and other kinds of natural history observations may be offered. It is hoped, however, that naturalists will also support local natural history publications.

Letters

Letters commenting on items appearing in this journal or on any developments or current events affecting natural history and environmental values are welcome. These should be brief, clear, pertinent, and of interest to a wide audience.

News and Comment

Informed naturalists, biologists, and others are invited to present documented narratives and commentaries upon current scientific and political events that affect Canadian natural history and the environment. Contributions should be as short as possible and to the point.

Book Reviews

Normally, only solicited reviews are published. Biologists and naturalists, however, are invited to submit lists of titles (complete with pertinent information regarding authors, publisher, date of publication, illustrations, number of pages, and price) for listing under "New Titles."

Special Items

As *The Canadian Field-Naturalist* has a flexible publication policy, items not covered in the traditional sections can be given a special place provided they are judged suitable.

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NOTICE

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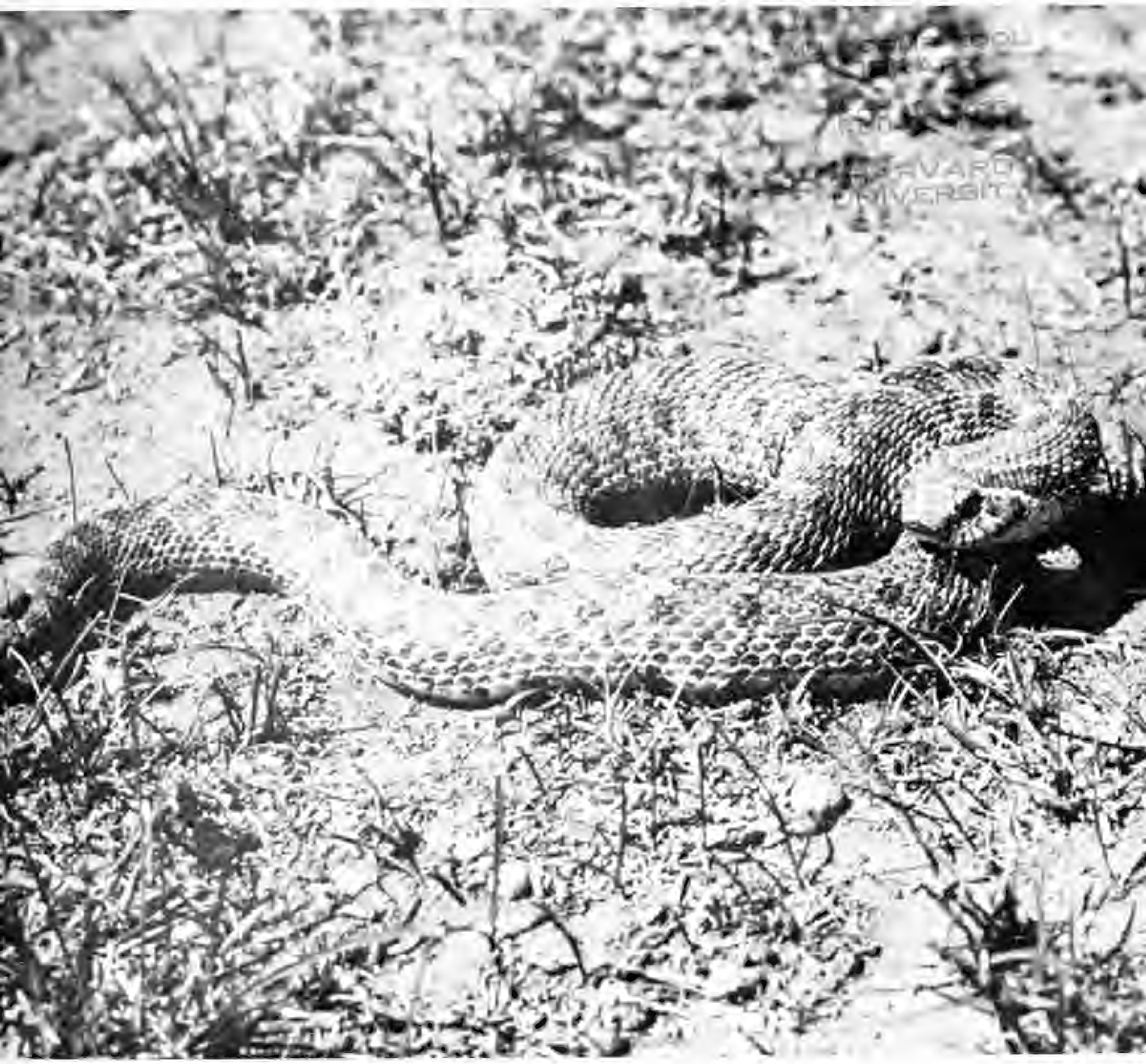

Volume 90, Number 4

October-December 1976

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Their Excellencies the Governor General and Madame Jules Léger

The objectives of this Club shall be to promote the appreciation, preservation, and conservation of Canada's natural heritage; to encourage investigation and publish the results of research in all fields of natural history and to diffuse information on these fields as widely as possible; to support and co-operate with organizations engaged in preserving, maintaining, or restoring environments of high quality for living things.

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* This Council is in office until the Annual Business Meeting in January 1977.

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The Canadian Field-Naturalist

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All material intended for publication should be addressed to the Editor:

Dr. Lorraine C. Smith, Department of Biology, Carleton University, Ottawa, Ontario, Canada K1S 5B6

Cover: Western Hognose Snake (*Heterodon nasicus nasicus*) photographed at 1000 hours on 20 May 1973 near Medicine Hat, Alberta by George B. Pendlebury. This snake is referred to as GBP in the article on page 416.

The Canadian Field-Naturalist

Volume 90, Number 4 October-December 1976

Small Mammal Communities of the Kluane Region, Yukon Territory

CHARLES J. KREBS AND IRENE WINGATE

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Krebs, C. J. and I. Wingate. 1976. Small mammal communities of the Kluane Region, Yukon Territory. Canadian Field-Naturalist 90(4): 379–389.

Abstract. A survey of small mammals was carried out near Kluane National Park in the southwestern Yukon in 1973 and 1974. Of 19 species recorded, 9 species of voles, mice, and lemmings were studied in detail with snap-trapping lines. Twenty-one habitats were analyzed, and the species composition of each determined. Kluane Park is in a zoogeographic tension zone and several species of small mammals reach their northern (or southern) limits in or near the park. Species diversity was highest in marshes along the Dezadeash River, where three rare species were found. The deer mouse, *Peromyscus maniculatus,* and northern red-backed vole, *Clethrionomys rutilus,* were the most abundant small mammals and occupied the widest habitat spectrum. There is very little niche overlap among the nine species of small rodents in the habitats they occupy. Abundance changes do not occur in synchrony in the northern and southern parts of the Kluane region.

If we are to conserve our natural resources, we must first catalogue them. Nowhere is this more important than in national parks, which should preserve whole ecosystems for future generations. This study attempts to add to the knowledge of the Kluane National Park region in the southwestern Yukon through an ecological survey of the shrews, mice, and lemmings.

Methods

The survey was carried out in and around Kluane National Park from 18 June 1973 to 26 September 1973 and from 27 April to 15 October 1974. The basic sampling technique used was snap-trap lines of 20 stations spaced at 50-ft (15.2-m) intervals in a straight line with three traps per station (Krebs 1964). Each line was left in position for 3 days and checked daily. Parallel lines were placed at least 200 ft (61 m) apart. Peanut butter was used as bait on all traps. Disturbance of traps by red squirrels (*Tamiasciurus hudsonicus*) and arctic ground squirrels (*Spermophilus parryii*) was occasionally severe and in general reduced the accuracy of the survey procedure.

Habitat was classified around each trapping station so that the observational unit was one trapping station with three traps set for 3 nights (or 9 trap nights). We used this unit because it was difficult to place an entire trap line in a single habitat. Our habitat classification attempted to follow the plant survey conducted by George Douglas (personal communication), but we were only partly successful with this coordination. We sampled some of the same sites that Douglas sampled, but were forced to classify habitats more crudely.

In our survey, we recognized 21 habitats, listed in Table 1 along with the plant communities recognized by Douglas. The alpine plant communities occur on a spatial scale that is coarse-grained to the rodents (Douglas, personal communication). Hence we group these tundra areas into two broad zones based on the density of shrubs. Alpine tundra areas support only small vascular plants and almost no shrubs are present.

TABLE 1—Habitats sampled during this survey and the equivalent plant communities recognized by Douglas (1974 unpublished report, Parks Canada)

Habitat sampled	Plant communities included
1. Alpine tundra	(complex mosaic)
2. Subalpine shrub tundra	(several shrub and herb communities)
3. Closed spruce communities	
(a) Closed spruce — moss	*Picea glauca/Hypnum revolutum* *Picea glauca/Thuidium abietinum*
(b) Closed spruce — birch	*Picea glauca/Betula glandulosa/Empetrum nigrum* *Picea glauca/Betula glandulosa/Carex aquatilis*
(c) Closed spruce — willow	*Picea glauca/Salix glauca*
(d) Closed spruce — buffaloberry	*Picea glauca/Shepherdia canadensis* (closed phase)
(e) Closed spruce — aspen	*Picea glauca/Populus tremuloides/Shepherdia canadensis/Linnaea borealis*
(f) Closed spruce	
4. Open spruce communities	
(a) Open spruce — aspen	3(e) above
(b) Open spruce — willow	*Picea glauca/Salix glauca/Arctostaphylos*
(c) Open spruce — birch	*Picea glauca/Betula glandulosa/Carex aquatilis*
(d) Open spruce — buffaloberry	*Picea glauca/Shepherdia canadensis* (open phase)
5. Deciduous forest communities	
(a) Aspen	*Populus tremuloides/Arctostaphylos uva-ursi/*
(b) Balsam poplar	*Populus balsamifera* (dry phase) *Populus balsamifera* (mesic phase)
(c) Balsam poplar-buffaloberry	*Populus balsamifera/Shepherdia canadensis*
6. Shrub communities	
(a) Willow	*Salix glauca*
(b) Shrub birch-meadow	*Betula glandulosa/Festuca altaica*
(c) Beach ridges	*Juniperus communis/Arctostaphylos uva-ursi/ Artemisia alaskana*
7. Other communities	
(a) Marsh	(not classified)
(b) Dryas flats	*Dryas drummondii*
(c) Grass-fireweed	*Calamagrostis*

There are several types of closed spruce forest and we include in this category everything that included white spruce (*Picea glauca*) as the important tree and in which trees were closely spaced (distance between trees, 3–6 m). Open spruce forests occur in a variety of forms and are often successional to fires. Spruce trees in these habitats are widely spaced (15 to 30 m) and other trees (trembling aspen, *Populus tremuloides*, or willows, *Salix* spp.) may be co-dominant with spruce. There is little difference in the dominant plants of open spruce and closed spruce communities of the same designation, and Douglas did not recognize this distinction for all forested communities.

Many other specialized habitats can be recognized and we have trapped only a few of these, the marshes along the Dezadeash River and the Slims River, beach ridges along the Dezadeash River, and *Dryas drummondi* flats.

The area studied was divided into three subregions as shown in Figure 1. The southern areas included the regions south and east of Bear Creek Summit, including the southern part of Kluane National Park. The southern areas were sampled along the Alaska Highway (Mile posts 1022–1028), Haines Highway (Mile posts 120–158), and the old Dezadeash Road west of Haines Junction. Helicopter surveys in the summer of 1973 to Goatherd Mountain, Sockeye Lake, Bates Lake, Profile Mountain, and Marble Creek completed our coverage of the southern areas. The central areas sampled included the area crossed by the Alaska High-

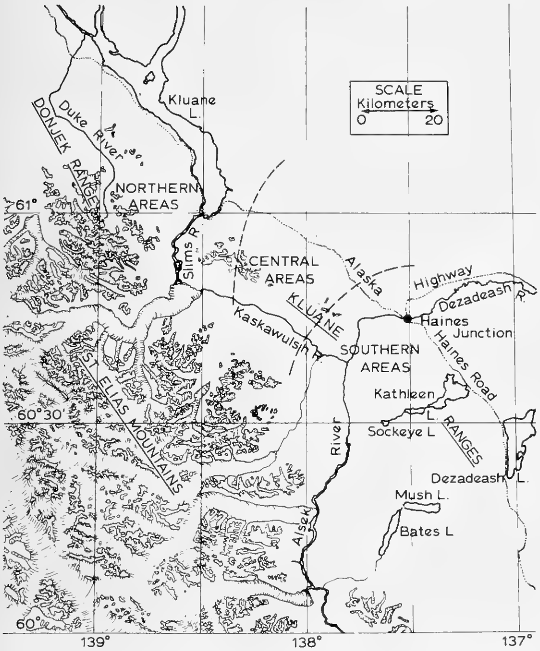

FIGURE 1. Map of study area in the Kluane region of the southwestern Yukon Territory.

way from Bear Creek Summit (Mile 1028.5) to Boutellier Summit (Mile 1049.8). The northern areas sampled included the Alaska Highway from Mile 1050 to Mile 1071, the Slims River area, and the Donjek River Valley around Hoge Creek. Helicopter surveys to Observation Mountain and Vulcan Mountain were made in 1973.

Species diversity was measured by Brillouin's formula (Pielou 1966), and evenness was calculated thus:

$$\text{evenness} = \frac{\text{observed species diversity}}{\text{maximum possible diversity}}$$

(see Pielou 1966).

Niche breadth, based on habitats occupied, was calculated from MacArthur's formula

$$B = \frac{1}{\Sigma p_i^2}$$

where B = niche breadth, p_i = proportion of species total density in habitat i.

Note that p is defined from our average density estimates:

$$p_i = \frac{d_i}{\Sigma d_i}$$

where d_i = number of individuals per 100 trap nights in habitat i.

Niche breadth can vary from 1.0 to the number of habitats sampled, and can be expressed as standardized niche breadth by dividing the number of habitats (range 0 to 1.0). Note that we deal here with only one dimension of the niche of these small mammals, the habitat niche.

Niche overlap between two species of small mammals was calculated from Pianka (1973) as follows:

$$o_{ij} = o_{ji} = \frac{\Sigma(x_{ik}\ x_{jk})}{\sqrt{\Sigma x^2_{ik}\ \Sigma x^2_{jk}}}$$

where o_{ij} = o_{ji} = niche overlap between species i and species j (range 0–1),

x_{ik} = proportion of species i numbers in habitat k

x_{jk} = proportion of species j numbers in habitat k.

Species reported in this paper were identified from keys provided in Hall and Kelson (1959) and Cowan and Guiguet (1956). Scientific nomenclature follows Banfield (1974). Some uncertainty in the field of distinguishing the dusky shrew, *Sorex obscurus*, and the masked shrew, *Sorex cinereus*, resulted in these two shrews being grouped in some of the data.

Results

Species Distributions

We recorded two species of shrews and nine species of rodents in the family Cricetidae during our survey. Table 2 lists these species along with other small mammals recorded, a total of 19 species. There are some notable species missing from this list. No bats were seen; the little brown bat, *Myotis lucifugus*, should also be in the area but was not seen.

Kluane National Park is situated in a zoogeographic tension zone. Many southern species of small mammals reach their distributional limits in or near the park, and many northern species extend south into this area. The deer mouse, *Peromyscus maniculatus*, is near the northwestern limit of its range in the Kluane region, as is the heather vole, *Phenacomys intermedius*, and the least chipmunk, *Eutamias minimus*. The southern limits of the ranges of the northern red-backed vole, *Clethrionomys rutilus*, the tundra vole, *Microtus oeconomus*, and

TABLE 2—Species of small mammals recorded in the region of Kluane National Park by this survey. Total number of specimens of cricetid and zapodid rodents obtained by snap trapping are given in parentheses

- Order Insectivora
  - Family Soricidae
    - *Sorex cinereus,* masked shrew
    - *Sorex obscurus,* dusky shrew
- Order Rodentia
  - Family Sciuridae
    - *Eutamias minimus,* least chipmunk
    - *Spermophilus parryii,* arctic ground squirrel
    - *Tamiasciurus hudsonicus,* American red squirrel
    - *Glaucomys sabrinus,* northern flying squirrel
  - Family Cricetidae
    - *Peromyscus maniculatus,* deer mouse (498)
    - *Clethrionomys rutilus,* northern red-backed vole (495)
    - *Phenacomys intermedius,* heather vole (23)
    - *Microtus pennsylvanicus,* meadow vole (111)
    - *Microtus oeconomus,* tundra vole (61)
    - *Microtus longicaudus,* long-tailed vole (45)
    - *Microtus miurus,* singing vole (40)
    - *Lemmus sibiricus,* brown lemming (4)
    - *Synaptomys borealis,* northern bog lemming (5)
  - Family Zapodidae
    - *Zapus hudsonius,* meadow jumping mouse (5)
  - Family Erethizontidae
    - *Erethizon dorsatum,* porcupine
- Order Lagomorpha
  - Family Leporidae
    - *Lepus americanus,* snowshoe hare
  - Family Ochotonidae
    - *Ochotona princeps,* American pika

the singing vole, *M. miurus,* occur near the park. The brown lemming, *Lemmus sibiricus,* has been recorded only recently by Youngman (1975) from this part of the Yukon, and our records represent a further range extension. Voucher specimens are deposited in the Vertebrate Museum, University of British Columbia.

Other rodent species observed were common boreal forest and tundra mammals with broad geographical distributions. The red squirrel, snowshoe hare (*Lepus americanus*), and the porcupine (*Erethizon dorsatum*) are the best examples of these widespread species.

Area Effects

We analyzed the distribution and relative abundance of the cricetid rodents separately for the northern, central, and southern areas depicted in Figure 1. Some of the less common species are not present in all these areas. The singing vole, *Microtus miurus*, has not been caught south of Mile 1050 of the Alaska Highway, and is thus absent from the central and southern areas. *Zapus* has never been caught in the northern areas.

We calculated the abundance of the cricetid species in the different areas by combining data over all months and over all habitats. Figure 2 gives the abundances for 1973 and Figure 3 for 1974. In 1973, 794 rodents were collected in 16 740 trap nights, and in 1974, 490 individuals in 21 870 trap nights. Central areas were trapped little in 1973, and these few data suggest that *Clethrionomys* was quite common in the central areas in 1973 and *Peromyscus* was rare.

Peromyscus and *Clethrionomys* were clearly the dominant species in southern areas in 1973 and 1974. *Peromyscus* constituted 47% of the catch in 1973 (649 specimens total of all species) and 43% in 1974 (114 specimens total of all species), while the corresponding percentages for *Clethrionomys* were 41% and 44%. In the central areas *Clethrionomys* was dominant in 1974 (69% of catch of 157 individuals) and *Peromyscus* was rare; *Microtus pennsylvanicus* was a distant co-dominant composing 13% of the samples. In the northern areas *Peromyscus* was again dominant making up 53% of the catch in 1973 (137 specimens total of all species) and 34% in 1974 (219 specimens total). *Clethrionomys* and a group of three species of *Microtus* were distant co-dominants, with each having about 10% of the catch in 1973, and in 1974 *Microtus pennsylvanicus* (26%) and *Clethrionomys* (20%) were co-dominants with *Peromyscus.*

Populations of small rodents often fluctuate in size from year to year, and hence the relative abundances of the different species can change. The variations among areas shown in Figures 2 and 3 are thus not surprising, and if anything may be less dramatic than one might expect. In general the small mammal communities of the Kluane region are dominated by *Clethrionomys rutilus* and *Peromyscus maniculatus,* which together constitute 70–80% of the catch.

Species diversity for each habitat was calculated from Brillouin's formula and also measured by the number of cricetid species. We used these two diversity measures in a two-way analysis of variance to determine whether the

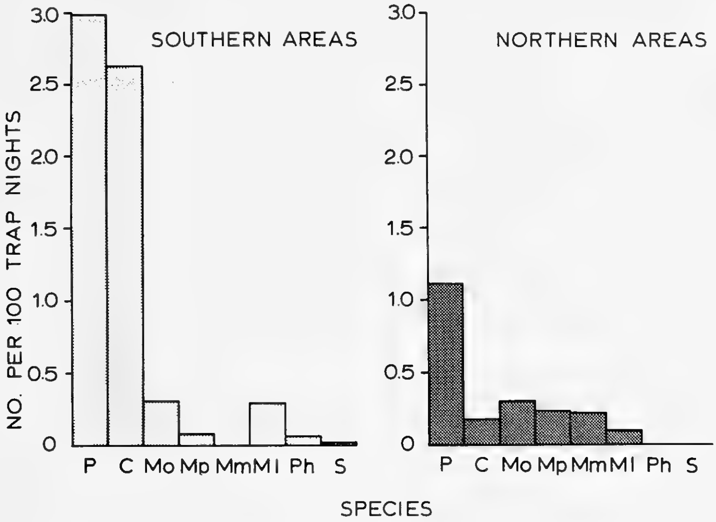

FIGURE 2. Density indices for small rodents during the summer of 1973. P = *Peromyscus maniculatus;* C = *Clethrionomys rutilus*; Mo = *Microtus oeconomus*; Mp = *M. pennsylvanicus*; Mm = *M. miurus*; Ml = *M. longicaudus*; Ph = *Phenacomys intermedius*; S = *Synaptomys borealis.*

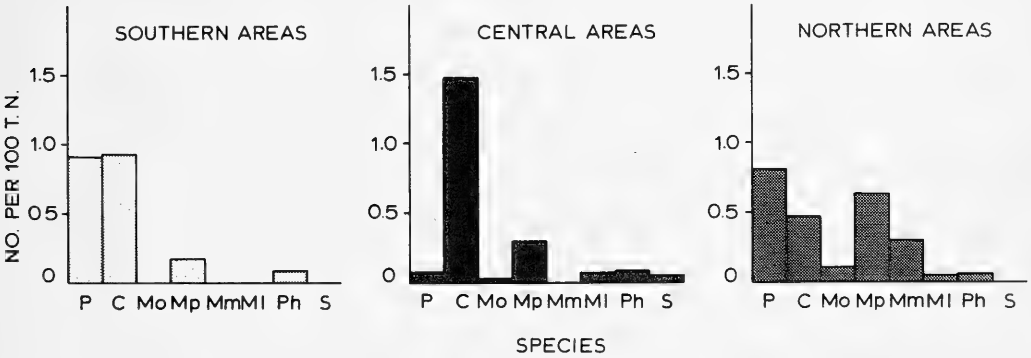

FIGURE 3. Density indices for small rodents during the summer of 1974. Species abbreviations as in Figure 2.

three areas sampled or the different habitats had different species diversity levels. We did two separate analyses, one for 1973 and one for 1974. For 1973 we compared the northern and southern areas and seven habitats sampled in both areas (alpine tundra, subalpine tundra, closed spruce, open spruce, balsam poplar, marsh, and *Dryas*). For 1974 we compared three areas and four habitats sampled in all areas (closed spruce, open spruce, marsh, willow). No comparison was significant, and consequently, within the data we have obtained, we can detect no significant variation in either measure of species diversity in different areas or in different habitats. Table 3 presents the average values for these measures of diversity. We did the same type of analysis on Pielou's measure of evenness and on the community dominance index and again found no significant variations due to area or habitat. Table 3 gives the average values. Thus if a given major habitat is trapped in the Kluane area, one can expect to catch 3.3–3.4 species, with 80–90% of the catch contained in the two dominant species, and an average diversity of

TABLE 3—Average values for measures of species diversity and dominance for small mammals in the Kluane region of the southern Yukon

Year	Number of species	Brillouin's diversity[a]	Evenness[b]	Community dominance index[c]
1973	3.4	0.95	0.76	80.1
1974	3.3	0.79	0.70	91.2

[a] Measured in bits per individual.
[b] Measured as a ratio, maximum 1.0.
[c] Percentage of individuals contained in two most common species.

0.8–0.9 bits per individual.

Habitat Effects

Table 4 indicates the abundance of the cricetid rodents in the different habitats during 1973 and 1974. These data were obtained by grouping the data from the northern, central, and southern areas. Some species, such as *Peromyscus maniculatus*, occur in almost all of the habitats; others, such as *Microtus pennsylvanicus*, are much more restricted in habitat range. We have quantified these differences by the measurement of standardized niche breadth (Pianka 1973) and, in Table 5 the niche breadths of each species for 1973 and for 1974 are shown.

Niche breadths are consistent over the two years, and the two dominant species, *Peromyscus maniculatus* and *Clethrionomys rutilus*, have the widest niches. Changes in niche breadths from year to year seem to parallel changes in abundance for all the *Microtus* species and for *Phenacomys* and *Synaptomys*. As population density increases in these voles, they seem to move into more habitats. This phenomenon did not occur in either of the two dominant species. Both *Peromyscus* and *Clethrionomys* declined in abundance from 1973 to 1974, yet their niche breadths increased slightly.

TABLE 5—Standardized niche breadths of eight cricetid rodents sampled by snap trapping in 18 habitats, Kluane area, Yukon Territory

Species	Standardized niche breadth 1973	1974
Peromyscus maniculatus	0.40	0.42
Clethrionomys rutilus	0.33	0.39
Microtus oeconomus	0.24	0.13
Microtus pennsylvanicus	0.07	0.12
Microtus miurus	0.12	0.12
Microtus longicaudus	0.19	0.16
Phenacomys intermedius	0.14	0.42
Synaptomys borealis	0.06	0.07

Species can occupy different habitats or may overlap each other. For example, both *Synaptomys borealis* and *Microtus pennsylvanicus* reached maximum abundance in marsh habitats (Table 4). To quantify this overlap, we used the niche overlap measure of Pianka (1973). Table 6 shows these values for 1973 and 1974. There is surprisingly little niche overlap for these eight species of rodents. The highest overlap was between *Synaptomys* and *M. pennsylvanicus* in both years. Other significant overlaps occurred only during one year. For example, the two dominant species, *Peromyscus maniculatus* and *Clethrionomys rutilus*, showed high overlap in 1973 but reduced overlap in 1974 when both species were less common. The net result is that most of these rodent species exploited the range of available habitats in different ways so that they did not usually overlap greatly. This result should reduce the possibility of interspecific competition.

The small-mammal fauna of some habitats is very similar. For example, both aspen and closed spruce habitats have *Peromyscus* as the dominant species, *Clethrionomys* as the subdominant, and low densities of *Phenacomys*. We have quantified this measure of similarity among habitats by the use of a hierarchical cluster analysis (Sneath and Sokal 1973, p. 230). The tree diagram of habitat similarity is shown in Figure 4. Similarity was measured by the percentage of similarity (Southwood 1966, p. 333) of the relative abundances.

Habitats in the Kluane region fall into five

TABLE 4—Number of rodents per 100 trap nights for each habitat trapped during 1973 (normal print) and 1974 (italics), Kluane region, Yukon (— indicates no animals caught)

			Closed spruce habitats						Open spruce habitats												
Species	Alpine tundra	Subalpine tundra	Closed spruce — moss	Closed spruce — birch	Closed spruce — willow	Closed spruce — buffaloberry	Closed spruce — aspen	Closed spruce	Open spruce — aspen	Open spruce — willow	Open spruce — birch	Open spruce — buffaloberry	Aspen	Balsam poplar	Balsam poplar — buffaloberry	Marsh	*Dryas drummondi*	Beach Ridge	Willow	Grass-fire weed	Shrub birch — meadow
Peromyscus	0.08	0.24	1.67	2.50	1.05	20.5	4.17	10.67		0.64	2.94		10.27	1.12	4.72	0.14	2.22	11.67	1.73	2.31	
maniculatus	—	—	*1.65*	—	*0.31*	*2.30*	*0.69*	*0.86*	*1.79*	*0.31*	*0.28*	*2.57*	*0.88*	*0.36*		—			*0.50*	—	—
Clethrionomys	0.28	0.16	—	19.16	3.00	10.0	10.0	5.22		1.04	4.90		5.72	0.40	—	0.14	—	0.28	1.48	0.93	
rutilus	—	*0.24*	*0.95*	*5.56*	*3.21*	*0.16*	*1.94*	*0.99*	*1.79*	*0.69*	*1.83*	*0.70*	*1.32*	*0.18*		—			*0.33*	—	—
Microtus	0.67	0.12	—	—	—	—	—	0.11		0.08	—		—	0.30	—	0.83	—	—	—	0.93	
oeconomus	—	*0.14*	—	—	—	—	—	—	—	*0.03*	—	*0.35*	—	—		*0.05*			-	—	—
M.	—	—	0.12	—	—	—	—	—		—	—		—	—	—	2.92	—	0.28	—	—	
pennsylvanicus	—	*0.19*	—	—	*0.10*	—	—	—	—	*0.03*	*0.17*	*0.12*	—	—		*3.06*			—	—	*1.11*
M. miurus	—	—	1.19	—	—	—	—	—		0.16	—		—	0.10	—	—	—	—	—	0.46	
	—	*0.28*	*0.55*	—	—	—	—	—	—	*0.03*	—	—	—	—		*0.05*			—	*1.46*	—
M.	0.02	0.91	—	—	—	—	—	—		0.56	—		0.17	0.10	—	—	0.37	—	—	—	
longicaudus	—		—	—	*0.30*	*0.08*	—	—	—	*0.03*	—	*0.12*	—	—		*0.05*			—	—	—
Phenacomys	—	—	—	—	—	—	—	0.11		—	—		—	0.20	—	—	—	—	0.37	—	
intermedius	—	—	—	—	*0.05*	*0.08*	—	—	—	*0.21*	*0.06*	*0.12*	*0.15*	*0.18*		—			*0.17*	—	*0.22*
Synaptomys	—	—	—	—	—	—	—	—		—	—		—	—	—	0.14	—	—	—	—	
borealis	—	*0.02*	—	—	—	—	—	—	—	—	—	—	—	—		*0.15*			—	—	—
Trap nights 1973	5040	2520	837	360	765	180	360	900		1251	306		594	981	360	720	540	360	810	216	
1974	*360*	*4221*	*1269*	*108*	*1962*	*1260*	*720*	*810*	*279*	*2880*	*1800*	*855*	*1359*	*558*		*2061*			*1206*	*342*	*900*

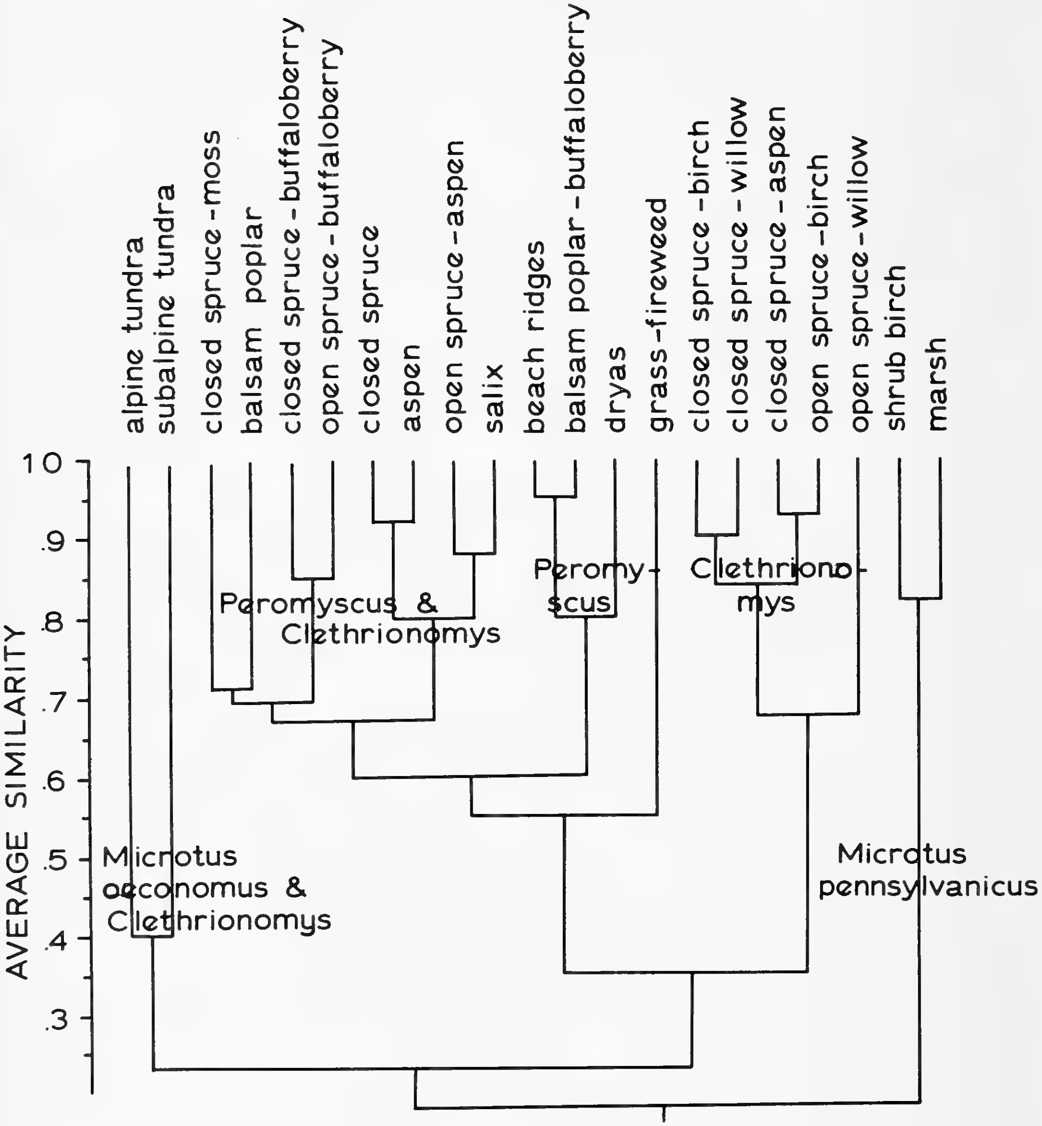

FIGURE 4. Cluster analysis of 21 habitats in Kluane region on the basis of their small-mammal communities.

broad categories on the basis of rodent species. Subalpine and alpine tundras are dominated by *Clethrionomys* and *Microtus oeconomus*. A broad range of common spruce habitats is dominated by a mixture of *Peromyscus* and *Clethrionomys*, and three minor habitats (beach ridges, *Dryas*, and balsam poplar-buffaloberry) are dominated completely by *Peromyscus*. *Clethrionomys* is the major species in a second set of widespread spruce habitats, and finally *Microtus pennsylvanicus* is the major species in marshes and in shrub birch, two communities that are infrequent in the Kluane area.

Year Effects

Populations of most rodents fluctuate dramatically in size. We have indicated in the previous sections how year-to-year changes can

TABLE 6—Niche overlap values based on habitat distribution of eight cricetid rodents in 18 habitats, Kluane area, Yukon Territory. Values above the diagonal are for 1973 data, below the diagonal are for 1974 data. High values for niche overlap are in bold face

Species	*Peromyscus*	*Clethrionomys*	*M. oeconomus*	*M. pennsylvanicus*	*M. miurus*	*M. longicaudus*	*Phenacomys*	*Synaptomys*
Peromyscus	1.0	**0.58**	0.09	0.04	0.09	0.10	0.16	0.00
Clethrionomys	*0.36*	1.0	0.05	0.01	0.02	0.06	0.11	0.01
Microtus oeconomus	**0.53**	*0.11*	1.0	**0.57**	0.25	0.12	0.12	**0.57**
M. pennsylvanicus	*0.03*	*0.03*	*0.17*	1.0	0.04	0.00	0.00	**0.99**
M. miurus	*0.13*	*0.05*	*0.07*	*0.04*	1.0	0.07	0.04	0.00
M. longicaudus	*0.38*	*0.43*	*0.34*	*0.18*	*0.01*	1.0	0.04	0.00
Phenacomys	*0.42*	*0.23*	*0.28*	*0.19*	*0.01*	*0.28*	1.0	0.00
Synaptomys	*0.00*	*0.01*	*0.19*	**0.93**	*0.06*	*0.14*	*0.00*	1.0

affect some overall measures of species diversity and niche overlap. With only two years of data it is impossible to discuss the 3- to 4-year cycles that characterize the populations of many small rodents (Krebs and Myers 1974), and we present here only some preliminary information.

Abundance changes do not necessarily occur in synchrony in the northern, central, and southern areas shown in Figure 1. Table 7 presents abundance data for the four species that are most common in our catches. *Peromyscus* densities remained approximately constant in the northern areas from 1973 to 1974, dropped slightly in the central areas, and dropped sharply in southern areas. *Clethrionomys* increased in the northern areas from 1973 to 1974, but declined in central and especially in southern areas in 1974. The two closely related voles, *Microtus oeconomus* and *M. pennsylvanicus,* showed quite different density shifts from 1973 to 1974.

Other species were sometimes judged to be at high density on restricted areas. *Microtus miurus* was relatively common in tundra areas in 1974, and less common in 1973. A localized high density of *Microtus longicaudus* was found in subalpine tundra near Sockeye Lake in 1973, but we have not found this species in large numbers anywhere else. *Phenacomys intermedius* was more common in 1974 than in 1973 but was still an uncommon species. We have not yet found a brown lemming population at high density and this species is very rare in the Kluane areas we have studied.

Discussion

There are few detailed surveys of the small mammals of the southwestern Yukon. The most detailed survey was carried out by N. A. Olsen (1968. An ecological study of the Alsek River area, 1967. B.Sc. thesis in Forestry, University of British Columbia) who surveyed eight habitats along the Alsek River (our southern area). He found a high species divesity in aquatic associations (marsh) along the Dezadeash River, with *Microtus pennsylvanicus* and *Zapus hudsonius* predominating. Our conclusions (see Figure 4) in general agree with those of Olsen who classified dominant species as follows:

Alpine and subalpine	*Microtus oeconomus, Clethrionomys*
Dense spruce forest	*Clethrionomys rutilus*
Open spruce forest	*Peromyscus, Clethrionomys*
Aspen forest	*Peromyscus*

Olsen's study was based on 3737 trap nights and 415 small-mammal captures, and was by far the

TABLE 7—Abundance (number per 100 trap nights) of four rodent species in 1973 and 1974 in different areas. All trap indices are based on a minimum of 360 trap nights; most are based on more than 1000 trap nights. Numbers in parentheses are actual numbers of individuals captured (— indicates no data available)

	Area					
	Northern		Central		Southern	
Species and area	1973	1974	1973	1974	1973	1974
Peromyscus maniculatus						
(a) Subalpine tundra	0.6(6)	0.0(0)	—	0.0(0)	0.0(0)	—
(b) Closed spruce	1.7(18)	1.5(53)	0.3(1)	0.2(2)	8.2(160)	0.8(13)
(c) Open spruce	0.5(5)	1.1(21)	—	0.1(4)	2.1(12)	2.6(16)
Clethrionomys rutilus						
(a) Subalpine tundra	0.1(1)	0.0(0)	—	0.7(10)	0.2(3)	—
(b) Closed spruce	0.1(1)	0.8(29)	5.8(21)	4.6(50)	8.7(171)	1.7(26)
(c) Open spruce	0.6(6)	0.7(13)	—	1.3(42)	3.8(22)	1.5(9)
Microtus oeconomus						
(a) Subalpine tundra	0.3(3)	0.3(6)	—	0.0(0)	0.0(0)	—
(b) Marsh	0.0(0)	0.0(0)	—	0.2(1)	1.7(6)	0.0(0)
Microtus pennsylvanicus						
(a) Subalpine tundra	0.0(0)	0.0(0)	—	0.6(8)	0.0(0)	—
(b) Closed spruce	0.1(1)	0.0(0)	0.0(0)	0.2(2)	0.0(0)	0.0(0)
(c) Open spruce	0.0(0)	0.1(2)	—	0.1(3)	0.0(0)	0.0(0)
(d) Marsh	3.9(14)	4.7(55)	—	1.1(6)	1.9(7)	0.6(2)

most complete survey for this area.

Five other surveys of the small mammals of the Kluane region have been reported in the literature. Rand (1945) drew together some general data on the mammals of the Yukon. Baker (1951) reported on some collections taken along the Alaska Highway and the Haines Highway, including a northward range extension for *Phenacomys intermedius* to the south end of Dezadeash Lake. Cameron (1952) reported on further collections in the area, including a northern range extension for the northern flying-squirrel, *Glaucomys sabrinus*, at Kathleen River. Banfield (1961) described a survey to the northern side of the park, and obtained a range extension for *Peromyscus maniculatus* at Wade Creek on the Donjek River.

There has been little information on the distribution of the singing vole, *Microtus miurus*, in the Kluane region. Murray and Murray (1969) described this species from its haypiles and sounds as being present between Sheep and Bullion Creeks in the Slims River area and on the north side of Steele Valley. Rand (1945) reported this species from the "St. Elias area" and cited a collection by C. H. D. Clarke at Tepee Lake. Youngman (1975) recorded the singing vole from Sheep Mountain and the head of Kluane Lake. We did not record this vole from either Observation Mountain or Vulcan Mountain, but we did obtain specimens from a live-trapping area at Mile 1050 on the Alaska Highway. We can find no records of *Microtus miurus* south of this locale, and this location is the currently known southern limit of the singing vole.

The brown lemming (*Lemmus sibiricus*) has never been recorded from the Kluane Game Sanctuary, and we have obtained two specimens from a live-trapping area at Bear Creek Summit, above Mile 1029 on the Alaska Highway. We have also obtained two specimens from a marsh near Mile 1047 on the Alaska Highway and two additional specimens from the Chikat Pass area of British Columbia. The maps of the brown lemming's distribution presented in Hall and Kelson (1959, p. 759) and in Banfield (1974, p. 186) are in error. Youngman (1975) was the first to record the presence of the brown lemming in the southwestern Yukon, and we have extended the distribution still further to the south.

Species diversity among small rodents is relatively high in the Kluane area. Hawes (1975,

p. 90) has shown that the highest diversity of microtine rodents in North America occurs in the mountains of the Yukon and Alaska. We have caught a higher diversity of rodents in trap-lines at Kluane than we have in similar trapping near Vancouver, British Columbia, near Berkeley, California, or in southern Indiana. Most habitats in Kluane contain three to four species of cricetid rodents, and a marsh along the Dezadeash River contained six species, the highest diversity we found in any habitat. Some competition might be expected in this situation, particularly among similar voles such as *Microtus oeconomus* and *M. pennsylvanicus.*

There is little information of a specific nature on habitat selection of small rodents in the Kluane region, except for the report by Olsen described previously. We cannot explain for any of these small mammals why they live in some habitats but not in others. In order to understand habitat preferences we would have to know the food habits and the competitive relationships among the species, and this work is yet to be done. A field study of *Peromyscus maniculatus* would be particularly interesting; at the edge of its geographic range, this species is a dominant in many habitats and has the broadest niche breadth of all the small mammals. These problems now await an experimental attack.

Acknowledgments

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Literature Cited

Baker, R. H. 1951. Mammals taken along the Alaska Highway. University of Kansas Publications, Museum of Natural History 5(9): 87–117.

Banfield, A. W. F. 1961. Notes on the mammals of the Kluane Game Sanctuary, Yukon Territory. National Museum of Canada Bulletin 192: 128–135.

Banfield, A. W. F. 1974. The mammals of Canada. University of Toronto Press, Toronto. 438 pp.

Cameron, A. W. 1952. Notes on mammals of Yukon. National Museum of Canada Bulletin 126: 176–184.

Hall, E. R. and **K. R. Kelson.** 1959. The mammals of North America. 2 volumes. Ronald Press, New York.

Hawes, D. B. 1975. Experimental studies of competition among four species of voles. Ph.D. thesis, Department of Zoology, University of British Columbia, Vancouver.

Krebs, C. J. 1964. The lemming cycle at Baker Lake, Northwest Territories, during 1959–62. Arctic Institute of North America Technical Paper 15. 104 pp.

Krebs, C. J. and **J. H. Myers.** 1974. Population cycles in small mammals. Advances in Ecological Research 8: 267–399.

Murray, B. M. and **D. F. Murray.** 1969. Notes on mammals in alpine areas of the northern St. Elias Mountains, Yukon Territory and Alaska. Canadian Field-Naturalist 83: 331–338.

Pianka, E. R. 1973. The structure of lizard communities. Annual Review of Ecology and Systematics 4: 53–74.

Pielou, E. C. 1966. The measurement of diversity in different types of biological collections. Journal of Theoretical Biology 13: 131–144.

Rand, A. L. 1945. Mammals of Yukon, Canada. National Museum of Canada Bulletin 100. 93 pp.

Sneath, P. H. A. and **R. R. Sokal.** 1973. Numerical taxonomy. Freeman, San Francisco. 573 pp.

Southwood, T. R. E. 1966. Ecological methods. Methuen, London. 391 pp.

Youngman, P. M. 1975. Mammals of the Yukon Territory. National Museums of Canada, Publications in Zoology Number 10. 192 pp.

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Plants of Coats Island, Hudson Bay, Keewatin District, Northwest Territories

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Gillett, John M. 1976. Plants of Coats Island, Hudson Bay, Keewatin District, Northwest Territories. Canadian Field-Naturalist 90(4): 390-396.

Abstract. The combined plant collections of A. E. Porsild, H. B. Collins, and the author from Coats Island, Hudson Bay, Northwest Territories are brought together into one comprehensive report. The list of species comprises 20 mosses, 1 hepatic, 14 lichens, and 116 species of vascular plants. The species of lichens, mosses, the hepatic, and 36 species of higher plants are additions to the known flora of Coats Island.

Résumé. Les collections de plantes cueillies sur l'Ile Coats, Baie d'Hudson, Territoires du Nord-Ouest, par A. E. Prosild, H. B. Collins et l'auteur, sont réunies dans un seul rapport complet. La liste des espèces comprends 20 mousses, 1 hépatique, 14 lichens, et 116 espèces de plantes vasculaires. Les lichens, mousses, hépatique, et 36 espèces de plantes vasculaires sont des additions à la flore déjà connue de l'Ile Coats.

During the period 21-27 July 1975, I had an opportunity to accompany one of our museum ornithologists, Henri Ouellet, on a short visit to Coats Island, Hudson Bay, site of the now extinct Sadlermiut culture (Bruemmer 1969). As I can ascertain, the number of plant collections taken from this island is relatively small. There are two collections in the National Herbarium, one made by A. E. Porsild[1] on 18 September 1930 from the east coast, and another made by Henry B. Collins, Jr. of the Smithsonian Institution (Collins 1955, 1956) from the north coast directly across from Bencas Island, 19-20 July 1954. Polunin (1940) did not refer to any earlier collections from Coats Island nor did he cite any publications pertinent to the subject in his papers on the equally interesting Mansel Island situated to the east of Coats Island (Polunin 1938b, 1947) nor in his paper on Southampton Island (Polunin 1938a). Hence it appears that we have rather scant botanical information on this southern arctic island, some 130 km long and 70 km wide. Porsild's collections were made in approximately the same portion of the island as mine but because each of us found species that the other did not, then presumably the localities, or at least the habitats, were not identical. The description of the area visited given in Porsild's report does not altogether accord with that of the area I visited. My cryptogamic collections are probably the first for the area, but owing to time limitations and insufficient acquaintance with the species of the group, are obviously incomplete.

The island is seldom visited except by Eskimo hunters in the fall. The arctic explorer Thomas Button saw it in 1612 and named Cape Pembroke; he also named the southwest tip Cape Southampton and the southeast tip Carys Swan Nest. A Hudson Bay Company post was set up in 1918 but this was moved to Coral Harbour in 1924 (Stewart 1935). A number of caribou surveys have been carried out both to assess the numbers of animals and to transfer them to 100-mi(160-km)-distant Southampton Island. All of the remaining surveys were by air and include those of Tener,[2] Harington,[3] Look,[4] and Parker,[5] so no collections could have been made.

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[1] Porsild. A. E. 1930. Report. Northwest Territories and Yukon Branch, Department of Indian and Northern Affairs, Ottawa. 42 pp.

[2] Tener, J. S. 1961. Coats Island caribou survey. Canadian Wildlife Service Report 893. 2 pp.

[3] Harington, C. R. 1965. Coats Island caribou survey, 1965. Canadian Wildlife Service Report 1420. 9 pp.

[4] Look, A. L. 1967. Coats Island caribou survey. Report to the Regional Administrator of the Arctic. 2 pp.

[5] Parker, G. R. 1970. Coats Island caribou survey. Canadian Wildlife Service Report 1419. 10 pp. + map.

In his action-packed report, Manning[6] did not mention any biological collections made by any member of his team.

Our collections were taken from the south side of Cairn Cove at 62°49′ N, 81°56′ W (Map 45J, UTM Ref. 17V/MV 452/6967). The camp was set up on the beach near the site of some Sadlermiut ruins. We also had an opportunity to visit for a few hours the edge of the high portion of the island between Cape Pembroke and Cairn Cove at 62°53′ N, 81°55′ W (Map 45J, UTM Ref. 17V/MV 453/6974) on 25 July 1975. The trip was made by rubber boat powered by an outboard motor.

Although a thorough botanical survey of the entire island has never been made, it is evident from a perusal of the total species obtained by three collectors from the northeast part of the island that the number is low (Table 1). The absence of many species may be explained by isolation. Many species may simply have never been able to reach the island or, having reached it, may not have been able to become established through lack of suitable habitats. Porsild[1] suggested that seeds of species of the Leguminosae are too heavy for wind transportation. Because Coats Island is located at the mouth of Hudson Bay and midway between the east and west shores, its floristic composition could include either eastern or western elements, or both.

An analysis of the floral list by comparison with the species lists by Hultén (1958, 1964, 1970) indicates that 68 (60%) of the 114 species of vascular plants can be classified as "circumpolar," and 21 (18%) can be considered as "Amphi-Atlantic." Twenty-five remain which do not fit into either category. Twenty-two (19%) of these have a general Canadian arctic distribution (Porsild 1957) and 3 (3%) can be considered to be eastern Arctic in their affinities. Evidently Coats Island, geographically southern Arctic and isolated from the major land mass, possesses a flora consisting chiefly of northern and eastern elements. This indicates that colonization following retreat of the ice has probably taken place from those directions rather than from the west. But this may be true only for the northeast corner of the island whence the collections were made. It would be of considerable interest to collect from the southwest corner and to compare the lists.

The location of Coats Island is shown in Figure 1. Except for a high Precambrian area with steep cliffs rising to about 180 m in the extreme northeast corner, the island consists chiefly of relatively flat-lying Paleozoic rocks with an undulating surface that does not rise above 100 m. On the flat portion, the most prominent topographical feature seems to be the raised beaches and the numerous tundra ponds associated with them. The complex pattern of abandoned beaches record the rise of the land as the sea regressed from the Paleozoic terrain following deglaciation. A large irregular lake occupies the center of the island.

Coats Island has been deglaciated in rather recent time (7500–8000 years B.P.) and is isolated from the mainland. Geologists are of the opinion (W. Blake, personal communication) that, as the glacial ice melted, the first open channel ran along the east side of Hudson Bay. This would suggest that the melt continued towards the center of the Keewatin ice sheet. Whether Coats Island emerged before or after the west coast of the Bay is not known. Probably only the high northeastern part of Coats Island remained above the sea following the retreat of the glaciers.

The Precambrian rocks are represented by a wide variety of gneisses and migmatites. The gneissic units consist of quartz-feldspar gneiss, garnet gneiss, and amphibolite gneiss. Layering is well developed and in places the layers are extremely folded and contorted. The migmatites range from massive to foliated granitic-textured rocks that contain discontinuous patches and remnants of layered gneiss. Quartz monzonite sills are locally present.

The Paleozoic terrain is underlain by limestones and dolomites of Late Ordovician and Middle Silurian age. These relatively undeformed strata onlap Precambrian crystalline rocks and dip gently southward at one or two degrees.

Because Coats Island is uninhabited, information regarding climate must be extrapolated

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[6] Manning. T. H. 1967. A report on the transfer of Barren-ground Caribou from Coats Island to Southampton Island, N.W.T. Canadian Wildlife Service Report 1143. 29 pp.

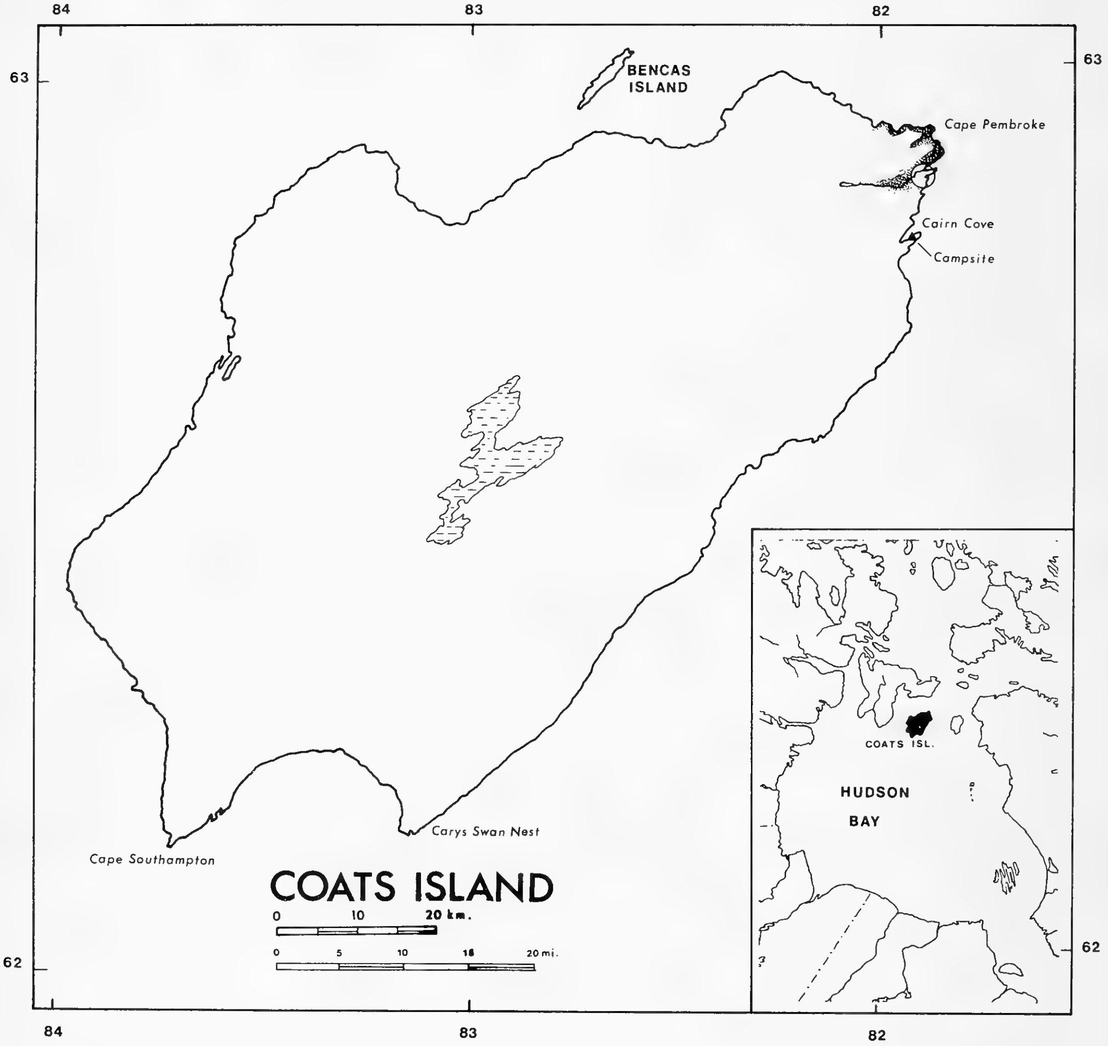

FIGURE 1. The study area, Coats Island, Hudson Bay, Northwest Territories.

from data for adjacent areas which have weather stations, such as Coral Harbour and Chesterfield (Bryson and Hare 1974). Of these two, the former is closer and perhaps approximates conditions on Coats. The mean daily temperatures for Coral Harbour, Southampton Island during the summer months are as follows: June 2.3°C, July 8.3°C, August 7.6°C, and September 0.9°C. Precipitation for the same months runs 26, 35, 38, and 33 mm, respectively. It was clear and comfortably warm while we were on the island except for a shower when we arrived and strong winds during one night.

TABLE 1 Checklist of the known flora of Coats Island—Species collected by A. E. Porsild are prefaced by an asterisk (*) and those collected by Collins by a plus (+); if no mark precedes the name, the species was collected only by the author; my collections are indicated by my collection number. The first set of vascular plants is deposited in the National Herbarium (CAN) and over a dozen replicate sets will be distributed.

Lichens

Cladoniaceae

Cladonia coccifera (L.) Wild. admixed with *Ochrolechia frigida* (Sw.) Lynge — 16892C; on rocks of ridge

Lecideaceae
Rhizocarpon geographicum (L.) DC. — 16912A; on pebbles

Parmeliaceae
Alectoria minuscula Nyl. — 16914; on pebbles
A. nigricans (Ach.) Nyl. — 16808B; dry tundra
Cetraria delisei (Borg ex Schaer.) Th. Fr. — 16808A; 16893; dry tundra
C. islandica (L.) Ach. — 16778; on rocky ridge
C. nivalis (L.) Ach. — 16792; on rock ledges
Parmelia alpicola Th. Fr. — 16912C; on pebbles

Stereocaulaceae
Sterecaulon alpinum Laur. — 16892A; on ridge rocks

Teloschistaceae
Xanthoria sorediata (Vain.) Poelt — 16921; on dry tundra

Umbilicariaceae
Omphalodiscus decussatus (Vill.) Schol. — 16911A; on rock
Umbilicaria havaasii Llano — 16911B; on rock
U. hyperborea (Ach.) Ach. — 16892B; 16912B; on ridge rocks and pebbles

Verrucariaceae
Verrucaria sp. — 16912D; on pebbles

Mosses

Ditrichaceae
Distichium capillaceum (Hedw.) B.S.G. — 16724, 16917: sand dunes and beaches

Dicranaceae
Dicranum muehlenbeckii B.S.G. — 16756; among rock litter with *Luzula confusa*

Pottiaceae
Tortella fragilis (Drumm.) Limpr. — 16829A; (admixture) on rock
Tortula ruralis (Hedw.) Gaertn., Meyer & Scherb. — 16843; habitat for *Draba nivalis* on rock ledges

Grimmiaceae
Grimmia alpicola Hedw. var. *rivularis* (Brid.) Wahlenb. — 16829; (admixture with *Tortella fragilis*)
Rhacomitrium lanuginosum (Hedw.) Brid. — 16713, 16920; rocky dry outcrops, a very common species

Bryaceae
Bryum calophyllum R. Br. — 16748; sandy beach
B. cryophilum Mart. — 16859; along a stream

Mniaceae
Plagiomnium ellipticum (Brid.) Kop. — 16702; wet beach slope

Aulacomniaceae
Aulacomnium palustre (Hedw.) Schwaegr. — 16860, 16706; meadows

Catoscopiaceae
Catoscopium nigritum (Hedw.) Brid. — 16786; admixture with *Campylium stellatum* on moist tundra: 16918; associated with *Carex atrofusca* Schk.

Amblystegiaceae
Calliergon giganteum (Schimp.) Kindb. — 16810; admixture with *Drepanocladus revolvens* at edge of pond
Campylium stellatum (Hedw.) C. Jens. — 16786; admixed with *Catoscopium*
Drepanocladus exannulatus (B.S.G.) Warnst. — 16725A, 16747
D. lycopodioides (Brid.) Warnst. — 16725; in a pond with *Hippuris vulgaris* and admixed with the above moss species
D. revolvens (Sw.) Warnst. — 16810; admixture with *Calliergon giganteum* at edge of a pond
D. uncinatus (Hedw.) Warnst. — 16696, 16728; pebble beach

Hypnaceae
Hypnum revolutum (Mitt.) Lindg. — 16695A; on beach pebbles

Hylocomiaceae
Hylocomium splendens (Hedw.) B.S.G. — 16779; on rocky ridge

Polytrichaceae
Pogonatum alpinum (Hedw.) Roehl. — 16919; on dry tundra

Hepaticae

Marchantiaceae
Marchantia polymorpha L. — 16913; on wet depression behind sea beach, large patch with *Ranunculus hyperboreus*

Vascular Plants

Polypodiaceae
Cystopteris fragilis (L.) Bernh. — 16846; at base of cliff
**Woodsia alpina* (Bolton) S.F. Gray

Equisetaceae
Equisetum arvense L. — 16855; about Sadlermiut dwelling remains
**E. scirpoides* Michx. — 16743; rocky stream gully
+*E. variegatum* Schleich. — 16803; sandy margin of stream

Lycopodiaceae
Lycopodium selago L. — 16716, 16830; rock outcrops and ledges

Gramineae
+**Alopecurus alpinus* L. — 16707; abundant on grassy slopes
+**Arctagrostis latifolia* (R. Br.) Griseb. — 16722, 16782, 16907; abundant in wet meadows
+**Arctophila fulva* (Trin.) Anders. — 16741; sand beach
+**Deschampsia brevifolia* R. Br.
+*Dupontia fischeri* R. Br. — 16721, 16794; wet meadows
Dupontia fischeri ssp. *psilosantha* (Rupr.) Hult. 16807, 16905; pond margins
+*Elymus mollis* Trin. — 16690; dominant beach grass, often forming a zone
**Festuca brachyphylla* Schultes — 16759, 16840; soil pockets on rock outcrops

*_Hierochloe alpina_ (Sw.) R. & S. — 16771, 16840; dry rocky ridges
+*_H. pauciflora_ R. Br.
+*_Pleuropogon sabinei_ R. Br.
*_Poa alpina_ L. — 16849; about Sadlermiut site
+_P. alpigena_ (Fr.) Lindm.
+*_P. arctica_ R. Br. — 16751, 16764, 16770; chiefly in bolder litter, some grassy areas
P. glauca Vahl. — 16841, 16865, 16858, 16895; wide range of habitats
Puccinellia langeana (Berl.) Th. Sor. — 16739, 16890; on sandy beach and in soil patches on rocky ridge
P. phryganodes (Trin.) Scribn. — 16740; abundant on tidal flats
Trisetum spicatum (L.) Richt. — 16730, 16852; common on beach in _Elymus mollis_ zone and about Sadlermiut ruins

Cyperaceae
*_Carex atrofusca_ Schk. — 16817, 16867, 16901; abundant in wet tundra meadows
C. bicolor All. — 16898, 16899; wet mud at border of pond
C. bigelowii Torr. — 16818, 16904; wet tundra ponds
C. capillaris L. — 16897; in tufts in a meadow; mentioned by Porsild, but no specimen found in CAN nor is species listed in his notes
*_C. glacialis_ Mack.
C. glareosa Wahlenb. var. _amphigena_ Fern. — 16823; moist tundra
*_C. lachenalii_ Schk. — 16795, 16827, 16848, 16864; common in several habitats, grassy meadow, about ruins, gravel stream beds
C. maritima L. — 16903; wet meadow back of beach area
+*_C. membranacea_ Hook. — 16784, 16834, 16850; meadows and about ruins
*_C. misandra_ R. Br. — 16712, 16799, 16801; dry rock outcrops
*_C. nardina_ Fries — 16717; rock outcrops
C. rariflora (Wahlenb.) Sm. — 16787; wet soggy tundra
+_C. saxatilis_ L.
C. scirpoidea Michx. — 16757, 16802, 16806, 16900; wet tundra and sandy stream beds
+*_C. stans_ Drej. — 16815; edge of pond
C. ursina Dewey — 16734, 16856; small clumps on tidal beach
*_Eriophorum angustifolium_ Honck. — 16790; margin of ponds, wet tundra
+_E. scheuchzeri_ Hoppe — 16789, 16906; sparse on wet tundra
Kobresia simpliciuscula (Wahlenb.) Mack. — 16839; dry rocky ridge

Juncaceae
*_Juncus biglumis_ — 16785; wet soggy tundra
*_Luzula confusa_ Lindeberg — 16752, 16908; occasional in rock litter and on grassy slopes
*_L. nivalis_ (Laest.) Beurl.

Liliaceae
*_Tofieldia pusilla_ (Michx.) Pers. — 16745; common on _Dryas_-covered plain

Salicaceae
+_Salix arctica_ Pallas — 16775, 16776; among rocks
S. arctophila Cockerell — 16729; sand and rocks of beach
+_S. herbacea_ L. — 16714, 16774; sheltered areas of rocky outcrop
*_S. lanata_ L. ssp. _calcicola_ (Fern. & Wieg.) Hult. — 16732, 16804; banks of stream
+_S. reticulata_ L. — 16782A; common on tundra slopes

Polygonaceae
+_Oxyria digyna_ (L.) Hill — 16847; ledges of cliffs and about ruins
+_Polygonum viviparum_ L. — 16780; dry _Dryas_-covered tundra

Caryophyllaceae
Arenaria humifusa Wahlenb. — 16700, 16785, 16761; deeply rooted in sand
+_A. peploides_ L. — 16694; in clumps on sand beach
A. uliginosa Schl. — 16826; sparse among rocks
*_Cerastium alpinum_ L. — 16701, 16742, 16820, 16855; beaches and meadows
+*_Melandrium apetalum_ (L.) Fenzl. ssp. _arcticum_ (Fr.) Hult. — 16720, 16782, 16857; wet meadows, tundra hummocks
Silene acaulis L. var. _exscapa_ (All.) DC. — 16715, 16821; scattered on rock outcrop
Stellaria humifusa Rottb. — 16763, 16793; top of shore of a salt-water pond
S. laeta Richards. — 16736; between beach dunes. Can be distinguished from _S. longipes_ by the larger flowers and brownish leaves
*_S. longipes_ Goldie — 16735, 16737, 16837; beach dunes and cliff ledges

Ranunculaceae
Ranunculus aquatilis L. var. _eradicatus_ Laest. — 16813; floating in pond
R. hyperboreus Rottb. — 16749, 16805, 16915; beaches, often in areas of decomposed seaweed
R. pedatifidus Sm. var. _leiocarpus_ (Trautv.) Fern. — 16708, 16811, 16851; abundant on grassy slopes and in meadows
R. pygmaeus Wahlenb. — 16766; sheltered rock outcrop at beach level
R. sulphureus Sol. — 16869; meadow

Papaveraceae
+*_Papaver radicatum_ Rottb. — 16750, 16861; sparse among rock litter

Cruciferae
Arabis alpina L. — 16862; along a stream
+*_Cardamine pratensis_ L. var. _angustifolia_ Hook. — 16731; tidal flat at mouth of a stream
+_Cochlearia officinalis_ L. — 16703; common in the _Elymus mollis_ beach zone
Draba glabella Pursh — 16910; gravel area
+_D. lactea_ Adams — Porsild's material under this name
+*_D. alpina_ L. — 16809, 16767, 16865, 16727, 16858, 16698, 16909, 16709; the common _Draba_ species of beaches, occasional in meadows

D. nivalis Liljebl. — 16845, 16842, 16758A; rock ledges and edges of ponds
+*D. groenlandica* Ekm.
+**Eutrema edwardsii* R. Br. — 16699, 16753, 16768, 16777, 16862; common in mossy damp places
**Lesquerella arctica* (Wormsk.) Wats. — 16819; sparse in a blow-out area of stream estuary

Saxifragaceae
**Chrysosplenium tetrandrum* (Lund) Fries — 16704; abundant in meadows and on grassy slopes
**Saxifraga aizoides* L. — 16733, 16812; common but widely spaced on the estuary plain
+**S. caespitosa* L. — 16693, 16726, 16796, 16822, 16836; abundant everywhere but extremely variable
+**S. cernua* L. — 16705; abundant on grassy slopes
+**S. hirculus* L. — 16709; common in meadows
**S. nivalis* L. — 16754; widely scattered in rock litter
+**S. oppositifolia* L. — 16695, 16765; abundant in most dry habitat. Past flower when we arrived
**S. rivularis* L. — 16825, 16916; hidden among rocks
**S.* cf. *tenuis* (Wahlenb.) Sm.
+**S. tricuspidata* Rottb. — 16755, 16894; common in patches in dry areas

Rosaceae
+**Dryas integrifolia* M. Vahl — 16821; common on dry tundra
**Potentilla hyparctica* Malte var. *elatior* (Abrom.) Fern. (no specimen in CAN under this taxon)
P. pulchella Pursh — 16760, 16896; dry sandy gravel on ridge
**Rubus chamaemorus* L.

Empetraceae
Empetrum nigrum L. — 16891; common on dry slopes

Onagraceae
**Epilobium latifolium* L. — 16738; occasional patches on rocky slopes

Hippuridaceae
Hippuris vulgaris L. — 16710; in ponds and along streams

Pyrolaceae
**Pyrola rotundifolia* L. ssp. *grandiflora* (Rad.) Andres — 16866; cliff ledges

Ericaceae
**Arctostaphylos alpinus* L.
**Cassiope hypnoides* (L.) D. Don
C. tetragona (L.) D. Don — 16798; snow-melt areas in lee of rock outcrops
**Ledum decumbens* L. reported by Porsild (1930) but no specimen found (CAN)
**Rhododendron lapponicum* L.
**Vaccinium vitis-idaea* L. — Several Ericaceous plants which Porsild collected and I did not, were probably restricted to the igneous hill which I did not have an opportunity to visit
**V. uliginosum* L. var. *alpinum* Bigel.

Diapensiaceae
**Diapensia lapponica* L. — 16828; hollows on dry ridge

Boraginaceae
Mertensia maritima (L.) F.J. Gray — 16692; sparse on sandy beach

Scrophulariaceae
+**Pedicularis flammea* L. — 16719; on hummocks in wet tundra
+**P. hirsuta* L.
**P. sudetica* Willd. — 16711, 16788, 16814; common on wet soggy tundra

Campanulaceae
**Campanula uniflora* L. — 16773, 16838; among rocks on dry ridge

Compositae
Antennaria canescens (Lge.) Malte — 16844; on rock ledges
**Chrysanthemum integrifolium* Richards. — 16718; on a flat dry rocky place on raised beach
* *Erigeron unalaschkensis* (DC.) Vierh (=*E. humilis* Grah.) — in Porsild's notes but no specimen found in CAN
+*Matricaria ambigua* (Led.) Kryl. — common on beach. This species was photographed but I neglected to take a specimen
+*Senecio congestus* (R. Br.) DC.

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R. R. Ireland identified the mosses and Pak-Yau Wong the lichens; these collections are in CANM and CANL respectively. G. A. Mulligan, Agriculture Canada, checked my determinations of *Draba*.

Literature Cited

Bruemmer, F. 1969. Southampton, Coats and Bencas Islands. North 16(4): 26–33.

Bryson, R. A. and **F. K. Hare.** 1974. World survey of climatology. Volume 11. Climates of North America. Elsevier, Amsterdam. 420 pp.

Collins, H. B. 1955. Archaeological work on Southampton and Coats Island. Arctic Circular 8(1): 2–5.

Collins, H. B. 1956. Archaeological investigations on Southampton and Coats Islands, N.W.T. National Museum of Canada, Annual Report 1954–55. pp. 82–89.

Hultén, E. 1958. The Amphi-Atlantic plants and their phytogeographical connections. Kungliga Svenska Vetenskapsakademiens Handlingar Series 4, Volume 7(1). 340 pp.

Hultén, E. 1964. The circumpolar plants. I. Vascular cryptogams, conifers, monocotyledons. Kungliga Svenska Vetenskapsakademiens Handlingar Series 4, Volume 8(5). 275 pp.

Hultén, E. 1970. The circumpolar plants. II. Dicotyledons. Kungliga Svenska Vetenskapsakademiens Handlingar Series 4, Volume 13(1). 463 pp.

Polunin, N. 1938a. The flora of Southampton Island, Hudson Bay. Journal of Botany, April 1938. pp. 93–103.

Polunin, N. 1938b. Vascular plants from Mansel (Manfield) Island, N.W.T. Canadian Field-Naturalist 52: 5–9.

Polunin, N. 1940. Botany of the Canadian Eastern Arctic. National Museum of Canada Bulletin 9, Part 1. 408 pp.

Polunin, N. 1947. Additions to the floras of Southampton and Mansel Islands, Hudson Bay. Contributions from the Gray Herbarium 165: 94–105 (Mansel Island, pp. 102–105).

Porsild, A. E. 1957. Illustrated flora of the Canadian Arctic Archipelago. National Museum of Canada Bulletin 146. 209 pp.

Stewart, S. J. 1935. Coats Island. Beaver. pp. 38–40.

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Estimation of Winter Mortality of Deer in Quebec

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Crête, Michel. 1976. Estimation of winter mortality of deer in Quebec. Canadian Field-Naturalist 90(4): 397–403.

Abstract. Snow depth, snow compaction, deviation of the minimum and maximum temperatures from the general mean, deer-track density, proportion of trails, sinking depth of deer in snow, the average diameter of the twigs at the point of browsing (dpb) of the most important deciduous shrub species and the area covered by the deer yard were measured every 2 weeks in a deer wintering area during the winters of 1973–1974 and 1974–1975. The mean dpb was used to estimate the quality of the deer browse. A multiple regression analysis revealed that the dpb variation through the winter was related to the sinking depth of deer in snow, to the time elapsed since the beginning of the winter, to the deviation of the minimum temperature from the general mean, and to the snow depth. I hypothesize that the quality of food ingested by deer, as estimated by the dpb, is related to the winter mortality of deer. Correlation coefficients were computed between the mean dpb and (1) the total number of deer found dead during the same period of time, (2) the number of deer dead from predation during this time interval, (3) the marrow fat content of those carcasses, and (4) the proportion of fawns among the carcasses. Only the last was significant in 1973–1974, whereas the first three were significant in 1975. A comparison between the number of carcasses found during each 2-week interval and each measurement taken in the deer yards showed that the dpb of all the measurements taken in the yards was the best index of deer winter mortality. The use of the dpb as an index of winter mortality could possibly be extended to all the deer range in Quebec.

Résumé. L'épaisseur de neige au sol, sa compacité, l'écart des températures minimale et maximale de la moyenne générale, la densité de pistes de cerfs, la proportion de sentier, l'enfoncement des cerfs dans la neight, le diamètre moyen des ramilles au point de broutage (dpb) de l'espèce décidue la plus importante et la superficie du ravage ont été mesurés à toutes les 2 semaines dans une aire d'hivernage du cerf pendant les hivers 1973–1974 et 1974–1975. Le dpb moyen a été utilisé pour estimer la valeur de la diète des cerfs à toutes les 2 semaines. Une analyse de régression multiple a révélé que la variation du dpb moyen en courant de l'hiver était reliée à l'enfoncement des cerfs dans la neige, au temps écoulé depuis le début de l'hiver, à l'écart par rapport à la moyenne générale de la température minimale et à l'épaisseur de la neige. L'hypothèse a été émise que la qualité de la diète des cerfs au courant de l'hiver telle qu'estimée par les dpb était reliée à la mortalité hivernale. Un coefficient de corrélation a été calculé entre les moyennes des dpb mesurées à toutes les 2 semaines et (1) le nombre de cerfs trouvés morts par toute cause de mortalité, (2) le nombre de cerfs trouvés morts par prédation seulement, (3) le pourcentage de lipide des fémurs de ces carcasses et (4) la proportion de faons parmie ces animaux morts. Seule la dernière relation était significative en 1973–1974, tandis que l'hiver suivant les trois premières l'étaient. Une comparaison entre le nombre de carcasses trouvées à toutes les 2 semaines durant l'hiver et chacune des mesures prises dans les ravages a permis de constater que les dpb était le meilleur indice de mortalité des cerfs parmi ceux considérés. L'expérimentation à la grandeur du Québec de l'emploi des dpb comme indice de mortalité du cerf est suggérée.

The winter mortality of white-tailed deer (*Odocoileus virginianus borealis*) is a very important limiting factor for this species in Quebec. The influence of the winter climate on the fluctuation of the deer harvest during the last decade is significant (Crête 1976). The deer mortality in winter (from December to April) for the last 3 years has represented between 60 to 75% of all the reported deer found dead annually from causes other than hunting (Huot et al. 1973; Bouchard et al. 1974; Bouchard and Gauthier 1975). Four surveys of dead deer, conducted in three deer wintering areas of eastern Quebec during the last two winters revealed that winter mortality affected between 20 and 40% of the estimated yard populations (C. Pichette 1975, unpublished manuscript; F. Potvin and J. Huot 1975, unpublished manuscript; Y. Roussel 1975, personal communication). The winter of 1973–1974 was moderate for this region but the following one was severe.

A network of snow stations was set up through the deer range during the winter of 1974–1975. I evaluated the data collected in order to establish the best measurements for estimating deer mortality in winter and thus for adjusting yearly harvest regulations.

Study Area

The study area included the white-tailed deer wintering areas of St. Côme and Venosta in southwestern Quebec (Figure 1). The St. Côme deer yard was located 70 km north of Montreal

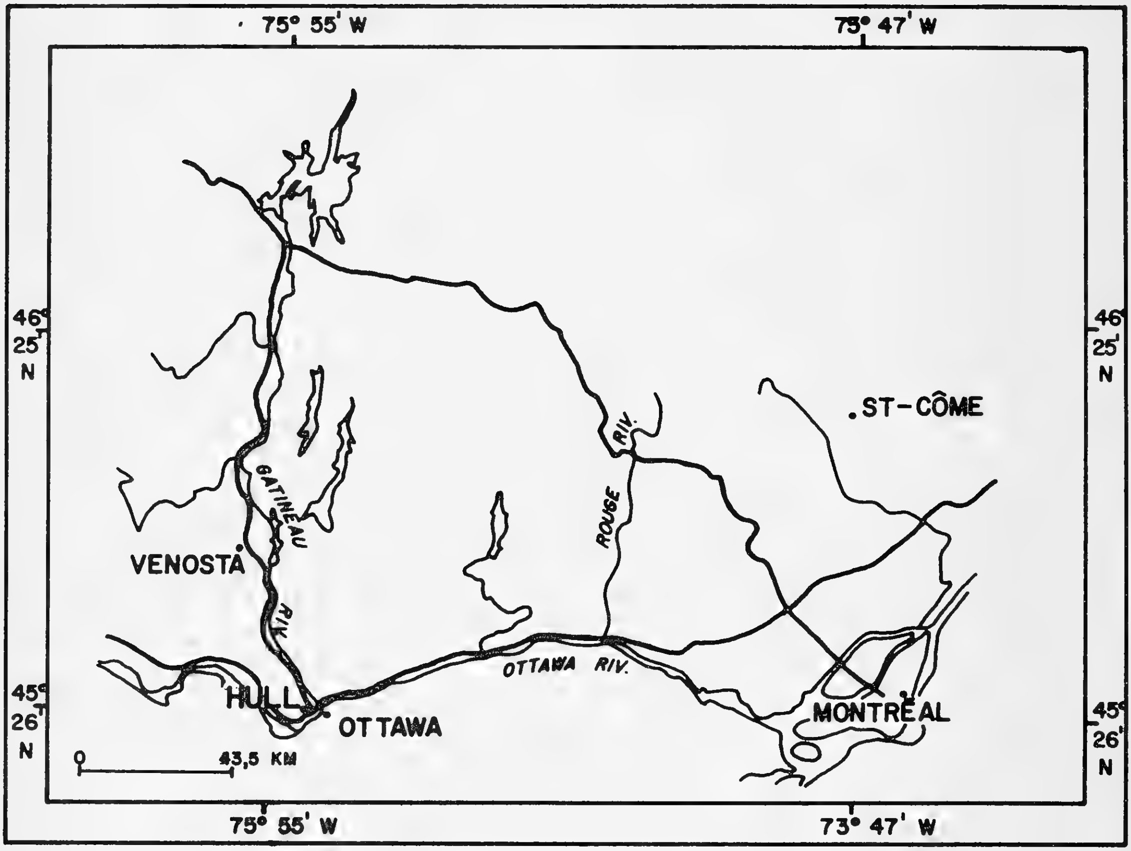

FIGURE 1. Location of the deer wintering areas studied in southwestern Quebec.

and lay in a steep and narrow valley of the Canadian Shield through which the Assomption River flows. The altitude of this wintering area varied between 250 and 450 m and the yard covered approximately 10 km² at the beginning of winter. The total deer population was estimated at 100 animals at the time of the study. Uneven stands of the forest type CBS as described by Huot (1974), interspersed with small abandoned fields formed the center of the yard where the study was conducted. The most important tree species were balsam fir (*Abies balsamea*), spruces (*Picea* sp.), white cedar (*Thuya occidentalis*), and jack pine (*Pinus banksiana*). The most preferred deciduous species of the feeding stratum were red maple (*Acer rubrum*) and sugar maple (*Acer saccharum*).

The deer wintering area of Venosta was 40 km north of Hull and occupied lowland and some hills of the Gatineau Valley. The altitude of the yard varied between 150 and 300 m and was on Canadian Shield bedrock. The wintering area covered about 35 km² at the beginning of the winter. An estimation of the population cannot be put forward for this yard because no surveys were conducted. Forest stands at the center of the yard where the study was carried out belonged to forest types CH_i, H_iC, and CBS described by Huot (1974). Balsam fir, spruces, white cedar, paper birch (*Betula papyrifera*), and aspen (*Populus tremuloides*) are the most frequent tree species, and hazelnut (*Corylus cornuta*) and mountain maple (*Acer spicatum*) are the most abundant shrubs of the feeding stratum (Huot 1972). Approximately one quarter of the area covered by the study was clear-cut for pulpwood 4 years previously; the remaining portion was uneven stands.

Methods

Deer movement and feeding activities and the meteorological data were taken every 2 weeks during the winters of 1973–1974 and 1974–1975. The study area changed from St. Côme the first year to Venosta the following winter. Measured in each wintering area were the snow depth, snow compaction, minimum and maximum temperature, area covered by the yard, deer track density, the proportion of trails, the depth of tracks, and the twig diameter at point of browsing (dpb).

The minimum and maximum temperatures were registered at the closest meteorological station. Their deviations from the general mean of the last 12 years were computed for the 2-week period preceding the field measurements. In 1975 only, the area covered by the yard was mapped from a light fixed-wing aircraft (a Cessna 180 or a Beaver) a few days before the field visit. The snow depth was measured with fixed graduated rods placed in a row 3 m apart (five per row in 1974 and 10 in 1975) in a coniferous and a deciduous stand of the wintering area. Conifers covered between 23 and 40 m^2 of basal area per hectare in the coniferous stand with the same basal area of deciduous stems in the other forest type. Snow compaction was estimated using a type of Verme's (1968) compaction gauge which exerted a pressure of 200 g/cm^2. The gauge was released at the snow level in 1974 and 5 cm above it in 1975. One compaction measurement was taken within a 1-m radius of each snow stake.

Deer track density was computed along a permanent transect walked on snowshoes: the transect was 0.5 km long in 1974 and 1 km long in 1975. All tracks crossing the transect were tallied as "single" or "trails"; two or more tracks following the same direction were tallied as a trail. The total number of single tracks and trails gave the deer track density per linear unit; at the same time the proportion of trails was calculated. The depth of the tracks was measured with a metre ruler in a fresh single track out of the old runways. The depth of the first 10-foot marks of three different tracks along the transect were scaled; the sample tracks were the first three met at three spaced points of the transect in order to eliminate the possibility of measuring the activity of the same deer. Each of those tracks were then followed until fresh browsed twigs of the most important deciduous species were found. The diameter of all browsed twigs on the first stem on which deer had fed were measured with a caliper to the nearest 0.1 mm. The dpb (diameter at point of browsing) values were measured downward on the stem starting at the top until 20 measurements were obtained. When there were not enough twigs browsed on the first stem, the sampling continued on the closest freshly browsed stem. It was then possible to measure on the same sample stems, twigs browsed previously during the winter.

For each field visit, the variables were measured; in 1974 they were taken on eight occasions from the beginning of January to mid-April and in 1975 one more series of observations was added at the end of December.

By analysis of all the variables measured in the yard I tried to verify the hypothesis that in a normal wintering area, the quality of the food ingested by deer depends on their ease of movement. Thus when movement is poor, deer are confined in the center of the yard and their browse supplies are restricted whereas with good movement conditions they have access to much more food around and in the yard. Poor movement conditions produce then a faster deterioration of deer's energetic reserves, which can increase their mortality rate.

The quality of deer diet was evaluated by means of dpb values since there is a direct negative relation between the distance from the terminal bud of a deciduous twig and its crude protein content (Bailey 1967; Cowan et al. 1970). The crude protein content seems a sound index to feeding value since there is generally a negative correlation between crude protein and cell wall constituents (Cowan et al. 1970); these in turn are not very digestible because of a high lignin content (Short and Reagor 1970). The variation of the dpb in relation to snow impediment was first observed on moose (*Alces alces*) in Quebec (M. Crête and E. Audy 1974, unpublished report presented at the 10th North American Moose Conference and Workshop, Duluth, Minnesota). On the other hand, the ease of deer movement depends on the snow quality and on the temperature (Verme 1968; Ozoga and Gysel 1972).

The mathematical relation between the variation of the dpb mean values during the winter and the direct and indirect movement measurements was evaluated through a step-wise multiple regression analysis. The most significant combination of independent variables was taken as the most probable explanation for the observed mean dpb variation. All variables had a significant partial regression coefficient. The time elapsed since the beginning of the winter was also included in the statistical analysis because of the increasing chance of measuring previously browsed twigs as the winter progressed.

To check the value of the browse quality for prediction of the deer mortality rate, the mean dpb values were compared, through a linear regression analysis, to the available data on reported deer mortality. Those direct mortality measurements were the number of deer found dead from all mortality causes in the region, the mean fat content of the deer femurs, the proportion of fawns among the deer carcasses, and the number of deer found dead from predation only. Other data collected in the wintering areas were also related to the mortality measurements in order to check if they were also valuable to predict deer mortality in winter.

Results and Discussion

Many modifications were made to the measurements taken in the deer wintering area studied in 1975 as compared to the year before. The area covered by the yard and the proportion of trails were added to the other movement measurements. Thus the usefulness of additional variables for estimating winter severity and comparison of their values to the dpb's were examined. On the other hand, the use of the compaction gauge was modified in order to eliminate the problem caused by breakable crusts which held the gauge but through which deer sank. The modification was successful since the compaction measurements were significantly correlated ($P < 0.05$) to the depth at which deer sank in snow during the second winter as opposed to the winter before. The increase in the number of snow stakes tended only to stabilize the mean of the snow depth. Finally, the lengthening of the permanent transect in 1975 aimed at ensuring a sufficient sample of deer tracks in a new poorly known wintering area.

The browse species studied was red maple (*Acer rubrum*) in 1974 at St. Côme, and mountain maple (*Acer spicatum*) the next winter at Venosta. Those two species were quite similar in shape since the mean diameter of the annual growth of all twigs was 6.10 mm ± 6.5% ($P < 0.05$) for red maple and 5.65 ± 6.8% ($P < 0.05$) for mountain maple. Table 1 presents the mean dpb computed through the winter and the summary of the weather conditions which prevailed in the study areas; Table 2 shows the best combination of independent variables which explained the variation of the average dpb values through the winter. At St. Côme, the combined effect of the sinking depth and the time elapsed since the beginning of the winter accounted for 65% of the observed mean dpb variation. At Venosta, mean minimum temperature, snow depth, and sinking depth explained 97% of the variation.

During the 1974 winter, the supporting quality of snow as measured by the sinking depth of deer was positively related to the dpb. The time elapsed since the beginning of the winter also played an important part in the dpb variation because deer probably fed more and more frequently on the same stems as winter progressed. During the 1975 winter, temperatures were above average until the end of February and under it thereafter, affecting the deer food quality. The increase in snow depth at the beginning of February and April contributed to enlargement of the dpb. Lastly, the supporting quality of the snow was inversely correlated to the mean dpb values. This contrast to the results of the preceding winter probably resulted from the absence of breakable crusts at the snow surface during the second winter. Breakable crusts markedly impede free movement of deer (Hepburn 1959).

Another combination of independent variables explained much of the observed dpb variation of the 1975 winter: in this combination, time elapsed since the beginning of the winter replaced the mean minimum temperature and the proportion of trails replaced the sinking depth.

Table 3 verifies the value of the mean dpb as a winter mortality index for deer. In 1974 the dpb was significantly correlated only to the proportion of fawns among the deer found dead during the winter; in 1975 the dpb variation was

TABLE 1—Mean dpb[1] observed through two subsequent winters in two different deer wintering areas and summary of the temperature and snow conditions which prevailed during the two winters

Dates	Mean dpb,[2] mm		Variation from mean min. temperature (°C)		Snow depth (cm)		Compaction gauge[3] (cm)		Sinking depth (cm)	
	1974	1975	1974	1975	1974	1975	1974	1975	1974	1975
11–25 Dec.	—	2.63	—	+7.8	—	26	—	21	—	32
26 Dec.–8 Jan.	3.18	2.71	+1.7	+4.4	48	28	32	24	21.4	28
9–22 Jan.	3.42	3.03	-6.7	+5.6	57	20	3	9	24.1	10
23 Jan.–5 Feb.	3.25	3.44	+2.8	-1.7	49	47	1	33	9.0	27
6–19 Feb.	3.40	3.29	-2.2	+4.4	58	45	24	38	20.5	29
20 Feb.–5 Mar.	3.80	3.61	+3.3	+7.2	53	44	6	12	23.2	10
6–19 Mar.	3.72	3.64	+0.6	-5.0	56	31	21	4	20.8	14
20 Mar.–2 Apr.	3.47	3.78	-5.6	-2.8	59	55	0	22	14.0	22
3–15 Apr.	3.32	3.73	0	-3.3	40	35	2	15	11.0	9

[1] dpb = diameter at point of browsing.

[2] Mean ± 10% ($P < 0.05$).

[3] Released at snow level in 1974 and 5 cm above it in 1975.

correlated to the total number of deer found dead from all causes, to the number of deer found dead from predators, and to the mean femur fat content of those carcasses. The 1975 results suggest that the quality of food ingested by deer is a good index of the winter mortality. The 1974 results, however, are far less conclusive.

Because of the few deer found dead during winter, all the carcasses from the north shore of the St. Lawrence River were pooled in order to obtain an acceptable sample size for each 14-day period. So the results from St. Côme for the 1974 winter, which came from a region where only about 20% of the carcasses were found (Huot et al. 1973; Bouchard et al. 1974;

TABLE 2—Combination of measurements taken in two deer wintering areas which best explained the observed winter variation of the mean dpb of the most important deciduous species browsed by deer and proportion of the variation which each variable eliminated (sinking depth= depth at which deer sink in the snow, time= time elapsed since the beginning of the winter, m min= variation from the general mean minimum temperature, snow depth= mean snow on the ground in coniferous and hardwood stands, + = positive influence, - = negative influence)

Wintering area	Independent variables	*F* value
St. Côme (1974)	dpb= + sinking depth** (20.7) + time* (44.5)	4.67*
Venosta (1975)	dpb= – m min*** (48.9) + snow depth*** (20.5) – sinking depth*** (27.8)	59.02***

***$P < 0.01$.
**$P < 0.05$.
*$P < 0.1$.

TABLE 3—Correlation coefficients computed from the regression of the mean dpb observed at intervals throughout the winter and some characteristics of the deer found dead during the same period of time on the north shore of the St. Lawrence River

	Year	*r* value
Deer dead from all causes of mortality	1974	0.20
	1975	0.66*
Deer dead from predation	1974	0.29
	1975	0.75**
% of fawns among dead deer	1974	0.65*
	1975	0.39
% of fat in femurs of dead deer	1974	-0.13
	1975	0.70**

**$P < 0.05$.
*$P < 0.1$.

Bouchard and Gauthier 1975), could deviate from the general trend of the southwestern deer range. On the other hand, Table 3 indicates that the variation of the food quality was more strongly related to the mortality by predation than to the mortality by all pooled causes.

The analysis of the results supported the use of dpb as an index of winter mortality of deer. But it was also possible that other measurements taken in the wintering areas could be better indices than the dpb. In order to check this possibility, a correlation coefficient was computed between the climatic and movement variables (mean minimum and mean maximum temperature, snow depth, snow compaction, area covered by the yard, track density, proportion of trails, depth of the tracks, time elapsed since the beginning of the winter) and the direct measurement of deer mortality in winter (number of carcasses found dead from all causes of mortality and number of carcasses found dead from predation). In 1974 no significant relation was found between those two groups; in 1975 only the temperature and the time elapsed since the beginning of the winter were correlated to the winter mortality ($P < 0.05$). The correlation coefficients, however, were less significant than those computed for the dpb. The temperature and the length of time elapsed since the beginning of the winter were related to the dpb; it was then expected that they would also be related to the winter mortality. The variation of the mean dpb appears to be the best index of the fluctuation of winter mortality for deer among those measured.

It would of course be more desirable to count dead deer to obtain an estimate of winter mortality. But the number of carcasses is registered by the game wardens and by the biologists whose field effort can vary from one winter to the next. As an example, a more intensive predator control program or a particular winter research program can completely bias the result from one region. On the other hand, as the winter mortality of deer can be different from one region to the other, an adequate number of carcasses has to be found to sample in each region. Those requirements cannot be met everywhere in Quebec.

The proportion of fawns among the deer found dead has been used because this age group seems to suffer more severely from starvation, as revealed by the faster decline of the fat reserve (F. Goudreault 1975, unpublished report presented at the 11th Northeast Deer Study group, Quebec City, Quebec). The greater vulnerability to winter mortality of calves was also observed on moose in Alaska (Bishop and Rausch 1974). As this variable is a proportion, it is often difficult to obtain a sufficient number of samples.

The femur fat content is also directly related to winter mortality. Goudreault (1975 unpublished report) has discussed its usefulness in Quebec. But this variable is difficult to relate to the food quality ingested by deer. Indeed, variation of the time since the beginning of the winter up until the steep decline in femur fat content indicates whether a winter is difficult. The fat content can probably not indicate when the wintering conditions again become easy for deer in spring. Moreover, a good sample size is often difficult to obtain for a regional analysis.

The estimation of winter severity by means of the dpb has the advantage that a statistically sound sample size is easily obtained, a continuous picture of the situation throughout the winter is given, and little time is required. Although its real value as a deer winter-mortality index must still be proven, the present results seem valuable enough to recommend the use of the dpb estimate in further studies throughout the deer range in Quebec where adequate counts of deer are available in wintering areas.

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Literature Cited

Bailey, J. A. 1967. Sampling deer browse for crude protein. Journal of Wildlife Management 31(3): 437- 442.

Bishop, R. H. and **R. A. Rausch.** 1974. Moose population fluctuations in Alaska, 1959–1972. Naturaliste Canadien 101(3/4): 559–593.

Bouchard, R., E. Audy, and **C. Gauthier.** 1974. Gros gibier au Québec en 1973 (exploitation par la chasse et mortalité par des causes diverses). Québec Biological Research Service, Special Report 3. 58 pp.

Bouchard, R. and **C. Gauthier.** 1975. Gros gibier au Québec en 1974 (exploitation par la chasse et mortalité par des causes diverses). Québec Biological Research Service, Special Report 5. 64 pp.

Cowan, R. L., J. S. Jordan, L. Grimes, and **J. D. Gill.** 1970. Comparative nutritive values of forage species. *In* Range and wildlife habitat evaluation—a research symposium. United States of America, Forest Service, Miscellaneous Publication 1147. pp. 48–56.

Crête, M. 1976. Importance of winter climate in the decline of deer harvest in Quebec. Canadian Field-Naturalist 90(4). This issue.

Hepburn, R. L. 1959. Effects of snow cover on mobility and local distribution of deer in Algonquin Park. M. A. thesis, University of Toronto, Toronto. 31 pp.

Huot, J. 1972. Winter habitat preferences and management of white-tailed deer (*Odocoïleus virginianus borealis*) in the Thirty-one Mile Lake area (Gatineau and Labelle counties, Québec). M.Sc. thesis, University of Toronto, Toronto. 165 pp.

Huot, J. 1973. Le cerf de Virginie au Québec. Québec Wildlife Service, Bulletin 17. 49 pp.

Huot, J. 1974. Winter habitat of white-tailed deer at Thirty-One Mile Lake, Québec. Canadian Field-Naturalist 88(3): 293–301.

Huot, J., R. Bouchard, and **C. Gauthier.** 1973. Gros gibier au Québec en 1972 (exploitation par la chasse et mortalité par des causes diverses). Québec Wildlife Service, Special Report 2. 65 pp.

Ozoga, J. J. and **L. W. Gysel.** 1972. Response of white-tailed deer to winter weather. Journal of Wildlife Management 36(3): 892–897.

Short, H. L. and **J. C. Reagor.** 1970. Cell wall digestibility affects forage value of woody twigs. Journal of Wildlife Management 34(4): 964–967.

Verme, J. L. 1968. An index of winter weather severity for northern deer. Journal of Wildlife Management 32(3): 566–574.

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Importance of Winter Climate in the Decline of Deer Harvest in Quebec

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Crête, M. 1976. Importance of the winter climate in the decline of deer harvest in Quebec. Canadian Field-Naturalist 90(4): 404–409.

Abstract. The effect of the mean winter temperature and the total snowfall and rainfall in winter on the Quebec deer harvest was studied by means of a multiple regression analysis. The period from 1963 to 1973, when a marked crash occurred in the deer harvest, is covered by the analysis. As the length of the hunting season varied considerably during this time interval, it was also included in the statistical analysis. The length of the deer season eliminated about 80% of the variation of the deer harvest in three regions of the deer range and accounted for 58 and 31% of the harvest fluctuation in the remaining two. The combined effect of the meteorological variables seemed to explain between 5 and 20% of the total harvest variation representing about half of the remaining harvest fluctuation. On the south shore of the St. Lawrence River, snow depth and its supporting quality as modified by rainfall were often related to the deer harvest of the next season. On the north shore, mean winter temperature seemed to act upon the snow supporting quality instead of rain. The unexplainable part of the harvest variation could mainly depend on the reduction of the summer and winter habitat, on overharvesting, on predation, and on summer and fall weather conditions.

Résumé. L'effet sur la récolte de cerf de Virginie de la température moyenne et des précipitations nivales et pluvieuses en hiver a été étudié à l'aide d'une analyse de régression multiple. La période allant de 1963 à 1973 a été couverte par cette analyse car une diminution sensible de la récolte est survenue pendant cet intervalle de temps. Comme la durée de la saison de chasse a varié beaucoup pendant ce temps, elle a aussi été incluse dans l'analyse statistique. La durée de la saison de chasse a contribué à éliminer environ 80% de la variation de la récolte pour trois des cinq régions de l'aire de répartition du cerf et a compté pour 58 et 31% de la fluctuation de la récolte dans les deux autres. L'effet cumulatif des variables météorologiques a semblé expliquer entre 5 et 20% de la variation de la récolte totale de cerfs, ce qui représente environ la moitié de la fluctuation que la durée de la saison de chasse n'élimine pas. Sur la rive sud du fleuve Saint-Laurent, la neige au sol et sa qualité de support modifiée par les chutes de pluie furent souvent en relation avec la récolté de cerfs de la saison de chasse suivante. Sur la rive nord, la température hivernale moyenne a semblé être l'agent de modification de la qualité de support de la neige en remplacement de la pluie. La partie inexplicable de la variation de la récolte pourrait principalement dépendre de la réduction de l'habitat d'été et d'hiver du cerf, de surexploitation, de la prédation et de la température estivale et automnale.

The Quebec Biological Research Service and the Wildlife Management Service joined their efforts to establish a network of snow stations through the entire range of white-tailed deer (*Odocoileus virginianus borealis*) during the fall of 1974. The establishment of the network tended to standardize the collection of snow data in relation to deer. This action was justified as many authors have emphasized the stress that winter imposes on deer and have discussed the physiological and behavioral mechanisms which this species has therefore developed (Hepburn 1959; Verme 1968; Ullrey et al. 1969, 1970; Silver et al. 1971; Ozoga and Gysel 1972; Moen 1973; Thompson et al. 1973; etc.).

Nevertheless, before paying more attention to measuring the winter severity, we felt that we had to analyze the impact that the climate could have played upon the decline of white-tailed deer which occurred during the last decade in Quebec (Huot 1973).

Methods

Four meteorological variables were considered in analyzing the importance of the climate of the previous winter (from November to April) upon the apparent drop in density of white-tailed deer: total winter snowfall, total winter rainfall, mean winter minimum temperature, and mean winter maximum temperature (Quebec Department of Natural Resources 1962–1972). The total snowfall was utilized as an index of the snow depth. The total rainfall and the temperature measurements were used because they can influence the quality of snow. On the other hand, the minimum and maximum temperatures were also used because they can act directly upon the deer's winter survival. Minimum temperature influences deer to seek shelter more than do other temperature measurements (Ozoga and Gysel 1972) and maximum temperature during daylight can lower deer's energetic needs (Silver et al. 1971). The analysis covered the period from 1963 to 1973 when a marked crash in deer harvest occurred (Huot 1973); data from the 1974 harvest were excluded because hunting regulations changed to a buck law.

Based on the results of the network of snow stations for the winter 1974–75, and on the dissimilar regional fluctuation of deer harvest since 1962 (Huot 1973), the analysis of the data was stratified in five regions. The annual deer harvest of one region was then related to the meteorological data from the preceding winter. A few meteorological stations per region close to known deer wintering areas were used for the analysis. This procedure was chosen because it was impossible to compute a general mean for the data from all the meteorological stations of one region; moreover, those meteorological data represented climatic conditions which prevailed in the vicinity of areas where there are wintering deer still.

The statistical importance of the relation between the meteorological data from the preceding winter and the white-tailed deer harvest was evaluated by means of a step-wise multiple regression analysis. The most significant combination of variables was kept as the most probable explanation for the observed deer harvests. But the length of the hunting season, a non-climatic variable which could have influenced markedly the deer harvest, was also included in the statistical analysis. Indeed, the season was shortened from 44 days in 1965 to 5 to 16 days in the last years.

Results and Discussion

Figure 1 shows the five regions into which the deer range was divided and the location of the 11 wintering areas where the impact of the winter climate on the next harvest was studied. Table 1 presents data for the mean climatic conditions of each region. In the Gaspé Peninsula, deer winter mostly in the lowlands close to Chaleur Bay. Snowfalls and rainfalls are moderate there and the average winter temperature is higher than elsewhere in Quebec: the influence of the Gulf of

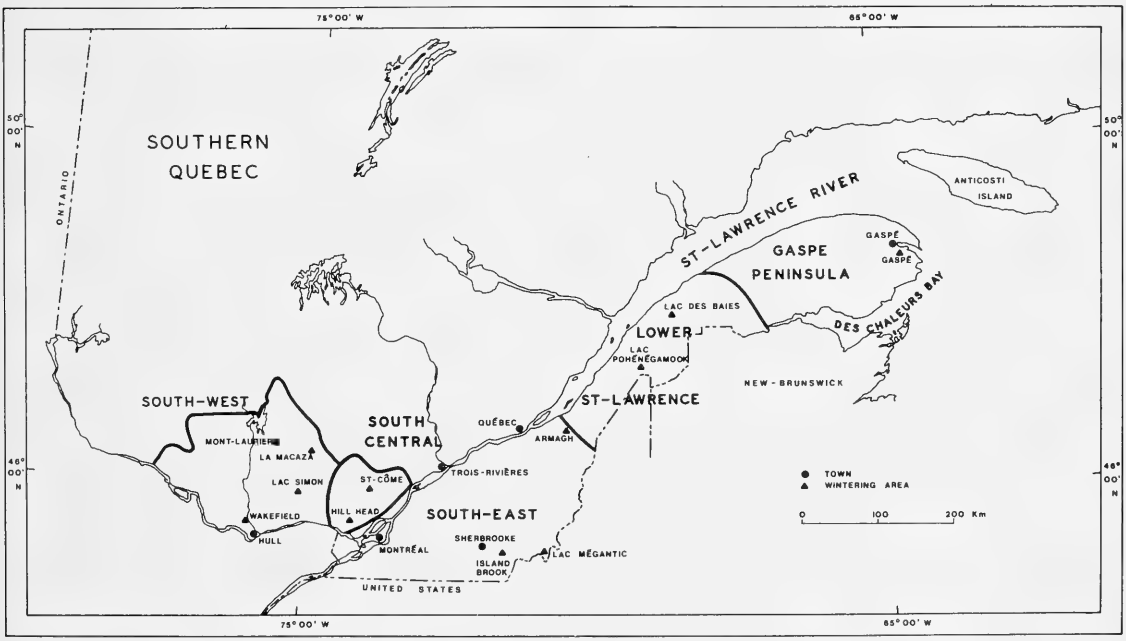

FIGURE 1. The white-tailed deer range in Quebec and location of the deer wintering areas studied.

TABLE 1—Mean winter (from November to April) weather conditions registered in the vicinity of 11 wintering areas of the white-tailed deer range in Quebec from 1962 to 1973

Regions Wintering areas	Total snowfall, cm	Total rainfall, cm	Mean min. temp., °C	Mean max. temp., °C
Gaspé Peninsula				
Gaspé	288	16.3	-9.6	-0.1
Lower St. Lawrence				
Lac des Baies	354	10.7	-11.7	-3.0
Pohénégamook	338	12.7	-11.8	-1.8
Southeast				
Armagh	278	20.0	-10.4	-1.7
Lac Mégantic	305	15.7	-10.4	-0.8
Island Brook	336	20.6	-10.7	-0.4
South-central				
St. Côme	289	20.1	-12.7	-0.2
Hill-Head	232	25.4	-9.6	-0.4
Southwest				
Lac Simon	230	20.3	-11.0	-0.2
La Macaza	291	17.8	-14.0	-0.3
Wakefield	242	23.1	-10.2	-0.1

St. Lawrence is probably important in this region.

The lower St. Lawrence region suffers the worst climatic conditions of all the deer range in the province. Snowfalls are abundant and the average temperature is low. Only rainfalls are lower than elsewhere. Nevertheless, this situation can be detrimental to deer if hard crusts are less frequent. In the southeast region, snowfall and rain are abundant except in the lowlands along the St. Lawrence River (Armagh) but winters are relatively warmer.

Snowfalls are light in the southern portion of the south-central region (Hill-Head) and higher in the north (St. Côme). Rainfall and temperature follow the opposite trend: rainfall is more abundant in the south of the region and temperature is warmer. Total snowfalls are the least important of all the deer range in the southwest region and rainfall is average. The southern part of this region is relatively warm in winter but it is much colder in the north (La Macaza).

For the 1974–75 winter, the analysis of the results from the network of snow stations revealed that the combined effect of the altitude and the distance of the Gulf of St. Lawrence and the St. Lawrence River were significantly related ($P < 0.01$) to the mean snow depth. The altitude had a positive influence on the snow depth whereas the distance of the river or the gulf had an inverse one. Although no statistical analysis has been made in order to explain the variations of the winter temperature in the deer range, it is obvious that the latitude, the altitude, and distance from large bodies of water mainly cause the differences.

Table 2 shows the annual deer harvest and the length of the season since 1963 for each region. Most stable harvests were in the Gaspé Peninsula region although the season was shortened by more than half. The harvest really dropped only in 1972. In the lower St. Lawrence region, the harvest was highest in 1965 and then lowered by 70% till 1973. During the same time, the season was shortened by 63% of its length. The 1965 harvest was also the largest in the southeast region. It then diminished by about 80%, as did also the season. In the south-central region, the peak of the harvest happened one year before and the subsequent reduction of the harvest and of the season was 90%. Moreover, the season

TABLE 2—Quebec deer harvest according to year and region of the deer range. Length of the season in days is given in brackets

	Number of deer					
Year	Gaspé Peninsula	Lower St. Lawrence	South-east[1]	South-central	South-west	Total harvest[2]
1963	703(44)	1530(44)	1989(30)	1562(33)	5914(39)	11 409
1964	857(50)	1719(41)	2635(41)	1923(45)	7019(45)	13 738
1965	800(37)	1905(44)	3018(44)	922(40)	5395(44)	12 542
1966	800(37)	1627(44)	2097(35)	635(37)	3377(37)	8 481
1967	933(30)	1316(30)	1882(28)	367(30)	2679(30)	6 876
1968	852(24)	1366(24)	2166(19)	C.S.[3]	2187(11)	6 234
1969	628(23)	697(23)	1382(16)	C.S.	2156(11)	4 689
1970	751(23)	675(23)	1135(16)	411(5)	2465(12)	5 524
1971	698(16)	685(16)	632(9)	277(5)	2345(12)	4 535
1972	588(16)	747(16)	750(9)	243(5)	2094(12)	4 321
1973	351(16)	529(16)	682(9)	221(5)	1807(12)	3 491

[1] There was a buck law in some parts of the region in some years; when occurring, the number of fawns and females was estimated at 60% of the total harvest.

[2] Estimated number of fawns and females excluded.

[3] Closed season.

was closed in 1968 and 1969. The southwest region yielded about half of the provincial harvest. The highest harvest during the period studied was also in 1964 and it then diminished by about 75%, as did the season. These results indicate generally a close relationship between the length of the hunting season and the annual harvest.

Table 3 presents the combination of the meteorological and non-meteorological variables which give the best explanation for the regional fluctuation of the observed deer harvest and the percentage of variation which each variable contributed to eliminate. The statistical level for the rejection of variables ($P > 0.2$) was low because the meteorological data were often less significant than the non-meteorological data in the regressions although the former were the main subject of the analysis. The computed regression equations are nevertheless valuable since each variable had approximately the same influence for all the wintering areas.

The reduction of the length of the deer season explained about 80% of the harvest variation in the lower St. Lawrence, southeast and southwest regions. This situation is logical as the deer season was generally shortened at the end when hunters were more efficient. In late November, the ground was more frequently covered with snow and deer could be more concentrated near the wintering areas (Verme 1973). Shorter seasons also contributed to lower the hunting pressure by reducing the number of persons who bothered to hunt. Although the season was generally shortened because of a reduction in the preceding harvests, lower deer densities as well as shorter seasons could be the prime cause of smaller harvests.

In the Gaspé Peninsula and south-central regions, the length of the deer season eliminated respectively 31% and 58% of the harvest variation. The lesser influence of the length of the season in the Gaspé Peninsula could be caused by the small number of local hunters and because great distance from large urban centers resulted in low hunting pressure. The opposite situation could happen in the south-central region which is close to Montreal. The unexplainable part of the harvest fluctuation could then depend on over-exploitation of deer populations as Bider and Pimlott (1973, unpublished report presented at the 9th North American Moose Conference and Workshop, Quebec City, Quebec) pointed out, and as Table 2 seems to show for 1965 to 1967.

The total snowfall was the most important of the studied climatic factors and its influence was significantly correlated to the next deer harvest in the Gaspé Peninsula, lower St. Lawrence, and southwest regions. Everywhere, the relationship

TABLE 3—Combination of meteorological and non-meteorological variables determined by a multiple regression analysis which best fit the observed harvest according to the regions of the deer range in Quebec, and percentage of variation eliminated by each variable (snow = total snowfall, rain = total rainfall, m max = mean winter maximum temperature, m min = mean winter minimum temperature, season = length of the deer season, + = positive influence, - = negative influence)

Regions Wintering areas	Independent variables affecting deer harvest	*F* value
Gaspé Peninsula		
Gaspé	+ season (31)* - snow (16)*	3.58**
Lower St. Lawrence		
Pohénégamook	+ season (84)** - snow (6)** - rain (3)*	28.34***
Lac des Baies	+ season (84)*** - snow (4)*	29.49***
Southeast		
Armagh	+ season (89)*** - snow (2)*** + rain (3)*	34.92***
Lac Mégantic	+ season (89)***	69.13***
Island Brook	+ season (75)*** + rain (10)*	14.05**
South-central		
St. Côme	+ season (58)* - m min (5)* - m max (14)*	5.57**
Hill-Head	+ season (58)**	9.63**
Southwest		
Lac Simon	+ season (77)*** - rain (15)** - snow (4)*	32.51***
La Macaza	+ season (79)*** - m max (5)*** - snow (6)**	21.07***
Wakefield	+ season (77)*** - m min (3)* - snow (5)*	13.69***

***$P < 0.001$.
**$P < 0.1$.
*$P < 0.2$.

between snowfall and harvest was negative. The importance of the total snowfall and, consequently of the snow depth, is normal since the relation between the depth at which deer sink in the snow and their metabolic rate is logarithmic (G. F. Mattfeld, 1973 unpublished report presented at the 30th Northeast Fish and Wildlife Conference, Dover, Vermont). A small increase in snow depth can then greatly impede deer movement.

The mean winter minimum or maximum temperature was related to the next deer harvest in three out of the five wintering areas studied in the south-central and southwest regions. In every case, colder mean winter temperatures favored a higher harvest of deer during the next fall. The colder air temperature would not have directly affected deer metabolism by increasing their energetic needs but rather would have acted upon the snow quality. Thaws and rains would have been less frequent during colder winters, thus lowering the occurrence of crusts, which are very detrimental to deer (Hepburn 1959).

The effect of the total rainfall was more variable according to wintering areas. It was positively correlated to the next deer harvest in the southeast region but this relationship was negative for the Pohénégamook and Lac Simon wintering areas. Winter rainfall could have affected deer survival by changing the snow supporting quality and its influence could have varied from one region to the other.

On the south shore of the St. Lawrence River, the snow depth and the modification of its supporting quality by rain would have been the most important climatic factors governing the next deer harvest. On the other hand, the mean winter temperature would have been the climatic factor which would have modified the snow supporting quality on the north shore of the river. The winter climate must have deeply influenced deer populations during the study period if we take into consideration the roughness of the meteorological data used in the analysis.

The fluctuation of the deer harvest which was not explained by the length of the season or by the winter severity represented between 5 and

20% of the total variation except for the wintering areas of Hill-Head and Gaspé. Many factors could have caused those fluctuations, the most important being winter and summer habitat losses, overharvesting, predation, and summer and fall weather conditions.

The destruction of winter habitat by clear-cutting occurred here and there throughout the deer range in Quebec and some large deer yards have been destroyed in the lower St. Lawrence and southwest regions. The loss of deer winter habitat was also caused locally by house and cottage construction. On the other hand, spring and summer habitat reduction was mainly caused by farm desertion in many parts of the deer range. Moreover, as farmers also cut small patches of timber in winter on their properties, they produced accessible browse for deer. It is probable that farm desertion also indirectly affected winter habitat.

Past excessive hunting contributed to diminished deer harvest in some seasons. Indeed, at times deer were hunted after they had already yarded because of deep snow on the ground (up to 30 cm). In this situation, hunting was very effective. Predation by wolves (*Canis lupus*) and by dogs (*Canis familiaris*) could also have influenced deer harvests by increasing the impact of winter weather severity and by lowering the survival of fawns in summer (Ballenberghe et al. 1975). Lastly, the weather during the summer and during the deer season could have modified the hunting results by acting upon the fawn survival in summer and upon hunter success in fall.

In spite of the statistical weakness of the meteorological data used in the regression equations, the winter climate seems to have been of major importance in the fluctuation of deer harvest in Quebec during the last decade and deer managers will always have to pay close attention to its effect on deer populations.

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Literature Cited

Ballenberghe, V. V., A. W. Erickson, and **D. Byman.** 1975. Ecology of the timber wolf in Northeastern Minnesota. Wildlife Monograph 43. 48 pp.

Hepburn, R. L. 1959. Effects of snow cover on mobility and local distribution of deer in Algonquin Park. M.A. thesis, University of Toronto, Toronto. 31 pp.

Huot, J. 1973. Le cerf de Virginie au Québec. Québec Wildlife Service, Bulletin 17. 49 pp.

Moen, A. N. 1973. Wildlife ecology. W. H. Freeman and Company, San Francisco. 421 pp.

Ozoga, J. J. and **L. W. Gysel.** 1972. Response of white-tailed deer to winter weather. Journal of Wildlife Management 36(3): 892–897.

Quebec Department of Natural Resources. 1962–1972. Bulletin météorologique. Volumes I(12)–XII(4).

Silver, H., J.B. Holter, N.F. Colovos, and **H.H. Hayes.** 1971. Effect of falling temperature on heat production in fasting white-tailed deer. Journal of Wildlife Management 35(1): 37-46.

Thompson, D. B., J. B. Holter, H. H. Hayes, H. Silver, and **W. E. Urban, Jr.** 1973. Nutrition of white-tailed deer. I—Energy requirements of fawns. Journal of Wildlife Management 37(3): 301–311.

Ullrey, D. E., W. G. Youatt, H. E. Johnson, L. D. Fay, B. L. Schoepke, and **W. T. Magee.** 1969. Digestible energy requirements for winter maintenance of Michigan white-tailed does. Journal of Wildlife Management 33(3): 482–490.

Ullrey, D. E., W. G. Youatt, H. E. Johnson, L. D. Fay, B. L. Schoepke, and **W. T. Magee.** 1970. Digestible and metabolizable energy requirements for winter maintenance of Michigan white-tailed does. Journal of Wildlife Management 34(4): 865–869.

Verme, J. L. 1968. An index of winter weather severity for northern deer. Journal of Wildlife Management 32(3): 566–574.

Verme, J. L. 1973. Movements of white-tailed deer in upper Michigan. Journal of Wildlife Management 37(4): 545–552.

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Aspects of the Ecology of the Faunas of Some Brackish-water Pools on the St. Lawrence North Shore[1]

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Williams, D. Dudley and Nancy E. Williams. 1976. Aspects of the ecology of the faunas of some brackish-water pools on the St. Lawrence North Shore. Canadian Field-Naturalist 90(4): 410–415.

Abstract. Some features of the ecology of brackish-water invertebrates found in rock pools along the St. Lawrence North Shore, in the region of Sept Iles, Quebec are described. The fauna consists of representatives of the following groups: freshwater euryhaline species, marine euryhaline species, and true brackish-water species. Of prime importance is their tolerance to changes in salinity and temperature. Certain assemblages of animals are found to be characteristic of low and high salinities. The rock pool is examined as an aquatic environment and is compared with a freshwater temporary pond.

The ecology of brackish-water animals is one area of research that has generally been neglected in Canada, although a few studies have been reported from the west coast (e.g., Saunders 1928; Morley and Ring 1972a, b), and Bousfield (1956, 1962) has looked at the marine littoral fauna of the east coast.

Definitions of brackish water vary. For example, Kinne (1964) defined it as lying within the salinity range 0.5‰ to 30‰, whereas Williams (1964), in a study of the lake typology in Australia, has applied this term to lakes having between 3‰ and 10‰ total dissolved materials. In this study we have accepted the views of Kinne.

Brackish-water invertebrates are of interest because they consist of two distinct factions: those of marine origin, and those derived from freshwaters. Green (1968) proposed the addition of a third faction, those of terrestrial origin, to include certain Collembola and oribatid mites, but he admits that as studies in this area are rather sparse, this subdivision may be premature. Selection has, over time, allowed forms from both freshwater and marine environments to adapt to the brackish-water habitat. For some species, this type of environment now represents the optimum habitat. Therefore, in brackish water, we can expect to find representatives of the following groups: euryhaline species that are primarily found in freshwaters but because of high salinity tolerances can extend their range; marine euryhaline species, which although found primarily in the sea, can extend into fresher waters; and those species that are primarily found in brackish water. In all three cases, it is likely that reproduction is confined to an optimum salinity range and that individuals found outside this, although they may be feeding and behaving normally, are non-reproductive (see Hartland-Rowe 1966). Bayly (1972) defined a similar trifid division of the faunas found in athalassic waters (i.e., those saline waters that have never been joined to the sea during recent geologic times), and Remane (1958) has further separated the euryhaline faunas according to the lowest salinities that certain types can tolerate.

In this paper we consider these three groups of brackish-water animals found in rock pools along the St. Lawrence North Shore.

Description of the Study Area

The rock pools sampled are located on the north shore of the Gulf of St. Lawrence in the vicinity of the Matamek Biological Research Station (50° 17′ N, 65° 57′ W), approximately 32 km east of Sept Iles, Saguenay County, Quebec (see Figure 1). In this region the shoreline topography consists typically of low areas of pre-Cambrian rock interspersed with sandy bays. The pools extend from the low to the high spring tide marks. Consequently, the degree and times of inundation by the sea vary as one moves up the shore. Pools near the lower limit are inundated twice daily, whereas those near the high-tide mark are flooded less frequently or not at all, but are subject to salt spray whenever wind

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[1] Contribution Number 23 from the Matamek Research Station, Quebec

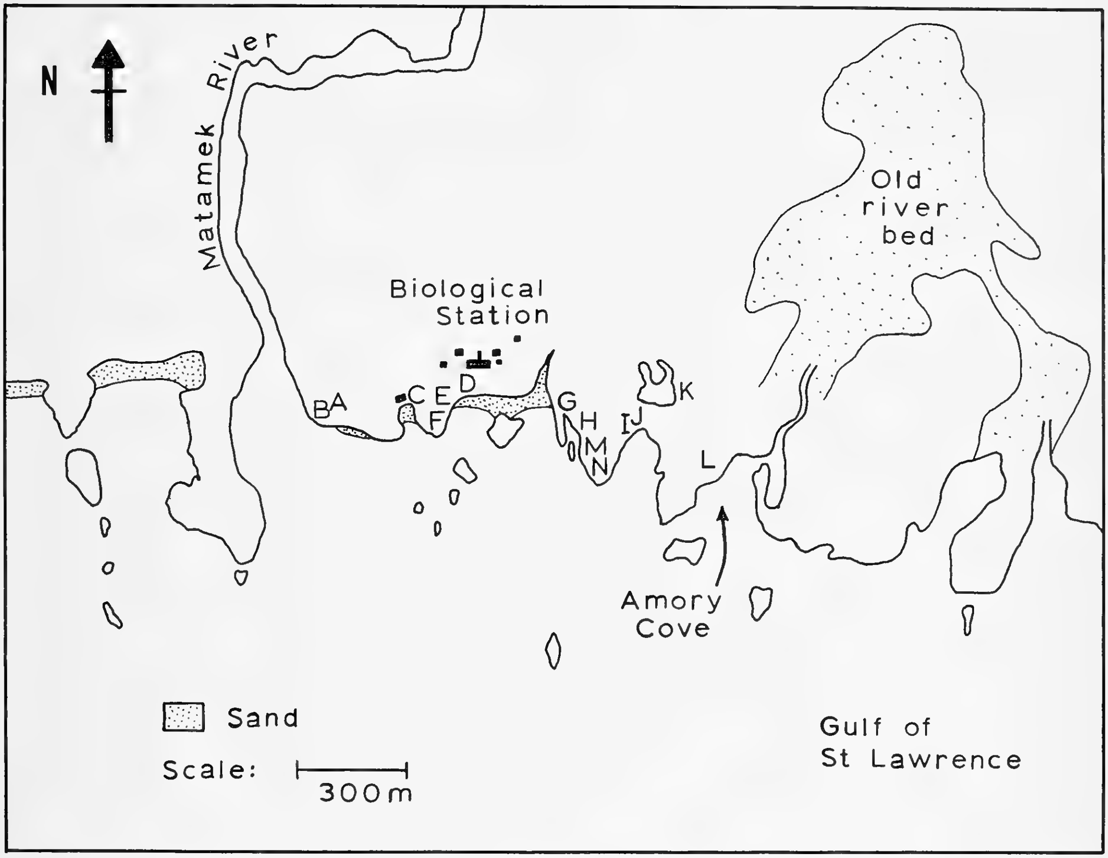

FIGURE 1. Map of sampling area. Locations of individual rock pools are marked with the letters A to N.

conditions are favorable. They have been formed mostly in depressions or fissures in the rock and whereas surface area varies from approximately 2 m^2 to 6 m^2, their depths are all close to 20 cm. The pool bottoms consist of bare rock covered with patches of sand and mud. The flora is dominated by algae ranging from *Cladophora* and some blue-green algae in the less saline pools, to *Pelvetia*, *Cladophora*, *Enteromorpha*, and *Ectocarpus* in the more saline ones. Only two vertebrates are commonly encountered in these pools, the toad, *Bufo americanus* Holbrook, and the three-spine stickleback, *Gasterosteus aculeatus* L. For a detailed description of the latter species in these habitats see Coad and Power (1973).

Materials and Methods

After some preliminary observations were made in the summer of 1971, faunal samples were collected from representative parts of each of 14 rock pools during late July 1974. Two samples were taken from each pool with the aid of a 135-μ mesh dip net, and a 3-min sampling period served to standardize the collecting method. The samples were preserved in 5% formalin and later the animals were separated from the sediment by a flotation technique (Hynes 1961). Representatives of the various taxa present were then hand-picked under a binocular microscope and identified. No attempt was made to quantify the animals collected other than to rate each species on a scale of abundant (20+ per sample), common (5–20), and rare (1–5).

Salinity was measured in each pool, at the time of collecting, by means of a Barnstead Conductivity Bridge (model PM-70CB) fitted with a 1.0 constant glass dip cell. Temperature was also recorded so that these readings could be converted to standard salinity as grams sodium chloride at 25°C (Golterman and Clymo 1969).

The Rock Pool as an Aquatic Environment

The two dominant variables in these pools were salinity and temperature; sunlight, degree of exposure, substrate, etc. were similar in all pools. Temperature fluctuations in all the pools were quite high, especially on a daily basis, although those nearer the sea were buffered slightly as a result of inundation by the tides. Pool D, for example, had a daily temperature range of from 13 to 29°C at the end of July 1974, during which time the corresponding air temperature range was only from 12 to 20°C. This water temperature range was close to the annual extreme, as earlier on in the year (early June) the daily range was only from 7 to 20°C with an air temperature range of from 7 to 15°C. During the winter months the temperature would probably not vary more than a few degrees above freezing. It seems likely, therefore, that many of the inhabitants of the pools are eurythermal. Salinity too showed considerable variation over short periods depending on the amount of precipitation and evaporation. Pools of initially low salinity, such as Pool A, varied little after rainfall, for example, from 0.04‰ to 0.03‰ after 1.2 cm of rain. The more saline pools were, however, affected considerably: Pool D had a uniform salinity of 31.0‰ before 1.2 cm of rain, but afterwards became stratified with the top 4 cm of water at 6.5‰ and the bottom 20 cm at 43.0%. These post-rain readings were taken in the morning and by afternoon the wind had caused mixing so that a uniform value of 38.3‰ was established. The degree of evaporation also changed the salinity, and Coad and Power (1973) recorded a change from 25‰ to 27‰ after 2 days (28.7 h) of bright sunshine.

Although no dissolved oxygen measurements were taken, both Pyefinch (1943) and Ganning and Wulff (1970) have shown large diel changes for rock pools in Wales and Sweden, respectively. Ganning (1971) has suggested that the inhabitants are selected for, and well adapted to, large annual and daily fluctuations in oxygen concentration.

The Fauna

Figure 2 shows the relationship between the salinities of the 14 pools studied and the animals they contained; the salinities have been arranged as an increasing series from 0.03‰ to 31.0‰. But because these observed values were likely to vary somewhat even on a daily basis the salinity tolerance ranges implied for the animals must be regarded as minimum ranges.

A typical high-salinity fauna consisting of *Littorina littorea*, *Mytilus edulis*, *Tellina* sp., an unidentified harpacticoid, and *Halocladius* (*H.*) *?variabilis* is apparent. Similarly, we can detect a low-salinity fauna comprised of *Ceriodaphnia reticulata*, ostracod sp. 1, *Aeshna interrupta*, *Arctocorixa* sp., *Limnephilus tarsalis*, *Oecetis* sp., *Rhantus* sp., *Hydroporus cocheconis*, *Procladius* sp., *Ablabesmyia* sp., and *Psectrocladius* sp. Species which have quite a considerable tolerance range but which tend to become less common at either end of the salinity scale (i.e., brackish-water forms), include *Eurytemora affinis* and *Trichocorixa verticalis fenestrata*. We should perhaps include *Gammarus duebeni*, a classic brackish-water species (Kinne 1959; Bousfield 1973) here, as although there is a gap in its salinity range, it was taken in pools ranging from 0.5‰ to 31.0‰. The remaining species in the figure either have a wide salinity tolerance or a distribution and abundance too sparse to determine their tolerance range.

Notes on Selected Species

Trichocorixa verticalis fenestrata belongs to a species group that lives by preference in more or less saline water bordering saltwater coasts (Sailer 1948). The holotype of this subspecies was taken from Natashquan, Quebec, some 200 km northeast of Matamek. Large nymphs of a species of *Arctocorixa* were taken commonly at up to 9.7‰. Their size suggests that they may have been *A. convexa* which occurs in pools at Bradore Bay (St. Lawrence North Shore) and Labrador (Hungerford 1948).

Limnephilus tarsalis occurred in salinities up

FIGURE 2. Relationship between the salinity of the 14 rock pools studied and the animals they contained.

● = Abundant ● = Common ● = Rare

to 19.8‰ and was not taken in collections further inland. Ross and Spencer (1952), however, give records from the interior of British Columbia, and Dodds and Hisaw (1925) recorded adults from the Colorado Rockies at elevations of 9000 to 11000 ft. At Matamek, mature larvae and pupae were both present with adults emerging each night during late July.

An unidentified species of *Chironomus* was found up to a salinity of 13.8‰. Stuart (1941) found that *C. dorsalis* could be successfully reared in 8.8‰ seawater but not in 17.5‰. This agrees with the tolerance range seen in the Quebec species. Similar distributions were apparent for *Tanytarsus* sp. and *Psectrocladius* sp. Two interesting species were *Halocladius* (*H.*) *?variabilis* and one from the *Cricotopus (Isocladius) sylvestris* group. Even though these two species were collected in only one or two pools, their total absence from the others seems to suggest that they occurred primarily at higher salinities. The former subgenus is typically found in inland saltwaters or along sea coasts (Hirvenoja 1973), and the latter is a euryhaline freshwater species which occurs in Europe to 8‰ (Hirvenoja, personal communication). Stuart (1941), however, found that *Cricotopus sylvestris* var. *ornatus* taken in shore pools at Millport, Isle of Man, preferred brackish water but could not tolerate more than 17.5‰.

Ephydra subopaca is a very widespread species often found in salt pools on both the Atlantic and Pacific coasts of North America. Johannsen (1935) found it in pools varying from 1.5 to 11.0‰. Its distribution at Matamek, however, indicates that it can tolerate almost full-strength seawater.

Ecology

It is difficult to speak of a community typical of the rock pools of the Matamek region for, as we have seen, the species composition of any one pool is largely dependent on its salinity range in combination with a great many other factors. One could, however, predict with reasonable accuracy the assemblage of animals likely to be found in a low- or high-salinity pool, although one or two particular species might be absent as a result of incomplete colonization by adults.

The low-salinity communities appear to be primarily detritus-based, as direct observation of feeding showed that most Ostracoda, Hemiptera, Copepoda, and Diptera were making use of this food source. The Cladocera fed on suspended organic matter and phytoplankton, whereas odonatan nymphs, coleopteran larvae, and tanypodine chironomids constituted the main predators. Caddisfly guts contained a mixture of diatoms, organic matter, and fungi, and the larvae were observed grazing on decomposing leaves of *Alnus* sp. and *Myrica gale* which had been blown into the pools.

In the high-salinity pools, close observation revealed that most of the inhabitants (e.g., *Littorina littorea*, the harpacticoid, *Gammarus duebeni*, and *Ephydra subopaca*) were herbivorous, grazing on the seaweeds, particularly *Enteromorpha*. This food source doubtless changes in quality and quantity throughout the year, as Ganning (1971), for example, has shown that physical changes, and thus probably palatability changes, occur in the thalli of *Enteromorpha* as a result of salinity shifts. Of the remaining taxa, the two bivalves were suspension feeders and the main predators were *Gammarus duebeni*, which fed readily on the harpacticoids, and the stickleback *Gasterosteus aculeatus*. It is interesting to note that in these higher-salinity pools, the diet of *Limnephilus tarsalis* included seaweed.

Discussion

Although a year-long study would yield much more information about other factors affecting these pools, the prime importance of tolerance to changes in salinity and temperature is clear and assemblages of animals characteristic of low and high salinities were found. Ganning (1971) states that rock pools have no parallels with other aquatic environments except shallow waters, ditches, etc. It seems to the authors, however, that there is a great similarity in the features of brackish-water rock pools and freshwater temporary ponds. In both habitats there is high primary productivity for part of the year because of abundant nutrients, high temperatures, etc., as well as plentiful detrital food. Both places have the advantage of few predators. Their disadvantages again are similar in that they both have highly variable physical conditions such as temperature and ionic concentrations. Thus both habitats are attractive for tolerant organisms that may be poor competitors in more stable environments but can take advantage of the abundant food and warmth to grow rapidly while conditions are favorable. Mechanisms for surviving severe conditions in rock pools as described by Ganning (1971) (e.g., short life cycles, rapid development, parthenogenesis, resistant eggs, and migration from pools) also apply to drought survival in temporary ponds (Hartland-Rowe 1966; Wiggins 1973).

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Literature Cited

Bayly, I. A. E. 1972. Salinity tolerance and osmotic behaviour of animals in athalassic saline and marine hypersaline waters. Annual Review of Ecology and Systematics 3: 233–268.

Bousfield, E. L. 1956. Studies on the shore fauna of the St. Lawrence Estuary and Gaspé Coast of Canada. National Museum of Canada Bulletin Number 136: 95–101.

Bousfield, E. L. 1962. Studies on littoral marine arthropods from the Bay of Fundy region. National Museum of Canada Bulletin Number 183: 42–62.

Bousfield, E. L. 1973. Shallow-water gammaridean Amphipoda of New England. Cornell University Press. 312 pp.

Coad, B. W. and **G. Power.** 1973. Observations on the ecology and phenotypic variation of the threespine stickleback *Gasterosteus aculeatus* L., 1758, and the blackspotted stickleback *G. wheatlandi* Putnam 1867 in Amory Cove, Quebec. Canadian Field-Naturalist 87: 113–122.

Dodds, G. S. and **F. L. Hisaw.** 1925. Ecological studies on aquatic insects. IV. Altitudinal range and zonation of mayflies, stoneflies and caddisflies in the Colorado Rockies. Ecology 6: 380–390.

Ganning, B. 1971. Studies on chemical, physical and biological conditions in Swedish rock pool ecosystems. Ophelia 9: 51–105.

Ganning, B. and **F. Wulff.** 1970. Measurement of community metabolism in some Baltic brackish water rock pools by means of diel oxygen curves. Oikos 21: 292–298.

Golterman, H. and **R. S. Clymo.** 1969. Methods for chemical analysis of freshwaters. International Biological Programme Handbook Number 8. Blackwell Scientific Publications, Oxford. 188 pp.

Green, J. 1968. The biology of estuarine animals. Sidgwick and Jackson, London. 401 pp.

Hartland-Rowe, R. 1966. The fauna and ecology of temporary pools in Western Canada. Verhandlungen Internationale Vereinigung für Theoretische und Angewandte Limnologie 16: 577–584.

Hirvenoja, M. 1973. Revision der Gattung *Cricotopus* van der Wulp und ihrer Verwandten (Diptera: Chironomidae). Annales Zoologici Fennici 10: 1–363.

Hungerford, H. B. 1948. The Corixidae of the Western Hemisphere (Hemiptera). Kansas University Science Bulletin Number 32: 1–827.

Hynes, H. B. N. 1961. The invertebrate fauna of a Welsh mountain stream. Archiv für Hydrobiologie 57: 344–388.

Johannsen, O. A. 1935. Aquatic Diptera: Orthorrhapha — Brachycera and Cyclorrhapha. Cornell University Agriculture Experimental Station Memoirs Number 177. 62 pp.

Kinne, O. 1959. Ecological data on the amphipod *Gammarus duebeni.* A monograph. Veröffentlichungen des Instituts für Meeresforchung in Bremerhaven 6: 177–201.

Kinne, O. 1964. The effects of temperature and salinity on marine and brackish water animals. II. Salinity and temperature-salinity combinations. Oceanography and Marine Biology Annual Reviews 2: 281–339.

Morley, R. L. and **R. A. Ring.** 1972a. The intertidal Chironomidae (Diptera) of British Columbia. I. Keys to their life stages. Canadian Entomologist 104: 1093–1098.

Morley, R. L. and **R. A. Ring.** 1972b. The intertidal Chironomidae (Diptera) of British Columbia. II. Life history and population dynamics. Canadian Entomologist 104: 1099–1121.

Pyefinch, K. A. 1943. The intertidal ecology of Bardsey Island, North Wales, with special reference to the recolonization of rock surfaces, and the rock-pool-environment. Journal of Animal Ecology 12: 82–108.

Remane, A. 1958. Okologie des Brackwassers. *In* Die Biologie des Brackwassers. Schweizerbartsche Verlag, Stuttgart. pp. 1–213.

Ross, H. H. and **C. J. Spencer.** 1952. A preliminary list of the Trichoptera of British Columbia. Proceedings of the Entomological Society of British Columbia 48: 43–51.

Sailer, R. I. 1948. The genus *Trichocorixa* (Corixidae: Hemiptera). *In* The Corixidae of the Western Hemisphere (Hemiptera). *Edited by* H. B. Hungerford. Kansas University Science Bulletin Number 32: 289–407.

Saunders, L. G. 1928. Some marine insects of the Pacific coast of Canada. Annals of the Entomological Society of America 21: 521–545.

Stuart, T. A. 1941. Chironomid larvae of the Millport shore pools. Transactions of the Royal Society of Edinburgh 60: 475–502.

Wiggins, G. B. 1973. A contribution to the biology of caddisflies (Trichoptera) in temporary pools. Royal Ontario Museum, Life Sciences Contribution, Number 88: 1–28.

Williams, W. D. 1964. A contribution to lake typology in Victoria, Australia. Verhandlungen International Vereinigung für Theoretische und Angewandte Limnologie 15: 158–163.

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The Western Hognose Snake, *Heterodon nasicus nasicus*, in Alberta

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Abstract. The Western Hognose Snake, *Heterodon nasicus nasicus*, is quite rare in Alberta, where it reaches the northwestern limit of its range. Seven new locality records help fill a distribution gap in eastern Alberta but do not represent any extension of range. As in other parts of the range, *H. n. nasicus* frequents prairie grassland where sandy soils are present. The annual active period is about 133 days in length and most activity occurs during periods of rising temperature in May, June, and July. In Alberta these snakes accept a variety of food including toads, small mammals, eggs, and possibly insects and garter snakes. Egg-laying may extend from the second week of June to at least the last week of July. Variability and defensive behavior are in keeping with specimens from elsewhere.

The Western Hognose Snake, *Heterodon nasicus nasicus*, has a wide geographic distribution that is roughly coincident with the prairie grassland vegetation zone east of the Rocky Mountains. The range of this animal extends from northern Mexico and Texas to southern portions of Canada's prairie provinces, i.e., southwestern Manitoba, southern Saskatchewan, and southeastern Alberta. The species occurs as far east as Minnesota and Kansas, but disjunct populations also occur in western Illinois (Conant 1958). The most comprehensive paper on the species is the monograph of Platt (1969). Relatively little is known, however, about *H. n. nasicus* in Canada where its range is limited and specimens are uncommon.

My investigation considered various aspects of the natural history of this snake at the northwestern limit of its range in Alberta. Information was obtained on 13 specimens from Alberta. Eleven of these were represented by preserved material and two were studied alive.

Distribution and Abundance

The Western Hognose Snake is a comparatively rare member of Alberta's herpetofauna. Moore (1953) cited only five localities from which specimens had been taken in the province; these were also mentioned by Logier and Toner (1961). Lewin (1963) referred to three specimens, two from localities other than those mentioned by Moore. I am not aware of any other published records for the species in Alberta.

Seven of the specimens examined during the course of this study represent new locality records (Figure 1). The geographic co-ordinates of these localities are as follows: 49°58′00″ N, 110°34′45″ W; 50°08′00″ N, 110°04′16″ W; 50°11′00″ N, 110°42′38″ W; 50°28′39″ N, 110°02′00″ W; 50°36′00″ N, 110°10′00″ W; 50°37′0″ N, 10°11′00″ W; and 50°37′07″ N, 110°05′40″ W. The new records help fill a distribution gap in eastern Alberta but do not represent any extension of range.

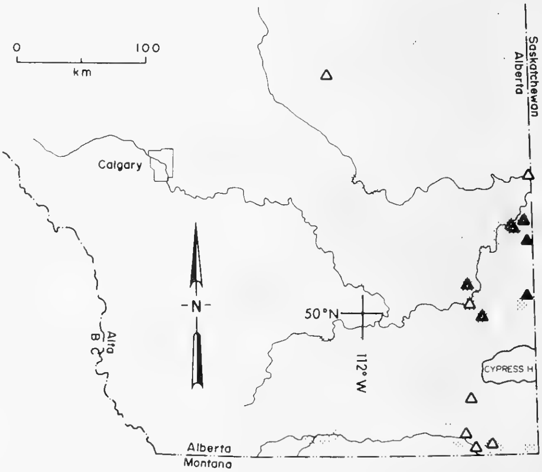

FIGURE 1. Locality records for *Heterodon n. nasicus* in Alberta. Hollow triangles are previously published records, solid triangles are new localities mentioned in this paper. Stippled areas represent surficial deposits that are dominantly or completely sandy.

The species in Alberta is probably represented by scattered semi-isolated populations (Platt 1969). Distribution to the west is likely limited by the existence of suitable substrate within the drier areas of the short-grass prairie. All but one of the Alberta *H. n. nasicus* were taken in prairie having a savannah climate with an annual rainfall of less than 15 cm. The limiting factor to the north may be related to the minimum frost-free period. A comparison of incubation periods for the Bull Snake, *Pituophis melanoleucus sayi* (Wright and Wright 1957), and *H. n. nasicus* (Platt 1969) indicates that eggs of the latter generally require more time to hatch. Hognose Snakes do not range quite as far north as the Bull Snake (Pendlebury 1973).

Williams (1946) did not include *H. n. nasicus* in his report on the vertebrates of the southern plains of Canada although four other reptilian species are discussed. His observations were based on information accumulated between the years 1923–1926 in areas having habitat suitable for the Western Hognose Snake, yet none of these snakes were seen.

I have found only one specimen of *H. n. nasicus* during eight summers of searching specifically for snakes in southeastern Alberta, and the 13 specimens examined represent all the material from Alberta that was available for study. These specimens were collected over a period of 46 years.

Cook (1970) inferred that the scarcity of this snake might be more apparent than real and may result from the animals' secretive behavior. Another possibility is that some Western Hognose Snakes have been misidentified owing to their superficial resemblence to the better known and more common Bull Snake, *P. m. sayi*, and the Prairie Rattlesnake, *Crotalus viridis viridis*. In the light of Platt's (1969) findings, however, and bearing in mind all available data pertaining to the Alberta specimens, I can only conclude that the Western Hognose Snake is, in fact, quite rare in the province.

Habitat

The habitat propensities of this snake have been mentioned by several authors and there is general agreement that this snake prefers the dry prairies, particularly where sandy soils are present. The same holds true for the species in Alberta, as indicated in Figure 1. All capture sites occur within, or in very close proximity to, areas where the surficial deposits are dominantly or completely sandy.

Field notes and museum records provided additional evidence on habitat for 11 of the 13 specimens studied.

A specimen (BRS) caught near Hilda "... was close to the top of a knoll on a south facing exposure. The soil is sandy, the vegetation is sparse. Spear grass (*Stipa comata*), sand dock (*Rumex venosus*) and rose (*Rosa acicularis*) were most plentiful around the site of capture. On the top choke cherry (*Prunus virginiana*) and cushion cactus (*Mamillaria vivipara*) were common" (Bryan R. Shantz, personal communication). The specimen (GBP) from 2 km west and 14.5 km north of Medicine Hat was found on the west side of a gravel road that separates cultivated land on the east from over-grazed rangeland on the west. Soils in this area are generally quite sandy. Sagebrush (*Artemisia cana*), cushion cactus (*M. vivipara*), and prickly pear cactus (*Opuntia polyacantha*) are common constituents of the flora. Two specimens (PMAA Z-69.42.4 and PMAA Z-71.70.16) captured in the same general area 14.5 km north and 15 km west of Hilda were found in "sandy prairie" and on a "prairie trail," respectively (PMAA Specimen Report). Another "prairie trail" 2.4 km west of Many Island Lake yielded PMAA Z-69.53.11. A snake (UAMZ 68) from Empress was caught "... by a roadside pool" (Moore 1953). One of the specimens (UAMZ 267) mentioned by Lewin (1963) was found "... in short grass surrounded by large rocks and prostrate juniper bushes. The area was on a south facing slope and at the first step at the top of the Milk River canyon rim." Specimen UAMZ 517 was found "... where highway 41 passes through some small sand hills" (Nick Panter, personal communication). The stomachs of two specimens (PMAA Z-71.70.16 and UAMZ 68) contained abundant sand, and faeces removed from five specimens (PMAA Z-69.42.4, UAMZ 1, UAMZ 68, UAMZ 69, and USMZ R56) also contained sand. One snake (PMAA Z-69.53.11) had a considerable amount of sand in its mouth.

Activity

The limited evidence available indicates that the Western Hognose Snake is diurnal in its activity. Ten of the 13 specimens were caught during daylight hours but actual capture time was recorded in only two cases. One (BRS) was collected about 1700 hours, the other (GBP) was found at 1300 hours. The three other specimens were road kills and their time of death is unknown. Table 1 summarizes the weather conditions that prevailed at meteorological stations near each of the capture sites.

Six (55%) of the 11 specimens for which there are sufficient data were found on a day with some rain or on a day following rain. Platt (1969) made no attempt to correlate activity with precipitation but did conclude that activity was related to periods of rising temperature, i.e., greater activity occurred if the mean maximum temperature was at least 2.2°C higher than the immediately preceding period. A similar situation may exist in Alberta, as seven of the 11 specimens were captured in periods of rising temperature.

Western Hognose Snakes have been captured in Alberta as early as 10 May and as late as 20 September for an annual active period of about 133 days. Ten (77%) were caught during May, June, and July. The limited number of specimens and the markedly unbalanced sex

TABLE 1—Temperature and precipitation on the day of capture and day prior to capture of *Heterodon nasicus nasicus* in Alberta

Specimen number	Capture location	Date of capture	Day of capture Temperature (°C)		Day of capture Precipitation (mm)	Previous day Temperature (°C)		Previous day Precipitation (mm)
			max.	min.		max.	min.	
BRS	50°28′39″ N, 110°02′00″ W	22 June 1972	25.6	9.4	3.56	21.7	13.3	0.00
GBP	50°11′00″ N, 110°42′38″ W	19 May 1973	28.3	9.4	0.00	24.4	8.3	0.00
NMNS 1444	49°59′00″ N, 110°34′45″ W	20 September 1927	21.1	0.0	0.00	13.3	8.3	0.00
PMAA Z-69.42.4	50°36′00″ N, 110°10′00″ W	30 May 1969	18.9	9.4	0.00	25.6	7.8	0.00
PMAA Z-69.53.11	50°08′00″ N, 110°04′16″ W	26 June 1969	22.2	11.7	0.00	18.9	12.2	0.76
PMAA Z-71.70.16	50°37′00″ N, 110°11′00″ W	24 July 1971	27.2	6.7	0.00	21.1	11.1	5.33
UAMZ 1	49°07′00″ N, 110°44′20″ W	2 July 1938	24.4	13.3	6.86	24.4	10.6	0.51
UAMZ 68	50°57′00″ N, 110°00′40″ W	13 July 1951	27.8	14.4	19.56	31.1	11.1	2.54
UAMZ 69	50°57′00″ N, 110°00′40″ W	13 July 1951	27.8	14.4	19.56	31.1	11.1	2.54
UAMZ 267	49°02′00″ N, 110°39′30″ W	15 June 1962	22.2	10.0	0.00	20.6	12.2	0.00
UAMZ 268	49°04′49″ N, 110°30′15″ W	July 1961	?	?	?	?	?	?
UAMZ 517	50°37′07″ N, 110°05′40″ W	10 May 1971	21.1	1.7	0.00	15.6	6.1	0.00
USMZ R56	49°23′47″ N, 110°41′40″W	?	?	?	?	?	?	?

NOTE—BRS = Bryan R. Shantz, GBP = George B. Pendlebury, PMAA = Provincial Museum and Archives of Alberta, UAMZ = University of Alberta Museum of Zoology, USMZ = University of Saskatchewan Museum of Zoology, NMNS = National Museum of Natural Science.

ratio precludes determination of a possible sex-based difference in seasonal activity as found in other parts of the range (Platt 1969).

Behavior

The stereotyped defense behavior of *H. n. nasicus* has undoubtedly received more attention than any other aspect of its nature. When confronted, the snake will simply try to crawl away, but if danger is imminent, the animal will try to bluff its way out of the predicament. The complete sequence of events consists of neck spreading, deep inhalation followed by forced expulsion of the air to yield a loud hiss, striking, and finally, if all else fails, feigning death. The nature and severity of the encounter can, however, modify or 'short-circuit' the sequence.

Lewin (1963) stated that a specimen (UAMZ 68) collected at Empress by Lister and Moore "... puffed itself up, hissed, then remained upside down in the hand." Another specimen (UAMZ 267) "... made no attempt to feign death nor did it become limp when captured. In fact it struck several times as it tried to escape" (Lewin 1963). Specimen BRS hissed when poked with a stick and then feigned death when struck. The snake escaped and was subsequently recaptured, at which time it again played dead. Later, "when removed from the pail it hissed but made no threat to strike. Its only action was to crawl slowly away from the observers" (Bryan R. Shantz, personal communication). Specimen GBP was first seen as it was crawling into a small rodent burrow. I grabbed the tail and posterior portion of the body but was unable to remove the animal from its refuge as the anterior portion of the body had been used to secure a hold within. Ten minutes later, after having been dug out of its retreat, the snake was placed on the ground. It immediately rolled over and played dead. The following day the snake was removed from the collecting bag for filming purposes. This time the snake attempted to escape, but when confronted, rolled on its back and again feigned death. With mouth agape and tongue extended, the snake everted its cloaca to expel urates and a small amount of blood.

Food

Toads have long been considered to be the principal food item of *H. n. nasicus*. Enlarged teeth at the back of the jaw and well developed adrenal glands have been cited as among the specializations directed toward the utilization of toads as prey. The teeth serve to deflate the toads that have pumped themselves up with air as a defensive tactic (Harrison 1971), and the enlarged adrenal glands apparently confer some protection against the toxic substances in toads (Oldham et al. 1970).

Other items that have been accepted are eggs from a turtle nest (Stebbins 1954); frogs, shrews, sparrows, rats, mice, lizards, garter snakes (Wright and Wright 1957); salamanders (Stebbins 1966); and tadpoles, lizard eggs, snake eggs, turtles, and voles (Platt 1969).

Experience with two living specimens and the results from the examination of the stomach and intestine contents of the preserved material gave some indication of the diet of the Western Hognose Snake in Alberta.

The specimen (BRS) from near Hilda was given into my care when it refused a diet of frogs and toads. The snake was placed in a terrarium that contained two Wandering Garter Snakes, *Thamnophis elegans vagrans*, (one adult, one juvenile), and an adult Plains Garter Snake, *Thamnophis radix haydeni*. The Hognose Snake immediately seized the *T. r. haydeni* about 6 cm behind the head and attempted to restrain its potential meal by using a rather interesting technique. Instead of throwing coils about the victim in the fashion of constricting colubrids, the Hognose Snake rotated about its own longitudinal axis with the result that the two snakes became intertwined. The heavier-bodied Hognose Snake was able to control the movements of the longer and more slender Garter Snake to a certain extent but the prey was eventually released as it proved to be too large and active to overcome. The Hognose Snake made no attempt to subdue either of the *T. e. vagrans*.

Faeces passed by the other specimen (GBP) three days after capture contained fur—positive evidence that the snake had preyed on small mammals. A pair of 2-week-old mice were voluntarily accepted after 4 weeks in captivity but all food was refused thereafter.

Chitinous insect debris was recovered from the faeces of one of the preserved specimens (USMZ R56). There was no other undigested residue such as fur, feathers, claws, or bone to suggest that these items were ingested by another animal that subsequently fell victim to the snake. The stomach of a specimen (UAMZ 68) from Empress contained a grasshopper femur and the collapsed shell of an unidentified egg that measured approximately 10 × 18 mm. A complete beetle and portions of ants were found in the stomach of another specimen (UAMZ 517) but these were probably eaten by a Plains Spadefoot Toad, *Scaphiopus bombifrons*, the remains of which were also found in the stomach.

Variability

In color, pattern, and squamation the specimens of *H. n. nasicus* from Alberta show just as much variation as representatives from other parts of the range. Descriptions have previously been given by Wright and Wright (1957), Conant (1958), Stebbins (1966), and Platt (1969).

Eleven of the 13 specimens examined have been kept in various preservatives for different periods of time so that comparisons on the basis of color are semi-qualitative at best. Nevertheless, it is apparent that the ground color of the Alberta specimens ranges from pale to medium shades of brown with blotches of somewhat darker brown. The blotches can be well defined (Figures 2a and 2b) or poorly defined (Figures 2c and 2d). The vertebral blotches are 2–2½ scales long and generally involve nine scale rows. The interblotch space is 1–2 scales in length. Vertebral body blotches average 37.2 in females

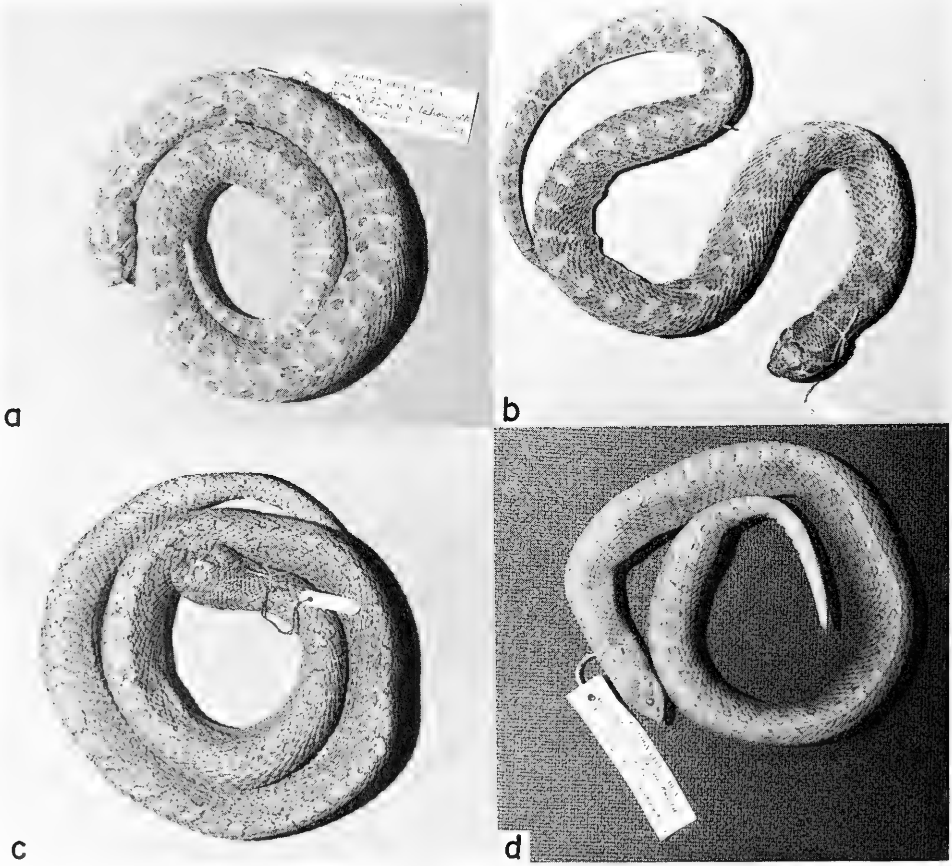

FIGURE 2. Variation in the Western Hognose Snake from Alberta: a, very defined dorsal and lateral blotches—UAMZ 267; b, dorsal blotches well defined but tend to merge with the spots on the lateral surfaces—PMAAZ69.42.4; c, lateral blotches poorly defined, dorsal interblotch spaces made very apparent by dark pigmentation—PMAA Z271.70.16; d, a relative pale specimen—UAMZ 68.

($n = 10$) and 32.5 in male ($n = 2$). In other parts of the range the average count is 38.9 for females and 34.8 for males (Platt 1969). The lateral spots are 1½–2 scales long and involve 2–5 scale rows. These markings are darker than the dorsal blotches. The number of tail blotches ranges from 8–19 in females and 11–15 in males.

The ventral body pattern of *H. n. nasicus* has variously been described as having a wide area of black covering the central portion (Ditmars 1939) or black pigmentation broken by scattered yellow markings to produce a somewhat checkered pattern (Stebbins 1954). Both pattern types (Figure 3) are represented by the Alberta specimens. The geographic distribution of the ventral pattern types is indicated in Figure 4. Unfortunately, the Craigmyle specimen could not be located and its ventral pattern type is unknown. Neither mean scale counts nor mean blotch numbers reflect the north–south division demonstrated by the ventral pattern types. I have no knowledge of the ventral pattern types in adjacent areas of Saskatchewan and Montana; hence, speculation concerning the significance and possible reasons for this curious distribution would be premature. The ventral surface on the tail of all specimens was uniformly dark. The cloacal area was light as in specimens from elsewhere.

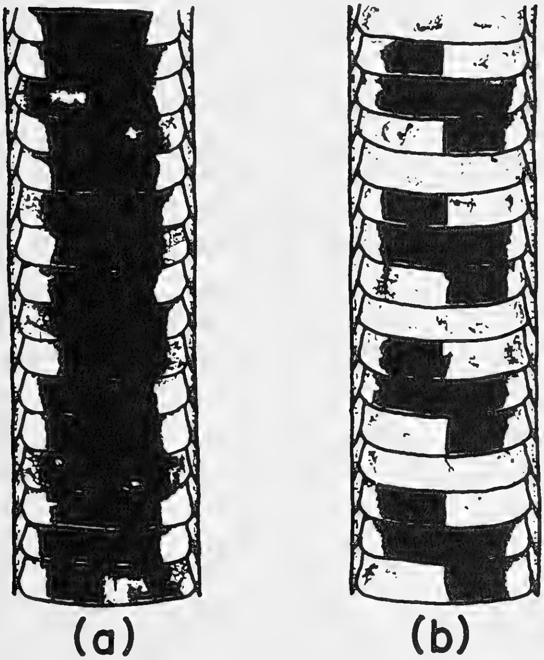

FIGURE 3. Ventral pattern types of *Heterodon n. nasicus* from Alberta. a, dark ventral stripe—UAMZ 268; b, checkered pattern—NMNS 1444.

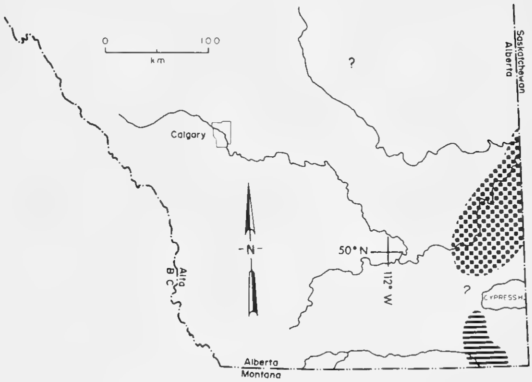

FIGURE 4. Distribution of ventral pattern types in Alberta. Horizontal lines represent the dark striped pattern and the checkered pattern represents the checkered ventral pattern.

Meristic data for the Alberta specimens are given in Table 2. With the exceptions of BRS and GBP which were measured in a relaxed state immediately after death, the snout–vent lengths (SVL) and total lengths (TL) were determined from preserved material.

Reproduction

Western Hognose Snakes lay 5 to 24 eggs, usually during July and August (Wright and Wright 1957). In Alberta, Moore (1953) reported a specimen (UAMZ 68) that laid four eggs over a 4-day period from 19–23 July 1951 and subsequently yielded seven more eggs at necropsy. Careful examination of this specimen revealed that there were, in fact, eight remaining eggs; two of these were closely packed and half the size of the others, and hence they were counted as one. Another specimen (UAMZ 267), captured 15 June 1962, contained nine large incompletely-developed eggs. The right oviduct was markedly stretched as though it had recently been emptied of its complement of fully developed eggs. Specimen BRS laid several eggs during the first few weeks of July 1972 (Bryan R. Shantz, personal communication) and another

TABLE 2—Scale counts for 13 specimens of *Heterodon nasicus nasicus* from Alberta. SVL = snout-vent length, TL = total length, SR = scale rows, V = ventrals, C = caudals, SL = supralabials, IL = infralabials, A = azygous, O = oculars, L = loreals, N = nasals, BB = body blotches, TB = tail blotches

Specimen number	Sex	SVL (mm)	TL (mm)	SR	V	C	SL	IL	A	O	L	N	BB	TB
BRS	F	521	602	23/23/19	140	36	8/8	11/10	12	11/11	3/3	2/2	37	10
GBP	F	487	568	23/23/19	139	37	8/8	10/10	17	11/11	2/2	2/2	36	13
NMNS 1444	M	373	468	23/21/19	132	48	8/8	10/9	12	8/9	2/3	2/2	32	15
PMAA Z-69.42.4	F	470	578	23/21/19	131	45	8/8	9/9	13	8/9	2/2	2/2	36	15
PMAA Z-69.53.11	?	?	?	23/??/??	?	?	8/8	10/10	13	10/11	2/2	2/2	?	?
PMAA Z-71.70.16	F	700	?	23/23/19	142	30+	8/8	10/10	16	7/8	2/2	2/2	36	11+
UAMZ 1	F	355	437	23/21/18	135	44	8/8	9/10	10	10/10	2/2	2/2	32	10
UAMZ 68	F	492	562	23/21/19	140	32	8/8	10/10	16	10/11	2/3	2/2	41	11
UAMZ 69	F	149	182	23/23/19	128	49	8/8	10/9	22	7/7	3/3	2/2	39	19
UAMZ 267	F	473	536	23/22/19	140	31	8/8	10/10	16	10/11	2/2	2/2	39	10
UAMZ 268	F	431	526	23/23/19	134	43+	8/8	9/9	14	11/10	2/3	2/2	37	8
UAMZ 517	M	555	640	23/23/19	141	34	8/7	9/9	12	7/8	1/1	2/2	33	11
USMZ R56	F	318	379	23/23/19	136	42	8/8	10/10	14	10/11	3/4	2/2	39	13

egg measuring 40 × 15 mm was found in the right oviduct on dissection. If UAMZ 267 had laid eggs shortly before being captured, a laying period that extends from at least as early as the second week of June to at least the last week of July is indicated for *H. n. nasicus* in Alberta.

Acknowledgments

I am indebted to the following individuals who made the specimens of *H. n. nasicus* in their care available for this study: F. R. Cook, National Museum of Natural Science (NMNS); W. J. Maher, University of Saskatchewan Museum of Zoology (USMZ); N. Panter, University of Alberta Museum of Zoology (UAMZ), H. C. Smith, Provincial Museum and Archives of Alberta (PMAA); and B. R. Shantz. The meteorological data were kindly provided by S. Supina, Department of the Environment. F. R. Cook and W. B. Preston read the manuscript and offered suggestions for its improvement.

Literature Cited

Conant, R. 1958. A field guide to reptiles and amphibians of Eastern North America. Houghton Mifflin Company, Boston, Massachusetts. 366 pp.

Cook, F. R. 1970. Rare or endangered Canadian amphibians and reptiles. Canadian Field-Naturalist 84(1): 9–16.

Ditmars, R. L. 1939. A field book of North American snakes. Doubleday and Company Incorporated, Garden City, New York. 305 pp.

Harrison, H. H. 1971. The world of the snake. J. B. Lippincott Company, Philadelphia and New York. 160 pp.

Lewin, V. 1963. The herpetofauna of southeastern Alberta. Canadian Field-Naturalist 77(4): 203–214.

Logier, E. B. S. and **G. C. Toner.** 1961. Check list of amphibians and reptiles of Canada and Alaska. Life Sciences Division, Royal Ontario Museum Contribution 53: 1–92.

Moore, J. E. 1953. The Hog-nosed snake in Alberta. Herpetologica 9(4): 173.

Oldham, J. C., H. M. Smith, and **S. A. Miller.** 1970. A laboratory perspectus of snake anatomy. Stipes Publishing Company, Champaign, Illinois. 98 pp.

Pendlebury, G. B. 1973. Additional records of the Bull Snake from Alberta. Blue Jay 31(1): 46–48.

Platt, D. R. 1969. Natural history of the Hognose Snakes *Heterodon platyrhinos* and *Heterodon nasicus*. University of Kansas Publications, Museum of Natural History 18(4): 253–420.

Stebbins, R. C. 1954. Amphibians and reptiles of Western North America. McGraw-Hill Book Company, Incorporated, New York. 536 pp.

Stebbins, R. C. 1966. A field guide to western reptiles and amphibians. Houghton Mifflin Company, Boston, Massachusetts. 279 pp.

Williams, M. Y. 1946. Notes on the vertebrates of the southern plains of Canada. Canadian Field-Naturalist 60(3): 47–60.

Wright, A. H. and **A. A. Wright.** 1957. Handbook of snakes of the United States and Canada. Cornell University Press, Ithaca, New York. 1105 pp.

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Mapping Wetlands on Beaver Flowages with 35-mm Photography

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Abstract. Beaver flowages and associated wetlands on the Chippewa National Forest, north-central Minnesota, were photographed from the ground and from the open side window of a small high-wing monoplane. The 35-mm High Speed Ektachrome transparencies obtained were used to map the cover-type associations visible on the aerial photographs. Nearly vertical aerial photos were rectified by projecting the slides onto a base map consisting of control points located by plane-table survey. Maps were prepared by tracing the recognizable stands of vegetation in the rectified projection at the desired map scale. Final map scales ranging from 1:260 to 1:571 permitted identification and mapping of 26 cover-type associations on 10 study flowages in 1971. This cover-mapping technique was economical and substituted for detailed ground surveys. Comparative data from 10 flowages were collected serially throughout the entire open-water season. Although developed for analysis of waterfowl habitat, the technique has application to other areas of wildlife management and ecological investigation.

Cowardin and Johnson (1973) developed a system of classifying areas of wetland vegetation for meaningful analysis of waterfowl use. Their system was restricted in purpose and in applicability, but was a logical outgrowth of the methods of Stewart and Kantrud (1971) when applied to a narrower problem. A study of waterfowl utilization of beaver (*Castor canadensis*) flowages on the Chippewa National Forest, north-central Minnesota (Kirby 1973) required some means of comparing total area and the diversity of plant communities in wetland habitats. My familiarity with an earlier version (Gilmour 1971) of Cowardin and Johnson's (1973) system suggested a comparable but even more site-specific approach to habitat analysis. Since the beaver flowages studied were within the same biogeographic area as that described by Gilmer (1971), it was expected that the same unit of vegetation, the "stand," defined as "an area of wetland vegetation with sufficient uniformity and size so as to be recognizable both on the ground and on aerial photographs" (Cowardin and Johnson 1973, p. 1) could be used, and that many of the stand types recognized in these earlier studies also would be present on the beaver flowages.

The objectives of the habitat analysis were (1) to map accurately the flowage boundaries, (2) to describe the flowages in terms of stand types or similar entities that would permit comparative analysis of habitat use by waterfowl and other fauna, and (3) to develop a technique that would permit successive measurements of the habitat throughout the year on a number of isolated areas.

Details of technique development and use, illustrated by selected data from the 1971 season, are presented below. This low-cost simple method of habitat analysis was developed to be applicable to beaver flowages, man-made impoundments, and similar wetlands throughout the Chippewa National Forest. In this respect it answered the call for more detailed analysis of the management program on the Chippewa (Mathisen 1970). This identification and mapping technique, however, has broad application to similar endeavors in both upland and lowland areas.

Study Area

The Chippewa National Forest is located in north-central Minnesota between 46°59′ and 47°51′ N, and between 93°17′ and 94°40′ W, encompassing the southeast corner of Beltrami County, northwest and north-central Itasca County, and the northern two-thirds of Cass County. Kirby (1973, pp. 9–18) described the area in detail. The area falls within Küchler's (1964) vegetation regions 93–95: Great Lakes Spruce-Fir Forest (*Picea-Abies*), Conifer Bog (*Larix-Picea-Thuja*) and Great Lakes Pine Forest (*Pinus*), respectively. Beaver flowage wetlands *per se* have not been described in north-central Minnesota. Knudson (1962) and Neff (1957) have discussed aspects of wetland succession in beaver flowages found in Michigan and Colorado that apply to Minnesota. Cowardin and Johnson's (1973) wetland community descriptions also apply to the vegetation on the beaver flowages.

A beaver flowage inventory conducted in 1970 located 429 areas that fitted the following definition of a beaver flowage: "a body of water and associated wetlands owing its existence primarily to the activities of beaver" (Kirby 1973, p. 20). Ten accessible flowages which were being actively maintained by beaver and that were typical of certain age and size classes were selected for intensive study of waterfowl utilization and habitat analysis (Table 1).

TABLE 1—Ages and areas of 10 beaver flowages investigated in 1971

Flowage[1] number	Age[2] (years)	Total area[3] (hectares) May 20	Total area[3] (hectares) July 17
125	23+	6.3	5.1
222	23+	3.3	2.3
285	3–4	8.0	8.0
300	22	8.1	5.1
310	16–17	10.8	10.8
425	3–4	6.1	4.5
435	16–17	1.9	1.9
600.34	9	2.2	2.1
730	24+	3.4	3.4
754	24+	5.1	5.1

[1] Flowage inventory designation.

[2] Time elapsed since either photographic records or historical accounts indicated the presence of beaver dams in the drainage. Photographic records from 1949 could age two flowages to at least 23 years. Two flowages held active beaver colonies in the 1930s, and were given ages of 24+ years.

[3] The flowage margin was considered the perimeter of the pool of standing water on the dates specified. Streams or rivers still within their pre-beaver activity banks were not considered impounded water.

Methods

Serial photographs were taken of the flowages throughout the open water season, 15 April to 1 November. Spring (April–May), early summer (June), late summer (July–August), and fall (September–October) were considered phenologically distinct for habitat analysis. At least four aerial views were included in each set of photographs for serial analysis of the habitat: two approximately vertical photos, one high oblique, and one low oblique. All aerial photography was taken through the open side window of a Cessna 172 with an Anscoset 35-mm camera. High-speed color transparency daylight film, Ektachrome ASA 160, was used for all photography. No filters were necessary since haze conditions were minimal. Film was exposed at 1:250 with apertures from f/4.0 to f/5.6 with a Rokkor f/2.8 45-mm lens. Approximately vertical photographs were obtained by banking over a flowage at as low an altitude as would permit complete camera coverage of the entire flowage. Aiming the camera beneath and to the aircraft's left from the right window while the plane was in the steep bank resulted in little image motion and as nearly vertical pictures as possible with a hand-held system. As many ground photographs as were necessary to cover all portions of the flowage and shoreline from the water's edge were taken with the same film and camera within 3 days of the aerial photography. During this ground photography, vegetation notes were summarized in sketch map form at each ground photo site.

From the photographs of each flowage, natural objects consistently identifiable from all camera angles were selected as control points for a base map. In order of visibility, the following were used: the beaver lodge, dam, lone conifers, hardwoods leaning over open water, isolated emergent vegetation patches, unique sections of flowage margin (bays, creek mouths, beaver canals), and downed timber and dead snags. Three or more control points along the flowage margin and as far apart from each other as possible were located and mapped by the intersection method described by Welch (1948, pp. 17–20) with a plane table and alidade. Base lines were measured with a steel tape. The completed control points base maps consisted of scaled diagrams of known objects on the 10 flowages.

Maps were prepared by projecting the most nearly vertical photographs onto the control points base maps which were attached to a movable surface constructed similar to an artist's tripod drawing stand. Either the projector (f/3.5 zoom lens, 10.2–15.2 cm) or projection surface or both were tilted to align the images of the control points with the control points base map. Slides that were distorted by severe tilt could not be used because some of the projected image was out of focus when the correct projection angle was reached. Corrections of up to 5° horizontally or vertically or both could be made when the projector was 9 m or farther from the screen. Ultimate aligned image size was controlled by reducing or expanding the scale of the control points base map with either an opaque (overhead) projector or a pantograph. The flowage boundaries and all differentiable patches of vegetation were traced on a sheet of rough-surfaced white paper placed over the control map. Simultaneous projection of the oblique aerial photographs on an adjacent screen aided in solving problems of interpretation and aided interpretation of the "stands" of vegetation. A ground check of the resulting map was then made to verify the reality and identification of the areas differentiated from the aerial photos. In some situations, additional field work was also necessary to verify or clarify problems with the delineation of the flowage margins. I spot-checked the integrity of the vegetation boundaries when the map was completed. After minor field corrections, the differentiable areas were given cover-type association names. Final area determinations were made with a compensating polar planimeter.

The cover-type associations were differentiated because of their suspected unequal value to waterfowl at different times of the year. The categories were sufficiently distinct for them to be consistently recognized at the site and on the ground photographs and were named in colloquial terms by referring to the dominant (to the eye) vegetation visible from the aerial photos. Areas of differentiable vegetation located on the aerial photographs were not subdivided on the basis of later ground survey information. In this respect, the designation of the associations was more descriptive than definitive and made no attempt to treat the botanical aspects of the stands in a thorough manner. The emphasis was always upon reliable repeatable identification from the photographs.

The scale of the final maps was determined by subjectively weighing the benefits of various scales of projection on the spring photography for each flowage. The selected map scale was then used for the remainder of the study. Small-scale projections gave better definition of cover-type association boundaries and the flowage margin, and facilitated the distinction of the control points. Large-scale projections increased the visibility of small stands and open water and decreased the significance of potential errors in the measurement of the areas of the types. Complex interspersion of stands required a larger map scale for the distinction of the types, even if reference to a smaller-scale projection was necessary for the identification of the stand. Final map scales ranged from 1:260 to 1:571. As the scale of the final projected image increased, unnecessary subdivision of the cover-type associations on the basis of apparent vegetation density occurred. Spot checks of the final maps resulted in the combination of some associations previously differentiated on the basis of density alone, but some density categories unique to single flowages, especially those flowages with large stands or very few stands, were kept intact by the addition of 'sparse,' 'moderately dense,' or 'very dense,' to the cover-type name when site-specific comparisons were necessary.

Results and Discussion

Figures 1–3 illustrate typical serial results for one beaver flowage. The cover-type associations identified in this flowage are described in Table 2. In all, 26 cover-type associations were

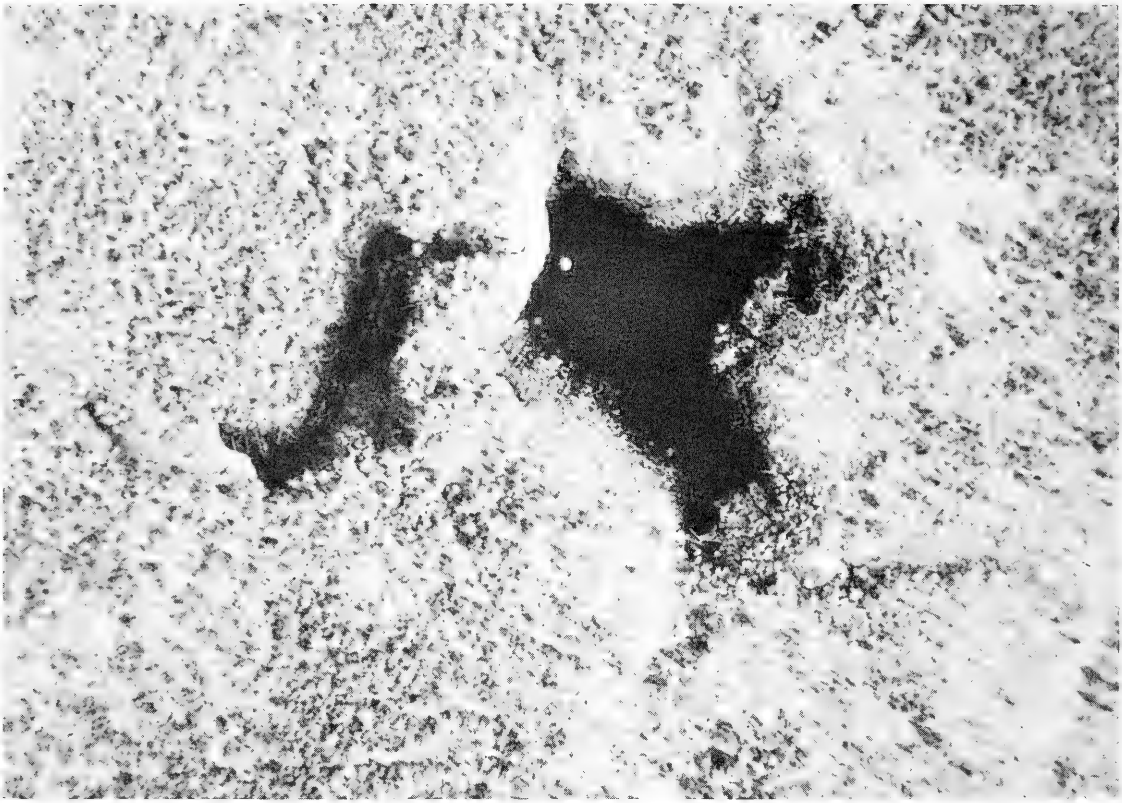

FIGURE 1A. Enlarged print of 35-mm High Speed Ektachrome aerial photograph of flowage 300, 20 May 1971. The larger flowage area in early spring required photography from a higher altitude and thus a smaller scale for complete coverage. The lack of detail in the surrounding uplands was due to scattered shadows cast by the leafless hardwood crowns of the light-toned forest floor litter. Water levels were high, flooding extensive areas of trees and shrubs along the flowage margin. Emergent vegetation was sparse and confined to the shallow water. Four active dams were present. The main lodge was visible near the dam in the main pool.

identified on the 10 study flowages. Vegetation differences from spring to summer were easily quantified. Differences from midsummer to fall could not be quantified from the aerial photographs alone. Changes in gross flowage area could be detected at any season. In flowages where the beaver were able to maintain water levels throughout the year, changes in vegetation were qualitative as the season progressed. In those flowages with widely variable water levels, quantitative changes outweighed the qualitative differences resulting from seasonal plant succession.

Sharp pictures were obtained at various airspeeds (129–160 km/h) even as low as 152 m above the flowage. Delineation of the flowage shoreline was possible even in dense stands of willows (*Salix* spp). and alders (*Alnus* spp.). Water standing in newly flooded areas was clearly visible through the still living tree and shrub crowns. Airspeeds as slow as possible were preferable for photographer comfort, care being taken not to yaw the aircraft. Operating the hand-held camera became difficult only in accelerated steep banks. The mapping technique permitted successive measurements of the vegetative cover throughout the open-water season. After the initial location of the control points, it

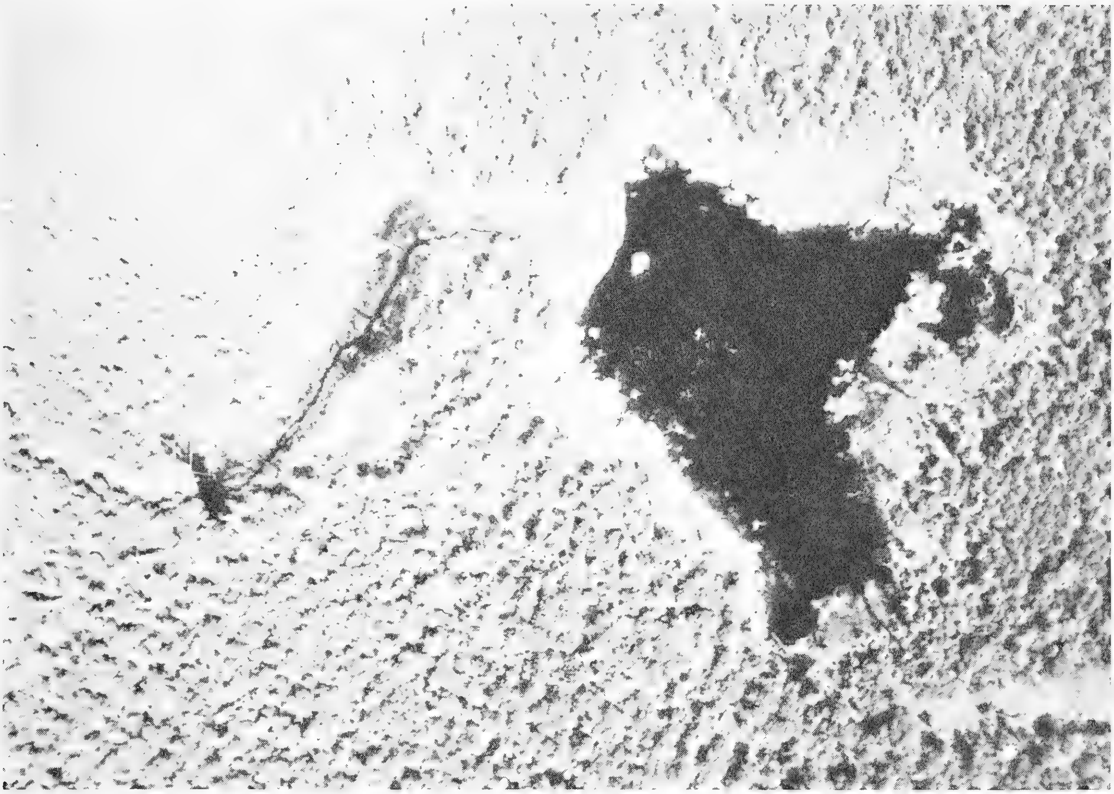

FIGURE 1B. Enlarged print of 35-mm High Speed Ektachrome aerial photograph of flowage 300, 17 June 1971. Water remained behind only two of the four dams present in early May. Emergent vegetation covered the entire lower pool except in the deep water by the dam and in the channels kept clear by the beaver. Lowered water levels (42 cm less than the level in Figure 1A) in the larger pool had drained flooded tree, shrub, and upland areas and encouraged emergent vegetation growth on the flowage margin.

was necessary only to project the latest aerial photographs onto the base map to construct the next flowage vegetation map.

Varying precision in delineating the cover-type associations resulted from varying the elevations from which the photographs were taken. But at the range of photo and map scales used, this did not present problems for comparative analysis. The complicated photogrammetry of oblique aerial photographs usually precludes their use in mapping (Howard 1970, pp. 100–105). But the loss in accuracy resulting from the use of approximately vertical photographs and a moveable projector and tiltable screen to rectify the image in the technique of this paper did not compromise my research objectives.

In this study, the aerial technique was selected because ground mapping was economically and logistically infeasible. Ground-truth data were therefore collected to gather information on stand characteristics, rather than the location of specific stand boundaries. I therefore have no estimate of the increase in precision of boundary delimitation that would have resulted from ground work of varying intensities. Spot checks of the completed maps, however, satisfactorily demonstrated the accuracy of the identification of the cover-type associations. Similar checks of

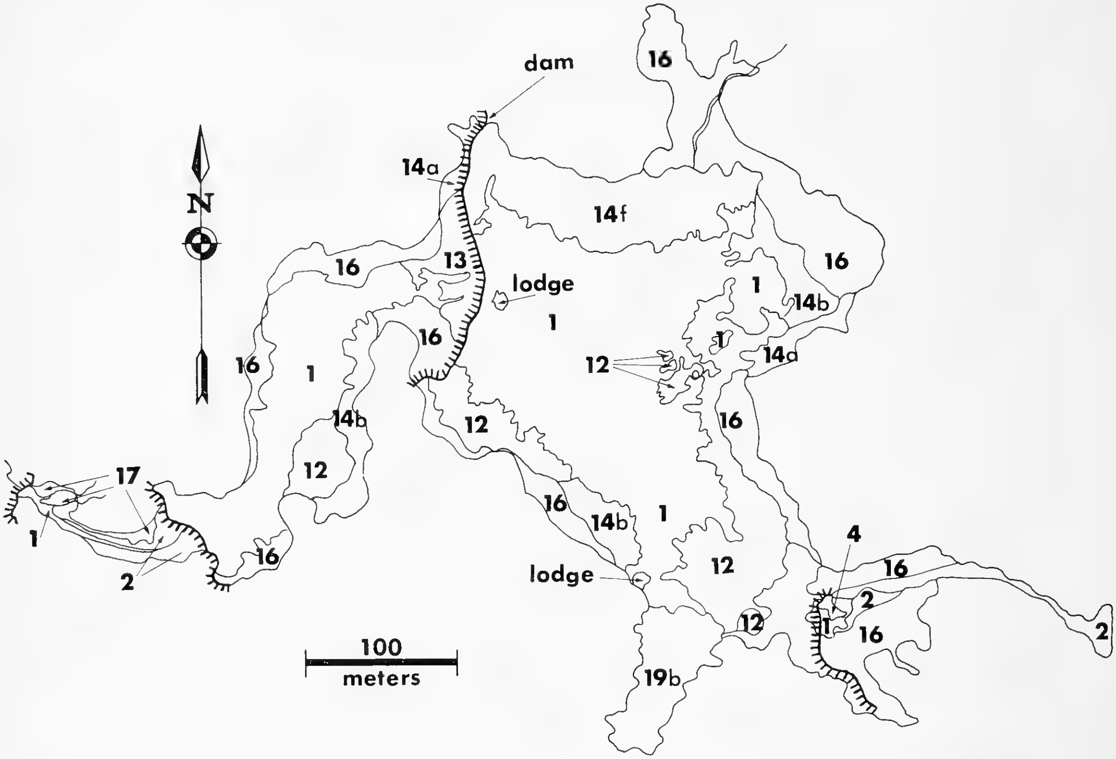

FIGURE 2. Vegetation map of flowage 300 made from the photograph in Figure 1A, 20 May 1971. The numbers refer to the cover-type associations listed in Table 2. There are large areas of open water (Type 1) and areas of flooded living trees and shrubs and upland areas (Types 16–19). Total flowage area was approximately 8.1 hectares.

the integrity of the vegetation boundaries as mapped, performed by running transects across navigable portions of the flowages, revealed only minor inconsistencies, all of which were felt to be well within the range of error expected from the rectification procedure used.

Thirty-five millimetre photography has been used in other studies (Willingham 1959; Klein 1970) and has been reviewed by Zsilinszky (1969). Low-altitude photographs, both oblique and vertical, have been used to collect ground truth, but not to construct maps in other wetlands studies (Vytautas et al. 1974). Disadvantages with the 35-mm system include tip and tilt of the image, image motion at low altitudes, and possible errors introduced by lens resolution capabilities, lens distortion, and lack of filter and platen flatness. Additionally, 35-mm film quality may vary depending upon age, temperature, and manufacturing variances. Advantages include high pictorial value at low cost, ease of film processing, and versatility of the aircraft-photographer-camera system. The advantages of color aerial photography have been thoroughly documented by the American Society of Photogrammetry and the Society of Photographic Scientists and Engineers (1969), Carneggie and Reppert (1969), Hostrop and Kawaguchi (1971) and others.

Expenses for one set of aerial photographs of all 10 flowages were limited to expenditures for aircraft rental ($25.00/h, 1.4 h per flight on a route with a minimum airline distance from the airport to each flowage and return of 260 km),

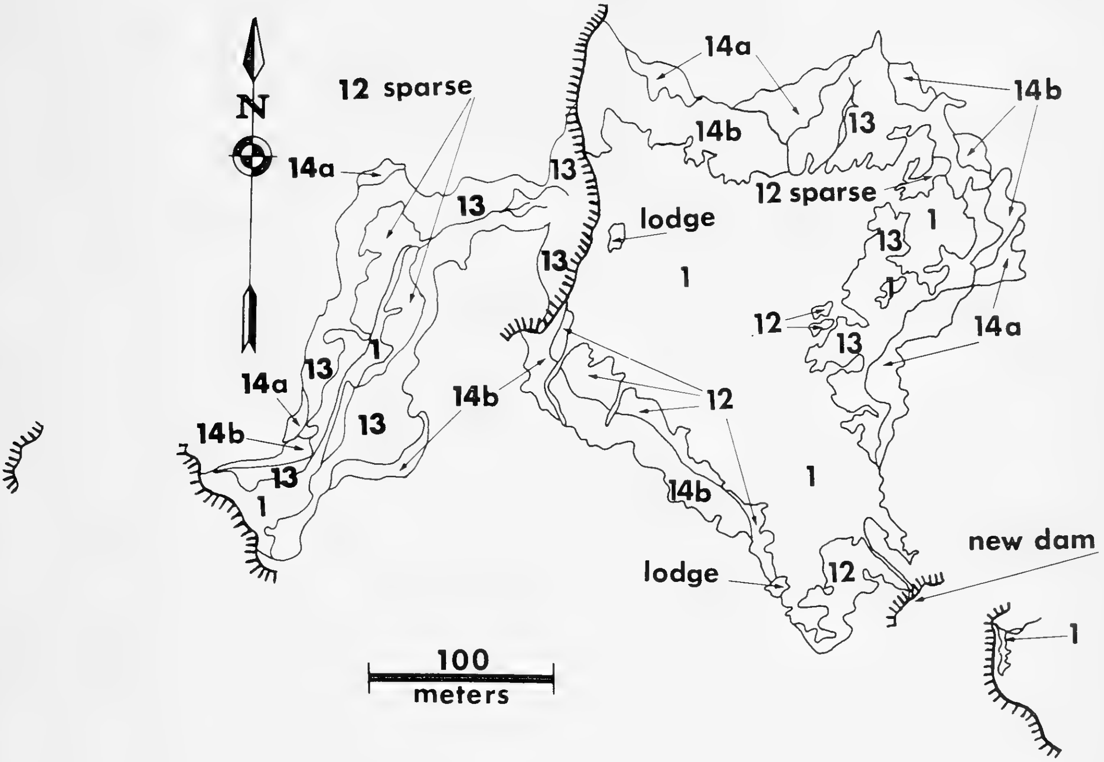

FIGURE 3. Vegetation map of flowage 300 made from the photograph in Figure 1B, 17 July 1971. The numbers refer to the cover-type associations listed in Table 2. Flowage surface area was now only 5.1 hectares. The lowest and highest pools in the drainage, as well as the pool formed behind a new dam constructed in late May 1971, were dry. Emergent vegetation was extensive and more dense (Types 12 and 13), but the area of flooded trees and shrubs was much reduced by the lowered water levels.

and expenditures for film and processing (approximately $15.99 per flight for 60 pictures) for a total of approximately $50.00 per flight. One complete set of ground photographs cost approximately $15.00 for the first set, then approximately $10.00 for every set thereafter. Comparable habitat inventory by ground survey or more sophisticated aerial techniques would assuredly have been much more expensive. The remaining costs of the project were in time for map preparation and collection of ground-control data.

A number of more sophisticated methods have been used to inventory wetland habitat (Mathisen 1966; Kelly and Conrad 1969; Lukens 1968; Nelson et al. 1970; Cowardin and Myers 1974), and a handbook of 35-mm aerial photography which emphasizes a special camera mount is now available (Meyer 1973). The technique of this paper is of value to the investigator without access to any more sophisticated techniques, and is particularly appropriate to low-budget resource management and inventory situations where standard vertical imagery from state, provincial, or federal resource agencies is not available and investment in large format aerial photography is not warranted. As Olson (1964) has emphasized, familiarity with the vegetation being studied is more important than experience in photographic interpretation. The low man-hour and equipment costs of this technique bring it within the reach of any investigator.

TABLE 2—Cover-type associations recognizable from aerial photographs (35-mm High Speed Ektachrome color transparencies) on flowage 300 in north-central Minnesota, 1971

Cover type		Description[a]
1	Open water	No emergent or floating vegetation
2	Sedge meadow	*Carex* spp., especially *C. lasiocarpa* and *C. aquatilis*; flooded with at least 10 cm of water in early spring; usually dry for a portion of the year
4	Sedges-cattails-grasses	More than 50% of the surface cover *Carex* spp.; the remainder *Typha* spp. and grasses, especially *Calamagrostris canadensis*
12	Emergents	Vegetation less than 50% *Carex* spp. standing in water and covering not more than 50% of the water surface (waterfowl can move among the vegetation without difficulty)
13	Heavy emergents	Thick stands of vegetation standing in water (waterfowl cannot move freely among the vegetation without difficulty). Included here are thick stands of sedge and cattail, thick stands of burreed (*Sparganium* spp.) and sweetflag (*Acorus calamus*), and thick stands of swamp horsetail (*Equisetum fluviatile*)
14a	Lowland brush (shrub swamp)	More than 50% of the surface cover a mixture of alders (*Alnus* spp.) and willows (*Salix* spp.). Bog birch (*Betula pumila*) and dogwoods (*Cornus stolonifera*) are also found in some areas
14b	Lowland brush-emergents	Combination of the two types as described above; percentage shrubs variable
14f	Lowland brush-emergents-flooded upland	A mixture of shrub swamp and upland areas flooded long enough to establish "emergents" as described above
16	Flooded living trees and shrubs	Scattered dead trees in open water; swamp hardwoods, especially black ash (*Fraxinus nigra*); lowland shrubs are present
17	Flooded dead trees and sedges	Areas with standing water only to midsummer; usually the edges of abandoned beaver flowages and semipermanent wetlands that have been incorporated into the active flowage
19b	Flooded high ground	Variable species, defined as the area on the flowage margin that is reflooded by heavy rains in early spring and summer when the flowage is at almost full pool; refers only to hardwood forest floor; more than 50% of the surface of the substrate is covered with leaf litter

[a] These descriptions consider only the vegetation dominant in terms of percent surface cover as viewed from an aircraft. All stands of the same type on a single area were usually quite similar in species composition, but the herbaceous vegetation associated with these "dominant" species varied widely between flowages within stand type.

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Literature Cited

American Society of Photogrammetry and the Society of Photographic Scientists and Engineers. 1969. New horizons in color aerial photography. Seminar Proceedings. 423 pp.

Carneggie, D. M. and **J. N. Reppert.** 1969. Large scale 70-mm aerial color photography. Photogrammetric Engineering 35(3): 249–257.

Cowardin, L. M. and **D. H. Johnson.** 1973. A preliminary classification of wetland plant communities in north-central Minnesota. United States Fish and Wildlife Service Special Scientific Report, Wildlife 168. 33pp.

Cowardin, L. M. and **V. I. Myers.** 1974. Remote sensing for identification and classification of wetland vegetation. Journal of Wildlife Management 38(2): 308–314.

Gilmer, D. S. 1971. Home range and habitat use of breeding mallards (*Anas platyrhynchos*) and wood ducks (*Aix sponsa*) in north-central Minnesota as determined by radio tracking. Ph.D. thesis, University of Minnesota, Minneapolis. 142 pp.

Hostrop, B. W. and **T. Kawaguchi.** 1971. Aerial color in forestry. Photogrammetric Engineering 37(6): 555–563.

Howard, J. A. 1970. Aerial photo-ecology. American Elsevier, New York, New York. 325 pp.

Kelly, M. G. and **A. Conrad.** 1969. Aerial photographic studies of shallow water benthic ecology. Proceedings of symposium on remote sensing in ecology, Madison, Wisconsin, 1968. *Edited by* P. L. Johnson. University of Georgia Press, Athens. pp. 173–184.

Kirby, R. E. 1973. Utilization of beaver flowages by waterfowl on the Chippewa National Forest, Minnesota. M.A. thesis, Southern Illinois University, Carbondale. 264 pp.

Klein, W. H. 1970. Mini-aerial photography. Journal of Forestry 68(8): 475–478.

Knudson, G. J. 1962. Relationship of beaver to forests, trout and wildlife in Wisconsin. Wisconsin Department of Conservation Technical Bulletin 25. 52 pp.

Küchler, A. W. 1964. The potential natural vegetation of the Conterminous United States. American Geographical Society Special Research Publication 36. 39 [and 111] pp.

Lukens, J. E. 1968. Color aerial photography for aquatic vegetation surveys. 5th Symposium on remote sensing of the environment proceedings. University of Michigan, Ann Arbor. pp. 441–446.

Mathisen, J. E. 1966. A plan for inventorying and developing wetland habitat on public lands. *In* Wood duck management and research: A symposium. *Edited by* J. B. Trefethen. Wildlife Management Institute, Washington, D.C. pp. 52–61.

Mathisen, J. E. 1970. Some aspects of man-made impoundments on the Chippewa National Forest. Seminar on wildlife and man-made water areas. Northern Prairie Wildlife Research Center, Jamestown, North Dakota. mimeo. 9 pp.

Meyer, M. P. 1973. Operating manual — Montana 35 mm aerial photography system (1st revision). Institute of Agriculture Remote Sensing Laboratory Research Report 73-3, College of Forestry, University of Minnesota, St. Paul. 50 pp.

Neff, D. J. 1957. Ecological effects of beaver habitat abandonment in the Colorado Rockies. Journal of Wildlife Management 21(1): 80–84.

Nelson, H. K., A. T. Klett, and **W. G. Burge.** 1970. Monitoring migratory bird habitat by remote sensing methods. North American Wildlife and Natural Resources Conference Transactions 35: 73–84.

Olson, D. P. 1964. The use of aerial photographs in studies of marsh vegetation. Maine Agricultural Experiment Station Technical Series Bulletin 13. 62 pp.

Stewart, R. E. and **H. A. Kantrud.** 1971. Classification of natural ponds and lakes in the glaciated prairie region. United States Fish and Wildlife Service Resource Publication 92. 57 pp.

Vytautas, K., F. C. Daiber, D. Bartlett, O. W. Crichton, and **A. O. Fornes.** 1974. Inventory of Delaware's wetlands. Photogrammetric Engineering 40(4): 433–439.

Welch, P. S. 1948. Limnological methods. Blakiston Company, Philadelphia. 381 pp.

Willingham, J. W. 1959. Obtaining vertical aerial photographic coverage with a 35 mm camera. Journal of Forestry 57(2): 108–110.

Zsilinszky, V. G. 1969. Supplementary aerial photography with miniature cameras. Photogrammetria 25(1): 27–38.

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Montane and Subalpine Plants of the Sweetgrass Hills, Montana, and Their Relation to Early Postglacial Environments of the Northern Great Plains

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Abstract. Relict montane and subalpine plant communities of the Sweetgrass Hills, a small, isolated mountain range in the northern Great Plains, are described. Although the montane forests occupy an extremely small area (less than 20 km^2), they are surprisingly rich in coniferous tree species, as they have representatives of seven taxa (including one hybrid). This is evidence that a montane coniferous forest belt, in addition to a boreal forest belt, followed the retreating Laurentide ice sheet as it left the area at the close of the Wisconsin glaciation. A lack of typical subalpine understory species indicates a shift to a climate no longer favoring the relict subalpine forest communities.

The Sweetgrass Hills, located in north central Montana near the Alberta border, are the smallest, the northernmost, and, in many respects, the most dramatically isolated of the intrusive "island" mountain ranges of the northern Great Plains. The high peaks rise abruptly from the surrounding prairie and support montane plant communities, including coniferous forests, which have their closest counterparts in the Cordilleran Rocky Mountains over 140 km to the west. Located approximately midway between the Rocky Mountains and the Cypress Hills of Alberta, the Sweetgrass Hills are in a position to provide many clues to the vegetational history of the northern Great Plains.

The fact that the Sweetgrass Hills and Cypress Hills projected as nunataks (ice-free islands) above the Wisconsin ice sheet has raised some interesting speculation that the higher peaks may have served as refugia for arctic-alpine plant species during the glacial maximum. No botanical investigations, however, have been conducted in the Sweetgrass Hills since the United States Northern Boundary Commission expedition of 1874. Dawson (1875) reports several species of plants taken in the Hills during this expedition, and comments that "a few of the plants, found at elevations above 6000 feet [1830 m] in the Rocky Mountains, appear also on the summits of the Buttes." A few additional specimens collected in the low foothills of the Sweetgrass Hills are reported by Chickering (1878).

This paper reports the first detailed study of the montane and subalpine flora of this isolated mountain range. The presence in the Sweetgrass Hills of certain disjunct species of unusual phytogeographic interest is documented, and a preliminary categorization of major plant communities is attempted. This is not intended to be a comprehensive flora of the area; more intensive study will undoubtedly reveal additional disjunctions.

The material presented here represents the results of collections made in the Sweetgrass Hills by Thompson during the summers of 1972–1975 in connection with a study of the fauna, and by Kuijt during the summer of 1975. Specimens collected are deposited in the Montana State University herbarium, Bozeman, and the University of Lethbridge herbarium, Lethbridge. Nomenclature follows that of Hitchcock and Cronquist (1973).

Description of the Study Area

Geology and Physiography

The Sweetgrass Hills are eroded remnants of three separate laccoliths, referred to as West, Gold, and East Buttes (Figure 1), resulting from igneous activity during the early Tertiary. The higher peaks consist of syenite-diorite porphyry, and the foothills are composed of various shales pushed up by the igneous activity (Kemp and Billingsley 1921). Extensive outcroppings of Madison limestone are found near the center of East Butte. In contrast, the Cypress Hills, 100 km to the northeast, are composed entirely of uplifted sedimentary rock.

The greatest area of uplift is found in East Butte, which has two major peaks above 2100 m in elevation, Mount Brown and Mount Royal. West Butte consists of a huge dome-shaped laccolith (Figure 2), which rises to 2130 m, and several minor ridges extending north and east. East and West Buttes rise approximately 1000 m above the surrounding plains and give rise to intermittent spring-fed streams which flow through steep canyons. Gold Butte, a minor uplifted area, is located between East and West Buttes.

Pleistocene History

Five drift sheets were deposited by Laurentide glaciers in this region during the Wisconsin (Broscoe 1965; Westgate 1965). The earliest of these, represented by the Elkwater Drift, advanced into northern Montana during the "pre-classical" Wisconsin about 54 500 years ago. This glacier extended as far south as Great Falls, Montana, completely surrounding the Cypress Hills and Sweetgrass Hills and nearly encircling the Bear Paw Mountains to the southeast. The ice sheet was approximately 300 m thick in the vicinity of the Sweetgrass Hills, and left the Cypress Hills nunatak about 90 m, and the Sweetgrass Hills nunataks about 600 m, above the ice surface (Alden 1932; Calhoun 1906; Stalker 1965; see Figure 3). The extent of local snow and ice accumulation on the unglaciated surfaces has not been determined.

The Elkwater glaciation was followed by an extensive interstadial which probably spanned the entire middle Wisconsin. The second major advance of the Laurentide Glacier is represented by the Wildhorse Drift, which was probably deposited about 20 000 years ago. This glacial

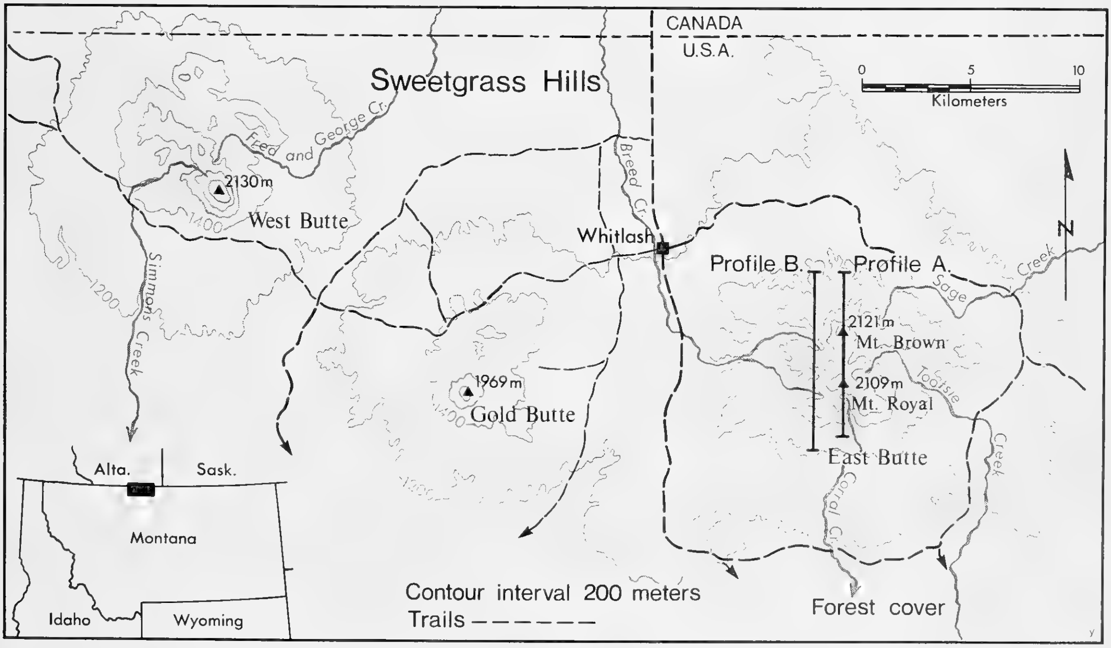

FIGURE 1. Map of the study area showing locations referred to in the text.

FIGURE 2. The laccolith of West Butte, seen here from the southwest, projects as a forested island above the surrounding sea of grassland and agricultural land.

advance extended nearly as far south as the Elkwater but did not completely encircle the Sweetgrass Hills. As the glacier receded, three minor re-advances occurred, all north of the 49th Parallel. The last of these took place earlier than 13 000 years ago (Bryson et al. 1970; Reeves 1973; Westgate 1965). Deep channels were cut quickly by the melting glaciers during deglaciation and are evident today as the steep canyons in the montane regions of the Hills.

Recent Climate

The Great Plains region surrounding the Sweetgrass Hills is best described as semi-arid steppe, characterized by low precipitation, cold winters, and hot summers. Data compiled at United States Department of Commerce recording stations near the Hills indicate an average annual precipitation of 30–35 cm for the area. The high peaks of the Hills intercept considerably more moisture than do the surrounding plains, and although no recording stations are located in the Hills themselves, the average annual precipitation there probably approaches 60–70 cm. This compares with approximately 46 cm per year for the Cypress Hills (Halladay 1965; Breitung 1954). In contrast, average annual precipitation in the Rocky Mountains to the west varies from about 40 cm at Babb to over 250 cm at Sperry Glacier in Glacier National Park (Choate and Habeck 1967).

Major Plant Communities

The high plains surrounding the Sweetgrass Hills break sharply to steep foothills at about 1400 m, and the lowest coniferous forests occur near this elevation; this is somewhat lower than that of the highest point of the Cypress Hills (1463 m). For convenience of discussion, major plant communities of the study area are divided into two groups, plains communities (those occurring primarily below 1400 m) and montane communities (those restricted to elevations above 1400 m).

Plains Communities

Agricultural Land. Most of the flat, arid prairie surrounding the Hills has been altered extensively by agriculture, and now supports a patchwork of strip-farmed wheat and other cereal grains (Figure 2). Little of the native prairie vegetation, which was probably dominated by *Agropyron smithii, Stipa comata,* and *Bouteloua gracilis* below about 1100 m, now remains.

Foothills Prairie. The higher steppe between the Buttes, from approximately 1100 to 1500 m, is similar to the foothills prairie described by Küchler (1964), normally supporting a climax

FIGURE 3. A fogbank separates East Butte and the distant West Butte laccolith, and presents a remarkable simulation of how the Laurentide Ice Sheet and the West Butte nunatak may have appeared during the Wisconsin glacial maximum. Lodgepole pine forest and montane grassland, visible in the foreground, cover most of the foothills of East Butte; a fringe of spruce, visible in the lower center, occurs along the banks of Breed Creek.

dominated by *Agropyron* spp., *Festuca* spp., and *Stipa comata*.

Coulee Scrub. Shallow coulees which dissect the foothills and escarpments of the plains carry no flowing water in summer, but support a low shrub association consisting primarily of *Amelanchier alnifolia, Rosa woodsii, Rubus* spp., *Salix* spp., and *Symphoricarpos albus.*

Riparian Shrubbery. The borders of many intermittent prairie streams are lined with well-developed shrub communities, generally dominated by *Amelanchier alnifolia, Crataegus douglasii*, and *Prunus virginiana.* This shrubbery is much taller than that of the coulees, reaching a height of 4–5 m along Breed and Simmons Creeks. Scattered stands of *Acer negundo* are found along some streams within the study area.

Riparian Forest. Rivers and larger streams throughout the northern Great Plains often support a well-developed forest association dominated by *Populus trichocarpa* and *P. deltoides.* This community extends well into the montane region of the Sweetgrass Hills, reaching elevations as high as 1500 m in the steep canyons of Breed Creek and Simmons Creek. Here the understory consists largely of dense shrubbery, including *Acer glabrum, Amelanchier alnifolia, Cornus stolonifera, Crataegus douglasii, Prunus virginiana,* and *Salix* sp., and such wet-mesic forbs as *Angelica arguta, Lathyrus ochroleucus, Mimulus guttatus, Potentilla rivalis, Smilacina stellata, Solidago gigantea, Viola adunca,* and *Viola canadensis.* Lush meadows, dominated by *Heracleum lanatum, Urtica dioica,* and the introduced grasses *Bromus inermis* and *Phleum pratense*, are found in shady openings.

Potholes and Reservoirs. Small glacial kettles, varying in size from a few square metres to several hectares and found as high as 1300 m, are abundant north and west of East Butte. These shallow ponds shrink rapidly in summer, and most are usually dry by late July. Some support a scant emergent vegetation including *Typha latifolia, Juncus* spp., *Scirpus* spp., and *Carex* spp. There are no natural lakes, marshes, or ponds within the Buttes themselves, although stockponds and small reservoirs are found as high as 1450 m; hence, wet communities analagous to the marsh communities of the Cypress Hills described by Breitung (1954) are absent from the Sweetgrass Hills.

Montane Communities

Forest zonation in the Sweetgrass Hills is similar to that described by Daubenmire (1943, 1952) for the coniferous forests of the Cordilleran Rocky Mountains and by Hoffmann (1960) for those of the Little Belt Mountains, another isolated mountain range in central Montana. *Pseudotsuga menziesii* occupies the lowest forest zone; the “base” elevations of the

Hills are apparently above the cold limits of *Pinus ponderosa.*

Figure 4 shows general vegetation profiles along two north-south transects through the montane regions of East Butte. It can be seen that most of the montane coniferous forests are associated with the cool, shady north-facing slopes, and that grasslands generally dominate the drier south-facing slopes. A description of the coniferous forests and other major montane and subalpine plant communities of the Sweetgrass Hills follows.

Montane Grassland. The grassland type covers most of the dry south-facing slopes and foothills between 1500 and 2000 m, as well as many of the non-forested portions of north-facing slopes. It is dominated by *Festuca scabrella, Festuca idahoensis,* and *Potentilla fruticosa*, and seems most closely related to the fescue prairie association described by Coupland and Brayshaw (1953) and found by Breitung (1954) and Newsome and Dix (1968) to cover the higher plateaus of the Cypress Hills. A wide variety of species occurs in the many microhabitats found within this grassland; these include *Allium cernuum, Anemone patens, Arabis nuttallii, Arenaria congesta, Balsamorrhiza sagittata, Besseya wyomingensis, Campanula rotundifolia, Carex phaeocephala, Castilleja cusickii, Castilleja lutescens, Claytonia lanceolata* var. *multiscapa, Collinsia parviflora, Delphinium bicolor, Draba aurea, Draba nemorosa, Erigeron compositus, Fritillaria pudica, Geranium viscosissimum, Geum triflorum, Hedysarum alpinum, Juniperus communis, Juniperus horizontalis, Lomatium cous, Lomatium triternatum, Lupinus argenteus, Potentilla gracilis, Ranunculus glaberrimus, Saxifraga occidentalis, Sisyrinchium angustifolium, Solidago multiradiata, Townsendia parryi,* and *Zigadenus elegans.*

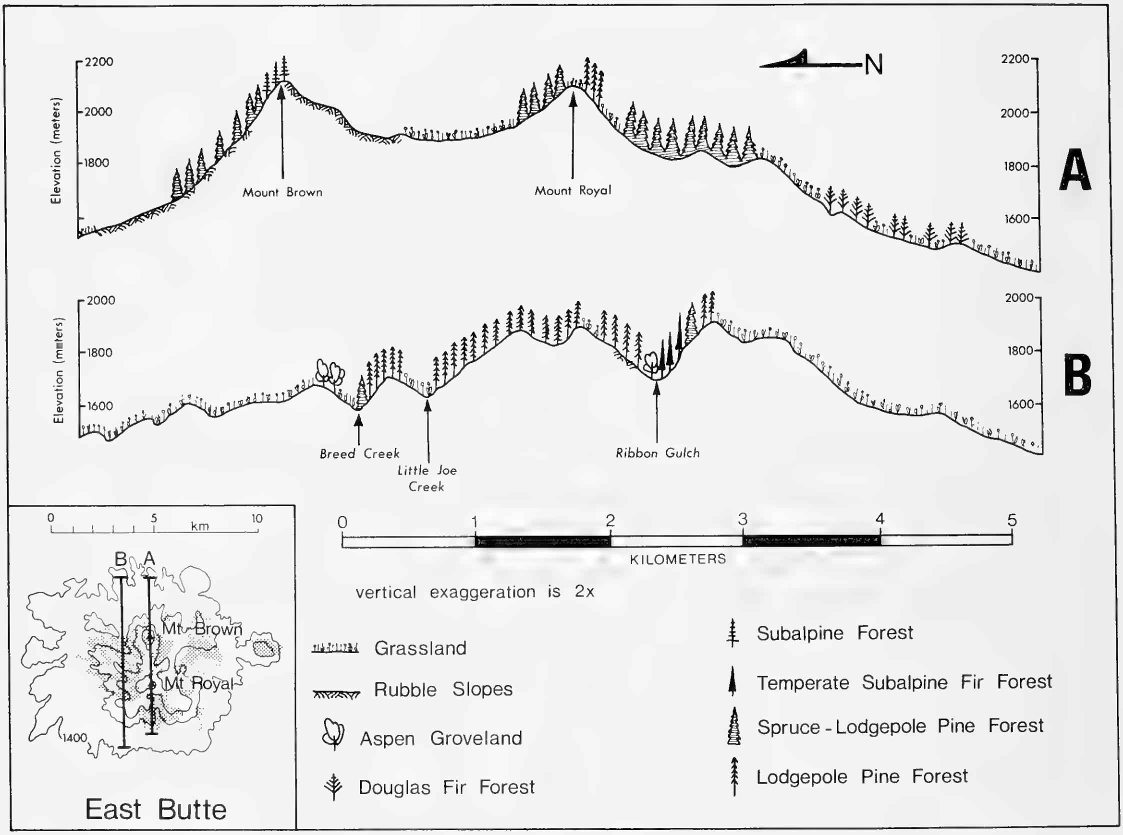

FIGURE 4. Vegetation profiles along two north-south transects through the montane regions of East Butte.

Subalpine Grassland. Small areas of grassland above timberline on the summits of Mount Royal and West Butte appear distinct in physiognomy from the lower-elevation montane grassland, and resemble alpine tundra in many respects. Here, mean summer temperatures are above the maximum for development of true tundra (as described by Löve 1970), but local conditions produce a tundra-like community of caespitose and stunted vegetation dominated by *Festuca scabrella* and *Potentilla fruticosa* and having *Polygonum bistortoides* as a major component. Timberline on the summits is due not to cold *per se* but to cold coupled with desiccation resulting from severe winds and intense summer insolation. Characteristic species found in this dry rocky grassland include *Arctostaphylos uva-ursi, Arenaria congesta, Carex xeranthica, Cerastium arvense, Erigeron caespitosus, Eriogonum umbellatum, Heuchera parviflora, Phlox hoodii, Saxifraga cernua, Sedum lanceolatum,* and *Senecio pauperculus.* On the steep shady north face of Mount Royal (Figure 5) is found a much moister grassland, in which are found *Carex albonigra, Carex eleocharis, Carex obtusata, Carex parryana, Dodecatheon conjugens, Epilobium angustifolium, Luzula spicata, Mertensia viridis, Penstemon confertus, Penstemon nitidus, Penstemon procerus, Poa alpina, Potentilla diversifolia, Rumex acetosa, Rumex acetosella, Saxifraga bronchialis, Saxifraga rhomboidea,* and *Senecio canus.*

Douglas Fir Forest. The lowest coniferous forests of the Sweetgrass Hills are found on north-facing slopes, and are dominated by *Pseudotsuga menziesii,* sometimes including scattered *Picea glauca* × *engelmannii* along major streams in East Butte. The understory of this forest type is by far the most well-developed of all coniferous forest types found in the Hills; it contains abundant shrubs, such as *Acer glabrum, Amelanchier alnifolia, Berberis repens, Chimaphila umbellata, Juniperus communis, Shepherdia canadensis,* and *Spiraea betulifolia,* and lush forbs, including *Arenaria lateriflora, Arnica fulgens, Clematis columbiana, Corallorhiza maculata, Fragaria virginiana, Galium boreale, Geranium richardsonii, Hackelia deflexa, Sedum lanceolatum, Smilacina stellata,* and *Thalictrum* sp. A Douglas fir savannah occurs on some dry south-facing slopes. On the rocky lower south slopes of West Butte, *Pseudotsuga menziesii* mingles with *Pinus flexilis,* but undergrowth is virtually absent.

Limber Pine Woodland. Pinus flexilis occurs along forest edges throughout the montane

FIGURE 5. The steep north face of Mount Royal, which supports a moist grassland containing many montane and subalpine elements, is viewed from a rubble slope near the summit of Mount Brown. Timberline is reached on the summit because of a combination of wind, cold, and desiccation rather than cold alone.

region and forms pure stands on the dry ridges east of Mount Brown (Figure 6).

Lodgepole Pine Forest. Dense, even-aged stands of *Pinus contorta* are found on steep north-facing slopes from 1500 to 2100 m; these probably date from the fires of 1889, which reportedly burned the forests of the Cypress Hills, the Sweetgrass Hills, and the surrounding prairie for hundreds of kilometres (Newsome and Dix 1968). These thickets are composed almost exclusively of trees 3–10 m tall and less than 3 dm diameter at breast height. Typically, uniform stands of *Pinus contorta* on north-facing slopes are fringed by *Pinus flexilis* at the ridge-top ecotone with montane grassland, and by *Picea glauca* × *engelmannii* along drainage bottoms (Figure 4). The understory is markedly depauperate, and supports only a very sparse growth of *Arnica cordifolia, Linnaea borealis, Spiraea betulifolia,* and ericaceous plants such as *Pyrola secunda, Pyrola uniflora, Pyrola virens, Vaccinium caespitosum, Vaccinium membranaceum, Vaccinium myrtillus,* and *Vaccinium scoparium.*

Spruce-lodgepole Forest. This forest type is found (on East Butte only) along streams and on north-facing slopes from 1600 to 2100 m. *Pinus contorta* and *Picea glauca* × *engelmannii* are dominant, and the understory is similar to that of the lodgepole pine forest. *Clematis tenuiloba* appears in the understory along Madison Limestone outcrops near the headwaters of Little Joe Creek.

Temperate Subalpine Fir Forest. From 1650 to 1800 m on the steep north-facing slopes above Ribbon Gulch (Figure 4) is found a forest type dominated by *Abies lasiocarpa* and *Picea glauca* × *engelmannii,* with scattered *Pinus contorta* and *Pseudotsuga menziesii.* Its understory contains *Acer glabrum, Campanula rotundifolia, Epilobium paniculatum, Linnaea borealis, Pyrola uniflora, Shepherdia canadensis,* and *Vaccinium scoparium.* This unusually low-elevation occurrence of *Abies lasiocarpa* is probably due to cold air drainage down the steep, shady canyon.

Subalpine Forest. Forests near the summits of Mount Brown and Mount Royal are apparently above the cold limits of *Pseudotsuga menziesii* and have *Pinus albicaulis* as a major component. *Pinus contorta, Pinus flexilis, Picea glauca* × *engelmannii,* and, on the north face of Mount Brown, *Abies lasiocarpa* are also found here. *Pinus albicaulis* and *Pinus contorta* dominate forest stands at timberline on the summit of West Butte. Surprisingly, *Abies lasiocarpa* is found on West Butte only on the dry rocky ridge south of the summit. Trees near the summits are short and stunted by high winds, some resembling krummholz as seen in the foreground

FIGURE 6. By looking east from the rubble slopes of Mount Royal and down the headwaters of Tootsie Creek, the arid ridges supporting limber pine woodland and the foothills prairie which surrounds the Buttes are visible in the distance. Outcrops of Madison limestone can be seen on the ridges near the left of center.

of Figure 5. *Abies lasiocarpa*, where it occurs, is often severely stunted and forms low shrub-like skirts. Understory plants are virtually absent from most stands of subalpine forest.

Aspen Groveland. Open groves of *Populus tremuloides* surrounded by grassland are found on grassy south-facing slopes as high as 1800 m (Figure 7). These are similar to the aspen groveland described by Lynch (1955) on the east slope of the Rocky Mountains and contain a lush understory of grasses, forbs, and shrubs, including *Agoseris glauca, Arnica cordifolia, Arnica sororia, Amelanchier alnifolia, Carex sprengelii, Collomia linearis, Erysimum cheiranthoides, Fragaria virginiana, Galium boreale, Geum aleppicum, Monarda fistulosa, Perideridia gairdneri, Pyrola asarifolia, Ribes setosum, Rosa woodsii, Rubus idaeus, Shepherdia canadensis, Spiraea betulifolia, Urtica dioica, Vicia americana,* and *Viola canadensis.*

Aspen Woodland. At lower elevations, between approximately 1400 and 1600 m, clones of *Populus tremuloides* are found scattered within the Douglas fir forest. These stands probably represent a fire-caused seral stage of the Douglas fir forest, as overall understory composition is similar to that of the surrounding Douglas fir forest. The aspen woodland covers a considerably larger area on West Butte than on East Butte.

Mountain Ravines. Within the higher montane region, between 1500 and 2000 m, major streams flow through steep rocky ravines. These are usually bordered by coniferous forests and support stands of *Populus tremuloides* and *Acer glabrum*. It is here that the most mesic plant communities are found; along the moist shaded banks of these ravines occur *Calypso bulbosa, Castilleja rhexifolia, Cornus canadensis, Cystopteris fragilis, Disporum trachycarpum, Epilobium paniculatum, Equisetum arvense, Gentiana amarella, Habenaria hyperborea, Heracleum lanatum, Lathyrus ochroleucus, Monarda fistulosa, Osmorhiza depauperata, Parnassia palustris, Smilacina racemosa,* and *Smilacina stellata* (Figure 8).

Rubble Slopes. Much of the higher montane area consists of forbidding slopes of coarse, loose, lichen-covered rock fragments, generally from 1 to 4 dm in diameter (Figures 5 and 6). *Picea glauca* × *engelmannii* and *Pinus contorta* form island-like clumps of up to 25 trees on several high rubble slopes; otherwise, the only vascular plants found growing on rubble slopes are an occasional *Eriogonum umbellatum, Arctostaphylos uva-ursi, Saxifraga bronchialis,* or *Rubus idaeus.*

Species Accounts

In the species accounts which follow, only

FIGURE 7. Representative stand of aspen groveland, East Butte.

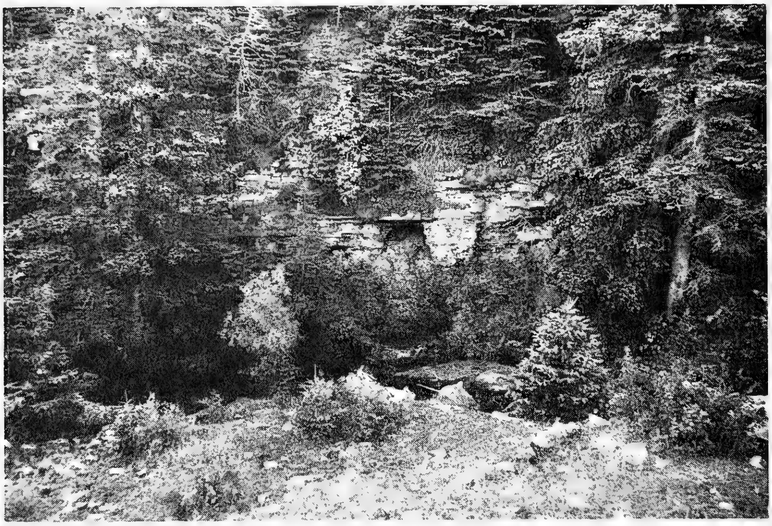

FIGURE 8. A mountain ravine along upper Breed Creek. Hybrid spruce dominates the forest adjacent to this ravine; lodgepole pine alone occurs a short distance upslope.

those species of plants found in the Sweetgrass Hills which represent significant range extensions or which are of particular phytogeographic interest are mentioned. A complete list of all plant species collected during this study is available at a nominal cost from the Depository of Unpublished Data, National Science Library, National Research Council of Canada, Ottawa, Canada K1A 0S2, or from the authors. Unless noted otherwise, the senior author's collections (LST) are deposited at the Montana State University Herbarium, and those of the junior author (JK) at the University of Lethbridge Herbarium.

Gymnospermae

CUPRESSACEAE

Juniperus scopulorum Sarg. Found on the lower rubble slopes on the south face of West Butte (JK 4747). This small tree has recently been reported as isolated individuals from Lethbridge and Cardston, Alberta; in its pure form it is extremely rare even in the mountains of western Alberta (Kuijt and Trofymow 1975). In the West Butte locality it appears to hybridize rather freely with *J. horizontalis* Moench, as about half of the individuals seem to be intermediate in stature.

PINACEAE

Abies lasiocarpa (Hook) Nutt. (= *A. balsamea* (L.) Miller subsp. *lasiocarpa* (Hook.) Boivin). Small stands of subalpine fir are found on the summit and north face of Mount Brown, on rubble slopes south of the summit of West Butte, and in the cool moist canyon of upper Ribbon Gulch as low as 1650 m (LST 489).

Picea glauca × *engelmannii* Parry. Common and widespread in the forests of East Butte from 1500 m to the summits, but found nowhere on West Butte. The individuals seen on East Butte are hybrid swarms resulting from introgression between *Picea glauca* and *Picea engelmannii,* as described by Daubenmire (1974) and Habeck and Weaver (1969); hybridization is apparent at all elevations. Trees with strong *glauca* characteristics predominate at lower elevations where *Pseudotsuga menziesii* is the indicated climax, and trees with strong *engelmannii* characteristics predominate at higher elevations where *Abies lasiocarpa* also occurs, as is the case throughout the area of sympatry of these two species. Vouchers of cones have been filed at the Washington State University Herbarium, Pullman, Washington (LST 488, 491; JK 4921).

Pinus albicaulis Engelm. Summits of West Butte, Mount Brown, and Mount Royal (LST 490), the greatest densities being found at the eastern timberline of West Butte. One individual found growing on a wind-swept ridge just south of the summit of Mount Brown measured nearly 6 dm in diameter at breast height, although standing scarcely 4 m in height.

Pinus contorta Dougl. ex Loud. Abundant and widespread above 1500 m; extensive even-aged stands are found on north-facing slopes throughout the montane region, probably dating from the fires of the late 1800s (JK 4786).

Pinus flexilis James. Common on dry exposed ridges and forest edges, especially in "rain shadows" on the east slopes of the Buttes (LST 493).

Pseudotsuga menziesii (Mirb.) Franco. Common below 1900 m; dominates the lowest coniferous forests in most areas of both East and West Buttes (LST 492).

Angiospermae

ACERACEAE

Acer glabrum Torrey. Mountain ravines and riparian forests at lower elevations (LST 863, 895; JK 4791, 4906, 4926).

BORAGINACEAE

Mertensia viridis A. Nelson. Subalpine grassland on the north face of Mount Royal (LST 420, 556).

CAPRIFOLIACEAE

Linnaea borealis L. Streambanks, lodgepole pine forest, and temperate subalpine fir forest (LST 626, JK 4932).

CARYOPHYLLACEAE

Arenaria lateriflora L. Moist lodgepole pine and Douglas fir forests, and aspen woodland (LST 605; JK 4847, 4915).

Arenaria rubella (Wahl.) Smith. Limestone cliffs along upper Tootsie Creek (JK 4953).

Silene parryi (Wats.) Hitchc. and Maguire. Higher montane grassland of West Butte (LST 779).

Stellaria longifolia Muhl. ex Willd. North-facing aspen groveland along Fred and George Creek (JK 4868).

COMPOSITAE

Agoseris glauca (Pursh) Raf. Common in aspen groveland and montane and subalpine grassland (LST 591, 644, 710, 750, 780, 829; JK 4935).

Antennaria anaphaloides Rydb. Protected slopes of both Buttes (LST 532, 608, 870; JK 4779, 4879).

Antennaria racemosa Hook. Mossy banks of upper Tootsie Creek (LST 602, 603; JK 4928).

Arnica cordifolia Hook. North-facing Douglas fir and lodgepole pine forests (LST 607; JK 4870).

Balsamorrhiza sagittata (Pursh) Nutt. Found only on limestone outcroppings along Iron Creek, East Butte (JK 4925).

Erigeron speciosus (Lindl.) DC. Montane grassland slopes of East and West Buttes (LST 784, 889; JK 4865, 4910).

Erigeron acris L. var. *debilis* Gray. Protected slopes and streambanks (LST 969, 979, 987; JK 4951).

Hieracium umbellatum L. Mossy banks of upper Tootsie Creek (JK 4943).

Senecio integerrimus Nutt. var. *exaltatus* (Nutt.) Cronq. Montane and subalpine grassland (LST 572; JK 4877).

Solidago multiradiata Ait. Moist subalpine grassland, north face of Mount Royal (LST 543).

Townsendia parryi Eaton. Montane grassland at middle elevations (JK 4850, 4929).

CORNACEAE

Cornus canadensis L. Moist mountain ravines (LST 439).

CRASSULACEAE

Sedum lanceolatum Torrey. Relatively common in montane and subalpine grassland, aspen woodland, and coniferous forests at all elevations (LST 594, 620, 708, 821; JK 4785).

CRUCIFERAE

Arabis glabra (L.) Bernh. Protected aspen grove near Fred and George Creek (JK 4876).

Descurainea richardsonii (Sweet) Schulz. South-facing montane grassland of West Butte (JK 4750, 4818).

Draba aurea Vahl. Ridge at head of Fred and George Creek (JK 4859).

Draba nemorosa L. East-facing meadows along upper Fred and George Creek (JK 4773).

Draba oligosperma Hook. Limestone outcrops along upper Tootsie Creek (JK 4952).

CYPERACEAE

Carex albonigra Mack. Moist subalpine meadows, north face of Mount Royal (LST 560).

Carex phaeocephala Piper. Drier south-facing subalpine grassland on West Butte and Mount Brown (LST 795).

ELEAGNACEAE

Shepherdia canadensis (L.) Nutt. Common as undergrowth of aspen woodland and coniferous forests (LST 693; JK 4899). Also collected in Writing-on-Stone Provincial Park (Alberta) just north of West

Butte (JK 4444).

ERICACEAE

Arctostaphylos uva-ursi (L.) Spreng. Montane and subalpine grassland, especially exposed rocky slopes (LST 419, 500, 816, 847; JK 4784, 4940).

Chimaphila umbellata (L.) Bartr. North-facing Douglas fir and lodgepole pine forests, West Butte (LST 617).

Pyrola asarifolia Michx. North-facing aspen grove, Fred and George Creek (JK 4867).

Pyrola secunda L. Occasional in the understory of coniferous forests, especially spruce – lodgepole pine forests (LST 435, 441, 451, 846, 852; JK 4950).

Pyrola uniflora L. Common in lodgepole pine forest and along mountain ravines within temperate subalpine fir forest (LST 434, 442, 854; JK 4949).

Pyrola virens Schweigg. Common in moist lodgepole pine forests (LST 436, 452, 457, 623, 844, 950; JK 4930).

Vaccinium caespitosum Michx. Protected aspen groves, mountain ravines, and lodgepole pine forests (LST 444, 454; JK 4878, 4941).

Vaccinium membranaceum Dougl. Understory of lodgepole pine and spruce – lodgepole pine forests, East Butte; occasionally found in adjacent grassland (LST 848).

Vaccinium myrtillus L. North-facing slopes in dense spruce – lodgepole pine forests, East Butte (LST 850; JK 4942).

Vaccinium scoparium Leib. Understory of lodgepole pine and spruce – lodgepole pine forests of East Butte; occasionally found in grassland bordering rubble slopes (LST 443, 849).

FUMARIACEAE

Corydalis aurea Willd. Gravel banks of Fred and George Creek (JK 4853).

GENTIANACEAE

Gentiana amarella L. Moist mountain ravines of both East and West Buttes (LST 964; JK 4914, 4927).

GERANIACEAE

Geranium richardsonii Fisch. and Trautv. Moist riparian forests along Breed Creek (LST 891).

Geranium viscosissimum Fisch. and Mey. Montane grassland, Fred and George Creek (JK 4824).

GRAMINEAE

Agrostis scabra Willd. Montane and subalpine grasslands of East Butte (LST 839; JK 4924).

Bromus ciliatus L. Mossy banks of upper Tootsie Creek (JK 4944).

Phleum alpinum L. Madison limestone outcrops in mountain ravines along upper Little Joe Creek, a tributary to Breed Creek (LST 973).

Poa alpina L. Moist subalpine grassland on the north face of Mount Royal (LST 542).

HYDROPHYLLACEAE

Phacelia linearis (Pursh) Holz. Montane grassland along Fred and George Creek (JK 4844).

JUNCACEAE

Luzula spicata (L.) DC. Moist montane and subalpine grassland of both East and West Buttes, generally above timberline (LST 516, 536, 706, 741; JK 4841, 4939).

LEGUMINOSAE

Astragalus vexilliflexus Sheld. Gravelly banks of Fred and George Creek, and along the lower edge of coniferous forest (JK 4792, 4849).

Hedysarum alpinum L. Moist mountain ravines (LST 980; JK 4843).

Lathyrus ochroleucus Hook. Montane grassland along Fred and George Creek (JK 4858).

Lupinus lepidus Dougl. Collected only from the ridge east of the head of Fred and George Creek (JK 4842).

LILIACEAE

Disporum trachycarpum (Wats.) Benth. and Hook. Understory of Douglas fir and lodgepole pine forests (LST 975; JK 4777).

Smilacina racemosa (L.) Desf. Shaded forests and woodland (LST 963; JK 4905).

Zigadenus elegans Pursh. Moist montane and subalpine grassland (LST 550, 557, 770, 820; JK 4808).

LORANTHACEAE (see VISCACEAE)

ONAGRACEAE

Epilobium alpinum L. Moist mountain ravines (LST 957; JK 4863, 4947).

Epilobium paniculatum Nutt. Douglas fir forests along Breed Creek (JK 4903).

ORCHIDACEAE

Calypso bulbosa (L.) Oakes. Moist mountain ravines near the head of Simmons Creek (LST 502).

Corallorhiza maculata Raf. Aspen groveland near Fred and George Creek (JK 4855).

Habenaria hyperborea (L.) R. Br. Moist mountain ravines, East Butte (LST 897; JK 4937).

POLEMONIACEAE

Collomia linearis Nutt. Montane grassland, aspen groveland (LST 690, 769, 777; JK 4874, 4918).

Polemonium pulcherrimum Hook. Rock outcrops within montane grassland (LST 430: JK 4900).

POLYGONACEAE

Eriogonum umbellatum Torrey. Dry rocky outcrops in montane and subalpine grassland (LST 568, 589, 714, 742; JK 4787, 4873, 4903).

Polygonum bistortoides Pursh. Common in subalpine grassland; also found in lower montane grassland along Fred and George Creek (LST 407, 461, 462; JK 4774).

Polygonum douglasii Greene. Coniferous forests and adjacent grassland at middle elevations (JK 4848; 4902).

Rumex acetosa L. Collected from only one area, on the moist north-facing slope of Mount Royal where outcrops of Madison limestone have produced calcareous soils. Although this arctic-alpine species. native to the American Arctic, has been naturalized from Eurasia in the eastern United States, it is believed to occur as a relict in the Sweetgrass Hills rather than as a garden escapee, since it has been reported in the vicinity of Montana only from alpine or subalpine areas in Glacier Park, the Bear Paw Mountains, and the Beartooth Plateau (Johnson 1962) (LST 417, 521, 553).

PORTULACACEAE

Claytonia lanceolata Pursh. Common in draws at middle elevations and even well below timber along Fred and George Creek. All plants collected have remarkably narrow leaves, contrasting with those in the Rocky Mountains of Montana and Alberta (JK 4775).

RANUNCULACEAE

Actaea rubra (Ait.) Willd. Mountain ravines; both red- and white-fruited forms have been observed (LST 860; JK 4769).

Clematis columbiana (Nutt.) Torrey and Gray. North-facing aspen groveland along Fred and George Creek (JK 4856).

Clematis tenuiloba (Gray) C. L. Hitchc. Apparently restricted to calcareous soils associated with outcroppings of Madison limestone on East Butte; the species here seems to reach its northern limits (LST 421, 970; JK 4936).

Ranunculus abortivus L. Forested areas along Fred and George Creek and Breed Creek (JK 4857; 4904).

Ranunculus glaberrimus Hook. Common in montane grassland (JK 4752, 4767, 4768).

RHAMNACEAE

Ceanothus velutinus Dougl. Collected from only one location, along a mining trail in dense lodgepole pine forest near the headwaters of Breed Creek (LST 426).

ROSACEAE

Geum aleppicum Jacq. Aspen groveland, West Butte (LST 656).

Potentilla arguta Pursh. Streambanks and aspen groveland, West Butte (LST 661; JK 4872).

Potentilla diversifolia Lehm. Moist montane and subalpine grassland (LST 416, 504, 546, 966; JK 4869, 4913).

Potentilla fruticosa L. Montane and subalpine grassland at all elevations (LST 431, 466, 689, 722, 811; JK 4823).

Potentilla glandulosa Lindl. Dry slopes above upper Tootsie Creek (JK 4945).

Potentilla gracilis Dougl. Riparian forests; montane and subalpine grassland (LST 464, 465, 505, 871).

Potentilla rivalis Nutt. Montane grassland adjacent to Douglas fir forest, East Butte (JK 4895).

Rubus idaeus L. Rubble slopes and dry grasslands at all elevations (LST 688; JK 4749).

Spiraea betulifolia Pall. Common in understory of coniferous forests at lower elevations (LST 984; JK 4907).

SALICACEAE

Populus trichocarpa Torrey and Gray (= *P. balsamifera* L. subsp. *trichocarpa* (T. & G.) Brayshaw). Dominates riparian forests of Breed Creek and Simmons Creek (LST 694, 696; JK 4814, 4821).

Populus tremuloides Michx. Forms groves or woodland at low to mid-elevations of both East and West Buttes (LST 695; JK 4820).

SAXIFRAGACEAE

Conimitella williamsii (D. C. Eaton) Rydb. Based on a single collection (LST 983) from the moist mountain ravines of upper Little Joe Creek; apparently here at its northern limits.

Heuchera parvifolia (Nutt.) Torrey and Gray. Rocky slopes in montane and subalpine grassland (LST 473, 534, 728, 809, 988; JK 4788, 4815).

Lithophragma parviflora (Hook). Nutt. Moist banks of Fred and George Creek and adjacent montane grassland (JK 4780, 4819).

Parnassia palustris L. Moist mountain ravines (LST 898, 954, 961, 972, 981; JK 4948).

Saxifraga bronchialis L. Douglas fir forests, rocky mountain ravines, and subalpine grassland of West Butte (LST 508, 721; JK 4789, 4862).

Saxifraga cernua L. Montane and subalpine grassland, East and West Buttes (LST 511, 593; JK 4793, 4864).

Saxifraga occidentalis Wats. Montane and subalpine grassland (LST 418, 424, 513; JK 4790).

SCROPHULARIACEAE

Castilleja rhexifolia Rydb. Moist mountain ravines of East and West Buttes (LST 857, 956, 958, 967, 978, 986; JK 4840, 4912, 4934).

Collinsia parviflora Dougl. Montane grasslands of West Butte (JK 4816).

Mimulus guttatus Fisch. Mountain ravines and streambanks (JK 4861, 4946).

Penstemon confertus Dougl. Subalpine grasslands, summit of West Butte (LST 730).

Penstemon procerus Dougl. Common in higher coniferous forests and rubble slopes (LST 404, 412, 544, 578, 579, 955).

UMBELLIFERAE

Angelica arguta Nutt. Moist mountain ravines and riparian forests, East Butte (LST 896).

Lomatium cous (Wats.) Coult. & Rose. Common in montane and subalpine grasslands; apparently near its northern limits here (LST 507, 540, 581, 763; JK 4781, 4866).

Lomatium dissectum (Nutt.) Math. and Const. var. *multifidum* (Nutt.) Math. and Const. Found only along a moist tributary to Fred and George Creek (JK 4813).

Lomatium triternatum (Pursh) Coult. & Rose. Lower montane grassland of West Butte (JK 4754, 4770).

Osmorhiza depauperata Phil. Moist mountain ravines (LST 624, 952, 971, 982; JK 4897).

Perideridia gairdneri (Hook. & Arn.) Math. subsp. *borealis* Chuang & Constance. Montane grassland and aspen groveland of East and West Buttes (LST 636; JK 4896, 4916).

Zizia aptera (Gray) Fern. Found only along a small tributary to Fred and George Creek (JK 4810).

VIOLACEAE

Viola adunca Smith. Gravelly banks of Fred and George Creek (JK 4771).

Viola canadensis L. Moist aspen woodland, Douglas fir forest, and riparian forest (LST 657, 867; JK 4772).

VISCACEAE (LORANTHACEAE, *sensu lato*)

Arceuthobium americanum Nutt. ex Engelm. Parasitic on *Pinus contorta*; only one locus of infection has been discovered, near the headwaters of Tootsie Creek (JK 4920).

Discussion

Seven taxa of arborescent conifers, including hybrid spruce (*Picea glauca* × *engelmannii*), are found in the Sweetgrass Hills, although the total area of coniferous forests is less than 20 km^2 and the nearest source flora is found over 140 km to the west. In contrast, the Cypress Hills, having nearly 500 km^2 of forests, support only two species of conifers, *Pinus contorta* and *Picea glauca*, the latter apparently showing no evidence of introgression with *Picea engelmannii* (Breitung 1954; Newsome and Dix 1968; Daubenmire 1974). In the discussion which follows, we relate the present distribution of coniferous trees to the probable sequence of changes in vegetation which occurred in the northern Great Plains during and immediately after the Wisconsin glacial maximum.

The montane forests of the Sweetgrass Hills and Cypress Hills may have originated via one of three means: (1) persistence of forest on the nunataks during the Wisconsin; (2) colonization of treeless surfaces through long-distance dispersal of disseminules from Cordilleran forests following retreat of the glacier, or (3) direct colonization of the area by belts of coniferous forest following the receding glacier.

The first of these alternatives, the persistence of conifers on unglaciated refugia in the Sweetgrass and Cypress Hills, is highly unlikely. Although the higher peaks were unglaciated, local accumulations of snow and ice probably would have rendered the environment there unsuitable for tree growth. Species such as *Pinus flexilis* and *Pseudotsuga menziesii,* which are present in the Sweetgrass Hills today, would hardly have found conditions suitable for growth in these periglacial environs. Also, this explanation fails to account for the presence of other Cordilleran species in the Sweetgrass and Cypress Hills.

The persistence of tundra on the nunataks during the height of Wisconsin glaciation is, however, feasible, and although no arctic-alpine relicts are found on the Sweetgrass Hills today (with the possible exceptions of *Luzula spicata* and *Rumex acetosa*), such a refugium could have easily been present but later supplanted by other species better adapted to the warmer, drier postglacial climate. As pointed out by Bamberg and Pemble (1968), arctic-alpine disjunctions are often correlated with calcareous substrates; the close association of *Rumex acetosa* with soils derived from limestone in East Butte suggests its persistence there as an arctic relict.

The second possibility is that of postglacial colonization of treeless areas by long-distance dispersal from the Rocky Mountains. A constant rain of disseminules of anemochorous (or even zoochorous) Cordilleran plant species carried by prevailing winds undoubtedly occurs even today. This dispersal may explain much of the strong Cordilleran influence in understory composition of both the Sweetgrass Hills and the Cypress Hills, although, as pointed out by Hedberg (1971) and Tryon (1971), successful dispersal does not insure establishment and persistence. Colonization by wind dispersal of the bulky conifer disseminules, however, is highly improbable, especially when the high conifer diversity and small target area of the Sweetgrass Hills are considered.

Johnson (1975) has suggested the Clark's Nutcracker (*Nucifraga columbiana*), a montane bird which inhabits the Sweetgrass Hills, as a likely vehicle for colonization of island mountain ranges by conifers, as these birds are known to bury caches of conifer seeds. If trees were indeed absent from the Sweetgrass Hills in early postglacial times, however, the conifer-loving Clark's Nutcrackers were certainly absent as well. Also, the distance between the Sweetgrass Hills and the Rocky Mountains is much greater than the daily foraging range of these birds. Thus, it is unlikely that these birds played a role in the establishment of conifers on the Hills. It is possible, however, that seeds of certain montane conifers (such as *Abies lasiocarpa* and *Pinus albicaulis*) could have been carried by these birds from nearby stands to the higher elevations of the Hills at a time when the entire area was forested.

The third alternative, colonization from migrating belts of coniferous forest following the receding Laurentide ice sheet, is felt to be the most likely, and merits discussion in some detail. Although the nature of the periglacial vegetation during the late Wisconsin has been the subject of considerable debate (Bryson et al. 1970; Löve 1959), pollen profiles and other evidence indicate that a belt of boreal forest, of which *Picea glauca* was a major component, stretched across most of the continent, possibly occurring as far west as Alberta and North Dakota (Fassett 1941; Kapp 1970; Ross 1970; Wright 1970). Evidence has been lacking from Montana, however, where no suitable pollen accumulation sites have been found, and the nature of the postglacial vegetation pattern is a matter of speculation. Based upon the evidence of the relict forests of the Sweetgrass Hills and the Cypress Hills, the following reconstruction of glacial and early postglacial events in this area can be outlined.

At the time of the Wisconsin glacial maximum, it is likely that montane forests were confined to a southwestern refugium (Figure 9A), probably centered in the low valleys of southwestern and central Montana. *Picea glauca* probably extended into Montana, perhaps hybridizing with *Picea engelmannii.* Other taiga conifers were probably confined to an eastern refugium. Species pairs of montane and boreal conifers (such as *Pinus contorta* and *Pinus banksiana, Larix occidentalis* and *Larix laricina,* and *Abies lasiocarpa* and *Abies balsamea*) and vertebrates (such as the Group VI birds discussed by Mengel 1970) were separated into these eastern and western refugia at this time, where divergence continued in response to the widely different environments.

At an early stage in the retreat of the ice sheet, forests of *Picea glauca* advanced rapidly into the newly available substrates left in the wake of the

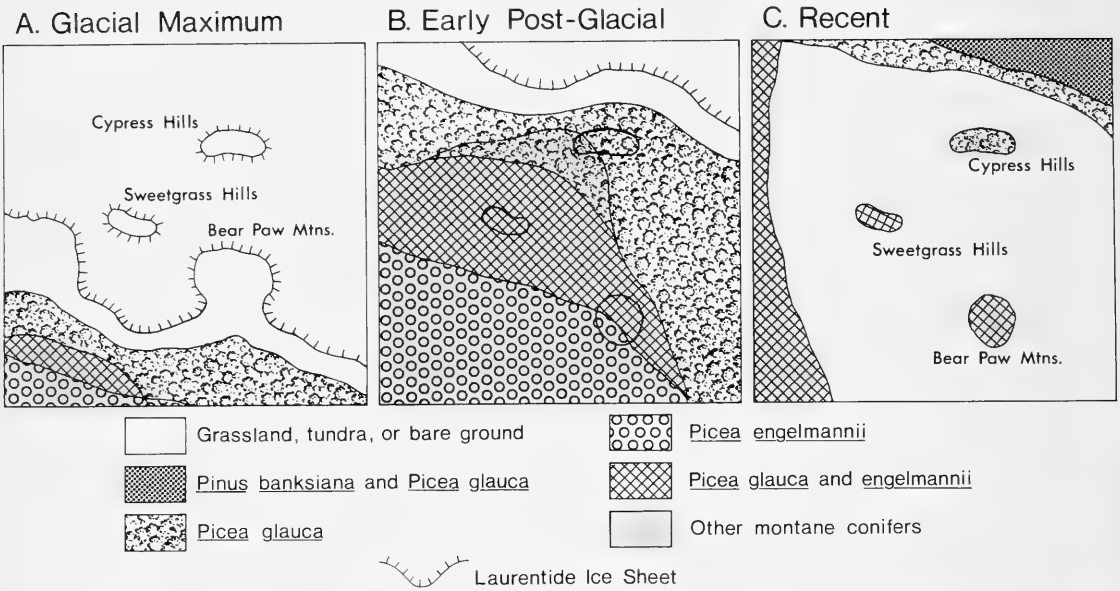

FIGURE 9. Diagrammatic representation of the probable sequence of post-Wisconsin vegetation changes in the northern Great Plains.

retreating glacier. For various reasons, other taiga conifers, including *Pinus banksiana*, did not expand westward into Montana with the *Picea glauca* forests.

As the glacier retreated north and east of the Cypress Hills (Figure 9B), this entire area of the northern Great Plains was overrun with conifers, *Picea glauca* forest following immediately behind the ice sheet and montane forest advancing farther south. As the melting Laurentide ice sheet opened a corridor to the Arctic, cold arctic air moved into northern Montana (Bryson et al. 1970), allowing montane conifers to persist at elevations as low as 1000 m. Montane mammals, including *Phenacomys intermedius, Sorex palustris,* and *S. nanus* (Thompson, unpublished data), and land snails (Russell 1952) followed the montane forests, also colonizing the island mountain ranges of the Plains region.

Presumably, although *Picea glauca* colonized the Sweetgrass Hills, the Cypress Hills, and the Black Hills of South Dakota, only the leading edge of the montane forest reached the Cypress Hills. Species such as *Pinus ponderosa, Pseudotsuga menziesii*, and *Pinus flexilis,* which require more moderate climates than existed during this stage in the history of the Cypress Hills, did not arrive as far north as the Cypress Hills, although the latter two reached the Sweetgrass Hills. It is unlikely that *Pinus ponderosa* ever extended as far north as the Sweetgrass Hills, which appear to remain above the cold limits of this species even today. The more cold-tolerant montane species, including *Abies lasiocarpa, Picea engelmannii, Pinus albicaulis,* and *Pinus contorta,* colonized the Sweetgrass Hills and possibly even the Cypress Hills during this period. Although *Pinus contorta* most certainly reached the Cypress Hills, *Picea engelmannii* either did not or else became extinct from the Cypress Hills before significant introgression with *Picea glauca* occurred. Perhaps extinction was also the fate of *Picea* populations on West Butte. More work on altitudinal gradations in hybrid *Picea* populations of the northern Great Plains region is needed to clarify the actual distribution of the two *Picea* species in early postglacial times.

Sometime near 10 000 years ago, local climatic conditions developed that initiated expansion of the grassland steppe vegetation characteristic of the northern Great Plains (Ogden 1967). This climatic change caused the coniferous forest belts to advance to ever higher elevations, until ultimately they were "stranded" as islands on uplifted areas where local climate and topography allowed a competitive advantage over the rapidly expanding grassland (Figure 9C). The elevations of the Sweetgrass Hills were sufficient to allow persistence of *Abies lasiocarpa* and *Pinus albicaulis*, but these species, if they actually reached the Cypress Hills, could not advance to suitably high elevations and became extinct.

It appears that post-Hypsithermal climatic changes may have caused the subalpine forest zone to advance upward "off the tops" of the Sweetgrass Hills; although small numbers of *Abies lasiocarpa* and *Pinus albicaulis* persist on the summits today, they do not appear to be reproducing successfully and may be on the way out. Also, a lack of typical subalpine understory plants, such as *Carex geyeri, Carex rossii, Hieracium gracile,* and *Juncus parryi,* suggests the summits are no longer cold and moist enough to allow *Abies lasiocarpa* to persist as a successfully reproducing component of the high coniferous forest.

Pinus banksiana and other characteristic conifers of the taiga probably expanded northwestward through the established *Picea glauca* forest only after grasslands separated the Cypress Hills from the boreal forest; this explains the presence of *Pinus contorta,* and not *Pinus banksiana,* as the sole coniferous associate of *Picea glauca* in the Cypress Hills. Thus, the Sweetgrass Hills remain as species-rich outposts of the Cordilleran montane forest, while the Cypress Hills are left with the curious juxtaposition of one Cordilleran and one boreal conifer.

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Literature Cited

Alden, W. C. 1932. Physiography and glacial geology of eastern Montana and adjacent areas. United States Geological Survey Professional Paper 174.

Bamberg, S. A. and **R. H. Pemble.** 1968. New records of disjunct arctic-alpine plants in Montana. Rhodora 70: 103–112.

Breitung, A. J. 1954. A botanical survey of the Cypress Hills. Canadian Field-Naturalist 68: 55–92.

Broscoe, A. J. 1965. The geomorphology of the Cypress Hills-Milk River Canyon area, Alberta. *In* Cypress Hills Plateau guidebook number 1. *Edited by* R. C. Zell. 15th Annual Field Conference of the Alberta Society of Petroleum Geologists. 288 pp.

Bryson, R. A., D. A. Baerreis, and **W. M. Wendland.** 1970. The character of late-glacial and post-glacial climatic changes. *In* Pleistocene and recent environments of the Central Great Plains. *Edited by* W. Dort, Jr. and J. K. Jones, Jr. University Press of Kansas, Lawrence. 433 pp.

Calhoun, F. H. 1906. The Montana lobe of the Keewatin Ice Sheet. United States Geological Survey Professional Paper 50. 62 pp.

Chickering, J. W. 1878. Catalogue of phaenogamous and vascular cryptogamous plants collected during the summers of 1873–1874 in Dakota and Montana along the 49th Parallel. United States Geological and Geographical Survey of the Territories Bulletin 4: 801–830.

Choate, C. M. and **J. R. Habeck.** 1967. Alpine plant communities at Logan Pass, Glacier National Park. Proceedings of the Montana Academy of Sciences 27: 36–54.

Coupland, R. T. and **T. C. Brayshaw.** 1953. The fescue grassland in Saskatchewan. Ecology 34: 386–405.

Daubenmire, R. F. 1943. Vegetational zonation in the Rocky Mountains. Botanical Review 9: 325–393.

Daubenmire, R. F. 1952. Forest vegetation in northern Idaho and adjacent Washington and its bearing on concepts of vegetation classification. Ecological Monographs 22: 301–330.

Daubenmire, R. F. 1974. Taxonomic and ecologic relationships between *Picea glauca* and *Picea engelmannii.* Canadian Journal of Botany 52: 1545–1560.

Dawson, G. M. 1875. Report on the geology and resources of the region in the vicinity of the 49th Parallel from the Lake of the Woods to the Rocky Mountains. British North American Boundary Commission, Montreal. 387 pp.

Fassett, N. C. 1941. Mass collections: *Rubus odoratus* and *R. parviflorus.* Annals of the Missouri Botanical Gardens 28: 299–374.

Habeck, J. R. and **T. W. Weaver.** 1969. A chemosystematic analysis of some hybrid spruce (*Picea*) populations in Montana. Canadian Journal of Botany 47: 1565–1570.

Halladay, I. R. 1965. Recent biota of the Cypress Hills Plateau: a general survey of the natural history. *In*

Cypress Hills Plateau guidebook number 1. *Edited by* R. C. Zell. 15th Annual Field Conference of the Alberta Society of Petroleum Geologists. 288 pp.

Hedberg, O. 1971. Evolution of the Afroalpine flora. *In* Adaptive aspects of insular evolution. *Edited by* W. Stern. Washington State University Press, Pullman. 86 pp.

Hitchcock, C. L. and **A. Cronquist.** 1973. Flora of the Pacific Northwest. University of Washington Press, Seattle. 730 pp.

Hoffmann, R. S. 1960. Summer birds of the Little Belt Mountains, Montana. Montana State University Occasional Papers Number 1. 18 pp.

Johnson, N. K. 1975. Controls of number of bird species on montane islands in the Great Basin. Evolution 29: 545–567.

Johnson, P. L. 1962. The occurrence of new arctic-alpine species in the Beartooth Mountains, Wyoming-Montana. Madrono 16: 229–233.

Kapp, R. O. 1970. Pollen analysis of pre-Wisconsin sediments from the Great Plains. *In* Pleistocene and recent environments of the Central Great Plains. *Edited by* W. Dort, Jr. and J. K. Jones, Jr. University Press of Kansas, Lawrence. 433 pp.

Kemp. J. F. and **P. Billingsley.** 1921. Sweet Grass Hills, Montana. Geological Society of America Bulletin 32: 437–478.

Küchler, A. W. 1964. Potential natural vegetation of the conterminous United States. American Geographical Society Publication Number 36. Map + 116 pp.

Kuijt, J. and **J. A. Trofymow.** 1975. Range extensions of two rare Alberta shrubs. Blue Jay 33: 96–98.

Löve, D. 1959. The postglacial development of the flora of Manitoba: a discussion. Canadian Journal of Botany 37: 547–585.

Löve, D. 1970. Subarctic and subalpine: where and what? Arctic and Alpine Research 2: 63–73.

Lynch, D. 1955. Ecology of the aspen groveland in Glacier County, Montana. Ecological Monographs 25: 322–345.

Mengel, R. M. 1970. The North American Great Plains as an isolating agent in bird speciation. *In* Pleistocene and recent environments of the Central Great Plains. *Edited by* W. Dort, Jr. and J. K. Jones, Jr. University Press of Kansas, Lawrence. 433 pp.

Newsome, R. D. and **R. L. Dix.** 1968. The forests of the Cypress Hills, Alberta and Saskatchewan, Canada. American Midland Naturalist 80: 118–185.

Ogden, J. G., III. 1967. Radiocarbon and pollen evidence for a sudden change in climate in the Great Lakes region approximately 10000 years ago. *In* Quaternary paleoecology. *Edited by* E. J. Cushing and H. E. Wright, Jr. Yale University Press, New Haven. 443 pp.

Reeves, B. O. K. 1973. The nature and age of the contact between the Laurentide and Cordilleran ice sheets in the western interior of North America. Arctic and Alpine Research 5: 1–16.

Ross, H. H. 1970. The ecological history of the Great Plains: evidence from grassland insects. *In* Pleistocene and recent environments of the Central Great Plains. *Edited by* W. Dort, Jr. and J. K. Jones, Jr. University Press of Kansas, Lawrence. 433 pp.

Russell, L. C. 1952. Land snails of the Cypress Hills and their significance. Canadian Field-Naturalist 65: 174–175.

Stalker, A. M. 1965. Pleistocene ice surface, Cypress Hills area. *In* Cypress Hills Plateau guidebook number 1. *Edited by* R. C. Zell. 15th Annual Field Conference of the Alberta Society of Petroleum Geologists. 288 pp.

Tryon, R. 1971. Development and evolution of fern floras of oceanic islands. *In* Adaptive aspects of insular evolution. *Edited by* W. Stern. Washington State University Press, Pullman. 86 pp.

Westgate, J. A. 1965. The pleistocene stratigraphy of the Foremost-Cypress Hills area, Alberta. *In* Cypress Hills Plateau guidebook number 1. *Edited by* R. C. Zell. 15th Annual Field Conference of the Alberta Society of Petroleum Geologists. 288 pp.

Wright, H. E., Jr. 1970. Vegetational history of the central plains. *In* Pleistocene and recent environments of the Central Great Plains. *Edited by* W. Dort, Jr. and J. K. Jones, Jr. University Press of Kansas, Lawrence. 433 pp.

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The Annual Antler Cycle in Newfoundland Caribou

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Abstract. I studied the occurrence, growth, and size of antlers of caribou (*Rangifer tarandus*) in Newfoundland from 1956 to 1966. All the mature males possessed antlers but many females had no visible antlers: 55% in the Interior Herd, 28% in the Humber Herd, and 91% in the Avalon Peninsula Herd. Antlers were first visible in mature stags in April, barren does in May, parous does in June 3 weeks after calving, yearlings in June, and male calves in August. Stags shed their velvet in the second and third weeks of September, 80% of the females shed their velvet 2–10 days before estrus (2–9 October), and 20% shed their velvet 2–3 weeks before breeding. Large stags shed their antlers in November and December, barren does in late March and early April, and parous does shortly after calving in June. The size of antlers was correlated with age, body size, and winter snow falls. Antlers were larger on animals in eastern Newfoundland than in western Newfoundland.

One aspect of the biology of caribou (*Rangifer tarandus*) about which naturalists and hunters inquire is the size and growth of antlers. Yet there is no comprehensive published account in the North American literature on the annual cycle of antler development. Kelsall's (1968) monograph on caribou provides only 4 pages on the subject. Skoog (1968) discusses in detail the annual cycle for Alaskan animals, but his thesis has not been published. The present study incorporates notes I made on antler development of wild caribou in Newfoundland from 1956 to 1966. Also, I observed antler development of five captive caribou raised by the Newfoundland Wildlife Division.

Observations

Antler Description

The antlers of Newfoundland stags are shorter, heavier, more broadly palmate, and have more points per area than those of other races (Figure 1) (Millais 1907; Dugmore 1913; Banfield 1961). I observed for example, that 25 (32%) of 77 mature stags had both brow tines palmate and only 8 (10%) had both brow tines digitate. On the Gaspé Peninsula of Quebec, I observed the converse: 2 (13%) of 15 mature stags had both brows palmate and 5 (33%) had both brows digitate. The mean number of points of 139 stags in Newfoundland was 16.0 and maximum 36 and, in 46 antlers of stags on the Gaspé Peninsula, the mean was 11.8 and maximum 26 (a point equals a protuberance longer than it is wide).

Antlerless Does and Stags

Many mature does in Newfoundland lacked antlers, and others had only a single antler. In the Interior Herd 45 ± 2% (± 95% confidence limits) of the adult does had antlers ($n = 2333$), although in the Avalon Peninsula Herd 9 ± 4% of the does carried antlers ($n = 232$) (see Bergerud 1971 for herd locations). In addition, many does did not acquire visible antlers until their third summer; in the Interior Herd 5 (8%) of 63 female calves had antlers in October and November and 3 (14%) of 21 yearling does possessed antlers; in the Humber Herd, 2 (14%) of 14 female calves had visible antlers in the fall, and 71 ± 8% of the adult does had antlers ($n = 122$).

Most male caribou had antlers. I observed, however, two male calves (6 months old) that had but one antler and three male calves that had no visible antlers ($n = 59$). All the yearling stags seen during the field work (with the exception of a one-antlered stag) had two antlers. Mature stags rarely failed to develop antlers. I never saw stags without antlers (hummels) in Newfoundland, but I did observe two hummels at Mount Albert, Quebec, in October 1959.

Antler Growth

The initiation of antler growth in caribou varies between sexes, between age classes, and between fertility classes (whether a doe is pregnant or barren) (Skoog 1968; Kelsall 1968). I first noted visible antlers for mature stags in

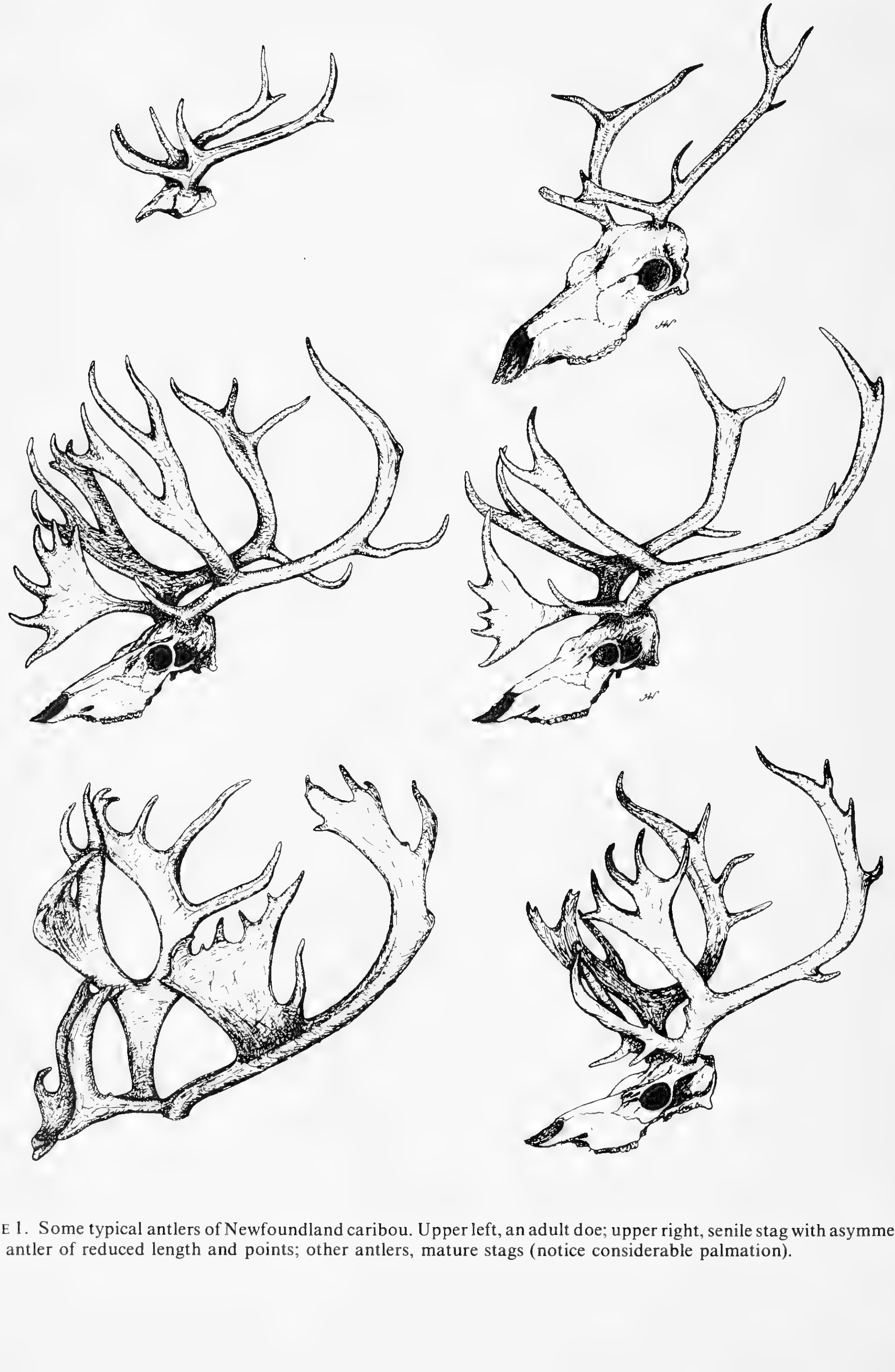

FIGURE 1. Some typical antlers of Newfoundland caribou. Upper left, an adult doe; upper right, senile stag with asymmetrical antler of reduced length and points; other antlers, mature stags (notice considerable palmation).

Newfoundland in April; for barren does in May; for yearlings and parous does in June (approximately 3 weeks after calving); and for male calves in August (Figure 2). Antler appearance *may* vary between years depending on winter and spring foraging conditions. My well-nourished captive caribou consistently commenced antler development before animals of similar age in the wild (Figure 3 vs. Table 1). Antler growth was initiated earlier in wild yearlings and 2-year-old animals in 1958 after a mild winter than in the years 1959–1961 when snow depths were greater (Table 1). Further, in 1958 many barren does in velvet were observed 25–31 May but not in the three other years (Table 2).

The growth rates of antlers in the wild was assessed by visually estimating the lengths of doe and stag antlers from April to June. Values were averaged by weekly or bimonthly intervals. The mean growth increment for stags from 30 April to 7 June was 5 to 14.5 cm ($n = 18$) and 1–14 June, 15 to 21.3 cm ($n = 28$). For nonparous does, the growth from 1 to 14 June was 6.4 to 8.9 cm ($n = 17$).

TABLE 1—Comparison of beginning of antler growth between years

	Date first recorded of new antlers and their length (cm)			
	12 months old		24 months old	
Year	Does	Stags	Does	Stags
1958	May 27 (2½)	May 23 2½)	May 24 (2½)	May 27 (5)
1959	?	June 5 (spikes)	May 22 (2½)	May 28 (5)
1961	none*	June 2 (7½)	June 2 (2½)	June 10 (2½)
1962	June 8 (2½)	June 5 (7½)	June 5 (4)	June 5 (2½)
1963	none*	none*	May 23 (2½)	May 29 (2½)

*No animals seen had developed antlers before 10 June.

The period of beam growth ranged from 90 to 130 days for captive animals (see Table 3). Two captive 2-year-old does completed their terminal growth on 17 and 19 August (approximately 100 and 127 days, respectively, after their antlers emerged). One captive doe that was pregnant

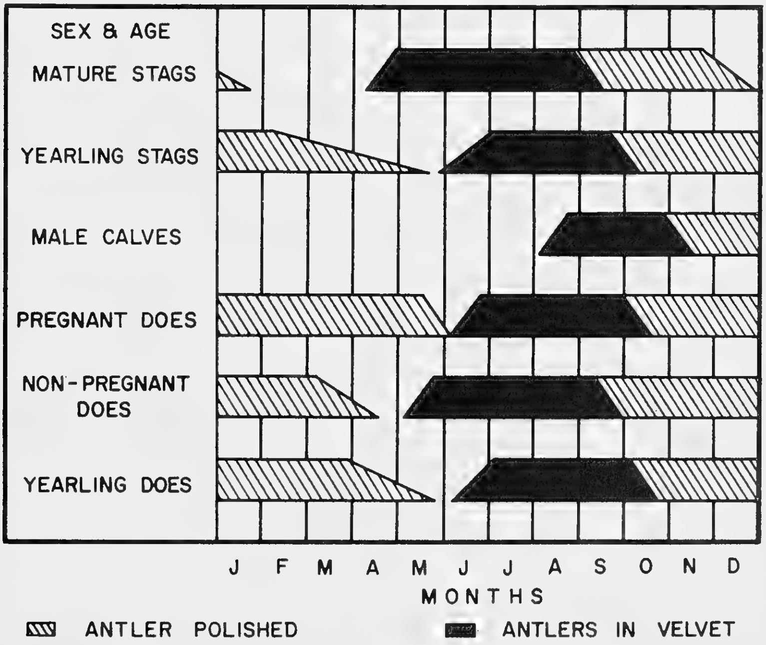

FIGURE 2. The annual cycle of velvet- and antler-shedding. The sloping lines on the bars represent the proportion of animals within each sex and age class that had visible antlers (only antlered does considered). For example, some yearlings stags cast their antlers in February and others in May.

TABLE 2—Initiation of antler growth in mature does

Date	Number in sample	Percentage of does in velvet 1958	1959	1960	1961
May 25–31	3110	6	<1	<1	2
June 1–7	1463	22	<1	2	2
June 8–14	1407	3*	2	2	7
June 18–22	1204	2	4	8	13

*The decrease in does in velvet cannot be explained, unless barren does left the calving grounds in 1958.

cast her right antler on 20 April and her left antler 56 days later on 15 June. A new right antler was discernable on 13 May and the left antler appeared shortly after 15 June. Both antlers required about 110 days to complete their terminal growth. The left antler continued to grow up until the time that the velvet was shed on 30 September. The growth interval for a captive stag was 117 days at the age of two and 126 days at the age of three (Table 4).

Two wild stags were observed on the Avalon Peninsula throughout the summer of 1959. The

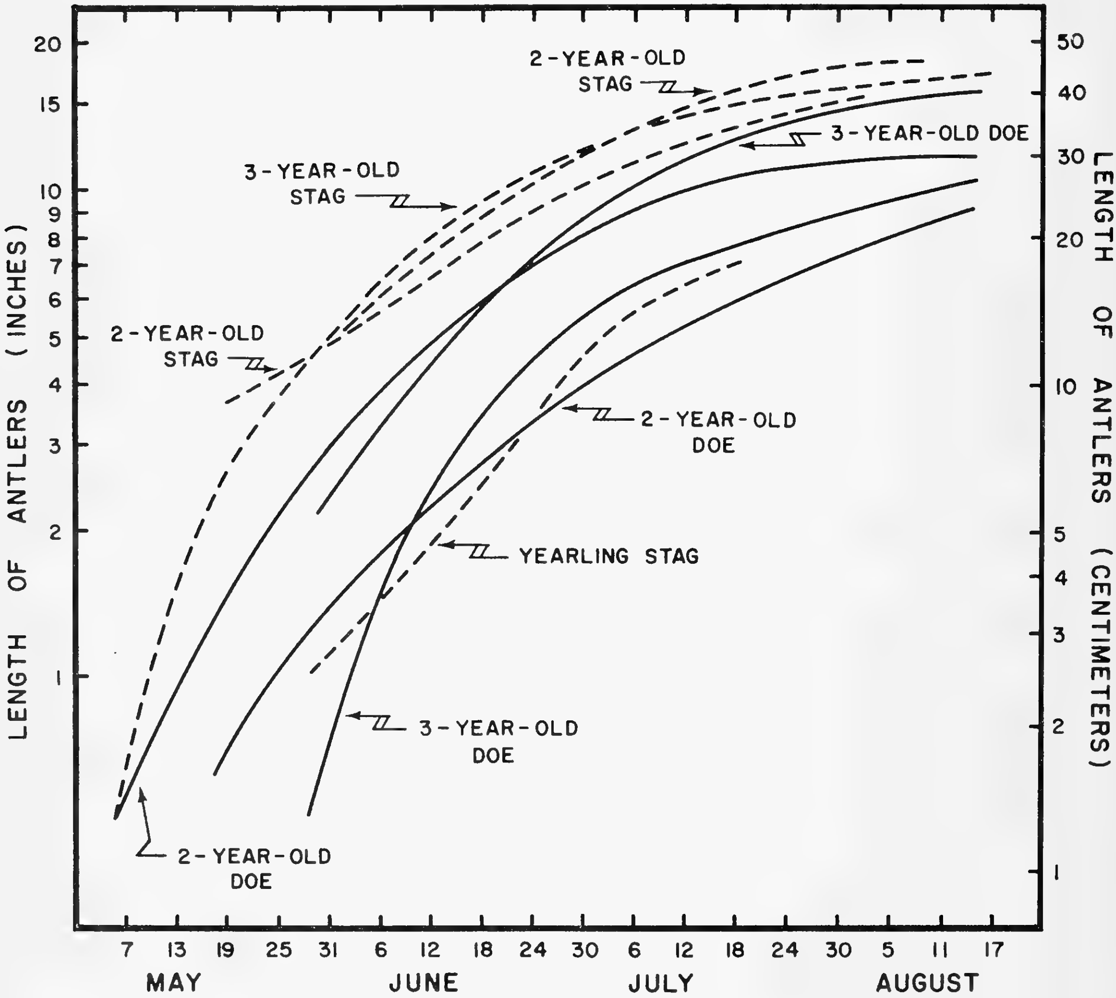

FIGURE 3. The growth of the antlers of captive caribou.

TABLE 3—The growth of the antler beams of five hand-reared caribou

Sex and age (antler head number[1])	Percentage main beam grown by				Instantaneous growth rate %/day			
	June 1	July 1	Aug. 1	Sept. 1	May	June	July	August
Stags								
2 years (3rd)	29	62	98	100	2	3	2	1
2 years	30	67	90	100	10	3	2	1
3 years (4th)	26	68	95	100	?	3	1	1
Pregnant doe								
2 years (3rd)[2]	—	12	45	84	—	—	5	2
Non-pregnant does								
2 years (3rd)	15	44	83	100	6	4	2	1
2 years (3rd)	26	71	96	100	7	8	1	tr[3]

[1] Based on the assumption that the first head is acquired as a calf.

[2] Based on the right antler, shed 15 June.

[3] Trace.

beams of the antlers did not appear to increase in length after the last week in June, even though one stag added four points to his antlers between June and mid-August. The points on the antlers of the other stag increased from 29 to 31 in July. I suspect that large stags on the Avalon Peninsula may commence antler growth in late March; thus, they may take only 90 days to complete their beam growth.

Generally the smallest tines were the last to develop on wild and captive animals; for the captive animals, these points were on the brow tines and the extremities of the main beams (Figure 4). In all the captive animals, however, the tips of the antlers grew throughout the whole antler growth period (Figures 4 and 5).

After the last tine had developed and after the antler had completed its beam growth, a period of rapid ossification and mineralization occurred before the velvet was shed. The length of this phase in one captive stag was as follows: yearling, 19 days; 2-year-old, 28 days; 3-year-old, 40 days; and 4-year-old, 40 days. The interval for a captive 2-year-old doe was 41 days.

Velvet-shedding

The earliest observation of a stag rubbing his velvet antlers was 11 August. This stag was again seen scratching his velvet against shrubby spruce 19, 20, and 22 August. Another stag, in a similar performance, was recorded 21, 24, and 27 August. The velvet appeared intact in these

TABLE 4—Some antler characteristics of a hand-reared stag from 1 to 5 years of age

Antler characteristics	Month and date			
	2nd head (1–2 yrs)	3rd head (2–3 yrs)	4th head (3–4 yrs)	5th head (3–5 yrs)
Antler growth commences	—	May 1	April 5	—
Beam length completed	Sept. 15	Sept. 2	Aug. 9	Aug. 5
Last point formed	—			
Right antler	—	—	Aug. 8	July 25
Left Antler	—	—	Aug. 8	Aug. 5
Velvet shed	Oct. 4	Sept. 23	Sept. 18	Sept. 14
Antlers Cast				
Right antler	April 14	April 14	Mar. 6	—
Left Antler	April 7	April 12	Feb. 26	—

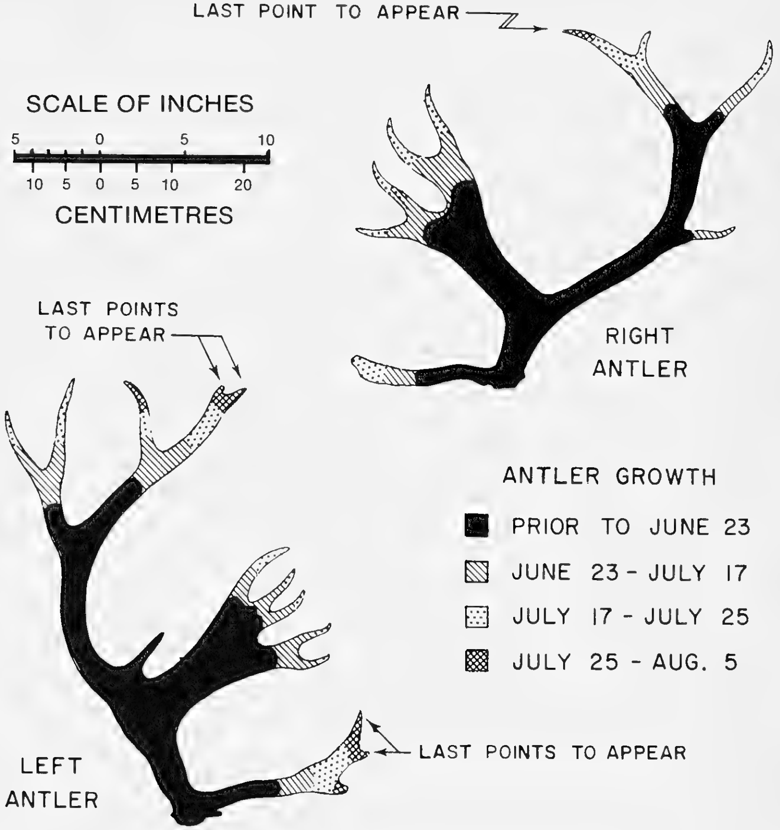

FIGURE 4. The growth of antlers of a 4½-year-old captive stag.

observations.

Millais (1907) listed the velvet-shedding period for Newfoundland stags as 7–12 September. My observations in 1957 began on 11 September; on that date I recorded two stags in velvet, one stag in the process of shedding, and a fourth animal with polished antlers. The following day I saw three stags without velvet and a fourth animal with small antlers that had velvet still hanging on his antlers. The last stag recorded in velvet on 18 September in 1957 was a small 7-point stag. A vigorous, captive yearling shed his velvet on 4 October. With each succeeding set of antlers, he shed his velvet earlier (Table 4). Another captive stag shed his velvet when 2½, 3½, and 4½ years old on 16, 1, 14 September, respectively.

Eighty percent of the does in Newfoundland shed their velvet 2 to 10 days (2–9 October) before coming into heat (Figure 6) (see Bergerud 1974a for dates of breeding). The period of velvet-shedding in these does was synchronized and abrupt (Figure 6). The remaining 20% of the females shed their velvet 2 to 3 weeks prior to breeding (Figure 6); some of these latter does were possibly barren in the previous year. Nonpregnant does initiate antler growth 2 to 3 weeks earlier than fertile does and may complete the growth cycle earlier. Many of the does I watched at Mount Albert, Quebec shed their velvet 1 to 15 days before breeding commenced in 1959 (Figure 6) (see Bergerud 1973, for details on breeding).

Caribou removed velvet by scratching with the hind feet and by rubbing the antlers on limber vegetation. I saw some animals eat their velvet. Contrary to popular opinion, in Newfoundland most of the balsam fir (*Abies bal-*

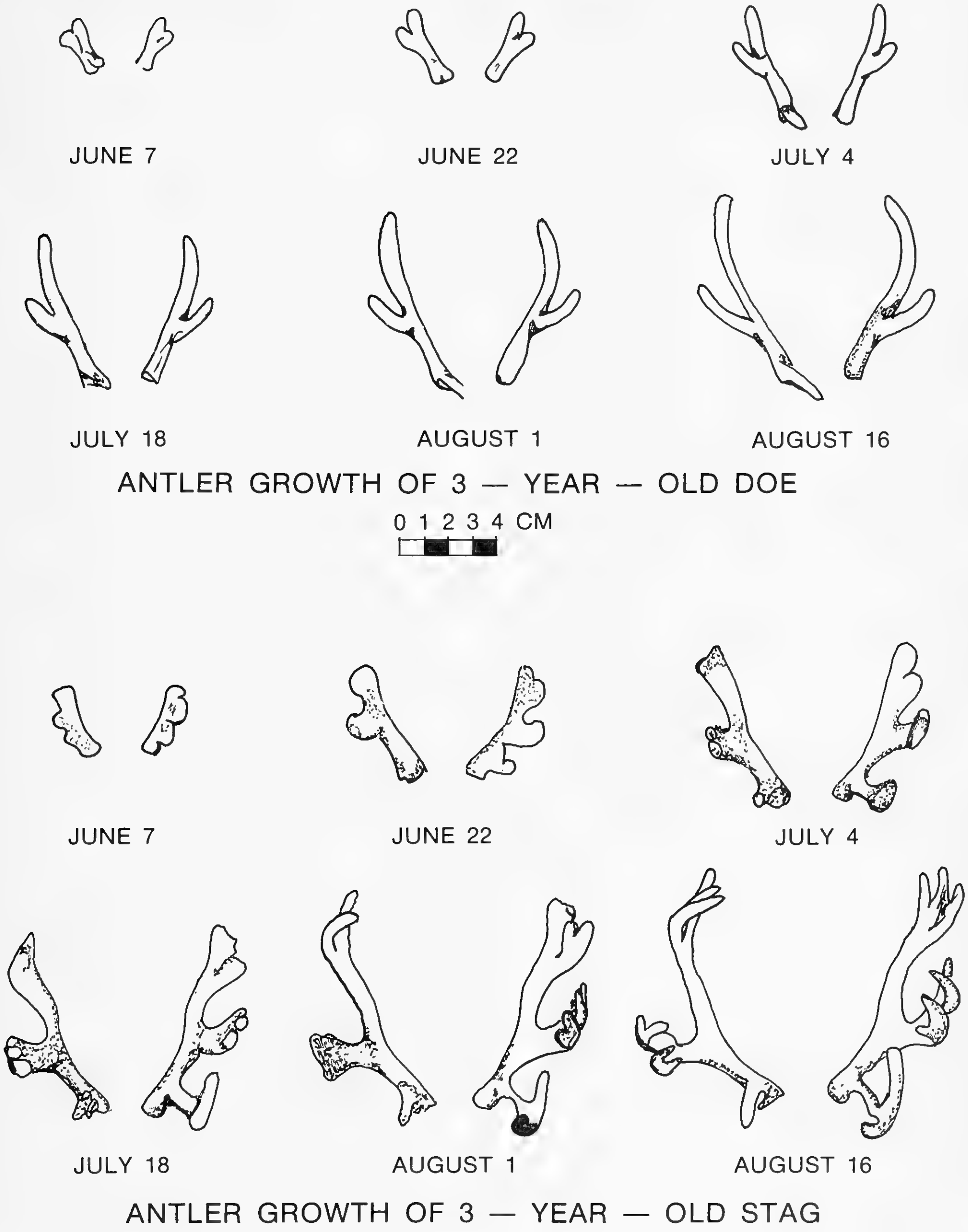

FIGURE 5. The growth of antlers of 3-year-old captive doe and stag.

samea) trees that are found with branches broken and the bark rubbed result from antler bush-thrashing by stags during the October rut and not from velvet removal.

Adult stags usually shed their velvet in 1 day; one captive stag completed the process in 8 hours. Does and younger stags took longer to shed their velvet. One yearling stag took 3 days.

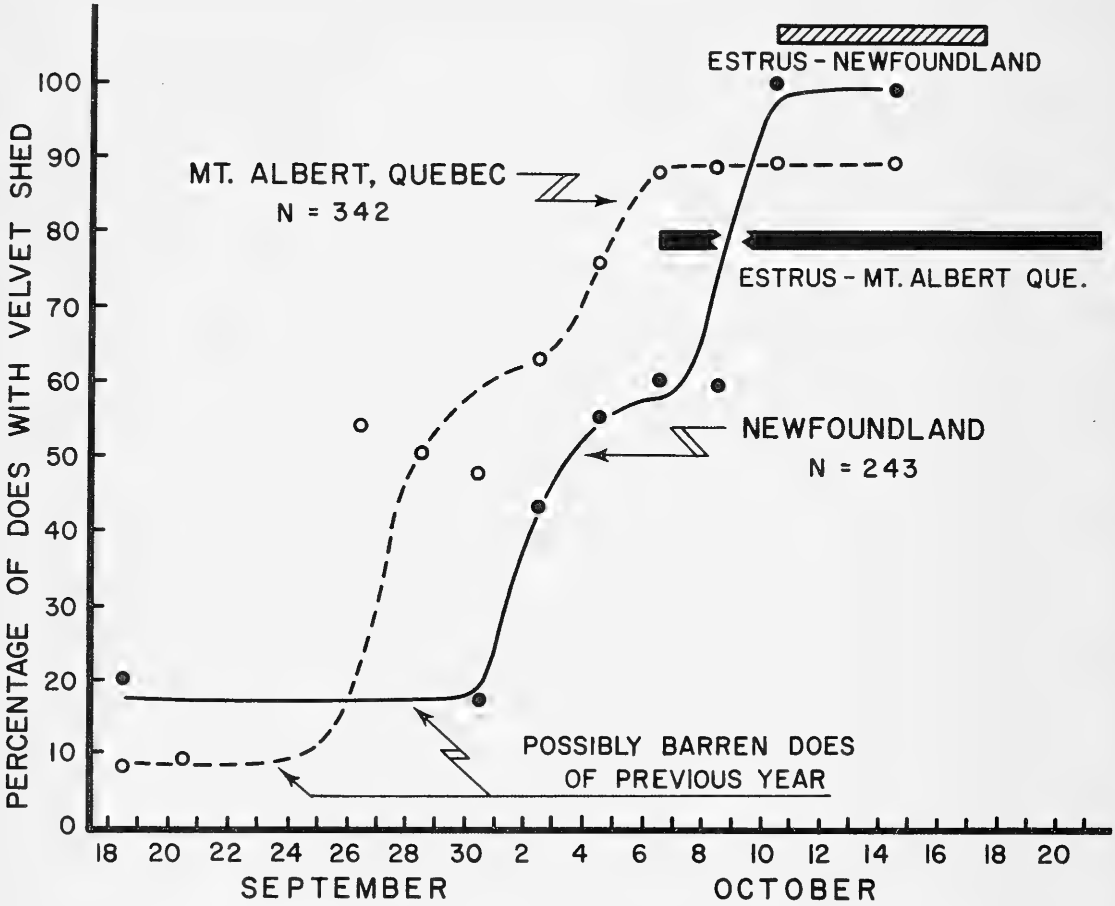

FIGURE 6. Comparison of velvet-shedding in does and its relation to the dates of estrus.

A wild yearling had his velvet partially removed on 28–30 September. A wild doe showed signs of velvet-shedding on 11 October, but still retained some velvet on 20 October. A wild yearling doe commenced to shed on about 29 September but had not completed the process by 9 October. Hanging strands of velvet and blood staining may persist for several days.

The normal sequence of shedding in yearlings and does was as follows: first day, loosening of the velvet in the middle of the beams; second day, antler clean at the center and shedding of the terminal tines; third day, peeling at the base and on the brow tines.

Antler-casting

Most large stags in Newfoundland dropped their antlers between 14 November and the end of December (Table 5). The earliest dates that stags had only one antler were 4 November 1960, and 11 November 1958. Some small stags continued to carry antlers well into March and April. A 2-year-old stag had antlers on 24 March 1961. Two yearling stags each possessed one antler the second week of April. In May and June 1957–1963, 4 of 279 yearling stags still retained antlers. Other yearlings showed scars of antlers that had been cast recently.

In Newfoundland barren does shed their antlers before the calving season. For example in 10 years during the calving season I observed only five does with antlers, that were not either clearly pregnant or lactating (had a visible udder) (Table 6). It is possible that some of these five animals had a smaller udder or were pregnant.

TABLE 5—Casting of stag antlers

Source and date	Stags in sample	Percentage of stags with		
		No antlers	1 antler	2 antlers
Field classifications				
November 11–30	76	—	5	95
December 4–5	37	46	5	49
December 14–16	11	73	9	18
March 4–17	98	94	4	2
March 22–April 11	24	96	—	2
Hunter returns (1949–50)				
November 7–14	49	2	1	98
November 15–21	40	8	—	92
November 22–30	35	17	—	83
December 1–7	16	44	—	56

Additional evidence that all barren females cast their antlers prior to the calving season was the fact that at the commencement of calving on 24 May only 37 ± 5% of the does carried antlers ($n = 401$). In October 45 ± 2% of the females had antlers. If 45% of the barren females (estimated at 16%, Bergerud 1971) possessed the antler phenotype and all shed their antlers before the calving season, the expected percentage of females carrying antlers on 24 May should be 38% (0.45 × 0.16 barren females equals .07, 45 − 7 = 38%).

The actual dates of antler-casting in the majority of the barren does were not determined. Wildlife Officer Stephen Hall saw four does in the Interior Herd that had recently cast one antler in the interval 24 March to 4 April 1961. In the period 4 March and 4 April (1959, 1961) 15 ± 3% of the does we saw had just one antler ($n = 465$). The actual percentage of does that possessed the one antler characteristic in the Interior Herd was 8 ± 2% ($n = 871$). Again a comparison of the change in ratios between one- and two-antlered does from 29 March to 13 April 1964 suggested some does cast their antlers in that interval (Table 7). Thus my data indicate that barren does cast their antlers in late March and early April.

TABLE 7—Presence of antlers on does in spring 1964

Date	One-antlered does	Two-antlered does	Ratio 1:2
March 29	5	24	1:4.8
April 5	8	22	1:2.8
April 11–12	41	94	1:2.3
April 13	26	52	1:2.0

The majority of the pregnant does cast their antlers a few days after parturition (Figure 7; see also Skoog 1968; Kelsall 1968). Four wild does that were captured shortly before parturition cast their antlers 3, 3, 6, and 6 days after parturition. There were some exceptions of parous animals casting after calving (see also Sokolov 1959, p. 287). Two does observed in mid-June had velvet antlers and newly born calves (Figure 8). A third doe with velvet antlers was collected on 20 June 1963, carrying a 2.8-kilo fetus (normal birth weight is $7\frac{1}{4}$ kilos, Bergerud 1971). These three does likely conceived in the second or third estrous periods. I also noted some pregnant does with antler scars the last week of May. The antlers of one pregnant doe fell off while being tagged on 27 May.

A few does (2.4%, $n = 1803$) continued to carry antlers after most of the calves were born,

TABLE 6—Antler characteristics of mature does in June

Week	Total adult does								
	Hard antlers			Antlers in velvet			No antlers		
	Udder	No Udder	Pregnant	Udder	No Udder	Pregnant	Udder	No Udder	Pregnant
June 1–7	117	2	7	—	27	4	628	89	28
June 8–14	74	2	3	2	16	—	917	38	16
June 15–21	5	1	—	15	53	1	970	107	1
Totals	196	5	10	18	96	5	2515	234	45

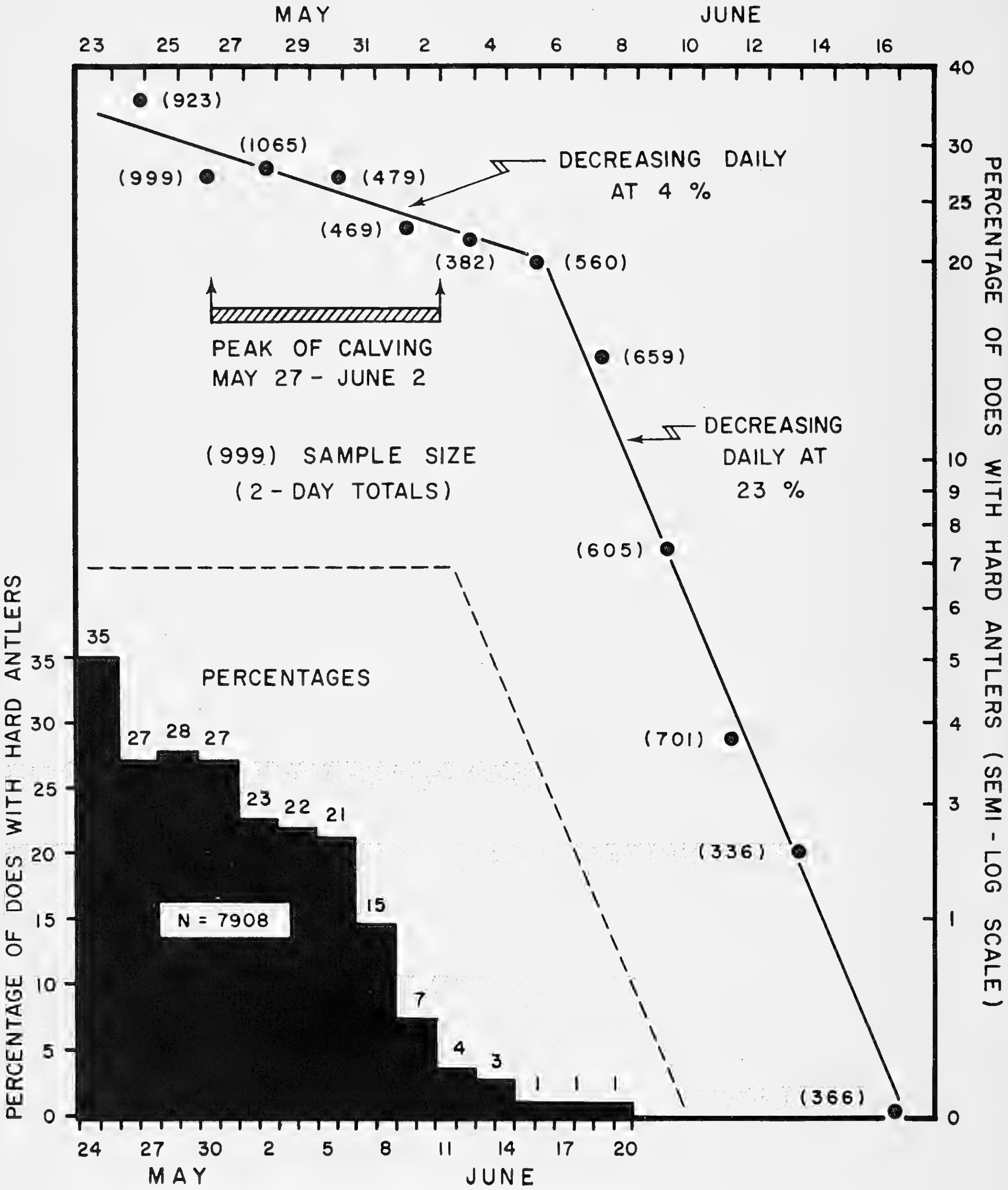

FIGURE 7. The casting of antlers of does in the spring, relative to calving dates.

some until 20 June (Figure 7). Forty-three does had hard antlers between 11 and 20 June. I believe these does conceived in second or third estrous interval and carried their antlers 10–20 days longer than other parous does. The best evidence for this hypothesis was based on the

FIGURE 8. A doe in velvet with a newborn calf.

retention of antlers and the frequency of does that calved late in 1958 (Table 8). In 1958 there were few, if any, calves born 3–8 June; however, from 10 to 12 June about 4% of the does gave birth (Table 8). From 9 to 12 June I counted nine does with antlers among 570 does (1.6%). From 13 to 16 June I saw no antlered does ($n = 215$). The percentage of antlered does expected, if 4% were pregnant, would be 1.8% (0.4 × 0.45). Several of these antlered does were observed to be clearly pregnant. These late does that calved late may have immediately cast their antlers following calving (Table 8).

Size of Antlers

The size of antlers depends in part on

TABLE 8—Comparison of the dates of calving and doe antler-casting, 1958

Dates May–June	Does counted	Percent calves[1] born	Number of newborn calves caught	Percent antlered females
20–30	89	4	1	34.8
24–27	424	20	15	34.6
28–31	211	53	11	28.9
1–4	157	some[2]	3[2]	15.9
5–8	29	none	none	10.3
9–12	570	4	5	1.6
13–16	215	none	none	0.0
Total	1,695	81[3]	35	—

[1] Based on calves/100 does.

[2] Some born June 1 and 2 but none on June 3 and 4, in 61 caribou seen.

[3] Not 100% since many young calves died, which resulted in an underestimate of calves/100 does.

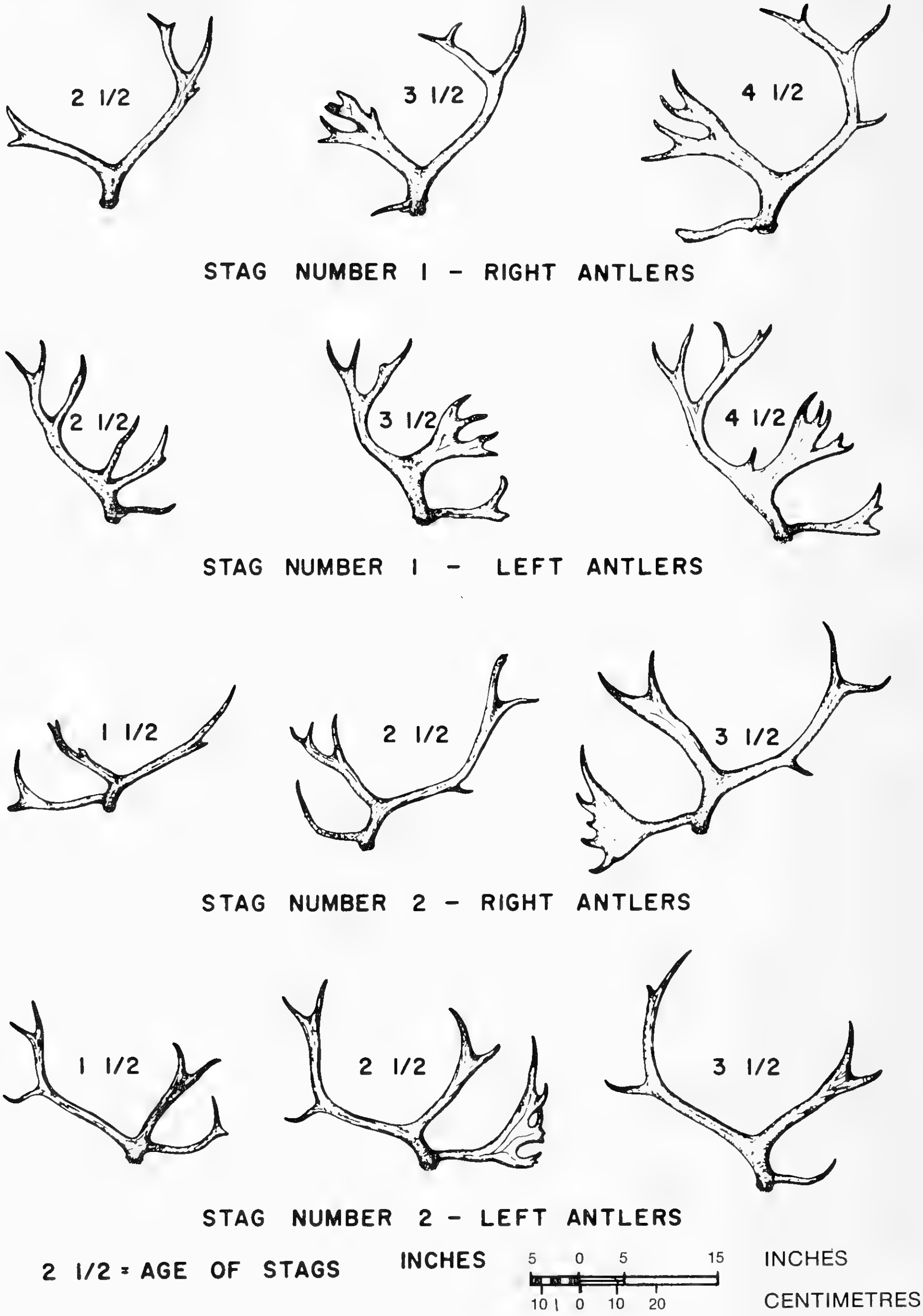

FIGURE 9. Comparison of the size and shape of subsequent antler sets of two captive stags.

nutrition, age, and genetic factors. The antlers of each captive caribou we raised had its own distinguishing features that we could recognize in subsequent antler sets (Figures 9 and 10). Antlers generally appear to increase in size until at least 6 years for stags and 3 to 4 years for does

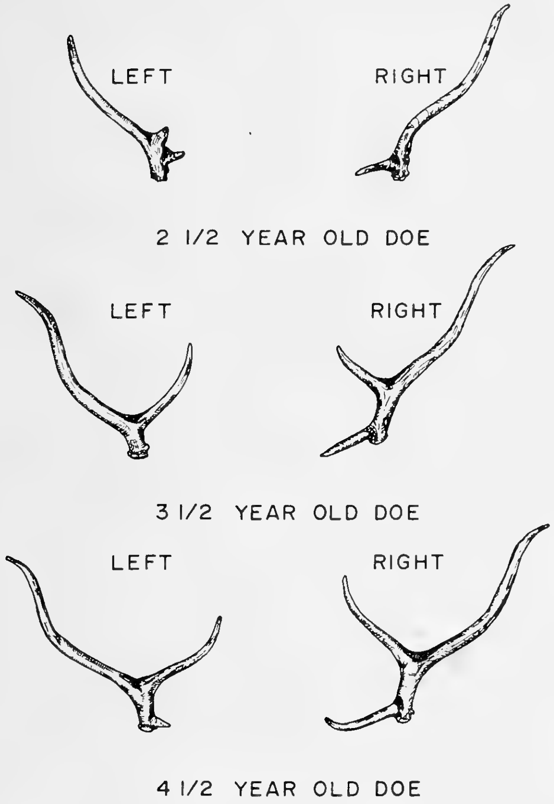

FIGURE 10. Comparison of the size and shape of subsequent antler sets of a captive doe.

(Table 9; Bergerud 1974a, Figures 15 and 17). The size of stag and doe antlers was weakly correlated with their weight (Bergerud 1974a) (Figure 11). Two observations suggest that Newfoundland antlers might be better developed following winters with little snow cover. In the first instance, four of the largest-antlered caribou ever shot in Newfoundland were secured in 1951 following the mildest winter in 25 years, 1938–1963 (Boone and Crockett records). Another mild winter occurred in 1957–58 when the total snowfall was 83.5 cm. During the following rutting season, I classified 142 mature stags as to antler size; 69% had large antlers and 20% had medium-sized antlers (see Bergerud 1973, Figure 4 to compare large vs. medium criteria). From 1957 and 1959–1964 the mean percentage of large-antlered stags was 30 ($n = 380$).

I compared winter snowfall statistics for 7 years with the number of antler points per stag reported on hunter returns. In tabulating the antler points, stags with fewer than 11 points were excluded to reduce bias resulting from changing age ratios. The correlation coefficient between points and snow fall was $r = 0.714$, $P < 0.10$. This weak correlation (based on crude snowfall statistics) is consistent with the view that winter nutrition may affect antler development.

Winter nutrition might also vary between areas within years and affect antler size. The Boone and Crockett Club listed the location of nine record-sized Newfoundland antler sets; six came from the eastern interior barrens, and of these, five were shot along the Gander River. The average number of antler points provided by hunter returns for the combined western interior herds of Newfoundland was 16.6 ± 0.35 points, and for the eastern interior herds was 18.3 ± 0.42 points ($t = 2.926$, $P < 0.01$; Table 10). The eastern figures exceeded the western statistics in 6 of 7 years (Table 10). In the seventh year only 13 returns from hunters were available for the eastern barrens. In addition, the point tallies for two-antlered does, based on my classifications, gave does in the western interior 5.6 ± 0.35 points per head and the eastern females 7.4 ± 0.37 points ($t = 3.415$, $P < 0.01$, $n = 114$). In the autumn I saw only four exceptionally large stag antler sets; all were seen in the eastern interior. Forage is less available in winter on the western subalpine woodland winter range than on the eastern barrens which have extensive lichen woodlands (Bergerud 1974b).

TABLE 9—Antler measurements of a hand-reared stag from 1½ to 6½ years of age

Antler measurements	Head number 2nd	3rd	4th	5th	6th
Total points					
Right	1	6	10	9	8
Left	2	8	10	15	16
Weight (kg)					
Right	1	0.45	0.73	1.27	—
Left	0.09	0.50	0.82	1.45	—
Length main beam (cm)					
Right	1	52.1	59.2	78.7	88.4
Left	30.5	53.1	59.9	76.2	96.5

TABLE 10—Comparison of stag antler points from hunter returns (all age groups considered) between the western and eastern Interior Herds (sample size in parenthesis)

Year	Western Interior	Eastern Interior	Total ± SE
1959	15.4 (34)	17.6 (57)	16.8 ± 0.94 (91)
1950	14.3 (36)	16.0 (67)	15.4 ± 0.75 (103)
1959	22.4 (31)	21.2 (13)	22.0 ± 1.08 (44)
1960	19.5 (67)	20.3 (34)	19.8 ± 0.87 (101)
1961	16.3 (113)	19.7 (59)	17.5 ± 0.61 (172)
1962	15.9 (145)	18.9 (81)	16.9 ± 0.53 (226)
1963	16.0 (127)	17.4 (63)	16.5 ± 0.53 (190)
Total	16.6 ± 0.35	18.3 ± 0.42	17.3 ± 0.26 (927)

Discussion

Caribou are unique among the cervids in that both sexes frequently have antlers. The chronology of annual growth cycles varies, however, between sex and age classes and probably between years. Also, the chronology of growth varies between geographical regions, and the findings reported here cannot be extrapolated. For example, Skoog's (1968) data showed that animals in the Nelchina Herd in Alaska were more precocial in antler development than caribou in Newfoundland:

	Initiation of Growth	
	Alaska	Newfoundland
Mature stags	March	April
Barren females	April	May
Yearlings	May	June
Parous females	1 wk after parturition	3 wks after parturition
Male calves	June	August

Both the Alaskan and Newfoundland herds calve at approximately the same dates, hence breed on similar dates. Thus the earlier growth of the Alaskan caribou compared to that of the Newfoundland animals cannot be explained by differences in the chronology of their reproductive cycles.

Two of my findings are in disagreement with the views of other workers in North America. I found that female caribou shed their velvet within 2 weeks of estrus. McEwan and Whitehead (1972), however, reported velvet-shedding about 24 days prior to estrus in captive caribou. They did not indicate whether their animals had calved the previous year. According to Sokolov (1959) barren does shed their velvet earlier than does that gave birth the previous season. Gurbunov (1939) stated that velvet-shedding occurred shortly before estrus in animals in the USSR.

Second, I found no evidence that some barren females carried their antlers to the calving season. In contrast, Lent (1965) felt that many barren does in Alaska still possessed their antlers at the commencement of calving. Skoog (1968) questioned the samples upon which Lent reached his conclusion. Work in Russia supports the view that barren females shed their antlers before the calving season. Shaposhnikoff (1955) stated "Barren female reindeer shed their antlers at different dates up to April, but pregnant females shed theirs only after calving . . . ." Likewise, Flerov (1952) states, " . . . The females preserve their antlers the entire winter and lose them 3 to 7 days following calving . . . The barren females shed their antlers before the pregnant ones in March and April" (see also Skoog 1968; Kelsall 1968).

A pertinent question relative to the size of antlers is whether there is selection for larger antlers through social behaviors of fighting and threatening. Antlers serve as weapons as well as dominace-rank symbols. Antlered does often threaten with antlers but antler-fighting in Newfoundland animals was rare, and even then fights were brief, non-fatal encounters. It is difficult to see how does could readily distinguish between antler sizes, since most sets were only 20–30 cm in length (Figure 11).

Antler-threatening and dominance-battles are common with stags in the rut (Bergerud 1974a). Dominance is often achieved through strenuous

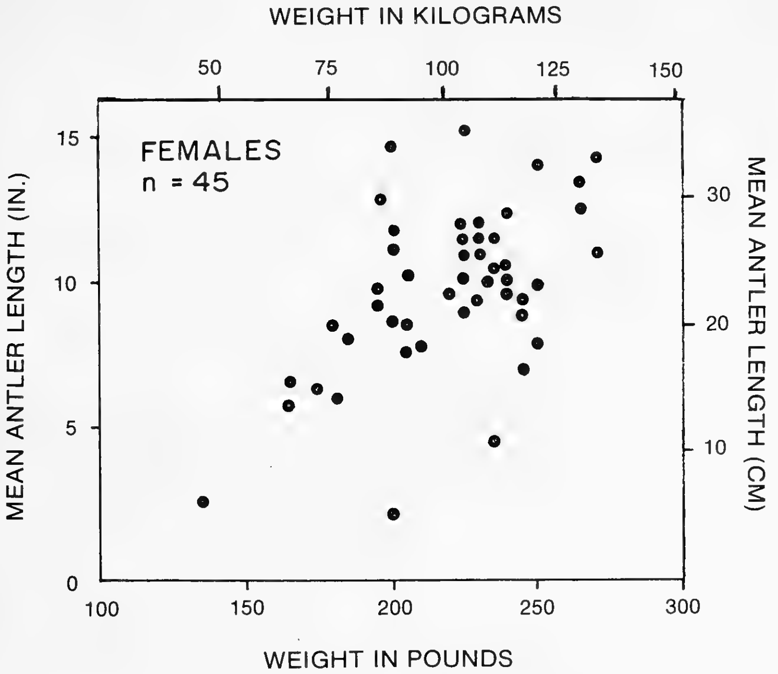

FIGURE 11. Antler length compared to whole body weight in females.

shoving matches, occasionally resulting in fatalities (Bergerud 1971, 1974a). In such encounters weight must be an important factor. The positive allometry between antler and body size in stags, and possibly in does is, in my view, a consequence of the advantageously large body size and not selection for larger antlers independent of body size.

Literature Cited

Banfield, A. W. F. 1961. A revision of the reindeer and caribou, genus Rangifer. National Museum of Canada Bulletin Number 117. 137 pp.

Bergerud, A. T. 1971. The population dynamics of Newfoundland caribou. Wildlife Monograph 25. 55 pp.

Bergerud, A. T. 1973. Movement and rutting behaviour of caribou (*Rangifer tarandus*) at Mount Albert, Quebec. Canadian Field-Naturalist 87(4): 357–369.

Bergerud, A. T. 1974a. Rutting behaviour of Newfoundland caribou. *In* The behaviour of ungulates and its relation to management. I.U.C.N. Number 24. Volume 1. *Edited by* V. Geist and F. Walther. Morges, Switzerland. pp. 395–435.

Bergerud, A. T. 1974b. The relative abundance of food in winter for Newfoundland caribou. Oikos 25: 379–387.

Dugmore, A. A. Radclyffe. 1913. The romance of the Newfoundland caribou. J. P. Lippincott Company, Philadelphia, Pennsylvania. 191 pp.

Flerov, K. K. 1952. Fauna of U.S.S.R. 1, Mammals. Chapter 2, Musk deer and deer. Academy of Science Press, Moscow, Leningrad. 257 pp.

Gurbunov, E. I. 1939. Sexual cycle and methods of diagnosis of rut in reindeer does. Transactions of the Institute of Agriculture Animal Husbandry and Fishing and Hunting Industry, Service of the Reindeer Industry 5: 101–134.

Kelsall, John P. 1968. The migratory barren-ground caribou of Canada. Department of Indian Affairs, Northern Development, Canadian Wildlife Service. 340 pp.

Lent, P. C. L. 1965. Observations on antler shedding by female barren-ground caribou. Canadian Journal of Zoology 43: 553–558.

McEwan, E. H. and **P. E. Whitehead.** 1972. Reproduction in female reindeer and caribou. Canadian Journal of Zoology 50(1): 43–46.

Millais, J. G. 1907. Newfoundland and its untrodden ways. Longmans, Green and Company, London. 340 pp.

Shaposhnikoff, F. D. 1955. Ecology and morphology of the Altai reindeer. Zoologicheskii Zhurnal 34(1): 191–207.

Skoog, Ronald O. 1968. Ecology of the caribou (*Rangifer tarandus granti*) in Alaska. Ph.D. thesis, University of California, Berkeley, California. 699 pp.

Sokolov, I. I. 1959. Fauna of the U.S.S.R. 1, Mammals. Chapter 3, Ungulates. Academy of Sciences U.S.S.R., Moscow, Leningrad. 639 pp.

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Notes

The 1973 Dickcissel Invasion of Southern Manitoba

The Dickcissel (*Spiza americana*) is very erratic in its breeding distribution. Its numbers, even in the center of its nesting range, fluctuate greatly from year to year. A locality may have an abundance of Dickcissels, only to have them disappear after a few years. On the other hand, areas such as southern Saskatchewan and Manitoba, in which Dickcissels normally do not occur, may suddenly experience invasions which may lead to successful reproduction. The next year there may be none.

In an earlier paper I tabulated and analyzed the records of occurrence of the Dickcissel in Alberta, Saskatchewan, and Manitoba (Sealy 1971). These observations indicated invasions of southern Saskatchewan in 1933 and 1934 and of southern Manitoba in 1921. Additional records from Manitoba (Table 1), contained in the files of the Manitoba Museum of Man and Nature, indicate that the 1933 and 1934 invasions also included southern Manitoba. Since 1934, only occasional individuals were seen in Saskatchewan (see Sealy 1971) and Manitoba (Table 1), and no apparent invasion occurred until 1973. This invasion appeared to be restricted to southern Manitoba since only one observation was reported from Saskatchewan when J. A. and S. Wedgewood saw two males and at least one female 7½ mi (12.5 km) south and 1 mi (1.7 km) west of Floral (see Shadick 1975).

In 1973, I first observed Dickcissels west of Isle des Chênes, Manitoba, on 7 July when 13 were observed, including one pair copulating. On that date a road-killed adult male (University of Manitoba Museum of Zoology Number 41) weighing 28.8 g with enlarged testes (left, 10.4 × 8.7; right, 10.3 × 9.5 mm) was found.

Those birds observed off the road were all associated with alfalfa (*Medicago sativa*) about 30 cm in height. A similar density of Dickcissels was observed in this area on three subsequent trips but by 15 July the alfalfa had been cut and the Dickcissels were gone. Dickcissels had not invaded this area when I visited it on 26 June.

Just north of this area, along the north side of the Red River Floodway, Vere Scott observed at least four males on 29 July 1973 and presumably the same males plus several others there on 30 July. These birds were also associated with alfalfa. When Scott returned to the area on 12 August, the alfalfa had been cut and no Dickcissels were present.

On 6 July 1973, H. W. R. Copland heard and saw a male Dickcissel perched in an alfalfa field just west of Selkirk. On 3 July R. W. Nero saw five pairs of Dickcissels just north of Raeburn. H. H. Axtell saw and heard two males on 6 July in a partly mowed field of sweet clover south of Lauder, and on 7 July he saw and heard one near Coulter, and observed three on 9 July near Sprague. At Lyleton, J. Murray saw possibly five individuals between 30 June and 13 July.

The late John Lane observed and heard three male Dickcissels adjacent to an alfalfa field on 8 June 1973 about 5 mi (8.3 km) northwest of Oak Lake. About an hour later a female joined one of the males and the pair flew along the fenceline for some distance before flying into the field. On 21 June two more males were found singing on a telephone wire adjacent to an alfalfa field, about 6 mi (10 km) southeast of Griswold. By mid-July the alfalfa in both areas had been cut and the Dickcissels had disappeared. B. Robinson saw five male Dickcissels near Brandon between 30 June and 3 July in association with alfalfa. By 29 July the alfalfa had been cut also and there were no Dickcissels.

On 14 June 1973, B. Koonz and C. Cuthbert observed a pair adjacent to an alfalfa field 4 mi (6.7 km) west of Carberry. On 4 July H. W. R. Copland visited this area and observed one singing male. At that time, however, the alfalfa was being mowed.

Only two reports of Dickcissels in Manitoba in 1974 were received and none in 1975. N. Foy saw three males about 3 mi (5 km) west of Tolstoi on 5 July 1974 and R. Knapton and J. Murray observed at least 10 males and two females in late July 1974, at Lyleton; the latter birds were gone within a week as the field was plowed.

J. L. Zimmerman (Abstract, Cooper Ornithological Meeting, Fort Collins, Colorado, 1970) has noted that the Dickcissel population reaches its highest densities in intermediate seral stages. Since its optimum habitat has therefore a spotty geographic distribution and undergoes relatively rapid change from year to year, the species must be opportunistic in its relationship to its environment. The density-dependent effect of territoriality in this species (Zimmerman 1971) insures the use of the most suitable habitat, forcing additional males into less acceptable vegetation or to seek out other areas, such as southern Manitoba, by "distant flight" behavior. Such flight behavior occurs after the individuals involved have interacted for a period of time in habitat

TABLE 1—Manitoba Dickcissel records between 1933 and 1972

Date	Number	Locality	Observer(s)
1933, June 4	2 pairs, single male, nest of 5 eggs	Woodlands	E. F. Parker (Lawrence 1933)
1933, June 9	4 or more pairs	W of Assiniboine Park	C. L. Broley (Lawrence 1933)
1933, June 10	nest	W of Assiniboine Park	A. H. Shortt (Lawrence 1933)
1933, June 11	nest	Woodlands	E. F. Parker (Lawrence 1933)
1933, June 17	1 male specimen[a]	St. Charles	A. H. Shortt (H. W. R. Copland personal communication 1974)
1933, June 18	4 colonies	Tuxedo — Headingly	C. L. Broley (Lawrence 1933)
1933, June 19	nest of 1 egg	W of Assiniboine Park	J. Pollock, J. English (Lawrence 1933)
1933, mid-June	"several"[b]	Grosse Isle	M. F. Crandall (Lawrence 1933)
1933, June 22	1 male specimen	Rosser	T. M. Shortt (H. W. R. Copland personal communication 1974)
1933, June 24	"abundant"	Winnipeg to Portage la Prairie — Delta	C. L. Broley (Lawrence 1933)
1933, June 25	nest of 3 eggs	Woodlands	E. F. Parker (Lawrence 1933)
1933, June 25[c]	3 nests, one with 5 eggs	Charleswood	A. Mackie (Lawrence 1933)
1933, late June	"common" with nest of 5 eggs (June 29)	Libau — Scanterbury	R. Fryer, O. P. Gibson (Lawrence 1933)
1933, July 9	"common"	Morris — Emerson	C. L. Broley (Lawrence 1933)
1933, August 13	1 male	Whitemouth	V. Latta (Lawrence 1933)
1934, May 28	1 seen	Souris	F. A. Hollies (Lawrence 1934)
1934, June 2	1 seen	Grosse Isle	M F. Crandall (Lawrence 1934)
1934, June 4	6 singing	E of Delta	C. L. Broley (Lawrence 1934)
1934, June 5	1 male	Woodlands	E. F. Parker (Lawrence 1934)
1934, June 14	1 male	MacDonald	A. J. Mackay (Lawrence 1934)
1934, June	"several"	Charleswood	O. A. Armstrong (Lawrence 1934)
1934	1 unsexed[d]	Charleswood	L. T. S. Norris-Elye (H. W. R. Copland, personal communication 1974)
1934, summer	"small colony"	Otterburne	H. Mossop (1959)
1941, June 20	pair	Beausejour	W. Craik (Lawrence 1941)
1945, summer	"numerous"	Souris	G. E. Willits (Lawrence 1945)
1951, July 14	1 male singing	St. Jean Baptiste	Godfrey (1953)
1959, summer	"several"	St. Boniface	D. Mossop (H. Mossop 1959)
1972, July 12	1 seen	Lyleton	J. Murray (Gardner 1972)

[a] Royal Ontario Museum Number 29874.
[b] Royal Ontario Museum Number 29941.
[c] A. Mackie also observed "colonies" near Winnipeg at Fort Garry, Headingly, and at the Agricultural Station at Glenlea.
[d] Manitoba Museum of Man and Nature Number 2098.

in the center of its range, where nest initiation begins in late May and peaks during late June in Illinois (Gross 1968) and Kansas (Zimmerman 1966) when arthropod production also is at a peak (Harmeson 1974). Therefore they do not usually occur in distant areas until later in the season. In the invasion years of southern Saskatchewan and/or Manitoba of 1921, 1933, 1934, 1973, most of the birds did not begin to show up until mid-June, and even later in 1973. At this time the alfalfa, a commonly grown fodder plant in southern Manitoba, is nearing maturity and apparently provides the necessary "habitat volume" (see Zimmerman 1971) for Dickcissels. Indeed, most Dickcissels observed in 1973 were associated with alfalfa. In all areas where later observations were made, the alfalfa had been cut and presumably the nests and young were destroyed or nest initiation was prevented and the Dickcissels had disappeared. Selection of lush alfalfa fields by the Dickcissel as nesting habitat during invasions of southern Manitoba is an ecological dead end.

Acknowledgments

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Literature Cited

Gardner, K. 1972. Wild wings. Winnipeg Tribune, 10 August 1972.

Godfrey, W. E. 1953. Annual report of the National Museum for fiscal year 1951/52. National Museum of Canada Bulletin 128. p. 45.

Gross, A. O. 1968. Dickcissel. *In* Life histories of North American cardinals, grosbeaks, buntings, towhees, finches, sparrows, and allies. *Edited by* A. C. Bent. United States National Museum Bulletin 237(1): 158–191.

Harmeson, J. P. 1974. Breeding ecology of the Dickcissel. Auk 91: 348–359.

Lawrence, A. G. 1933, 1934, 1941, 1945. Chickadee notes, 638–640, 642, 655, 689, 691 1056, 1127. Winnipeg Free Press, Winnipeg, 16, 23, 30 June 1933; 14 July 1933; 13 October 1933; 8, 24 June 1934; 20 June 1941; 14 September 1945.

Mossop, H. 1959. Dickcissels. Chickadee notes, 235. Winnipeg Free Press, Winnipeg, 17 July 1959.

Sealy, S. G. 1971. The irregular occurrences of the Dickcissel in Alberta, Manitoba and Saskatchewan. Blue Jay 29: 12–16.

Shadick, S. 1975. Highlights of Saskatoon bird observations 1970–1974. Blue Jay 33: 165–168.

Zimmerman, J. L. 1966. Polygyny in the Dickcissel. Auk 83: 534–546.

Zimmerman, J. L. 1971. The territory and its density dependent effect in *Spiza americana*. Auk 88: 591–612.

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Herring Gull Trapped in the Ice

In the fall of 1975, I studied movements of gulls between garbage dumps and the St. Lawrence River around Quebec City. I focused my attention on movements between the river and a dump near Lake St. Charles, a lake 5 × 0.5 km located 15 km northwest of the city. Gulls travel irregularly during the day between the dump and the lake but at night most of them sleep on the lake. At dusk, especially when the tide is low, from 10 to 40% may return to the St. Lawrence River. In November as many as 1600 gulls were present in the region; most of these were Herring Gulls (*Larus argentatus*), with about 1% Great Black-backed Gulls (*Larus marinus*) and 1% Iceland Gulls (*Larus glaucoides*).

On the windless night of 23–24 November, the temperature fell to −14°C and a great part of the lake froze. On 24 November at 0630 hours I saw an adult Herring Gull trapped in the ice about 300 m from the shore. The bird was seen for 3 days until 26 November, when unfortunately observations were interrupted. Every morning at dawn, the gull tried to escape by beating its wings, but could not raise its body. During the morning, as the air became warmer, sporadic attempts just succeeded in freeing the body feathers, but half of the left foot web remained imbedded in the ice. In the daytime, few release efforts were seen and other gulls were sometimes attracted; it was then difficult to distinguish the captive which behaved similarly to the free-flying individuals, preening, sleeping, or turning the head in all directions. Temperature increased some days later, rain occurred 30 November, ice partly melted and on 1 December, when observations began again, the gull could not be seen. It was difficult to discern whether the bird had freed itself or had been predated.

This seemed an unusual observation to most ornithologists I consulted, but a local resident claimed to have observed a similar incident at least once in the past.

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Spiranthes magnicamporum Sheviak, an Addition to the Orchids of Canada

Abstract. The recent discovery of *Spiranthes magnicamporum* Sheviak at several locations in southwestern Ontario extends its known range significantly in the northeast. Described in 1973, this orchid was previously known from the midwestern United States, reaching its northeastern limit at disjunct stations in western Ohio. In southwestern Ontario, *S. magnicamporum* is essentially restricted to areas of natural, prairie-like vegetation, and it may have persisted in some of these areas since the xerothermic period. Calcareous sandy meadows associated with the lower lakes appear to be the most important habitat. In contrast, the closely related *S. cernua* (L.) Rich. is widespread in southern Ontario, owing to the colonization of disturbed habitats resulting from human activity. The associated species, distinguishing characteristics, and ecology of *S. magnicamporum* in Ontario are briefly discussed.

During a recent autumn field trip to investigate prairie vegetation in southwestern Ontario, I was particularly interested to find the Great Plains Ladies'-tresses Orchid, *Spiranthes magnicamporum* Sheviak.

The distribution of this recently described species (Sheviak, C. J. 1973. A new *Spiranthes* from the grasslands of central North America. Botanical Museum Leaflets, Harvard University 23(7): 285–297) was previously known to encompass an area extending from northwestern Indiana onto the Great Plains from Texas to North Dakota, with disjunct populations on the prairies of western Ohio and the black belt of the Mississippi and Alabama (Sheviak, *op. cit.*). The distribution of this orchid in Ontario is shown in Figure 1. Field work during the autumn of 1975 disclosed its presence on the Ojibway Prairie south of Windsor in Essex County, on Walpole and Squirrel Islands, at the east end of Ipperwash Beach in Lambton County, and at the base of Long Point in Norfolk County. At each of these locations more than 20 flowering plants were found and a voucher specimen was collected (CAN, DAO, TRT). A search for *S. magnicamporum* among *S. cernua* collections of major eastern Canadian herbaria (TRT, CAN, DAO) revealed a few additional localities. All of these recently discovered stations extend the known range significantly further into the northeast.

In Ontario *S. magnicamporum* has been observed to grow in a variety of habitats and with a variety of different plant associates, but always occurs in open

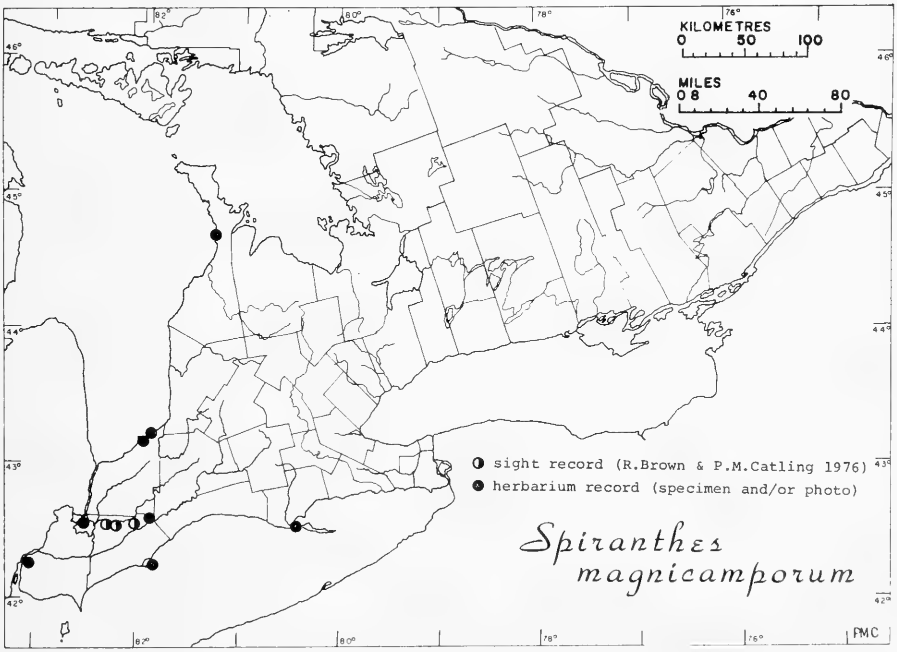

FIGURE 1. Distribution of *Spiranthes magnicamporum* in Ontario based on specimens at CAN, DAO, and TRT.

(i.e., unshaded) situations, and usually in sandy alkaline soils. In the less disturbed prairie situations at Ojibway, *Sorghastrum nutans, Andropogon scoparius, Solidago juncea, Solidago nemoralis, Aster laevis,* and *Aster azureus* were frequent associates. Other associates included *Pycnanthemum virginianum, Asclepias tuberosa, Euphorbia corollata, Liatris spicata, Poa pratensis,* and *Aster ericoides.* Nearby in an old sand pit, *S. magnicamporum* grew with *Poa compressa, Gerardia purpurea, Prunella vulgaris, Liatris spicata, Potentilla anserina, Juncus effusus,* and *Spartina pectinata. Spiranthes magnicamporum* was also found growing in some recently disturbed situations on Squirrel Island, such as steep sandy canal banks where the vegetation was dominated by *Asclepias syriaca, Poa compressa,* and *Equisetum arvense*, and also in a young cottonwood (*Populus deltoides*) stand with *Melilotus alba, Muhlenbergia mexicana, Esquisetum arvense,* and *Solidago canadensis.*

The most important habitat of *S. magnicamporum* in Ontario, however, in terms of numbers of both plants and populations, appears to be the calcareous sandy meadows (Figure 2) that occur around the lower lakes in association with sand dunes (e.g., Ipperwash Beach), sand spits (e.g., Long Point), and deltas (e.g., Squirrel Island). Since these meadows appear to have developed as a result of shoreline deposition and are influenced to a greater or lesser extent by the nearby major body of water, they may conveniently be referred to as "littoral meadows." Here *S. magnicamporum* forms part of a characteristic group of species including *Sorghastrum nutans, Andropogon scoparius, Panicum virgatum, Panicum implicatum, Eleocharis elliptica, Scleria verticillata, Cladium mariscoides, Gentianella crinita* ssp. *procera, Parnassia glauca, Lobelia kalmii, Gerardia purpurea,* and *Solidago ohioensis,* and to a lesser extent *Tofieldia glutinosa, Hypericum kalmii, Aster laevis, Lysimachia terrestris, Poa compressa,* and *Solidago nemoralis.* In these areas *S. magnicamporum* may occur over a wide moisture regime. At Ipperwash Beach flowering plants were found rooted in wet sand in areas dominated by *Eleocharis elliptica* and *Scleria verticillata,* through variously moist sand to dry lower dune slopes with *Sorghastrum nutans, Andropogon scoparius, Buchnera americana, Liatris cylindrica, Carex eburnea,* and *Solidago*

FIGURE 2. Open prairie habitat of *Spiranthes magnicamporum* at Long Point, Ontario. The vegetation here is dominated by *Andropogon scoparius, Sorghastrum nutans, Poa compressa, Panicum virgatum, Parnassia glauca, Gentianella crinita* ssp. *procera, Solidago ohioensis,* and *Solidago nemoralis.* The trees to the right and left are immature cottonwoods.

nemoralis.

Although species composition may vary at any one site over a period of years, the littoral meadow associations appear to be relatively stable and long lasting in the areas mentioned. It seems likely that the continuous disturbances of fluctuating lake levels resulting in periodic drought or inundation, as well as a relatively high soil pH because of upward percolation and surface evaporation of ground water, are among the important factors contributing to the perpetuation of the littoral meadow vegetation. It is important to note here that the littoral meadow and dune or ridge systems are often in a state of continued development so that new habitats are produced in the immediate vicinity as quickly as natural succession claims the older ones. This relative stability and continuous development of the littoral meadows results in a constantly available habitat for species of open situations with calcareous sandy soils.

In addition to the natural processes described above, fires, either naturally occurring or resulting from aboriginal activity, may also have been important in maintaining prairie-like habitats for long periods in southwestern Ontario. This may apply especially to the Ojibway Prairie area south of Windsor.

Sheviak (*op. cit.*) has suggested the probability of an eastward extension of the range of *S. magnicamporum* during the warmer and drier xerothermic period, and a subsequent shrinkage of range (especially in the northeast) to scattered isolated stations where suitable prairie-like habitats lingered despite the climatic changes favoring forest. Considering the present restriction of *S. magnicamporum* in southwestern Ontario to isolated stations where other species with western affinity occur, and admitting the possibility of continuous availability of prairie habitats, it seems possible that the existing isolated prairie-like areas actually represent relicts of a once more-widely distributed, and more continuous prairie vegetation in southern Ontario.

A closely related species, *S. cernua* presents an interesting comparison from a geographical and ecological point of view. *Spiranthes cernua* is widespread throughout southern Ontario, and although found in some of the littoral meadows and other "prairie-relict" areas, it is not restricted to these areas. The abundance of this species has been greatly stimulated by human activities that result in suitable disturbed habitats for colonization such as roadside ditches, old gravel pits, and pasturelands. The wide distribution and importance of anthropogenic habitats to *S. cernua* in Ontario is in direct contrast to the restricted distribution and apparent importance of natural habitats to *S. magnicamporum* in the same geographical area.

When both *S. cernua* and *S. magnicamporum* are available for comparison in fresh condition they are easily distinguished. The yellowish coloration in the thickened center of the lip, the ascending and/or diverging lateral sepals (Figure 3), the lesser dorsal curvature of the flowers, and narrowness of the flowers are all distinctive features of *S. magnicamporum*. The flowers of *S. magnicamporum* appear more slender than those of *S. cernua* when viewed from above, because of the narrower and frequently somewhat longer lateral petals. Single flowers from several specimens of each species were measured. The ratio of length to width of the lateral petals was always above 5.0 in *S. magnicamporum* and always less than 5.0 in *S. cernua.* Other characters of *S. magnicamporum* are also quite distinctive. These include a rhombic-ovate lip without a suborbicular dilated base, smaller basal calli on the lip (distinctly less than 1 mm in length) usually as wide across the base as high, tuberously thickened roots (often to 1 cm thick), strongly fragrant flowers, and the absence of leaves at flowering time.

Although *S. cernua* is the species most likely to be confused with *S. magnicamporum* in Ontario, *S.*

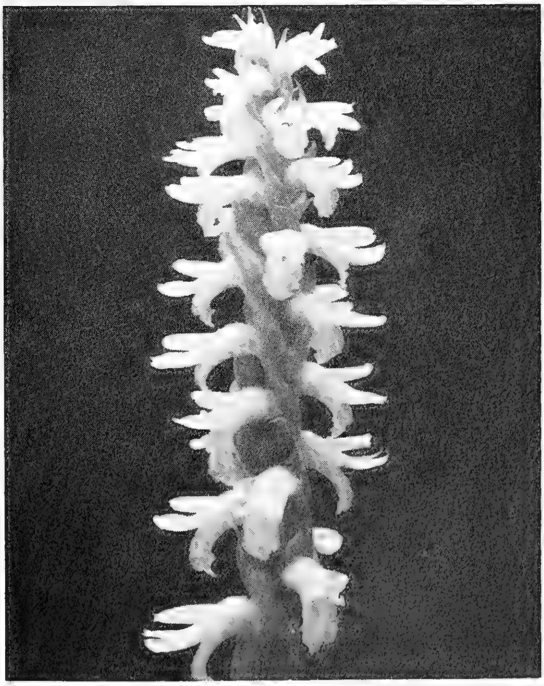

FIGURE 2. Flowering spike of *Spiranthes magnicamporum* photographed at Ipperwash Beach, Lambton County, 28 September 1975.

odorata (Nutt.) Lindl. and *S. ochroleuca* (Rydb.) Rydb. have been a source of confusion elsewhere. The former is a tall leafy plant of the southeastern United States, that does not range into Ontario, whereas the latter is northeastern but rare (if at all present) in Ontario. Most of the characters used to distinguish *S. magnicamporum* from *S. cernua* may be used to separate it from these species also (e.g., fugaceous leaves, tuberously thickened roots, slender white flowers with yellow lips and relatively little dorsal curvature).

In addition to the morphological differences there are some ecological and phenological differences between *S. cernua* and *S. magnicamporum* in Ontario. *Spiranthes magnicamporum* tolerates much drier sites than *S. cernua*, although both may occur together in moist places. *Spiranthes magnicamporum* has a later average date of anthesis in southwestern Ontario. From mid-September to early October, when *S. magnicamporum* is at its peak, most plants of *S. cernua* from the same region are completely past flowering, or have only a few of the uppermost flowers intact.

Fortunately the area of Ojibway Park where *S. magnicamporum* occurs is a protected nature reserve. It is important here to note that in some situations in Illinois, C. J. Sheviak (1974. An introduction to the ecology of the Illinois Orchidaceae. Illinois State Museum, Scientific Papers 14: 1–89) reported that disturbance was conducive to the development of large colonies of *S. magnicamporum*. Natural disturbances such as fire and grazing help to maintain prairie vegetation in many areas, and it may be necessary to create such disturbance in order to maintain *S. magnicamporum* and other unusual prairie species in southwestern Ontario.

Acknowledgments

I extend special thanks to Charles J. Sheviak for verifying the identification of recent collections from Ojibway, Walpole Island, and Ipperwash Beach and I thank him and W. J. Cody for kindly reading my manuscript. S. M. McKay, K. L. McIntosh and R. Brown assisted in the field.

Addendum

The distribution of *S. magnicamporum* alone should not be interpreted as a distribution of "prairie-relict" vegetation in southern Ontario. Some species (including *S. magnicamporum*) characteristic of calcareous and/or wet and mesic prairie are found in Ontario essentially in the littoral meadow and dune systems along the Great Lakes shores and associated major rivers. There are other western species comprising apparent "prairie-relict" communities, however, that are characteristic of acid soil and/or drier prairie. Some of these occur in southern Ontario at points removed many miles from the Great Lakes shores.

Since this article was written Ross Brown has shown me *S. ochroleuca* in Kent and Lambton counties.

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Four New Bird Records for Banks Island, Northwest Territories

While engaged in polar bear observations between 4 May and 25 June 1974 at Nelson Head, a 396-m cliff at the southern tip of Banks Island, we maintained a list of all birds sighted. Of the 24 species recorded, the Red-breasted Merganser (*Mergus serrator* Linnaeus), Savannah Sparrow (*Passerculus sandwichensis* (Gmelin)), Harris' Sparrow (*Zonotrichia querula* (Nuttall)), and Fox Sparrow (*Passerella iliaca* (Merrem)) are new records for Banks Island (Manning et al. 1956; Porsild 1951).

On 12 June two single Red-breasted Mergansers were seen flying over the ice south of Nelson Head. Again on 15 June, two more single Red-breasted Mergansers were seen flying over the ice. Godfrey (1966) cites the most northern range of this species in Canada as occurring along the northern Yukon and Northwest Territories coast. Smith (1973) recorded a Red-breasted Merganser in the Holman region of Victoria Island, 160 km southwest of Nelson Head.

On 9 June a Savannah Sparrow was heard singing in a sedge meadow near our camp. On 10 June another was heard on a different sedge meadow near camp. On both occasions an unsuccessful search was made for the bird. Despite the fact that no visual identification was made we are familiar with the song of this species and are therefore confident of the identification. Godfrey (1966) cites the northern range of this species as occurring along the northern Yukon and Northwest Territories coast, including Herschel Island and the islands of the Mackenzie Delta, with casual occurrence on Southampton Island and Pelly Bay, Northwest Territories. Parmalee et al. (1967) recorded the Savannah Sparrow on Victoria Island southeast of our study area.

On 15 June a Harris' Sparrow was heard singing near camp and was subsequently identified visually. A photograph was obtained showing positive identification. Godfrey (1966) does not mention any sightings of this species in the arctic islands and states that the northern limit of its range is the Mackenzie Delta. Parmalee et al. (1967) recorded several sightings of the Harris' Sparrow on Jenny Lind Island, a small island of approximately the same latitude as the Mackenzie Delta.

On 24 May a Fox Sparrow was seen with a small flock of Dark-eyed Juncos (*Junco hyemalis* Linnaeus) at the edge of a sedge meadow. T. W. Barry (personal communication) has also observed them on Banks Island in early spring. He suggested that Fox Sparrows may arrive early with mixed flocks of other species and return to the mainland shortly thereafter. Godfrey (1966) cites the northern limit of this species' range as the northern Northwest Territories coast from the Mackenzie Delta to Cape Parry.

The above sightings are new records for Banks Island and indicate that movement does occur from the mainland across Amundsen Gulf to Banks Island, a distance of only 120 km. Since no breeding record was obtained for any of the four species, the breeding ranges delineated by Godfrey (1966) remain unchanged.

The taxonomic nomenclature used follows the AOU Check-list (1957) and, for the Dark-eyed Junco, its amendment (AOU 1973). We gratefully acknowledge the advice and information given by T. W. Barry, Canadian Wildlife Service, and thank I. Stirling and R. Fyfe, Canadian Wildlife Service for reviewing the manuscript.

Literature Cited

American Ornithologists' Union. 1957. Check-list of North American Birds. Fifth edition. Baltimore, Maryland. 691 pp.

American Ornithologists' Union. 1973. Thirty-second Supplement to the American Ornithologists' Union Check-list of North American birds. Auk 90: 411–419.

Godfrey, W. E. 1966. The birds of Canada. National Museum of Canada Bulletin 203. 428 pp.

Manning, T. H., E. P. Hohn, and **A. M. Macpherson.** 1956. The birds of Banks Island. National Museum of Canada Bulletin 143: 1–144.

Parmalee, D. F., H. A. Stephens, and **R. H. Schmidt.** 1967. The birds of southeastern Victoria Island and adjacent small islands. National Museum of Canada Bulletin 222: 1–229.

Porsild, A. E. 1951. Bird notes from Banks and Victoria Island. Canadian Field-Naturalist 65: 40–42.

Smith, T. G. 1973. The birds of the Holman Region, Western Victoria Island. Canadian Field-Naturalist 87: 35–42.

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Glacial Refugia, Endemism, and Stickleback Populations of the Queen Charlotte Islands, British Columbia

The biota of The Queen Charlotte Islands (53°N, 132°W) has long been recognized as distinct from that on the mainland (Dawson 1880). Endemic birds, mammals, an invertebrate, angiosperms, tracheophytes, and bryophytes have been described (Foster 1965; Bousfield 1958; Calder and Taylor 1968; Schofield *in* Calder and Taylor 1968). Recent studies reveal divergence in a fish, *Gasterosteus aculeatus* L., the threespine stickleback, as well (Moodie 1972a,b; Moodie and Reimchen 1976).

There is thus endemism in many of the major taxa (only one native amphibian is present and there are no reptiles). Explanations for this divergence are contradictory but not necessarily mutually exclusive. Calder and Taylor (1968) and McCabe and Cowan (1945) believe refugia allowed the survival of resident populations in spite of glaciation. Others are of the opinion that some populations differentiated after deglaciation (Foster 1965).

However attractive the refugia hypothesis may be, geological evidence indicates the islands were heavily glaciated during the Wisconsin stage of the Pleistocene epoch (Sutherland Brown and Nasmith 1962). These workers describe unglaciated areas as inhospitable habitats, less than 9.1 km^2 in area, at high altitudes, cold and windswept. Nevertheless, Foster (1965) maintains that several of the endemic mammals could have survived on the islands throughout their glaciation.

The purpose of this communication is to discuss previously described populations (Moodie 1972a,b; Moodie and Reimchen 1976) of *G. aculeatus* in terms of the controversy regarding postulated refugia and the origin of other endemic groups on the islands. Our past studies, although not dealing with historical aspects of stickleback evolution, do provide information pertinent to the question. We have no plans for a future biogeographical study of the origins of the endemic populations because we are not convinced a methodological approach exists that would yield results that would significantly reduce the uncertainty which inevitably characterizes conclusions concerning historical questions such as these.

Divergence in the sticklebacks is unlike that of most other groups in which endemics occur, either throughout the islands as in the case of *Euarctos americanus carlottae* (black bear) and *Martes americana nesophila* (pine marten), or in one region, for example, the vascular plants, all of which are found in the Queen Charlotte Ranges and mountains of the Skidegate Plateau. Instead, morphologically distinct stickleback populations are often found in each lake; fish of Boulton Lake often lack the pelvic girdle, very large melanistic fish occur in Mayer Lake, and most fish in Skonun Lake lack lateral scutes (Moodie 1972b; Moodie and Reimchen 1976). The taxonomic status of these stickleback populations is undetermined, partly because the taxonomy of the parent species is unsettled (Miller and Hubbs 1969; Hagen and McPhail 1970). At least one population, however, parapatric with a form like that common on the mainland, may meet the criteria of the biologically defined species. Other populations show extremes of variation which match or exceed that known for the species over its entire and extensive range (Moodie and Reimchen 1976).

There is also a distributional contrast between the endemic fish and other groups: the most divergent stickleback populations are found in the Queen Charlotte Lowlands (Figure 1), whereas all the endemic vascular plants are confined to higher altitudes as stated above. (We must note, however, that the sampling of fish populations in these islands is far from complete.)

A pre-glacial evolution of these populations could be indicated if endemic populations occupy sites which might have escaped glaciation, if existing populations were founded by fish surviving in refugia elsewhere, or if variation among populations shows a geographic pattern reflecting possible pathways of dispersal from a refugium.

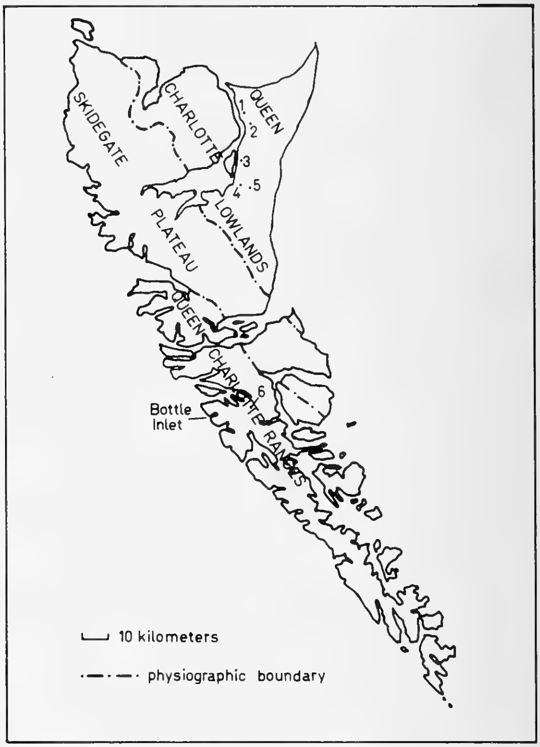

FIGURE 1. Map of the Queen Charlotte Islands, British Columbia. Lakes referred to in the text are indicated by numbers as follows: 1 Drizzle, 2 Skonun, 3 Boulton, 4 Loon, 5 Mayer, 6 Takakia.

It is unlikely the divergent populations of Boulton, Mayer, Skonun, and Drizzle Lakes occupy sites which were not ice-covered. Various glacial flutings, drumlins, and evidence of an outwash plain are present in the vicinity of these lakes (Sutherland Brown 1968, Figure 2).

The possibility of fish survival elsewhere in the islands is equally remote. High mountain tops or narrow strips of land between the ice front and the sea would scarcely be suitable habitats for fish populations. At present, high lakes such as Takakia and others on the west coast between the mountains and the sea, for example, one north and another south of Bottle Inlet, apparently lack fish. Some of the variant populations phenotypically resemble distant ones on the mainland or elsewhere. Fish of Boulton Lake are in several ways similar to some on Texada Island, 658 km to the south: however, this site too was glaciated. Sticklebacks in other lakes, such as Skonun, often lack lateral plates as do some in southern California and Europe. To us it is only reasonable to assume these similarities are due to convergence rather than ancestry.

There is no pattern to the variation among populations which might suggest a sequence of dispersal of related populations from a refugium to places elsewhere, as Foster (1965) hypothesized for mouse populations of these islands. At least some of the distinctive variation is locally advantageous (Moodie 1972a; Moodie and Reimchen 1976): large fish with long spines occur in Mayer Lake where predation is intense, and in nearby Loon and Boulton Lakes, the absence of predator fish appears to have allowed the loss of spines and other anti-predator adaptations typical of the genus.

All of the preceding forces us to conclude these populations have evolved *in situ*, following deglaciation and recolonization from the sea. Access to presently land-locked lakes could have occurred during the period of deglaciation and isostatic rebound. Presumably the founding populations were derived from *trachurus*, the typical marine form of *G. aculeatus* which probably then, as now, inhabited the estuaries and bays of the islands.

This conclusion does not necessarily weaken or invalidate the arguments of those working on different organisms in which the nature of the endemism suggests the existence of refugia. Plants are more vagile than fish and could perhaps survive in miniscule, transitory refugia. The fact that several of the endemic plants of the Queen Charlotte Islands are components of disjunct distributions (Schofield 1969) indeed suggests they are relicts rather than the product of post-glacial evolution (assuming convergence is not involved).

The alternate hypothesis, a post-glacial evolution for these populations of sticklebacks, confronts us with two potential problems. Some may question the likelihood of such extensive divergence in a time span of 8000–10 000 years (^{14}C isotope dates *in* Sutherland Brown 1968 and personal communication). Often variation in *G. aculeatus* has been considered the product of survival in different glacial refugia (Miller and Hubbs 1969, p. 63; Münzing 1972, p. 83). We believe, however, that much of the variation in sticklebacks is recent; the result of post-glacial evolution in which glacial refugia had little significance. Bell (1974) reached a similar conclusion with regard to a stickleback population in a lake only 5000 years old. Evidence for rapid evolution in other fishes was provided by Myers (1960).

A more difficult matter is that mainland populations have had about equal time in which to diverge and yet have apparently not done so. (The adjacent mainland, however, has scarcely been sampled.) One factor which could be important in accounting for differences between mainland and island populations is the low diversity of the island fish communities. On the mainland there may be up to five species in addition to all those present on the islands (Carl et al. 1959). Island communities thus can contain less than half the number of species found on the mainland (Moodie and Reimchen 1976). The absence of other species may have placed some stickleback populations in novel selective regimes resulting in intensified selection for anti-predator adaptations due to the lack of alternate prey. In other island populations where predators and competitors are absent, there has been a relaxation of selection by these agents.

In conclusion, despite the temptation to expect a common (and thus parsimonious) basis for all endemism in the Queen Charlotte Islands, we believe sticklebacks in the Queen Charlotte Islands have undergone rapid post-glacial evolution, perhaps accelerated by the limited diversity of the fish fauna. We wish to emphasize that the evolutionary history postulated for different taxa must be determined independently on the basis of evidence relevant to that group. Any other approach could lead to circular reasoning. Our conclusions thus should not be seen as bearing one way or another on those proposed by others interested in the history of the flora and fauna of the Queen Charlotte Islands.

We are deeply grateful to Jennifer and John Davies whose kindness made our time on the islands productive and enjoyable. Patti Moodie, Alex Peden, and Keith Morgan helped to collect the fish. Casimir Lindsey read the manuscript. Financial assistance was provided by National Research Council of Canada grants to J. Ralph Nursall and G. E. E. Moodie.

Literature Cited

Bell, M. A. 1974. Reduction and loss of the pelvic girdle in *Gasterosteus* (Pisces): a case of parallel evolution. Natural History Museum, Los Angeles County, Contributions in Science 257. 36 pp.

Bousfield, E. L. 1958. Freshwater amphipod crustaceans of glaciated North America. Canadian Field-Naturalist 72: 55–113.

Calder, J. A. and **R. L. Taylor.** 1968. Flora of the Queen Charlotte Islands. Part 1. Canada Department of Agriculture Monograph 4. 659 pp.

Carl, G. C., W. A. Clemens, and **C. C. Lindsey.** 1959. The fresh-water fishes of British Columbia. British Columbia Provincial Museum, Handbook 5. 192 pp.

Dawson, G. M. 1880. Report on the Queen Charlotte Islands 1878. *In* Geological Survey of Canada, Report of Progress for 1878–1879. pp. 1B–239B.

Foster, J. B. 1965. The evolution of the mammals of the Queen Charlotte Islands, British Columbia. British Columbia Provincial Museum, Occasional Papers 14. 130 pp.

Hagen, D. W. and **J. D. McPhail.** 1970. The species problem within *Gasterosteus aculeatus* on the Pacific Coast of North America. Journal of the Fisheries Research Board of Canada 27: 147–155.

McCabe, T. T. and **I. McT. Cowen.** 1945. *Peromyscus maniculatus macrorhinus* and the problem of insularity. Transactions of the Royal Canadian Institute 1945: 117–215.

Miller, R. R. and **C. L. Hubbs.** 1969. Systematics of *Gasterosteus aculeatus*, with particular reference to integradation and introgression along the Pacific Coast of North America: a commentary on a recent contribution. Copeia 1969: 52–69.

Moodie, G. E. E. 1972a. Predation, natural selection and adaptation in an unusual threespine stickleback. Heredity 28: 155–167.

Moodie, G. E. E. 1972b. Morphology, life-history and ecology of an unusual stickleback (*Gasterosteus aculeatus*) in the Queen Charlotte Islands, Canada. Canadian Journal of Zoology 50: 721–732.

Moodie, G. E. E. and **T. E. Reimchen.** 1976. Phenetic variation and habitat differences in *Gasterosteus* populations of the Queen Charlotte Islands. Systematic Zoology 25: 49–61.

Münzing, J. 1972. Polymorphe Populationen von *Gasterosteus aculeatus* L. (Pisces, Gasterosteidae) in sekundaren Integradationszonen der Deutschen Bucht und benachbarter Gebiete. Faunistisch-Ökologische Mitteilungen 4: 69–84.

Myers, G. S. 1960. The endemic fish fauna of Lake Lanao and the evolution of higher taxonomic categories. Evolution 14: 323–333.

Schofield, W. B. 1969. Phytogeography of northwestern North America: bryophytes and vascular plants. Madroño 20: 155–207.

Sutherland Brown, A. 1968. Geology of the Queen Charlotte Islands. British Columbia Department of Mines and Petroleum Resources, Bulletin 54. 226 pp.

Sutherland Brown, A. and **H. Nasmith.** 1962. The glaciation of the Queen Charlotte Islands. Canadian Field-Naturalist 76: 209–219.

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A White Pelican and a Gannet near Holman, Victoria Island, Northwest Territories

On 10 June 1975, my Inuit assistant, Jimmy Memogana, sighted a White Pelican, *Pelecanus erythrorhynchos*. It was flying low, in a southerly direction, over the sea ice of the Amundsen Gulf near Naudlat, approximately 50 km to the southeast of the village of Holman (70°44′N, 118°30′W). Memogana had ample opportunity to examine closely the bird in flight, using an 8-power telescopic gunsight. This man is thoroughly familiar with the avifauna of the area and has assisted me in bird studies in the past. The bird was described as large and white with a long bill under which there was a pouch. The neck was said to be held in a crooked position during flight. There is no doubt about the identity of this sighting.

On 15 September 1975, a Holman hunter shot a lone Gannet, *Morus bassanus*, near Holman Island. The carcass was later picked up and brought to me by Allen Joss of Holman. It proved to be a mature female with the following measurements: wing, 434.0 mm (unflattened); tail, 201.0 mm; exposed culmen, 94.0 mm; tarsus, 70.0 mm. The skin is in the collection of the National Museum of Natural Sciences.

No previous sightings had been made of either species in the Holman area. The furthest-north nesting for White Pelicans is near Fort Smith, Northwest Territories, but one accidental has been listed from Liverpool Bay on the mainland coast approximately 467 km to the southwest of the present record (American Ornithologists' Union. 1957. Check-list of North American birds. 5th edition. Baltimore, Maryland. 691 pp.). The Gannet is an even more surprising accidental, as it breeds very locally along the North Atlantic coast; the northernmost colony is on Funk Island (49°46′N, 53°11′W) located off the east coast of Newfoundland.

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Behavior of a Moose Calf on Norfolk Island, Ontario

On 27 May 1975 a female moose with a young calf was seen frequenting a small 1.2-ha (0.5-acre) island on Norfolk Lake (48°03′N, 82°32′W) near Foleyet, Ontario. During the following week, daily observations were made in an attempt to understand better the use of islands during the early life stages of a young moose calf.

Various authors have commented on mother-infant relationships in moose. Some have suggested the importance of swampy muskegs as calving areas (Spencer and Hakala 1964; Peek et al. 1974) whereas others have commented on the importance of islands for similar activities (Peterson 1955; Rausch and Bratlie 1965). All agree that a preference for isolated areas is shown at time of parturition (Stringham 1974).

The Norfolk Lake island is an ellipitical-shaped island with its longest axis oriented in an east-west direction. More than 90% of the island's vegetation is mature conifer.

While passing the island in a canoe, approximately 15 m from the south shore, my attention was drawn by the activity of the calf. It was moving from the south side of the island, over the crest, to the north side of the island. When I circled the island the mother was first seen motionless, in what appeared as an attentive position. The calf, in contrast, appeared to ignore me and showed some activity which might have been in response to the blackflies and mosquitos which were plentiful at that time.

Upon my return to the south side of the island, I heard splashing and saw that it was the cow. She had moved into the deep water from the north shore of the island and circled back into the shallow water of the island's eastern shore. After moving towards me, she stopped, splashed about, backed off, and then moved towards me again. Finally she crossed the lake and entered the bushes. It was my impression that this entire sequence was designed to attract me away from the island and her calf.

On 28 May I circled the island and saw one flickering ear of the calf silhouetted against the sky. The calf arose and started vocalizing perhaps in response to my activity. The mother did not appear to be with the calf. The calf continued to call for approximately 30 to 40 min, then lay down in about the same position from which it had risen. This time, however, more of the animal was visible from my vantage point.

I waited for approximately another ½ h while the calf remained on the ground. Then I decided to disturb the calf again to determine what it would do and whether the cow would appear. Since splashing of paddles did not appear to disturb the calf, I left the canoe and approached the calf on foot. The calf watched my approach until I was within 5 m. Then it arose and walked silently and slowly into the only clump of shrubby vegetation on the island where it again curled up on the ground.

I left the island and continued my watch from the east shore of the lake. During an hour in this position no activity or sounds were heard from the island. Throughout 2.5 h of observing time, the cow had not been with her calf.

On 29 May I circled the island and noted the calf curled up on the crest of the island in approximately the same location as was first noted on the previous day. I did not disturb the calf. During 1.5 h of observation the calf did not change its position and the cow was not seen. The same was noted on 30 May.

Upon my arrival at the lake on 31 May, I could clearly hear and see the calf on the island. It was moving near the water on the south shore of the island and was bleating repeatedly. As I approached the island, the calf took short steps towards me rather than retreat. It continued to move about, bleating continually, for approximately 30 min, then it lay on the ground in an open exposed spot on the south side of the island. As before, it ceased to vocalize as soon as it lay down. There it remained for an hour interrupted only by a 15-min period of activity and attempted browsing.

I approached the calf on foot to within 3 m. The calf made no effort to get up or to vocalize. No movement was noted. Ten minutes later I approached the calf again. This time the calf arose and moved towards me, then started to bleat again.

I remained in the area until approximately 1415 hours when the cow returned and entered the island from the deep water of the west shore. It walked up the west slope to the crest of the island where she was clearly silhouetted against the sky. The calf made no effort to greet her but remained in its curled up position. By this time the cow and her calf had been separated for more than 4 h.

I approached the island with the intention of observing the mother-calf interaction; however, the cow proceeded down the north side of the island into the water and across the lake. Through the whole sequence the calf remained on the ground on the south side of the island. The cow did not return during a further hour of observation.

On 2 June I returned to the lake, but detecting no moose activity I examined the island on foot. On the crest of the island in a small depression, I found the calf dead.

No cuts, abrasions, or breaks were noted on the body. Although the body was cold it was not stiff, the legs and neck still remaining flexible. The intact calf weighed 17.3 kg (38 lb). Although the cause of death was not determined from the complete autopsy by E. R. Addison, Wildlife Research Branch, Maple, Ontario, nothing indicated that starvation was implicated.

According to Lent (1974) mother-infant relations in ungulates may be classed as either hider or follower types. He feels that moose show the hider–type traits whereas other investigators feel moose are of the follower type (Altmann 1956; Espmark 1969). It is my feeling that moose may best be described as intermediate, as suggested by Stringham (1974).

The basic characteristics of a successful hider–type infant include remaining silent and inactive in the absence of its protector (mother) and blending into its surroundings. The Norfolk calf showed almost no tendency to adapt itself to any of these restrictions. Its vocalization, selection of resting sites, and silhouetted movements on the crest of the island all tended to attract attention.

It is possible that the normal mother-infant behavioral patterns may have been affected by my presence. I anticipated this problem and made every attempt to minimize my time in the area. The question still remains as to whether the observed behavior was normal or abnormal.

I am grateful to Conservation Officer Tim Riordan for field assistance and to Dave Fraser and my wife Pat for editorial criticisms.

Literature Cited

Altmann, M. 1956. Patterns of social behaviour in big game. Transactions of The North American Wildlife Conference 21: 538–545.

Espmark, Y. 1969. Mother-young relations and development of behaviour in roe deer. Viltrevy (Stockholm) 6: 461–540.

Lent, P. C. 1974. Mother-infant relationships in ungulates. *In* The behaviour of ungulates and its relation to management. Edited by V. Geist and F. Walther. IUCN New Series 24: 14–55.

Peek, J. M., R. E. LeResche, and **D. R. Stevens.** 1974. Dynamics of moose aggregations in Alaska, Minnesota, and Montana. Journal of Mammalogy 35(1): 126–137.

Peterson, R. L. 1955. The North American moose. University of Toronto Press, Toronto. 280 pp.

Rausch, R. A. and **A. Bratlie.** 1965. Annual measurements of moose calf production and mortality in southcentral Alaska. Proceedings of the 45th Annual Conference of Western Association State Game and Fish Commissioners. pp. 140–146.

Spencer, D. L. and **J. B. Hakala.** 1964. Moose and fire on the Kenai. Transactions of the 3rd Annual Tall Timbers Fire Ecology Conference. pp. 10–33.

Stringham, S. F. 1974. Mother-infant relations in moose. Naturaliste Canadien 101: 325–369.

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First Record of the Eastern Pipistrelle in New Brunswick

A single specimen of the eastern pipistrelle (*Pipistrellus subflavus*), collected on 29 February 1976 in Kitt's Cave near Hammondvale, Kings County, New Brunswick, appears to be the first for this province. Previously, the only pipistrelles in the Maritimes had been collected in Nova Scotia (J. S. Bleakney. 1965. Journal of Mammalogy 46: 528–529); There were 16 specimens collected between 1959 and 1965.

The New Brunswick specimen was taken approximately 38 m from the entrance of a limestone cave with considerable water passing through it at most times of the year. The cave ends at a sump after approximately 92 m of passage. Temperature at the cave ceiling where the solitary bat was hibernating was 3°C. Although the cave was thoroughly searched no other bats of any species were discovered.

The pipistrelle, a female, was fairly fat on the back and belly, around the intestines, and about the fallopian tubes. The ovaries were undeveloped. The specimen (skin and skeleton) is deposited in the collection of The New Brunswick Museum (Mammal 1216).

The author is indebted to Stanley W. Gorham for confirming the identification and sex of the specimen.

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First Boreal Owl Nest for Ontario, with Notes on Development of the Young

The Boreal Owl, *Aegolius funereus richardsoni*, is mainly confined to the boreal forest (Godfrey 1966) which in Ontario lies north of Lake Superior. At irregular intervals during late winter Boreal Owls move south of their normal range; such movements have been termed irruptions (Catling 1972). They have occurred in Saskatchewan (Houston 1960; Anweiler 1960), Minnesota (Green 1966, 1969), and southern Ontario (Catling 1972). The last author has summarized the five known irruptions since 1920 in southern Ontario and deals at length with the 1968–69 invasion. In addition to these invasions single Boreal Owls are seen occasionally in southern Ontario at 4- or 5-year intervals (Fleming 1907, 1913; Eifrig 1907; Soper 1923; Calvert 1925; Lloyd 1932; Saunders 1937). Individual birds have been recorded as far south as Long Island, New York (Buckley and Kane 1975). The few nests of this species documented at the National Museum of Natural Science in Ottawa for North America are as follows: northern British Columbia, 1; Alberta, 9; Saskatchewan, 1; Manitoba, 4; Northwest Territories, 1; Alaska, several; Nova Scotia, 3; and Labrador, 1. Until 1975 none was known for Ontario.

In the spring and summer of 1974 and 1975 (26 March – 26 July 1974 and 19 March – 8 June 1975) I studied vocalizations and habitat selection of the Boreal Owl in northern Ontario. My study area was 60 km WSW of Kapuskasing in boreal forest type B4 (Rowe 1972). This area is typically composed of mature black spruce (*Picea mariana*), white spruce (*P. glauca*), balsam fir (*Abies balsamea*), balsam poplar (*Populus balsamifera*), trembling aspen (*P. tremuloides*), and white birch (*Betula papyrifera*).

The Nest

I located five prospective nest sites; three by observing males attracting females to nest cavities and two by finding the female in the nest. All were in trembling aspen, four in live trees and one in a dead tree. The core of overmature trees of this species is usually rotten and the lower branches also rot and break off creating cavities. The rotten wood may in turn be excavated by the Common Flicker (*Colaptes auratus*) or Pileated Woodpecker (*Dryocopus pileatus*) for nests.

The five nest cavities that I found were at a height of 11 to 17 m. Diameter of the entrance hole was 6.0 × 6.0 cm to 14.0 × 7.0 cm; depth of the cavity was from 5 to 35 cm and the cavity diameter was 20 to 25 cm. Only one of these nests became active and I located it on 2 May 1975 (Figure 1). It was in a small cavity 16.6 m high in a live trembling aspen. The cavity extended only 5 cm below the entrance hole, which mesured 6.0 × 8.5 cm, and measured 25 × 20 × 20 cm. In Tengmalm's Owl (*A. f. funereus*), a European subspecies, the smallest nest cavity reported from Sweden was ellipsoid, measuring 19 × 15 cm, and the smallest entrance hole measured 7.5 × 9.5 cm (Norberg 1964). In northwest Germany, Kuhk (1949) stated that Tengmalm's Owl prefers very small entrance holes, as little as 6.3 cm in diameter. März (1968) noted that the nest cavity varied from shallow to very deep but averaged 30 cm in depth.

For this species of owl, unusual nest sites include an "old decayed stump," deserted open nests of Gray-cheeked Thrushes (*Hylocichla minima*) and Rusty Blackbirds (*Euphagus carolinus*) (Bent 1938), a squirrel (*Sciurus* sp.) nest, and even an abandoned

FIGURE 1. Female Boreal Owl with the two youngest nestlings at 13 and 15 days of age in the first known nest for Ontario.

crow (*Corvus* sp.) nest (März 1968). Kuhk (1949) does not believe there is good supporting evidence for most unusual nest sites reported. Both subspecies do use nest boxes when available and especially so when there are not enough suitable holes in trees (März 1968; Norberg 1964; nest record cards from Manitoba, courtesy of H. W. R. Copland, Coordinator, Prairie Nest Record Scheme).

I did not climb to the nest on the day I located it, since early disturbance may cause the female to desert (Norberg 1964). Light tapping at the base of the trunk caused the female to appear immediately at the entrance and look down, confirming that the nest was occupied. On 14 May I climbed to the nest for the first time. As I ascended the female watched me but did not leave the nest. When I looked through the entrance hole she merely snapped her mandibles at me twice. There were only three eggs in the nest, which seems to represent the minimum clutch size as the average is five to six and the maximum seven to eight (Bent 1938; Norberg 1964; Kuhk 1949). Perhaps both the low clutch-size in the active nest and the fact that only one nest was active were related to a population low in rodents. Variability in clutch size is an adaptation in response to the food resource as shown by Linkola and Myllymäki (1969). In 1975 I ran trap-lines in my study area to census the small mammals; 960 trap-nights yielded only 40 small rodents including 23 deer mice (*Peromyscus maniculatus*), 14 southern red-backed voles (*Clethrionomys gapperi*), two rock voles (*Microtus chrotorrhinus*), and one woodland jumping mouse (*Napaeozapus insignis*).

On my visits to the nest (usually twice every second day, morning and evening) the female never left; her strongest reactions were snapping her mandibles, hissing, and ruffling her plumage while spreading her wings. These are all typical elements of threat display in owls (Bent 1938). I often found whole or partly eaten prey in the nest in the morning but this had usually disappeared by evening. The prey included two deer mice, two southern red-backed voles, two woodland jumping mice, and one White-throated Sparrow (*Zonotrichia albicollis*), and two items that I could not identify. After the eggs hatched, prey was only infrequently left in the nest. I did not determine when the female left the nest to regurgitate pellets and defecate, as she must have since she did not appear to do this in the nest. Kuhk (1949) believed the female leaves the nest for a few minutes daily in the early morning.

The first egg hatched 23 May, the second was hatched by 26 May, and the last egg hatched on 27 May. With an average incubation period of 28 days (Kuhk 1949) the clutch was probably initiated about 25 April.

I had attached a radio transmitter to the male of the active nest to follow his movements; however, after 3 June he disappeared perhaps as a result of predation or problems with the telemetric equipment. During brooding the female depends solely on the male for her own food as well as that of her young, until they are 2 to 3 weeks of age. Therefore, after the male disappeared I provided the female with mice, which she readily accepted, for another several days until 9 June, at which time she departed. Not wishing to abandon the young I transported them to the Owl Rehabilitation Research Foundation in Vineland, Ontario (see *Ontario Naturalist*, August 1975) to be raised there.

Development of the Young

Weights of the young are given in Table 1. The weight gain was rapid. März (1968) stated that at the height of the growing period young Tengmalm's Owls need 65 gm of food (three to four mice) per day. While I fed the female I was able to see how she fed the young, which were 8 to 12 days of age at the time. The nestlings became very active and vocal when I presented the food to the female and would bite the female around the bill and eyes. She responded by tearing a piece off a mouse, and with her eyes closed held the piece up. The most aggressive of the young would grap the food and swallow it. This sequence would then be repeated until there were no more mice left or until the nestlings were satiated.

Little is known of the plumage development in nestling Boreal Owls so my observations are noteworthy. I closely inspected each young outside the nest on 31 May, and 1, 3, and 5–9 June. The oldest nestling was largest and seemingly received more food and developed faster than the youngest. At hatching the owlets are scantily covered with a short velvety white natal down along pterylae; apteria are wide and

TABLE 1—Growth of Boreal Owl nestlings, measured by weight changes from 1 week to 6 weeks of age

	Weight of nestling Boreal Owls (gm)		
Date	Oldest+	Middle	Youngest
31 May	—	—	19.0
1 June	>50	>50	—
3 June	90.5	62.0	34.0
5 June	123.5	84.5	49.5
7 June	130.5	106.5	59.5
9 June	155.5	131.5	88.5
19 June++	160	150	130
26 June ++	156	150	133
3 July++	156	158	138

+ Male, sexed after death.
++At the Owl Rehabilitation Center.

pinkish. Feather development is rapid and first noticed on the humeral, alar, and upper spinal tracts, and on the ventral tracts on the breast. At 7 days of age blackish pin feathers are visible. These pin feathers emerge completely by day 9. By 11 to 12 days, nestlings are fairly well covered with a juvenal plumage of fluffy chocolate brown contour feathers; apteria are still visible especially on the lower back and abdomen.

The oldest nestling at 12 days was brooded less frequently than the others and did not shiver when removed from the nest. Presumably this bird was able to maintain body heat. Also at this age young can sit upright but have difficulty keeping their head steady; this problem was solved at 14 days of age. At 13 to 14 days the remiges emerge. At the same age, the young when handled show a mild threat response by snapping their mandibles. At 15 days the oldest showed development of down on the apteria on the stomach.

The eyes were open at 10 days in the oldest, at 12 days in the middle, and at 11 days in the youngest. Initially the iris has a blue tinge. By 17 days the oldest owlet had developed pupillary light response and the iris was now yellow. By 15 days white feathers below the commissure had emerged and at 17 days white feathers in a narrow band dorso-medial to the eyes appeared. These white markings resemble those of nestling Saw-whet Owls (*Aegolius acadica*), and probably function as sign stimuli to adults bringing food (Norberg 1964).

Close observation of the young by me terminated at 17 days (9 June). At 48 to 52 days of age, on 14 July, the young Boreal Owls had just begun the post-juvenal molt. Adult feathering was visible around the facial disc. By mid-August the young were in full adult plumage.

Concluding Remarks

My field studies strongly suggest that the Boreal Owl in Ontario is not as rare as has been previously thought. Within the apparent breeding area, in preferred habitat with suitable nest holes and ample food, I am certain that this owl will prove to be fairly common. To find this species, I suggest listening for vocalization in the primary calling period between March and May.

Acknowledgments

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Literature Cited

Anweiler, G. 1960. The Boreal Owl influx. Blue Jay 18(2): 61–63.

Bent, A. C. 1938. Life histories of North American birds of prey, part 2. Smithsonian Institute, United States National Museum, Bulletin 170. 482 pp.

Buckley, P. A. and **R. Kane.** 1975. The winter season, December 1, 1974–March 31, 1975, Hudson–St. Lawrence region. American Birds 29(3): 667–672.

Calvert, E. W. 1925. A preliminary list of the birds of Lindsay district, Ontario. Canadian Field-Naturalist 39: 49–51.

Catling, P. M. 1972. A study of the Boreal Owl in southern Ontario with particular reference to the irruption of 1968–69. Canadian Field-Naturalist 86: 223–232.

Eifrig, G. 1907. Early appearance of certain northern species at Ottawa, Canada. Auk 24: 110–111.

Fleming, J. H. 1907. Birds of Toronto, Canada. Auk 24: 71–89.

Fleming, J. H. 1913. Ontario bird notes. Auk 30: 225–228.

Godfrey, W. E. 1966. The birds of Canada. National Museum of Canada Bulletin 203. 428 pp.

Green, J. C. 1966. Influx of northern owls, winter 1965–66. Loon 38(2): 44–45.

Green, J. C. 1969. Northern owl invasion, winter 1968–69. Loon 41(2): 36–39.

Houston, S. 1960. The year of the owls. Blue Jay 18: 105–110.

Kuhk, R. 1949. Aus der Fortpflanzungsbiologie des Rauhfusskauzes, *Aegolius funereus* (L.). Festschrift von Erwin Stresemann, Heidelberg. pp. 171–182.

Linkola, P. and **A. Myllymäki.** 1969. Der Einfluss der Kleinsäugerfluktuationen auf der Brüten einiger kleinsäugerfressender Vögel im südlichen Häme, Mittelfinnland 1952–1966. Ornis Fennica 46: 45–78.

Lloyd, H. 1932. The birds of Ottawa, addenda. Canadian Field-Naturalist 46: 123–127.

März, R. 1968. Der Rauhfusskauz. Die Neue Brehm-Bucherei, 21 Abbildungen. A. Ziemsen Verlag. Wittenberg Lutherstadt. 48 pp.

Norberg, Å. 1964. Studier över Pärlugglans (*Aegolius funereus*) ekologi och etologi. Vår Fågelvärld 23: 228–244.

Rowe, J. S. 1972. Forest regions of Canada. Department of the Environment, Canadian Forestry Service, Publication 1300. 172 pp.

Saunders, W. E. 1937. Golden Eagle and Richardson's Owl in Brant County, Ontario. Canadian Field-Naturalist 51: 44.

Soper, J. D. 1923. The birds of Wellington and Waterloo Counties, Ontario. Auk 40: 489–513.

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Herring Gulls Breeding on Cliff at Niagara Falls, New York

Herring Gulls (*Larus argentatus*) have been recorded nesting at various heights in trees, on boulders, lighthouse ledges, walls, breakwaters, steel structures, cliffs, and in niches or crevices in natural and man-made steep rocky slopes. They have been reported breeding on cliff ledges in coastal areas of eastern North America. I think that the following account is of special interest because I have been unable to learn of any other gull colony on the Great Lakes where ledges of vertical natural cliffs are used for nesting. This may be owing to a paucity of suitable cliffs in the region.

The Niagara Falls colony is situated in the Niagara River gorge on the cliff face and on unvegetated parts of the talus slope below it at the western end of Goat Island between the American and Canadian Falls (Figure 1). The depth of the gorge here is about 65 m. It is divided into a 10-m-high upper vegetated slope, a cliff about 22 m, and a talus slope 33 m in height.

The year that the colony was first established is not known. R. W. Sheppard (personal communication) recalls that it came to his notice about the mid-1960s. It is likely that it was initiated in the early 1960s or perhaps late 1950s. Herring Gulls first began to establish themselves in colonies of Ring-billed Gull (*Larus delawarensis*) in the mid-1940s.

We first studied this colony through telescopes from the Canadian side of the Niagara River on 24 and 25 July 1974, counting about 75 adults and 20 large young. Most of the young were on rocks at or near the river edge or in the water, and only one, with two adults, was noted on a cliff ledge about 15 m up the face. About 25 adults were on ledges. It appeared that about 15 ledges might be suitable for nesting, but we could not see a nest with certainty.

On 10 June 1975, A. R. Clark, J. C. Burke, Jr., and I descended into the gorge to examine the colony and later viewed it from the Canadian side of the river. We counted 110 adults, 43 active nests on the talus and boulder slope and 8 active nests with adults on seven cliff ledges. There were possibly active nests obscured by small bushes on at least two more ledges. Of the eight cliff nests, we saw three with one young each, one with two young, and one with three young. (Of the 43 slope nests, 24 contained one to three eggs, 14 held one to three young, 3 had one egg and two young, and 2 had one egg and one young). The nest ledges are fairly narrow and variable in width. They range from about

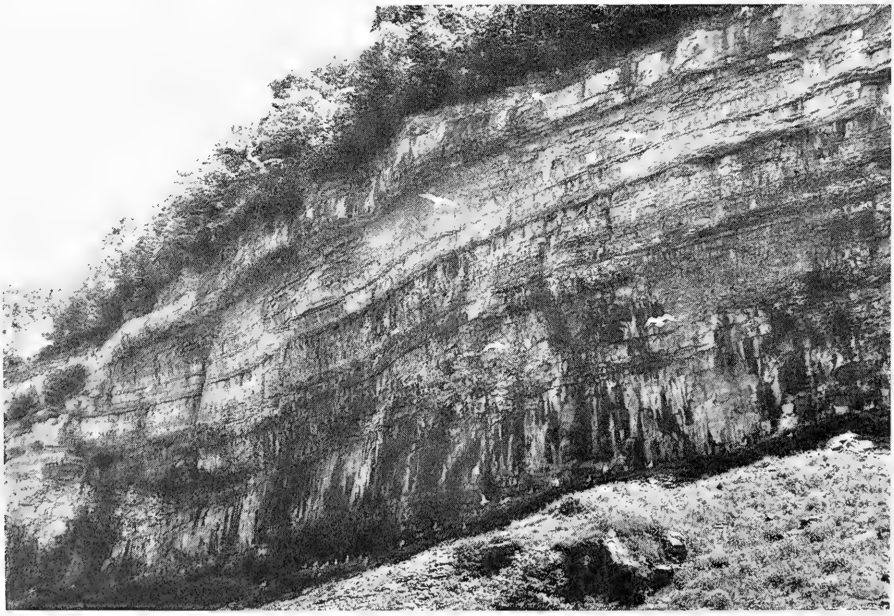

FIGURE 1. Herring Gull colony on Goat Island at Niagara Falls. Gulls at nest sites can be seen on cliff ledges at far left and on the talus slope at the cliff base.

1.5 to 8 m in length, are scattered along the cliff face, and are located from 10 to 20 m above the cliff base. We noted two dead Starlings (*Sturnus vulgaris*) and a Mudpuppy (*Necturus*) beside nests on the talus slope.

There may be some mortality of young from falling off the ledges, and losses probably occur from rock slippage on the talus slope. This nesting colony, however, appears to be a generally successful one. It is the only one solely of this species in the Niagara Frontier Region. Considering its relative freedom from human disturbance and the fact that Herring Gulls seem to be maintaining their numbers in Ring-billed Gull colonies in the region, it should persist indefinitely.

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The History of the Wild Turkey in Ontario

In Ontario, the Wild Turkey (*Meleagris gallopavo*) was never widely distributed, although the species was apparently common south of Georgian Bay before the 20th century. The purpose of this paper is to record the existing evidence, including references from obscure sources, for the occurrence of the bird in Ontario. Such information is required prior to any consideration of potential reintroduction of the species.

Historical Occurrences

The Ojibway Indians named the bird, "Misisse," inferring "big bird." These Indians formerly inhabited parts of southern and central Ontario, but not New York or other adjacent states and it is probable, therefore, that the existence of this name indicates the presence of the bird in the parts of Ontario inhabited by those people.

Early in the 17th century, the Jesuits recorded the presence of the species and the apparent mythical significance which the Indians associated with it (Wright 1915). Sagard (1632) noted that in some districts, especially near the Tobacco tribe (north of Lake Erie and west of Lake Ontario), turkeys occurred and that they were wild and could easily escape from hunters. He noted also that the Huron Indians named the Wild Turkey, "Ondettontaque," a name of unknown significance which was given prior to the mid-17th century (at which time the Iroquois Indians drove the Hurons from southern Ontario). Father Jerome Lalement (1641) observed that they (the Neutral Indians inhabiting Ontario west of the Niagara River) "have multitudes of wild turkeys which go in flocks through the fields and woods."

In 1703, LaHontan noted large numbers of Wild Turkeys along the north shore of Lake Erie, including flocks comprising 50 or 60 individuals. Jeffreys (1760) observed that the birds were common and that they avoided cultivated land. In 1793, Captain Brant encountered in the vicinity of the Niagara River, a flock of Wild Turkeys of which 17 were shot (Campbell 1793).

The status of the species in southern Ontario during the first half of the 19th century has been variously reported, perhaps as a result of fluctuating turkey abundance. Gourley (1822) recorded that Wild Turkeys were once numerous westward and southward from western Lake Ontario, although they had become scarce by 1822. The species was apparently common in 1824, however, and flocks of 8 to 10 were frequently observed in "parts of the upper province" (Talbot 1824). During the 1830s and early 1840s, the birds were reportedly abundant (Orr 1910). In 1833, a flock of 30 was seen near Adelaide, Middlesex County (Magrath 1813) and by 1838, the birds frequently damaged crops of maize in Norfolk County (Need, T. 1838. Six years in the bush, Unpublished records, Royal Ontario Museum.). During the severe winter of 1842, the Ontario population of turkeys declined and did not recover until 1856 (McIlwraith 1886).

Concerning the status of the bird in 1866, King (1866) noted that it occurred in the forests north and west of Lake Superior and west of Amherstburg, near Chatham and Hamilton and in other parts of southwestern Ontario but not in Quebec. The reference to turkeys north and west of Lake Superior, however, undoubtedly refers to the Sandhill Crane (*Grus canadensis*), a species which was, and still is, frequently locally named 'turkey.' By the mid-1860s, the birds no longer occurred in the vicinity of cities and towns but were present in the maple-walnut forests of the extreme southwest (Small 1867). In the 1870s, Wild Turkeys were plentiful in parts of their former Ontario range (Anon. 1874), especially in

Lambton County ("Jack" 1878). In Elgin County, about 1870, Dobbin observed a flock comprising more than 100 individuals in a fall wheat field (Orr 1909).

The most significant decline apparently occurred during the 1880s. The birds were locally common in 1880, particularly near the Detroit River and many were observed in December of that year (date unknown, but temperature recorded as -22° F) (G.P.G. 1881) although they were absent or rare throughout the remainder of their former Ontario range (Morden and Saunders 1882). In 1881, three gobblers were shot on the Leguis farm near Mitchells Bay (McIlwraith 1886). On 11 December 1884, Dr. Garnier, a well-known sportsman noted that, although he had previously killed many turkeys in Kent County, he observed only one in 1884 (McIlwraith 1886).

In 1883, as a result of declining Wild Turkey populations, the province of Ontario prohibited the exportation of turkey carcasses (Anon. 1883). From 1 July 1886 the species was completely protected in Ontario until 1889, the fine for possession being $5 to $25 for each bird or egg (Anon. 1886).

By 1899, only one flock remained in Kent County (Conover 1899) and by 1904, it was the opinion of the Ontario Chief Game Warden that no Wild Turkeys remained in the province (Clarke 1948). A few individuals were observed in 1905, however, on the Canadian Pacific Railway line between London and Chatham (Anon. 1905) and the species apparently persisted until at least 1909 (Orr 1909).

There are 30 confirmed Ontario records for this species, all prior to 1907, in the Royal Ontario Museum (Figure 1). In addition, there is one confirmed nest record (13 eggs found by W. E. Saunders in 1878, Delaware township, Middlesex County). Eight specimens, included in the above, are in the Royal Ontario Museum collection (ROM) (Table 1). The last confirmed records for Wild Turkey in southern Ontario are given in Table 2 (unpublished ROM records).

TABLE 1—Wild Turkey specimens in the Royal Ontario Museum

Specimen number	Date	Location
29-4-19-1	—	St. Thomas
74050	—	Indian Village, Precise location unknown
69046	1868	Brant County
34-5-8-3	—	Kingsville
34-5-8-4	—	Kingsville
78795	1200–1400 A.D.	Lot 2, Concession 2, Chatham Township
37177	October 1871	Morpeth
72177	Prior to 1900	Strathroy

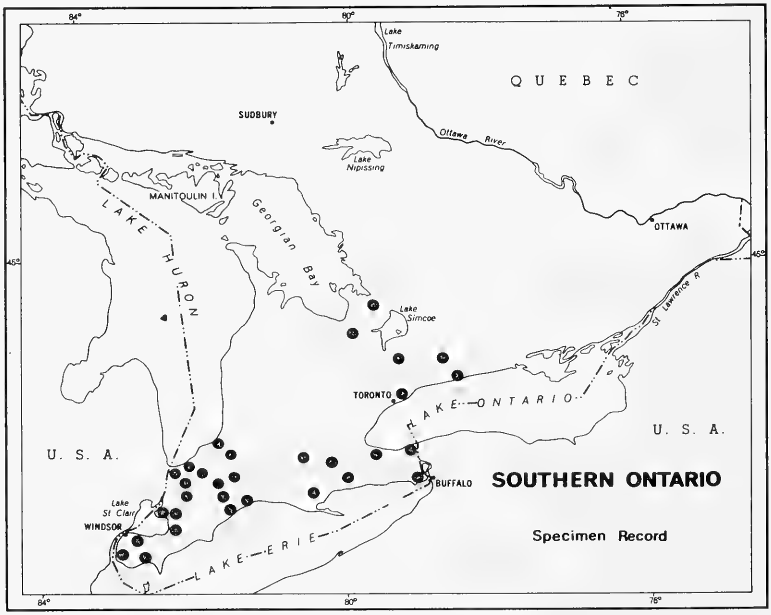

FIGURE 1. Confirmed records of Wild Turkeys in Ontario. Nest records are not included.

TABLE 2—Most recent records from the Royal Ontario Museum of Wild Turkeys in Ontario

Location	Date
Sarnia	1878
Maidstone	1881
Port Stanley	1897
Simcoe	1897
Welland	1897
Port Dalhousie	1897
Oxford City	1897
Aurora	1907

Changes in Habitat

The causes for the decline of the Wild Turkey in Ontario are not known precisely but it is likely that destruction of forests within their former range was primarily responsible. Although the Huron, Tobacco, and Neutral Indians, inhabiting southwestern Ontario until the mid-17th century, caused local forest destruction in order to grow corn and other crops (Sagard 1632), it is likely that hardwood forests were insignificantly reduced. The forest cover was apparently not continuous, however, particularly in Kent and Essex Counties. In the late 17th century, Lake St. Clair was surrounded by "vast meadows" with a few vineyards and forests some distance away (Hennepin 1698). P. McNiff (1793. Letter to the Lieutenant Governor of England, dated July 1793. Archives, Ontario Ministry of Natural Resources.), who conducted the original land surveys in the vicinity of Lake St. Clair, noted that along the south shore of Lake St. Clair from Peach Island to the mouth of River la Tranche (Thames River) was barren plain and wet lowlands. At the entrance of River la Tranche and inland for a distance of about 6 mi, extensive meadows and marshes occurred with only a few trees. North of the river, the meadows and marshes extended "as far as you can see" (McNiff *ibid.*). Eight miles from the mouth of River la Tranche, the forests were more extensive, particularly near the river, but forests did "not extend more than 30 acres" from the shore. Beyond the forests, extensive plains occurred, even in the vicinity of London. But beyond St. Marys, extensive pine forests grew on both sides of the river, except near Indian villages.

During the 19th century, large forest tracts were destroyed and by 1884, only 35% of Middlesex County, 17% of Oxford, 25% of Brant, 24% of Norfolk, and 30% of Elgin, respectively, consisted of forest (Clarke 1948). Forest destruction has continued in the 20th century and, as a result, by 1958, only 2.3% of Middlesex County, 5.5% of Norfolk, 0.9% of Elgin, 1.6% of Essex, and 2.7% of Kent, respectively, consisted of forest (hardwood and softwood combined) (Anon. 1958).

It has also been suggested that the species lost genetic quality through mingling with domestic turkeys (Clarke 1948) although recent studies of the behavior of Wild Turkeys elsewhere indicate that this is not likely (Foote 1959). It is nonetheless possible that association with domestic birds may have resulted in disease in Wild Turkeys. Declines in turkey populations have been attributed to such associations in Pennsylvania (Roberts, H. L. 1956 Report W-46R-3. Pennsylvania Game Commission, Harrisburg.). Whatever the causes, the bird also declined and vanished in Minnesota by 1871, in northern Indiana by 1870, in Michigan by 1886, and in Wisconsin by 1872 (Leopold 1931).

Archaeological Evidence

It is evident from the foregoing that the bird occurred in Ontario generally south of 49°N and west of 79°W. Archaeological evidence, although scant, is of some assistance in suggesting the former range. Wild Turkey elements were found at an Indian village in Chatham Township, dated 1200–1400 A.D. (Table 1). Turkey bones were also found in refuse deposits at a Tionontati Indian village site near Creemore, Nottawasaga Township and at a post-European Huron village (17th century) in Tay Township (Wintemberg 1935). In addition, one element has been found at each of the Hamilton site and the Knight-Tucker site, both in Wentworth County and occupied by Iroquoian Indians in the 16th century (unpublished records, Department of Archaeology, University of Toronto). Finally, Wild Turkey elements were found at the Bosomworth site, a pre-Iroquoian, pre-agricultural Indian village in East Guillambury Township (unpublished record, Department of Archaeology, University of Toronto).

Attempted Reintroductions

There was an open season for Wild Turkeys in Ontario until 1928, although there were several years in which the season was closed (e.g., 1902 to 1905). Furthermore, the Ontario Game and Fish Act still recognizes the species as a game bird, although extirpated, in the event that a successful reintroduction should occur.

Several releases of Wild Turkeys have been made in Ontario, all made up of individuals reared at game farms. Most of the attempts failed and apparently none of the resulting populations was self-sustaining.

On 6 May 1949, two males and four females (Latham game-farm stock obtained from Pennsylvania) were released on the farm of Dr. Haigmire in Bosanquet Township, Lambton County. By October 1955, the flock consisted of about 50 individuals and in November 1956, 75 individuals were observed in the vicinity (unpublished records, Ontario Ministry of Natural Resources (OMNR)). In 1958 only one individual remained.

Thirty young birds, reared at the Ontario Game Bird Farm at Normandale, were released in 1952 at Rondeau Park, in Mosa Township and at Normandale (five pair at each location). None of these birds or their progeny was seen after 1957.

In September 1954, the Toronto Anglers and Hunters released 56 8-week-old turkeys (game-farm birds) at Lot 15, Concession 8, Clarke Township, Durham County (OMNR records) but these birds had vanished by 1957.

In 1962, one male and two females (game-farm stock) were released at the Claremont Conservation Area. Both females successfully reared broods in 1963 and by 1964 the resident flock comprised about 40 individuals (unpublished ROM records). Subsequent to this introduction, a Wild Turkey nest containing 12 eggs was found on 25 July 1965 on Concession 8, Pickering Township, Ontario County (first nest record for released turkeys, ROM record). There have been no observations of the species in that vicinity for several years.

Since 1968, the Orillia Fish and Game Club has released Wisconsin-Pennsylvania game-farm Wild Turkey hybrids at several locations in the vicinity of Lake Simcoe. Subsequently, there have been 12 brood sightings, and a nest containing 12 eggs was found on July 1972 on the Kitchen farm, about 8 mi west of Orillia.

In July 1975, the Oakville Anglers and Hunters released an unknown number of game-farm turkeys near Bronte Creek, Halton County. Several of these birds have been subsequently observed.

The only existing flocks of Wild Turkeys in Ontario are a result of recent releases. Furthermore, all are maintained through the winter by various forms of artificial feeding. Such flocks exist in the vicinity of Ivy Lea International Bridge and on Griffith Island in Georgian Bay. Birds resulting from the Orillia releases are frequently reported during the winter at bird-feeding stations in the Orillia-Meaford area and it is doubtful that they would survive without such human assistance.

In at least one unsuccessful introduction, the nematode *Heterakis* may have caused mortality among the released stock (unpublished OMNR records). But recent evidence suggests that inferior Wild Turkey release stock invariably fails to re-establish populations and that wild-trapped individuals, rather than game-farm birds, are more successful (Foote 1959). Virtually all North American releases of game-farm Wild Turkeys have been unsuccessful. Conversely, almost all releases of wild-trapped individuals have been successful. Thus, Foot (1959) noted,

> "Sickles . . . Hardy, Gilpin and others presented crystal-clear evidence of the futility of playing with game-farm stock when restoration is the objective. Why some states continue . . . is almost beyond my comprehension."

It is reported that fewer than 30 wild-trapped individuals are required to establish a Wild Turkey flock in optimum habitat, although additional birds may be required in marginal turkey habitat. Should it be desirable to re-establish the species in Ontario, it is likely that only wild-trapped birds, possibly from New York, West Virginia, or Virginia, where climate is similar to that of Southern Ontario, would suffice.

Conclusions

It is apparent that obscure publications, such as those referred to in the text, often provide valid historical information relative to former animal distribution. The evidence I have presented indicates that the Wild Turkey probably occurred farther north in Ontario than has been suggested by previous authors. Thus, in the event that a reintroduction of Wild Turkeys, using wild-trapped stock, should take place in the province, possible release sites which might now be considered should be relatively remote from human interference and inevitable poaching (which might jeopardize the success of any such project).

Literature Cited

Anonymous. 1874. Shot gun and rifle. Forest and Stream 1: 381.

Anonymous. 1883. Ontario non-export. Forest and Stream 21: 125.

Anonymous. 1886. Ontario game laws. Forest and Stream 26: 186.

Anonymous. 1905. Fishing and shooting on the line of the Canadian Pacific Railway. Canadian Pacific Railway. 25th Edition. pp. 23–24.

Anonymous. 1958. Forest resources inventory—Lake Erie district. Ontario Department of Lands and Forests Report 22: 12–13.

Campbell, P. 1793. Travel in the interior inhabited parts of North America in the years 1791 and 1792. Edinburgh. pp. 202–203.

Clarke, C. H. D. 1948. The Wild Turkey in Ontario. Sylva 4: 4–12.

Conover, F. H. 1899. Quail in Essex County, Ontario. Rod and Gun in Canada 1: 52.

Foote, L. E. 1959. Summarization of the first national Wild Turkey symposium. Proceedings of the First National Wild Turkey Symposium. pp. 192–195.

G.P.G. 1881. Our Detroit letter. Forest and Stream and Rod and Gun 15: 451.

Gourley, R. C. 1822. A statistical account of Upper Canada. Volume 1. pp. 171–172.

Hennepin, L. 1968. A new discovery of a vast country in America. *Edited by* R. B. Thwaites. London. pp. 109, 558.

"Jack." 1878. Game bag and gun. Forest and Stream and Rod and Gun 11: 409.

Jefferys, T. 1760. The natural and civil history of the French Dominion in North America. Part 1. London. p. 39.

King, W. R. 1866. The sportsman and naturalist in Canada. Hurst and Blackett, London, 334 pp.

LaHontan, B. 1703. New voyages to North America. London. Volume 1. pp. 83–99.

Lalement, J. 1641. Jesuit relations and allied documents. *Edited by* R. G. Thwaites. Imperial Press, Cleveland. Chapter 21. p. 197.

Leopold, A. 1931. Game survey of the north central states. Madison.

Magrath, T. W. 1833. Authentic letters from Upper Canada; with an account of Canadian field sports. *Edited by* T. Radcliffe. (Reprinted McMillan, Toronto, 1967.) p. 181.

McIlwraith, T. 1886. Birds of Ontario. Hamilton Association, Hamilton. p. 130.

Morden, J. A. and **W. E. Saunders.** 1882. List of the birds of western Ontario. Canadian Sportsman and Naturalist 2: 192.

Orr, J. E. 1909. Some old time reminiscences of old Ontario. Rod and Gun in Canada 11: 524–526.

Orr, J. E. 1910. Some old time reminiscences of old Ontario. Rod and Gun in Canada 11: 1048–1052.

Sagard, G. 1632. The long journey to the country of the Hurons. Champlain Society, Toronto. (Reprinted 1939.) p. 220.

Small, H. B. 1866. The Canadian handbook and tourists guide. Longmoore and Co., Montreal. p. 169.

Talbot, E. A. 1824. Five years residence in the Canadas. Volume 1. Royal Ontario Museum records. p. 229.

Wintemberg, W. J. 1935. Archeological evidence of the presence of the Wild Turkey in Simcoe County, Ontario. Canadian Field-Naturalist 49: 125.

Wright, A. H. 1915. Early records of the Wild Turkey. III. Auk 32: 61–63.

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Are There Two Species of Pygmy Shrews (*Microsorex*)?

In his recent taxonomic revision of the genus *Microsorex*, Long (1972) tentatively listed two living species, *M. hoyi* and *M. thompsoni*. The latter is said to differ from *M. hoyi* in being smaller, in having a short skull (cranial length usually < 15.6 mm), minute teeth, a flattened cranium (the ratio of cranial breadth to depth in "old adults" usually being about 1.7), and in being more grayish in color (Long 1972, 1974). Long (1972) stated, without presenting evidence to support his claim, that the two forms are readily distinguishable in two areas of parapatry, southern Wisconsin and the Gaspé Peninsula.

In Canada, populations of *Microsorex* east of the St. Lawrence, except those of the Gaspé Peninsula, are referred to *M. thompsoni*; those of the rest of the country to *M. hoyi* (for further details on distribution see Long 1972). While reviewing *Microsorex* from Canada in the collection of the National Museum of Natural Sciences, I had an opportunity to evaluate Long's diagnostic characters using data provided in his paper (Long 1972) as well as data derived from our own specimens.

The coefficient of difference, C.D., (Mayr 1969) calculated for the skull lengths of the two forms given by Long (1972), using appropriate weighting (Simpson et al. 1960) where sample means were used in the calculation of the species means, is 0.588. This value corresponds to a non-overlap $< 75\%$ and a probability of misidentification (Lubischew 1962) > 0.25. Condylobasal lengths of eight *M. thompsoni* from Nova Scotia and New Brunswick and 27 *M. hoyi* from the rest of Canada (Table 1) show a non-overlap of 89% and a probability of misidentification of 0.11.

A comparison of the means for the length of the unicuspid series and the length of P^4 (Table 1) showed no significant difference in the former and a significant difference ($P = 0.02$) for the latter. The overlap in the length of P^4 is, however, considerable ($>50\%$). When length of P^4 was plotted against condylobasal length, observations for the two forms were found to cluster along a common trend line with an estimated slope of 0.04, strongly suggesting a negative allometric relationship between these two variates. Large animals, therefore, tend to have a relatively smaller P^4 than small ones. The difference in the size of the teeth of *M. thompsoni* and *M. hoyi* appears to be the result of the difference in overall size, with the smaller *M. thompsoni* having comparatively larger teeth relative to condylobasal length than the generally larger *M. hoyi*.

The covariation of cranial breadth and depth, including data from Long (1972), is depicted in Figure

TABLE 1—Comparison of three cranial variates (in millimetres) of *Microsorex* from New Brunswick and Nova Scotia (1) and the rest of Canada (2)

Cranial variates	Sample size	Mean	Standard deviation	Coefficient of variability	Observed range
Condylobasal length	(1) 8	14.03	0.197	1.40	13.6–14.2
	(2) 27	14.79	0.423	2.85	13.7–15.8
Length of unicuspids	(1) 11	1.39	0.094	6.78	1.25–1.50
	(2) 19	1.39	0.130	9.38	1.05–1.55
Length of P^4	(1) 11	1.10	0.070	6.36	1.00–1.25
	(2) 20	1.15	0.063	5.46	1.05–1.25

1. We see that the observations of *M. thompsoni* lie entirely within the 95% equal frequency ellipse for *M. hoyi*. The observations for *M. thompsoni* are, with one exception, thoroughly interspersed among those of *M. hoyi* and the means for each of the subspecies show similar deviations from the major axis. It is obvious from the graphic comparison in Figure 1 that the ratio of cranial breadth to depth does not separate the two forms. To the contrary, the covariation of the two cranial variates suggests no difference between the two forms other than that of size.

As to color, specimens from the Maritimes could not be separated from specimens from other localities in eastern Canada, including the Gaspé, on the basis

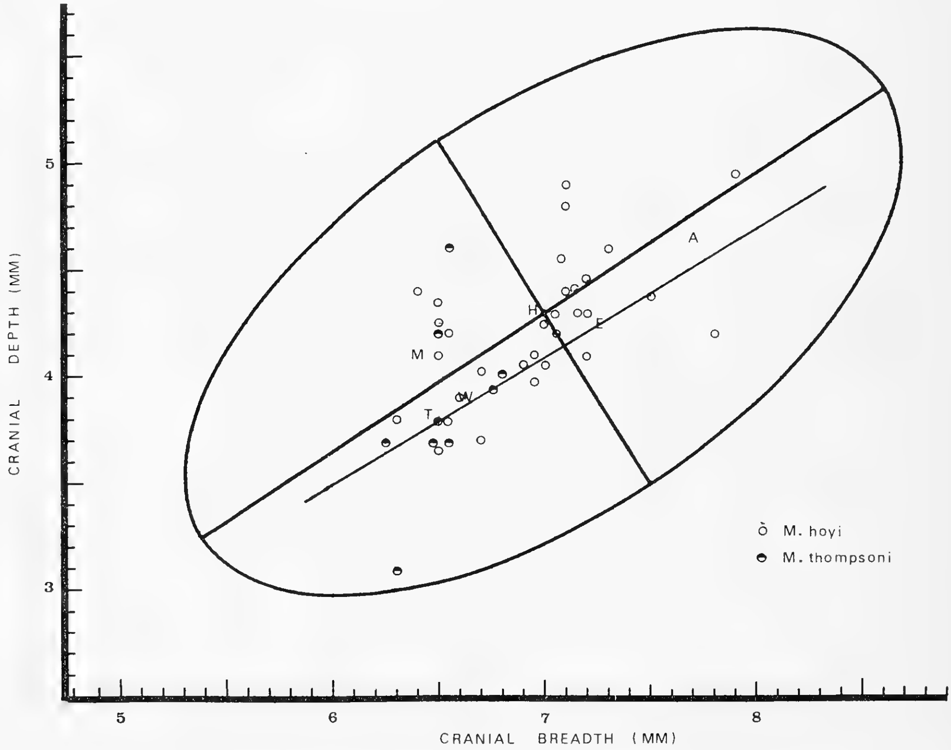

FIGURE 1. Covariation of cranial depth and cranial breadth in *M. hoyi* and *M. thompsoni*. The ellipse represents the bivariate distribution of *M. hoyi*. It encloses an area in which 95% of all observations for *M. hoyi* are expected to lie. The slope of the major axis $b = 0.666$, the correlation coefficient between the variates $r = 0.602$. Bivariate means for the different subspecies shown based in part on Long (1972), are as follows: A = *alnorum*; E = *eximius*; H = *hoyi*; M = *montanus*; W = *washingtoni*; T = *thompsoni*. The line below the major axis represents the 1.7 cranial breadth to depth ratio, or its reciprocal (0.58), claimed to characterize *M. thompsoni* by Long (1972).

of color by three persons asked to do so.

Of all diagnostic characters listed by Long (1972) only size appears to be of any use in separating the two forms. The difference in size between *M. hoyi* and *M. thompsoni* is, however, no greater than that found between many subspecies. The non-overlap for condylobasal length falls just below the conventional level of subspecific difference (Mayr 1969). Available evidence indicates a general tendency for southern forms to be smaller than northern forms in this genus (Long 1972), and it seems probable that animals from critical areas of contact between the two forms will prove to be intermediate in size.

As the degree of difference between the two forms is no greater than that between intergrading subspecies, it would be preferable, on the basis of the present evidence, to treat *M. thompsoni* as a subspecies of *M. hoyi.*

Literature Cited

Long, C. A. 1972. Taxonomic revision of the mammalian Genus *Microsorex* Coues. Transactions of the Kansas Academy of Science 74(2): 181–196.

Long, C. A. 1974. *Microsorex hoyi* and *Microsorex thompsoni.* Mammalian Species Number 33. 4 pp.

Lubischew, A. A. 1962. On the use of discriminant functions in taxonomy. Biometrics 18(1–4): 455–477.

Mayr, E. 1969. Principles of systematic zoology. McGraw-Hill Book Co., New York. 428 pp.

Simpson, G. G., A. Roe, and **R. C. Lewontin.** 1960. Quantitative zoology. Harcourt, Brace and Co., New York. 440 pp.

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Breeding of the Marbled Godwit, *Limosa fedoa*, in James Bay

Although the Marbled Godwit (*Limosa fedoa*) has been observed regularly on the west coast of James Bay for many years, definite proof that it may breed there has not been forthcoming. This note reports the first breeding record of the species from James Bay and discusses its status there. The nearest previously known breeding areas were some 900 km to the southwest on the grasslands of the Canadian prairies (central and southern Manitoba) and south into central Montana, the Dakotas, and west-central Minnesota (AOU 1957; Godfrey 1966).

Records of the Marbled Godwit in James Bay date back to 1860, when Drexler saw and collected a bird at or near Moose Factory (Preble 1902; Todd 1963). Locations of records mentioned in the text are marked in Figure 1. Spreadborough, who visted James Bay in 1896 and 1904, stated that the species bred on both coasts (Macoun and Macoun 1909), but no evidence was advanced in support of this statement. Subsequent sight and specimen records have confirmed the regular occurrence of the Marbled Godwit on the west and south coasts. Todd (1943, 1963) described finding over a dozen birds at the mouth of the Mississicabi River in Hannah Bay on 24 and 25 June 1941. Five specimens were collected, but dissection indicated that the birds were not in breeding condition. In 1947, Manning (1952) collected the male of an apparent pair near North Point on 3 June, and another male on the south coast of Akimiski Island on 23 June. No notes were made on the behavior of the birds or their breeding condition, though neither specimen (in the National Museum of Natural Sciences, Ottawa) has any obvious incubation patch. The testes measured 14 mm and 10 mm, respectively. Other records from the southern part of James Bay include the following: one at the mouth of the Harricanaw River on 15 June 1926, and seven at East Point on 16 June 1926 by G. M. Sutton (Todd 1963); 10 on Ship Sands Island on 15 June 1943 (R. H. Smith, unpublished manuscript); and a bird behaving as though it had a nest or young nearby on Ship Sands Island, 24–30 June 1968 (R. S. Brodey, letter to the National Museum of Natural Sciences, Ottawa).

The most extensive records indicating probable breeding of the Marbled Godwit in the James Bay area were obtained by Hagar (unpublished notes), who visited the west coast of the bay and the northwest and southwest coasts of Akimiski Island in 1966. The possibility of the Marbled Godwit breeding on Akimiski Island was first suggested by conversations with John Buckalew, who had seen Hudsonian and Marbled Godwits there while banding geese in 1957. On 9–10 July 1966, Hagar saw numerous Marbled Godwits, mostly in groups of two to six at Branch Creek, 8 km north of the North Channel of the Albany River on the west coast of James Bay. A single bird was also seen 6 km south of the Kapiskau River on 10 July. Between 14 and 18 July, large

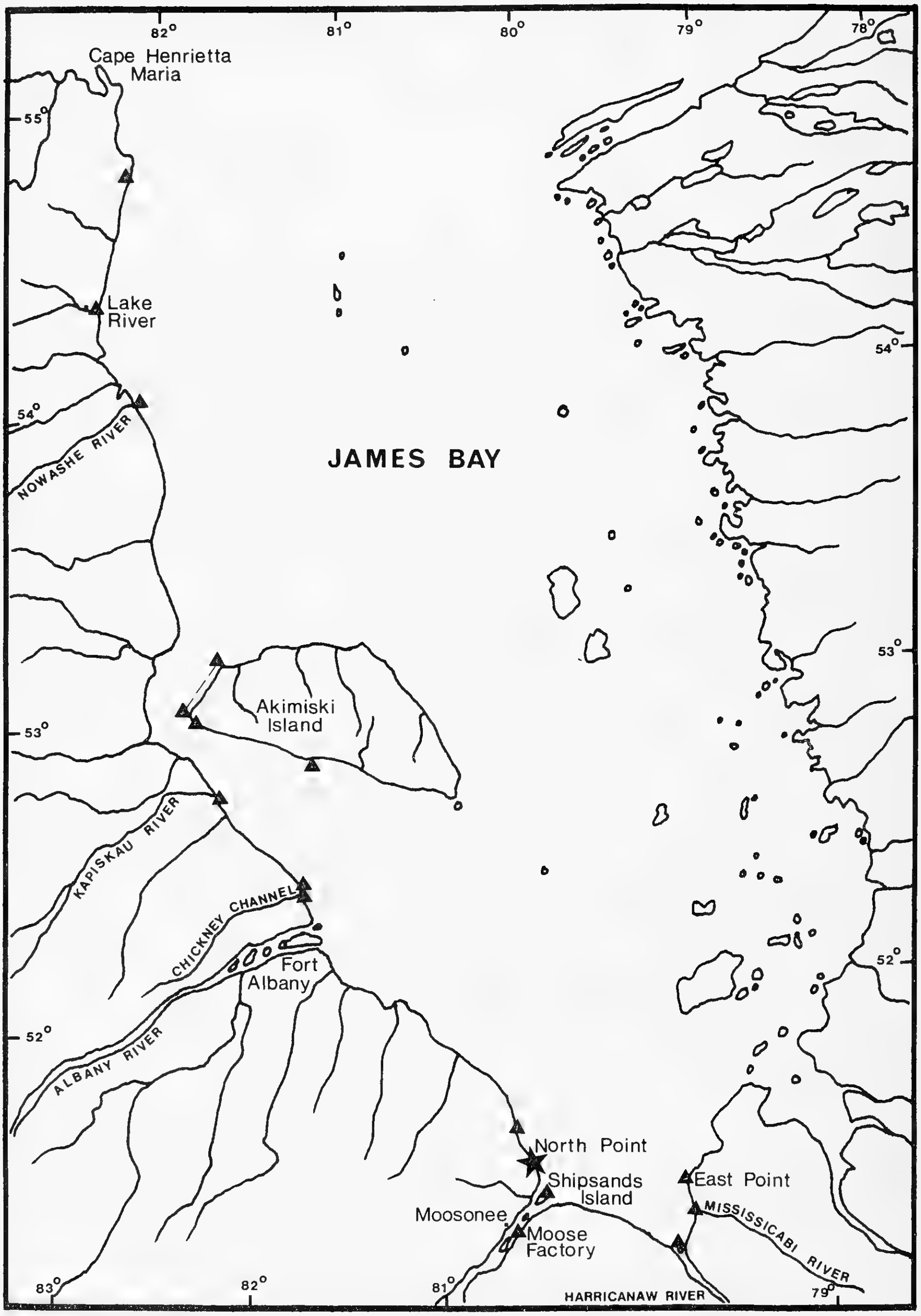

FIGURE 1. Locations where Marbled Godwits have been recorded on the west coast of James Bay are shown by solid triangles (▲). The star (★) denotes the location, 5 km south of North Point, where the first breeding record for James Bay was obtained in 1975.

numbers were observed on the marshes along the northwest coast of Akimiski Island and a single bird on the south coast. Many of those on the northwest coast acted as though they were breeding, and detailed descriptions of the behavior of pairs observed on 17 and 18 July leave little doubt that the birds were guarding young, though none of these could be found. The likelihood of breeding was strongly supported by the collection of two males with well developed brood patches, the skin of which was still soft and swollen, suggesting recent incubation. It was estimated that there were about five pairs of Marbled Godwits to the linear mile along the northwest coast of Akimiski Island between 12 and 19 July. On the return journey along the James Bay coast, Hagar saw a flock of 300–400 Marbled Godwits among about 1300 godwits at the Chickney Channel 10 km north of the North Channel of the Albany River on 24 July. The next day 10–15 Marbled Godwits were seen there and five or six on 26 July. Seven others were seen between the Albany and Moose Rivers in the period 8–25 August. Both Hagar (unpublished notes) and Todd (1963) comment on the similar appearance of the habitat in James Bay to that occupied by Marbled Godwits on the prairies, with which they were familar.

Morrison was engaged in field work at North Point from 7–28 August 1974, 15–21 May, and 16 July to 26 August 1975, Manning from 15 May to 16 July 1975. In 1974 four Marbled Godwits were observed on 10 and 11 August. In 1975, the species was first recorded on 28 May, when three birds were seen on the coastal marsh 2 km south of North Point. From one to three were seen either near the same place or on the coastal marsh up to 3 km south of it on 29 May, 1, 6, 7, 8, 19, and 28 June. These sightings were all thought to be of the same birds, which several times behaved as though they had nests or young, though they performed in widely different places and after a while flew off. On 4 July all three were seen near the gravel ridges 5 km south of North Point and closer to the shore than previously. After a long search a single young bird about 10 days old was found by Manning's retriever. The bird was collected (Number 63 284, National Museum of Natural Sciences). This was the same locality in which Manning had collected the male of an apparent pair in 1947. Two adults were observed in the area on 6, 17, 20, 21, and 23 July, and their alarm behavior strongly suggested that they were still guarding young. Similar behavior was encountered in a pair found about 3 km north of North Point in an area where a series of creeks cut across the coastal marsh. The birds were first seen on 18 July, when a further four Marbled Godwits appeared in response to their alarm calls. The pair again behaved as though they had young on 21 July, though none could be found in the long marsh vegetation, and on this occasion 11 other Marbled Godwits were seen. Eight Marbled Godwits were seen in the area to the north of the creeks on 29 July.

Small numbers of Marbled Godwits were seen on the coast during July and the first half of August. Numbers recorded were these: July 12 (10), 23 (4), 29 (3), 31 (1), August 1 (6), 2 (4), 5 (4), 8 (2), 9 (2), 11 (5), 13 (5), 22 (4), 24 (1). Three juvenile birds were trapped during banding operations on 13 August.

The available evidence now suggests that the Marbled Godwit breeds on Akimiski Island, particularly the north coast, and along the southern half of the west coast of James Bay where suitable habitat occurs. Whether it may breed along the northern half of the west coast is uncertain, the only record being that of Peck (1972), who states that six were seen about 40 km south of Cape Henrietta Maria by a party from the Royal Ontario Museum on 27 July 1948. Occasional Marbled Godwits have been seen during aerial surveys along this part of the coast and the Ontario coast of Hudson Bay, e.g., at Nowashe River, Lake River, and Severn River (Morrison, personal observation and H. G. Lumsden, personal communication).

The size of the breeding population is not known, but the numbers found by Hagar on Akimiski Island and his observation of 300–400 at the Chickney Channel in 1966 suggest that it may consist of considerably more than a thin scattering of pairs in suitable habitat. It is interesting to note that the James Bay Marbled Godwits are separated from the nearest breeding grounds on the prairies by a distance of 800–1000 km and may form a discrete population. It seems unlikely that birds from the prairies would move to the James Bay coast when the anticipated direction of their autumn migration would be towards wintering areas to the south and west along the coasts of California and Mexico. One may speculate whether James Bay may be the breeding area of the population which winters on the east coast of North America south from southeastern South Carolina (Bent 1927). Work at North Point in 1975 and observations in 1966 suggest flocking and departure in the latter part of July for adults and in mid-August for juveniles. These dates correlate with those given by Bent (1927) for arrival in North Carolina: mid- to late July for adults, juveniles about a month later. At one time, the Marbled Godwit was abundant on the Atlantic coast during migration (Bent 1927), but its numbers were markedly reduced during the days of market hunting. Hagar (unpublished notes) has observed that the species appears to be increasing slowly on the Carolina and Florida coasts in recent decades from a low point in the 1920s and 1930s.

In summary, previous records have shown the regular occurrence of the Marbled Godwit on the west and south coasts of James Bay. Some observations suggested possible breeding, but definite proof of nesting was not obtained until 1975. It is not known whether the James Bay population may be an extension of the one on the prairies, or whether it may form a discrete unit. It is possible that the James Bay birds may be the ones that migrate to wintering areas on the east coast of the USA.

Literature Cited

American Ornithologists' Union. 1957. Check-list of North American birds. 5th Edition. American Ornithologists' Union, Baltimore. 691 pp.

Bent, A. C. 1927. Life histories of North American shorebirds. Part 1. United States National Museum Bulletin 142. (Reprinted Dover Publications Inc., New York, 1962). 420 pp.

Godfrey, W. E. 1966. The birds of Canada. National Museum of Canada Bulletin 203. 428 pp.

Macoun, J. and **J. Macoun.** 1909. Catalogue of Canadian birds. Geological Survey of Canada, Department of Mines. viii + 761 + xviii pp.

Manning, T. H. 1952. Birds of the west James Bay and southern Hudson Bay coasts. National Museum of Canada Bulletin 125. 114 pp.

Peck, G. K. 1972. Birds of the Cape Henrietta Maria region, Ontario. Canadian Field-Naturalist 86: 333–348.

Preble, E. A. 1902. A biological investigation of the Hudson Bay region. United States Department of Agriculture, Division of Biological Surveys, North American Fauna Number 22. 140 pp.

Todd, W. E. C. 1943. The western element in the James Bay avifauna. Canadian Field-Naturalist 57: 79–80.

Todd, W. E. C. 1963. Birds of the Labrador Peninsula and adjacent areas. University of Toronto Press and Carnegie Museum, Toronto. 819 pp.

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A Fern, *Polystichum braunii* ssp. *purshii,* New to Labrador

This note adds the eastern holly fern or Braun's holly fern, *Polystichum braunii* (Spenner) Fée ssp. *purshii* (Fern.) Calder and Taylor, to the 674 vascular plants reported for Labrador by E. Rouleau (1956. A checklist of the vascular plants of the province of Newfoundland. III. Contributions de l'Institut botanique de l'Université de Montréal Number 69: 41–106). This taxon was first found in mid-August 1970 in the spray zone of Churchill Falls, growing in a rocky pocket on an exposed north-facing slope that received a heavy fall of spray. Fronds were few in number and grew to a length of 54 cm. Sori were immature. In 1971 it was found in dense thickets of *Alnus crispa* which received relatively light and intermittent spray. Here the fronds were numerous and vigorous and attained 80 cm in length. When collected on 14 August, sori were abundant and mature and some had dehisced.

M. L. Fernald (1928. The eastern American variety of *Polystichum braunii.* III. Rhodora 30: 28–30) reported *Polystichum braunii* ssp. *purshii* as occurring in northern and western Newfoundland, Anticosti Island, northern and western Nova Scotia, southern New Brunswick, Gaspé Peninsula, to the Algoma District of Ontario, south to Maine, New Hampshire, Vermont, Massachusetts, New York, Pennsylvania, and Michigan. It was also collected by E. C. Smith near Cape Freels on the Bonavista Peninsula of eastern Newfoundland in 1945.

Voucher specimens for the Labrador and eastern Newfoundland specimens are on deposit in the Agnes Marion Ayre Herbarium, Department of Botany, Memorial University of Newfoundland.

This find extends the known northern range of the taxon by approximately 400 km north from Anticosti Island and 600 km northwest from Newfoundland.

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A Range Extension of *Nocomis micropogon,* the River Chub, into Eastern Ontario

Until now the known distribution in Canada of *Nocomis micropogon*, the river chub, was restricted to southwestern Ontario. Scott and Crossman (1973) indicated that the range for this species included tributaries of southern Lake Huron, Lake St. Clair, Lake Erie, and the western end of Lake Ontario.

In August 1973 during a biological survey of the Madawaska River, a tributary to the Ottawa River, 135 specimens of *N. micropogon* were collected between Latchford Bridge (45° 17′ N, 77°28′ W) and Griffith (45° 15′ N, 77° 10′ W). Another specimen was subsequently collected by the authors in July 1974 at Jewellville (45° 19′ N, 77°32′ W) approximately 12 km upstream. Collections of specimens were made by means of a 1.2-m trap net, a mesh seine net, 1.2 m × 9.1 m × 1 cm, a dip net, and a Smith-Root Type V electrofisher.

The present location is 250 km (155 mi) northeast of the Humber River (43°38′ N, 79°23′ W) which was the previous easternmost range limit (Scott and Crossman 1973). It is also 160 km (99 mi) north of the New York State tributaries of the upper St. Lawrence River and Lake Ontario where this species also occurs (Figure 1).

Numbers and sizes of specimens (Table 1) suggest a substantial breeding population. Age–growth estimates (Scott and Crossman 1973) indicate that the individuals range from 1 to 5 years of age. Meristic and morphometric data were taken on 28 specimens, following the methods of Hubbs and Lagler (1964) and were found to concur with those given by Scott and Crossman (1973). Most of the specimens are deposited in the Royal Ontario Museum (ROM) collection (see Table 1 for catalogue numbers).

The habitat of the fish collected from the six stations along 31 km of the Madawaska River was similar to that described by Lachner and Jenkins (1967). The river bottom consisted of 60% to 80% mixed boulder and rubble; the remainder was sand and gravel. Our data were consistent with those of Lachner (1952) who stated that *N. micropogon* prefers large streams and rivers. The sampled area of the Madawaska River was over 50 m wide whereas Eneas and Highland Creeks, tributaries of the Madawaska River, were 9 and 15 m wide, respectively. Water temperatures ranged between 21 and 23°C, turbidity was less than 7 Jackson Turbidity Units, and aquatic vegetation was sparse.

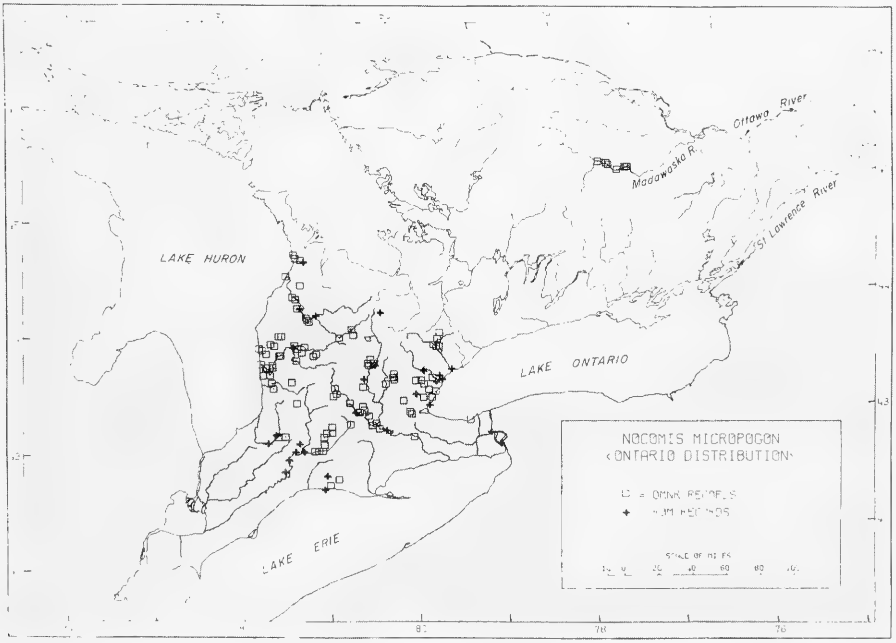

FIGURE 1. Distribution records for *Nocomis micropogon* in Ontario, illustrating the range extension and previous range limits.

TABLE 1—Numbers and sizes of specimens collected at each station, showing location, date collected, and Royal Ontario Museum catalogue number

Catalogue number	Locality		Number of specimens	Size range (T.L., mm)	Date collected
32046	Eneas Creek	45°17.5′, 77°25.9′	12	31–165	2 August 1973
30158	Madawaska River	45°14.8′, 77°13.5′	14	45–183	20 August 1973
30159	Madawaska River	45°14.5′, 77°10.7′	11	77–131	20 August 1973
30160	Highland Creek	45°15.3′, 77°13.5′	59	35–131	19 August 1973
30161	Madawaska River	45°13.7′, 77°19.3′	12	46–174	15 August 1973
*	Madawaska River	45°15.2′, 77°11.7′	16	44–70	18 August 1973
*	Madawaska River	45°17.9′, 77°25.3′	11	36–99	17 August 1973
30880	Madawaska River	45°19.0′, 77°32.0′	1	158	10 July 1974

*Not catalogued.

This section of the Madawaska system is popular for anglers seeking *Stizostedion vitreum*, walleye, and *Esox lucius*, northern pike. We suggest that *N. micropogon* was introduced by the accidental release of bait fishes. It is unlikely that a natural movement of the species can account for its occurrence because of the great distance between this population and its known range. If so, this illustrates the possibility of potential changes in the environment by the release and establishment of a cyprinid fish outside of its natural range.

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Literature Cited

Hubbs, C. L. and **K. F. Lagler.** 1964. Fishes of the Great Lakes region. The University of Michigan Press. Ann Arbor, Mich. 213 pp.

Lachner, E. A. 1952. Studies of the biology of the cyprinid fishes of the chub genus *Nocomis* of northeastern United States. American Midland Naturalist 48(2): 433–466.

Lachner, E. A. and **R. E. Jenkins.** 1967. Systematics, distribution, and evolution of the chub genus *Nocomis* (Cyprinidae) in the southwestern Ohio River Basin, with the description of a new species. Copeia 1967(3): 577–580.

Scott, W. B. and **E. J. Crossman.** 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada Bulletin 184. 966 pp.

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Recovery of a Swordfish (*Xiphias gladius*) Sword from a Fin Whale (*Balaenoptera physalus*) Killed off the West Coast of Iceland

The 18-cm-long tip of a swordfish (*Xiphias gladius*) sword (Figure 1) was found embedded in the posterior part of the hypaxial musculature or "tail meat" of a 63-ft female fin whale (*Balaenoptera physalus*) killed July 1973 at position 63°22′ N, 26°15′ W off the west coast of Iceland.

The occasionally observed close association between swordfish and large whales (Brown 1960) and the recovery of swords from blue (*Balaenoptera musculus*) (Ruud 1952; Jonsgård 1959) and fin whales (Jonsgård 1962) in the Antarctic and from fin (Nemoto 1959) and sei whales (*Balaenoptera borealis*) (Machida 1970) in the North Pacific lends credibility to the idea that swordfish attack whales. Recently, a 49.5-cm-long marlin (*Makaira* sp.) "spear" was recovered from the dorsal surface of the rostrum of an Antarctic minke whale (*Balaenoptera bonaerensis*) (Ohsumi 1973).

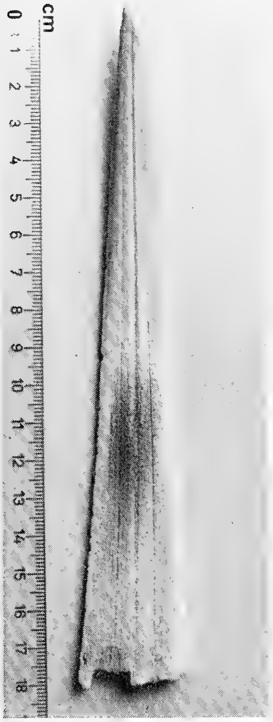

FIGURE 1. Tip of a swordfish sword recovered from the posterior hypaxial muscle of a 63-ft female fin whale taken off the west coast of Iceland July 1973.

Perhaps of more significance than providing evidence for rarely seen interspecific associations, the finding of the swordfish sword possibly indicates something about the migration of fin whales around Iceland.

Swordfish are generally considered to be tropical and sub-tropical fish usually found in water warmer than 24°C and not in water colder than 12–13°C (Ovchinnikov 1970). The whaling grounds off the west coast of Iceland usually do not exceed 10°C. The 24°C isotherm in the Northeast Atlantic occurs at approximately 35° north latitude, that is at the level of North Africa. The northern limit of swordfish distribution as indicated by the 12° isotherm would be at approximately 60° north latitude. Next to the European coast the 12° isotherm extends as far as northern Norway (Leim and Scott 1966; Ovchinnikov 1970).

A single swordfish specimen was found washed ashore on the east coast of Iceland in 1936 (Saemundsson 1949). Although swordfish have not been sighted in the waters between Iceland and Europe, their occurrence here is still open to question (Tåning 1958).

The fin whale population hunted off the west coast of Iceland is thought to be distinct from that found off the east coast and catch statistics suggest that they may form part of the same stock that was hunted off northern Norway (Jónsson 1965). The southward migration of fin whales in the North Atlantic during the winter is discussed in some detail by Jonsgard (1966).

Although it is possible that fin whales could come into contact with swordfish in Icelandic waters it seems more likely that any association between these two species would occur in warmer waters, probably south of 40°N during the winter calving period.

Literature Cited

Brown, S. G. 1960. Swordfish and whales. Norsk Hvalfangst-Tidende 49(8): 345–351.

Jonsgård, Å. 1959. New find of sword from swordfish (*Xiphias gladius*) in Blue whale (*Balaenoptera musculus*) in Antarctic. Norsk Hvalfangst-Tidende 48(7): 352–360.

Jonsgård, Å. 1962. Three finds of swords from swordfish (*Xiphias gladius*) in Antarctic fin whales (*Balaenoptera physalus* L.). Norsk Hvalfangst-Tidende 51(7): 287–291.

Jonsgård, Å. 1966. Biology of the North Atlantic fin whale (*Balaenoptera physalus* L.). Hvalradets Skrifter 49: 1–62.

Jónsson, J. 1965. Whales and whaling in Icelandic waters. Norsk Hvalfangst-Tidende 54(11): 245–253.

Leim, A. H. and **W. B. Scott.** 1966. Fishes of the Atlantic coast of Canada. Fisheries Research Board of Canada Bulletin 155. 485 pp.

Machida, S. 1970. A swordfish sword found from a North Pacific sei whale. Scientific Reports of the Whales Research Institute, Tokyo 22: 163–164.

Nemoto, T. 1959. Food of baleen whales with references to whale movements. Scientific Reports of the Whales Research Institute, Tokyo 14: 149–290.

Ohsumi, S. 1973. Find of a marlin spear from the Antarctic minke whales. Scientific Reports of the Whales Research Institute, Tokyo 25: 237–239.

Ovchinnikov, V. V. 1970. Swordfishes and billfishes in the Atlantic Ocean. Ecology and functional morphology. Israel Program for Scientific Translations, Jerusalem 1971. (*Translated from Russian.*) 77 pp.

Ruud, J. T. 1952. Do swordfishes attack large baleen whales? Norsk Hvalfangst-Tidende 41(4): 191–193.

Saemundsson, B. 1949. The zoology of Iceland. Volume IV. Marine Pisces. Part 72. Reykjavik. 150 pp.

Tåning, A. V. 1958. On the breeding areas of the swordfish (*Xiphias*). Deep Sea Research 3 (Supplement): 438–450.

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Audubon's Shearwater, a Species New for Canada

In the morning of 8 September 1975, Canada's first specimen of the Audubon's Shearwater, *Puffinus lherminieri lherminieri* Lesson, was found dead by J. Stuart McGiffin on the lawn of his home, some 4½ to 5 km north of Almonte, Ontario. The species is widely distributed (in eight subspecies) in the tropical Atlantic, Pacific, and Indian oceans. The nominate race breeds in the Lesser Antilles, Bahamas, Virgin Islands, and on Bermuda and wanders northward to Cape Hatteras, North Carolina, rarely to coastal Massachusetts.

How this pelagic bird was able to stray so far inland and so far north is not readily explainable. In reply to my query, Project Meteorologist William Hodge of the United States National Oceanic and Atmospheric Administration writes (9 October 1975) as follows: "I have looked through our hurricane track charts and weather maps and find that the indications are inconclusive. There were no remarkably strong weather systems moving from the Caribbean toward Ontario in the weeks just preceding September 8....Southerly winds of relatively short duration occurred in your area ahead of the low pressure systems that appear on the maps of September 1, 2, 6, and 8. Whether these were significant, I do not know.

"The only hurricanes from mid August to early September were Caroline and Doris. The latter can be ruled out immediately because it stayed east of longitude 50 degrees west. Caroline formed in the central Gulf of Mexico August 29, moved west-northwest, and dissipated over Mexico September 1."

Thus it is uncertain whether meteorological conditions were a major factor in carrying this bird so far outside its normal range. One must consider also the possibility that the bird might have been transported by human agencies as a hoax, but this can almost certainly be ruled out. Careful examination showed that the specimen was in very fresh condition, the plumage in excellent shape, the eyes, interior of the mouth, and the feet moist and soft with no drying out effects characteristic of preservation by freezing. The stomach was empty. The body showed no visible fat. There was a small contusion at the base of the foreneck, possibly indicating a collision in flight with hydro wires nearby. The McGiffin residence is on the west shore of the Mississippi River. The shearwater was doubtless attracted to, and probably following, this body of water. The above evidence in total thus makes it clear that no hoax was involved in this surprising record.

In size and coloration this specimen is referable to the nominate race. Colors of the soft parts were, eyes brown; bill, culmen blackish, most of remainder of bill bluish gray; legs and feet, grayish flesh except outer side of outer toe and outer side of tarsus bluish to bluish gray.

The specimen, a female, was donated in the flesh by Mr. and Mrs. McGiffin to the National Museum of Natural Sciences where it was prepared as a study skin (catalogue number 62529).

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Records of the American Painted Lady in Newfoundland

The American painted lady (*Cynthia virginiensis* (Dru)) (Lepidoptera: Nymphalidae) ranges from Nova Scotia to Mexico and Central America east of the Sierras (W. J. Holland. 1930. The butterfly book. Doubleday and Co. Inc., New York. p. 154.): it has not been reported from Newfoundland. The Canadian National Collection of Insects contains a specimen of *C. virginiensis* collected on Sable Island (R. F. Morris, personal communication). I here report on a number of observations on the species in Newfoundland.

On 11 September 1972 a butterfly, subsequently identified as an American painted lady, was observed sunning itself on a footpath in the Oxen Pond Botanic Park, St. John's, Newfoundland (47°34′ N, 52°43′ W) and another was photographed feeding on *Buddleia davidii* ('Mayford Purple') on 13 September in the same location. Sixteen days later another specimen showing almost no sign of wear was collected within 50 m of the first two sightings. These three specimens constitute the first records of *C. virginiensis* in Newfoundland. Another specimen was taken at Musgrave Town, Bonavista Bay, Newfoundland (48°24′ N, 53°53′ W) on 18 October 1972 (R. F. Morris, personal communication). Gregory (1975. Checklist of the butterflies and skippers of Canada. Lyman Entomological Museum and Research Laboratory, Ste. Anne de Bellevue, Quebec. 44 pp.) reports the presence of this species in Newfoundland without noting whether the specimen referred to was obtained from the mainland portion or the island portion of the province. This record undoubtedly refers to the observations noted above.

On 9 August 1975 on a headland at Ferryland, Avalon Peninsula (47°01′ N, 52°51′ W) I observed two (possibly three) American painted ladies in company with red admirals (*Cynthia atalanta* (L.)), Milbert's tortoise shells (*Nymphalis milberti viola* (dos P.)), and the painted lady (*Cynthia cardui* (L.)). Most specimens were feeding on the flowers of yarrow (*Achillea millefolium* L.), a widespread and common alien.

Another specimen of *C. virginiensis* was observed on 30 August 1975 at Bay Bulls, Avalon Peninsula (47°19′ N, 52°49′ W), feeding from the flowers of knapweed (*Centaurea nigra* L.), another widespread and very common alien species.

Cynthia virginiensis is a member of a family well known for its seasonal movement (Williams, C. B. 1958. Insect migration. Collins, London. 235 pp.); it is therefore possible that the above records are migrants. But one would expect such fragile migrants to show signs of wear. Of the six specimens observed by me, only one (that observed on 30 August 1975) showed signs of wear. These observations suggest that the specimens observed in Newfoundland were of local, rather than exotic origin.

The two species of painted ladies are somewhat different in size, markings, and color. The only reliable method of distinguishing the two species in the field, however, was to observe the number of spots on the underside of the hind wings. The painted lady has a row of four spots on each hind wing whereas the American painted lady has only two such spots.

It is suggested that the American painted lady occurs occasionally in Newfoundland, at least on the Avalon Peninsula. Its apparent anonymity is largely due to its close resemblance to the painted lady and the lack of field observers in the area.

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Courtship Feeding in Belted Kingfisher (*Megaceryle alcyon*)

This note summarizes an observation published previously in a regional journal (Hamel, D. 1975. Le nourrissage symbolique (courtship feeding) chez un couple de Martin-Pêcheurs (*Megaceryle alcyon*). Bulletin Ornithologique 20: 80–82). My search of the relevant literature did not reveal another account of courtship feeding in Belted Kingfishers.

On 28 May 1975 at 1300 hours EST, I was at Port-au-Saumon in Charlevoix County, Quebec, a hamlet 160 km northeast of Quebec City on the north shore of the Saint Lawrence River. The temperature was 20°C, the wind light from the northwest, and the sky cloudy.

Posted on the Port-au-Saumon pier, with a Zoom 20–45× telescope, I was watching a male Belted Kingfisher hovering near the shore. The tide was halfway in. The bird dived, disappeared under the brackish water, and came out with a fish, 8 to 10 cm long, in its beak. He flew to one of his favorite perches, an electric wire that spans the bay.

A female kingfisher, recognizable from its rusty pectoral band and sides, landed on the wire a short distance (between 2 to 3 m) from the male. She slid her feet along the wire to go nearer her mate, while he did the same. In doing so, the birds several times executed a 180° turn. When they were side by side, the male offered the female the fish, which she swallowed at once. The approximate duration of this courtship feeding behavior was one minute. The birds left their perch almost immediately. Because of the noise of the rapids, it was impossible to hear any vocalization.

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Buffalo Wolf (*Canis lupus nubilus*) Skeleton Discovered near Eyebrow, Saskatchewan

On 8 June 1973 the major portion of a wolf skeleton, later identified by the National Museum of Canada as the subspecies *Canis lupus nubilus* (C. G. van Zyll de Jong, personal communication), was exposed 16 km north of the town of Eyebrow, Saskatchewan. This subspecies of wolf disappeared from the prairies in the 1930s and the specimen represents the most complete skeleton located in Canada to date.

The coulee where the specimen was found is distinct from nearby coulees along the Qu'Appelle Valley. It is prominently dissected and wooded with many variably exposed ridges throughout. Eyebrow Lake is located at the base of the coulee. The excavation of a coyote (*Canis latrans*) den on a steep east-facing slope resulted in the collapse of the den site exposing a larger chamber 0.6 m in diameter. Soil texture varied between sand and sandy loam. This chamber appeared to be airtight and not connected to the coyote den, and the wolf skeleton was found inside, partially buried and lying on its right side.

The skeleton, believed to be an adult male, was in excellent condition. The following skeletal elements were collected: skull, a complete cranium with both mandibles; vertebrae, seven cervical including the atlas and axis, nine thoracic, five lumbar including three that were fused as a result of injury or disease, the sacrum, and four caudal; ribs, 20; forelimb, left scapula, left humerus, left radius, and left ulna; hindlimb, pelvis, proximal end of the right femur, left femur, left tibia, left fibula, left astragulus, left calcaneum, and three tarsals. In addition, there were three first phalanges, two second phalanges, one third phalanx, and a claw.

No wolf specimens have been recovered from Alberta that were verified as the subspecies *Canis lupus nubilus* (J. D. Soper. 1964. The mammals of Alberta. Hamly Press Ltd., Edmonton. 402 pp.). Two skulls, one stored in the Manitoba Museum of Man and Nature (catalogue number MMMN 372) and the other in the National Museum of Canada (catalogue number NMC 17574) have been documented as this subspecies of wolf. The former was shot near Morris, Manitoba in October 1943, and the latter was recovered from an Indian midden 16 km northwest of Silton, Saskatchewan. Silton is approximately 80 km east of Eyebrow. The skeleton of the Eyebrow wolf will be stored at the Saskatchewan Museum of Natural History, Regina.

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Concentration of Foraging Common Ravens along the Trans-Canada Highway

While traveling the Trans-Canada Highway (Lake Superior route) from Kenora to Wawa, Ontario, on 29 and 30 August 1975, we noticed an exceptional number of Common Ravens (*Corvus corax*) spread out almost uniformly along the highway. Although 307 ravens were counted along the road, we suspected that we missed many owing to their concealment in the trees along the highway. Most of the ravens we saw perched on trees (70%), some flew parallel to and away from the road (20%), and a few sat on the ground along the edge of the highway (10%). The distance we traveled while counting ravens was 945 km, meaning a Common Raven was seen on the average of about every 3 km. On five occasions ravens flew down to the road surface or its edge and picked up unidentified small birds apparently killed by passing vehicles. As it was fall migration, many birds were passing north to south over the east–west highway.

Previous observations by the junior author on Canadian highways during other seasons have indicated raven populations of a much lower density. In January 1970 and 1972 no concentrations of Common Ravens were observed along the Trans-Canada Highway between Thunder Bay and Sault Saint Marie, Ontario. There was no actual count of the ravens seen, but the number definitely did not exceed 50. Also, very few small birds were seen on the 1970 and 1972 trips except at Marathon, Ontario, where Pine Grosbeaks (*Pinicola enucleator*) were seen frequently from the highway on both trips.

Additional observations with no systematic counts were made on the upper peninsula of Michigan. During the winter of 1967–68 Common Ravens were seen frequently along a 100-km portion of Michigan Route 28, where they fed on Red Crossbills (*Loxia curvirostra*) that had been killed by cars. In contrast, during other winters when crossbills and other finches were scarce, ravens were almost absent from Michigan Route 28 and were seen mainly around town dumps (Adkisson, unpublished data).

Concentrations of Common Ravens have been reported in the past, typically in conjunction with food sources such as dumps (Dorn 1972; Brown 1974; Conner et al. 1975). These concentrations, however, are usually clumped and not distributed linearly as we observed on the Trans-Canada Highway in 1975 and in Michigan during finch invasions.

We suggest the possibility that Common Ravens were concentrating along the Trans-Canada Highway in order to feed on the migrant birds that were killed by passing vehicles. We further suggest that this behavior is not unique in this opportunistic species, but occurs whenever such food sources appear. The behavior might be expected during both spring and fall migrations.

We thank Kenneth O. Horner for his contributions to the manuscript.

Literature Cited

Brown, R. N. 1974. Aspects of vocal behavior of the raven (*Corvus corax*) in interior Alaska. M.Sc. thesis, University of Alaska, Fairbanks. 139 pp.

Conner, R. N., I. D. Prather, and **C. S. Adkisson.** 1975. Common ravens and starling reliance on sentinel common crows. Condor 77: 517.

Dorn, J. L. 1972. The Common Raven in Jackson Hole, Wyoming. M.Sc. thesis, University of Wyoming, Laramie. 65 pp.

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First Records of the Rock Vole (*Microtus chrotorrhinus*) and the Gaspé Shrew (*Sorex gaspensis*) from Nova Scotia and a Second Record of the Thompson's Pygmy Shrew (*Microsorex thompsoni*) from Cape Breton Island

A survey of the mammals of Cape Breton Highlands National Park, conducted from July to September 1974, yielded some noteworthy discoveries. Two Gaspé shrews (*Sorex gaspensis*) were captured on 1–2 August along a small stream on South Mountain. Six rock voles (*Microtus chrotorrhinus*) and one Gaspé shrew were collected 17–20 August in the Grande Anse Valley. A Thompson's pygmy shrew (*Microsorex thompsoni*) was trapped on 14 September in the Cheticamp River Valley and on 15–16 September three Gaspé shrews were caught in the same area.

The rock vole and the Gaspé shrew were previously recorded no closer to Cape Breton Island than the mountainous regions of New Brunswick (Banfield, A. W. F. 1974. The mammals of Canada. University of Toronto Press, Toronto and Buffalo. 438 pp.). The individuals of those species in Nova Scotia are members of an apparently relict population. The only other record for the Thompson's pygmy shrew from Cape Breton Island is of one collected by R. M. Anderson from Ingonish Centre in 1925 (Cameron, Austin W. 1958. Mammals of the islands in the Gulf of St. Lawrence. National Museum of Canada Bulletin 154, Biological Series 53. 165 pp.).

All mammals were collected during 500 trap-nights in each of the areas involved. Museum Special snap traps, spaced in pairs at 10-m intervals along a 500-m transect, were set for 5 consecutive nights. Bait used was a mixture of peanut butter, rolled oats, and cooking oil.

Two Gaspé shrews were trapped beside a small cool stream on the north side of South Mountain. Speckled alder (*Alnus rugosa*) was common along the stream, and tree species in the canopy included spruces (*Picea* spp.), white birch (*Betula papyrifera*), and balsam fir (*Abies balsamea*), with scattered red maple (*Acer rubrum*), striped maple (*Acer pensylvanicum*), and mountain maple (*Acer spicatum*). Herbs, ferns, and grasses were abundant along the edge of the brook. That is a preferred habitat, as elsewhere the Gaspé shrew has been taken from beneath mossy boulders along swift-flowing stream banks in spruce forests, a habitat similar to that of the water shrew (*Sorex palustris*) (Banfield, *op. cit.*). Other species captured along the stream during the same 500 trap-nights were nine southern red-backed voles (*Clethrionomys gapperi*), eight woodland jumping mice (*Napaeozapus insignis*), five masked shrews (*Sorex cinereus*), and five water shrews.

The rock voles and one Gaspé shrew were captured in a forest of mature sugar maple (*Acer saccharum*) and yellow birch (*Betula alleghaniensis*) along the north-facing slope of the Grande Anse Valley. All six rock voles were caught along a 50-m segment of the transect through that stand. That particular area differed somewhat from the surrounding forest: the canopy was more open, resulting in a larger number of shrub-sized striped maple and sugar maple, and brambles (*Rubus* spp.) and hazelnut (*Corylus cornuta*) were observed. The ground was broken rock, with boulders ranging from 0.5 to 2 m across, and covered with moss and scattered woodfern (*Dryopteris spinulosa*). That habitat is apparently typical for the rock vole. The first rock vole caught was a large female with seven placental scars. The other five animals, three males and two females, were all subadults and possibly from that litter of seven. Other animals trapped during the same 500 trap-nights were 73 southern red-backed voles, 35 masked shrews, 18 deer mice (*Peromyscus maniculatus*), 5 woodland jumping mice, 1 eastern chipmunk (*Tamias striatus*), and 1 short-tailed shrew (*Blarina brevicauda*).

The Thompson's pygmy shrew and three Gaspé shrews were caught in a forest of beech (*Fagus grandifolia*) and sugar maple on the south-facing slope over 300 m from the Cheticamp River, the nearest open water. The trap-line was at the base of a steep rocky hill where the substrate was broken rock covered with a heavy leaf-litter. Ground plants were scarce, woodfern and Christmas fern (*Polystichum acrostichoides*) being the most common. Pygmy shrews apparently prefer grassy areas, so that the area in the Cheticamp Valley would not be considered typical habitat for Thompson's pygmy shrew. The long-tailed shrew (*Sorex dispar*), which is closely related to the Gaspé shrew and is found in the Appalachian Mountains in Maine, inhabits cool, moist, dark, mossy talus rocks. Most specimens have been taken underground in talus slopes beneath rock outcroppings in dense forests (Banfield, *op. cit.*). Obviously the Gaspé shrew in Cape Breton can be found in similar circumstances. As well as the Thompson's pygmy shrew and Gaspé shrews, 1 woodland jumping mouse, 7 deer mice, 23 red-backed voles, and 26 masked shrews were trapped on the south slope of the Cheticamp Valley.

The assistance of C. G. van Zyll de Jong of the National Museum of Natural Sciences in identifying the specimens is gratefully acknowledged. The study was conducted under the auspices of the Canadian Wildlife Service for Parks Canada.

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Twin Fetuses in Woodland Caribou

No direct evidence of twinning in natural populations of caribou (*Rangifer tarandus*) has been reported (Egorov 1965; Kelsall 1968; Bergerud 1971; Parker 1972). Twinning has occurred, however, in captive forms of barren-ground caribou (*R. t. groenlandicus*) (McEwan 1971) and reindeer (*R. t. tarandus*) (Palmer 1934; Egorov 1965; Nowosad 1973).

On 29 March 1973, during biological investigations of caribou near Grand Rapids, Manitoba, a 4-year-old female woodland caribou (*R. t. caribou* Gmelin) was fatally wounded by an immobilizing dart. She was in good physical condition, antlered, and capable of lactating. Twin fetuses, a female and a male, were found *in utero* and the following measurements were recorded:

	Female	Male
Total length	654 mm	660 mm
Height to shoulder	426 mm	451 mm
Left hind foot	263 mm	274 mm
Tail length	64 mm	64 mm
Weight	3.47 kg	3.86 kg

The sexual dimorphism found here supports evidence reported by Bergerud (1975), Krebs and Cowan (1962), and Nowosad (1973) for fetuses and newborn calves of *Rangifer*.

McEwan and Whitehead (1971) stated that weight of calves at birth ranged from 4.5–5.9 kg. Thus, the caribou fetuses were well developed although calving probably would not have occurred until late May. Newborn calves with cows were observed in the same area on 28 May.

When first observed the female was in a group of 15 caribou, mostly cows and juveniles. A second caribou with "spike antlers" remained near the dead female until the carcass was removed. This young caribou was possibly her calf of the previous year. This is supported by biotelemetric studies of caribou near Reed Lake where yearlings and 2-year-olds tended to remain near their mother on summer and fall range.

Twinning suggests excellent breeding potential in a species occurring in low densities near the southern limits of its geographical range in Manitoba.

I thank Dr. W. O. Pruitt, Jr. for reviewing this note.

Literature Cited

Bergerud, A. T. 1971. The population dynamics of the Newfoundland caribou. Wildlife Monographs Number 25. 55 pp.

Bergerud, A. T. 1975. The reproductive season of Newfoundland caribou. Canadian Journal of Zoology 53(9): 1213–1221.

Egorov, O. V. 1965. Wild ungulates of Yakutia. English Translation, 1967, United States Department of Commerce, Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia. 204 pp.

Kelsall, J. P. 1968. The migratory barren-ground caribou of Canada. Canadian Wildlife Service Monographs Number 3. 340 pp.

Krebs, C. J. and **I. Mct. Cowan.** 1962. Growth studies of reindeer fawns. Canadian Journal of Zoology 40: 863–869.

McEwan, E. H. 1971. Twinning in caribou. Journal of Mammalogy 52(2): 479.

McEwan, E. H. and **P. E. Whitehead.** 1971. Measurement of the milk intake of reindeer and caribou calves using tritiated water. Canadian Journal of Zoology 49(4): 443–447.

Nowosad, R. F. 1973. Twinning in reindeer. Journal of Mammalogy 54(3): 781.

Palmer, L. J. 1943. Raising reindeer in Alaska. United States Department of Agriculture Miscellaneous Publication Number 207.

Parker, G. R. 1972. Biology of the Kaminuriak population of barren-ground caribou. Part 1: Total numbers, mortality, recruitment, and seasonal distribution. Canadian Wildlife Service Report Series 20. 93 pp.

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Some Winter Food Habits of Lynx (*Felis lynx*) in the Southern Mackenzie District, Northwest Territories

A collection of lynx (*Felis lynx*) scats was made in June of 1974 along seismic lines adjacent to the Kakisa River (60°31′ N, 119°41′ W) and Heart Lake (60° 45′ N, 116°37′ W). This study was incidental to an ecological study of marten (*Martes americana*) at the Heart Lake Biological Station from 1974 to 1975. A brief description of the terrain and vegetation may be found in Rowe (1972).

Fourteen scats from the Kakisa River area and four from Heart Lake could be dated to the winter of 1973–74. The scats were dried, broken apart, and prey remains identified. Mammal items could be readily recognized by hair characteristics (Adorjan and Kolenosky 1969), teeth, and claws. Feathers were keyed to order by the downy feather barbules (Day 1966).

Lynx were rare in both areas, possibly as a result of a low in snowshoe hares (*Lepus americanus*) following a high in the latter's population during 1971–72 (W. A. Fuller, personal communication). Other potential prey species, red squirrel (*Tamiasciurus hudsonicus*) and grouse (mostly Spruce Grouse, *Canachites canadensis*), were common.

Few studies of winter food habits from a comparable area have been published. Van Zyll de Jong (1966) reported findings in 52 digestive tracts from the

TABLE 1—Percentage of occurrence of food items in lynx scats from Kakisa River and Heart Lake, Northwest Territories

Prey species	Frequency of occurrence[a]		
	Kakisa River ($N = 14$)	Heart Lake ($N = 4$)	Combined ($N = 18$)
Mammal			
Lepus americanus	78.6%	100.0%	83.3%
Tamiasciurus hudsonicus	64.3%	25.0%	55.5%
Clethrionomys spp.[b]	7.1%	—	5.5%
Bird			
Galliformes	14.3%	25.0%	16.6%

[a] Calculated by dividing the number of scats containing the item by N and multiplying by 100.
[b] Found at interface of *C. gapperi* and *C. rutilus*.

southern Mackenzie District and Alberta collected in 1961–1963, a period when lynx and hare populations were high. His study showed a frequency of occurrence of 79% for snowshoe hare, 10% for meadow vole (*Microtus pennsylvanicus*), and 2% for red squirrel.

Nellis *et al.* (1972) reported prey items from lynx digestive tracts, kill sites from trailed lynx, and scats from central Alberta during winters of 1965–1969 when lynx and hare populations were low. Of biomass consumed, 79% was snowshoe hare, 9% was Ruffed Grouse (*Bonasa umbellus*), and 3% was red squirrel.

In this study (see Table 1) the frequency of occurrence of snowshoe hare (83.3%) was comparable to that of other studies, although that of grouse (16.6%) was only slightly greater than previously reported. That of red squirrel (55.5%), on the other hand, was considerably greater. This tendency may indicate a shift by lynx to a buffer prey species during a low in its major prey. As Nellis and Keith (1968) have demonstrated, however, prey numbers may not be the only consideration in lynx utilization of hares. Snow conditions, particularly supporting strength, and the consequent effect on ease of movement by predator and prey is also important. Snow data is available for this study (W. A. Fuller, unpublished data) but, as the period concerned covers only one winter and is not a comparison, it is not included.

Funding for this study was provided by grants from the Canadian Wildlife Service and National Research Council of Canada to W. A. Fuller; I thank them for this support. A. M. Martell and W. A. Fuller kindly provided constructive criticism of this paper.

Literature Cited

Adorjan, A. S. and **G. B. Kolenosky.** 1969. A manual for the identification of selected Ontario mammals. Ontario Department of Lands and Forests Research Report (Wildlife) 90. 64 pp.

Day, M. G. 1966. Identification of hair and feather remains in the gut and faeces of stoats and weasels. Journal of Zoology 148: 201–217.

Nellis, C. H. and **L. B. Keith.** 1968. Hunting activity and success of lynxes in Alberta. Journal of Wildlife Management 32: 718–722.

Nellis, C. H., S. P. Wetmore, and **L. B. Keith.** 1972. Lynx-prey interactions in central Alberta. Journal of Wildlife Management 36: 320–329.

Rowe, J. S. 1972. Forest regions of Canada. Canadian Forestry Service Publication 1300. 172 pp.

Van Zyll de Jong, C. G. 1966. Food habits of the lynx in Alberta and the Mackenzie District, NWT. Canadian Field-Naturalist 80: 18–23.

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Scott's Oriole near Thunder Bay, Ontario

An adult male Scott's Oriole (*Icterus parisorum*) was observed on 9 November 1975 at Silver Islet Landing, approximately 30 km ESE of Thunder Bay. The bird was first noted by Jessie Rolandson, Carl Rose, Hector and Vi Shanks, and Margaret Stevenson on a lawn beside a summer cottage near the base of a cliff within 150 m of the open waters of Lake Superior. The bird was photographed at a distance of about 8 m by Arne Maki who used a 350-mm lens. The oriole was disturbed and flew out of sight behind a row of private camps. Later the same afternoon other members of the Thunder Bay Field Naturalists on the field trip returned to the area, and Douglas Asquith and Beth Hunter saw the bird and noted details of the plumage.

The bird was bright lemon-yellow in color except for the black head, chest, back, wings, and the central portion and tip of the tail. Several observers referred to the tail pattern as the reverse of that of a Northern (Baltimore) Oriole. The bird was about the size of an Evening Grosbeak. The beak was long and pointed. The next day there was a heavy snowstorm and the bird was not seen on subsequent visits to the area.

Scott's Oriole is a summer resident of the southwestern United States and Mexico. It winters south of the American border. Recent casual records include an immature Scott's Oriole banded at Duluth, Minnesota, on 23 May 1974 (Sundquist, K. 1975. Scott's Oriole banded in Duluth. Loon 47(1): 22–24).

The developed film slides were shown to John P. Ryder, Lakehead University, who confirmed the identification. Readily identifiable duplicate slides were forwarded to W. Earl Godfrey, National Museum of Natural Sciences, and to Clive E. Goodwin, chairman of the Ontario Ornithological Records Committee. This is the first known record of Scott's Oriole in Canada.

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Toponymy as a Tool in Biogeography: An Example from Newfoundland

Toponymy can be a helpful tool in biogeographical research, especially in tracing the history of local biotic communities. Place names that indicate past environmental conditions or catastrophic events may be particularly important when written reports of such events are non-existent, and when field evidences are obliterated (Seibutis 1974). An illustration of such circumstances may be found in the Notre Dame Bay area of northeastern Newfoundland.

Northeastern coastal Newfoundland has a marine-modified subarctic type of climate (Koeppen's Dfc)[1] capable of supporting a well-developed northern coniferous forest. The various climate/vegetation relationship formulae (e.g., see Mather and Yoshioka 1968), or the forest productivity indices (e.g., the Paterson's "Climate, Vegetation, Productivity Index" (Lemieux 1961)), indicate that the vegetative cover of the area should be a forest. The present vegetation, however, exhibits a "patchy," contrasting character from one place to another, and from one island to another: the boreal forest of Rowe's type B29 (Rowe 1972), barrens, and intermediate vegetation types are dispersed in an emulsion-like pattern. It cannot be correlated either with the very slight climatological differences, or with the variations in soils. Detailed research, however, has indicated that the main environmental factor responsible for this condition is fire (Mednis 1971). Although direct evidence of past vegetation fires appears only sporadically, and written reports are very few, numerous place names, including those of some of the presently forested places, indicate that fires have occurred in the area, in some instances even centuries ago.

Of the total of 448 geographic names that appear on the Botwood sheet (2E) of the Canadian National Topographic System maps (1:250 000), there are at least 43 place names (or 9.6%) referring to fires (see Figure 1). As a part of a place name, the term "burnt" is the second most frequently used term (after "wild") in this area. "Burnt Head," for example, is used for seven different places, three of them located on Long Island, only 1.5 to 2.4 km apart.

In some instances the place name infers the degree of the burn, as for example, "Coal All Island" and "Cinder Island," located approximately 1 km apart (see Figure 1, inset); they contrast with the adjacent "Green Island." Some names may even lead to the identification of the type of vegetation burned, as, for example, "Alderburn," whereas others, indicating the seral stages of post-disturbance recovery of the northern coniferous forest, may be interpreted as inferring to former vegetation fires. Names like "Birchy Bay" and "Aspen Cove" belong to this group.

In the case of the Notre Dame Bay area, the linguistic origin of the place names may reflect the sequence of frequenting and settling of the area, and, consequently, the approximate age of the fire. The first Europeans to leave place names in this area were the Portuguese, who have frequented it since the beginning of the 16th century. They were followed by the French and the English.

The more prominently located coastal features

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[1] The Dfc type is characterized by the average monthly temperature for the coldest month between -3° and -38°C; with 1 to 4 months averaging above 10°C; and with precipitation evenly distributed throughout the year in sufficient amounts to supply moisture for a forest vegetation (Blüthgen 1964).

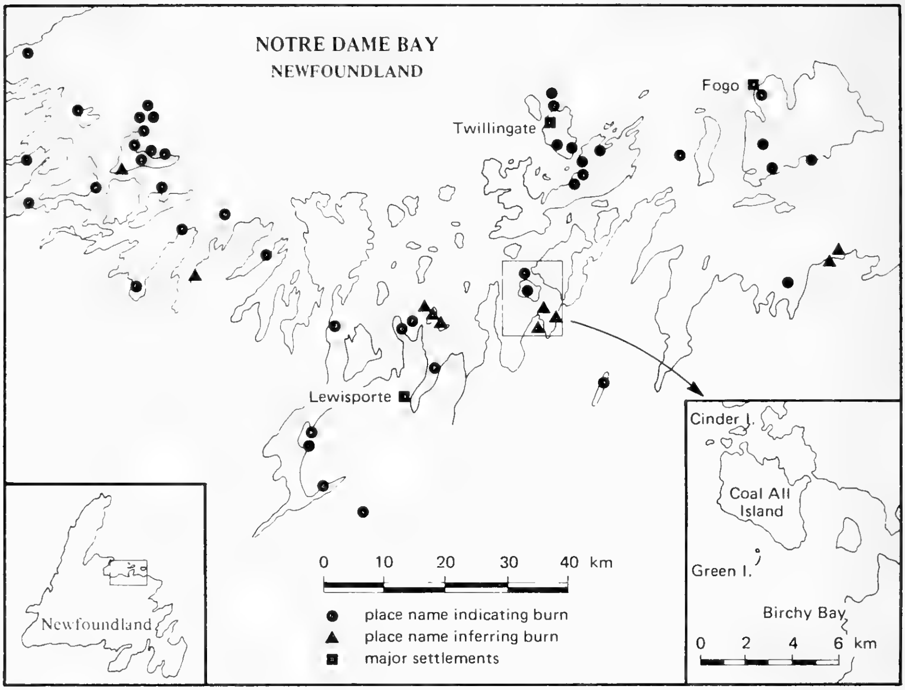

FIGURE 1. Location of place names referring to fires.

facing the open Atlantic were discovered and named earlier than those located deeper in the bay. Hence the name of the largest island at the entrance to the bay, Fogo Island, is one of the oldest place names in Newfoundland. It first appears as y:do fogo (Fogo Island) on a map drawn by Pedro and Jorge Reinel in or before 1519, and it means "Fire Island" in Portuguese. "Cap Brulé"[2] (Burnt Cape) near the western entrance to the bay is of French origin, and, consequently, not as old as the names of Portuguese origin. It should be noted, however, that even most of the English place names are relatively old, probably originating about the time the first English fishermen frequented and settled the area at the end of the 17th century. Several "Burnt Islands" and "Burnt Heads" appear on the earliest sea charts of the area, surveyed by Michael Lane in about 1785, and by Frederick Bullock in 1826[3].

Place names, at best, are only indicators reminding the researcher to consider the possibility that vegetation fires may have occurred in a given area. Only a more detailed field investigation can properly appraise the actual role of the fire in development of local vegetation types and their distribution.

Literature Cited

Blüthgen, J. 1964. Allgemeine Klimageographie. Walter de Gruyter and Co., Berlin. 599 pp.

Lemieux, G. J. 1961. An evaluation of Paterson's CVP Index in eastern Canada. Canada Department of Forestry, Forest Research Branch, Technical Note Number 112. 11 pp.

Mather, J. R. and **G. A. Yoshioka.** 1968. The role of climate in the distribution of vegetation. Annals of the Association of American Geographers 58(1): 29–41.

Mednis, R. J. 1971. A phytogeographical analysis of the occurrence of vegetation patterns on Fogo Island, Newfoundland–Labrador, Canada. Ph.D. thesis, Boston University. 173 pp.

Rowe, J. S. 1972. Forest regions of Canada. Department of the Environment, Canadian Forestry Service Publication Number 1300. 171 pp.

Seibutis, A. A. 1974. Paleogeography, toponymy and ethnogenesis. Izvestiya Akademii Nauk SSSR Seriya Geograficheskaya 1974(6): 40–53.

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[2] Cape Brulé is the approved name of the Canadian Permanent Committee on Geographical Names

[3] Both charts are in the Public Archives of Canada, Ottawa.

Canada Geese Killed during Lightning Storm

On the afternoon of 28 August 1975, my wife and I observed the unusual death of six Canada Geese (*Branta canadensis*) during a prairie lightning storm. Six Canada Geese were observed flying over the Bill White ranch approximately 15 km southwest of Maple Creek, in the Cypress Hills region of southwestern Saskatchewan. A violent lightning and thunder storm was in progress at the time. During a particularly bright flash of lightning, the geese, which were flying at an elevation of 150–200 m, were observed plummeting to the ground. They appeared to be unconcious as they fell since there were no wing beats or struggling during the fall.

We immediately retrieved the geese. Although all the birds had multiple skeletal fractures as a result of the fall, there was no external evidence of damage. A detailed necropsy was not conducted. The flock consisted of two adult birds, a male and female, and four juvenile birds. The adult male wore a band numbered 638-45497. Subsequent data from the band return indicated that the bird was banded, as a young-of-the-year in 1965, some 50 km to the east of where it was killed.

It is interesting to consider how mortality such as we observed would occur. It is known that a gradient of electrical energy forms around a lightning discharge, the intensity of the field becoming less as the distance from the charge increases. The gradient can be relatively steep, so that a sizeable current can be set up within a conductor over a span of less than a metre. Although it is conjecture, it is possible that the geese were within an area of gradient of sufficient intensity to induce a fatal current. It is also possible, but less probable, that the birds were affected by the concussion of the immediate thunderclap.

The death of birds as a result of lightning is not well documented in the literature. Its occurrence is likely rare, and of very little significance in terms of mortality of any bird species.

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Range Extension for the Brown Bullhead in Manitoba

Towards the end of a recreational canoe trip on the Bloodvein River system between Red Lake, Ontario, and Lake Winnipeg, Manitoba, two fish that were encountered nowhere else on that system were caught in a single pool. Measurement particulars and color photographs enabled them to be identified as brown bullheads, *Ictalurus nebulosus* (Lesueur), from keys and descriptions given by W. B. Scott and E. J. Crossman (1973. Freshwater fishes of Canada. Fisheries Research Board of Canada, Bulletin 184).

Diagnostic criteria used for separating them from similar species included their total lengths of 22 cm and 38 cm, their unmarked coloration of muddy-brown above and gray-brown below, and their unforked caudal fins. Of particular interest were the three stout spines forming the first ray of the dorsal and pectoral fins, and the ability to lock these in an erect position.

Occurrence of this species is unrecorded in Manitoba north of the mouth of the Red River, at the southern extremity of Lake Winnipeg. The northwestern limit of its known range is the Whitesand-Assiniboine system in Saskatchewan, at about the same latitude as the present record (Scott and Crossman, *op. cit.*). One specimen was taken on the evening of 14 August 1975 and the other in the morning of 15 August in a pool at 51°30′ N, 96°10′ W. It was about 80 km upstream from the mouth of the Bloodvein River, above five significant falls and many rapids. Discussion with natives of the area revealed a familiarity of long standing with the fish, so this is probably not a new invasion but simply a previously unrecorded population.

We thank A. Kooyman for confirming the identification.

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News and Comment

Canadian National Directory of IBP Areas, Second Edition 1968–75

The second edition of the National Directory will be available by 1 July 1976.

The National Directory is a condensed compilation of the ecological check sheet surveys of National and Provincial Parks, ecological reserves, natural areas, wildlife refuges, and unprotected wildland areas on public and private lands completed under the auspices of the Conservation Subcommittee, Canadian Committee for the International Biological Programme (CCIBP/CT) and its successor, the Associate Committee on Ecological Reserves, National Research Council of Canada (NRCC/ACER). The first edition contained 965 individual summary sheets; the second contains an additional 363 sheets. The directory is published in an unbound 22 × 28 cm notebook format; it is divided into 10 geographic regions, each with an accession list, with an introduction and guide for potential users. It can be purchased complete or as regional separates. Owners of the first edition may obtain supplements for either the complete directory or separate regions.

Price of the Second Edition, complete, is $50.00; price of the Supplement, complete, is $15.00. Accession lists of surveyed areas (included in above prices) may be obtained at $3.00 for Canada and $0.50 per region. Individual summary sheets are $0.25 each. All prices quoted include handling and mailing by parcel post in Canada. USA purchasers please add $1.00 per order; other foreign purchasers will be billed for extra costs.

		Number of summaries and price	
	Region*	Second edition	Supplement
1	British Columbia	218 ($11.00)	80 ($ 4.00)
2	Alberta	197 ($10.00)	50 ($ 2.50)
3	Saskatchewan	111 ($ 5.50)	N/A **
4	Manitoba	61 ($ 3.00)	N/A
5	Ontario	483 ($24.00)	217 ($11.00)
6	Quebec	25 ($ 1.50)	8 ($ 1.00)
7	Maritimes: NB, NS, PEI	116 ($ 6.00)	N/A
8	Newfoundland	67 ($ 3.50)	N/A
9–10	Arctic and Subarctic: NWT, YT	50 ($ 3.00)	8 ($ 1.00)

* Defined on provincial and territorial boundaries.
**N/A indicates no additions since first edition.

Ontario Bluebird Nest Boxes

In 1976 there were over 100 pairs of Eastern Bluebirds using nest boxes erected by L. A. Smith. This success comes after 10 years of work, expenses over $1000 for timber, nails, screws, paint, and galvanized steel sheet and tubing, and the erection of 500 boxes. If you or a group are operating a nestline trail and would like to share your problems and discuss possible remedies, write to Mr. L. A. Smith, 481 Vaughan Road, Apt. 207, Toronto, Ontario M6C 2P6.

NOTICE

Extra copies of the special **Raptor issue** of *The Canadian Field-Naturalist,* Volume 90 (Number 3) 1976 are available from The Business Manager, *The Canadian Field-Naturalist*, Box 3264, Postal Station C, Ottawa, Ontario K1Y 4J5 at a cost of $4.00 plus $0.27 postage.

Copies of the special **Peregrine Falcon issue**, Volume 84 (Number 3) 1970 are also available from The Business Manager at a cost of $3.00 plus $0.27 postage.

SPECIAL THANKS

The Publications Committee of The Ottawa Field-Naturalists' Club acknowledges with special thanks the contributions of the **National Research Council of Canada** and **The Canadian National Sportsmen's Show** toward the publication of this volume.

Book Reviews

ZOOLOGY

Atlas of Eastern Canadian Seabirds

By R. G. B. Brown, D. N. Nettleship, P. Germain, C. E. Tull, and T. Davis. 1975. Information Canada, Ottawa. 220 pp. $6.75 in Canada; $8.10 other countries.

This important, technical contribution is "to bring together and summarize basic information on the ecology and pelagic and breeding distributions for the seabirds of the Gulf of St. Lawrence, the Atlantic Provinces and the eastern Canadian Arctic." The objective is realized by a review of the literature on pelagic seabird distribution in the northern Atlantic and the results, to date, of the PIROP (Programme Intégré de Recherches sur les Oiseaux Pélagiques) studies initiated by Brown and Germain in 1969 and the Canadian Wildlife Service's "Studies on northern seabirds" also started in 1969 under the direction of Nettleship.

The *Atlas* is divided into five sections:

1. Quantitative observations on seabirds: the background to the Atlas maps. Here we are introduced to the Smithsonian Institution Pacific Ocean Biological Survey Program (POBSP) method of collecting ornithological data at sea. Various parameters including the numbers of birds seen at each sighting, time of sighting, ship's position, birds' plumage and behavior, weather, and ocean conditions are coded for computer analysis. The authors adequately qualify their slight modification to the POBSP system and explain its inherent biases. The *Atlas* maps are of three formats: quantitative, rarebird, and colony. The quantitative maps are of two types, one series showing the average number of birds seen per 10-min watch under good conditions, and effort maps which depict the number of acceptable 10-min watches on which the average number of birds was based. The rarebird maps are based on the frequency of positive sightings, not population size, for the less common species (e.g., Atlantic Puffin, *Fratercula arctica*) and those species which are hard to separate at sea (e.g., Thick-billed and Common Murres, *Uria lomvia* and *U. aalge*). Colony maps show the location of breeding colonies mostly from Nettleship's aerial surveys between 1967 and 1974.
2. The oceanography of the northwest Atlantic and the eastern Canadian Arctic. This section maps and discusses, with references, the main current systems, average extent of ice cover, limit of drift ice, and oceanographic zonation within the survey area.
3. Factors influencing the breeding ranges of seabirds. This is an interesting but far too brief one-page summary of elements which are known to limit seabird distribution. Valuable references are cited for detailed studies of seabird ecology.
4. Seabird vulnerabilities: the use of the Atlas in environmental impact studies. This chapter includes six maps showing breeding colonies and pelagic concentrations of seabirds on a seasonal basis. Its value will lie in aiding those involved in assessing the potential consequences of oil spills at different times of year. The maps are based on Murre and Dovekie (*Plautus alle*) pelagic distributions, Nettleship's observations in the vicinity of Devon Island in 1972, and 492 locations of colonies of 10 species.
5. Seabird distributions: species summaries. The bulk of the *Atlas* is in this portion. Both descriptive (text) and quantitative (map symbols) information is presented on the breeding and pelagic distributions of 39 species. Ten tables show individual colony location (name), position (coordinates), size (population), census year, and an authority for 10 species.

The report *is* an atlas which, according to my dictionary, is a book of maps. Of the 220 pages, 139 (63%) are devoted to 282 maps. Twenty-nine pages contain tables only (not including two appendices detailing the PIROP coding system and lists of seabird records not included on any map because of the sparsity of observations) and one page is a non-map figure explaining the map symbols. There are 165 references of which 157 are available in published form. The 28 pages of text are consisely and professionally written. The format is similar to the familiar *Report Series* published by the Canadian Wildlife Service. The pages measure 8½ × 11 inches and are bound by soft cover. There are no pictures. A disturbing characteristic of the *Atlas* is the amount of unused paper. Five of the 220 pages are blank! Seventy pages are only half filled or less. For example, on page 160 the map of Razorbill (*Alca torda*) distribution takes up only 19% of the usable area on the page. On page 191 only 14 lines of text are placed in the left-hand column. The two maps on page 192 could have been placed on page 191 under the scant textual material. In times of fiscal restraint this format seems wasteful. One redeeming factor, however, is the ample room for notes to modify the maps.

Together with the Canadian Wildlife Service's *Arctic Ecology Map Series* (1972) and the recent IBP's *Ecological Sites in Northern Canada* (1975), this *Atlas* should be required reading for business concerns and government to help effectively safeguard ecologically important and sensitive areas. Additionally, the authors point out that the material can be used as a guideline for pure research into the badly overlooked discipline of pelagic ornithology. Although the price is reasonable, the technical nature of the *Atlas* will not likely appeal to the general readership.

The publication is dedicated to three pioneers of seabird ecology: Finn Salomonsen, Leslie M. Tuck, and V. C. Wynne-Edwards.

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Where to go Birdwatching in Canada

By David Stirling and Jim Woodford. 1975. Hancock House Publishers, Saanichton, British Columbia. 127 pp. Paper, $3.95.

This small paperback (18 × 11 cm), according to the back cover, purports to be "a guide to hundreds of special locations across Canada where great birding can be expected." A 12-page introduction fleetingly discusses such topics as "Field Guides," "Bird Check Lists," "Binoculars," and "Photography." The main part of the book (77 pages) is a list of outstanding localities for bird-finding, province by province, but the coverage is very uneven; twenty pages are devoted to British Columbia, but Quebec is dismissed in five pages, and Manitoba in four. The book also includes a list of "Bird Clubs" (although one wonders if the "Dogwood Canoe Club" and "Trail Riders of the Canadian Rockies" qualify under this heading), a summary of results from the 1972 Christmas Bird Count (year not stated), and regional bird check-lists for the four major regions of Canada. British Columbia is again favored in the latter two sections; for British Columbia, but not for other provinces, unusual species seen on Christmas Counts are listed, and abundance symbols are given in the bird check-list.

One need not look far to find many errors in the book, especially in names of birds. These include misspelled names like "Black Oyster Catcher" (p. 9) and "Gyr Falcon" (p. 29), long-obsolete names like "American Egret" (p. 70) and "Atlantic Puffin" (p. 89), and even howlers like "Steller's Blue Jay" (p. 31) and "Yellow-throat Warbler" (p. 78). The "Common Guillemot" on page 88 will be better known to Canadian readers as a Common Murre. Pages 73 and 74 appear to have been transposed. The text contains numerous incorrect statements, such as "Over ninety-five per cent of the bird species found in Canada have been recorded in British Columbia" (p. 23). The regional check-lists are best ignored, as each omits numerous species and includes others not recorded from the region in question.

One good feature of the book is the 78 attractive black-and-white photographs which are scattered through the text. But it seems redundant to have six photographs (on different pages) of Bald Eagles, four each of Common Murres and Canada Geese, and three of Common Puffins. A photograph of a Ruby-crowned Kinglet caught on a burdock (p. 65) is an interesting curiosity, but out of place in a bird-finding guide.

Parts of this book have been reprinted from the four-part series "Birds of North America," reviewed earlier in this journal by L. L. Goulden, C. A. Campbell, and I. A. McLaren (Canadian Field-Naturalist 88: 379–380, 1974). Many of the criticisms levelled by these reviewers are also applicable here.

My main criticism of the book is that, in addition to its many errors, it is simply much too brief to be of any great value to anyone. For example, Point Pelee, which the authors dismiss in eleven lines, probably deserves a three- or four-page account, with lists of particular species to look for at different times of year, and specific directions on how to reach the area, where to stay, etc. In short, what is needed is a book which covers Canada the way O. S. Pettingill's two bird-finding guides cover the United States, or at least regional guides like James A. Lane's excellent "Birder's Guides" to southeastern Arizona, southern California, and other areas. Stirling and Woodford's book is admirable in its aims, but a much more detailed and comprehensive account will be required to be of any real help to the Canadian birdwatcher with an itchy foot.

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Birds of the Kananaskis Forest Experiment Station and Surrounding Area: an Annotated Checklist

By John M. Powell, Tom S. Sadler, and Margaret Powell. 1975. Environment Canada, Canadian Forestry Service, Northern Forest Research Centre, Edmonton, Alberta. Information Report NOR-X-133. 36 pp., paper. Available free.

Based largely on the authors' personal observations from 1962 through 1973, this slim volume presents a briefly annotated list of 139 bird species observed on the Kananaskis Forest Experiment Station, located on the east slopes of the Rockies about 65 km west of Calgary. A four-page introduction briefly describes the study area and outlines the sources of records included in the report. In addition to the main bird list, two supplementary lists are also given: one includes 51 additional species recorded from the area immediately surrounding the Station (Canmore east to the Stoney Indian Reservation), and the other includes a further 35 species recorded from nearby areas such as Banff to the west and Cochrane to the east, and which could possibly occur on the Station. I found the presentation of three separate lists a trifle inconvenient; it might have been simpler to give one list, and indicate birds on the first and second supplementary lists by asterisks, daggers, or other such symbols.

I was surprised to find no mention in the list of references of Clarke and Cowan's paper on the birds of Banff National Park (Canadian Field-Naturalist 59: 83–103, 1945), which, though now dated, is probably still the most useful paper on birds of the surrounding area. A map of the study area would have been helpful, and I would also have appreciated a brief discussion (similar to that of Clarke and Cowan) comparing birds at the Experiment Station with those from areas immediately to the east and west, for the avifauna in this region changes rapidly in a short distance. Nevertheless, these criticisms are minor, and the authors of this report have made a valuable contribution to our knowledge of Alberta birds.

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Reptiles and Amphibians of Australia

By H. G. Cogger. 1975. Reed, Sydney, Australia. (North American distributors: Tuttle, Rutland, Vermont). 584 pp, 786 figures, 664 maps. $44.50.

Many excellent books have been published on the mammals, birds, reptiles, and amphibians of Australia. Now for the first time since Boulenger's monographs (1882–1896), Dr. Cogger has produced a work which includes all the known species of reptiles and amphibians from that continent. This publication will be welcomed by scientists and naturalists alike.

This splendid book is of quarto size, with the dust jacket in full color. The binding and paper appear to be very good quality. The front end papers usefully present a map of Australia giving the more important place names, and the back end papers depict the climatic zones and vegetation.

The text begins with preface and acknowledgments. The introduction (pp. 13–34) contains information on the following: descriptions, zoological names, common names, distribution, habitat, subspecies, making an identification, conservation and protection, location of specimens, collecting methods, preservation of specimens, captive specimens, snake bite and treatment. The remainder of the text (pp. 35–429) deals with the orders, families, genera, and species of amphibians and reptiles. The glossary (pp. 563–567) is useful. There is also a good selected reference list and index.

The entire work is well planned and is the result of many years of field work and research. About 664 species are described (136 amphibians and 528 reptiles). There are 786 excellent photographs which show most of the species. Of these, 192 are in full color, and the 594 black-and-white are on a plain but similar background.

Keys to families, genera, and species are given. These seem quite adequate for the scientist or naturalist, and there are detailed photographs to check when one is working with keys. There is a paragraph or two dealing with each family and genera; also a range map for each species is included.

The description of each species contains the common name, scientific name, and figure number where the photographs may be located. The description is based mainly on color, with the exception of certain pertinent characteristics such as smooth or granular skin, teeth, webbed or unwebbed toes. There is a short note on distribution; and the metric system is used throughout the text. Under "habit," mention is made if the species is found in a wet or dry area, also other particulars. Subspecies are dealt with very briefly (under the species) with a word or two on their distribution. Cogger states, "Where a subspecies has not received universal or unequivocal acceptance it is not listed." The reviewer has not totaled the subspecies but certainly the number is sizeable. A checklist of the species and subspecies would have been useful; however, owing to space limitations, and the fact that a "primary checklist of Australian reptiles and amphibians" is to be published soon by the Australian Museum, the inclusion of a checklist would simply be a duplication.

In the higher classification of frogs of Australia Cogger follows convention and uses Leptodactylidae and Hylidae instead of a recent proposal which would place the Australian leptodactylids in the family Myobatrachiadae, and the hylids in Pelodryadidae. Should one be looking for the genus *Hyla* in Australia it will no longer be found; the frogs are there as always, but under the generic name *Litoria*. The work on crocodiles, turtles, lizards, and snakes is well organized, with one family of crocodiles, four of turtles, five of lizards, and six of snakes being recognized.

Few, if any, works covering such a large area as Australia will be entirely free of minor errors. No doubt the extensive use that this publication will receive, both in the library and in the field, may bring several to light; for example, Cogger (p. 35) uses "Apoda" when referring to the caecilians, though the now generally accepted name for that order is Gymnophiona.

Because of the large size, this book is primarily for library use; however there is little doubt that it will be used in the field as frequently as in the library. Certainly for field work in Australia this would be the book to consult first. For one's own bookshelf and libraries generally, it is a must for anyone interested in Australian herpetology.

Dr. Harold Cogger, Curator of Reptiles and Amphibians, Australian Museum, is to be congratulated on this magnificent and monumental work. It will be a major reference source for many years.

STANLEY W. GORHAM

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The Life of Birds

By Joel Carl Welty. 1975. Saunders, Philadelphia. 2nd Edition. 623 pp. $18.50.

There have been extensive ornithological developments in the 13 years that have elapsed since the first edition of *The Life of Birds*. To gain a comprehensive overview of these developments for the revised edition, Welty consulted 6000 references, most of them published since 1960. I believe that the new expanded volume (77 more pages including one new chapter, wider and longer pages, and $18.50 compared with $9.00) maintains its usefulness to the nonprofessional and professional by presenting the basic facts of bird biology in an enthusiastic style.

Since the first and second editions have been reviewed in several ornithological journals (e.g., Wilson Bulletin, 1963, Volume 75: 284–285; Auk, 1965, Volume 82: 113–114; Bulletin of the Texas Ornithological Society, 1975, Volume 8: 12; Bird-Banding, 1976, Volume 47: 88–89), I will only summarize my major criticisms, which have been adequately discussed previously. The chapter on evolution contains imprecise and poorly stated sentences, several text statements need citations, and throughout the text, inconsistent and misleading statements dealing with detail need clarification.

All graphics and photographs in the revised edition maintain their attractiveness although the paper appears to be of lower quality. The use of many photographs of worldwide birds is especially refreshing. The reworking of the family tree of birds is an improvement. Common names of North American birds do not reflect recent changes adopted by the American Ornithologists' Union and at times usage is inconsistent. *Turdus migratorius* is alternately called American Robin and Robin throughout the book.

Having used the first edition extensively in my introductory ornithology course and in later years, I am positive that the second edition with all its breadth and overall completeness will continue to be used by ornithological students, both in and out of the classroom, to understand the life of birds.

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Mountain Sheep and Man in the Northern Wilds

By Valerius Geist. 1975. Cornell University Press, Ithaca, N.Y. 248 pp. $10.

In recent years, biologists have become more committed than ever to analyzing the past, present, and future social, economic, and environmental circumstances of man which might collectively be termed the "human condition." Thankfully, social comment is no longer the sole realm of sociologists and philosophers. The unique perspective that biologists bring to analyses of the human condition is the rich data base they possess of other species from which important comparisons are made. Valerius Geist's new book is not pessimistic. It is not optimistic either. It is an even-tempered, clear, and important narrative of the functions of behavior and communication in two groups, sheep and man. And it is much more.

Here is the situation in which the author uses an extensive and quite obviously intimate knowledge of the ways of Stone's sheep as a basis for some very constructive dialogue on the human condition. Geist's study of sheep began in the early 1960s on the Spatzisi Plateau area of Northern British Columbia (now a 2-million-acre provincial park). He describes well the vicissitudes of the lonely vigil any careful observer must suffer. We get a compelling description of the Spatzisi, and of its inhabitants, human and otherwise. Eventually we are introduced to Stone's sheep, and follow their lives as Geist observed them. A technical account of these observations can be found in his *Mountain Sheep: A Study in Behavior and Evolution* (University of Chicago Press, 1971).

A long chapter on animal combat and communication discusses the formidable equipment the rams carry on their heads, with which they parcel out resources. Geist disposes of the comfortable myth that holds that animal combat is "ritualized" to the point where some sort of mutual altruism protects the combatants from serious injury. "In a dangerously armed species, that is, mountain goats, bears, and most carnivores, the opponent who is heedless about launching into battle faces prompt and certain retaliation" (p. 93). This apparently selects against actual fighting except where it is unavoidable, and then injury or death does occur. Geist makes some interesting remarks about aggression, violence, and sex. He alludes to the possibility that our apparent fascination with violence (no matter how much we decry it) may be misplaced sexual energy, and relates certain basic human satisfactions to a well-done aggressive act.

Next Geist explores status-seeking behavior in sheep and man. This discussion sweeps from the mountains of British Columbia to the corporate board rooms of Toronto or Montreal. He is setting us up for what is to follow, of course, but meanwhile we get an immediate sense of real life as the biologist sees it. Creatures do what they do because they must. Period. Geist is not dogmatic about what proportion of our behavior is learned or innate, and his argument would leave Skinnerians thumbing back through their sources. The Spatzisi is no Walden Two perhaps, but it cradled some insights that go well beyond freedom and dignity.

The last third of the book is given over mostly to a discussion of the human condition. Geist argues that co-operation and communication in *Homo sapiens* must have evolved in cold periglacial climates, because only a harsh environment could produce intelligence as an adaptive strategy. And clearly intelligence is an evolutionary experiment that may have an unpleasant (for us) result. Periglacial man then reinvaded the warm climates eventually to foster the first civilizations. This proposition is tantalizing and requires some unravelling. A long discussion of modern society, complete with sex-role definition and the behavioral consequences of alienation is the real pith of the book. The whole point is that man is undeniably part of Nature, but the full implications of this fact seem to have evaded our collective psyche. The *full* implications are hardly redeeming to the present conventional social context. Creatures do what they do because they must. But man does what he wants. The consequence, according to Geist, is an "anti-society" based on anti-nature life styles, irrational needs, alienation, and various other social pathologies. The power of this argument is the book's greatest strength.

It is difficult to be critical of the book. I was disappointed to see it published outside of Canada; and the photographs did not reproduce well on the yellow paper used. Although the book is non-technical narrative, sufficient biology and theory is present to warrant an index. The ever-present trap of over-anthropomorphizing his subjects was avoided for the most part, even though the sheep may have "bovimorphized" him! The main themes are woven together against a charming tapestry of a warm, personal story and humorous anecdotes. Geist writes surpassingly well. This book is a solid contribution to sociobiology and a profoundly good read for a wide audience.

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Quetico Fishes

By E. J. Crossman, illustrated by P. Buershcaper. 1976. Royal Ontario Museum and The Quetico Foundation. 86 pp. $3.

The main body of this book is divided into three parts: introduction, a guide to fishes, and a history of fishes in the Quetico area. The guide includes the major portion of the book, 72 pages, and it is this section that will be of greatest interest to the angler and canoeist. A checklist of the 48 species known to occur within the boundary of the park includes two species not dealt with in detail in the species accounts. The shortjaw cisco is known from only one locality, and the creek chub cannot currently be verified as occurring in the park.

The species accounts are broken into two groups: sports fishes (16 species) and others (32 species plus creek chub). The brook trout, normally high on the list of sports fishes, is included with "others" because of its infrequent occurrence in the park. The accounts of sports fishes give information on recognition, size, habits, "fishability," and edibility. Growth data on these species are usually from populations outside the park, but serve as indicators for those in the park. The accounts of "other" or non-sports species are abbreviated, but include tidbits on natural history, recognition, and edibility. A useful pictorial "glossary" diagrams the features and terms encountered in the descriptions. Each species is illustrated, and the backgrounds in the drawings, although sketchy, add a touch of vitality. I especially like those of the sunfishes and minnows, but a few, e.g., the silver lamprey and the sauger, are stiff.

The sections on distribution list, firstly, the species and the water body they occur in and, secondly, the water bodies (with longitude and latitude) and the species found therein. These sections seemingly duplicate one another, but in fact will be real time-savers for anglers, managers, and zoogeographers.

The history of Quetico fishes includes a summary of events as the pool area became deglaciated, and explains the changes in drainage patterns. There is also a distributional theory which explains the present occurrence of fishes in the area. This section will be of considerable interest to zoogeographers and the serious amateur, perhaps less so to the average angler. A small section points out that only Lac la Croix and the Maligne River have ever been commercially fished in the past, and that no commercial fishing occurs in the park at present.

The introduction adequately explains the rationale and use of various sections of the guide. An index to species of fishes is included.

To my mind, the only deficiency in the book is the lack of a map of Quetico Park. The guide is remarkably free of errors, and the easy style of writing has produced only a few awkwardly-phrased sentences, e.g., the rock bass during spawning "is aggressive and will attempt to chase even swimmers" or the two dorsal fins of the smallmouth bass "do not appear almost separated." These criticisms are minor, however, and I know the guide will be welcomed by anglers in the park. The guide was conceived to report on the results of an inventory of fishes in the park and it does this admirably and in a fashion which serves several interests — those of anglers, managers, zoogeographers, and general naturalists. The ability of the book to withstand the Peden water test suggests that it will not come apart in the field if it gets wet.

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The Odonata of Canada and Alaska

By E. M. Walker and P. S. Corbet. 1975. Volume 3, Part III: the Anisoptera — three families. University of Toronto Press, Toronto. XVI + 307 pp. $25.00.

Few are those who have not marvelled at the beauty and grace of dragonflies as they skim back and forth on shimmering wings. It is well merely to admire such creatures of beauty, but to delve into the secrets of their lives is to approach the epitome of marvel and understanding. And there is yet much to be learned of their lives. For example, as of the writing of this volume now under review, the nymphal stage in the life cycle of *Williamsonia fletcheri*, one of the rarest of the green-eyed skimmers, had not yet been found. This dragonfly in the adult form is known to occur in Canada from New Brunswick to Manitoba. The key to understanding the lives of dragonflies is through such volumes as *The Odonata of Canada and Alaska,* because they are also keys to all that has been learned.

With this volume, long awaited by dragonfly enthusiasts, the monograph on the Odonata of Canada and Alaska is now complete — or would be if volumes one and two were not temporarily out of print. These volumes are scheduled for reprinting, I understand, but unfortunately at a much higher price. Volume one, published in 1953, included, as well as the introduction, the Zygoptera or damselflies, and volume two, published in 1958, included four families of the Anisoptera or dragonflies: the Aeshnidae or darners; the Petaluridae or graybacks; the Gomphidae or clubtails; and the Cordulegastridae or biddies. This final volume covers the superfamily Libelluloidea, including the Macromiidae or belted skimmers, the Corduliidae or green-eyed skimmers, and the Libellulidae or common skimmers. As the name suggests, this latter group includes our most common dragonflies, with 11 genera and 44 species occurring in Canada. A total of 20 genera and 76 species of dragonflies is included in this volume.

Volume three continues in the same excellent style set by Professor E. M. Walker in the first two volumes. There are keys, for both adults and nymphs, to the families of Libelluloidea, to the genera and to the species. In conjunction with the excellent illustrations, I have found the keys easy to use. Each species account is of at least one page, usually two to three pages, and includes a synonymy, a general description, a detailed description of each sex and the nymph, habitat and range, and the distribution in Canada. Detailed field notes, discussing such aspects of dragonfly biology as flight period and behavior, contribute significantly to the text.

This is a book I would recommend to anyone interested in dragonflies or in aquatic biology. The only complaint I have with this volume is the high price, which will tend to put it beyond the reach of many would-be dragonfly enthusiasts, especially considering the price of the entire set of three volumes.

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Opération coelacanthe

By Jean Anthony. 1976. Vivre et revivre l'aventure 7. Collection edited by Anne and Jacques Arthaud. Librarie Arthaud, Paris. 201 pp., illus.

The coelacanth is one of the creatures which has caught and kept the imagination of the public, a fish of a group older than the dinosaurs but which survived them, long thought to be extinct but now known still to survive off Africa. Hence it is called a living fossil. We are fortunate to have this account by one of the two men who know it best and who have changed it from one whose anatomy was almost unknown to one whose anatomy is among the best known, Jean Anthony.

The first chapter gives the history of the coelacanth, describes the discovery of the tiny brain, the fat-invested swim bladder, the curiously placed kidney, the mysterious rostral organ, on the first French specimen, as well as telling something of the evolutionary significance of the enigmatic species, *Latimeria chalumnae.*

Subsequent chapters spin the story of an expedition to the Comores Archipelago in search of a freshly caught or if possible a living specimen. This joint international expedition by the Muséum national d'Histoire naturelle of Paris, The Royal Society of London, and the National Academy of Sciences of United States took three years to plan and three months to carry out. From the high-quality impressions of the French coelacanth monographs one was led to believe that good financial support for the project was provided. One is therefore surprised to learn that difficulty was found in obtaining funds from the French government; a boat and vehicle had to be obtained from local sources. The biggest problem was securing authority from the labyrinthine government administration in the time available, almost making the actual expedition itself seem simple.

The international coelacanth committee solicited requests from scientists for fresh anatomical samples for research projects so that the fullest use would be made of any specimen caught. Resulting requests included 30 kg (66 lb) of muscle from one scientist, half a dozen eyes and hearts from several others, brain and other tissues, each accompanied by particular methods of preservation. Plans were made on how to satisfy all these requests and a schedule for the participants to share the work in the Comores.

The last half of the book is devoted to the expedition itself. Five days after arrival in Moroni, Grande Comore Island, a telephone call announced the capture of a live coelacanth on the neighboring island. Samples from it and a second specimen caught in the last days of the expedition were dispersed to fifty laboratories around the world. Subsequent findings greatly advanced our knowledge of this fish.

In the final pages of this book we learn that the coelacanth is a live-bearer, giving birth to young about a foot long. As background we learn of these perfumed islands, the land and seascape, the market place and the fishermen. The style is colorful and spiced with touches of humor. There are a few miniscule errors; species names, for example, are usually capitalized. The illustration of internal organs bears no indication of which end is anterior, which will confuse the average reader. A colorful cover and color plates in the text of "old fourlegs," scales, eggs, the brave fishermen who venture a kilometre offshore in tiny dugouts to capture this vigorous fish, and a mysterious antique silver model of the coelacanth of unknown origin, embellish the book.

The book is well-written, informative, and enjoyable to read. It is recommended to anyone interested in biology. Congratulations are offered to Anthony for this semi-popularization. It may be mentioned as a footnote that the manuscript of the third and final monograph on the coelacanth has been submitted for publication.

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BOTANY

Biology of Plants

By Peter H. Raven, Ray F. Evert, and Helena Curtis. 1976. 2nd edition. Worth, New York. 685 pp. $15.95.

This is an excellent introductory college text, noticeably strengthened in comparison with the first edition (by Raven and Curtis). The 29 chapters are democratically divided among all of the major subdisciplines of botany, with due attention to biochemistry, cytology, physiology, genetics, evolution, anatomy, ecology, physiology, biogeography, and the morphology and taxonomy of major groups. The inclusion of topics is comprehensive, whereas the exposition of each subject is sufficiently limited and simplistic that an undergraduate student should not be overwhelmed. The style is informal and lucid.

The authors adopt R. H. Whittaker's five-kingdom scheme of living things, classifying the blue-green algae and the bacteria in the Monera, and the remaining algae, the slime molds, and the protozoans in the Protista, leaving the Fungi, the Animalia, and the Plantae. The Plantae include only the bryophytes and the higher plants. Obviously this modern narrow circumscription of the plant kingdom is out of step with the usual segregation of biology departments into botany and zoology divisions. Pragmatically, the authors treat all groups traditionally considered to be plants, leaving the Animalia and the protozoans for the zoologists.

The book is exceptionally up to date, reporting many new findings and developments. This is an important consideration for an instructor choosing a text because recent discoveries (for examples, in relation to plate tectonics, the modes of photosynthesis, and the origin of mitochondria and chloroplasts) have dated many books currently in use as texts. Although remarkably topical, the book also provides excellent historical perspectives of developments in botany.

The book is very accurate and quite well structured pedagogically. A standard format for reproductive cycles of different plant groups simplifies comprehension. Numerous diagrams and photographs are present, most of them clarifying the text. Many of the color photographs are superb. But the photograph showing that "the Indian pipe, *Monotropa* entirely lacks chlorophyll" has obviously been color distorted since the plant shown is quite green (p. 343). Included in the very few minor errors I could detect was the reference to water hemlock (*Cicuta*) as *Daucus carota* (p. 346), and to calactin as an alkaloid (p. 385).

Biology of Plants deserves to be considered for use in introductory courses in botany. As well, it can be recommended to those without any formal scientific background who wish a very readable accounting of the many fascinating discoveries of the diverse fields within botany.

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The Bird's Nest Fungi

By Harold J. Brodie. 1975. University of Toronto Press, Toronto. 199 pp., illus. $25.

This is a world monograph, presenting the results of a lifetime of study and research on the bird's nest fungi. The taxonomic treatment deals with more than sixty species of bird's nest fungi. In addition, there are chapters on many interesting aspects of these fungi, including the mechanisms evolved for spore dispersal, the production of fruit bodies in culture, nuclear behavior, and spore development. The sixty-four illustrations include photographs, microphotographs, line drawings, and diagrams. There is a short glossary of technical terms, a bibliography containing 149 titles, and a detailed index to subject matter.

In the taxonomic treatment there are keys to the genera and species, with the exception that the very large genus *Cyathus* is keyed to sections only. The formal description of each species is accompanied by references to illustrations, information on culture characters, distribution and ecology, and a comparison with similar species. The observations which follow each description are of particular value, giving the reader the benefit of the author's extensive research, and including notes on type material.

Destined to take its place as a classic among mycological writings, the attractively designed and copiously illustrated book seems to be directed not only to professional mycologists, but also to keen students and amateur botanists. In the historical section, the contributions of earlier investigators are detailed with genuine appreciation for each original observation or perceptive interpretation that has led to a better understanding of these fungi. The text is liberally sprinkled with challenges to future researchers, as the author points out various problems that remain still to be solved.

The style of writing is direct and clear, with revealing glimpses of the author's scientific curiosity, humor, and professional integrity, all of which add to the attractiveness of the book. This work will be indispensable to students of bird's nest fungi. It will also have great appeal for amateur naturalists. Unfortunately, its high price is likely to keep it confined to the shelves of scientific institutions.

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ENVIRONMENT

Environmental Education

By James A. Swan and William B. Stapp *(Editors)*. 1974. Halsted Press, Division of John Wiley and Sons, New York. 349 pp. $15.

To some, environmental education is the art of changing public attitudes towards the environment. It is education with an emphasis on the environment. The 15 papers included in *Environmental Education* have a different approach. Their emphasis is upon education rather than the environment.

The contributors to *Environmental Education* all share a common fundamental attitude: that our educational systems are not producing an environmentally aware and informed public. "Those now growing into adulthood cannot be expected to be much more intellectually skilled, more compassionate, more in touch, than most of the 'educated' generation that preceded them . . . this condition of relative stasis is a consequence of the dependence of a public school system on the standards of the society for which it is educating new members." Many of the papers propose alternative educational methods; others report of testing alternatives. Basic to all papers is the concept that the content is only effective when the presentation is appropriate.

The major areas of concern, as identified within this text are citizen participation in environmental decision-making; utilization of mass media; and teacher responsibility. Each of these concerns is dealt with in at least one paper.

The eleventh paper examines citizen participation in resource management decision-making. "As increasing numbers of 'citizens' become sensitive to environmental problems through improved education and wider dissemination of information, there will be corresponding increase in public expectancies of improvement in the planning and decision making actions which affect environmental resources." It is pretty well accepted among today's resource managers that the public should have some say in the future of public-owned resources. *Environmental Education* is suggesting that this is not meant as tokenism but rather efforts should be made to provide the contributing citizenry with the appropriate education to make a viable contribution.

One of the principle forms of non-classroom education is the media. "We owe the current environmental information explosion to the public, and we can expect little further increase in environmental news until there is a further increase in public concern." As it presently exists, the mass media can contribute little to environmental awareness. Its potential as an educational tool does exist but to be effective it will have to undergo a major change in format and philosophy.

Critical to any educational program is the aptitude and attitudes of the teacher. "The role of the teacher is to create a learning environment, assist students in acquiring information, provide guidance to the student, and participate with the student in the learning process." Various contributors to *Environmental Education* suggest that present-day teachers are not approaching the problem of environmental teaching in the most effective way possible. "The traditional approach to conservation education has been to 'teach the facts' and assume that if people 'get the facts' about resource problems they will become concerned about the problems."

For those concerned with environmental teaching there is a great deal in this book. The contents do not include profound environmental philosophies. What they do contain are methodologies for teaching. As the senior editor aptly states, "This book is concerned with developing educational programs to better prepare people for living in harmony with the environment and themselves." This book is not a book on the environment, this is a book on education.

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Eyes on the Wilderness

By Helmut Hirnschall. 1975. Hancock House, Saanichton, British Columbia. 175 pp. $7.95.

Recorded with care as a personal tribute to the country of his adoption by the writer-illustrator, this book combines lovely faithfully-observed drawings of wild animals and birds, with personal mini-adventures in the Canadian bush, linked lightly to Indian legends.

Spurred by a childhood fascination for unfettered wildlife which was not fully satisfied in the tamed patchwork setting of his native Austria, Helmut Hirnschall looked to Canada for this freer environment. On his arrival, he at once embarked on a series of short journeys through northern Ontario along backroads, by second-hand car and by kayak, camping out on rivers, when time was available to him.

The writer's findings form the body of his subject, observed with a shining warmth and charm which leaves on whatever it touches a mint-newness of impression. The delicacy of a porcupine's paw, the sweetness of its eye; Snowy Owls traced in margins like cross kittens, highlight his array of tiny factual items. He exactly describes the owl's eyelid covered by minute feathers, which can be moved independently, or the tree-climbing life-style of the porcupine using his claws, tail, and barbs.

He furnishes wanted information to the amateur nature-buff, reminders to the more experienced observer and the delight of sharing in freshly perceived discoveries. Beautifully produced and designed in hard cover with a foreword by Chief Dan George, the book should be especially suited to the enjoyment of children, a valued acquisition for their libraries.

The concluding pages describe the writer's return after an absence, to the cabin, broken and abandoned in the changed wilderness, of a former friend, an old trapper, and he draws the inevitable moral. To echo the foreword, it is to be hoped that it still may not be too late for such a book to hold up a light against the destruction by greed, of a domain free to all but which can never be replaced nor its ruin ever morally explained to a future generation of children.

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NEW TITLES

Zoology

Animal migration and navigation. 1976. By Philip Street. Scribner, New York. 144 pp., illus. $8.95.

†**The bird finder's 3-year notebook.** 1976. By Paul S. Eriksson. Eriksson, New York. $7.95.

†**Birds of the Rosetown-Biggar District, Saskatchewan.** 1975. By Wayne E. Renaud and Don H. Renaud. Saskatchewan Natural History Society, Regina. Special Publication Number 9. 121 pp. Paper $4.

***A book of Canadian animals.** 1976. By Charles Paul May. Illustrated by John Crosby. MacMillan, Toronto. 115 pp. Paper $4.95.

†**A book of Canadian birds.** 1976. By Charles Paul May. Illustrated by John Crosby. MacMillan, Toronto. 115 pp. Paper $4.95.

†**Common Canadian Atlantic fishes.** 1976. By W. B. Scott and S. N. Messieh. Huntsman Marine Laboratory, St. Andrews, N.B. 106 pp., illus. $3.50.

***Common New Guinea frogs.** 1976. By J. I. Menzies. Wau Ecology Institute, Wau, Papua, New Guinea. Handbook No. 1. 75 pp., illus. $3.20.

Ducks, geese, and swans of North America. 1976. By F. C. Bellrose. Stackpole, Harrisburg, Pennsylvania. 536 pp. $21.95.

Eagles of the world. 1976. By Leslie Brown. David and Charles, Newton Abbot, England. £4.95.

Everyday birds. 1976. By Tony Soper. David and Charles, Newton Abbot, England. £2.95.

A field guide to the butterflies of the West Indies. 1976. By Norman D. Riley. Quadrangle (New York Times), New York. 224 pp., illus. $12.50.

A field guide to the nests, eggs and nestlings of British and European birds. 1976. By Colin Harrison. Quadrangle (New York Times), New York. 432 pp., illus. $12.50.

Fish communities in tropical freshwaters. Their distribution, ecology and evolution. 1975. By R. H. Lowe-McConnell. Longman, New York, xviii + 338 pp., illus. $26.50.

†**The giraffe.** Its biology, behavior and ecology. 1976. By Anne Innis Dagg and J. Bristol Foster. Van Nostrand Reinhold, New York. 210 pp.

†**A guide to the birds of Panama.** 1976. By Robert S. Ridgely. Illustrated by John A. Gwynne, Jr. Princeton University Press, Princeton, J.J. xv + 394 pp. $15.

***Handbook of North American birds.** Volume 2: waterfowl, part 1, and Volume 3: waterfowl, part 2. 1976. Edited by Ralph S. Palmer. Yale University Press, New Haven, Connecticut. 521 pp. and 560 pp., illus. $30 each.

†**Hawks, falcons, and falconry.** 1976. By Frank L. Beebe. Hancock House, Saanichton, B.C. 320 pp., illus. $12.95.

†**The insects and arachnids of Canada.** Part 2. The bark beetles of Canada and Alaska. Coleoptera: Scolytidae. 1976. By Donald E. Bright, Jr. Agriculture Canada, Ottawa. Canadian Faunal Series No. 2. 241 pp., illus. Paper $7 in Canada, $8.40 elsewhere.

***Insects that feed on trees and shrubs.** 1976. By Warren T. Johnson and Howard H. Lyon. Cornell University Press, Ithaca, N.Y. 464 pp., illus. $35.

†**Mammalogy.** 1976. By Harvey L. Gunderson. McGraw-Hill, New York. 483 pp., illus. $19.80.

Moments of discovery. Adventures with American birds. 1976. By Eliot Porter. Text by Michael Harwood. Clarke-Irwin, Toronto. Illus. $31.75.

†**Les oiseaux et le péril aviaire.** Écologie et la zone de l'aéroport international de Montréal. 1976. Par Raymond McNeil, Normand David et Pierre Mousseau. Les Presses de l'Université de Montréal, Montréal. 255 pp. $10.

Parent birds and their young. 1976. By Alexander F. Skutch. University of Texas Press, Austin. xx + 504 pp., illus. $27.50.

†**Précis de zoologie: vertébrés.** 1. Anatomie comparée. 1976. Par Charles Deviller et P. Clairambault. Masson, Paris xi + 468 pp., illus. 120F.

†**A preliminary guide to the littoral and sublittoral marine invertebrates of Passamaquoddy Bay.** 1976. By R. O. Brinkhurst, L. E. Linkletter, E. I. Lord, S. A. Connors, and M. J. Dadswell. Huntsman Marine Laboratory, St. Andrews, N.B. 166 pp., illus. $3.

***Quetico fishes.** 1976. By E. J. Crossman. Illustrated by P. Buerschaper. Royal Ontario Museum and Quetico Foundaation, Toronto. 86 pp. $3.

***Reptiles and amphibians of Australia.** 1975. By H. G. Cogger. Reed, Sydney. (North American distributer Tuttle, Rutland, Vermont). 584 pp., illus. $44.50.

†**The screech owl: its life history and population ecology in northern Ohio.** 1975. By Laurel F. van Camp and Charles J. Henny. U.S. Fish and Wildlife Research Center, Denver. North American Fauna No. 71. v + 65 pp. Free.

†**The turtles of Canada.** 1976. By Barbara Froom. McClelland and Stewart, Toronto. 120 pp., illus. $8.95.

†**Vertebrate biology.** 1976. By Robert Thomas Orr. 4th edition. Saunders, Philadelphia. 472 pp., illus. $13.35.

***Where to go birdwatching in Canada.** 1975. By David Stirling and Jim Woodford. Hancock House, Saanichton, B.C. (Distributed by Clarke Irwin, Toronto). 127 pp. Paper $3.95.

Wildlife now. 1976. Edited by Nigel Sitwell. David and Charles, Newton Abbot, England. Illus. £4.50.

Botany

***Biology of plants.** 1976. By Peter H. Raven, Ray F. Evert, and Helena Curtis. Worth, New York. 685 pp. $15.95.

The biology of slime moulds. 1975. By J. M. Ashworth and J. Dee. Macmillan, Toronto. 72 pp. Paper $3.95.

***Catkin bearing plants (Amentiferae) of British Columbia.** 1976. By T. C. Brayshaw. British Columbia Provincial Museum, Victoria. Occasional Paper No. 18. 176 pp., illus. $3.

***Guide to the vascular flora of Illinois.** 1975. By R. H. Mohlenbrock. Southern Illinois Press, Carbondale. Paper $7.95; cloth $12.95.

Mount Revelstoke National Park wildflowers. 1976. By Parks Canada, National Museum of Natural Sciences and British Columbia Provincial Museum, Victoria. 96 pp., illus. $2.50.

***A panorama of Canadian forests.** 1975. By Albert Potvin. Canadian Forestry Service, Ottawa. 254 pp., illus. $13.50 in Canada, $16.20 elsewhere.

†**Plant biology.** A laboratory manual for elementary botany. 1976. By Robert W. Long and Knut Norstog. Saunders, Philadelphia. 231 pp. Paper $6.15.

†**Plant names.** 1976. By Thomas S. Lindsay. Gale, Detroit. (Republication of a 1923 edition). viii + 93 pp. $8.

Environmental

†**Algonquin Park.** 1976. A series of 9 trail guides by Dan Strickland and two booklets: "Mammals of Algonquin Provincial Park" and "Reptiles and amphibians of Algonquin Provincial Park." By D. Strickland and Russell J. Rutter. Illustrated by Howard Coneybeare. Ontario Ministry of Natural Resources, Whitney. 9 × 10¢, 2 × 50¢.

Amazon jungle: green hell to red desert? An ecological discussion of the environmental impact of the highway construction program in the Amazon basin. 1975. By R. J. A. Goodland and H. S. Irwin. Elsevier, New York. x + 156 pp., illus. $13.75.

Biology and geology of coral reefs. 1975. Edited by O. A. Jones and R. Endean. Academic, New York. Volume 3: biology 2. 488 pp. $37.50.

Ecological investigations of the tundra biome in the Prudhoe Bay region, Alaska. 1975. Edited by Jerry Brown. University of Alaska, College. Biological papers of the University of Alaska Special Report No. 2. $10.

†**Energy flow — its biological dimensions.** A summary of the IBP in Canada 1964-1974. 1975. Edited by Thomas W. M. Cameron and L. W. Billingsley. Royal Society of Canada, Ottawa. x + 319 pp. $5.

***Environmental education.** 1974. By James A. Swan and William Stapp. Halsted (Wiley), New York. 349 pp. $15.

Environmental indices. 1976. By Herbert Inhaber. Wiley-Interscience New York. xiv + 178 pp., illus. $14.50.

†**Environmental values, 1860–1972: a guide to information sources.** 1976. Edited by Loren C. Owings. Gale, Detroit. Volume 4 in the Man and the Environment Information Guide Series. 324 pp. $18.

†**Introducing the sea.** 3rd edition. 1976. By Martin L. H. Thomas. Huntsman Marine Laboratory, St. Andrews, N.B. 112 pp., illus. $4.

An introduction to the biology of marine life. 1976. By James L. Sumich. Brown, Dubuque, Iowa. 360 pp. Paper $9.95.

†**The John Dorr Nature Laboratory: management for ecological values.** 1976. By Karen Cathey, Susan Cooley, and Kate Ligare. Yale University School of Forestry and Environmental Studies, New Haven. 64 pp., illus. Paper $3.

***Marine sediment transport and environmental management.** 1976. Edited by Daniel Jean Stanley and Donald J. P. Swift. Wiley, New York. xv + 602 pp. $35.

***Nature and urban man.** 1975. Edited by Gerald B. McKeating. Canadian Nature Federation, Ottawa. Special Publication No. 4. Proceedings of a conference, 21–27 August 1974, University of Western Ontario, London. 134 pp., illus. $4.

The sandhills of Carberry. 1976. By John E. Dubois. Manitoba Museum of Man and Nature, Winnipeg. 48 pp., illus. $3.50.

Structure and function of tundra ecosystems. 1975. Edited by T. Rosswall and O. W. Heal. Swedish Natural Science Research Council, Stockholm. Ecological Bulletin No. 20. 450 pp. 50 Sw Cr.

The western Swan Hills. Alberta's forgotten wilderness. 1976. By the Alberta Wilderness Association and the Edmonton Chapter, National and Provincial Parks Association, Calgary, Edmonton. 45 pp., illus. $3.

Miscellaneous

The arctic circle. Aspects of the north from the circumpolar nations. 1976. Edited by William C. Wonders. Longman, Don Mills, Ontario, xiv + 146 pp., illus. Cloth $6.95; paper $3.95.

Harvesting polluted waters. Waste heat and nutrient-loaded effluents in the aquaculture. 1976. Edited by O. Devik. Plenum, New York. Proceedings of a workshop. xii + 324 pp., illus. $29.50.

†**Man of the woods.** 1976. By Herbert F. Keith. Burns and MacEachern, Don Mills, Ontario. (Paperback edition of a 1972 publication). 164 pp., illus. $5.95.

†**Review of the coal exploration policies and programs in the eastern slopes of Alberta.** Report and recommendations. 1976. By the Alberta Environmental Conservation Authority, Edmonton. 113 pp. Paper free.

†**The use of pesticides and herbicides in Alberta.** Report and recommendations. 1976. By the Alberta Environmental Conservation Authority, Edmonton. 208 pp. Paper free.

*Assigned for review.
†Available for review.

Information Concerning Content of *The Canadian Field-Naturalist*

Articles

The Canadian Field-Naturalist is a medium for publication of research papers in all fields of natural history. If possible, major articles should be illustrated.

Notes

Short notes on natural history and related topics written by naturalists and scientists are welcome. Range extensions, interesting behavior, pollution data, and other kinds of natural history observations may be offered. It is hoped, however, that naturalists will also support local natural history publications.

Letters

Letters commenting on items appearing in this journal or on any developments or current events affecting natural history and environmental values are welcome. These should be brief, clear, pertinent, and of interest to a wide audience.

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Informed naturalists, biologists, and others are invited to present documented narratives and commentaries upon current scientific and political events that affect Canadian natural history and the environment. Contributions should be as short as possible and to the point.

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Normally, only solicited reviews are published. Biologists and naturalists, however, are invited to submit lists of titles (complete with pertinent information regarding authors, publisher, date of publication, illustrations, number of pages, and price) for listing under "New Titles."

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As *The Canadian Field-Naturalist* has a flexible publication policy, items not covered in the traditional sections can be given a special place provided they are judged suitable.

Reviewing Policy of *The Canadian Field-Naturalist*

Manuscripts submitted to *The Canadian Field-Naturalist* are normally sent to an Associate Editor and at least one other reviewer. If their comments concerning the scientific merit and suitability of the manuscript for publication are widely divergent or if an original referee's field of competence does not cover the entire contents of the manuscript, one or two additional referees are asked to review it. Referees are requested to complete their reviews within three weeks or to return the manuscript immediately and suggest an alternate reviewer. Reviews offering a general appraisal of the manuscript followed by specific comments and recommendations for revision are most useful to the Editor and author.

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Compiled by R. EMMERSON WHITING

Index to Book Reviews

Membership and Subscription Fees
The Ottawa Field-Naturalists' Club

It is that time of the year when Membership fees fall due for 1977. Please renew your Membership with the first notice and save the Club money, time, and effort.

In 1976 the Club sent out 319 *second notices* at a cost of over $25.00 for stamps plus ten manhours of labor. It also costs money to ask the computer for the second notice label run.

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Chairman, Membership Committee

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Authors should submit three complete manuscripts with two copies of figures (in addition to the originals) for use by referees. Manuscripts are accepted in either English or French. They should be typewritten on paper measuring 8½ × 11 inches, and if possible, the paper should have numbered lines. Margins should be 1 to 1½ inches wide to allow for copy marking. All text matter, including quotations, footnotes, tables, literature citations, and captions for figures should be double-spaced. Only words meant to appear in italics should be underlined. Every sheet of the manuscript should be numbered. Generally words should not be abbreviated; this includes references to tables and figures as well as literature citations. Authors are requested, however, to use SI symbols for units of measure.

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An abstract is required for all Articles but is optional for Notes. Authors are requested to use at least one given name. Literature cited should be listed alphabetically according to author and should be placed immediately after the main body of the text, except in Letters to the Editor. If only one or two references are cited, they should be inserted in the text. The tables should be titled and numbered consecutively in arabic numerals, and each should be placed on a separate page after the Literature Cited. Captions for figures should be typed together on one page. The places in the text for tables and figures should be marked in the margin.

Extensive tabular or other supplementary material not essential to the text should be submitted on letter size paper (8½ × 11") for the Editor to place in the Depository of Unpublished Data, National Science Library, National Research Council of Canada, Ottawa, Canada K1A 0S2. A notation in the published text should state that the material is available, at a nominal charge, from the Depository. Two copies are required for the Depository.

The **CBE Style Manual**, third edition (1972), published for the Council of Biology Editors, Committee on Form and Style, by the American Institute of Biological Sciences, is recommended as a guide to contributors.

Webster's New International Dictionary is the authority for spelling. In a case, however, of difference in the spelling of a common name, and in the use of a variant name, a decision of a learned society is preferred.

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Reprints

An order form for the purchase of reprints will accompany the galley proofs sent to authors.

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Book Reviews

Mailing date of previous issue 1 October 1976

Erratum

1975. Canadian Field-Naturalist 89(4). *The King Eider in Ontario* by R. M. Alison. The statement that "Two females and five young from their broods were collected in July 1947 at Cape Henrietta Maria (Manning 1952), but the specimens have since been lost" is in error. The specimens, two females and *seven* (not five) downy young are in the National Museum of Natural Sciences, Ottawa and are numbered 32440–32448. Also, the first evidence, not mentioned by the author, that King Eiders nested at Cape Henrietta Maria was obtained by R. H. Smith and reported by J. L. Baillie (1961. More new Ontario breeding birds. Ontario Field Biologist 15:1–9).

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