



JOHN PEMBERTON RYDER

The breeding biology of Ross' goose in the Perry River region, Northwest Territories



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in the Perry River region,
Northwest Territories**

by John Pemberton Ryder



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Indian Affairs and Northern Development**

Top left—Incubating Ross' goose. Only the female incubates. (J. P. Ryder).

Top right—Pair of Ross' geese (J. P. Ryder).

Bottom left—Nesting habitat at Karrak Lake, N.W.T. (J. P. Ryder).

Bottom right—The goose in the background shows aggressive posture (J. P. Ryder).

Issued under the authority of the
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Studies of a nesting colony of Ross' geese at Arlone Lake, in the Perry River region, N.W.T., during the summers of 1963 and 1964 are described. The explorations, climate, vegetation, fauna, and Eskimos of the area are reviewed. The history of the Ross' goose in the Perry River region is given.

The following factors in the biology of Ross' goose are discussed: arrival dates, nest initiation, incubation, post-nuptial movements, mortality, predation, productivity, and competition.

Sight reports of Ross' geese during the spring migration of 1964 are correlated with the northward movement of the 40°F isotherm. The possible advantage of this migration-control mechanism is discussed.

No courtship behaviour was observed during the study period at Arlone Lake, suggesting that such activities are completed farther south. Ross' geese use islands for nesting, presumably as a defence against mammalian predators. Highest nest densities were found in the mixed, birch, rock, and open areas, which provide both cover and grazing areas.

Eggs are laid every 1½ days with an 8- to 9-day egg-laying period. Clutch sizes, which average three, may be controlled by the short Arctic season. Late nesters lay smaller clutches. Only 93 frost-free days are available to complete the reproductive phase. In 1963 and 1964 the Ross' geese utilized over 80 per cent of this period.

The high degree of attentiveness during the incubation period results in maximum hatching success. Mortality and predation are generally low on the nesting islands. Productivity was estimated from counts of 1-week-old and younger broods.

Most losses in 1964 occurred in the United States.

Goslings are polymorphic with gradations between yellow and grey. A differential mortality against female goslings occurs during the first 3 weeks of life. It is suggested that a large influx of lesser snow and blue geese during the reproductive phase would be detrimental to the Ross' geese.

It was concluded that the population of Ross' geese nesting at Arlone Lake in 1963 and 1964 was not subjected to excessive limiting factors.

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Introduction

The Ross' goose, *Anser rossii* Cassin, is North America's smallest arctic-nesting goose. During the early 1950's concern for the species' survival arose because of the low numbers reported migrating through the Canadian Prairie Provinces and on the wintering grounds in California. Lack of knowledge concerning its breeding habits made management procedures subjective and inefficient.

In the spring of 1963, the author initiated a preliminary study of Ross' goose on a nesting area in the Perry River region, N.W.T. The main objectives of the study were:

- (1) to study the reproductive biology of the Ross' goose on the nesting grounds;
- (2) to study the post-breeding biology of the Ross' goose;
- (3) to study interspecific relationships on the nesting areas.

Activities were confined to Arlone Lake (67°22'N., 102°10'W.), N.W.T., in the Perry River region, and to the mouth of the Perry River. This region constitutes the traditional nesting ground, although in recent years smaller colonies have been reported from the Hudson Bay and James Bay areas (Barry and Eisenhart, 1958; Cooch, 1954; MacInnes and Cooch, 1963) and Banks Island (Barry, 1960b; Manning *et al.*, 1956). Arlone Lake, according to the Kogmiut Eskimos, was the location of a well-established nesting colony, and was named "Pikiulik", which means "nesting lake". Gavin (1945) reported the presence of a Ross' goose colony at Arlone Lake as early as 1938.

Data on previous ornithological work in this area are sparse. Biological survey work was carried out by Mr. Angus Gavin during his stay in the area from 1937 to 1941 (Gavin, 1945, 1947). The geography, birds, and mammals were investigated in 1949 (Hanson *et al.*, 1956), and in 1962 a waterfowl banding crew studied the potential of the area for goose banding (MacInnes and Weske, 1962).

Early exploration

The region adjacent to the Perry River lies in one of the least explored areas of the Canadian North. Samuel Hearne (1795) was the first white man to penetrate the interiors of the western Keewatin and eastern Mackenzie districts during his search for the mouth of the Coppermine River. Hearne's first two trips, 1769 and 1770, into the barren regions were short and he did not get far north from his base point at Churchill, Manitoba. The third expedition, 1770 and 1771, followed the wooded areas of the tree-line far south of the barrens. The nar-

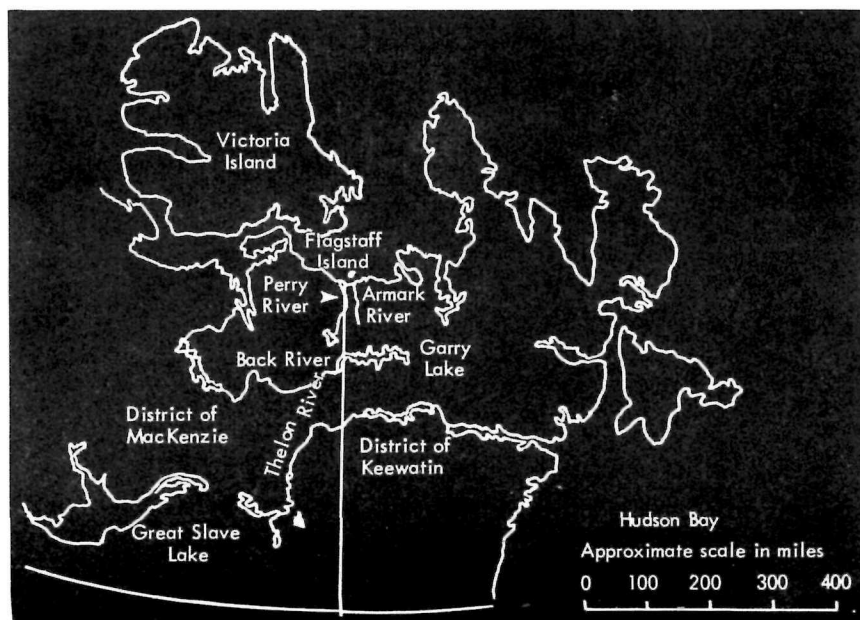
rative of his journey contains many notes of natural history and in his closing chapter the author gives a detailed account of many of the animals with which he came in contact during his years in the North.

Captain George Back (1836) explored and described the area surrounding the Great Fish River (Back's River) during the years 1833 to 1835 (Fig. 1). His main contribution lay in the description of the region northeast of Pelly and Garry Lakes. The maps he constructed of the region as far as Montreal Island (67°51'N., 96°25'W.), at the mouth of the Back River, remained the only ones until 1948 (Baird, 1949). Although Back's primary purpose for going into the North was to find the lost party of Captain John Ross (1829-33), he kept natural history notes of many of the regions traversed. Preble (1908) states that Back did not encourage the collection of natural history specimens and that medical duties largely prevented Mr. Richard King (surgeon and naturalist of the expedition) from doing so. However, the flora and fauna described by King, although not original (see Pennant, 1792), gave insight into the flora and fauna of the regions explored.

The coast of the Queen Maud Gulf, into which the Perry River flows, was mapped by Thomas Simpson between 1837 and 1839 as far east as the Castor and Pollux Rivers on Boothia Peninsula (Simpson, 1843). Unfortunately he did not penetrate into the area south of the Queen Maud Gulf.

The first white man to travel into the region

Figure 1 Map of Northwest Territories, Canada.



immediately adjacent to the Perry River was David T. Hanbury in 1902. Part of his expedition proceeded north from Lake Pelly following the Ti-her-uak River (Armark) to the mouth. The route he followed was 30 to 40 miles east of the then unknown Perry River. Hanbury (1904) describes this region as follows:

The river [Armark] flowing to the north after leaving Ti-her-yuak Lake traverses a very sterile area which here justifies the name Barren Lands. No vegetation is to be seen except a few blades of grass here and there, while rocks, both fragmentary and *in situ* are everywhere to be seen. Small shoal lakes with sandy bottoms are formed by widenings of the river.

Hanbury's descriptions and maps of the area were original.

Angus Gavin was the first white man to penetrate into the immediate territory drained by the Perry River. He acted as post manager for the Hudson's Bay Company of Flagstaff Island (67°48'N., 102°16'W.), N.W.T., from April 1937 to July 1941. Gavin (1945) says of the region:

To the south lay an unmapped and unexplored territory lying between the coast and Back's River. I made my first journey into the interior in March 1938 when I accompanied hunters of a tribe of Caribou Eskimos to the Garry Lakes, returning alone about two weeks later. This was a traverse of 85 miles, and, I am told, is the first penetration of the territory by a white man.

Gavin made other inland trips, up to 30 miles, during the summers of 1938 and 1941, taking notes of the geology, geography, climate, flora, and fauna of the region (Gavin, 1945, 1947).

In the summer of 1949 the first scientific party into the Perry River region centred its activities around the geography, birds, and mammals (Hanson *et al.*, 1956). The results of this investigation shed new light on the habits and occurrences of various plant and animal species and brought up-to-date the available maps of the area. Hitherto unmarked topographic features were placed on the National Topographic Map Series 1953, produced by the Department of Mines and Technical Surveys. Hanson *et al.* (1956) say of the region:

In view of the scant attention given by exploring parties to the country lying between the Back River and the arctic coast, it is not surprising that maps of this area in 1949 were sketchy. The course of the Perry River was indicated by dotted lines and our bubble sextant observations showed that its mouth was about 15 miles farther west than shown, placing it in the District of Mackenzie instead of the District of Keewatin.

Subsequent investigations in the Perry River region have been primarily ornithological, consisting of a study of the potential for waterfowl banding (MacInnes and Weske, 1962), and the present investigation.

Recorded history of the Ross' goose in the Perry River region

The Ross' goose was first reported by Samuel Hearne in 1770 in a record of his attempts to find the Coppermine River. He reported large flocks near the main nesting area at Perry River, and it is unfortunate that no one took his words seriously until the nesting area was discovered in 1938 by Mr. Angus Gavin.

Cartwright (1940) states that it may have been on Hearne's second or third attempt to find the Coppermine River that he saw the flocks of "Horned Wavy", but judging from the dates it was probably on the second attempt, in 1770.

Clarke (1940) acknowledged Hearne's observations when he said: "In the interior we have from Hearne as good a hint as any yet available." The Indians during their summer travels saw almost everything there was to see on the land but no one ever reported finding the nest of the Ross' goose. Part of the problem was the lack of exploration between the Back River and the arctic coast, which "have been travelled by no white man at all in summer" (Clarke, 1940).

The species was not described for science until almost a century after Hearne's report when, in 1861, John Cassin named it *Anser rossii* in honour of Bernard Rogan Ross, Chief Factor of the Hudson's Bay Company at Fort Resolution, Great Slave Lake (Cassin, 1861). Ross was so honoured because he sent specimens to Cassin between the years 1859 and 1861.

Following the formal naming of the species the location of the nesting grounds was for many decades the subject of speculation. During the years 1861-66 Roderick Ross MacFarlane, manager of the Hudson's Bay Company post at Fort Anderson, induced many of the Company's officers in the Mackenzie district to participate in the search and interrogate the natives as to where the Ross' goose nested (Cartwright, 1940). MacFarlane postulated that it probably nested along with the more abundant lesser snow geese on the arctic islands. He says:

I have always regretted that I was unable, owing to the abandonment of the post, summer 1866, to carry out my intention of devoting at least two seasons to a personal exploration of the breeding grounds of this [Ross' goose] and some other birds which are believed to resort to Liverpool Bay and the "Eskimo Lakes" and thence also to the Delta of the Mackenzie River.

Sergeant Charles Mackenson of the Royal Canadian Mounted Police, Cambridge Bay, who obtained information from the Kogmiut Eskimos, was the first to indicate that Perry River might be the

location of the nesting grounds. Stimulated by Mackenson's suggestion, Mr. Charles E. Gillham of the United States Department of the Interior, Fish and Wildlife Service, flew over the Perry River region in 1938 and observed what he thought were Ross' geese. He says (Kortright, 1960):

From the air the writer [Gillham] could see countless large white birds in these marshes; whether they were swans, Snow Geese or Ross' Geese only time will prove. Gillham planned to return to the same region in 1939 to search specifically for Ross' geese. Unfortunately the project was abandoned owing to the death of Gillham's pilot.

On June 30, 1938, Angus Gavin, manager of the Hudson's Bay Company post at Perry Island set out to find the nesting grounds. His account of the successful journey is published in *The Beaver* of December 1940. Gavin's route took him 8 miles up the Perry River from the mouth, then 15 miles southeast along a small tributary of the Perry to a small lake (now called Discovery Lake, 67°33'N., 101°49'W.).

Gavin (1940) says:

On entering the lake, we could see them [Ross' geese] flying all over the place. The lake was long and narrow, and studded with two or three hundred reefs of varying shapes and sizes up to about 500 by 50 yards. One of the islands nearest us was covered with the white dots of the nesting birds. Through the glasses they reminded us of ptarmigan in winter garb. As we approached they rose in large flocks over our heads, loudly protesting at our invasion of their domain. Others took it very philosophically, and not until we had actually landed did they get off their nests.

In a discussion of Gavin's accomplishments Cartwright (1940) states:

There is something singularly appropriate—a sort of poetic justice—in the fact that the solution to the last remaining ornithological enigma of North America—the whereabouts of the nesting grounds of Ross's Goose—should be accomplished by officers of the Hudson's Bay Company.

Breeding distribution of Ross' goose

The distribution of nesting colonies of Ross' geese has not been completely established. Before 1953 the only known colonies were restricted to the Perry River region. Soper (1952) states that the Perry River region presumably accommodates all the Ross' geese in existence. Snyder (1957) remarks that the known summer range is restricted to the interridge country inland from the coast in the Perry River area. Amadon (1953) said the species exhibits a relict distribution in that it was once more widespread. MacInnes and Cooch (1963) support this idea and postulate that this may have resulted through exclusion from other areas by the larger, more aggressive lesser snow goose (*Anser caerulescens*). Hanson *et al.* (1956) did not mention

other possible nesting grounds.

Samuel Hearne (1795) made the first mention of Ross' geese in the area 200 miles northwest of Churchill, Manitoba. Small numbers were reported nesting in the Hudson Bay area in 1953 (Cooch, 1954), Boas River delta on Southampton Island in 1956 (Barry and Eisenhart, 1958), and McConnell and Boas Rivers in 1960 and Boas River in 1961 (MacInnes and Cooch, 1963). A total of 52 Ross' geese have been reported so far from these areas. Colonies have been observed on Banks Island, N.W.T., (Manning *et al.*, 1956 and Barry, 1960b) and at various points along the Queen Maud Gulf from the Ellice River to Sherman Inlet (Barry, 1960b).

The increase of reports of nesting Ross' geese from areas other than the Perry River might at first indicate that the species was penetrating new areas. MacInnes and Cooch (1963) explain the situation in the eastern Arctic as follows:

It is not safe to assume that this represents a recent eastward extension of Ross's Goose range from the Perry River area. In view of Hearne's old records it is more likely that a very small population has always been present in the eastern Arctic, and that the recent increase in the number of observations merely reflects increased activity by ornithologists, particularly in the North.

Probably the same conclusion can be reached concerning those reports from the western Arctic, based on observations from Banks Island, N.W.T. Höhn (1959) says that there is strong evidence that some Ross' geese migrate on a more westerly route to breeding grounds which have not yet been discovered.

If future investigations uncover additional nesting colonies or individuals from the eastern and western extremities of the Canadian Arctic as well as from the large area along the Queen Maud Gulf, the species can no longer be considered one of North America's relict species. This possibility is particularly encouraging in view of the sparse investigations that have taken place in the central Arctic (Appendix 6).

Population status of Ross' goose

Over the past two decades there has been an apparent increase in the total number of Ross' geese (Fig. 2). Hanson *et al.* (1956) were the first to count Ross' geese along the Queen Maud Gulf and estimated 2,000 in 1949 between the Perry River and the Simpson River, N.W.T.

In 1952 it was believed that the total number was still 2,000 and decreasing (Lloyd, 1952). By 1958 estimates indicated that the population was over 10,000 (Munro, 1958). Since 1955 annual counts of Ross' geese have been undertaken each

February on the wintering grounds in California by the United States Department of the Interior, Bureau of Sport Fisheries and Wildlife.

In July and August of 1960 T. W. Barry of the Canadian Wildlife Service surveyed the central Canadian Arctic in an effort to count Ross' geese on the major nesting colonies. The survey extended from the Anderson River (69°45'N., 129°00'W.) on the west, along the coast of the Queen Maud Gulf to Sherman Inlet (68°00'N., 98°21'W.) on the east. A total of 9,000 Ross' geese was observed at inland points all along the gulf and more than 200 were seen on Banks Island (see Table 1). These numbers are considerably lower than the estimate made on the winter grounds in the spring of 1960 (Fig. 2). Barry (pers. comm.) says that at the time of the survey (August 16–22, 1960), most of the geese had completed their post-nuptial moult and were able to fly. Consequently many of the birds located were a considerable distance from the nesting sites.

Figures obtained from California aerial surveys for 1963 and 1964 show that the number now stands at about 32,000. This estimate has in part been substantiated by Mr. A. Dzubin, who in the autumn of 1962 estimated 35,000–40,000 from counts made at Kindersley, Saskatchewan, a major staging area for Ross' geese.

Figure 2 Winter population estimates of Ross' goose in California.

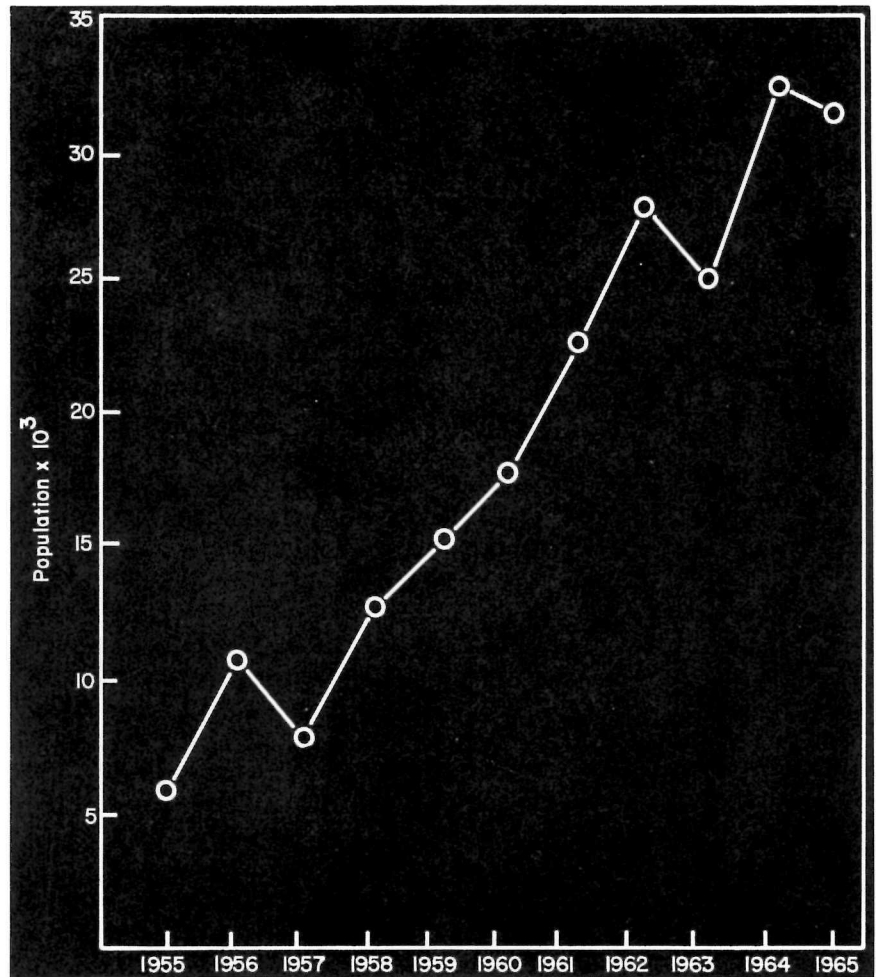


TABLE 1 Location and number of Ross' geese observed during 1960 aerial surveys*

Location	Number reported
Banks Island (72°N., 123°W.)	200 (+) (estimated)
Queen Maud Gulf mainland	9,000 (estimated)
Atkinson Pt. (67°55'N., 103°W.)	48
Perry River (67°42'N., 102°15'W.)	282
Ogden Bay River (67°40'N., 101°30'W.)	12
Pitok River (67°42'N., 101°18'W.)	22
Simpson River (67°45'N., 100°40'W.)	101
McLaughlin Lake and River (67°45'N., 98°25'W.)	2,365

*Data from Barry, 1960b.

Study area

Location and topography

The Perry River drains a part of the Canadian or Hudson Bay Precambrian Shield. Its mouth lies at position 68°N. , 102°W. , about 75 miles north of the Arctic Circle (Fig. 3). It is immediately west of the Mackenzie-Keewatin border. This region is part of the vast area often called the "Barren Grounds". At the close of the Tertiary Period the Canadian Shield, an area of approximately two million square miles, was uplifted unequally and warped into the familiar approximate saucer shape, with a central depression in the Hudson Bay area. The Torngat Mountains of the Ungava section of northern Labrador are the highest region in the Laurentian Province, and the broad Hudson Bay coastal plain section is the lowest. Intermediate is the Keewatin section, the western boundary of which is located at the contact of the typical Precambrian rocks of the shield with the Paleozoic and Mesozoic rocks of the plains (Kimble *et al.*, 1955).

The terrain from the arctic coast inland to Arlone Lake is monotonously flat and wet in summer. It is relieved only by the presence of morainal deposits or whaleback hills (Fig. 4) as described by Hanson *et al.* (1956). Past north to northwest glacial movement is clearly evinced by the scars and frost cracks exposed on these Precambrian outcroppings, by the north-south flow of the many, nearly parallel rivers which drain the region, and by the north-south running axes of the numerous lakes.

The hills are often formed completely of gravel deposits, but more commonly of solid rock. The height of these hills usually does not exceed 100 feet, although Hanson *et al.* (1956) recorded one as high as 800 feet just north of MacAlpine Lake at position $66^{\circ}46'\text{N.}$, $102^{\circ}35'\text{W.}$

Between the hills are valleys and wide stretches of tundra, more specifically grass tundra according to the classification of Kendeigh (1961). This area is typified by tussocks which are formed from the effects of frost heaving. Baird (1964) described their formation as resulting from differential frost heaving in the predominantly wet mineral soil. The tussocks are one or more feet in diameter and height with a core of heaved mineral soil and a tuft of rhizomes and leaf bases on the top and sides.

The Perry River drains primarily from MacAlpine Lake ($66^{\circ}40'\text{N.}$, $102^{\circ}15'\text{W.}$). Important tributaries enter via an unnamed river at position $66^{\circ}57'\text{N.}$, $102^{\circ}6'\text{W.}$, Laine Creek ($67^{\circ}36'\text{N.}$, $102^{\circ}9'\text{W.}$), and Gavin River ($67^{\circ}38'\text{N.}$, $102^{\circ}5'\text{W.}$). During the spring runoff innumerable temporary streams empty into the Perry River. The volume of water discharged

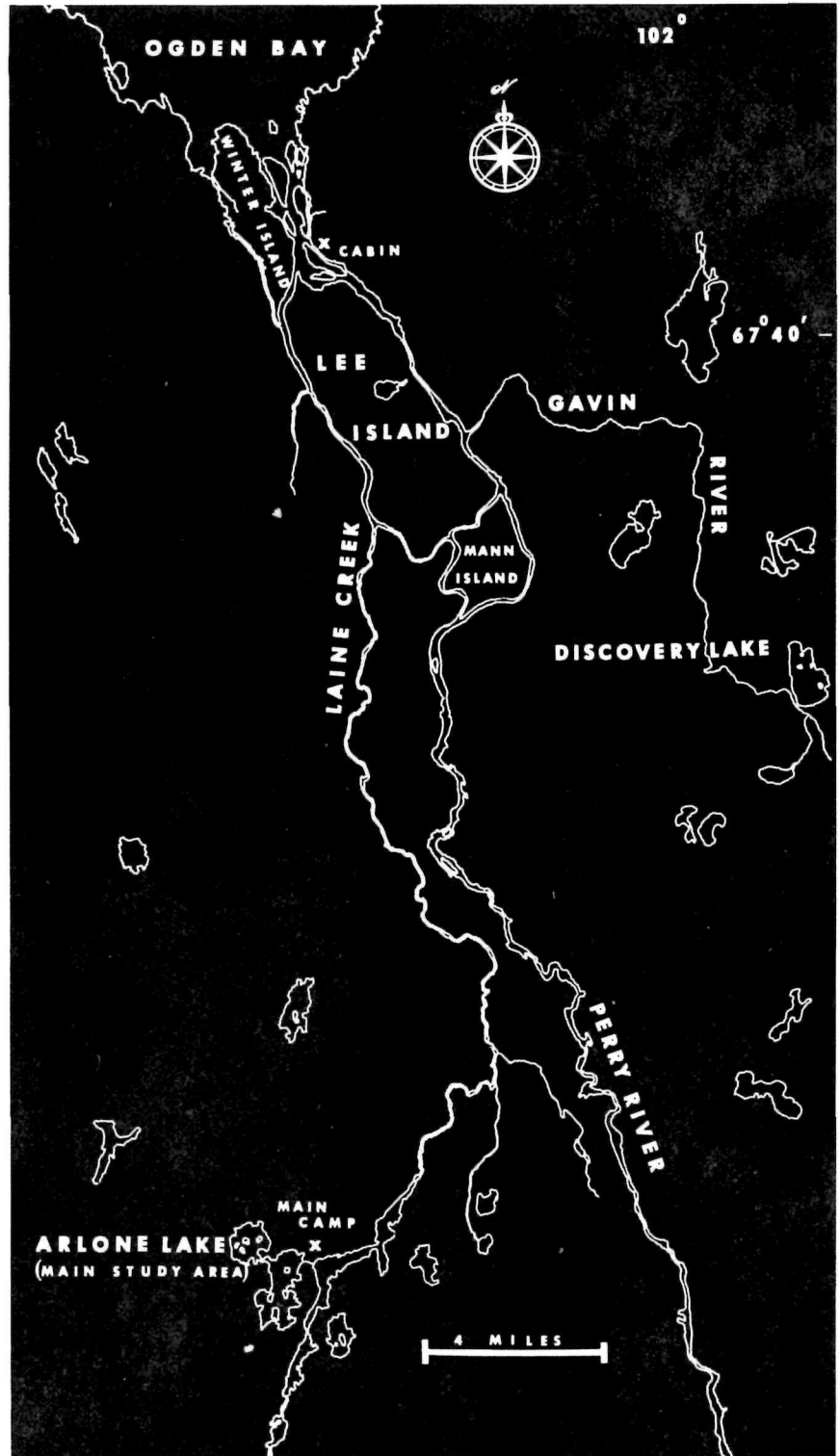


Figure 3 Map of the Perry River showing location of study.

has been calculated at 10^6 cubic feet per minute and the maximum depth is approximately 15 feet. The velocity varies from 1 to 2 miles per hour (Hanson *et al.*, 1956).



Figure 4 Morainal deposits in the Perry River region, N.W.T.

Arlone Lake (67°22'N., 102°10'W.) is about 24 miles south of the mouth of the Perry River. It has a maximum width of 1 mile and maximum length of 2 miles (Fig. 5). The greatest recorded depth is 9 feet 5 inches with an average depth of only 3 feet 9 inches. It contains seven islands, five of which are used by nesting Ross' geese (Figs. 6-10).

The short arctic season may prevent an extensive growth of aquatic and emergent vegetation and aquatic fauna. In 1963 and 1964 bottom ice continually rose until the middle of July leaving little time for plant and animal growth in the water. The almost constant winds prevailing in the summer result in the water being continually turbid. Despite the shallowness of the lake, at no time during either season of field work was the bottom visible.

The topography around Arlone Lake consists of glacial moraines and extensive grass tussock or meadow tundra, numerous small lakes, and temporary streams. The lake was still completely ice covered on June 2, 1963, and June 1, 1964 (Fig. 11), although 2 to 3 inches of water covered the ice in 1964. By June 12, 1963, and June 15, 1964, there was sufficient water to float the rubber boat. Before this the ice was sufficiently solid that we and other mammals were able to get to the islands from the mainland.

Climate

Gavin (1945) recorded -59°F as the coldest winter temperature. During the summer of 1963 we recorded 82°F on June 30 and July 6. In 1964 the highest temperature was 89°F on July 10 (see Table 2 for summary of weekly temperatures).

Kimble and Good (1955) state that the strict classification of arctic regions into continental and coastal regimes is not valid because the extremely uniform topography poses no barrier for either continental or coastal influences. The region of the

study area is probably influenced both by continental air masses approaching from the south and by the onshore winds which bring cold air from the still frozen Arctic Ocean.

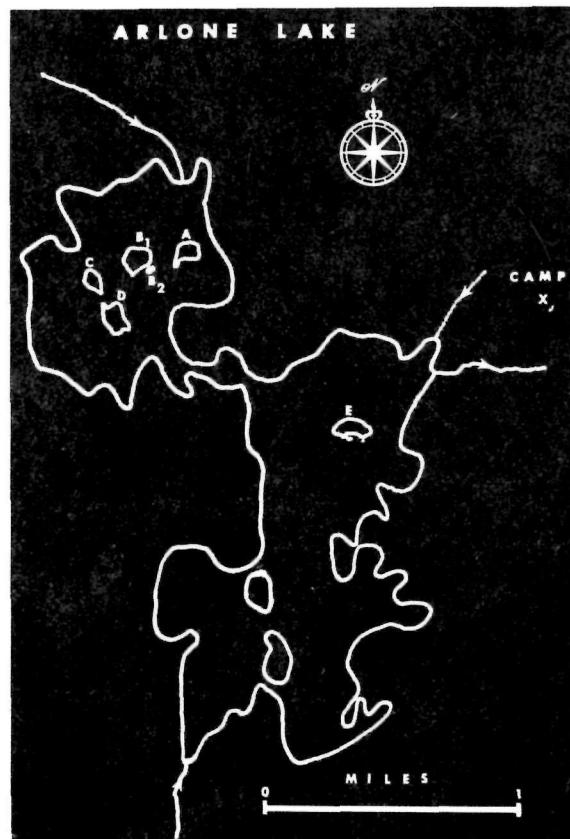


Figure 5 Map of Arlone Lake, N.W.T., showing position of nesting islands used by Ross' geese.

ISLAND A

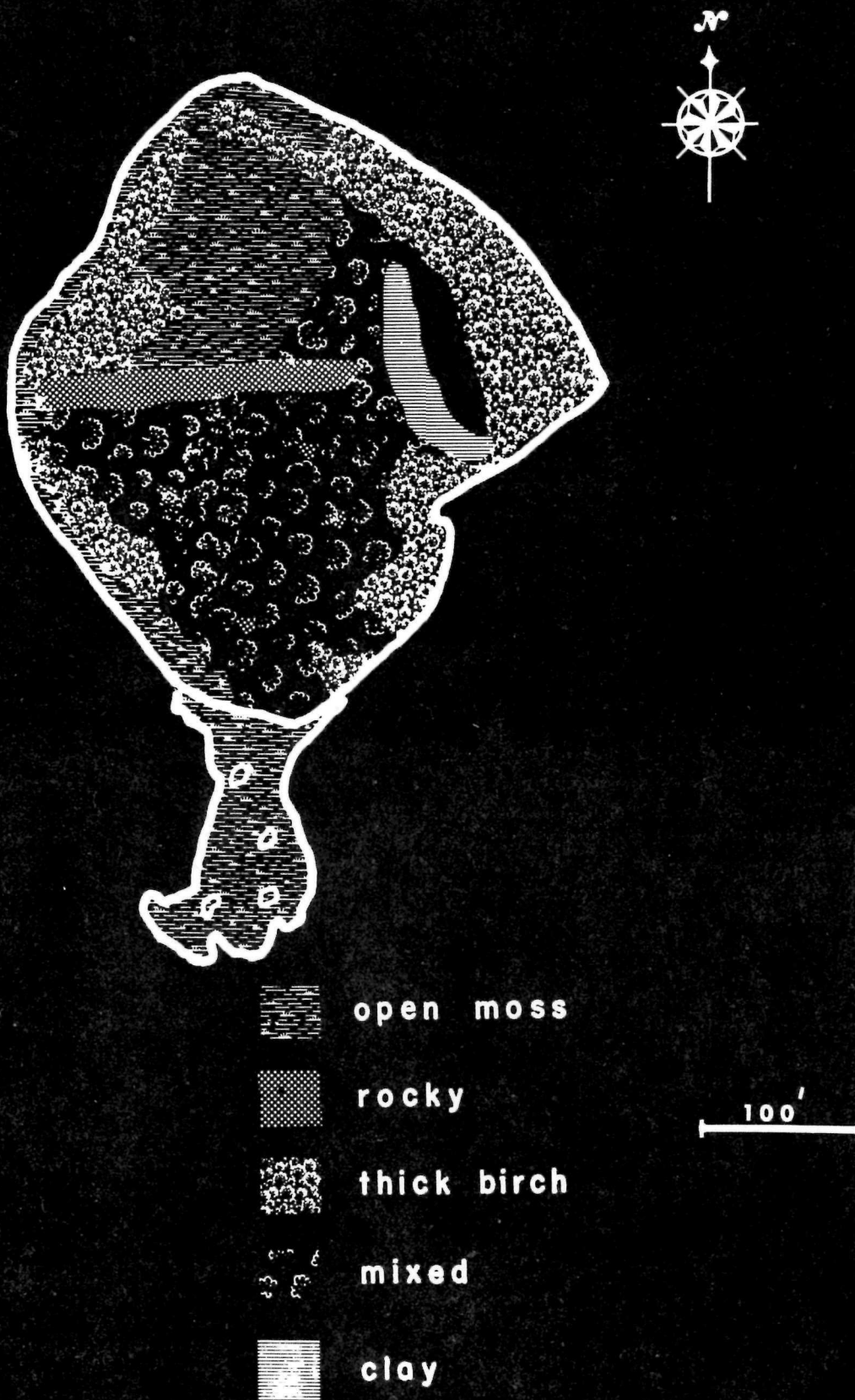


Figure 6 Habitat map of island A, Arlone Lake, N.W.T.

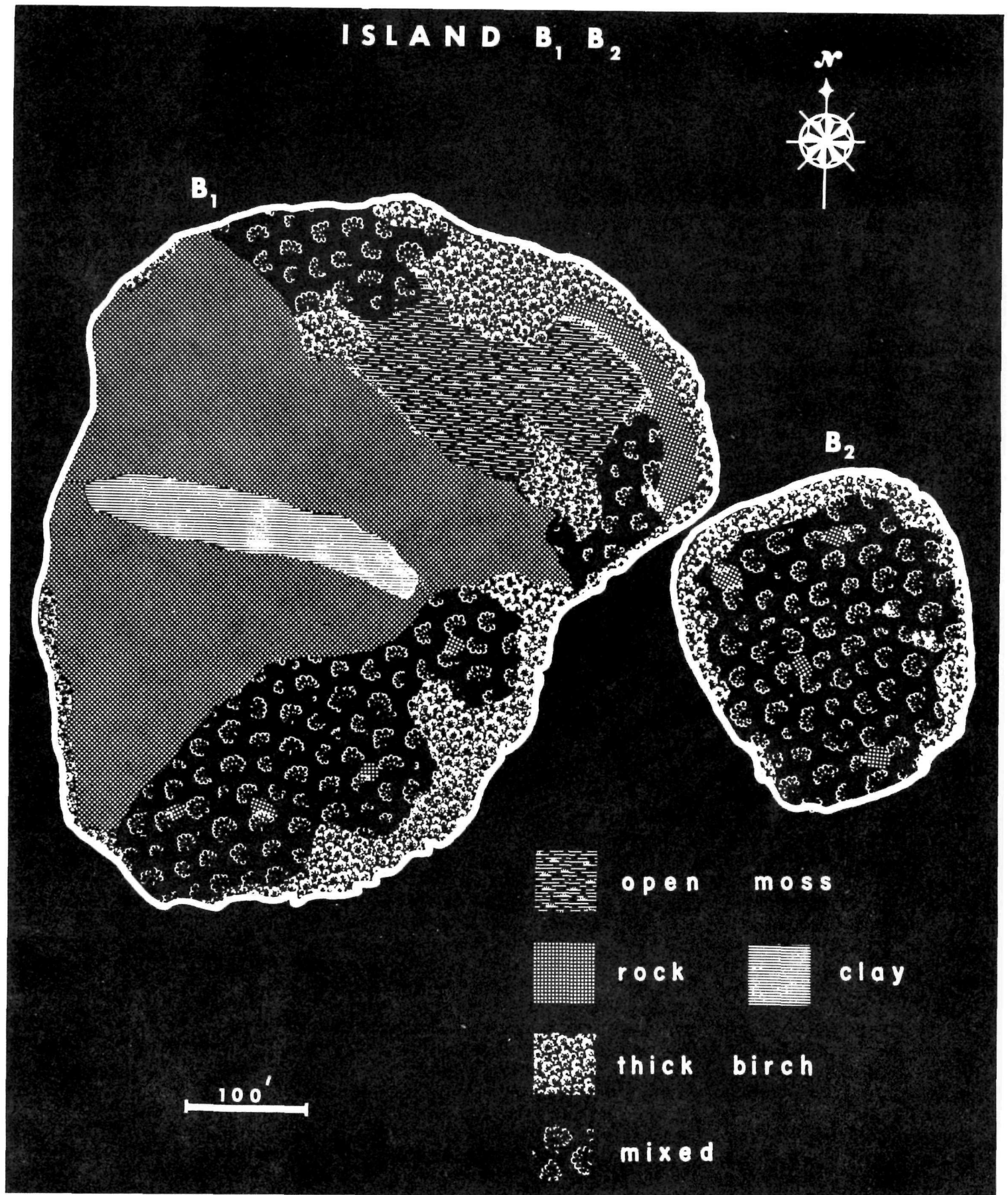


Figure 7 Habitat map of island $B_1 B_2$, Arlone Lake, N.W.T.

ISLAND C

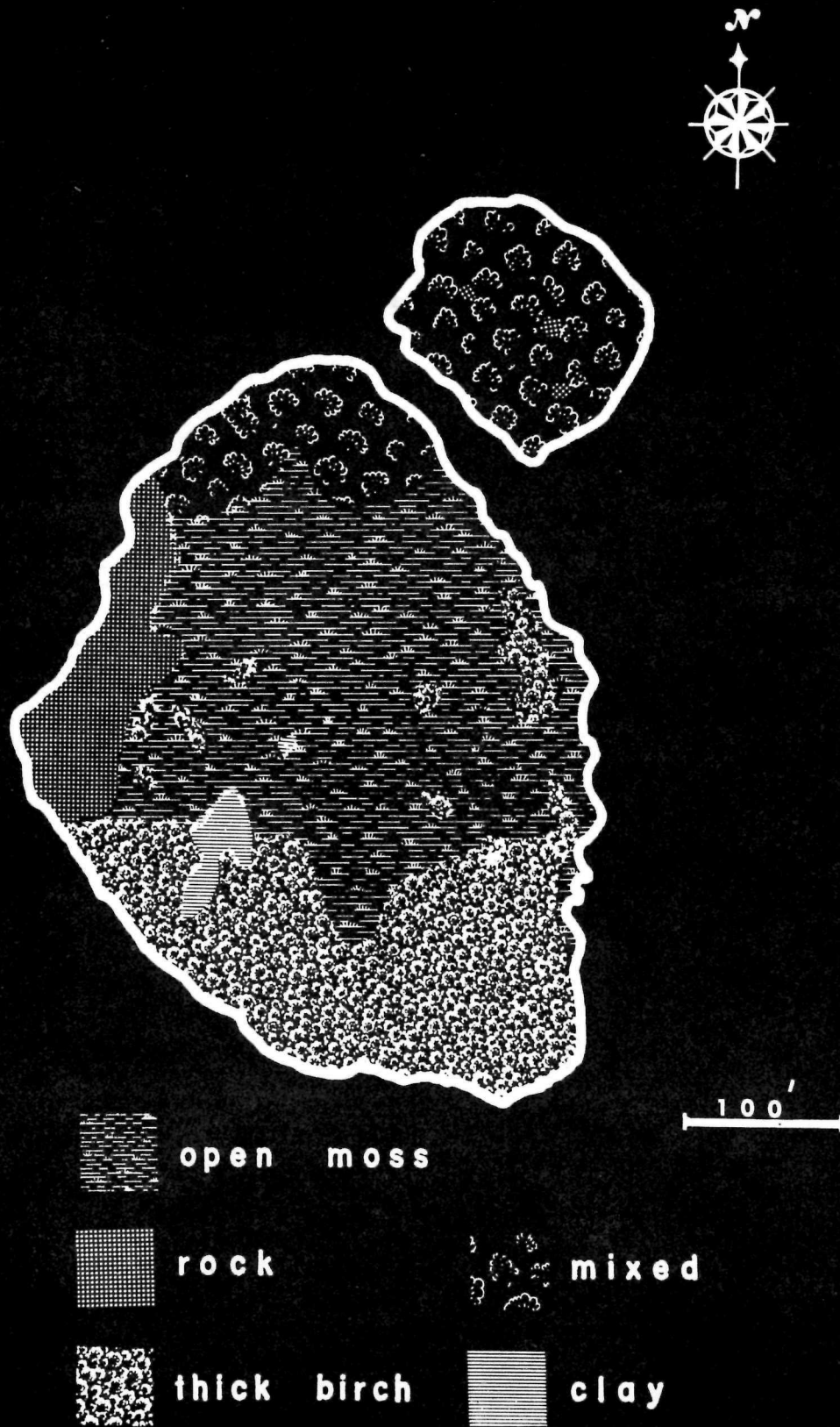
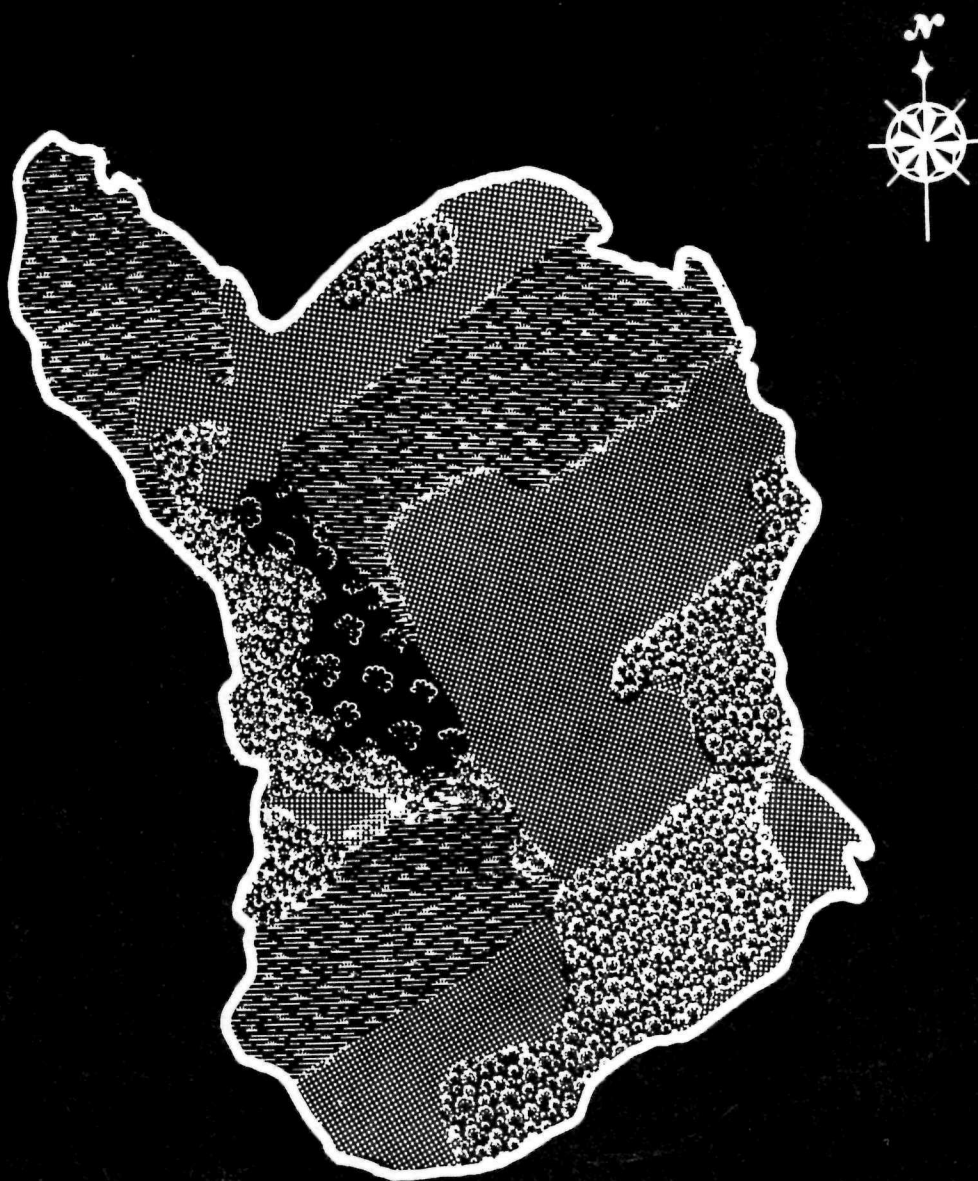


Figure 8 Habitat map of island C, Arlone Lake, N.W.T.

ISLAND D



 open moss

 rock

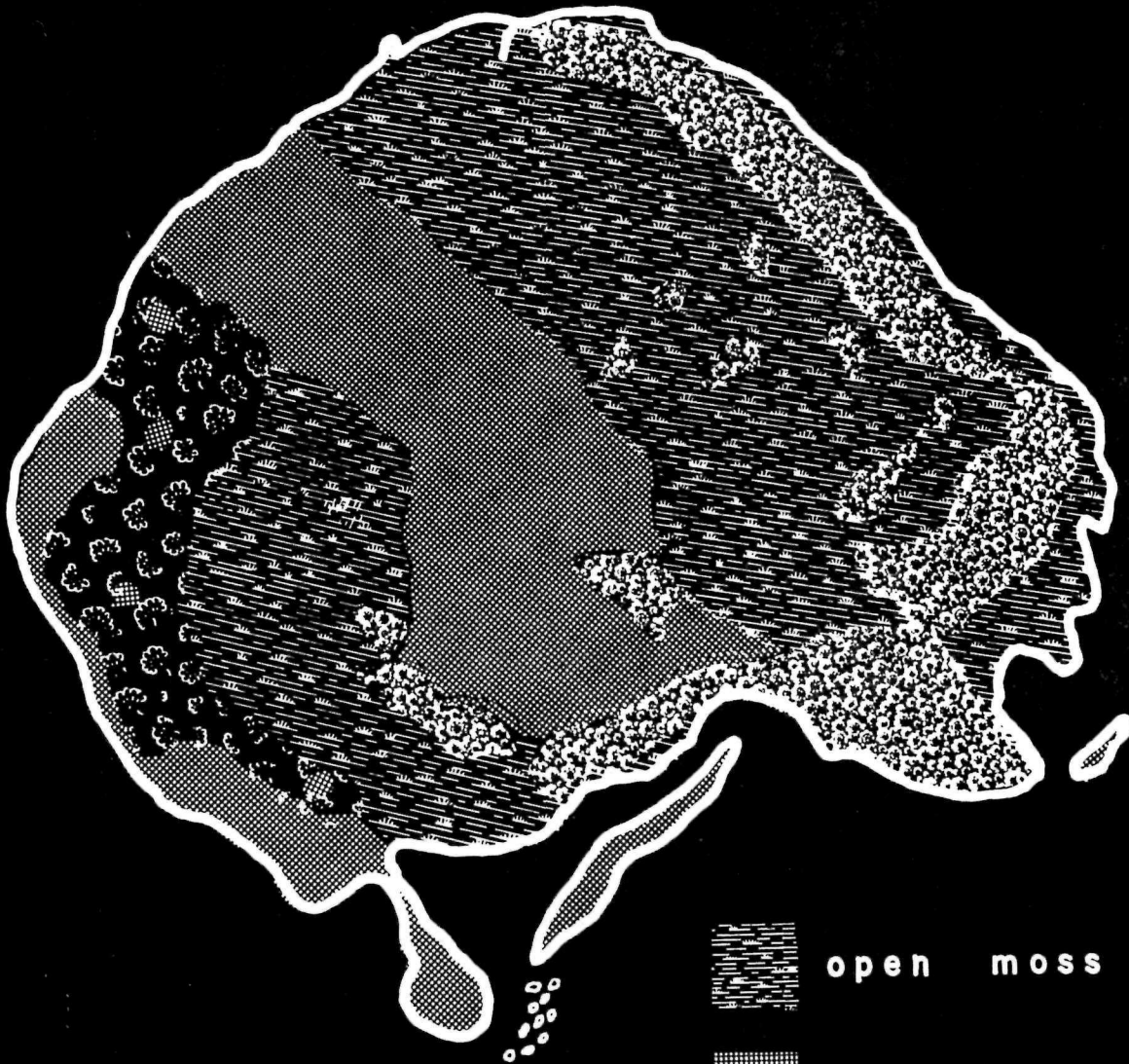
 thick birch

 mixed

100'

Figure 9 Habitat map of island D, Arlone Lake, N.W.T.

ISLAND E



open moss



rock



thick birch



mixed

100'

Figure 10 Habitat map of island E, Arlone Lake, N.W.T.

Vegetation

The vegetation of the study area most closely approximated Baird's (1964) dwarf shrub – heath tundra and the grassland tundra. The former is the most florally complex and colourful of the tundra areas, being characterized by the predominance of *Betula* spp., *Vaccinium* spp., *Cassiope* spp., and *Cladonia* spp. The grassland tundra is characterized by the presence of frost-heaved tussocks of *Eriophorum* spp. and *Carex* spp. In the immediate area of Arlone Lake there were three major areas which were botanically distinguishable. These were the islands in the lake, the grassy or meadow tundra, and the glacial moraines. Representative floral samples were secured from each of these regions (Appendix 1).

We collected a total of 19 families, including 25 identified species and 6 unidentified species. The distribution of these is presented in Table 3.

It is clear that the islands have more species in common with the moraines than with the grassy tundra. This may be explained by the similarity of substrate and altitude of the islands and moraines. Both are higher than the tussock tundra and have a

rocky shallow soil in contrast to the deeper soil and permafrost of the tundra.

All the vegetation is dwarfed. The maximum height of the birch and willow is 3 feet. Most individuals are prostrate and clumped. These characteristics cause the vegetation to be referred to as cushion plants. These morphological characteristics are attributed to at least two growth-limiting factors in the area, windchill and sparse precipitation. Two other well-documented factors, the low nitrogen content of the soil and the disruption of the soil by frost, possibly further reduce annual plant productivity (Baird, 1964). Wilson (1957) has shown that the annual growth increment of *Salix arctica* on Cornwallis Island, N.W.T., is about one-third the total plant weight whereas in temperate climates such a growth occurs in less than a week. It has been shown that the annual productivity of arctic flora in terms of weight of plant material per unit area is only one per cent of that in temperate regions (Wilson, 1957). In the study area a 10-year-old birch stem had a basal diameter of 4.3 mm.



Figure 11 Snow and ice conditions at Arlone Lake, early June.

TABLE 2 Temperature data (°F) from Perry River region

Date	Max.	Min.	Mean	No. days above 32°F	No. days below 32°F	Range
1963						
Arlone Lake						
June:						
3-9	56	20	34	7	5	20-56
10-16	72	33	48	7	0	33-72
17-23	74	32	46	6	0	32-74
24-30	82	33	54	6	0	33-82
Monthly mean = 45.5°F						
July:						
1-7	82	35	54	7	0	35-82
8-14	74	35	54	5	0	35-74
Mouth of Perry River						
15-21	65	34	48	5	0	34-65
22-28	80	36	56	7	0	36-80
Monthly mean = 53°F						
August:						
1-4	69	33	50	4	0	33-69
5-10	76	37	54	6	0	37-76
Monthly mean = 51°F						
1964						
Arlone Lake						
June:						
1-6	64	27	38	6	5	27-64
7-13	44	22	34	7	7	22-44
14-20	54	26	36	7	5	26-54
21-27	69	28	42	7	4	28-69
28-30	64	37	47	3	0	37-64
Monthly mean = 39.4°F						
July:						
1-4	68	34	48	4	0	34-68
5-10	89	40	62	6	0	40-89
Mouth of Perry River						
15-18	80	34	52	4	0	34-80
19-25	66	32	46	3	0	32-66
26-31	82	33	52	6	0	33-82
Monthly mean = 52°F						
August:						
1-6	82	36	50	6	0	36-82

TABLE 3 Distribution of flora types at Arlone Lake, N.W.T., 1963 and 1964

	Islands	I/T shared	Tundra	T/M shared	Moraine	M/I shared	T/M/I shared
Plants	20	3	14	3	14	5	2
Unique	9		6		2		

Fauna

The fauna of the study area is poor when compared to more temperate regions. During the two study seasons 45 avian and 11 mammalian species were observed. Hanson *et al.* (1956) recorded 47 avian and 6 mammalian species when his party was in the region in 1949. First observations of species are presented in Appendix 2a and b. The commonest avian species in 1963 was the Lapland longspur (*Calcarius lapponicus*), while the rarest was the short-eared owl (*Asio flammeus*). In 1964 the Lapland longspur was again commonest with a noticeable lack of the snowy owl (*Nyctea scandiaca*). This lack is attributed to the scarcity of lemmings and red-backed voles in 1964. The most common mammal in the region in both years was the brown lemming (*Lemmus trimucronatus*) and the rarest mammal was the gray wolf (*Canis lupus*) with only one sighted in two seasons. Aleksuik (1964) summarizes the fauna observations made during 1963. The major differences noted in 1964 were the scarcity of snowy owls, lemmings, and red-backed voles, and the abundance of the arctic fox (*Alopex lagopus*), with only one sighted in 1963 and ten in 1964.

Eskimos

The natives of the Perry River tribe are the Kogmiut or "Swan People". The Eskimo name for the Perry River is Koguak which means "the place of the swans". The Kogmiut are part of a larger group of Eskimos, the Ahiarmiuts, which includes those living on the shores of the Queen Maud Gulf.

The Ahiarmiuts are part of a still larger group, the Kitdlinermiut of Rasmussen, which takes in all the natives inhabiting the area between Bathurst Inlet and the south shores of Victoria Island and the shores of the Queen Maud Gulf (Hanson *et al.*, 1956).

The total native population at Perry River in 1963 was 77 according to Hudson's Bay Company records. Gavin (1945) reported 35 people living at Perry River between 1937 and 1941. Very little immigration or emigration seems to occur within the Kogmiut. Only two families that were at Perry River in 1963 had moved when we arrived there in 1964, both because of sickness.

The Kogmiut are in general one of the most primitive groups of Eskimos left in the Canadian Arctic (Pryde, *pers. comm.*). Of the 77 people we met, only 6 could speak English with any skill.

Their pattern of life follows a strict routine governed by the seasons. In the spring the families converge for seal hunting, which lasts until the early part of June when the melting rivers make conditions on the sea ice too hazardous. During June, fishing camps of 2 to 12 tents are set up, usually along the estuaries of one of the four main rivers in the region, Ellice, Perry, Pitok, and Armark. The fish are commonly caught in nets and are either eaten right away by humans or dogs, or dried and saved for the winter season. From mid-July to October hunting of caribou is the chief activity. Regular hunting parties are not commonly organized by the Kogmiuts; instead, each hunter is responsible for his own needs. Trapping the arctic fox occupies the winter.

Methods

Reproductive biology of Ross' goose

All field studies at Arlone Lake started before the arrival of the geese. Notes were kept on the approximate numbers of geese arriving daily. This was accomplished by daily visits to each island.

A total of 301 nests was marked during the study (160 in 1963, 141 in 1964). Complete nest histories were kept from 67 nests in 1963 and 81 in 1964. In addition, 93 nests from island E furnished information on clutch size, nesting and hatching success, nest density, and habitat preference.

Ten nests from island C were used to test the ability of the Ross' goose to incubate successfully a hyperclutch. Fifty nests from island D were used to determine the effects of depleting the clutch.

The 148 nests from which complete nest histories were obtained were visited before 9 a.m. when conditions allowed. When weather was inclement the visits usually took place later in the day. The histories date from the laying of the first egg to the hatching of the last one in the clutch.

Nests were marked with wooden stakes 1½ feet long. All eggs were marked with a soft lead pencil or scarlet nail polish. In 1964 a nest card form was used to record nesting data (Appendix 3).

The total number of nests in the colony was counted twice each season, June 18–22 and July 3–6, 1963, and June 19 and July 4, 1964. In 1964 notes were kept on the location of each nest.

Trapping of incubating female Ross' geese was attempted with a falconer's bow trap. Three females were trapped and marked in 1963 (June 26, July 1 and 5). A total of 148 was marked later the same year during banding operations at the mouth of the Perry River. Of these, 20 (10 pairs) were recorded on the Arlone Lake nesting ground in 1964.

Throughout both seasons notes were kept on behaviour of the geese. Two territories were marked out by placing four stakes 3 feet from the nest in north, south, east, and west directions. Activities of the male and female were then recorded on graph paper for 2 hours. The results of these observations were used to determine territory size.

A total of 72 Ross' geese was collected on the study area (28 in 1963 and 44 in 1964), 49 of these adult and 23 young. Data were recorded from each specimen on a standard form (Appendix 4).

Autopsies were done on 57 geese (40 adults and 17 young). All food and parasites collected were preserved for later identification. Records were kept of the colour of each gosling when hatched in each brood. In addition, 192 day-old goslings were caught by hand. Sixty-four were weighed to the

nearest gram, and sex and colour phase noted. The sex and colour phase of the remaining 128 goslings were recorded. Of the 192 goslings, 83 were leg-banded with a plastic, expandable band. The colour of the band indicated sex and colour phase.

After the departure of the geese from the nesting area, all unhatched eggs in the colony were broken. The number in the nest, habitat in which the nest was located, and condition of the eggs (sterile, dead embryo, or addled) were noted.

Habitat analysis

Maps were constructed of each island by dividing them into two halves by a rope stretched along the longest axis of the island. Every 100 feet along this rope another rope was placed at right angles running to the shore. This formed a number of transects the lengths of which were known. These were then transferred to scale onto graph paper.

The insular nesting grounds were divided into four major habitats: birch, in which *Betula* sp. predominated in a clumped or matted form; rock, primarily boulder piles and individual rocks on the open areas; moss, which was the only cover on the rocky substrate; and mixed, in which the three former categories were interspersed.

Floral analyses were completed during the 1964 season. Coverage and frequency of represented plants were determined following the method described by Daubenmire (1959). All plants encountered during the analyses were pressed and dried for subsequent identification.

Post-breeding biology of Ross' goose

After the nesting season the study was continued at the mouth of the Perry River (67°42'N., 102°11'W.), where a banding program was followed from July 30 to August 10, 1963, and July 11 to August 10, 1964. Concurrently, notes were kept on flock size and sex ratios. Through co-operation from Alex Dzubin of the Canadian Wildlife Service, population counts and brood sizes were obtained of Ross' geese on their autumn migration through Kindersley, Saskatchewan (51°27'N., 109°10'W.).

Meteorological data were collected from certain areas along the spring migration route in an attempt to correlate movements with weather conditions. United States Fish and Wildlife refuge managers located in the Pacific Flyway were alerted to watch for major concentrations of Ross' geese in their respective areas during the spring of 1964. Fish and Game officials in Alberta and Saskatchewan were sent letters requesting the same information.

Results

Reproductive biology of Ross' goose

Spring migration and arrival

Dates

The exact arrival dates of Ross' geese on their arctic nesting grounds are not given in the literature. Hanson *et al.* (1956) recorded them at the junction of the Gavin and Perry Rivers on June 7, 1949; we observed the geese earlier at Arlone Lake in 1963 and 1964, however.

In 1963 the first Ross' geese (12) were sighted flying over Arlone Lake on June 5. Canada geese (*Branta canadensis*), white-fronted geese (*Anser albifrons*), and lesser snow geese (*Anser caerulescens*) had been recorded earlier—May 25, June 1, and June 3 respectively (Appendix 2). The arriving Ross' geese were invariably in small flocks of 2 to 50 individuals and they were not in association with lesser snow geese. On June 7, 50 white geese were seen on island B₁B₂, most being Ross'. Seventy Ross' geese were seen on these same islands on June 8. The peak arrival occurred on June 8. Ross' geese continued to arrive until the end of June, when a total of 1,538 nesting geese were present on the six nesting islands.

In 1964 the arrival of Ross' geese followed much the same pattern, with small flocks first appearing over Arlone Lake followed by a rapid build-up of the population. The first Ross' geese (19) were seen flying in a north-northwest direction over our camp on June 1. At this time we counted 45 lesser snow geese in the vicinity of the lake but saw no white geese on the nesting islands. On June 2, 19 Ross' and 25 lesser snow geese were seen on island E. Poor weather conditions on June 3 prevented our visiting the islands, but on June 4 a larger number of Ross' geese had arrived. June 4 was considered to be the peak arrival date. By June 9, 1,812 Ross' geese and 356 lesser snow geese were present at Arlone Lake.

Correlation with weather

Birds which migrate approximately 2,300 miles from their wintering area to their nesting grounds require some external factor that will govern their movements so that they arrive on the nesting grounds when conditions will permit successful nesting. Presumably one of the most efficient mechanisms by which a species can obtain such information is to follow a weather clue. This has been termed the phenological influence of weather on migration (Welty, 1962). Lincoln (1939) depicted the movements of various spring migrants in relation to spring temperatures and drew isochronal lines of migration which corresponded to certain isotherms.

He described the spring movements of the Canada geese, and stated that the northward migration keeps pace with the advance of the 35°F isotherm. SOWLS (1955) has shown that the arrival of summer-resident ducks in a region is greatly influenced by weather conditions. He states that the northward-moving waterfowl push against a barrier that gives way gradually, but inevitably. Sudden changes in the barrier result in appropriate movements in the population; when the barrier of cold air masses moves south, the migration sometimes retreats.

The isotherm of phenological theory was applied to the 1964 spring migration of Ross' geese by mapping the spring isotherm advance monthly from the California wintering grounds to the Perry River nesting grounds (Fig. 12). It was found that the prevailing isotherm in central California during January was 40°F, and that the isotherm which persisted over the nesting area in June 1964 was between 30°F and 40°F. The information on the migration includes reports of 12,531 Ross' geese from the following locations: Merced and Willows, California; Burns, Lakeview, and Klamath Falls, Oregon; Charlo, Montana; Strathmore and Haybay, Alberta.

The results suggest that the migration of this species does follow a particular spring phenology pattern. The geese arrive at each reported location subsequent to the 32°F isotherm, thus assuring that the melt has started and that water and food will be available along the route. Although it is assumed that local weather conditions can either speed up or delay migration, the isothermal lines are seemingly followed, so that by the time the geese reach Perry River the spring melt has started and the nesting cycle can begin without delay. Table 2 shows that in 1963 and 1964 the average temperatures for the first week in June were 34°F and 38°F respectively.

From conversation with the Eskimos of Perry River I learned that they usually see the first migrants during the last week of May. This may be true in an early spring or when suitable weather conditions prevail farther south. However, the spring of 1963 was late, thus delaying the birds approximately 1½ weeks. Reports from the Canadian Weather Review for May 1963 state that most stations on the Prairie Provinces experienced mean temperatures 2 to 4 degrees below normal, and new record minimum temperatures for the month were set in Alberta. In the Northwest Territories temperatures were 4 to 7 degrees below the monthly normal for May.

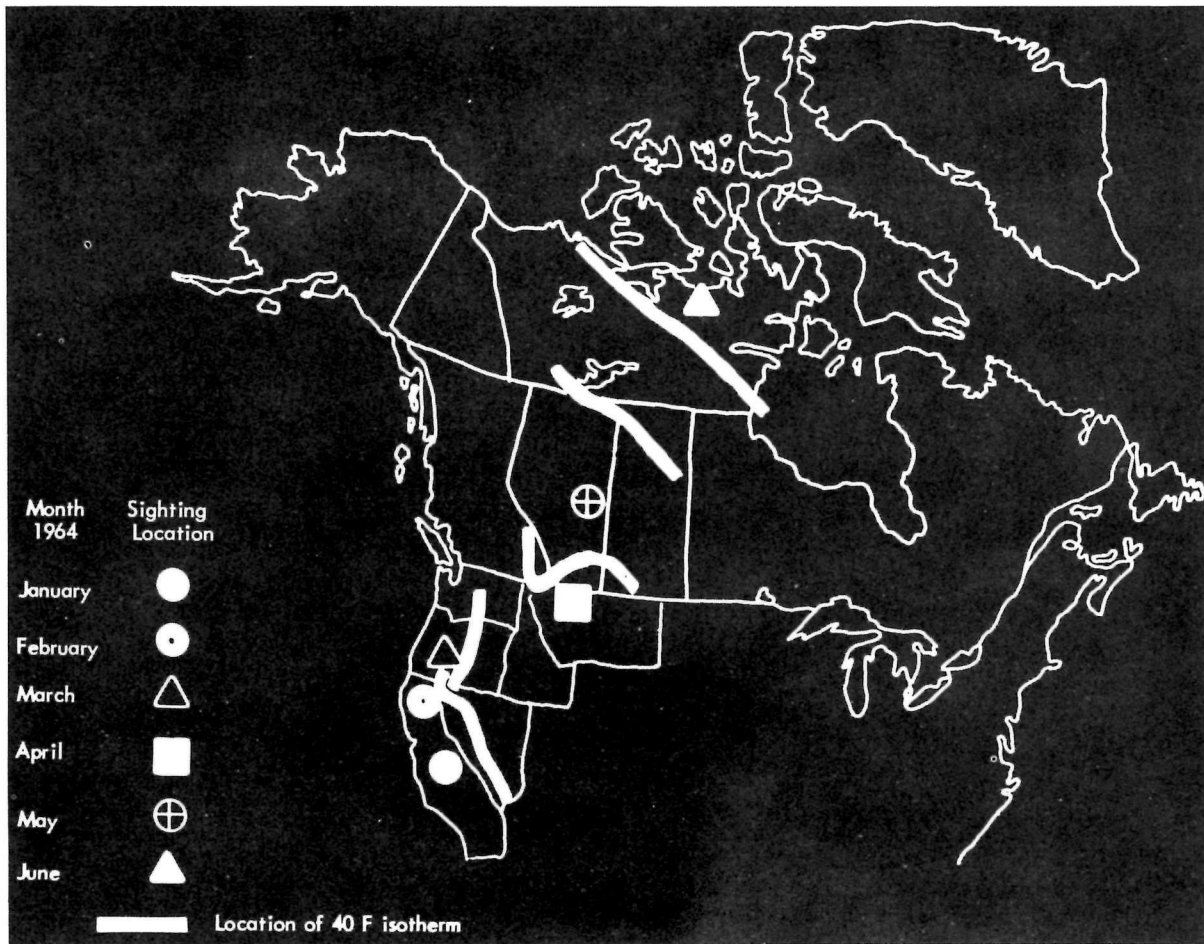


Figure 12 Migration-phenology pattern of Ross' goose, 1964, based on 12,531 sightings.

Breeding condition on arrival

Ross' geese are presumed to be mated by the time they reach the nesting islands. There was no evidence of copulation or even of the courtship flights which have been noted in the lesser snow goose and the Atlantic brant at this stage (Cooch, 1953; Barry, 1956). The only "courtship" displays seen were the very common territorial triumph displays.

Mr. L. Sugden has twice observed copulation between Ross' geese that were migrating through Alberta on April 27, 1963. Sugden (pers. comm.) describes the procedure as follows:

No preliminary display noted—male mounted female in about one foot of water, grasped her nape with his bill. During act, which lasted approximately fifteen seconds, the female was completely submerged for about four seconds. At the termination of the copulation the male slid off the female's side and appeared to swim against her side. Both birds then ruffed their feathers, stretched out of the water and flapped their wings.

The second observation by Sugden reads as follows:

This pair copulated within a few seconds of the first pair and complete act was witnessed. Their behaviour was similar to the first pair, except that the female did not completely submerge, the duration of the act was about twelve seconds and after the male slid off the female's back he moved away from her to about two feet, at which time both fluffed their feathers and flapped wings.

These observations are consistent with the copulatory procedure described by Delacour and Mayr (1945) for the subfamily Anserinae.

Gonads collected from 37 Ross' geese after their

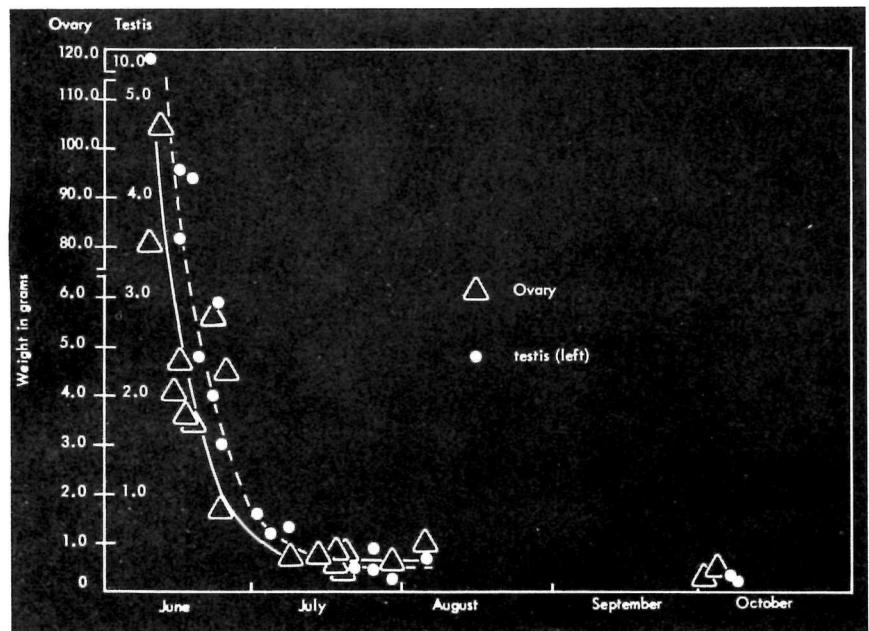


Figure 13 Gonad weight changes of Ross' geese during the breeding season, 1963 and 1964.

arrival showed a continuous weight decrease. This suggests (Fig. 13) that copulation probably occurs prior to the arrival on the nesting grounds and that the birds are physiologically capable of nesting and egg laying when they arrive. Barry (1962) found that the testes of the American brant *Branta bernicla hrota* showed a continual decrease in weight and a low sperm count at the time of arrival and thereafter. He concluded that copulation had occurred farther south in that species. In the

Ross' goose, as in other arctic-nesting species, the courtship procedure is a lengthy and strenuous process, one which would most certainly be selected against where the season is so short (Barry, 1962). It seems almost inevitable that copulation should occur during the spring migration so that successful completion of egg laying, incubation, hatching, and brood raising can be achieved during the short summer season. This latter point can readily be seen by analysing Figure 14. The temperatures plotted here are long-term averages from Cambridge Bay, N.W.T., (Climate of Canada 1959-60) the closest meteorological station to the study area. The Ross' geese arrive just before the mean 32°F and depart just before the mean temperature drops again. Each of the breeding phases is so timed that the final phase is completed prior to a drop in temperature below the freezing point. By the time the mean temperature falls again to 32°F the population has moved south toward the first major staging areas of Alberta and Saskatchewan, Canada.

Nesting

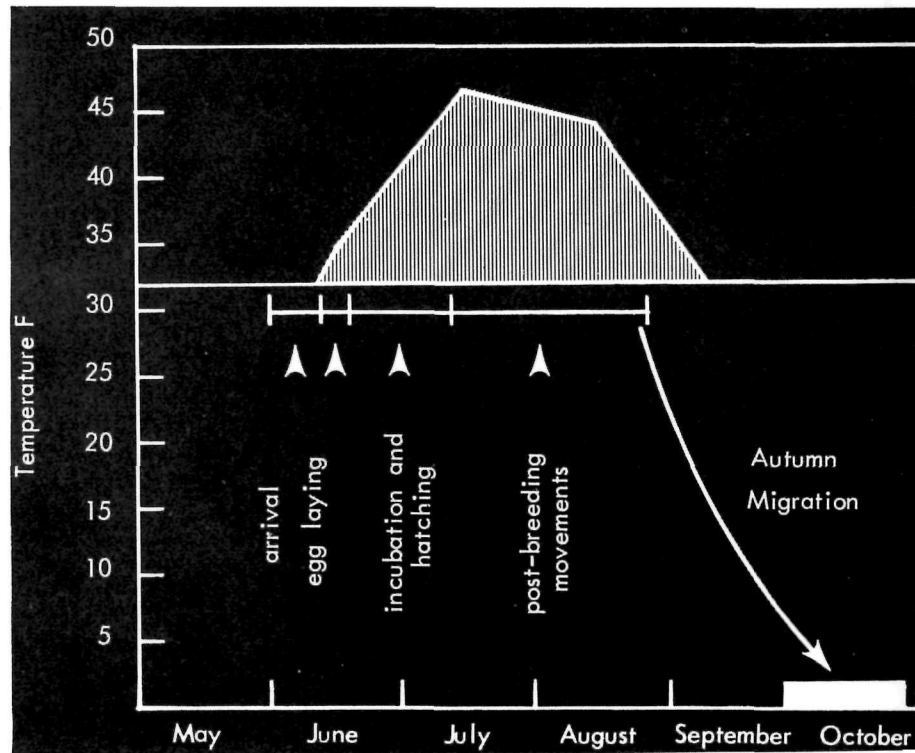
Nest site availability

Although the Ross' geese are physiologically capable of nesting almost immediately after their arrival on the nesting grounds, weather and snow conditions may delay such activities.

In 1963 nesting was delayed for 5 days, presumably as the result of strong southerly winds June 5-9. The effect of the wind on the geese was marked. Dense concentrations of Ross' and lesser snow geese congregated on the leeward side of the islands. On June 9, after the winds had subsided, the geese dispersed over the entire area to begin nesting activity.

In 1964 nest construction started just 3 days after the geese were first observed (June 1). Strong winds and small amounts of snow did not deter the geese from initiating nesting activities.

The effect which snow can have was seen on island B₁ in early June 1964. An estimated 20 per cent of the optimum habitat was covered with snow or was submerged under snow-melt water which prevented geese from using this terrain. The drainage on the islands is poor, and permafrost (Hanson *et al.*, 1956) prevents absorption into the soil causing water to remain in pools until much of it has evaporated. Minimum daily temperatures during early June invariably dropped below 32°F, causing the pools to freeze, which further retarded the removal of surface waters. Not until an area was



drained did the geese build their nests in it.

The nesting grounds at the time of geese arrival in 1963 and 1964 provided space for immediate nesting, but wind and snow conditions in 1963 delayed nesting.

Nest construction

As soon as the weather and snow conditions are favourable, nest construction begins with materials available at the nest site. The nests on the open moss regions are composed primarily of plucked moss and old scats; those in the thick birch stands are made of dead leaves, twigs, and scats; and those in the mixed regions are composed of moss, twigs from birch and willow, or masses of grass. There is considerable variation in the care taken in the construction of the nest. Many are poorly constructed in that they are extremely shallow and offer absolutely no protection for the eggs. Other nests are elaborately built with thick walls and deep cups. It may be that the better nests are built by older, experienced birds and the poorly constructed nests by young birds or first nesters.

Measurements of the outer and inner diameter and depth of nests are presented in Table 4. There is no significant difference in the dimensions of inner diameter and depth among the various habitat types ($P > .05$). However, the thickness of the nest wall was greater in those nests built in the open.

Figure 14 Extent of Ross' goose reproductive phase in relation to frost-free period, Perry River region, N.W.T.

TABLE 4 Dimensions of nests in relation to habitat (measurements in inches)

Habitat	Open	Rock	Birch	Mixed
Outer diameter	19.3 (15-28)	16.6 (12-22)	15.4 (10-24)	16.3 (12-19)
Inner diameter	6.2 (4-7)	6.4 (5-7)	6.3 (4-9)	6.9 (6-8)
Thickness of nest wall	13.1	10.2	9.1	9.4
Depth	3.2 (2.25-4.5)	2.7 (2-3.5)	2.3 (1.5-3.5)	2.5 (2-2.75)
n =	40	25	43	14

Nest site requirements

In order to obtain information on the preference of the Ross' goose for particular habitats, vegetational cover on the islands of Arlon Lake was investigated. This information was compared with that obtained by observing specific vegetational cover at the nest sites. Only from these two sources can accurate and meaningful conclusions be made in regard to the nest site preference of the species and the density of nests in a particular area.

The results of such studies enable one to determine whether the dispersal of the geese on the

islands is random or whether there is selection by the geese. Table 5 presents data on the available nesting cover (potential coverage) on each of the islands, and nest rating percentage of Ross' geese nests within these regions. Table 6 presents the density of nests within each habitat on the islands.

It will be noted that the greatest density is in the mixed habitat and the lowest in the open area. The rocky and birch areas have intermediate preference. The data from island A and island C show preferences for the birch areas instead of the rocky areas. This is the opposite of the densities of the

TABLE 5 Comparison of nest cover and potential coverage of the four major habitats on Arlon Lake islands

Habitat	A	B ₁ B ₂	C	D	E
Mixed	58(27)	50(39)	39(21)	56(9)	24(8)
Rock	2(4)	16(7)	6(7)	8(7)	26(6)
Birch	33(22)	20(14)	18(9)	28(30)	39(43)
Open	7(47)	14(40)	37(63)	8(54)	11(43)
	100(100)	100(100)	100(100)	100(100)	100(100)

Note: the figures in the left-hand columns indicate nest rating per cent. The figures in parentheses indicate potential coverage per cent.

TABLE 6 Density of nests in each major habitat on islands (per 1,000 sq. ft.)

Habitat	Mixed	Rock	Birch	Open
Island				
A	2.17	0.40	1.50	0.15
B ₁	4.10(5.90)	4.10	3.40	0.83
B ₂	3.70	—	3.80	—
C	19.60	2.80	6.50	1.80
D	20.60	4.50	3.10	0.60
E	6.70	4.00	2.60	0.80
Mean =	9.50	3.27	3.42	0.84

Average for colony = 4.26 nests/1,000 sq. ft.

other islands. Islands A and C are exceptional in respect to their rocky areas. On island A this area is localized and composed of small rocks situated on the highest portion of the island. This makes it far inferior as a protective site to any of the other regions except the open area. On island C most of the rocks are located at the east end of the island in low clusters that offer no grazing area for the geese. The rocky regions on the other islands have rocks large enough for protection and sufficiently dispersed to afford ample grazing area.

The thick birch stands provide adequate protection but no grazing area, and the open areas provide no protection. The mixed region, being composed of small birch stands and rocks, provides for both protection and grazing. It seems that the above two

conditions are required for maximum density.

On island B₁ the data show equality of preference between the mixed and rocky areas. This apparent discrepancy is due to the fact that about 20 per cent of the total mixed cover of this island was covered with snow during the nesting period. If this is taken into consideration the density in the mixed area was 5.9 nests per 1,000 square feet. This agrees with the results from the other islands.

It is felt that two limiting factors determine the density of nests in a given region. These are, sufficient protection from the elements and ample space for grazing. Moss or grass must be present on the area. Figures 15-18 show the four main habitat types on the islands.



Figure 15 Mixed habitat.

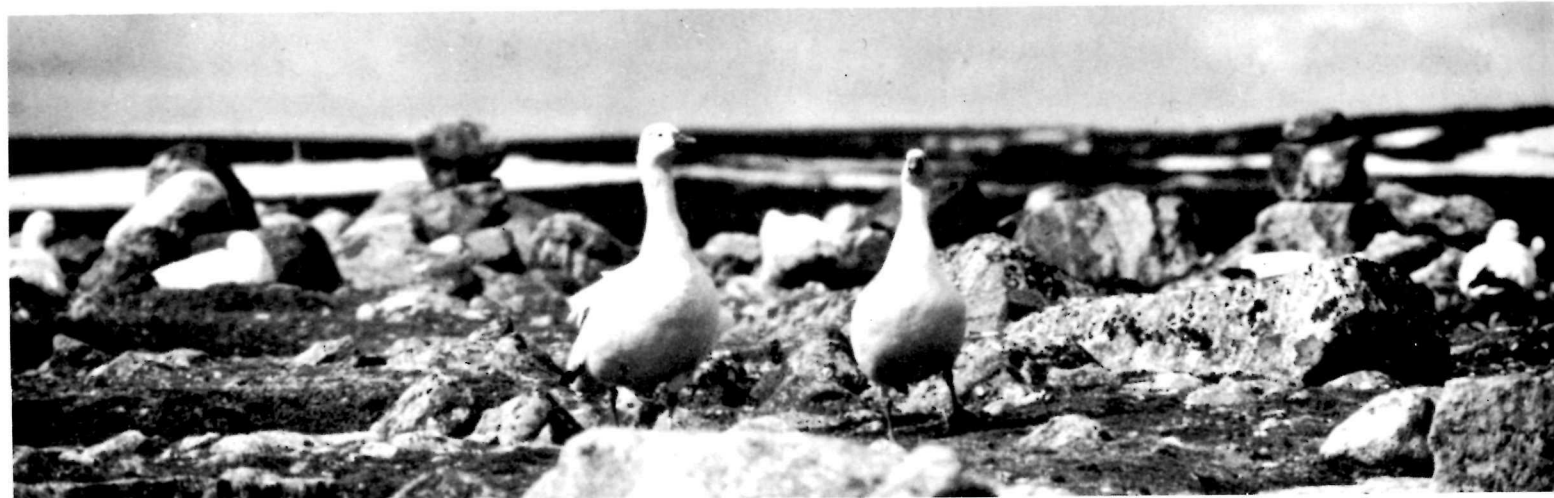


Figure 16 Rock habitat.



Figure 17 Birch habitat. White "spots" are feathers caught in the low trees.

Figure 18 Open habitat.



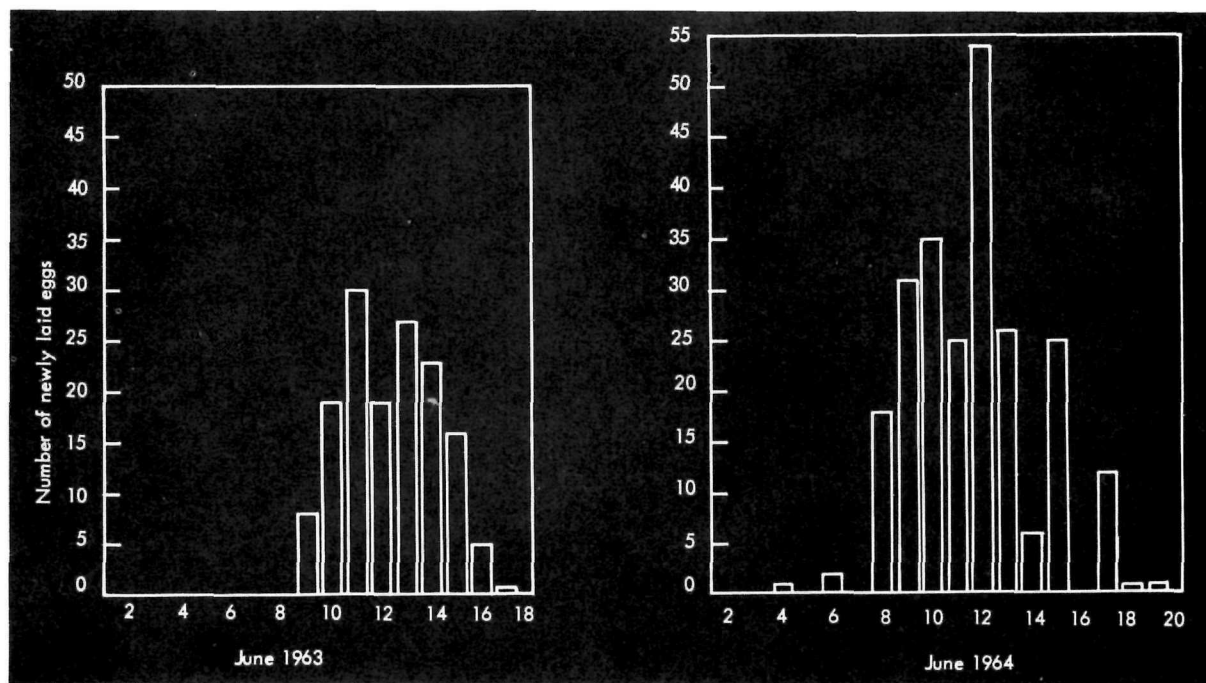


Figure 19 Frequency of egg laying in Ross' goose, 1963 and 1964.

Egg-laying period

Dates

In June 1963 and 1964 there was no delay between nest construction and egg laying. In 1963 the first Ross' goose nests (29) and the first eggs (22) were seen on June 9. On June 8 no nests were observed on any of the islands so that initial nest construction in 1963 took place on the morning of June 9.

In 1964 the first Ross' goose nest was seen June 4. In both years the lesser snow goose started laying before the Ross' goose, in 1963 by 2 days (June 7), and in 1964, six snow goose nests were found on June 4 in comparison to only one Ross'. Figure 19 shows the frequency of egg laying in terms of newly laid eggs.

The 1963 egg-laying period lasted from June 9–17, a period of 9 days. Egg laying started on June 4, 1964, but the bulk of the population did not begin to lay until June 8.

The modal date of nest initiation was virtually the same in both years despite the earlier arrival of the Ross' geese in 1964. In that year early nesters were harassed by arctic foxes. Ten foxes were seen between June 11 and 26 in comparison to only one in 1963.

Behaviour

The Ross' goose lays one egg every 1.5 days on the average (56 clutches). During the egg-laying period the geese remain on the islands for much of the time, although pair flights to the mainland are very

common. The geese spend short periods at the nest site at this time. When on the territory, one member of the pair appears to watch for intruders while the other grazes. Territorial defence appears to be taken in rotation. Sometimes, however, both birds act together to expel another goose from the territory. Territorial interactions were not observed to be sex specific as it is common to see females successfully evict males of Ross' and lesser snow geese from the territory. When a pair of intruders enters the territory the male defender heads the charge with the female right behind.

The defence posture of the Ross' goose is typical of members of the genus *Anser* but differs markedly from *Branta*. Typically, the Ross' defence procedure takes the form of a charge with the neck held horizontally and the mouth agape (Fig. 20). In *Branta* the neck is in the form of a sigmoid curve and not stretched straight out. I was able to distinguish two types of vocalization that accompany the charges, their use depending upon the intensity of the interaction with the intruder. The first was a high-pitched squawk given by both members of the pair, if both are involved, and the second a low moaning grunt given before and after the charge. The former vocalization is heard only during the more intensive or "near contact" scuffles or when actual physical contact is achieved. The latter call is most commonly heard during the more subdued interactions, but occasionally during the

serious conflicts. When the male has successfully driven an intruder out of the territory, he returns to the female and, with neck stretched upwards at 60°, he utters the low moaning sound. This behaviour on return of the mate is considered to be a form of post-nuptial display (any display or ceremony that takes place between the sexes after copulation has ceased and incubation begins) (Van Tyne and Berger, 1961). Delacour and Mayr (1945) state that this "triumph ceremony" is characteristic of the geese and that it plays an important part in the pair-bond display. Armstrong (*in* Van Tyne and Berger, 1961) says birds which exhibit this post-nuptial display recapitulate briefly the features of the pairing ceremony.

The period of the territorial flight is short, usually lasting only a few seconds. Very little resistance is shown by intruders, who usually run away or take flight immediately. Even the larger lesser snow goose does not resist the small Ross' goose.

During egg laying the geese were timid and tended to retreat from the territory for no apparent reason. When disturbed, large groups took flight, soon splitting into smaller sub-flocks which settled on the lake 10–40 yards from the island. Within 10–15 minutes the small groups and pairs returned

to the islands and settled down on the territories. At this time territorial disputes were at a maximum. It seemed that the birds invariably landed in the wrong territory, causing great disturbance among the other geese. An uproar continued until the birds had arranged themselves on the appropriate territories.

Territories

Two territories were mapped from observations of two pairs of Ross' geese on island B₁ (Figs. 21 and 22). The greatest diameter of the two territories in the open and rock habitat was 8 and 12 feet respectively.

The islands not only supply territorial space but also communal areas. Generally, the communal areas are located on the open moss regions and not in the thick birch stands. Thus the actual density of nests per unit area of the island is not a valid reflection of the territory size, because of the incorporation of space lacking nests (Table 5). Barry (1960a) noted that within Atlantic brant nesting colonies there existed communal areas in which the males often stayed close to their own territories during the incubation period. This was not observed in the Ross' goose. The males appeared to stay in the confines of their own territories.



Figure 20 Defence posture of Ross' goose.

Clutch sizes

The modal clutch size for Ross' geese at Arlone Lake was four although the average for each island was approximately three, in both seasons (Table 7). In most cases a numerical decrease in clutch size occurs during the incubation period. The resulting difference is not significant, however ($P>0.05$). In the event of a retarded season, as in 1963, or heavy predation at the beginning of the season, the average clutch size tends to decrease. Clutches started later in the season are smaller than those started early (Table 8). Under optimum conditions *Anser rossii* has 93 days in which to complete the nesting and moulting cycle (see below).

If a season is retarded or initial predation destroys first laying attempts, the phases of the nesting cycle can be shortened as much as a week by laying a smaller clutch. In 1963 and 1964 Ross' geese utilized 86 per cent of the frost-free period to

TABLE 7 Clutch sizes of Ross' geese from Arlone Lake, 1963 and 1964

Island	No. of active nests	Mean clutch before incubation	Mean clutch after incubation
A	124	3.73	3.69
	69	2.77	2.95
B ₁	189	3.80	3.59
	255	3.64	4.06
B ₂	65	3.78	3.48
	75	3.53	3.40
C	16	3.44	2.93
	199	3.40	3.36
D	133	3.62	3.54
	308	3.84	3.50
E	242	3.65	3.59
1963 Total	769	3.67	3.47
1964 Total	906	3.58	3.47

TABLE 8 Clutch size of Ross' geese in relation to date of first egg

Date of first egg	Mean clutch	
June 9, 1963	4.06	
June 10, 1963	3.61	n = 40
June 11, 1963	3.08	
June 8, 1964	5.00	
June 9, 1964	4.28	n = 58
June 12, 1964	2.85	

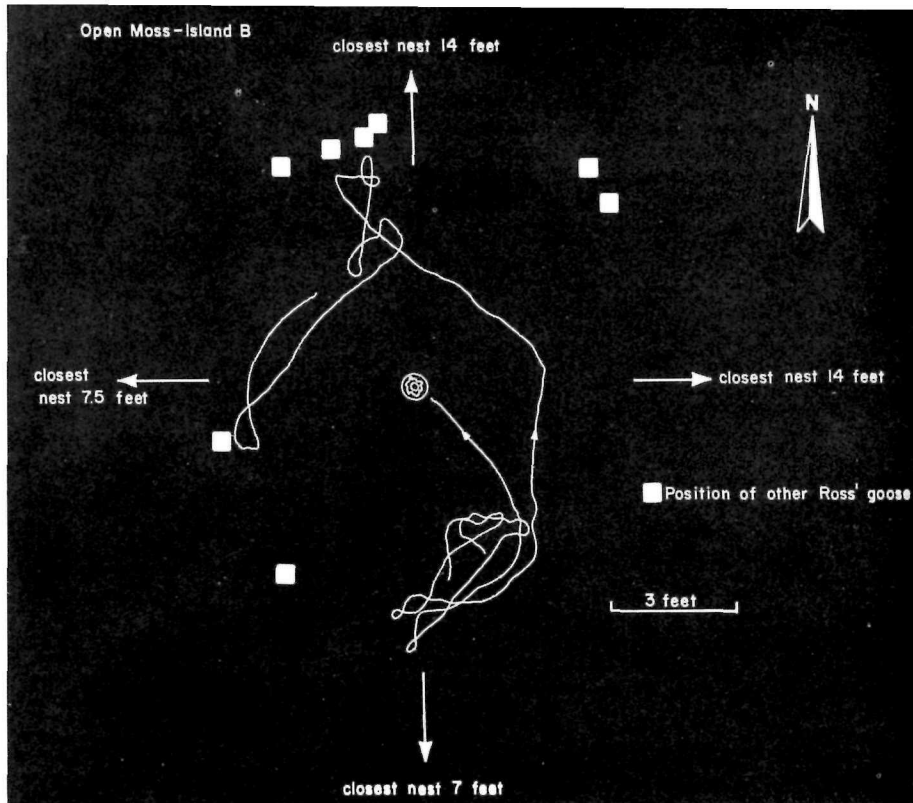


Figure 21 Ross' goose nesting territory in open area.

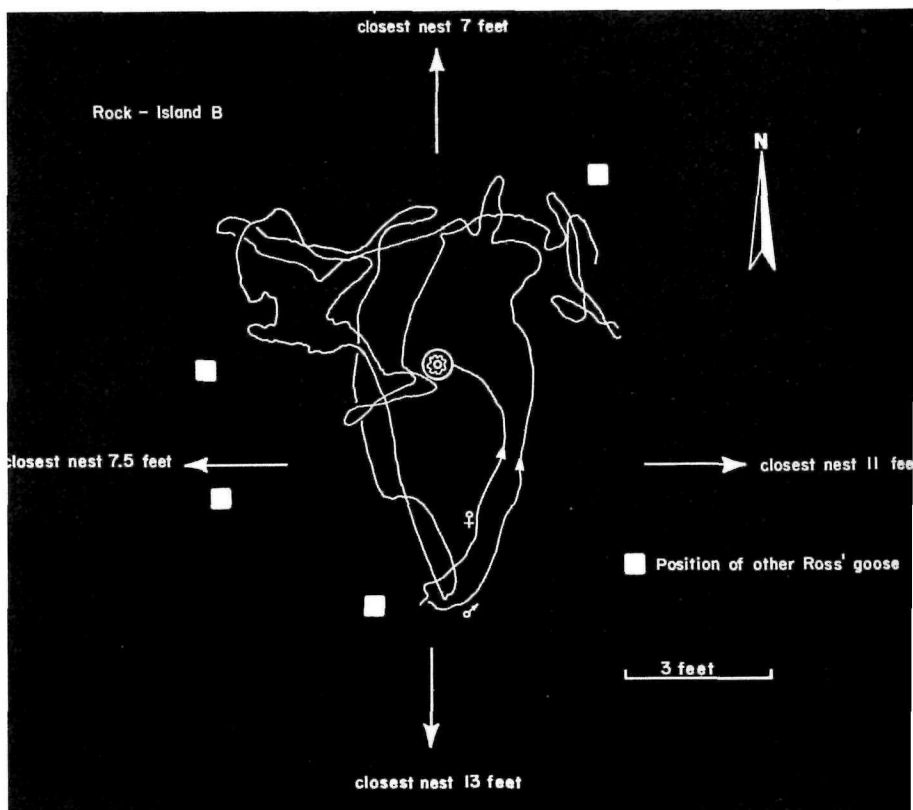


Figure 22 Ross' goose nesting territory in rocky area.

complete the reproductive cycle (Fig. 14). Clutches were generally smaller in 1964 than in 1963 (Fig. 23). There was no difference in clutch size for nests in four major habitats on the islands. Data are presented (Table 9) from 1964 which suggest that clutch size is not influenced by the habitat in which the nest is located.

On June 17 and 18, 1964, eggs were removed

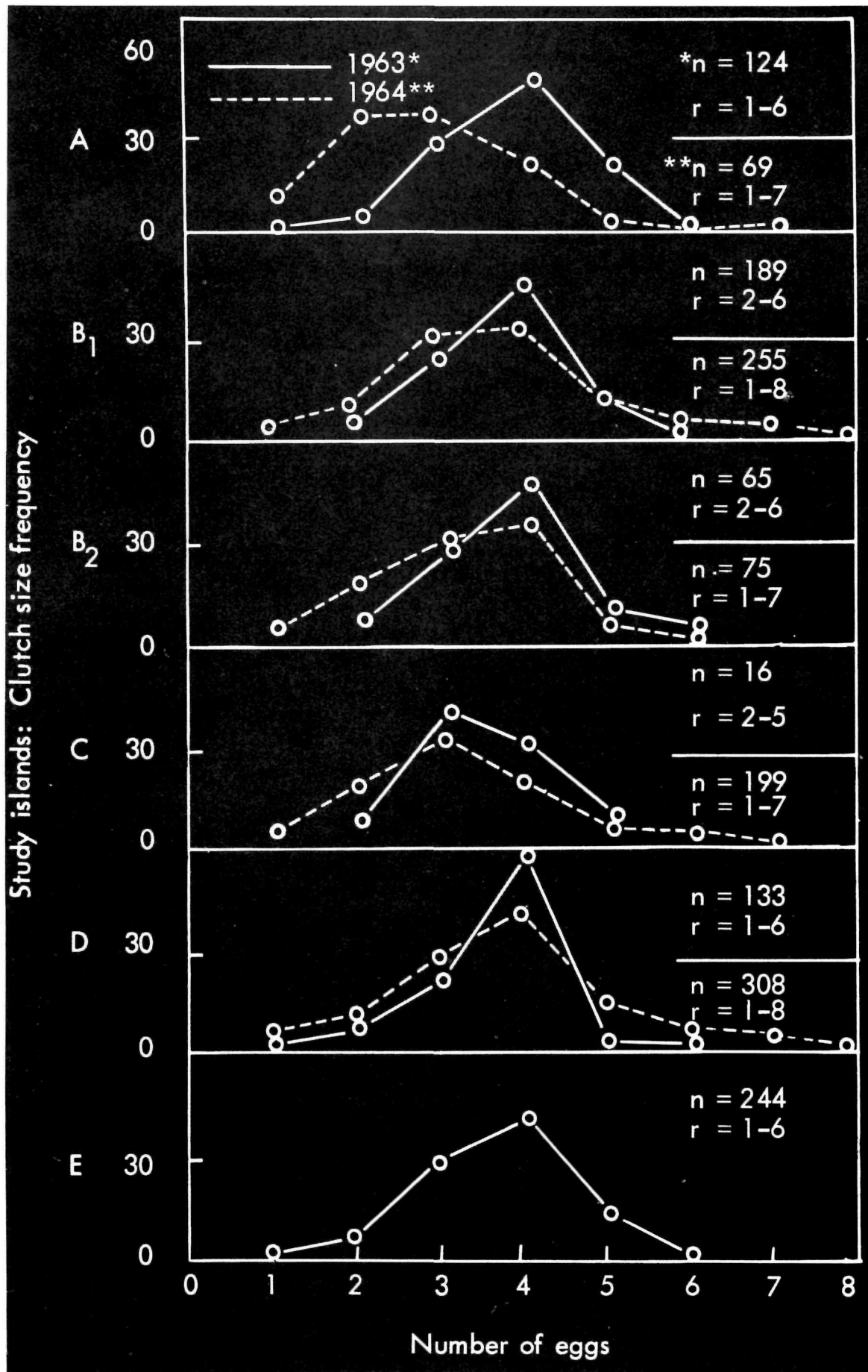


Figure 23 Clutch size frequency of Ross' geese nesting at Arlone Lake, N.W.T., 1963 and 1964.

from 50 nests on island D. The number of eggs removed varied from one to the complete clutch (Table 10). On June 18, 1964, eggs were added to ten nests on island C. The number of eggs added varied from two to ten (Table 11). The purpose of the depletion experiment was to determine whether

a bird would lay more eggs in the nest, that is, make up a loss, or remain with the remnant of the clutch, or desert the depleted clutch. The addition experiment was primarily to determine how many eggs above the normal the species could successfully hatch.

TABLE 9 Clutch size in relation to habitat, 1964

Island	Mixed	Rock	Birch	Open
A	2.99 (40)*	2.00 (1)	2.60 (23)	2.40 (5)
B ₁	3.91 (122)	3.89 (37)	3.16 (62)	3.26 (34)
B ₂	3.70 (37)	3.00 (7)	3.60 (20)	3.18 (11)
C	3.45 (78)	3.76 (12)	3.85 (35)	3.08 (74)
D	3.82 (174)	3.54 (24)	4.02 (85)	3.60 (25)
E	—	—	—	—

Note: numbers in parentheses are sample size.

TABLE 10 Egg depletions from complete clutches, island D, Arlone Lake, June 17 and 18, 1964

Nest number	Initial clutch	Depleted clutch	Total eggs	No. eggs hatched	Per cent success	
					Nesting	Hatching
1-5	4	1	15	14	100	93
6-10	4	2	10	10	100	100
11-15	4	3	5	5	100	100
16-20	4	4	0	0	abandoned	
21-25	3	1	10	8	100	80
26-30	3	2	5	4	100	80
31-35	3	3	0	0	abandoned	
36-40	2	1	5	2	40	40
41-45	5	2	15	14	100	93
46-50	5	5	0	0	abandoned	
Total 50	185	120	65	57	64	88

TABLE 11 Egg additions to completed clutches, island C, Arlone Lake, June 18, 1964

Nest number	Initial clutch	Augmented clutch	No. hatched	Per cent success	
				Nesting	Hatching
1	4	10	9	100	90
2	3	12	0	0	0
3	5	7	0	0	0
4	3	11	0	0	0
5	4	9	0	0	0
6	4	8	1	100	12
7	3	7	0	0	0
8	3	13	0	0	0
9	4	14	0	0	0
10	5	15	0	0	0
10	38	106	10	20	10.2

A high percentage of hatching and nesting success was observed when at least one egg was left in a nest. In the nests with completely depleted clutches, the geese abandoned the site. The nests to which eggs were added showed very poor success. None had 100 per cent hatching success. The eggs were invariably scattered around the nest site (Fig. 24) and later were destroyed by predators.

Incubation period

The incubation period for the Ross' goose has been calculated to be 22 ± 1.3 days (range = 19–25; $n = 45$ last eggs laid). The incubation period is taken as the average time interval between the laying of the last egg and the emergence of the young bird from the shell of that egg. The last egg was used in the above calculation because no incubation was noted prior to its deposition. Incubation had commenced by June 18 of 1963 and 1964.

The beginning of incubation was marked primarily by a noticeable silence over the colony, by the lining of nests with plucked down, which initially disperses like snow over the islands, and by a unique flocking behaviour of the geese.

Data were compiled on the relation between deposition of down and completion of the clutch. It was found that 82 per cent of the nests had down in them after the laying of the last egg, 16 per cent after the penultimate, and 2 per cent before the penultimate egg. Sample size was 55 clutches.

Behaviour

In the 1963 study season three nest-trapped marked females were used to determine the roles of the sexes in incubation and territory protection. After several hours of observation of these marked geese and other unmarked individuals I concluded that only the female incubates. That finding was further substantiated in the 1964 season when ten neck-banded females nested on the islands. These females were never seen to exchange incubation responsibilities with the males.

The Ross' geese are not close sitters. The longest observed period of incubation was 46 minutes. When the bird was off the nest the pair did not leave the territory. Generally the incubating female sat on the nest for a short time, then left it and accompanied the male on the territory to feed but not to defend. During the time the female is on the nest the male remains near, within the territory, ready to defend it (Fig. 25).

The incubation posture of the Ross' goose is similar to other members of the genus *Anser* (Fig. 25). The head and neck are held vertical, not



Figure 24 Destroyed eggs around a hyperclutch nest of Ross' goose.

Figure 25 Incubating posture of Ross' goose.



horizontal as in *Branta*. While incubating the female frequently pulls nest material towards her body with the bill. She often moves in circles while on the nest, presumably rotating the eggs, in this way distributing heat over the complete clutch as well as rotating the developing embryo.

As mentioned above, one of the characteristics of the incubation period is the unique flocking behaviour of the birds. Previously it was mentioned that during the egg-laying period when the birds were disturbed they would alight in large groups subsequently splitting into smaller flocks. During the incubation period the birds would similarly take to the air when disturbed, but instead of splitting up, the flock tended to revolve in a huge circle directly over the island. Within 5–10 minutes the geese were back on their respective territories after the usual territorial disputes. It was obvious that attentiveness had increased.

Under undisturbed conditions the female, before leaving the nest, always covered the clutch by pulling down over the eggs with her bill. This behaviour also occurred during the relief period when she accompanied the male on the territory. The probable survival value of such activity was made clear on the evening of July 11, 1963, when, during a check of island E, I came across an unhatched nest containing four eggs. These eggs had been pipping, but there was no sign of the parents. I therefore assumed the nest to be abandoned. I broke open all four eggs and found that three of the goslings were alive and one was dead. Leaving three of the goslings including the dead one outside the nest, I put the remaining live gosling without its egg shell inside the nest and covered it with down. I left the nest momentarily, then came back to find four parasitic jaegers at the nest. These birds had devoured all the goslings that were left outside the nest, but the one which was covered with down was untouched, even though it was making a considerable amount of noise with its high-pitched squeak.

It was stated earlier that the geese arrive on the nesting grounds in family groups. These family groups are intact until the incubation period, when the yearlings leave the nesting territories and distribute themselves on the communal areas and the mainland feeding regions. Flocks of obvious non-breeders are seen flying around the nesting lake and with time the radii of their flights get wider and wider until by the time the hatching phase starts, most of these birds have left the lake and are on the moult migration.

After the beginning of the incubation period no more than two geese were seen to occupy a single territory, whereas previously three or four geese in one territory were not uncommon. I have observed the yearlings participate with the adults in territorial defence but this is the only apparent function they serve on the islands.

Hatching period

The first pipping was seen on July 5, 1963, and July 3, 1964. Peak hatch dates for the two seasons were July 7–8 and July 5–6 respectively. Figure 26 shows the hatching frequency for 1964.

The goslings are precocious. They are helpless until dry, but by the time they leave the nest a few hours after hatching they have developed protective instincts of concealment. When approached on land they crouch with head and neck flat on the ground. This makes them extremely difficult to see, as they blend well with the surrounding terrain. On water they sometimes dive to elude predators.

The parents guard the young fiercely. When a newly hatched brood is approached, the female leads the goslings away, while the male opposes

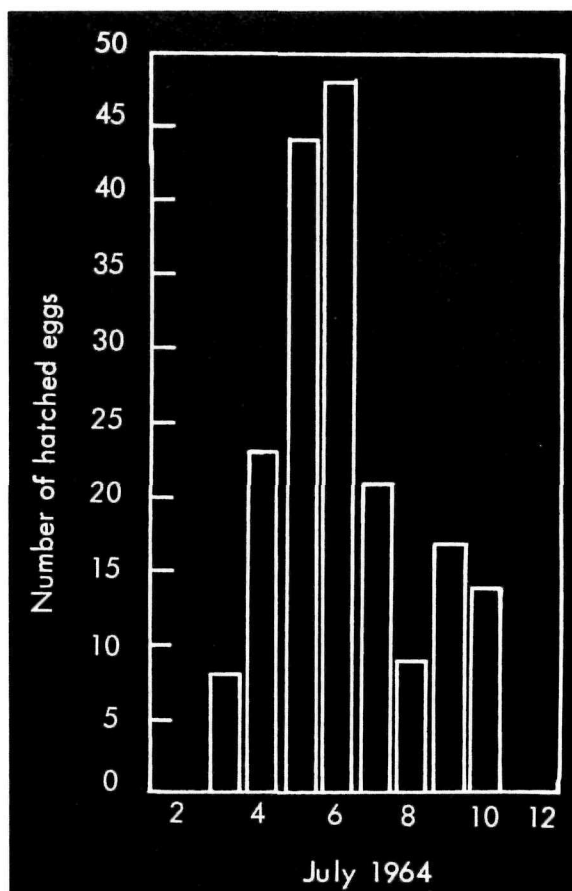


Figure 26 Hatching frequency of Ross' goose, 1964.

the intruder with wings outspread and mouth agape. As soon as the female and the brood are far enough away the male then flies to her side.

Nesting and hatching success

The factors which tend to decrease the initial clutch size and potential productivity of a species are predation and desertion. In 1963 the histories of 93 nests from island E, which initially contained a total of 351 eggs ($\bar{x} = 3.77$), were followed from June 24 to the end of the incubation period July 8. Three of the nests, representing a total of 12 unproductive eggs, did not hatch at all. If a successful nest is defined as one in which at least one egg hatches, then in 1963 the nesting success was 96.7 per cent. The fate of individual unproductive eggs is given in Table 12a.

In 1964 the same study was done with 59 marked nests on island B₁B₂. A total of 230 eggs was laid in the 59 nests ($\bar{x} = 3.89$). The nesting success was 83 per cent. The fate of individual unproductive eggs is given in Table 12b. Nine dump nests in the colony contained from 10 to 29 eggs.

The initial colony clutch count done on June 19, 1964, showed that a total of 3,244 eggs was present on that date (906 nests). The estimated number of eggs in the colony on July 4 was 3,143. This was calculated by multiplying the total number of nests (906) in the colony as determined on June 19

by the average clutch size of 300 nests ($\bar{x} = 3.47$) counted on July 4. This indicates that 101 eggs (3.1 per cent) were lost during the period between June 19 and July 4.

To find out the validity of the apparent low percentage loss of eggs (3.1 per cent), the loss of 101 eggs is disregarded and it is assumed that the geese, under suitable conditions, could have produced an average clutch size of 3.64 (that of island B₁). Then the total number of eggs laid would have been $3.64 \times 906 = 3,298$. The percentage loss would then be 4.7 per cent, which is very similar to the 3.1 per cent obtained from the original data.

This shows that total nest counts can be used to determine losses throughout the nesting season, and that the high loss due to predation found on island B₁ in 1964 does not reflect the activities of predators on the whole colony.

Post-breeding biology of Ross' goose
Movements

After the hatching period the geese leave the nesting islands and begin their post-nuptial moult. This movement is slow but continuous, as small flock units or family groups move to inland lakes and river courses. The common unit is made up of 2 to 15 families. By July 9, 1963, and July 10, 1964, over 80 per cent of the Ross' geese had left the nesting islands. This is less than a week after the peak hatching dates for the colony.

A few Ross' geese and lesser snow geese move down the Perry River as far as its estuary. The maximum number of Ross' geese on the Perry River from August 1-10 was 500-800, based on the number caught during banding operations in 1963. After 420 Ross' geese had been banded, retrapping occurred. This number represents approximately 33 per cent of the nesting population at Arlone Lake.

Three weeks after the hatching period the post-nuptial flocks are large, sometimes numbering as many as 200 geese. Seldom does one see a single family group. The geese remain in these large flocks around the lakes and rivers until the moult is completed. In the last week of August the geese are capable of flight and prepare to migrate south.

Moult

The moulting sequence of the Ross' goose is similar to that of the blue goose (*Anser caerulescens*), as described by Cooch (1958). The Ross' goose goes through one moult per year, immediately following the breeding season. The timing and synchronization of moult stages in adult breeders

TABLE 12a Fate of 351 eggs in 93 nests, 1963

Fate	Number		Per cent	
Hatched	329		93.7	
Unhatched				
No. embryo	4		1.1	
destroyed	8		2.2	
dead embryo	7		2.1	
addled	3	22	0.9	6.3
Total	351		100.0	

TABLE 12b Fate of 230 eggs in 59 nests, 1964

Fate	Number		Per cent	
Hatched	182		79.2	
Unhatched				
No. embryo	4		1.7	
destroyed	33		14.4	
dead embryo	7		3.0	
addled	4	48	1.7	20.8
Total	230		100.0	

and goslings is one of the most important phases of the life cycle. If, after raising a successful brood, a bird cannot complete the moulting period before the onset of cold weather, complete mortality of the individual and brood occurs.

Although more quantitative data are required on the moulting sequence in Ross' geese, sufficient information has been collected to make general comments.

The first moulting geese seen on the Perry River after the nesting season are the non-breeders and sub-adults, which retire from the nesting area at the beginning of the incubation period. By the middle of July birds of this group have lost the flight feathers. This is approximately 1 week before the breeding birds, who complete ecdysis by July 20-25, 15 to 20 days after the peak hatch date. Feather spikes appear on the breeding birds at the end of July. Generally, the central tail feather and tenth primary appear first in all age groups.

The moult of the goslings is well synchronized with that of their parents. The birds of the year attain sheathed spikes of tail, primaries, secondaries, and scapulars 21 days after the modal hatch date.

Brood count analysis of productivity

Figure 27 summarizes the actual productivity of Ross' geese for 1963 and 1964. Complete data on brood size during migration are available for 1964 only. As has been pointed out earlier, there is an insignificant loss during the incubation period. Following the hatch, an immediate drop in brood size results from abandonment, trapped goslings, and predation. Subsequent to this initial elimination of the "weak" members of the population, it appears that size of broods up to 3 weeks old continues to drop. This is then followed by an apparent increase in brood size from counts made on the Saskatchewan staging area.

The brood size counts made when the goslings are 3 weeks old are not valid owing to "flock clumping" between the brooding and non-brooding flocks. Brood data collected during banding procedures or from aerial photographs tend to decrease the proportion of young to adults. It is difficult to obtain reliable data of this kind unless a brood flock is singled out and kept segregated from the flocks possessing no broods. This integration of flocks is readily apparent from banding experience. When the canoe approaches any number of separate flocks, the disturbance immediately results in flock integration. Presumably the same situation occurs with a low-flying aircraft. Thus, it is useless to try

to evaluate yearly production of this species from brood counts made at the age of 3 weeks.

The data from Saskatchewan were made from direct observations of family groups in Kindersley. The family unit is discrete and can be easily separated from the birds which have no familial responsibility. However, one discrepancy is possible with this method of counting. In late nesting seasons such as 1962 the geese are subject to high hunting pressure, which may break up family groups and result in wandering of unattached young. These orphans may then be adopted by other family groups. It may also be that late-hatching geese are not physiologically capable of migration from Saskatchewan at the time their parents depart, but are adopted by later-leaving families (Dzubin, 1965). Whatever the cause of the disproportionate number of young geese appearing on the staging area, it is inevitable that for accurate brood information, such as has been obtained by Dzubin, counts be taken of discrete family groups before the hunting season. Simple ratios of young to adults taken from flocks after the beginning of the hunting season or from banded samples are extremely biased and offer no accurate information on the production of young for a given year.

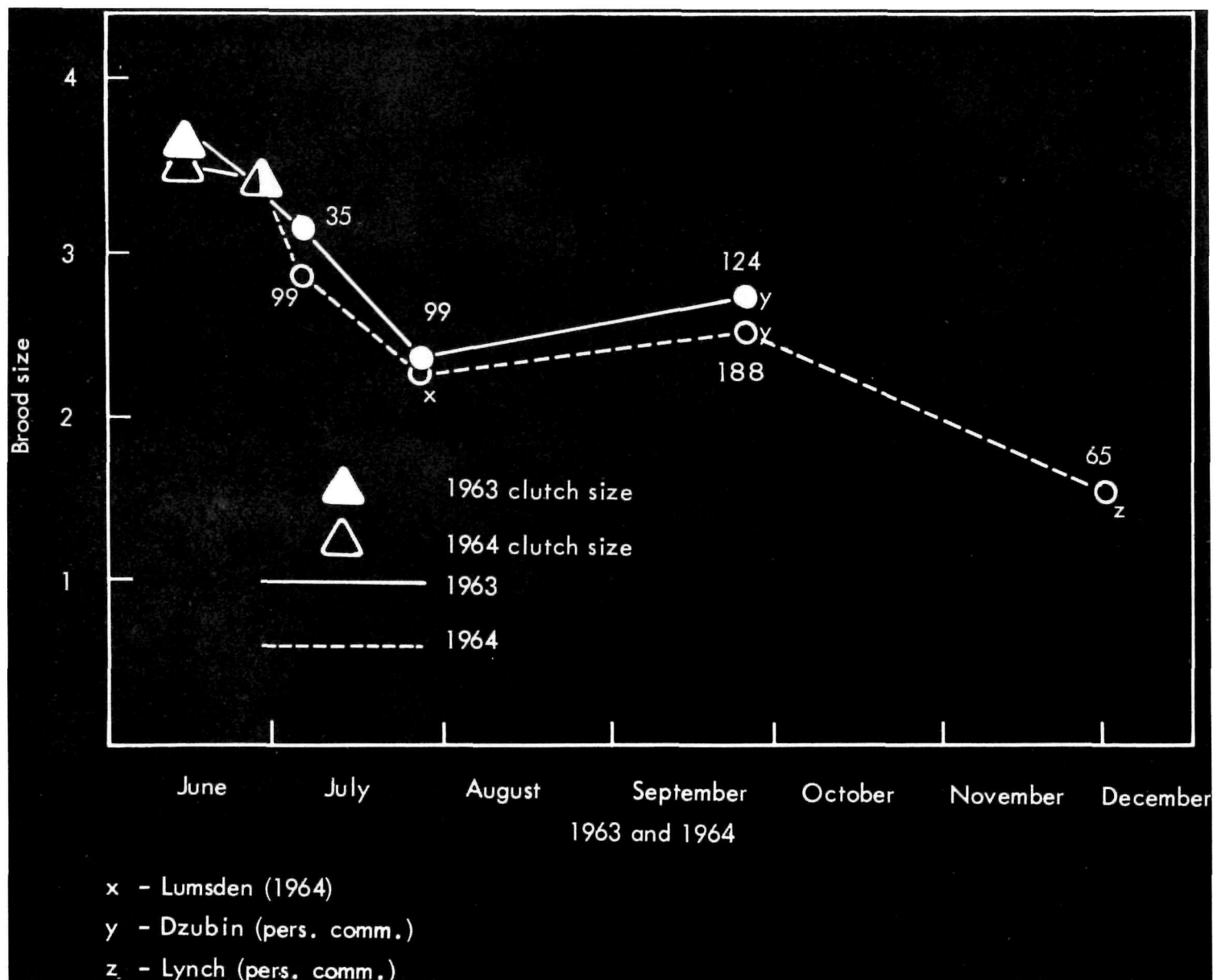
Counts taken in Saskatchewan may possibly give a more reliable estimate of realized or actual productivity because by the time birds of the year have flown that far south they have the potential to continue to the wintering grounds. Lynch's figure of 1.65 young per family of Ross' geese is taken from the 1964 season after natural mortality and hunting pressure. Table 13 shows the numerical and percentage decrease in brood size from 1-week-old and younger broods at Perry River to broods counted in California.

Although the data are taken from 1 year's tabulation, they do suggest that mortality is greatest from Canada south to California. This is the period in the life of the species which has to receive management attention so that population numbers can be maintained.

Physical attributes

Growth, weight, and morphometrics

The body weights of the adult geese are at a maximum at the time of arrival on the nesting grounds (Fig. 28). A steady decline follows, especially in the females, until the end of the incubation period. Abdominal fat is exceptionally abundant at arrival time, particularly in the females. A rapid decrease in fat thickness occurs into the incubation period.



The males were observed to lose this fat more rapidly than the females.

Barry (1962) found that a weight loss occurred

during the hatching and moulting period in the male American brant. The female nesting brant showed a continual decrease in weight from the

Figure 27 Productivity of Ross' geese from clutch and brood counts, 1963 and 1964.

TABLE 13 Brood size data from the 1964 migration of Ross' geese

	Size of brood	No. of broods in sample	% decrease from last count	Total % decrease
Perry River	2.88	99		
Saskatchewan	2.72*	188	6	
California	1.65†	65	39	42

*Dzubin, 1965.

†Lynch, J. (pers. comm.).

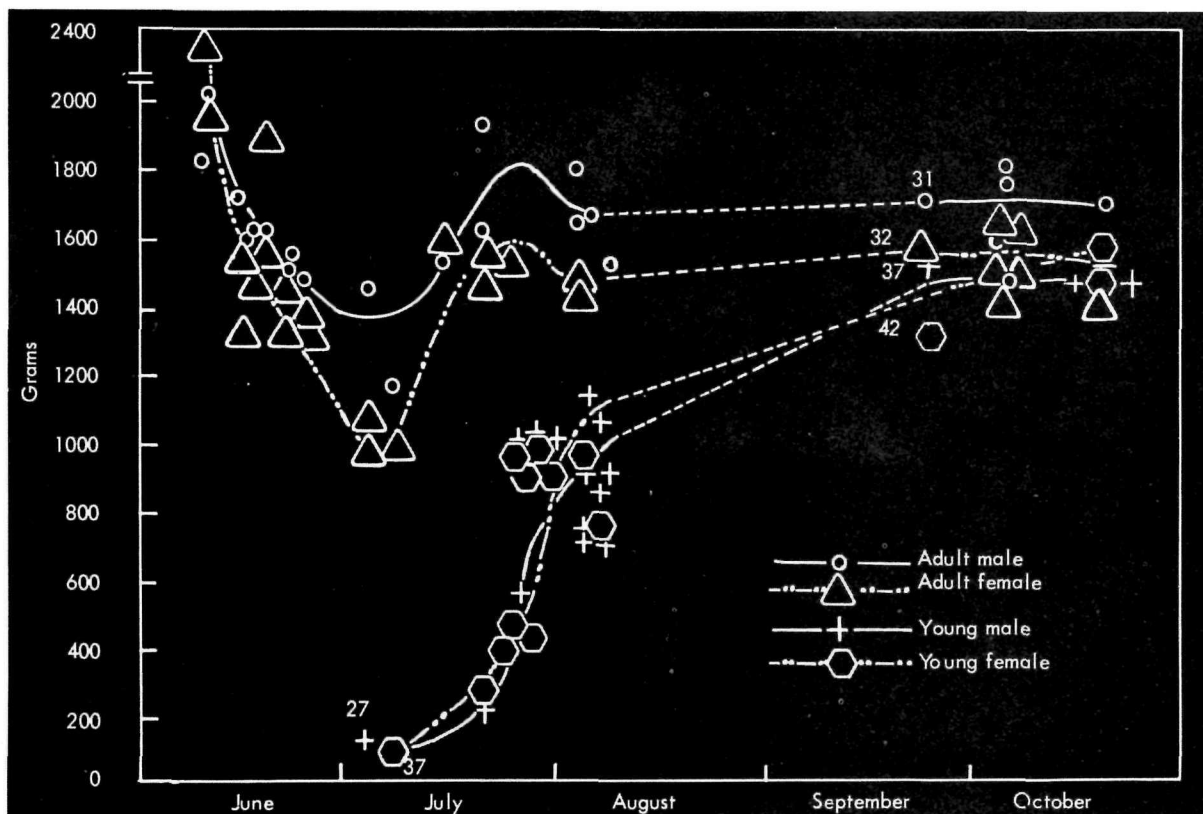


Figure 28 Weight changes of Ross' geese during 1963 and 1964 seasons.

time of arrival until hatching, at which time a gradual increase occurred. Cooch (1958) found that during the egg-laying period the female blue goose showed marked decrease in weight followed by a steady decline into the incubation period. The male blue goose showed a sharp decline in weight into the egg-laying period from a maximum at arrival. This was followed by a levelling off and increase approximately coinciding with the hatching period. Following the hatching period, the males again lost weight. This was recorded both in male and female nesting Ross' geese.

Following the post-nuptial moult, the Ross' geese maintain a fairly constant weight, at least until they reach the first staging area in Saskatchewan.

Sex ratios

The sex of the geese was determined in both adults and young on the basis of presence or absence of the penis. This method proved successful for sex determination of the newly hatched goslings.

A 1 : 1 ratio was shown in newly hatched goslings from a sample of 90 males and 102 females (Table 14). Three-week-old goslings showed a sex ratio of 137 males : 100 females. The latter difference is significant and indicates a differential female mortality during the first 3 weeks of life. The adult

sex ratio, as determined from 1963 banding samples was 84 males : 99 females.

Colour ratios

The goslings of Ross' geese are polymorphic. The colours range from almost pure yellow to gray. Individuals were separated arbitrarily into one of two colour categories to determine relative ratios.

The data from 1963 are sparse because of the difficulty of defining a colour group for each individual. The data include only those observations in which colour was obviously one phase. The ratios are presented in Table 15.

In 1964 it was decided that the gradations of each of the basic colour phases could be placed into one or the other on the basis of apparent preponderance of one colour. Therefore, pearly-gray, white, and dark gray were placed in the gray class and yellow-green, dark yellow, black-yellow, and light yellow were placed in the yellow class.

The growth curve of the goslings is sigmoid (Fig. 14), and the weight gain is exceptionally rapid. At hatching the average gosling weight is 65 grams. This increases to an average of 900 grams by the end of the fourth week of age. All 10 primaries, all secondaries, and some tertiaries are growing in by the end of the third week. Tail feathers and body

TABLE 14 Sex ratio of newly hatched Ross' geese

Colour	No. of geese	Sex		Ratio of yellow to gray	Ratio of male to female
		Male	Female		
Yellow	63	30	33	1 : 2	1 : 1
Gray	129	60	69		1 : 1
Total	192	90	102		1 : 1

TABLE 15 Colour combinations of 1-day-old Ross' geese broods observed at Arlone Lake, N.W.T., 1963

Colour	No. of broods		Per cent	
Unrecorded		5	15	
Recorded		29	85	
monomorphic		23		79
yellow	10	}		43.5
gray	13			56.5
dimorphic		6		21
yellow	4	}		67
gray	2			33
Total		34	100	100

TABLE 16 Physical measurements of Ross' geese

	Culmen I	Culmen II	Tarsus (total)	Mid-toe	Flat wing
Sample 1	23 (31)*	23 (31)	24 (31)	24 (31)	19 (31)
2	27 (32)	27 (32)	27 (32)	27 (32)	24 (32)
3	8 (37)†	8 (37)†	11 (37)†	11 (37)†	— (37)†
4	7 (42)†	7 (42)†	8 (42)†	8 (42)†	— (42)†
5	3 —	3 —	3 —	3 —	—
6	5 —	5 —	5 —	5 —	—
Range 1	4.10–4.57 (3.6–4.6)	4.21–5.41	8.03–9.12 (8.1–8.9)	5.06–5.88 (4.8–5.7)	22.9–39.5 (36.0–40.3)
2	3.81–5.00 (3.5–4.3)	4.34–5.14	7.62–9.50 (7.5–8.6)	4.64–5.64 (4.5–5.4)	24.0–39.1 (35.5–38.2)
3	2.68–3.77 (3.5–4.2)	2.86–3.88	4.80–8.93 (7.4–8.9)	2.78–5.66 (4.6–5.6)	— —
4	2.05–3.10 (3.4–4.7)	2.50–3.74	5.09–8.07 (7.4–8.5)	2.79–5.34 (4.4–5.3)	— —
5	1.46–1.67 —	1.75–2.10	3.65–4.09 —	2.46–2.70 —	— —
6	1.50–1.55 —	1.73–1.93	3.58–3.87 —	2.32–2.60 —	— —
Mean 1	4.27 (4.12)	4.93	8.56 (8.48)	5.40 (5.18)	37.10 (38.64)
2	4.08 (3.90)	4.69	8.29 (8.05)	5.39 (4.84)	35.75 (36.85)
3	2.97 (3.94)	3.57	7.37 (8.27)	4.57 (5.04)	— (36.49)
4	2.65 (3.79)	3.13	6.81 (7.88)	3.92 (4.83)	— (35.38)
5	1.54 —	1.88	3.80 —	2.61 —	—
6	1.51 —	1.81	3.76 —	2.46 —	—
S.D. 1	0.154 (2.28)	0.233	0.100 (2.29)	0.223 —	0.350 (8.65)
2	0.236 (2.08)	0.070	0.361 (3.17)	0.223 —	2.710 (8.39)
3	0.310 (2.54)	0.368	4.170 (3.37)	0.980 —	— (8.53)
4	0.380 (2.76)	0.463	1.15 (2.87)	0.858 —	— (9.49)
5	0.12 —	0.190	0.25 —	0.120	—
6	0.05 —	0.070	0.12 —	—	—

1 Adult male

2 Adult female

3 Young males (3 weeks old)

4 Young females (3 weeks old)

5 Young males 1 day old

6 Young females 1 day old

*Data in brackets, courtesy, Mr. A. Dzubin, Canadian Wildlife Service, Saskatoon, Saskatchewan.

†Young Ross' geese 10–12 weeks old (Dzubin).

TABLE 17 Colour combinations of 1-day-old Ross' geese broods observed at Arlone Lake, N.W.T, 1964

	Broods		Individuals		Ratio of yellow to gray broods	Ratio of yellow to gray individuals
	Number	%	Number	%		
Broods of one colour	53	53.5				
yellow individuals	21	21.2	47	16.5	1 : 2	1 : 2
gray individuals	32	32.3	85	29.9		
Mixed broods	46	46.5				
yellow individuals			66*	23.3		1 : 1
gray individuals			86*	30.3		
Total	99	100		100		

*Not significantly different χ^2 test at 95 per cent confidence level.

TABLE 18 Extensivity of helminth infections of Ross' geese collected during 1963 and 1964

	Arlone Lake		Perry River		Kindersley	
	Adults	Young	Adults	Young	Adults	Young
No. autopsied	26	1	3	12	8	3
No. negative	3 (11%)	0	0	2 (17%)	0	0
Cestodes	2 (8%)	0	2 (67%)	9 (75%)	3 (38%)	2 (67%)
Trematodes	13 (50%)	0	1 (33%)	0	0	0
Nematodes	20 (80%)	1 (100%)	2 (67%)	0	6 (75%)	2 (67%)

pin feathers are also coming in by this time (see Moulting).

Table 16 presents body measurements of both sexes of adults, and three age groups of goslings, 1-day-old, 3-week-old, and 10- to 12-week-old. The data on 10- to 12-week-old goslings, and all other information contained in parentheses, were taken on migrating Ross' geese in Saskatchewan.

The tarsus and mid-toe growth of the young geese is extremely rapid. These structures increase to almost adult proportions by the age of 3 weeks. At 10 weeks of age they are within the adult range. The same rapidity is observed in the growth of the upper mandible. Culmen I and II have increased almost 100 per cent by 3 weeks of age.* At 10 weeks of age the bill measures within the adult range.

Data were not recorded on flat wing, tail, and total length measurements of goslings because of the extreme variability of the structures owing to differential hatching times and the fact that broken or bent feathers on many of the young birds were difficult to measure accurately.

*Culmen I: length of upper mandible from the point where the feathered integument of the forehead fuses into the horn portion of the mandible, to the tip of the bill.
Culmen II: length of upper mandible from the maximum lateral extent of mandible to tip of bill.

The results of the 1964 brood counts are outlined in Table 17 in the same style as Hanson *et al.* (1956). Most of 99 broods were monomorphic. Within these broods twice as many individuals were placed in the gray-phase class as in the yellow-phase class. This ratio did not hold true for the mixed broods in which there was a 1 : 1 ratio of yellow : gray individuals.

Interspecific relationships

Parasitism

A total of 57 Ross' geese, 40 adults and 17 young, were autopsied to determine helminth types present during the reproductive phase of the geese. The geese were collected from three areas, Arlone Lake, the Perry River, and Kindersley, Saskatchewan.

Identifications were made with the aid of Dr. J. C. Holmes, Messrs. M. Colbo, J. R. Gallimore, and L. Graham of the Department of Zoology, University of Alberta, Edmonton, Alberta.

Table 18 presents data on percentage infection found during the study.

The most commonly occurring helminths were the nematodes. These were found primarily in the ventriculus where mixed infections of *Amidostomum*

sp. and *Epomidiostomum* sp. occurred, the latter being more common. Three specimens of *Tropisurus* sp. appeared in the proventriculus of two adult Ross' geese collected at Kindersley, Saskatchewan.

Two types of cestodes occurred in the small intestine. One was identified as *Hymenolepis* sp. The other was not identified because of a lack of sufficiently good specimens.

Trematodes occurred only in the caecum. Three types were identified: *Notocotylus attenuatus*, two specimens of *Echinostomum revolutum*, and one specimen of *Zygocotyle lunatum*.

Evidence of mortality or emaciation resulting from parasite infections was lacking during the nesting and post-nuptial moult periods. Cestodes were observed protruding from the vent of both adults and young during the banding operations in 1963.

Predation

The mortality of adults on the nesting grounds is almost nonexistent. A few old rifle shells were found in the area but these were probably used by the Eskimos for spring caribou hunts rather than for killing geese. The Eskimos I interviewed showed little interest in geese as a food resource and said they do not bother the waterfowl unless the caribou or seal hunting is poor. Hanson *et al.* (1956) state that the Eskimos appeared to have been the primary factor in the eradication of the Ross' goose colonies near the coast. This could possibly have resulted in abandonment by the geese of such colonies as Discovery Lake, which was originally described by Gavin (1940).

In 1963, three dead adult Ross' geese were found on the shore of south Arlone Lake. The condition of these specimens indicated that death had occurred a year earlier so the cause could not be determined. However, the feathers of one of the specimens were scattered around a large birch patch suggesting that it may have been killed by an arctic fox or other mammalian predator.

In early June 1964, two Ross' and two lesser snow geese were found dead on the islands of Arlone Lake. All except one snow goose were in the egg-laying posture. The snow goose had obviously been attacked and killed by an arctic fox. The cause of death of the other geese is not known. All had one egg in the uterine portion of the oviduct. Although none of the birds was at a nest site, the activity of arctic foxes at this time may have flushed them from their nests, thus adding a stress factor to the already present stress of laying. This could

possibly result in death.

When arctic foxes are abundant, as in June of 1964, the protective value of the islands as a refuge from predators is almost completely eradicated. The foxes visited the islands as long as an ice bridge remained between the islands and the mainland. Subsequently they ceased to harass the geese. The protective value of the insular nesting habitat is readily realized at this stage when a definite water barrier prevents mammalian predation and ensures a potentially productive season.

Although three species of jaeger, glaucous gulls, and snowy owls nested in the area their numbers and predatory importance were low (Table 19). At the beginning of the hatching period a marked increase in avian predators occurred, primarily glaucous gulls. On July 7, 1963, 13 of these gulls were seen encircling island B₁ at the same time. This is a high concentration for the area as earlier one or two gulls per hour was normal. Numerous observations were made of young Ross' geese being snatched off the water and devoured whole by this large predator. Lemieux (1959) found that jaegers were in large numbers on the Bylot Island (73°13'N., 78°34'W.) greater snow goose colony, but he notes the relative insignificance of these as important predators. Barry (1956) noted that gulls and jaegers at Boas River (63°40'N., 85°50'W.), N.W.T., take a heavy toll of eggs and young of Atlantic brant.

Five snowy owls nested at Arlone Lake in 1963. None were seen in 1964, presumably because of the lack of microtine rodents. No predatory activities of snowy owls were seen during either study season. Lemieux (1959) found the same lack of predation by owls in the Bylot Island greater snow goose colony.

TABLE 19 Number of avian predator nests recorded at Arlone Lake, N.W.T., 1963 and 1964 seasons

Species	Number of nests	
	1963	1964
<i>Stercorarius pomarinus</i>	0	0
<i>Stercorarius parasiticus</i>	0	0
<i>Stercorarius longicaudus</i>	1	0
<i>Larus hyperboreus</i>	1	1
<i>Larus argentatus</i>	0	0
<i>Nyctea scandiaca</i>	5	0
Total	7	1

A number of factors on the islands cause some loss of young Ross' geese. The extensive birch stands act as traps from which the newly hatched goslings find it impossible to escape once entangled. Twenty-one goslings in 1963 and 17 in 1964 were rescued from these areas. It is likely that many more goslings were not found because it is hard to see them under the thick cover. Apparently the trapped goslings are abandoned by their parents who make no extra effort to recover their progeny other than calling them. Old, Eskimo caches and rock piles acted as traps in the same way, but to a lesser extent. It seems almost ironical that the most favoured nesting habitat (birch and rock) should be somewhat detrimental to the young.

Egg loss to predators was generally low at Arlone Lake. In 1963 the hatching success was exceptionally high (93.5 per cent). The presence of arctic foxes at the start of the season in 1964 decreased the potential production and success of the colony, but survival in the late 1963 season was not much better. Foxes destroyed 144 Ross' and 122 lesser snow goose nests in the first week in June 1964. In 1964, island E was deserted because of the destruction of nests by arctic foxes. Once the foxes leave the colony the goose nests are preyed upon by only a small number of avian predators, from which the geese suffer little. The geese stay close to their nests and are adept in warding off the predators.

Egg fertility is high in Ross' geese. Not more than 1 per cent of the total eggs in the colony were sterile. Cooch (1958) found that infertile, crumpled, and rolled out eggs seldom exceeded 1 per cent of the total in blue geese. Hanson (1950) found that fertility in the Canada goose (*Branta canadensis*) was 93 and 94 per cent in California and Utah respectively.

Competition with the lesser snow goose

The Ross' geese nesting at Arlone Lake share the islands with the larger and often more aggressive lesser snow geese. In 1963 and 1964, 726 and 356 snow geese were recorded nesting at Arlone Lake. It was of interest to find out whether the two species competed for nesting sites and food, and to discover if the presence of the larger species had any detrimental effect on the productivity of the Ross' goose population.

Calculations of snow goose nest density were made for each habitat on all the islands and in addition the feeding grounds were observed daily to detect any evidence of behavioural competition for food.

Table 20 presents the density of snow goose nests at Arlone Lake for 1964. With such a small population of a potentially competitive species in a comparatively large colony of Ross' geese, it is difficult to arrive at any definite conclusions regarding nest site preference of the snow goose in this area. The data do suggest that they, like the Ross' geese, shun the open regions and prefer the cover afforded by edge areas of birch and mixed habitats. Although this apparent similarity of nest site could easily give rise to a serious competitive situation, there was no evidence of it occurring at Arlone Lake. Density and clutch sizes of Ross' geese in the regions of highest density of snow geese (i.e. mixed areas of islands C and D) were the same as in areas where snow goose density was low (islands A and B₁B₂ mixed areas), suggesting snow geese were not displacing Ross' geese from preferred nesting locations.

TABLE 20 Nesting densities of the lesser snow geese at Arlone Lake (nests per 1,000 sq. ft.)

Island	Habitat			
	Open	Rock	Birch	Mixed
A	0.06	0.81	1.01	0.44
B ₁ B ₂	0.08	0.74	1.63	0.44
C	0.07	1.66	0.63	1.66
D	0	0	1.02	4.61

Food is abundant in the area. Numerous feeding stations around the pools on the tundra mainland attract small groups of integrated flocks of snow and Ross' geese at all times of the day. Interspecific interactions were far less common in these areas than were the intraspecific type between Ross' geese. Only when an individual came too close to another did a dispute occur.

The threshold of competition between the lesser snow goose and the Ross' goose is not known, but at present it does not appear to have been reached in the Arlone Lake colony, at least to the point where it has noticeable effect on the Ross' goose population. If many of the larger species were to migrate into the Perry River region some time in the future, effective displacement of the Ross' geese might occur. Cooch (1963) is of the opinion that if blue-phase *Anser caerulescens* continue to increase in the Hudson Bay drainage, a population capable of supplying large donor populations to the western regions will be established within 15 to 20 years. That possibility is disturbing in view of the relict

distribution of the Ross' goose, which may have resulted, as MacInnes and Cooch (1963) say, from competition with the larger and more aggressive *A. caerulescens*. If the blue-phase and white-phase snow geese invade, in ever-increasing numbers, the specialized nesting habitat of the Ross' goose, then the Ross' goose populations of the central Arctic may be displaced into an environment to which they cannot readily adapt.

The foregoing is speculative and has not yet been observed in any existing colony of Ross' geese. The obvious limiting factor at Arlone Lake is nesting space, which could be seriously depleted by a substantial increase in the population of lesser snow and blue geese.

Banding operations

Banding operations were a major part of the post-breeding study of the Ross' goose. Information from banding is essential for future determination of mortality, life-table construction, and migration routes. Very few Ross' geese have been banded in the immediate vicinity of the nesting grounds in the Perry River region (see Hanson *et al.*, 1956; MacInnes and Weske, 1962).

The banding techniques used were those outlined by Cooch (1953). A temporary camp was constructed (Fig. 3—cabin) from which the operations were based. Each day we canoed 15 miles up the Perry River, intercepting as many flocks of moulting geese as possible.

In 10 days in 1963, 493 geese were banded, 409 Ross' and 84 lesser snow geese. Sexes were distinguished in both age classes by banding the left foot of males and the right foot of females. Age-sex classes were further differentiated by using coloured neck bands (Craighead and Stockstad, 1956).

The procedure was highly successful in terms of percentage of flocks captured. As long as the geese were not permitted to reach land they were exceptionally easy to drive into the banding corral. If the geese reached solid ground before capture they easily outran a man. Under such circumstances it was necessary to band the geese before the later stages of endythesis. At that time the geese would rush for the banks of the river as soon as the canoe was observed. Before this they were tame and easy to handle.

The Kogmiut are very efficient at driving the geese into the corral and were of great assistance on the project.

The Ross' goose, which nests only in the Arctic, must leave the California wintering grounds each spring and migrate north at a rate that will correlate their movements with the appearance of food along the route and with the exposure of nesting habitat and food in the North. This correlation, which appears to exist in the spring migration of Ross' geese, is achieved, in part, by the geese following the 40°F isotherm. Other as yet uninvestigated environmental and (or) physiological factors may be equally important in the control of migration (Farner, 1955).

The physiological readiness for egg laying, which is shown to exist in Ross' geese upon arrival on the nesting grounds, suggests that the lengthy pairing and courtship procedures are completed by that time. This enables the geese to commence nesting activities immediately and thus complete reproduction during the short arctic season. Lack of courtship activities has been reported in other arctic-nesting geese (Barry, 1962; Höhn, 1957; and Lemieux, 1959). Although the extent of time required to complete the pairing and courtship procedures is not known, it is reasonable to assume that they have a negative selective value in the Arctic (Barry, 1962). The observation of copulation in Ross' geese in Alberta and the continual regression of gonad weights following arrival support these contentions and suggest that Ross' geese utilize the Arctic as strictly a nesting rather than a breeding area.

Following arrival on the nesting grounds, initiation of nesting activities is controlled by two conditions. The first of these is that potential nest sites must be exposed. Lack (1933) said that a marked difference in breeding time can clearly be correlated with only one factor—the suitability of the ground for nesting. This was found to be partially true on the islands at Arlone Lake. Snow-covered habitat which, when exposed, provides optimum nest sites was ignored and the geese utilized exposed sub-optimal regions. On island B₁ where approximately 20 per cent of the mixed region was snow covered, a high density of nests occurred in the poorer but uncovered region. The second factor which delays nest initiation is local inclement weather. The 5-day delay in 1963 was directly caused by gale-force winds. Soper (1930), in his classic monograph on the blue goose, reported that in the summer of 1929 “decidedly unpleasant” conditions of cold, penetrating wind and below-freezing temperatures caused the arriving flocks of blue geese to turn south. Barry (1962) found that the Atlantic brant

made long flights back and forth over the snow fields when nesting habitat was not available. After the thaw started, the flocks subdivided and nesting activities began.

The presence of arctic foxes in the study area did not delay nesting attempts.

The dispersion of the geese on the nesting islands is not random. A definite nest-site selection occurs. The nesting habits of the Ross' goose show that edge habitat is most suitable. One would think that because of the lack of coverage which is provided by tall bushes and emergent vegetation farther south in their range, the geese would naturally utilize any region which furnishes maximum protection against the elements. Such was found not to be the case. Optimum habitat not only must provide coverage but also a grazing area. This exists in the form of mixed regions of small birch stands, rock, and open moss. The purely rock areas offer less protection from the elements. Depending on the direction of wind and rain, the rock-type nest site could be as suitable as the mixed regions or as poor as the completely open areas. The lack of protection of the open areas is reflected in the increased thickness of nest walls. Since nests in the birch and rocky areas receive insulation from the immediate surroundings, nest walls need not be so thick.

In so far as the female is not attentive during the egg-laying period, certain behavioural characteristics have developed which increase the survival rate of the eggs during the period when the female is off the nest. The formation of comparatively small, closely guarded territories protects the nest and eggs from the activities of other geese and ensures the presence of the adults on the territory to drive off potential predators. When the adults do leave the territory they cover the eggs with nest material, which screens the eggs from the prying eyes of gulls and jaegers. Soper (1942) concluded that the down which lines the nest also helps retain warmth during the birds' absence. This mechanism was shown to protect goslings also.

There is relatively little variation in clutch size of the Ross' goose. The factors which control clutch size are not known. It has been shown in this work that fidelity occurs in depleted clutches except where no eggs are left in the nest and that almost complete abandonment results from additions to a completed clutch. Delacour (1964) states that eggs are occasionally pushed out of the nest during normal movements, especially in the case of large clutches. The very sight of a few eggs lying

around a "hyperclutch" nest may cause the female to abandon the rest of the clutch. Predators may be attracted to these unprotected eggs, harassing the adults to the point of desertion. In this study all the eggs out of the nest were broken. This possibly induced the female to desert. The data show that the species will not tolerate an excessively large clutch. The laying and hatching of each egg in a clutch of Ross' geese consume approximately 2 per cent of the frost-free period. It does not include the incubation period. Large clutches would tend to jeopardize the success of the whole brood because of the limited time available for the reproductive phase. The ultimate control of clutch size may be the time factor, which prevents laying of excessively large clutches. Additional data are presented which suggest the feasibility of time as the factor controlling clutch size. Clutches started later are smaller than those started earlier, to compensate for the time lost in nest initiation. Cooch (1958), Lemieux (1959), and Barry (1962) found a negative correlation between date of the first egg and final clutch size in blue geese, greater snow geese, and Atlantic brant respectively.

It is unlikely that renesting occurs in the Ross' goose. The continuous regression of gonads following arrival and the determinate laying character of the species would prevent successful secondary ovulation and fertilization. Complete ovary and testicular recrudescence would be required, judging from the gonad size at the end of the laying period (Fig. 6). Coupled with this time-consuming physiological requirement, the short season would definitely limit such a mechanism. Cooch (1958) and Barry (1962) found no renesting in blue geese and Atlantic brant.

The high degree of attentiveness shown during the incubation period is reflected by a sudden silence in the colony. The birds do not leave the territories often but obtain most of their requirements from the territory. The appearance of down strewn over the colony is the result of active plucking of the breast feathers by the incubating female, providing added insulation to the eggs. Hanson (1959) states that if, as a result of increased prolactin level at the time of egg laying, waterfowl moulted the incubation patch promiscuously as do most passerines, the feathers would not be available for placement in the nest. The positive correlation observed in this study between later stages of egg laying and increased down deposition agrees with Hanson's (1959) view that the plucking behaviour is highly dependent on complete development of the

sexual (hormonal) cycle as suggested by the fact that down is placed in the nest only in the later part of the egg-laying period. It is presumed that prolactin is the hormone chiefly responsible for the development of the feather plucking in geese near the end of the egg-laying cycle. According to Welty (1962), prolactin, which is secreted from the pituitary gland, depresses the production of both lutenizing and follicle stimulation hormone and initiates broodiness (nesting and incubation).

The tightly knit flocks observed during the incubation period are attributed to attentiveness at this stage. The flocking is certainly not a general character of the Ross' goose during earlier phases. Van Tyne (1961) mentions the existence of these post-breeding flocks but gives no causal explanation. Emlen (1952) is speculative in his account of avian flocking. He attributes gregariousness to a positive binding force, which according to Van Tyne (1961) is absent during the breeding season and active during the post-breeding period. The high degree of attentiveness during incubation, the basic cause of the clumping of flight groups, maintains the least distance between the birds and their nests during disturbance. The rapid return of the birds to the nest is another indication of augmented attentiveness.

The synchronous hatching of the eggs of Ross' geese and the precocious characteristics of the goslings ensure optimum survival and productivity. The amount of food available on the nesting islands is not sufficient to feed 3 or 4 thousand newly hatched goslings. Departure of the parents to the feeding areas on the mainland to bring back food would allow the goslings to become easy prey for avian predators. Consequently the parents must simultaneously provide food and protection for the young. This is accomplished by a marked movement of the family groups from the nesting area immediately after the clutch has hatched to regions where food is available. The movement of the family dictates that each of the young be approximately equal in size so that potential for food acquisition and ability to keep up with the rest of the family are equal throughout the brood. Such abilities result only from a synchronous hatch.

Delacour (1964) and Hochbaum (1960) state that the post-breeding movement of waterfowl takes the birds to regions where they are protected from predators and have a large food supply while undergoing the annual wing moult. I cannot agree with Hochbaum (1960) when he states that the moulting shift rarely occurs in breeding geese or swans. The

whistling swan moves from its place of breeding to large lakes or streams where moulting occurs (Kortright, 1960), and observations made during this study on Canada geese, snow geese, and white-fronted geese also disagree with Hochbaum. Apparently no constant geographical direction is shown in the shift, and as Hochbaum (1960) points out, it is an ecological rearrangement of the population, with a bias toward large marshes and lakes.

The cause of the moult migration in Ross' geese is not known. In view of the abundance of food in the immediate vicinity of Arlone Lake there is no apparent reason for the extent of the movement. Hanson and Smith (1950) state that post-breeding movements of the Canada goose are orientated toward extensive feeding areas. Hanson *et al.* (1956) observed that a slow movement of Ross' geese toward the coast following the nesting season occurred in 1949, and that this movement was partly overland, thus avoiding rapids and enabling the young to feed on insects and plants. Observations made during this research agree somewhat with those findings; however, the small proportion of the total breeding population from Arlone Lake which was later seen on the Perry River does indicate that there is no mass movement to the coast via the most obvious water route, the Perry River, and that the movement from the breeding group is a random movement of flocks from place to place on the tundra, during which time moulting occurs.

It has been shown that loss of eggs during the nesting season is insignificant. Predation is the most important cause of egg destruction. Following the hatching period, mortality of young birds increases but it is suggested that in the long run, this has a decided advantage to the species in that weak individuals and perhaps undesirable genotypes are eliminated from the population. Taverner (1940) summarized this idea when he stated:

Under certain abnormal conditions there may be such a thing as over-predation that fails to stop with the weaklings and makes inroads upon the strong; but all successful races can safely withstand the normal attacks of their natural enemies under the conditions through which they were evolved and have persisted. Were it otherwise, *ipso facto*, they could not have originated and survived to date.

The predators recorded during this study do not seem to exploit significantly the "strong" individuals in the population.

The differential female mortality during the first 3 weeks after hatching cannot be explained. If it had been found that a high percentage of females were of the yellow phase it might have been pos-

sible to make a correlation with mortality in that yellow may be more obvious to predators than gray. This would, in effect, increase the mortality of females and in part justify the findings of this research. However, both males and females show the same colour ratios at hatching (1 : 2, yellow : gray). The higher mortality of females appears to be purely sexual and does not, from evidence presented, correlate with the colour phases.

The colouration of Ross' goslings cannot be said to be distinctly a case of pure dimorphism. As Hanson *et al.* (1956) pointed out, and as is substantiated in this study, polymorphism is common. The yellow and gray phases are extremes of the colour types, and the gradations or mixed colouration which occur make it exceedingly difficult to categorize accurately all individuals. A subjective index of classification may be used, as in this study, to show that a preponderance of the gray phase exists. However, different researchers might not agree how to categorize a gosling possessing characters of both phases. Hanson *et al.* (1956) obtained a Mendelian 3 : 1 ratio of yellow : gray. Williamson (1957) used Hanson's data to determine genetic dominance of the colour phases. Williamson erroneously concludes "The goslings of Ross's Goose (*Anser rossii*) may have either yellow or gray plumage, and this seems to be a case of simple dimorphism". Conclusions based on subjectively placed categories of colouration do not solve the problem of if, and much less why, an apparent predominance occurs. At this stage the cause of one colour type seemingly being more common than another is not known. Certainly, as yet no selective value has been shown to exist for one pure phase, and at present the problem appears to be not the action of a single pair of alleles but possibly an action of multiple alleles. Such alleles do not result in distinct colouration, but rather form one extreme to the other. Jaap, cited in Snyder and David (1957), found three sets of alleles affecting the plumage and colour variations in the mallard duck.

The weights of the adult geese on arrival at the nesting grounds are at a maximum compared to the other reproductive phases. Hanson (1962) found the same condition in Canada geese (*Branta canadensis*) upon arrival on the nesting grounds. The pattern of fattening in the Ross' goose is still unknown, but Hanson (1962) found that the Canada goose followed much the same pattern as species which migrate leisurely. He states that the abundance of fat in arriving geese is necessary to

supply energy from the time of arrival on the breeding grounds until the snow cover has left and new plant growth is again available. The subsequent weight loss observed in Ross' geese may well result from the utilization of the stored fat supply, the relatively sparse food available at the time, and the physiological stresses of territory formation, nest initiation, and egg laying. The greater total weight loss exhibited by females results from ovary and oviduct regression, increasing attentiveness to the nest site, and minimal food consumption. The males continue to graze on the territory and do not show such a substantial weight loss. Irving (1960) thinks that fat reserves may be important to males during the intense period of courtship and territory maintenance. Courtship is not a stressful activity in male Ross' geese, as this phase is completed before arrival in the North. The more rapid decline of male fatness has been explained by Hanson (1962). He states that because of the relative passiveness of the females during courtship procedures, they arrive in the North fatter than the males, and maintain comparable amounts of fat longer.

Following the hatching period both adult and young Ross' geese gain weight rapidly. The abundance of mature flowers, leaves, and stems, the long photoperiod, and the prolonged trek over the tundra all allow for an increased food intake during the nesting period. Another noticeable weight loss occurs during the moulting period, when birds of the year mature. Hanson (1962) states that this is perhaps the period of greatest stress in the life of the adult Canada goose. Data presented from this research and reports from other workers (Barry, 1962; Cooch, 1958) indicate similar stress in the Ross' and other arctic-nesting geese. Hanson (1962) discusses the possible physiological causes of stress in the moulting geese that may lead to a decrease in weight. He states that a marked increase in the metabolic rate occurs as a result of the utilization of muscle protein in the formation of feathers. Marshall (1960) says that moulting imposes a severe strain on birds in that a large amount of blood is required for the new feather growth.

In summary, the reproductive phase of the Ross' goose does not appear to be the limiting factor of the population nesting at Arlone Lake. Nesting and hatching success is high, and mortality of the adults and young is low. At present, competition with the lesser snow goose is not affecting productivity.

The two study seasons at Arlone Lake were good ones. Neither climate nor biotic factors decreased

markedly the production of Ross' geese. However, in such an unstable ecosystem, late seasons or excessive continued predation could cause drastic annual drops in the productivity of the geese. In 1964 the white-fronted geese (*Anser albifrons*) nesting in the extreme western Arctic suffered greatly because of the late season and subsequent flooding of the nesting habitat. The studies of Barry (1962), Cooch (1958), and Lemieux (1959) all point out that climate during the reproductive phase is probably the most important limiting factor controlling annual reproduction in arctic-nesting geese. Such works should be considered as standards when extrapolating for other geese nesting under relatively similar conditions. Until we have further data on the frequency of late seasons and inclement weather during the reproductive phase of the Ross' geese, we will not know specifically how such occurrences affect the species.

The importance of predation cannot be minimized. Arctic fox damage to the Arlone Lake colony in 1964 resulted in the complete evacuation of one of the major nesting islands. The insular habitat presumably saved the colony from complete destruction. Until we know if the remaining nesting colonies of Ross' geese are insular, we cannot say that mammalian predators do not control the annual productivity.

The need for future study on the Arlone Lake and other nesting colonies is clear. We have now a general over-all picture of the effects of weather, predation, and human beings on a specific area, but long-term studies are essential to provide additional and comparative information.

Summary

1. This study of the breeding biology of Ross' goose in the Perry River region was carried out during the summers of 1963 and 1964 at Arlone Lake and Perry River, N.W.T.
2. The spring migration of Ross' geese in 1964 correlated with the northward movement of the 40°F isotherm.
3. Pairing and courtship activities are completed before arrival on the nesting grounds.
4. Nest initiation depends upon the presence of exposed and suitable nest sites and suitable weather conditions on the nesting islands.
5. Excessive mammalian predation at the start of the nesting season results in the abandonment of nesting islands.
6. The distribution of nests is not random. Highest densities occur in edge areas of mixed birch, rock, and open terrain.
7. Subsequent eggs in the clutch are laid every 1½ days with a resultant egg-laying period of 8 to 9 days for the whole colony.
8. The average clutch size is three, and the most common clutch four. No significant differences in clutch size occur among the four major habitats.
9. A negative correlation exists between date of first egg laid and final clutch size.
10. Little attentiveness to the nest is shown before the incubation period. The beginning of incubation is marked by silence over the colony, excessive plucked down in the nests, tight flocking of disturbed groups, and rapid return to nests.
11. The incubation period is 22 days.
12. The covering of eggs with nest material by the female before the parents leave the territory has a selective advantage.
13. Nests in open habitat are larger than those in regions which provide coverage.
14. Renesting probably does not occur in the study area.
15. Ross' geese do not abandon a partially depleted clutch, but will desert excessively large clutches.
16. Hatching of a clutch is synchronous and assures maximum survival of goslings. The hatching period lasts approximately 8 days.
17. Predator numbers increased during the hatching period.
18. Nesting and hatching success was extremely high.
19. The post-nuptial migration of the Arlone Lake colony is not directed along the Perry River, but occurs as a dispersal over the tundra from the nesting area to the coast. Very few Ross' geese reach the coast.
20. Predation was low during the reproductive phases of 1963 and 1964. The greatest percentage loss in 1964 occurred in the United States.
21. A 1:1 sex ratio exists in the adults and newly hatched goslings.
22. A differential mortality occurs against females during the first 3 weeks of life (137 males : 100 females).
23. It is suggested that brood counts taken while the adult geese are moulting are invalid.
24. Body weights of adults are at a maximum on arrival at the nesting grounds. Body weight drops immediately after arrival and again during the post-nuptial moult.
25. The growth rate of the goslings is rapid, showing the typical sigmoid curve.
26. Parasite extensity throughout the reproductive season is low.
27. No noticeable competition existed between the Ross' goose and the lesser snow goose at the Arlone Lake colony in 1963 and 1964. It is suggested that excessive immigration of lesser snow and blue geese into Ross' geese nesting areas would have a detrimental effect on the Ross' geese.
28. The insular nesting habitat at Arlone Lake is an efficient protective device against continuous mammalian predation.
29. The reproductive phases of 1963 and 1964 were not the limiting stages in the life of the Ross' goose at Arlone Lake.
30. Food is not a limiting factor on the nesting grounds.
31. The frost-free period in the study area lasts 93 days. In 1963 and 1964, 86 per cent of this period was used to complete the reproductive phase.
32. Continued study of the reproductive phase of Ross' geese is required to determine quantitatively the effects of late seasons and heavy predation. Comparative ecological data are needed from other nesting colonies.

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Appendices

Appendix 1 Representative flora from Arlone Lake study area

Islands	Tundra	Moraines
	<i>Arctophila fulva</i>	<i>Dryopteris fragrans</i>
	* <i>Hierochloe alpina</i>	<i>H. alpina</i>
	Gramineae	
	<i>Carex bigelowii?</i>	
<i>Carex supina</i>	<i>Carex supina</i>	
	<i>Eriophorum vaginatum</i>	<i>E. vaginatum</i>
	<i>Juncus</i> spp.	
<i>Salix</i> spp.	<i>Salix</i> spp.	<i>Salix</i> spp.
<i>Betula glandulosa</i>	<i>B. glandulosa</i>	<i>B. glandulosa</i>
	<i>Caltha palustris</i>	
<i>Ranunculus sabinii</i>		
<i>Papaver radicatam</i>		<i>P. radicatam</i>
Cruciferae		
<i>Saxifraga tricuspidata</i>		<i>S. tricuspidata</i>
<i>Potentilla hyparctica</i>		<i>P. hyparctica</i>
	<i>Potentilla</i> sp.	
<i>Rubus chamaemorus</i>		
Leguminosae		
<i>Empetrum nigrum</i>	<i>E. nigrum</i>	
<i>Epilobium</i> sp.		
	<i>Epilobium latifolium</i>	<i>E. latifolium</i>
<i>Hippuris vulgaris</i>		
<i>Cassiope tetragona</i>		<i>C. tetragona</i>
		<i>Ledum decumbens</i>
<i>Rhododendron lapponicum</i>		
<i>Vaccinium Vitis-idaea</i>		<i>V. Vitis-idaea</i>
<i>Pedicularis sudetica</i>	<i>P. sudetica</i>	
<i>Petasites frigidus</i>		
<i>Senecio congestus</i>		
Compositae		

*Lines joining areas depict species common to these regions.

Appendix 2a Avian phenology chart Perry River, N.W.T., 1963

Species	Common name	Date	No.
<i>Buteo lagopus</i>	Rough-legged hawk	May 22	1
<i>Nyctea scandiaca</i>	Snowy owl	May 22	1
<i>Plectrophenax nivalis</i>	Snow bunting	May 22	30
<i>Larus argentatus</i>	Herring gull	May 22	5
<i>Grus canadensis</i>	Sandhill crane	May 25	35
<i>Branta canadensis</i>	Canada goose	May 25	25
<i>Olor columbianus</i>	Whistling swan	May 31	3
<i>Lagopus mutus</i>	Rock ptarmigan	May 31	100
<i>Anser albifrons</i>	White-fronted goose	June 1	10
<i>Corvus corax</i>	Northern raven	June 1	2
<i>Eremophila alpestris</i>	Horned lark	June 2	4
<i>Anser caerulescens</i>	Lesser snow goose	June 3	4
<i>Calcarius lapponicus</i>	Lapland longspur	June 4	100
<i>Pluvialis dominica</i>	Golden plover	June 4	10
<i>Anser rossii</i>	Ross' goose	June 5	12
<i>Anas acuta</i>	Pintail duck	June 5	15
<i>Larus hyperboreus</i>	Glaucous gull	June 6	5
<i>Erolia bairdii</i>	Baird's sandpiper	June 6	10
<i>Arenaria interpres</i>	Ruddy turnstone	June 6	6
<i>Stercorarius pomarinus</i>	Pomarine jaeger	June 7	7
<i>Clangula hyemalis</i>	Oldsquaw duck	June 7	5
<i>Somateria mollissima</i>	Common eider	June 7	4
<i>Somateria spectabilis</i>	King eider	June 9	4
<i>Phalaropus fulicarius</i>	Red phalarope	June 9	50
<i>Charadrius hiaticula</i>	Ringed plover	June 9	1
<i>Mergus serrator</i>	Red-breasted merganser	June 9	3
<i>Squatarola squatarola</i>	Black-bellied plover	June 10	5
<i>Xema sabini</i>	Sabine's gull	June 10	2
<i>Sterna paradisaea</i>	Arctic tern	June 10	5
<i>Asio flammeus</i>	Short-eared owl	June 11	1
<i>Erolia melanotos</i>	Pectoral sandpiper	June 13	5
<i>Passerculus sandwichensis</i>	Savannah sparrow	June 13	1
<i>Falco peregrinus</i>	Peregrine falcon	June 13	1
<i>Ereunetes pusillus</i>	Semipalmated sandpiper	June 13	2
<i>Gavia arctica</i>	Arctic loon	June 14	2
<i>Gavia stellata</i>	Red-throated loon	June 14	1
<i>Stercorarius parasiticus</i>	Parasitic jaeger	June 14	1
<i>Stercorarius longicaudus</i>	Long-tailed jaeger	June 14	2
<i>Anas carolinensis</i>	Green-winged teal	June 24	3
<i>Lobipes lobatus</i>	Northern phalarope	June 24	2
<i>Aquila chrysaetos</i>	Golden eagle	July 31	1
<i>Toxostoma rufum</i>	Brown thrasher	Aug. 13	1

Appendix 2b Avian phenology chart, Perry River, N.W.T., 1964

Species	Common name	Date	No.
<i>Branta canadensis</i>	Canada goose	June 1	10
<i>Anser albifrons</i>	White-fronted goose	June 1	4
<i>Anser caerulescens</i>	Lesser snow goose	June 1	4
<i>Anser rossii</i>	Ross' goose	June 1	19
<i>Lagopus mutus</i>	Rock ptarmigan	June 1	8
<i>Calcarius lapponicus</i>	Lapland longspur	June 1	200
<i>Plectrophenax nivalis</i>	Snow bunting	June 1	150
<i>Pluvialis dominica</i>	Golden plover	June 1	3
<i>Erolia bairdii</i>	Baird's sandpiper	June 1	50
<i>Grus canadensis</i>	Sandhill crane	June 1	100
<i>Larus argentatus</i>	Herring gull	June 1	4
<i>Larus hyperboreus</i>	Glaucous gull	June 1	1
<i>Eremophila alpestris</i>	Horned lark	June 1	3
<i>Stercorarius pomarinus</i>	Pomarine jaeger	June 2	8
<i>Anas acuta</i>	Pintail duck	June 2	7
<i>Buteo lagopus</i>	Rough-legged hawk	June 2	1
<i>Falco rusticolus</i>	Gyr Falcon	June 3	1
<i>Asio flammeus</i>	Short-eared owl	June 3	1
<i>Hirundo rustica</i>	Barn swallow	June 4	1
<i>Corvus corax</i>	Northern raven	June 8	2
<i>Arenaria interpres</i>	Ruddy turnstone	June 8	1
<i>Clangula hyemalis</i>	Oldsquaw duck	June 8	5
<i>Stercorarius longicaudus</i>	Long-tailed jaeger	June 8	1
<i>Sterna paradisaea</i>	Arctic tern	June 9	13
<i>Olor columbianus</i>	Whistling swan	June 9	4
<i>Gavia arctica</i>	Arctic loon	June 10	2
<i>Calidris canutus</i>	Knot	June 10	5
<i>Stercorarius parasiticus</i>	Parasitic jaeger	June 11	2
<i>Somateria spectabilis</i>	King eider	June 12	5
<i>Charadrius semipalmatus</i>	Semipalmated plover	June 13	1
<i>Phalaropus fulicarius</i>	Red phalarope	June 14	1
<i>Erolia melanotos</i>	Pectoral sandpiper	June 17	2
<i>Ereunetes pusillus</i>	Semipalmated sandpiper	June 20	2
<i>Xema sabini</i>	Sabine's gull	June 27	2
<i>Acanthis flammea</i>	Common redpoll	June 27	1
<i>Gavia stellata</i>	Red-throated loon	June 30	2
<i>Mergus serrator</i>	Red-breasted merganser	July 5	2
<i>Falco peregrinus</i>	Peregrine falcon	July 12	2
<i>Erolia alpina</i>	Dunlin	Aug. 2	2

Appendix 3 Ross' goose nest history card

Nest no.	Island	Dimensions	Habitat type	Distance	Eggs														
					1	2	3	4	5	6	7	8	9	10					
Egg fate																			
Date hatch																			
Remarks																			

Appendix 4 Ross' goose data form

No.....	Date.....	Collector.....	Sex.....
Location.....		Elevation.....	
Habitat			
Method of collection.....			
Weather: Temp.....		Wind.....	Snow cover (%).....
Weight.....	Age.....	Culmen I.....	Culmen II.....
Plumage			
Wart length.....	Tarsus length.....	Mid-toe.....	
Wing spread (flat).....	Tail length.....		
Total length.....	pre-ovulatory follicles.....		
	post-ovulatory follicles		
	atretic follicles		
Oviduct width.....	Adrenals.....	Fat	
Keel depth.....	Pectoral muscle.....	E.I.....	
Food			
.....			
Lens weight.....			
Previous tag marks			
.....			
Remarks:			

Appendix 5 Food habits

Data on Ross' goose food habits were obtained from analysis of 26 ventriculi (Table 21). Of these, 8 were collected in the 1963 field season and 18 in 1964.

TABLE 21 Results of food analysis of 26 Ross' goose ventriculi collected in the Perry River region, 1963 and 1964

Food item		Frequency of occurrence	
		June	July
Roots	Gramineae	1	—
	Cyperaceae	2	—
	unidentified	3	2
Leaves	Gramineae	—	1+1G*
	Cyperaceae	—	—
	<i>Carex</i> spp.	—	3+3G
	<i>Betula</i> spp.	—	2
	unidentified	2	3+5G
Stems	Gramineae	1	1G
	Cyperaceae	—	1
	<i>Carex</i> spp.	—	1G
	<i>Eriophorum</i> spp.	—	1G
	unidentified	—	1
Spikelets	Gramineae	—	2
	Cyperaceae	—	1
	<i>Carex</i> spp.	—	3+3G
	<i>Eriophorum</i> spp.	1	3

*G = gosling.

The only available data on food habits of Ross' geese on the nesting grounds are documented by Hanson *et al.* (1956). They state:

Contents of 5 gizzards [were] examined: 2 gizzards contained the stems and leaves of the sedge *Eriophorum*, though in one there were only trace quantities, the third contained mainly *Eriophorum* with some *Carex*, the fourth was largely *Carex* with some *Poa*, and the fifth gizzard was empty.

In the early spring and during June the geese feed largely on the roots of sedges. This is most likely because stems, leaves, and flowers are not yet mature or do not furnish sufficient nutrients in early spring. Later in the season the geese utilize primarily leaves and spikelets. This is especially true of the young geese during the post-hatching migration across the tundra. Lemieux (1959) found a similar sequence in the feeding habits of the greater snow goose (*Anser hyperborea atlantica*). He states that in the early spring, roots of the

legume *Oxytropis maydellians* and *Polygonum viviparum* (knotweed) were utilized. Later on, especially when broods were accompanied by parents on land, the common foods consisted of blades of grass and leafy plants. Although the goslings' food consisted primarily of marsh vegetation, blades of grass were common. Delacour (1964) in his review of food habits of Anserinae makes no mention of animal matter being utilized by these birds and states that a major part of the food consists of grasses, sedges, and semi-aquatic vegetation. None of the specimens of Ross' geese collected during this study contained animal material in the digestive tract. Barry (1956) observed young captive American brant feeding on mosquitoes and larvae as well as short grass and flowers of *Ranunculus*.

Appendix 6 Results of 1965 survey

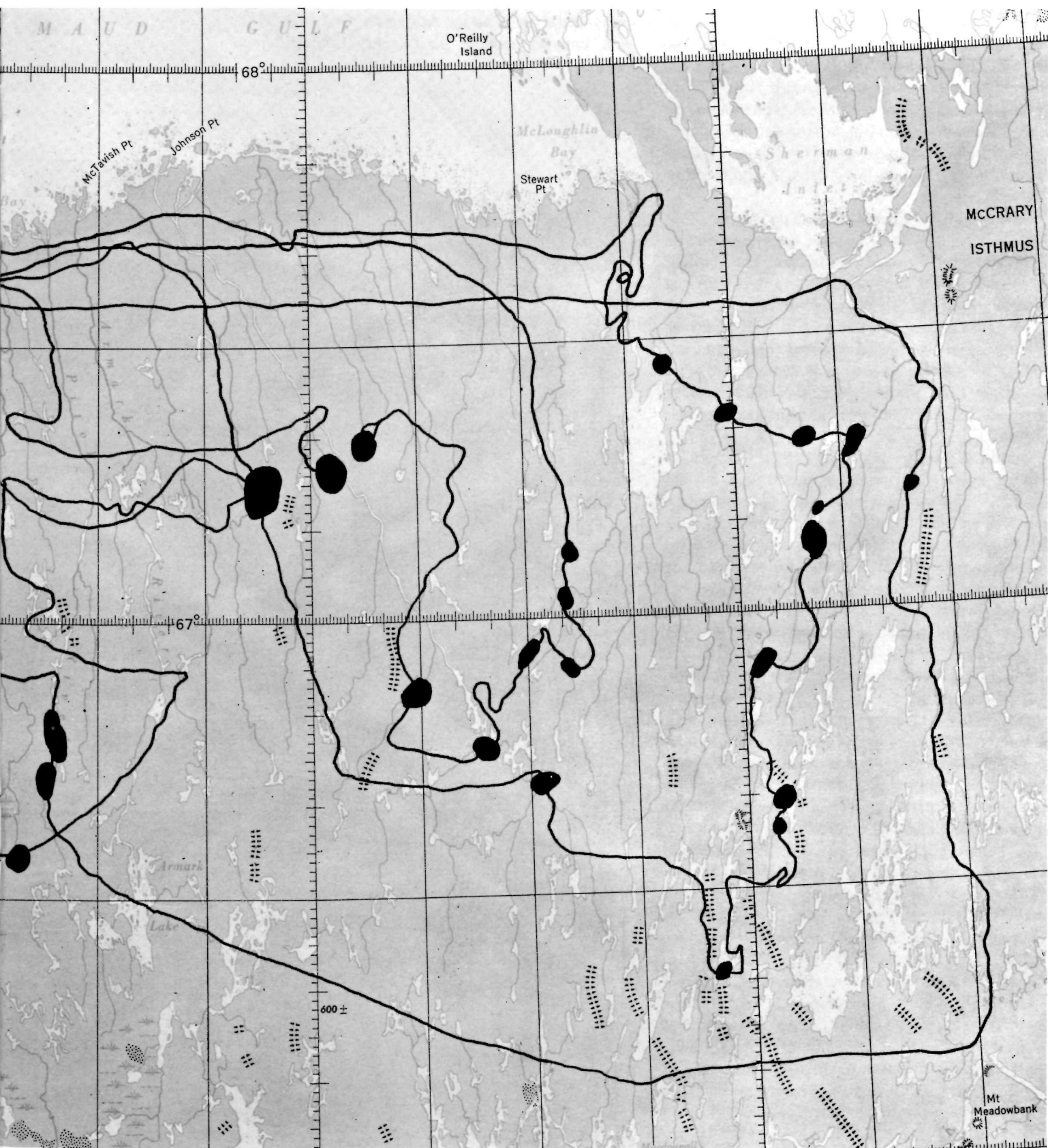
I conducted an aerial reconnaissance of the breeding grounds of Ross' geese in the Queen Maud Gulf region, N.W.T., from July 9 to 12, 1965. Twenty previously unrecorded nesting colonies of Ross' geese were found between latitudes $66^{\circ}21'N.$ – $67^{\circ}22'N.$ and longitudes $97^{\circ}02'W.$ – $104^{\circ}15'W.$ (Fig. 29). A total of 32,086 Ross' geese was observed during the survey (30,037 nesting and 2,049 non-nesting). All colonies were located on islands in lakes. Suitable nesting islands offered protection, in the form of rocky and dwarf shrub areas, against wind and to some extent rain and snow. Islands with contour providing leeward protection from the elements were utilized rather than "flat" ones. Suitable nesting lakes were those large enough to prevent predators swimming to the islands and shallow enough so that at the start of the nesting season no ice bridge between the islands and the mainland would be available to predators. Probably any depth over 5 or 6 feet would be unsuitable judging from studies completed at Arlone Lake. This lake averages 3 feet in depth and the start of the nesting season coincides with the ice breakup.

The survey took place during the latter half of the incubation period, consequently the pre-breeders and failed breeders were located at varying distances from the nesting colonies. Although 2,049 moulting Ross' geese were seen in small flocks away from the colonies at this time, the figure does not represent the total non-breeding component of the population. Many flocks were probably missed, and in some instances counts were not taken close to colonies because of our preoccupation with the nesting individuals.

The view that the Ross' goose is one of North America's relict and rare species will be invalidated if additional colonies are uncovered during future systematic aerial surveys of the eastern and western extremities of the Canadian Arctic and the large central area along the Queen Maud Gulf.



Figure 29 Map of study area showing Ross' goose colonies observed July 9-12, 1965, during aerial reconnaissance. Solid circles indicate colonies and hollow circles indicate flocks of non-nesting birds. (World Aeronautical Chart of Thelon River, No. 2081, 1:1,000,000, produced by Department of Mines and Technical Surveys.)



Résumé

L'auteur donne un compte rendu des études effectuées durant les étés de 1963 et 1964 dans une colonie de nidification de l'oie de Ross, au lac Arlone, dans la région de la rivière Perry (T. du N.-O.). Suit un aperçu général des explorations, du climat, de la végétation, de la faune et de la population esquimaude, ainsi que l'historique de l'implantation de l'oie de Ross dans la région de la rivière Perry.

Sont étudiés les aspects suivants de la biologie de l'oie de Ross: les dates d'arrivée dans cette aire de nidification, le début de la nidification, l'incubation, les déplacements post-nuptiaux, la mortalité, la déprédation, la fertilité et la concurrence.

L'auteur fait une corrélation entre des mentions de la présence de l'oie de Ross au cours de la migration printanière de 1964 et le déplacement, vers le nord, de l'isotherme de 40°F. Il étudie l'avantage que peut présenter cet élément pour régir les migrations.

Durant la période visée par l'étude faite au lac Arlone, aucun comportement de parade n'a été observé, ce qui donne à penser que cette activité a lieu plus au sud. L'oie de Ross fait son nid dans des îles afin de se défendre, croit-on, contre les mammifères prédateurs. Les plus fortes densités de nidification ont été relevées dans des étendues rocheuses parsemées de bouleaux et dans des espaces dégagés offrant toutefois des abris et de la végétation basse.

La ponte a lieu à intervalles d'un jour et demi, et la période de ponte dure de 8 à 9 jours. Le nombre des œufs, qui est en moyenne de trois, peut être limité par la brièveté de l'été arctique. Les oiseaux qui nichent tard, ont des couvées plus restreintes. La reproduction doit se faire durant les 93 jours exempts de gel. En 1963 et en 1964, la ponte a duré plus de 80 p. 100 de cette période.

Le haut degré de soin au cours de la période d'incubation assure le succès maximum de la couvaison. La mortalité et les déprédations sont généralement faibles dans les îles où cette oie niche. On a estimé la fertilité d'après des relevés des couvées d'oisons âgés d'une semaine ou moins. En 1964, la plupart des pertes ont eu lieu aux États-Unis.

Les oisons sont polymorphiques, la teinte de leur duvet variant entre le jaune et le gris. La mortalité est plus élevée chez les oisons femelles durant leurs trois premières semaines de vie. On estime que la venue d'un fort contingent de petites oies blanches et d'oies bleues nuirait à l'oie de Ross durant la période de reproduction.

L'auteur conclut que la population d'oies de

Ross qui a niché au lac Arlone en 1963 et en 1964, n'a pas été victime de facteurs limitatifs trop sérieux.



Canadian Wildlife Service
Department of Indian Affairs and Northern Development

