Arctic Gas

BIOLOGICAL REPORT SERIES
VOLUME THIRTY-FIVE

ORNITHOLOGICAL STUDIES CONDUCTED IN THE AREA OF THE PROPOSED GAS PIPELINE ROUTE: NORTHERN ALBERTA, NORTHWEST TERRITORIES, YUKON TERRITORY AND ALASKA, 1975

Edited by
W. W. H. GUNN, C. E. TULL, T. D. WRIGHT

Prepared by
L. G. L. LIMITED, ENVIRONMENTAL RESEARCH ASSOCIATES

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CANADIAN ARCTIC GAS STUDY LIMITED

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PLATE 1. Female Gyrfalcon at nest. (The nest, #479, was visited to collect the eggs for analysis once it had been determined that the eggs would not hatch.)

CHAPTER I

A STUDY OF WINTERING AND NESTING GYRFALCONS ON THE YUKON NORTH SLOPE DURING 1975 WITH EMPHASIS ON THEIR BEHAVIOUR DURING EXPERIMENTAL OVERFLIGHTS BY HELICOPTERS

JOSEPH B. PLATT
C. ERIC TULL

ABSTRACT

Studies of Gyrfalcons were conducted on the Yukon North Slope during the period from January to July, 1975, to determine whether Gyrfalcons winter in the area, to study the nesting behaviour and nesting success of the birds, and to determine the effects on Gyrfalcons of disturbance caused by helicopter overflights and by human presence. Supplementary data on occupancy and productivity of nest sites were collected during 1976.

Gyrfalcons were found to winter in the vicinity of nest sites. Willow Ptarmigan, which occur in flocks in the willow scrub during the winter, appear to be the principal prey item for the wintering Gyrfalcons.

Gyrfalcons nested successfully during 1975 at 12 nest sites and fledged 38 young birds--a productivity of 3.2 young/successful nest. The number of successful nests was similar to that of 1974 but was much reduced from that of 1973. The productivities of successful nests, however, was similar for all three years. Detailed observations were made of the behaviour of nesting Gyrfalcons during each stage of the nesting cycle.

Nesting Gyrfalcons were disturbed more frequently by helicopter overflights at an altitude of 150 m than by overflights at 300 m. They were not visibly disturbed by helicopter overflights at an altitude of 600 m. Birds were less disturbed by helicopters during the winter than they were during the nesting period (March-June).

When kept to a comparatively low frequency, disturbance to nesting Gyrfalcons by helicopter overflights and by human presence did not affect the nesting success of the birds. Disturbance should, however, be considered as a possible factor that may lead to the failure of Gyrfalcons to reoccupy disturbed nest sites in the year following the disturbance.

ACKNOWLEDGEMENTS

We wish to thank the Canadian Wildlife Service (C.W.S.) for their continuing cooperation in this project and for their logistical support during the winter surveys. In particular we wish to thank Richard Fyfe and Harry Armbruster of C.W.S. for providing banding records, for examining the embryonic content of addled eggs, and for their personal insight and encouragement in the project.

We wish to thank the Yukon Game Branch and, in particular, Mr. David Mossop of the Yukon Game Branch for collecting the 1976 Gyrfalcon nesting data. Mr. Mossop realized the importance of determining the status of the nest sites that had been studied during the previous years, arranged to collect this information, and kindly released this information to the authors. Without his assistance the supplement could not have been written.

The field studies were conducted by the senior author. J.D. Weaver, S.K. Sherrod, and W.R. Koski accompanied Platt during parts of the field program. R.A. Davis, W.W.H. Gunn, S.R. Johnson, W.R. Koski, W.J. Richardson, G.F. Searing, and T.D. Wright assisted in the preparation of this report. J. Erwin prepared the typescript.

The Laboratory of Ornithology, Cornell University, Ithaca, New York, provided support facilities for Platt--a student at the university. Some of the data presented in this report will be used as part of his Ph.D. dissertation at Cornell University. Platt wishes to thank T.J. Cade of the Laboratory of Ornithology for encouragement and support during his thesis project.

The Arctic Gas Biological Report Series, of which this report is a part, is a series of consultant project reports presenting data based on field and laboratory studies. The format and presentation vary among reports in accordance with the authors' discretion.

The data for this work were obtained as a result of investigations carried out by LGL Limited, Environmental Research Associates, for Canadian Arctic Gas Study Limited.

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SUPPLEMENT

INTRODUCTION

The North Slope of the Yukon Territory is an important area for nesting Gyrfalcons (*Falco rusticolus*). Gyrfalcons were found to be nesting there in 1974 during the period from mid-March to mid-July (Platt, 1975). Cade (1960) has postulated that Gyrfalcons may remain in their Arctic breeding grounds throughout the year.

Several large-scale developments are currently being proposed for parts of the Arctic. Little is known of the effects on raptors of such large-scale developments. Studies of disturbance to raptors (reviewed by Platt [1975]) suggest that disturbance by human activities may cause a reduction, dislocation, or extirpation of a part of a raptor population and that raptors are most vulnerable to disturbance during the earlier stages of the nesting cycle, i.e. before and during egg-laying and during incubation.

Platt (1975) observed the behaviour of four pairs of nesting Gyrfalcons during experimental helicopter flights over their nest sites. During these tests, Gyrfalcons invariably either flew away from helicopters or assumed stress postures when helicopters passed 150 m above their nest sites. Gyrfalcons were less severely disturbed when helicopters passed 300 m above their nest sites.

Three important questions that were not answered by the 1974 study were the following:

1) whether Gyrfalcons were present on the Yukon North Slope during the winter months,
2) whether the Gyrfalcons that were subjected to helicopter overflights in 1974 would reuse the same nest sites in 1975, and
3) at what altitudes helicopters could fly over nesting Gyrfalcons without eliciting a visible response.

The present study was conducted to continue the studies of 1974 and to answer the above questions. The specific objectives of the present study were the following:

1) to gather data during January and February to determine
   a) whether Gyrfalcons were present in the study area and, if so, what their activities were at this time, and
   b) whether an adequate prey population was present to support over-wintering Gyrfalcons;
2) to gather data on the roles of male and female Gyrfalcons during the various stages of the nesting cycle;
3) to determine the productivity of successful Gyrfalcon nests in the study area during 1975;

4) to determine the visible responses of Gyrfalcons to the presence of helicopters

   a) at various distances above an occupied nest site, and

   b) at repeated intervals within 2.5 km of a nest site;

5) to compare the nesting success of Gyrfalcon pairs that were exposed to helicopter disturbance with that of pairs that were not exposed to such disturbance; and

6) to compare the reoccupancy in 1975 of Gyrfalcon nest sites that were and were not disturbed by helicopter overflights during 1974.

The data gathered during this study, when combined with similar data from previous years, will provide an information base that can be used to assess the impact of the proposed Arctic Gas pipeline on the bird populations of the area and to develop environmental recommendations to mitigate the impacts on the birds of the area.

STUDY AREA

The study area was located primarily on the North Slope of the Yukon Territory, but a small portion of the study area was located in the Northwest Territories. The study area of approximately 19,500 km^2 was bounded on the east by 136° 00' W, on the west by 140° 11' W, on the north by the Beaufort Sea, and on the south by an arbitrary line parallel to the coast and approximately 100 km inland. Over a dozen rivers flow through the area. The banks and cliffs of these rivers provide most of the Gyrfalcon nest sites. Knolls and outcroppings on the coastal plain also provide nest sites.

In order to protect the nesting Gyrfalcons from unauthorized visitation by the public, the locations of nest sites are not revealed in this report.

METHODS

Winter Surveys

Nest sites of Gyrfalcons on the Yukon North Slope are known from studies conducted during 1973 by the Canadian Wildlife Service (C.W.S.) and during 1974 by Platt (1975). A Bell 206 helicopter was used to visit known Gyrfalcon nest sites during the period 15 to 25 January 1975 and again during the period 15 to 25 February 1975. Nest cliffs were examined from the air and on foot for evidence of Gyrfalcon presence during the winter. The amount of snow in each eyrie (nest ledge) was noted. Coastal cliffs and major water courses were surveyed for Gyrfalcons that were away from known nest sites. Surveys were conducted at 140 km/hr and at an altitude of 30 m above the ground.

Non-systematic surveys of samples of all major habitat types were flown at 70 km/hr and 5 m above ground in order to determine which potential prey species were present during the winter.

Estimates of the numbers of ptarmigan in eight plots were also made. The plots were selected from an altitude of 500 m above the ground. Each plot consisted of a stand of willow that was 0.5 ha in area or larger, that had a percentage cover by willow greater than 50%, and that was surrounded by a willow-free area. The plots were located in the valleys of Rapid Creek, Blow River, Babbage River, and Crow River; patches of willow meeting the above criteria were found neither above 300 m ASL nor in the western third of the study area. The helicopter flew back and forth across each plot about 5 m above the ground cover. Because ptarmigan were reluctant to enter the open area surrounding the plot, the birds that were present gathered at one end of the plot as the helicopter approached. An estimate was made of the number of ptarmigan that had gathered at the end of the drive and that were seen to have escaped during the drive.

Gyrfalcon prey remains and regurgitated pellets of undigested hair, bones, and feathers were collected from areas near nest sites and perch points; prey remains and contents of pellets were identified with the aid of study skins and skeletons.

Nesting Studies

In order to monitor the progress of each Gyrfalcon pair through its nesting cycle, all of the known Gyrfalcon nest sites in the study area were observed periodically between 25 March and 15 June 1975. The helicopter was landed at least 1.5 km from each nest and the observer approached on foot to a point no closer than 400 m from the nest; there he made observations of the nest with 8X binoculars and a 15X to 60X telescope.

At three nest sites extended observations of the nesting behaviour of Gyrfalcon pairs were made from a blind. Such observations were made during the period prior to egg-laying, during egg-laying, during incubation, and during the nestling stage of the nesting cycle. Blinds were located 450 m from the nest during the pre-egg-laying stage, 300 m from the nest during the egg-laying and incubation stages, and 100 m from the nest during the nestling stage.

Between 20 June and 1 July 1975, all known Gyrfalcon nest sites were visited. Any young that were present were examined in order to determine their ages and sexes. Through back-dating from this information, the timing of previous stages of the nesting cycle was estimated. Whenever it was possible, the young Gyrfalcons were banded in order that the birds could be identified if recaptured or found dead at a later date. The productivity of successful Gyrfalcon pairs in the study area was determined from the ratio of the number of young birds known to have been produced to the number of pairs known to have produced young birds.

During June, rock outcrops and river cliffs within the study area were examined with a view to the discovery of Gyrfalcon nest sites that were unknown prior to 1975. Sites that appeared to be potentially suitable for nesting Gyrfalcons were examined both from the air and from the ground.

Helicopter Disturbance Experiments

Experimental flights by a Bell 206 turbine-powered helicopter were conducted over Gyrfalcons at six nest sites and in three hunting territories during the winter and at 17 nest sites during the nesting period.

For the overflights during the nesting period, the helicopter passed over the nest at 160 km/hr and at one of four heights above the nest--150 m, 300 m, 365 m, or 600 m. Flights over nests passed parallel to and about 60 m in front of the nest cliff. Each nest was subjected to no more than two such overflights during any one stage of the nesting cycle.

Winter overflights were conducted under much more variable conditions because it was difficult to determine the locations of the birds and because it was desired to flush the birds in order to determine their ages and sexes.

The disturbance considered in this study is visible disturbance--disturbance that could be seen by an observer located at a distance from the birds. A Gyrfalcon was considered to have been disturbed by an overflight if, during the overflight, either it flushed from its perch without previously indicating the normal flight intention movements or it assumed a stress posture while it continued to incubate (see Platt [1975]). Gyrfalcons were considered to be undisturbed if they were not disturbed during this study.

In order to test nesting Gyrfalcons for their habituation to helicopter overflights, three nest sites were each subjected to a series of from 6 to 10 helicopter flights within a two week period during the nesting period. These flights passed in front of the nest cliffs at a height of 150 m above the nest and at distances of 1.6 to 2.4 km from the nest.

Occupied nest sites were chosen for the prolonged observations from a blind or for the helicopter disturbance tests according to two criteria --nests were selected that could be observed from a distance of 300-400 m and nests in the eastern part of the study area were preferred for logistical reasons. Tested nest sites varied considerably in physical features such as exposure, presence or absence of overhang, and configuration of neighbouring cliffs.

RESULTS

Winter Surveys

Gyrfalcons

At least seven Gyrfalcons were seen in January. Based on the relative sizes of the birds and the average rates of beating the wings, six of these birds were identified as males and one was identified as a female. During February, at least 11 Gyrfalcons were observed; six of these birds were males and five were females. Some of the falcons seen during January were probably seen again during February. One Gyrfalcon was seen under poor light conditions and its age could not be determined. All of the other Gyrfalcons that were seen during the winter surveys had yellow feet and light breasts; these characteristics indicate that these birds were all more than one year old.

Ten of the 18 winter sightings of Gyrfalcons were of lone birds that were observed some distance from known nests. Four were seen during January and six during February. All of these birds were seen near patches of willow; one was flying above coastal cliffs and the other nine were either flying or perched in river valleys. One bird was observed to fly slowly around some scattered willow bushes and to hover above each bush.

Eight of the 18 Gyrfalcon sightings occurred at nest cliffs. Three lone birds (two males and a female) were seen at nest cliffs during January; a lone male and two pairs were seen at nest cliffs during February.

Twenty-eight Gyrfalcon nest sites that were used during either 1973 or 1974 were visited during January 1975. These sites were examined again at least once in February and three additional nest sites were examined then for the first time. Fourteen of the 28 nest cliffs that were visited during January showed signs of activity by Gyrfalcons. Thirteen of these 14 nest cliffs also showed evidence of recent Gyrfalcon activity when revisited during February. Two nest cliffs that did not show evidence of having been frequented in January had abundant signs of Gyrfalcon activity when examined during February. One of the three nest cliffs that were visited only during February also showed signs of Gyrfalcon activity. Thus 16 of the 31 nest cliffs that were examined in February showed evidence of Gyrfalcon activity and a total of 17 nest cliffs were frequented by Gyrfalcons during either January or February. The nest sites that were frequented were located throughout the study area at both high and low elevations and near all of the borders of the study area.

Gyrfalcons used two types of perches at the nest cliffs. One type, the perch point, was situated in an open location that always commanded a view of more than 180° and often commanded a view in every direction.

Perch points were marked by scattered excrement and foot tracks but only occasionally by regurgitated pellets. The only prey remains that were found during the winter surveys were found at three perch points. Perch points were found at every nest cliff that was frequented by a Gyrfalcon; they occasionally occurred at more than one location on a nest cliff.

The other type of perch, the roost, was located on the face of the nest cliff--either in a crevice or under a large overhang. The field of view from these roosts was estimated to be between 90° and 130° in all cases. Regurgitated pellets and dozens (in some cases hundreds) of individual excretions on top of the snow were present at these roosts. Roosts were found at 13 of the 17 nest cliffs that were frequented by Gyrfalcons.

The eyrie (nest ledge) was examined at 29 of the 31 nest sites (eyries at two cliffs had been lost due to wearing away of the cliff face). Table 1 shows the winter occurrence of Gyrfalcons at nest cliffs where the eyries were filled with snow and at nest cliffs where the eyries were free of snow in relation to the nesting history of the eyries during the preceding summer. (Winter occupancy implies occurrence at the nest cliff but not necessarily at the eyrie.) The results suggest that, of the 16 nest sites that were not successfully occupied in 1974 (no eggs were laid or young raised), the birds preferred during the succeeding winter to frequent those nest sites that had snow-free eyries; however,

TABLE 1. Snow Conditions and Winter Utilization of Gyrfalcon Nest Sites.*

	Eyrie Snow-free	Eyrie Snow-filled
Nest site not successfully occupied** in 1974		
Nest cliff frequented in winter†	6	2
Nest cliff not frequented in winter	2	6
Nest site successfully occupied in 1974 and not disturbed by helicopters or by prolonged human presence during this study		
Nest cliff frequented in winter	2	4
Nest cliff not frequented in winter	2	0

* Eyries had worn away at two of the nest cliffs that were examined. Nest sites that were disturbed during 1974 are not included in this table.

** Successfully occupied -- eggs laid or young raised.

† Winter of 1974-1975.

this suggested preference was not statistically significant (one-tailed Fisher exact test; P = 0.066). This suggested preference for snow-free eyries was not evident at the eight nest sites that were successfully occupied in 1974 and that were not disturbed during the nesting period (either by helicopter overflights or by the presence for a week or more of a human on foot at a blind). However, the sample size for these eight sites was too small to permit meaningful statistical assessment of the effect of snow conditions at eyries on the winter occupancy of these sites.

There was evidence (foot tracks) that Gyrfalcons had walked into three of the 14 eyries that were snow-free in January. In late February these three eyries showed further evidence of such visitations, and a fourth showed evidence of having been visited for the first time. There was no evidence during January or February that the birds had made the nest cup (scrape) that is usually formed during the early stages of falcon courtship (Bent, 1938, p. 46).

Winter Availability of Prey Species

In order for Gyrfalcons to successfully spend the winter in the study area, a sufficient number of prey animals must be present.

There was evidence of the presence on the study area of only three mammalian species or species groups--snowshoe hare (*Lepus americanus*), weasel (*Mustela* spp.), and an unidentified microtine rodent--that could serve as prey species for Gyrfalcons.

Evidence of snowshoe hares was common in the spruce communities of the Old Crow Flats and the Mackenzie Delta. Small numbers were seen in the study area in the upper portions of some of the river valleys that contained stands of spruce. Snowshoe hares also occurred in the lower sections of some of the river valleys in the few areas that contain stands of willow 2-3 m in height. Although a Gyrfalcon is capable of catching and killing a snowshoe hare (Dementiev, 1960), the sparse distribution of snowshoe hares away from forested areas makes them a potential but minor prey item.

Because weasels are relatively rare in the study area and because they spend much of the winter beneath the snow where they feed on microtine rodents (MacLean *et al.*, 1974), weasels are unlikely prey species for Gyrfalcons.

The size of the microtine rodent population in the study area was not determined. Tracks were occasionally seen on the snow in the foothills. Microtine rodents were generally scarce in the foothills during the summers before and after the winter surveys, but they were locally common on the coastal plain (Platt, unpublished). Arctic microtine rodents are active under the snow during the winter. When present on the surface of the snow they would be highly vulnerable to Gyrfalcons. Of 26 winter pellets of Gyrfalcons that were gathered at nest sites throughout the study area, four were wholly and six were partially composed of the remains of microtine rodents.

In addition to the Gyrfalcon only three species of birds--Snowy Owl (*Nyctea scandiaca*), Common Raven (*Corvus corax*), and Willow Ptarmigan (*Lagopus lagopus*)--were seen in the study area.

Three single Snowy Owls were seen in January and two were seen in February. One Snowy Owl was seen on the sea ice 2 km from land; the others were seen in river valleys near the coast. Groups of ravens were seen at the Komakuk Beach and Shingle Point DEW Line stations. Single ravens were seen in river valleys on four occasions during January and on six to eight occasions during February. Because Snowy Owls and Common Ravens are large and comparatively scarce, they are probably not potential prey items for Gyrfalcons.

Willow Ptarmigan were the most abundant form of animal life that was observed on the North Slope during the winter. They were found from the sea coast to 60 km inland and from sea level to approximately 600 m ASL. Large numbers of ptarmigan were also seen on Herschel Island, in the Mackenzie Delta, and in the Old Crow Flats. Both male and female Willow Ptarmigan were collected in the study area during the winter. Although Rock Ptarmigan (*Lagopus mutus*) are present in the study area during the summer, none were identified in either the winter flocks of ptarmigan or the Gyrfalcon prey remains.

All of the ptarmigan that were seen during the winter were in flocks that included between 13 and 400 birds; the mean flock size was estimated to be 60 birds. All of the flocks were found in close association with willow communities. Willow patches throughout the study area contained abundant signs of ptarmigan feeding activity and the patches of tall willows with deep snow cover contained numerous roost sites. Densities of ptarmigan in the eight willow plots that were censused ranged from 0 to 591 ptarmigan/ha (Table 2). The two plots that did not contain ptarmigan showed signs of recent ptarmigan activity.

Of 26 winter pellets of Gyrfalcons that were gathered at nest sites throughout the study area, 22 pellets contained ptarmigan remains. Ptarmigan remains were also found at three winter perch points. Because of the evidence that Gyrfalcons commonly prey on ptarmigan during the winter and because ptarmigan are abundant on the North Slope during the winter, ptarmigan are considered to be the primary prey item for the Gyrfalcons that winter on the North Slope. They are also the primary prey of Gyrfalcons on the North Slope during the breeding season (Appendix 1).

Nesting Success

Table 3 summarizes the nesting success during 1975 at each of the 34 known Gyrfalcon nest sites in the study area. Two of the nest sites were discovered during the course of the June surveys (birds did not nest at these sites in 1974) and a third site was visited only during the June surveys. The progress of the nesting birds was periodically monitored at the 31 other nest sites from the stage prior to egg-laying to the stage of fledgling young.

TABLE 2. Censuses of Willow Plots on the Yukon North Slope, February 1975.

Area of Plot (ha)	Number of Ptarmigan	Ptarmigan/ ha
3.0	350	117
2.0	80	40
1.0	150	150
0.7	400	571
0.7	125	179
0.7	90	129
0.5	0*	0
0.5	0*	0

* Contained signs of recent ptarmigan activity.

TABLE 3. Activity at Gyrfalcon Nest Sites on the Yukon North Slope, January - June 1975.

Nest*	Winter Condition of Nest Ledge	Activity at nest site: January	February	March-April	June
210	Snow-filled	Roost	Roost	Occupied	4 young
804	Open	Roost	Roost	Occupied	4 young
819	Snow-filled	No activity	Roost	Occupied	4 young
896	Open	Not visited	No activity	Occupied	4 young
139	Snow-filled	Perch point	Perch point	No activity	Scrape**, defended
415	Open	No activity	No activity	Occupied	Scrape, defended
567	Snow-filled	Perch point	No activity	Occupied	Scrape
788	Snow-filled	No activity	Roost	No activity	Scrape, defended
479	Open	Roost	Roost	Occupied	4 addled eggs
954	Snow-filled	Roost	Roost	Occupied	No activity
936	Snow-filled	Roost	Roost	Occupied	3 young
510	Open	No activity	No activity	No activity	No activity
893	Open	Roost	Roost	Occupied	2 young
915	Open	Not visited	Perch point	Occupied	1 young
508	Open	Roost	Roost	Occupied	3 young
747	Open	Roost	Roost	Occupied	2 young
280	Open	No activity	No activity	Occupied	Scrape
782	Open	Perch point	Perch point	No activity	No activity
925	Open	Roost	Roost	No activity	No activity
708	Snow-filled	Roost	Roost	No activity	No activity
646	Snow-filled	No activity	No activity	Occupied	Scrape
975	Snow-filled	Roost	Roost	No activity	No activity
226	Snow-filled	Not visited	No activity	No activity	No activity
496	Snow-filled	No activity	No activity	No activity	No activity
870	Not intact	No activity	No activity	No activity	No activity
558	Open	No activity	No activity	No activity	No activity
579	Not intact	No activity	No activity	No activity	No activity
091	Snow-filled	No activity	No activity	No activity	No activity
528	Open	No activity	No activity	No activity	No activity
860	Snow-filled	No activity	No activity	No activity	No activity
296	Snow-filled	No activity	No activity	No activity	No activity
401	Not visited	Not visited	Not visited	Not visited	4 young
942†	Not visited	Not visited	Not visited	Not visited	3 young
871†	Not visited	Not visited	Not visited	Not visited	4 young
Totals	15 Snow-filled 14 Open 3 Not visited 2 Not intact	14 Frequented 14 No activity 6 Not visited	16 Frequented 15 No activity 3 Not visited	15 Occupied 16 No activity 3 Not visited	12 Produced young 1 Produced eggs 3 Scrapes, defended 3 Scrapes, undefended 15 No activity

* Nests are referred to by numbers that have been assigned by C.W.S.
** Scrapes occur earlier in the year but ledges were not inspected until June.
† Discovered in June.

Detailed observations of Gyrfalcon behaviour during each stage of the nesting cycle are presented in Appendix 1.

At least one Gyrfalcon was present at 15 of the 31 nest sites that were visited during the period prior to egg-laying (25 March to 23 April). Eleven of these 15 nest sites had shown signs of Gyrfalcon activity during the January or February visits.

Gyrfalcons laid eggs at 13 of the 34 known nest sites in the study area (at 10 of the 15 sites known to have had Gyrfalcons present during the stage prior to egg-laying). Egg-laying at all sites in the study area began between 10 and 28 April 1975.

Twelve of the 13 pairs of Gyrfalcons that laid eggs hatched some or all of their eggs. The estimated earliest and latest dates of hatching were 26 May and 13 June. At least one young Gyrfalcon was fledged at each of the 12 nests where eggs were hatched. A total of 38 young birds were fledged--a productivity of 3.2 young/successful nest.

Occupancy during 1974, snow conditions in the eyrie during the winter of 1974-75, utilization of the nest cliff during the winter of 1974-75, and nest success during 1975 were interrelated. Of the nest sites that were not successfully occupied during 1974, either eggs or young birds were produced at four of the eight eyries that were snow-free during the winter, but at none of the eight eyries that were snow-filled during the winter

(Table 4). The preference for snow-free eyries as "new" nest sites (i.e., nest sites that were not successfully occupied during the previous year) was significant (one-tailed Fisher exact test; P = 0.038). Of the nest sites that were successfully occupied in 1974 but that were not disturbed, there was no such preference for snow-free eyries as nest sites. Either eggs or young birds were produced at three of the four eyries that were snow-free in winter and at three of the four eyries that were snow-filled during the winter (Table 4).

During March or April Gyrfalcons were visiting 11 of the 17 nest sites that were frequented during the winter. Gyrfalcons were also found at four additional sites that had shown no sign of activity during the winter. Eggs were laid at only one of these four sites, whereas they were laid at nine of the 11 sites that were frequented during the winter.

Of the nest sites that were not successfully occupied during 1974, eggs were laid or young produced at a significantly higher proportion of the sites (four of eight sites) where birds were present during the winter of 1974-75 than of the sites (none of the 10 sites) where birds were not present during the winter (one-tailed Fisher exact test; P = 0.023) (Table 5). The sample size of sites that were successfully occupied during 1974 and that were not disturbed was, however, too small to permit meaningful statistical assessment of the effects of winter presence on the success of these nests during the succeeding summer (Table 5).

TABLE 4. Nesting Results and Winter Eyrie Conditions.†

	Eyrie Condition in Winter	
	Snow-free	Snow-filled
Nest site not successfully occupied* in 1974		
Produced eggs or young in 1975	4	0
No eggs or young in 1975	4	8
Nest site successfully occupied in 1974 and not disturbed by helicopters or by prolonged human presence during this study		
Produced eggs or young in 1975	3	3
No eggs or young in 1975	1	1

† Eyries had worn away at two of the nest cliffs that were examined. Nest sites that were disturbed during 1974 are not included in this table.

* Successfully occupied -- eggs laid or young raised.

TABLE 5. Nesting Results and Winter Utilization of Nest Cliffs.

	Winter Occurence†	
	Site Frequented	Site Not Frequented
Nest site not successfully occupied* in 1974		
Produced eggs or young in 1975	4	0
Site defended in June 1975 but no eggs or young	0	0
No activity in 1975††	4	10
Nest site successfully occupied in 1974 and not disturbed by helicopters or by prolonged human presence during this study		
Produced eggs or young in 1975	5	1
Site defended in June 1975 but no eggs or young	1	0
No activity in 1975	0	1

† Winter of 1974-1975.

* Successfully occupied -- eggs laid or young raised.

†† Includes some sites where scrapes were formed but that were not defended in June and that showed no evidence either of perching or of kills.

Disturbance by Human Presence

Habituation of Gyrfalcons to humans on foot occurred at both sites (#479 and #508) where a blind was located 300 m from the nest. One pair was observed during egg-laying, the other during incubation. During the first two or three days of observations, each falcon would either flush from its perch or assume a stress posture (if it was incubating) when the observer approached or left the blind. After this initial period each bird would either remain on its perch or, if it was incubating, would continue to incubate in a posture that became increasingly normal with each successive day. Habituation cannot readily be determined at the site (#508) where a blind was located 100 m from the nest site during the brood-rearing stage as this site had been subjected during the incubation period to human presence at a blind located 300 m from the nest.

Disturbance by Helicopters

Responses to Helicopter Overflights

Thirty experimental helicopter flights over Gyrfalcon nests were conducted during the period 25 March to 5 June 1975. These overflights were conducted at 17 Gyrfalcon nest sites. Twelve overflights were conducted during the two weeks prior to egg-laying, 10 during the two weeks of egg-laying, and eight during the five weeks of incubation.

Table 6 presents the results of the experimental overflights that were conducted in 1975 during the nesting period. The 1974 results are also

TABLE 6. Responses of Gyrfalcons at Nest Sites to Helicopter Overflights*, March-June, 1974 and 1975.

YEAR	NEST	STAGE WHEN TESTED	ALTITUDE OF HELICOPTER ABOVE EYRIE (m)	RESPONSE TO HELICOPTER†				
				Undisturbed		Disturbed		
				1	2	3	4	5
1975	139††	Pre-egg-laying**	300		M			
		Pre-egg-laying**	150				M	
		"Incubation"	300		M			
	280††	Pre-egg-laying	365		M			
		Pre-egg-laying	150					M
	415††	Pre-egg-laying	300		F			
		Pre-egg-laying	150					F
	567††	Pre-egg-laying	300		M			
		Pre-egg-laying	150				M	
		"Egg-laying"**	600	M				
		"Egg-laying"**	300				M	
	804	Pre-egg-laying	365	F				
	819	Pre-egg-laying	300				M	
		Pre-egg-laying	600	U				
	893	Egg-laying	150					MF
	896	Egg-laying	365				F	
	915	Egg-laying**	365		F			
		Egg-laying**	150					F
	954††	Pre-egg-laying	365				M	
		"Egg-laying"	365		M			
	281***	Egg-laying	150					MF
	401	Egg-laying	365	U				
	508	Egg-laying	600		MF			
		Incubation	600		MF			
		Incubation	600		F			
	646††	"Incubation"	300				M	
	747	Incubation**	365		F			
		Incubation**	150					F
	975††	"Incubation"	600		M			
	479	Incubation	600	MF				

TABLE 6 (cont'd).

YEAR	NEST	STAGE WHEN TESTED	ALTITUDE OF HELICOPTER ABOVE EYRIE (m)	RESPONSE TO HELICOPTER†				
				Undisturbed		Disturbed		
				1	2	3	4	5
1974†††	567	Pre-egg-laying**	300				M	F
		Pre-egg-laying**	150					MF
	139	Egg-laying**	300		MF			
		Egg-laying**	150			F	M	
	954	Incubation**	300		M			
		Incubation**	150			F	M	
	415	Incubation**	300				M	
		Incubation**	150					M
	280††	Pre-egg-laying**	300		M			
		Pre-egg-laying**	150				M	

* For each nest site tests are listed in the consecutive order in which they were conducted.

† 1 Watched briefly, normal posture.
2 Watched until out of sight, normal posture.
3 Watched, stress posture.
4 Flushed, maintained altitude.
5 Flushed, low weaving flight.

†† Lone bird at nest site.

** Both tests conducted on same day.

*** Nest 281 was outside the study area.

††† From Platt (1975).

M Response of male Gyrfalcon.

F Response of female Gyrfalcon.

U Response of Gyrfalcon of unknown sex.

listed for comparison in Table 6. The five categories of behaviour are those that were used during the 1974 study (Platt, 1975). Because observations of behaviour were not made in 1975 during the several days following the overflights, the 1974 behavioural category "abnormal behaviour after disturbance" was not determined during 1975 and has been omitted from Table 6. On some occasions the behaviour of both Gyrfalcons at a nest was observed; on some occasions only one bird was present or could be observed. It should be noted that some tests were of lone birds (7 males, 1 female) that occupied nest sites. For these birds the terms "egg-laying" and "incubation" have been used to denote the stages that nesting pairs had generally attained at the times that the tests were conducted.

The sample size of helicopter overflights was too small to look simultaneously at the relationships between the altitudes of the overflights, the presence of a lone bird or a pair at a nest, the sexes of the birds, the stages of the nesting cycle, and the intensities of the disturbances.

Both lone birds and pairs appeared to react similarly to helicopter overflights. Of the lone birds that were tested, 47% were disturbed; of the paired birds that were tested, 55% were disturbed. Although the sample sizes are too small for statistical testing, the reactions of lone birds and the reactions of paired birds appeared to differ only for the overflights at an altitude of 300 m. At this altitude none of the four lone birds tested during the pre-egg-laying stage were disturbed but three of the four lone birds tested during the "egg-laying" or "incubation" stages were disturbed. For the paired birds, however, all of the three birds tested at 300 m during the pre-egg-laying stage were disturbed, but none of the three birds tested at this altitude during the egg-laying or incubation stages were disturbed.

Both sexes appeared to react similarly to helicopter overflights. Of the males that were tested, 55% were disturbed; of the females that were tested, 53% were disturbed. Although the sample sizes are quite small, no differences were evident in the reaction of the two sexes for different altitudes of overflights or for different stages of the nesting cycle.

Table 7 shows the number of helicopter disturbances to individual birds during 1974 and 1975 for each stage of the nesting cycle that was tested. The birds appeared to react similarly during each of the three stages. There was an inverse relationship between the percentage of the birds that were disturbed and the altitude of the helicopter above the nest. All of the Gyrfalcons that were tested at an altitude of 150 m during the breeding season were disturbed by the overflights. None of the birds that were tested at an altitude of 600 m showed signs of stress during the overflights.

A significantly greater percentage (100%) of the overflights at an altitude of 150 m caused disturbance than of those at 300 m (43%) (one-tailed Fisher exact test; $P = 0.0003$). The percentage of the overflights at an altitude of 300 m that caused disturbance was also significantly greater than that at 600 m (0%) (one-tailed Fisher exact test; $P = 0.027$).

TABLE 7. Summary of Responses to Helicopter Overflights at Various Stages of the Nesting Cycle, March-June, 1974 and 1975.

STAGE WHEN TESTED	ALTITUDE OF HELICOPTER ABOVE EYRIE (m)			
	150	300	365	600
Pre-egg-laying				
No. of Overflights	7	7	3	1
No. of Disturbances*	7	3	1	0
% Disturbed	100%	43%	33%	0%
Egg-laying				
No. of Overflights	7	3	4	3
No. of Disturbances	7	1	1	0
% Disturbed	100%	33%	25%	0%
Incubation				
No. of Overflights	4	4	1	6
No. of Disturbances	4	2	0	0
% Disturbed	100%	50%	0%	0%
Total				
No. of Overflights	18	14	8	10
No. of Disturbances	18	6	2	0
% Disturbed	100%	43%	25%	0%

*Bird either flushed from perch or assumed stress posture.

Table 8 shows the degree of disturbance to individual birds for each altitude of helicopter overflight during 1974 and 1975. Of the birds that were disturbed by the helicopter overflights, 61% of those tested at 150 m had the most severe disturbance reaction (flushed with low weaving flight) but only 17% of those tested at 300 m had the most severe disturbance reaction. However, this suggested difference in severity of reactions was not statistically significant (one-tailed Fisher exact test; P = 0.077).

Eight overflights of Gyrfalcons perched in the vicinity of six nest sites were conducted during the winter surveys in January and February. The results of these overflights are described in Appendix 2. The birds did not appear to be as disturbed by the helicopter during the winter as they were during the nesting period. They did not flush until the helicopter was approximately 100 m or less from them. Although these Gyrfalcons exhibited stress behaviour when the helicopter passed near them, they often appeared reluctant to flush. This reluctance may have been related to the extreme temperature at the time of the tests (-35° to -40°C).

Three overlights were conducted during January or February of lone Gyrfalcons that were perched on promontories located several kilometres from any nest cliff. These birds showed the least response to helicopters of any of the Gyrfalcons that were tested in either 1974 or 1975. None of the birds exhibited a disturbed reaction when the helicopter passed 100 m above them; they simply watched from normal perched positions.

TABLE 8. Summary of Degree of Disturbance* by Helicopter Overflights, March-June, 1974 and 1975.

REACTION OF GYRFALCON	ALTITUDE OF HELICOPTER ABOVE EYRIE (m)			
	150	300	365	600
1. Watched briefly, normal posture	0	0	2	4
2. Watched until out of sight, normal posture	0	8	4	6
3. Watched, stress posture	2	0	0	0
4. Flushed, maintained altitude	5	5	2	0
5. Flushed, low weaving flight	11	1	0	0

* All stages of the nesting cycle have been combined.

Habituation to Helicopter Disturbance

Three Gyrfalcon nests were each exposed to repeated helicopter flights in order to determine whether the birds habituate to helicopter flights (i.e., show a lessening of the response to helicopters after repeated exposures). Each nest was exposed during a two week period of the nesting cycle to from 6 to 10 helicopter flights at lateral distances of 1.6 to 2.4 km from the nests. The behaviour of the birds was observed during at least the first and last flight past each nest.

Table 9 presents the results of the habituation tests. The number of tests is too small to draw any valid conclusions; the three pairs of Gyrfalcons were disturbed by only two of the 14 flights that were observed.

When the helicopter was in sight, the birds always became alert, although one did so only briefly. They compressed their feathers, watched the aircraft, and sometimes turned on their perches toward the helicopter. In one case a falcon left its perch without displaying the normal intention movements even though the helicopter passed no closer than 1.6 km (laterally) from the nest.

When the helicopter was not in sight but could be heard by the observer and presumably by the Gyrfalcons, the birds did not visibly respond to the sound of the helicopter. They did not change their perches in order to see the source of the noise. This lack of response to sound also occurred at one nest after the young had hatched--an unscheduled helicopter passed out of sight from but within 200 m of a pair of Gyrfalcons at their nest and did not elicit a response from the birds.

TABLE 9. Habituation of Gyrfalcons* to Helicopter Flights Past Nest Sites, April-May 1975.

Nest	Stage when Tested	Flight No.	Lateral Distance from Nest (km)	Response to Helicopter**					
				None	Undisturbed		Disturbed		
				0	1	2	3	4	5
819†	Pre-egg-laying (2-15 April)	1	1.6			x			
		2	1.6						
		3	2.4			x			
		4	2.0						
		5	1.6	x					
		6	1.6			x			
		7	1.6						
		8	1.6						
		9	1.6						
		10	1.6						x
479	Egg-laying (16-29 April)	1	1.6			x			
		2	2.0		x				
		3	1.6						
		4	2.4	x					
		5	1.6	x					
		6	1.6						
		7	1.6			x			
508††	Incubation (14-25 May)	1	1.6			x			
		2	1.6	x					
		3	2.0						
		4	2.4						
		5	2.0				x		
		6	2.4			x			

* Because most birds were not flushed, sexes of birds could rarely be determined. Usually only the bird at the nest was observed.

** 0 Helicopter out of view, no response.
1 Watched briefly, normal posture.
2 Watched until out of sight, normal posture.
3 Watched, stress posture.
4 Flushed, maintained altitude.
5 Flushed, low weaving flight.

† Previously subjected to overflight at 300 m on 25 March (response 4) and to overflight at 600 m on 28 March (response 1).

†† Previously subjected to overflights at 600 m once during egg-laying, once during incubation on 23 April and once on 14 May two hours before first habituation test (all response 2).

Breeding Success of Disturbed Gyrfalcons

Throughout this section data collected in 1974 as well as 1975 are considered.

During 1974 and 1975, Gyrfalcons were disturbed by helicopter overflights at eight nest sites during the period prior to egg-laying. Young were raised at the two such sites where pairs of birds were present. No young were raised at any of the six such sites where only lone birds were observed.

Table 10 shows the nesting success in 1974 and 1975 of each nest site at which eggs were laid and the history of disturbance at each site. Only one nest at which eggs were laid was abandoned after being disturbed. This nest was abandoned five days after being disturbed, probably because of severe weather conditions (Platt, 1975). The pair successfully renested nearby and the two nests are considered as one successful nest in the treatment of the data. Eggs did not hatch at one other nest. Examination of these eggs revealed no sign of embryonic development although the pair was observed to copulate. This pair was tested during the egg-laying stage for habituation to a series of helicopter flights at lateral distances of 1.6 km to 2.4 km from the nest; there was no visible evidence of disturbance during these tests. Because Gyrfalcons commence incubation before the last egg is laid (Platt, unpublished) two disturbances would have been necessary to have chilled all of the eggs before embryonic development had started in any of the eggs. The failure of these eggs to hatch is probably due to a failure of the birds to fertilize the eggs.

TABLE 10. Nesting Success of Disturbed and Undisturbed Gyrfalcons*, 1974 and 1975.

	No. of Nests that did not Raise Young	No. of Nests that Raised Young	No. of Young Produced	Productivity/ Successful Nest
Tested by Helicopter.				
Subjected to Human Presence†				
Disturbed** by Helicopter				
prior to egg-laying		2	7	3.5
first during egg-laying		1	2	2.0
first during incubation		1	4	4.0
Not Disturbed by Helicopter	1	1	3	3.0
Not Subjected to Human Presence†				
Disturbed** by Helicopter				
prior to egg-laying		-	-	-
first during egg-laying		3	7	2.3
first during incubation		2	5	2.5
Not Disturbed by Helicopter		2	8	4.0
Not Tested by Helicopter				
Subjected to Human Presence†		1	4	4.0
Not Subjected to Human Presence†		12††	36	3.3

* For those nest sites where eggs were laid.

† Of a week or more in duration.

** Bird either flushed from perch or assumed stress posture.

†† Number of young not known for one nest.

Young were raised at all of the other nests where eggs were laid. Eleven nest sites where the numbers of young produced are known were subjected neither to helicopter overflights nor to the presence for a period of a week or more of a human on foot at a blind located 300-400 m from the nest. The productivity of these sites was 3.3 young/successful nest. The productivity of the seven nests that were tested by helicopter but not subjected to human presence was 2.9 young/successful nest. The productivity of the five nests that were both tested by helicopter and subjected to human disturbance was 3.2 young/successful nest. The differences among these productivities were not significant (Kruskal-Wallis; $H = 0.4$; $df = 2$; $n = 11, 7, 5$; $P > 0.8$).

It is possible, from Table 10, to examine separately the productivities of nests where disturbed reactions were and were not observed. The productivity of the five nests that were disturbed by helicopter overflights but that were not subjected to human presence was 2.4 young/successful nest. The productivity of the four nests that were both disturbed by helicopter and subjected to human presence was 3.3 young/successful nest. The productivity of the 13 nests that were not subjected to human presence and that were either not tested by helicopter overflights or not disturbed when tested was 3.4 young/successful nest. The differences among these three productivities were also not significant (Kruskal-Wallis; $H = 3.4$; $df = 2$; $n = 13, 6, 4$; $P > 0.1$).

If the factor of human presence is ignored, the difference in productivities between the 12 nests that were not tested by helicopter overflights (3.3 young/successful nest) and the 12 nests that were tested

(3.0 young/successful nest) was not significant (two-tailed Mann-Whitney; U = 61; n = 12, 12; P > 0.1). The difference in productivities between the nine nests where birds were disturbed by the overflights (2.8 young/successful nest) and the 15 nests where the birds were not tested or not disturbed when tested (3.4 young/successful nest) was also not significant (two-tailed Mann-Whitney; U = 45; n = 9, 15; P > 0.1).

If the helicopter tests are ignored and the productivities are compared between the sites where observations were made from a blind for a week or more and the sites that were not subjected to prolonged human presence, then the difference in productivities between the 18 nests that were not subjected to human presence (3.1 young/successful nest) and the six sites that were subjected to human presence (3.3 young/successful nest) was not significant (two-tailed Mann-Whitney; U = 47; n = 18, 6; P > 0.1).

Reoccupancy in Succeeding Year of Disturbed Nest Sites

Of the 13 Gyrfalcon nests that produced young in 1974, four were subjected to two helicopter overflights during the 1974 nesting cycle, one overflight at an altitude of 150 m above the nest and one at 300 m. Birds were disturbed by one or both of the overflights at each nest site. Three of these four nests and one additional nest were subjected to the presence of a human on foot who conducted 7 to 10 days of observations from a blind located 300-400 m from each nest. Three of the five disturbed nests had snow-filled eyries and birds present during the winter of 1974-75; two had snow-free eyries and no evidence of birds present during the winter. Eight of the 13 nests were not disturbed either by helicopter or by the presence of a human on foot; Table 1 gave the observations of snow conditions and falcon presence at these eight nests during the winter of 1974-75.

Table 11 shows the reoccupancy in 1975 of the successful 1974 nest sites. None of the five nest sites that were disturbed during 1974 were reoccupied in 1975 to the stage where the adults produced eggs, but eggs were laid during 1975 at six of the eight nest sites that were subjected neither to helicopter overflights nor to human presence during 1974. The difference in reoccupancy between the disturbed nest sites (0%) and the undisturbed nest sites (75%) is significant (one-tailed Fisher exact test; $P = 0.016$). Because the reoccupancy (to the stage where eggs were laid) of nest sites that were successfully occupied and not disturbed during 1974 appeared to be independent of winter snow conditions at the eyrie and appeared not to be strongly dependent on the occurrence of birds at the site during the winter, and because birds were present during the winter at three of the five successful 1974 sites that were disturbed during 1974, the failure of Gyrfalcons to nest in 1975 at the five nest sites that were disturbed during 1974 appears to be a result of the disturbance that occurred to the birds at these sites during 1974.

TABLE 11. Reoccupancy of Successful 1974 Gyrfalcon Nests.

Status of Successful Nest in 1974	STATUS OF NEST SITE IN 1975 Produced Eggs or Young	Defended in June No Eggs or Young	No Activity*
Disturbed by helicopter† and subjected to human presence††		1	2
Disturbed by helicopter but not subjected to human presence		1	
Not disturbed by helicopter but subjected to human presence			1
Not disturbed by helicopter or subjected to human presence	6	1	1
Total	6	3	4

* Includes some sites where scrapes were formed but that were not defended in June and that showed no evidence either of perching or of kills.

† Bird either flushed from perch or assumed stress posture. (Disturbance to birds occurred in 1974 at all sites where helicopter tests were conducted.)

††Of a week or more in duration.

DISCUSSION

Winter Occurrence in Study Area

Gyrfalcons compete for nest sites with Common Ravens and with the three other raptors that nest on cliffs in the study area--Golden Eagle (*Aquila chrysaetos*), Rough-legged Hawk (*Buteo lagopus*), and Peregrine Falcon (*Falco peregrinus*). Gyrfalcons frequently use nests that have been constructed by ravens or by the other cliff-nesting raptors and cliffs that are known to have been used by Gyrfalcons have later been used by one of the other species (White and Cade, 1971; Platt, unpublished). By spending the winter in the study area adult Gyrfalcons may have an advantage in nest selection over the other cliff-nesting raptors in that they are able to occupy preferred nest sites before the other species have returned in the spring from the south.

Another advantage to Gyrfalcons of wintering in their breeding range is that the birds can commence the breeding cycle during the winter. There is thus sufficient time available to the birds to renest if the eggs are lost during the early stages of incubation. Renesting by Gyrfalcons occurred in the study area on two occasions during 1974 (Platt, 1975).

The results of the winter surveys for potential prey species suggest that raptors that spend the winter in the study area must be capable of consistently killing ptarmigan--the only sufficiently abundant potential prey species. Adult Gyrfalcons have hunting abilities that are well-adapted to the taking of ptarmigan. It is possible, however, that juvenile Gyrfalcons may lack the hunting efficiency necessary for consistently taking ptarmigan. Manniche (1910) and Bird and Bird (1941) reported that lemmings made up the vast majority of the stomach contents of juvenile Gyrfalcons in Greenland during the fall and early winter. (They did not, however, supply any information on relative abundances of prey species).

Most of the Gyrfalcons that winter in southern Canada and the United States are juveniles (Platt, 1976). The present study found that all of the Gyrfalcons that wintered on the study area and whose ages could be determined were adults. The presence of only adult Gyrfalcons in the Arctic during the winter is probably a result of there being both an advantage for the adults to remain (nest site selection and possible renesting) and a disadvantage for the juveniles to remain (difficulty in obtaining food).

It is not known whether Gyrfalcons occur on the study area each winter, but it is expected that they winter on their breeding grounds whenever the numbers of ptarmigan are sufficient to support the birds. (Willow Ptarmigan are at least in part migratory [Irving *et al.*, 1967], but the percentage of the birds that normally leave the Yukon North Slope during the winter is not known nor is the minimum population that over-winters in the study area). Juvenile Gyrfalcons probably disperse to the south during September, October, or November. Figure 1 places the known activities of Gyrfalcons on the Yukon North Slope into a proposed 12 month activity pattern.

Nest Site Selection

There is a considerable degree of relocation of Gyrfalcon nest sites from one year to the next. Thirteen pairs of Gyrfalcons nested on the study area during each of 1974 and 1975. The 26 nests for the two years were located at 20 nest sites. These 20 nest sites were widely-separated and distinct rather than alternate sites within the same territories. Although the number of breeding pairs was the same in both years, seven of the 13 pairs that bred during 1975 did so at nest sites that were not used during 1974. Because the adult birds were not banded, it is not known how many of the birds that nested in 1975 were the same as those that nested in 1974. Some of the birds that nested at new locations in 1975 may have been birds that did not nest in the study area in 1974 or birds that nested for the first time in 1975. Some may have been birds that chose new nest sites in 1975 because of natural factors or because of disturbance at their previous nest sites.

The nest sites where Gyrfalcons nested successfully without disturbance during 1974 appeared to be favoured as nest sites during 1975. The tendency to reoccupy such a site appeared to be independent of the snow conditions at the eyrie. Birds were present during the winter at 75% of these nest sites. These nest sites were probably reoccupied in preference

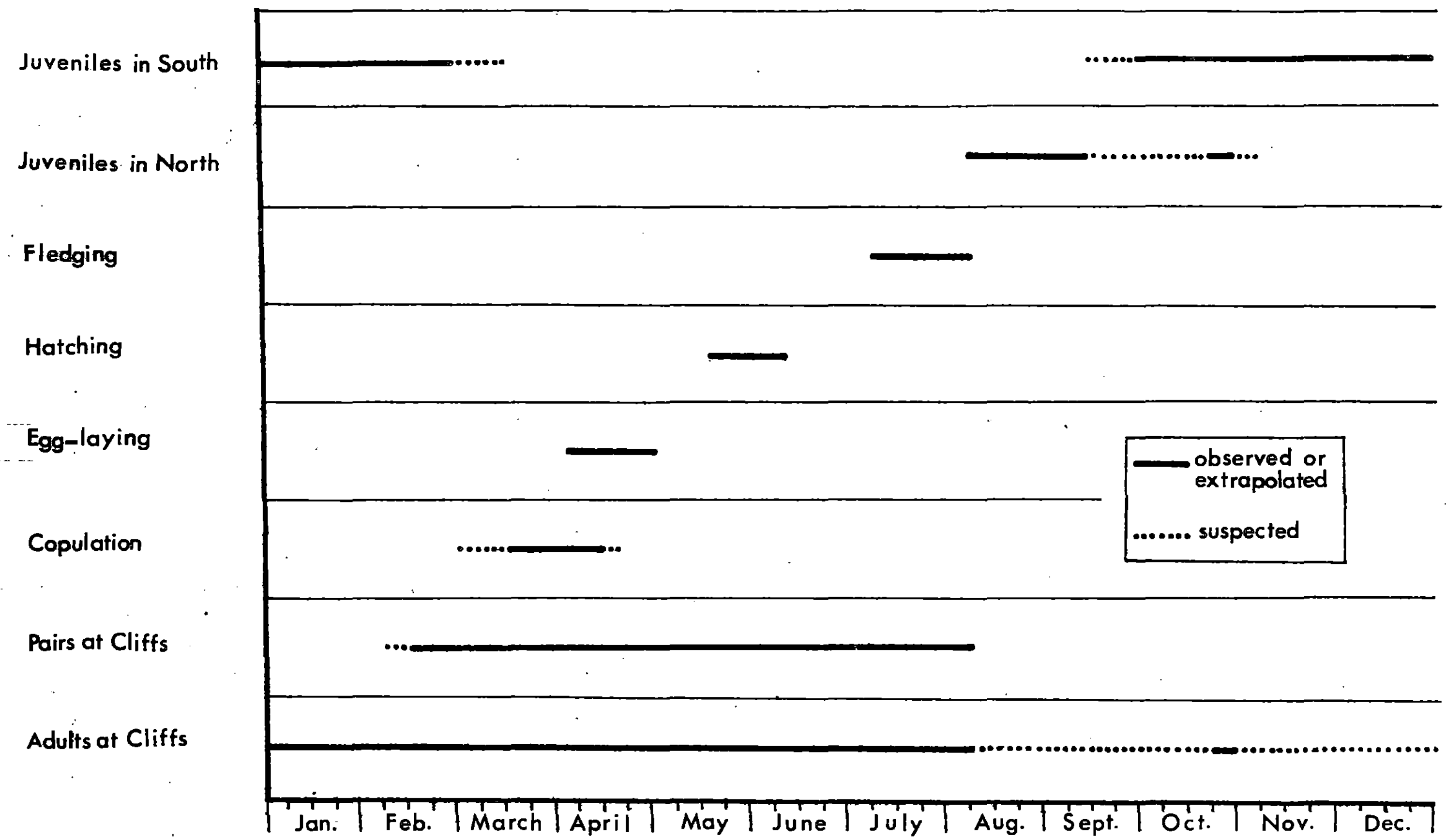

Figure 1. Hypothetical Yearly Activity Pattern for Gyrfalcons on the Yukon North Slope.

to new nest site locations by one or both of the birds that successfully nested at the sites during the previous year. That falcons tend to return to the same nest cliff each year has been documented for Peregrine Falcons by Hall (1955).

Some nest site selection had occurred by February when pairs were found at some of the nest sites. Of the nest sites that were not successfully occupied during 1974, nesting in 1975 occurred at significantly more of the sites that were occupied during the winter of 1974-75 than at the sites that were not occupied during the winter.

Selection of "new" nest sites (sites that were not successfully occupied during the previous year) does not appear to occur in response to the numbers of prey that would be available when the Gyrfalcons raise their young. The prey base that is present during the winter when the site selection occurs is quite different from the prey base that is present during the spring. Migratory birds and hibernating mammals are unavailable during the winter and ptarmigan occur in flocks during winter but as scattered territorial birds during spring.

If selection of "new" nest sites is not attributable to the availability of prey for the raising of young, then it is perhaps due to the acceptability of the nest structure to the birds. Gyrfalcon eyries with a prominent cliff projection over the nest (described by Cade [1960] as a common feature of Gyrfalcon nests in Alaska) were not common on the Yukon

North Slope; approximately two-thirds of the sites did not have such a projection. In the absence of such a projection, the tendency of a nest site to be filled in with snow is dependent upon the orientation of the nest site to the prevailing winds and to the winds associated with winter storms. The birds that occurred during the winter at nest sites where birds did not nest successfully during the previous summer appeared to prefer nest sites with eyries that were snow-free. For these sites nesting (to the stage of egg-laying) occurred only at sites where the eyries were snow-free. These data suggest that nest sites that are open during the winter are preferred as "new" nest sites for egg-laying. It is possible that open nest sites are selected in order to allow the birds to perform the early courtship displays that occur on the nest ledge and that more early displaying by males may be required in order to encourage females to accept "new" sites than is required in order to encourage females to reoccupy previously used nest sites.

Gyrfalcon Numbers

Although the productivity of successfully-breeding pairs of Gyrfalcons on the Yukon North Slope remained high in 1974 and 1975, the number of Gyrfalcons that nested successfully in the study area decreased sharply from 1973 to 1974 and changed little from 1974 to 1975. Table 12 lists the nesting history during the years of 1973, 1974, and 1975 at each of the 34 known Gyrfalcon nest sites in the study area. At least 29 pairs produced young in 1973, at least 13 pairs produced young in 1974, and 12 pairs produced young in 1975. (There would probably have been only one

TABLE 12. Breeding History of Gyrfalcon Nest Sites on Yukon North Slope, 1973 to 1975.

Nest Site	1973*	1974**	1975
210	3 young	3 young	4 young
804	3 young	4 young	4 young
819	3 young	2 young	4 young
896	3 young	3 young	4 young
139	3 young	2 young	Adult, scrape
415	2 young	3 young	Adult, scrape
567	1 young	3 young	Scrape
788	3 young	3 young	Adult, scrape
479	2 young	3 young	4 eggs
954	3 young	4 young	No activity
936	Adult	? young†	3 young
510	3 young	4 young	No activity
893	? young	No activity	2 young
915	2 young	No activity	1 young
508	? young	No activity	3 young
747	4 young	Adult	2 young
280	3 young	Adult	Scrape
782	1 young	2 adults	No activity
925	3 young	2 adults	No activity
708	4 young	2 adults	No activity
646	3 young	No activity	Scrape
975	1 young	No activity	No activity
226	3 young	No activity	No activity
496	4 young	No activity	No activity
870	? young	No activity	No activity
558	4 young	No activity	No activity
579	2 young	No activity	No activity
091	2 young	No activity	No activity
528	No activity	4 young	No activity
860	3 young	?	No activity
296	4 young	?	No activity
401	No activity	2 adults	4 young
942	?	No activity	3 young
871	?	No activity	4 young
Number producing young	29	13	12
Number of nests where number of young known	26	12	12
Number of young at these nests	72	38	38
Productivity per successful nest	2.8	3.2	3.2

* Data from GWS banding records.
** Information collected by Platt during 1974 study.
† At least two young.

or two unknown pairs, if any, that nested successfully in the study area in 1974).

The productivity of successful nests was 3.2 young/successful nest in 1975, 3.2 young/successful nest in 1974, and 2.8 young/successful nest in 1973. The differences in productivities among the three years were not significant (Kruskal-Wallis; $H = 2.6$; $df = 2$; $n = 26, 12, 12$; $P > 0.2$). Table 13 lists the productivities per successful nest for all known North American studies of Gyrfalcons. The average yearly productivity per successful nest for the Yukon North Slope is as high as that for nests in any other area of North America that has been studied.

It is difficult to account for the decrease in the numbers of breeding Gyrfalcons from 1973 to 1974. High mortality during the winter of 1973-1974 might have caused the decrease, but there is no direct evidence of the occurrence of heavy mortality and the cause of such supposed mortality is not known.

Another possible factor is the amount of prey available during the early nesting season, when the Gyrfalcon pairs were forming. If the numbers of ptarmigan available then were not sufficient, there might have been a decrease in the number of pairs of Gyrfalcons that commenced the nesting cycle. Maher (1974) showed that a change in the abundance of rodent prey from one year to the next had a direct effect on the number of rodent-eating jaegers (*Stercorarius* spp.) that nested in an area. For

TABLE 13. Number of Young at Successful North American Gyrfalcon Eyries.

Region	Year	No. of Young	No. of Nests with Known No. of Young	No. of Young per Successful Nest	Source
Seward Peninsula, Alaska	1968	76	28	2.7	D.G. Roseneau[3]
	1969	93	37	2.5	D.G. Roseneau[3]
				Average 2.6	
Colville River, Alaska	1952	12	4	3.0	Cade (1960)
	1956	11	5	2.2	Cade (1960)
	1957	4	3	1.3	Cade (1960)
	1959	24	10	2.4	Cade (1960)
	1967	28	10	2.8	T.J. Cade[1]
	1968	28	10	2.8	T.J. Cade[1]
	1969	26	9	2.9	T.J. Cade[2]
	1971	25	10	2.5	T.J. Cade[1]
	1975	32	12	2.7	T.J. Cade[2]
				Average 2.5	
Colville River Drainage, Alaska	1975	62	25	2.5	T.J. Cade[2]
North Slope, Alaska	1957	7	3	2.3	Cade (1960)
	1958	4	2	2.0	Cade (1960)
				Average 2.2	
North Slope, Yukon	1973	72	26	2.8	CWS[4]
	1974	38	12	3.2	Present study
	1975	38	12	3.2	Present study
				Average 3.1	
Ungava Bay, Québec	1967	8	3	2.7	J.D. Weaver[2]
	1968	6	2	3.0	J.D. Weaver[2]
	1969	6	2	3.0	J.D. Weaver[2]
	1970	12	3	4.0	J.D. Weaver[2]
	1971	4	2	2.0	J.D. Weaver[2]
	1972	15	5	3.0	J.D. Weaver[2]
	1975	7	2	3.5	J.D. Weaver, R.B. Berry[2]
				Average 3.0	
Southwest Greenland	1972	8	3	2.7	Burnham *et al.* (1974)
	1973	10	4	2.5	Burnham *et al.* (1974)
	1974	10	3	3.3	W.A. Burnham[2]
	1975	6	2	3.0	W.A. Burnham[2]
				Average 2.9	

[1] Unpublished annual reports to the Arctic Institute of North America.
[2] Unpublished field notes.
[3] Progress reports to Alaska Department of Fish and Game.
[4] Banding records of CWS.

those Gyrfalcons that did nest, however, the amount of prey available later in the year in both 1974 and 1975 was sufficient to maintain a high average production of young from the successful nests. Ground squirrels out of hibernation and migrant birds could have augmented the Gyrfalcon prey base sufficiently to maintain this high productivity. There was no evidence at any of the nest sites of starvation (as has been recorded in Alaska [Cade, 1960]).

If low numbers of available prey during late winter account for the low numbers of nesting Gyrfalcons in 1974 and 1975 in comparison with 1973, then it would be expected that many non-nesting birds would be present in the study area. There was little evidence of the presence of such birds in the study area. Lone birds at nest sites would only account for a small fraction of these birds. The majority of the birds that did not nest may have emigrated from the study area to areas where sufficient prey was available.

Effects of Disturbance

Platt (1975) discussed the possible effects that disturbance may have on nesting Gyrfalcons. The present study has documented the importance of winter occupancy for successful nesting to occur at "new" nest sites. Disturbance during the winter or during the early stages of the nesting cycle in February and early March when the pair bond is being formed could influence the nesting success. As the nesting cycle progresses, the attachment of a pair of Gyrfalcons to a nest site appears to increase and the birds are probably less likely to abandon a nest site because of disturbance. However, disturbance may also be critical during the incubation period. Hunter *et al.* (1976) have shown that there is an apparent increase in embryo sensitivity to interruption of incubation in the eggs of Ring-billed Gull (*Larus delawarensis*) as the embryos become older. Interruption of incubation due to disturbance of nesting Gyrfalcons could prove fatal to the embryos through exposure to the temperatures that prevail at the time of incubation (well below 0°C).

Disturbance experiments on raptors (especially aircraft disturbance) are difficult and expensive to conduct. (For logistical reasons only helicopter disturbance experiments were conducted during this study.) The only practical measures of disturbance are behavioural changes that are visible from a distance. Sample sizes for disturbance tests are small and the results are often only suggestive rather than conclusive. The results of individual tests have been reported in detail in this report--whether or not the tests have been conclusive or have suggested trends--in order that future workers may utilize these results in conjunction with their own work to better understand the effects of disturbance to nesting Gyrfalcons.

A possible source of error in the interpretation of the effects of disturbance results from the fact that the nests could not be continuously monitored. Disturbance may have occurred at nests when the observer was not present and hence nests that are considered undisturbed in this study may in fact have been disturbed. Because nest sites occurred in comparatively isolated locations and because no nest sites were located near known sources of disturbance, unknown disturbance probably occurred at most at one or two sites.

In the present study Gyrfalcons showed evidence of habituation to the presence of a human on foot when he approached or departed from a blind located at least 300 m from the nest. This habituation occurred over a period of several days. Closer approach on foot during the early stages of the nesting cycle could result in greater disturbance to the birds.

Because of the small sample sizes the results of helicopter overflight disturbance tests have necessarily been pooled. The results have, for the most part, been assessed only as to whether or not the birds were disturbed and not as to the degree of disturbance. Data from both years have been pooled, as have data from paired and lone birds, data from both sexes, and data from the various stages of the nesting cycle. There did not appear to be any marked differences in reactions to helicopter overflights between the years, between the sexes, or among the various stages of the nesting cycle. The only apparent difference was in the reactions of paired and lone birds at different stages of the nesting cycle; this apparent difference occurred only for helicopter overflights at an altitude of 300 m.

The amount of disturbance to nesting Gyrfalcons by helicopter overflights decreased markedly with increased altitude of the helicopter above the nest site. Nesting Gyrfalcons were invariably disturbed by helicopters that passed at an altitude of 150 m above the nest site. Birds were frequently disturbed by overflights at an altitude of 300 m, but significantly less frequently, and possibly less severely than by overflights at 150 m. There was no visible disturbance to nesting Gyrfalcons by helicopters that passed above the nest sites at an altitude of 600 m.

The data concerning the lateral distances at which Gyrfalcons are disturbed and their habituation to such disturbance are inconclusive. Nesting Gyrfalcons may be disturbed by a helicopter that passes the nest site at a lateral distance of 2 km if the helicopter can be seen from the nest. But a helicopter that could not be seen from the nest has been observed to pass within 200 m of a nest without eliciting a response from the birds. Because Gyrfalcons nest on cliffs, they are much more susceptible to disturbance from some directions than they are from others. A source of potential disturbance may closely approach a nest from some directions without disturbing the birds because it can be neither heard nor seen from the nest. However, if the source of potential disturbance comes into view of the nest on such a close approach, the disturbance to the nesting Gyrfalcons may be severe.

The effects that disturbance has on nesting Gyrfalcons should be assessed according to the following criteria (Platt, 1975):

1) whether the birds abandon the nest site,

2) whether the productivity of the nesting birds is affected, and

3) whether the nest site is successfully reoccupied during the following nesting season.

Because of the small sample sizes and because many of the birds were subjected both to helicopter overflights and to human presence, it is difficult to assess separately the effects of the two types of disturbance.

Abandonment of a nest site prior to egg-laying is difficult to determine. Neither of the two sites where pairs of Gyrfalcons were disturbed by helicopter overflights prior to egg-laying were abandoned; the birds laid eggs at both sites. But no eggs were laid at any of the six sites where only single birds were observed (a second bird may have been present but was not observed) and where these birds were disturbed by helicopter overflights during the pre-egg-laying period of the nesting cycle. The reasons for the failures to nest at these sites could not be determined; they cannot necessarily be attributed to disturbance. The presence of unmated birds at nest sites is a common phenomenon in falcons (Cade, 1960; Roseneau, 1972) and the unmated birds probably failed to attract a mate for reasons other than helicopter disturbance.

Once eggs had been laid no nest was abandoned as a consequence of disturbance either from helicopter overflights or from human presence. Only one nest was abandoned--apparently because of the severe weather conditions--and the birds renested nearby. The failure of the Gyrfalcons at another nest site to hatch their eggs probably resulted from a failure of the birds to fertilize the eggs. Young were raised at all of the other disturbed sites where eggs were laid.

There was no significant difference in the productivities of successful Gyrfalcon nests between those nests that were disturbed by helicopter overflights and those that were not disturbed. Helicopter disturbance has also been shown not to affect the nesting success of Bald Eagles (*Haliaeetus leucocephalus*) and Peregrine Falcons (White and Sherrod, 1973).

Although some relocation of nest sites is a natural phenomenon in Gyrfalcons (see Roseneau, 1972), Gyrfalcons in 1975 successfully reoccupied significantly more of the nests that were successful and undisturbed in 1974 than of those that were successful and disturbed during 1974. None of the five nest sites that were successful but disturbed in 1974 were successfully reoccupied during 1975. This failure of disturbed birds to reoccupy a nest site during the following year does not appear to result from winter conditions at the nest site. From the 1975 data it appears to be due to the disturbance that the birds were subjected to during the previous nesting season, but data collected in 1976 suggest that disturbance is possibly not the cause (see Supplement).

Disturbance to nesting Gyrfalcons thus does not appear to affect their nesting success during the year of the disturbance. But it may possibly cause the birds to choose a new nest site location during the year following the disturbance or perhaps not to nest at all. (The

1975 activities of the specific falcons that were disturbed during 1974 are unknown). Natural selection probably ensures that nest sites are selected so as to best benefit the species. Relocation of nest sites as a consequence of unnatural causes such as disturbance is more likely to decrease than to increase the probability of successful reproduction. (No such decrease, however, was evident between 1974 and 1975). Relocation of nest sites as a result of disturbance to nesting Gyrfalcons would thus be a serious consequence.

In the studies of 1974 and 1975, Gyrfalcons have been subjected to disturbance at a comparatively low frequency. No more than two helicopter overflights were conducted at any nest during any stage of the nesting cycle; at most one of these overflights was conducted at the low altitude of 150 m above the nest. No nest was subjected to more than four overflights during the entire nesting cycle (although three nests were subjected to additional flights past the nest sites at lateral distances of from 1.6 km to 2.4 km). Prolonged human presence at a site before the eggs had hatched was restricted to going to and from a blind located at least 300 m from the nest. The nests were visited only to band the young at a time when the young were almost ready to fledge--a time when the bond of the adults to the nest and young is probably strongest. Disturbance to nesting Gyrfalcons at higher intensity as a result of increased aircraft traffic, of increased human presence, or of human presence closer to the nests could possibly result in reduced nesting success or in abandonment of nests.

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A P P E N D I C E S

APPENDIX 1. Observations of Nesting Behaviour.

Extended observations of the behaviour of pairs of nesting Gyrfalcons were made from a blind at selected nest sites.

Pre-egg-laying Stage

An occupied Gyrfalcon nest site (#819) was observed for 49 hours during a 12-day period that began 26 days before the birds laid their first egg.

Although both falcons would occasionally leave the area either separately or together, one falcon was usually at the nest cliff during the observation periods. When both were present they generally perched within 30 m of each other but no closer to each other than 2 m. The birds often spent as much as five hours at one time simply perched on an outcrop together. When strong winds accompanied severe temperatures (below -18°C), they perched on the leeward face of a cliff--the only time they were seen to use this perch.

Fifteen copulations were seen during the period of observation at this site; the first occurred during the first day of observation. A sixteenth copulation was observed during an earlier visit to the site 29 days before egg-laying. The approach of the male or his shifting on his perch preceded the assumption by the female of a copulation soliciting posture. In this posture, the female leaned forward with her beak pointed down, her back horizontal, and her tail raised until level with the back.

As the male approached, the female leaned further forward, lowering her head and raising her tail. The male flew directly to the female and then, while hovering less than 0.5 m above her back, positioned himself so as to face the same direction as the female. The male then landed on the lower back of the female. He continued flapping while standing on his tarsi with his tail pointed straight down. The female's tail was turned to the side and twisted, thereby making her cloaca accessible to the cloaca of the male. Coition lasted from 4 to 12 seconds. The male usually flew directly from the back of the female to a distant perch, but on occasion he fluttered to a perch within 1 m of the female. Twice the female was seen to assume the copulation posture at the approach of the male only to have him land on a perch near her.

Nine of the 14 observed copulations were either immediately preceded or followed by a visit to the eyrie by one of the birds. On four occasions the male flew from the eyrie to the female and copulation occurred. On another four occasions he flew directly from a copulation to the eyrie; on one of these occasions, however, he did not land but only passed close to the ledge. On one occasion the female visited the eyrie immediately after copulation.

Three types of nest ledge activity were observed prior to egg-laying. The most common was a *Visit* in which the bird either stood in a normal perch position on the edge of the eyrie or walked into the eyrie and stood upright. *Visits* ranged from 1 to 21 minutes in length.

In the second type of nest ledge activity, the *Individual Ledge Display*, the falcon walked slowly into the eyrie in a low horizontal position, with its beak almost touching the nest surface and with its tail relaxed. The bird began a continuous "chup" vocalization and it either remained stationary or turned slowly on the ledge. The male performed the *Individual Ledge Display* more often than did the female. Scraping by either sex followed this display. The bird rested the upper portion of its breast on the substrate and thrust its feet backwards, thereby pushing away the surface material. This motion formed a depression, the scrape, which eventually held the eggs. After a series of scraping motions the falcon often faced in a different direction and resumed scraping.

The third and most complex nest ledge activity was a *Mutual Ledge Display*. It occurred when the female arrived at the nest while the male was performing an *Individual Ledge Display*. Both adults stood and faced each other over the scrape in the same horizontal position that was used in the *Individual Ledge Displays*. Both birds gave a faster series of the same "chup" call. After about a minute of *Mutual Ledge Display*, the male consistently left the eyrie, but the female often remained and began scraping.

In captivity during the period prior to egg-laying, females followed males around the breeding chambers begging food from them (Platt, unpublished). Although the male was not seen to supply food to the female in the present study, she was observed on the nest cliff to eat prey which may have been supplied by the male. On three occasions the female was observed to follow the male out of the nesting area. On one of these occasions she followed him to three different perches as the birds flew up the river. These occurrences may correspond to the following and begging that was observed for captive females.

Three aerial manoeuvres were observed that are believed to be courtship flight displays. The most common was the *Undulation-roll*. While in level flight at moderate speed the male Gyrfalcon began a brief glide with the wings extended. The body was then rotated laterally (wing-over-wing) about 20° for one second, then rotated about 180° in the opposite direction. When it had half completed this second rotation (roll) the falcon began a steep dive. The dive became vertical with the ventral surface of the bird facing in the original direction of flight. This position was held as the falcon dived for 30 to 50 m; the wings were then returned to their original orientation by rotating them in the opposite direction from the original 180° roll. Once the bird had returned to the normal flight position, it terminated the dive. The momentum from the dive then carried the bird upward at a steep angle. When the bird had reached the original elevation from which it had begun the dive, it sometimes began the sequence again.

The *Undulation-roll* was often accompanied by other flight displays and was usually performed in sets of two undulations, although sets of three undulations were occasionally seen.

Variations often occurred in the execution of the *Undulation-roll*. If a second undulation was performed, the initial 20° roll was deleted and the bird rotated laterally 180° as it levelled off at the top of the climb from the first undulation. This oriented the dorsal surface downward when the falcon was horizontal. The lack of air speed may have accounted for the deletion of the partial roll preceding the 180° roll.

A second variation also occurred between undulations; in this variation, rather than rolling laterally to begin the second undulation, the falcon sometimes began the dive by pitching backwards while flying vertically upwards. In this manner it performed an inside loop.

The second type of courtship display was the *Roll* when executed apart from the undulation phase of the display. While in long dives at angles between 30° and 60°, the male falcon often rolled laterally and oriented its dorsal surface to the ground. As in the initial undulation of the *Undulation-roll*, a partial roll of about 20° in one direction preceded a 180° roll in the other direction. The position with the dorsum down was maintained for one to two seconds; the roll was then reversed and the dive continued in the normal flight position. The bird was not seen to repeat this display in a series.

The male was once seen to execute the *Roll* in level flight. This Roll occurred as the falcon passed within a few metres of the nest ledge after having levelled off from a long dive. It differed from the rolls that were usually performed in that the inverted position during the horizontal flight was maintained for three to four seconds and the wings were held close to the body. These differences may have been due to the occurrence of strong winds that provided the necessary air speed for this variation.

During courtship displays by the male, the female occasionally soared above the nest cliff. A *Mutual Floating Display* was twice performed when the male positioned himself 2 or 3 m above the female and both birds began a slow descent at about a 20° angle. Both birds had their wings partially closed and held slightly above their backs; the legs were extended down and the tails were spread. The distance between the birds was kept fairly constant during the 10 to 13 second period of floating. A gutteral "graak, grak, grak, ..." call was given by the male during the display; this was the same call that was given by either sex when intruding raptors were chased from the nesting area. After one of the floating displays when the pair had drifted apart, the male dived as if to strike the female and passed within 1 m of her.

Egg-laying Stage

A pair of Gyrfalcons (#479) was observed during the egg-laying stage. More than 74 hours of observations were made of their behaviour during a 10-day period. The female laid the first egg on the third day of observation and laid the fourth (and last) egg seven days later. Observations continued for four days after the clutch had been completed.

Copulation was observed on the day before the first egg was laid, during the eight days of egg-laying, and on the day after the last egg was laid. Unlike the pair of Gyrfalcons observed earlier in the nesting cycle, this pair did not copulate in association with visits to the nest. Nest ledge activity prior to egg-laying was limited to *Visits* to the eyrie and *Individual Ledge Displays* with scraping. The latter display was somewhat modified by the female; in addition to scraping she rocked from side to side and forward and backward in the scrape. She also remained lying quietly in the scrape for periods of 30 to 50 minutes. Prior to egg-laying, the female's breast was heavily stained from scraping; the male showed only slight staining.

Scraping ceased after the female had laid the first egg; the staining faded thereafter. Subsequent eggs were laid about 60 hours apart. The first egg was left uncovered for periods of over one hour at -9°C ambient temperature. Four minute exposures were not uncommon until the third egg had been laid; after that time the exchange of incubation duties was accomplished in about two minutes.

Incubation Stage

The same pair of Gyrfalcons (#479) was observed for 30 hours during the four days following the completion of the clutch of eggs and for 44 hours during six days late in the incubation period. A second pair (#508) was observed for 83 hours during 10 days in the middle of the incubation period. Both pairs had begun egg-laying in the third week of April and both had clutches of four eggs.

The duration of incubation was noted at one nest; it required 35 days from the laying of the last (fourth) egg. This is the same time required for incubation as that for six clutches of Gyrfalcon eggs that were laid in captivity and then artificially incubated after seven days of natural incubation (Platt, unpublished). Through back-dating from the ages of the young birds when they were banded and from observations of the adult activities during visits to the nest sites, the duration of incubation at three additional nests on the Yukon North Slope was estimated to have been 35 or 36 days.

Only the female Gyrfalcons were observed to have been incubating at the onset of darkness and at the onset of dawn; they are believed to have incubated throughout the night. Males incubated during the morning and late afternoon while the females fed on prey brought to them by the males. Early afternoon incubation by the male was observed, but it was not associated with feeding by the female.

The majority of incubation was performed by the female Gyrfalcons. The periods of incubation by the females during daylight hours were significantly greater than those of the males (one-tailed Mann-Whitney; $U = 18$; $n = 10, 9$; $P < 0.025$); they averaged nearly twice as long as those of the males (Table 14).

Maestrelli and Wiemeyer (1975) reported the same incubation disparity in captive breeding Bald Eagles (*Haliaeetus leucocephalus*). Enderson *et al.*

TABLE 14. Observed Length* of Daytime Incubation Periods†.

	Males		Females	
	Entirely timed	Began before observer arrived	Entirely timed	Began before observer arrived
	192	200	200	132
	253	134	183	130
	175	120	89	158
	89	104	192	109
	141	312	126	252
	71		585	155
	112		346	122
	90		410	611
	138		215	190
			260	245
				132
				345
				177
average duration	140.1	174.0	260.6	212.2
	±58.4	±85.3	±148.6	±137.1

* In minutes.

† Measurements were made at two Gyrfalcon nest sites.

(1972) reported an incubation pattern for Peregrine Falcons that is similar in three ways to that observed in Gyrfalcons--only the female Peregrine Falcon incubated at night, the female incubated during the day for periods that were twice as long as those of the male, and the duration of incubation periods by the male decreased during the month of incubation.

When a male returned from a hunting foray he would enter the nesting area carrying the prey item in his feet. He would give a fast wailing call which began when he was more than 1.5 km from the nest cliff and continued until he arrived in the nest area. At the nest cliff the male would land on a perch and the female would leave the nest to obtain the food that he had brought. The perched male would stop wailing and begin a series of "chup" calls that increased in intensity as the female approached. The female would land next to the male and move quickly to take the food with her foot and beak. She would utter a loud, very fast series of "chup" calls during her approach and during the taking of the food. The male usually remained within 1 m of the female for up to a minute, then would fly directly to the nest and begin to incubate. Both nests had a specific location where the transfers of food usually occurred; these locations were marked by abundant prey remains. Two transfers of food occurred at the nest; in both cases the female immediately left the nest with the prey item.

The females at both nests were frequently observed to cache uneaten portions of prey items during the incubation period. Once a female had apparently satisfied her hunger, she would fly with the uneaten portion in her talons to a location that was repeatedly used as a cache site. There she would walk with the item in her beak, putting it down and picking it up as many as eight times. This procedure would be repeated at three or four places within an area of approximately 1 m^2. None of the cache sites were protected against mammalian depredation nor was the food in any way concealed. Only the females were observed to remove food from the caches.

After the female had fed, groomed, and perched quietly for a period of time, she would return to the eyrie and the male would leave immediately.

On six occasions a male was observed to land at the nest without carrying food while the female was incubating. These occasions took place during the week after egg-laying. They were preceded by the male making a wailing call while he perched near the nest or while he flew slowly past the nest. On two occasions the female left as the male arrived and the male began to incubate the eggs. On three occasions the male landed at the nest but the female did not permit him to incubate the eggs. Instead, she adopted a low posture with the neck outstretched and gave a series of agonistic four to five syllable "Chuh-uh-uh-uh" calls. The male then left the nest. On the sixth occasion for a period of two hours the male uttered wailing calls from several perches and flew repeatedly past the nest. He then landed on the nest, but instead of waiting for the female to rise from the eggs, he moved into the small space between the female and the back wall of the cliff and crowded the female off the eggs. This male did not show such "eagerness" to incubate during the later phases of the nesting cycle. In fact the length of the incubation period of the males appeared to decrease as the season progressed.

No differences were apparent between the two pairs of Gyrfalcons in their postures and activity patterns at the nests. When a bird arrived on the nest ledge it paused briefly, then walked in a nearly horizontal position towards the eggs. Once it reached the scrape, the steps taken were very slow. The feet were raised higher than usual and the toes were loosely clenched. The falcon moved over the eggs and carefully worked the feet between them; it then lowered its body onto the eggs. As it settled, two movements were made, apparently to bring the eggs in contact with the skin of the brood patch rather than with the feathers. One movement was a rocking motion from side to side; the feet were shifted forward and under the eggs in the same motion. The second movement was a sudden jerking back of the head with the beak pointed downwards. This "head throw" was usually repeated three or four times. It was also frequently performed while the bird stood prior to entering the nest scrape. At irregular times during incubation periods an incubating bird would perform one or both of the settling movements; a turn of approximately 90° would often accompany these movements. At both nests where observations were made the scrape was placed so close to the back wall of the ledge that a bird could not incubate while facing outward because its tail would strike the wall. The placement of the scrape against the back wall probably provided the greatest amount of protection from the weather.

All of the incubating birds participated in "rimming" the nest. To do so the bird extended the beak outward, dragged it through the substrate, and picked up pieces of debris which were then dropped closer to the bird. In this manner, a ridge was formed around the nest; this ridge was surrounded by an area clear of debris. These features were not found at scrapes where incubation had not occurred. Incubating adults were observed to become very involved in biting bits of debris and in reaching out to secure distant pieces of debris. On approximately 12 occasions an incubating bird continued to move forward to pick up debris until it had moved completely out of the nest scrape; in so doing it left the eggs uncovered for several seconds.

Incubating birds were commonly observed to sleep during the daylight period. Usually the bird simply rested its beak on the nest substrate after it had closed its eyes; in this position a bird would sleep for only a short period. But an incubating bird would also frequently place its beak on its back; in this position it would sleep for over 15 minutes.

Excretion from the nest ledge was observed to occur only twice during the 20 days of observations of incubation. On both occasions the female had been on the nest for more than five hours.

Each bird preened intensively at the end of each incubation period.

Male and female Gyrfalcons differed in their activities when they were not incubating. Males brought in all of the food that was consumed by the female. Females were not seen to fly out of the nest area; males did so several times each day. The females fed exclusively in the nest cliff area; the males were only occasionally seen to feed in the nest cliff area on items that had been left (but not cached) by the female. Much of the prey that was brought to the female was already partially eaten, and the male often had a distended crop upon arrival.

Both the male and the female Gyrfalcons were observed to bathe and to drink in pools of runoff water on top of the still-frozen rivers and in pools on the tundra. A male Gyrfalcon was seen to dust-bathe on two successive days at the same location and at the same time (late afternoon). The site used was at the top of a steep, south-facing bank that was free of vegetation. Both occurrences of dust-bathing closely resembled the movements of normal water-bathing except that the bird began by scratching the soil with its feet. While it faced uphill, the bird dropped to its breast and began to pump its pelvic region into the dirt. The wings were vigorously shuffled in and out from the body and the falcon tilted from side to side by alternately lowering each shoulder. The beak was often lowered to the ground; it could not be determined whether this lowering of the head was an attempt to immerse the head as is done in water-bathing. After a minute of intense bathing the falcon had travelled tail-first about 1 m down the slope. It then walked up the slope, scratched the earth, and began the process again. Dust-bathing on both days lasted about four minutes; it was followed by extensive preening.

Falcons that were not incubating often slept on the usual perches. To do so they simply closed their eyes while in a normal relaxed posture or they placed the beak in the middle of the back under the scapular feathers. They did not move to a protected "roost" type of perch before they slept.

Post-hatching Stage

A nest that contained three young Gyrfalcons (#508) was observed for 166 hours on 13 days during the first three weeks after the eggs had hatched.

The female performed all of the feedings that were observed; she used food supplied by the male as well as her own kills. (The male at a nest observed in the 1974 study fed the young about 50% of their meals [Platt, unpublished]). The food transfers from the male to the female occurred either at a perch or at the nest. The female always began a stereotyped begging response when the male entered the area with food. She crouched on the perch with the body feathers puffed out and the wings partially extended; she would often flap her wings. In this posture she would give a repeated single note call similar to that given by the young when they begged for food. The female occasionally flew toward the approaching male; when she did so her wing beats were shallow and she held her tail slightly fanned and pointed downward. Such flights were accompanied by the begging vocalization. When she received the prey on a perch she would carry it to the nest and then feed the young. If the male landed at the nest with the food, the female would fly to him and take the food; the male would then immediately leave the nest.

On seven occasions the female falcon was observed to remove food from the nest and to cache it. She was observed to retrieve cached food and to feed it to the young on five occasions. One cached item was retrieved five hours after it had been cached; a second was retrieved eight hours after it had been cached. The male was not observed to cache any food.

When the young were nine days old the female left the nest area for the first time since the hatching of the eggs. She was away from the nest area for about two hours. Each day thereafter she was away from the nest area for two to three hours per day. These absences ended in her return to the nest with food. It is not known whether she captured the prey herself or obtained it from the male when out of view of the observer. However, when the young were 14 days old, the female returned carrying a ground squirrel at a time when the male was already at the nest with a ptarmigan. During the next two weeks the female gradually increased the time that she was away from the nest site by making two or three presumed hunting forays per 24 hour day. During the period of observation, however, the time that the female was away from the nest area was never as great as that of the male.

When in the nest area the female either perched at one of two perch points that were located 100 m downriver from the nest, or she brooded the young. Only the female was observed to brood the young; her periods of brooding (those that were completely timed) averaged 43 minutes and ranged from 17 minutes to 70 minutes in length. Four incomplete brooding periods of 118, 111, 100, and 100 minutes were also observed. Brooding was generally performed immediately after feeding, but during a heavy rain the female flew to the nest and brooded until the shower had abated. Brooding was not observed even during rain showers once the young were 10 days old.

On 32 occasions measurements were made of the elapsed time from the time when an adult Gyrfalcon left the nest area until it returned with food. On 11 occasions Gyrfalcons returned with ptarmigan; the average duration of each such hunt was 188 minutes (standard deviation $\pm$ 89 minutes). On 15 occasions Gyrfalcons returned with mammalian prey; the average duration of each such hunt was 131 $\pm$ 94 minutes. On six occasions Gyrfalcons returned with small birds; the average duration of each such hunt was 129 $\pm$ 90 minutes. The durations of the ptarmigan hunts did not differ significantly from the durations of the mammal hunts (two-tailed Mann-Whitney; $U = 50.5$; $n = 11, 15$; $P > 0.1$).

Adult Gyrfalcons were observed to bring 54 food items to the nest during the 166 hours of observation (Table 15)--an average of one feeding

TABLE 15. Prey Items Fed to Young Gyrfalcons, 11-27 June 1975.

	Number of individuals	% of total items	Number known supplied by male	% of items known supplied by male
Ptarmigan[1]	21	39%	10	47%
Arctic Ground Squirrel[2]	14	26%	4	28%
Passerine bird	7	13%	6	86%
Microtine rodent	6	11%	5	83%
Small and undetermined[3]	4	7%	3	76%
Small sandpiper	2	4%	1	50%
	54	100%	29	

[1] All adult birds.

[2] Often less than fully grown.

[3] Passerines or microtines.

every 184 minutes. The longest observed period between feedings was 508 minutes. Ptarmigan were the most common prey and represented the greatest contribution in biomass to the young birds. The biomass of prey brought to the young was estimated to be composed of more than 90% ptarmigan and ground squirrels. This preponderance of ptarmigan and ground squirrels in the diet of Gyrfalcons was also reported by Hagen (1952), Cade (1960), Dementiev (1960), and Roseneau (1972).

Storer (1966) predicted that during the breeding season a male raptor would contribute a greater proportion of smaller prey items to the young than would the female. The male Gyrfalcon observed during June contributed more items than the female that were smaller than a ground squirrel or a ptarmigan, and the female may have contributed more ground squirrels and ptarmigan than the male (Table 14). (Because food brought to the nest by the female may have been given her by the male beyond the range of view of the observer, all of the percentages that express the male contribution to the amount of prey killed are necessarily minimal).

Defence of Territory

Only eight instances of territorial defence against intruding birds were observed in 1975 (as compared to 25 in 1974 [Platt, 1975]). Golden Eagles, Common Ravens and a Gyrfalcon were attacked. As in 1974 Golden Eagles were chased vigorously; in one case an immature eagle was forced to land on the ground 400 m from a Gyrfalcon nest and was then struck repeatedly by both adult Gyrfalcons.

Two of the 1975 observations were of particular interest. The first occurred two weeks before the first egg was laid at a nest site. A pair of Gyrfalcons allowed two ravens to fly within 70 m of them and to land 30 m from the Gyrfalcon nest. Only when the ravens had landed did the falcons protest their presence by flying toward the intruders. The ravens then took flight and the falcons did not pursue them. This tolerance of ravens was not seen to occur once the eggs were laid.

The other observation of particular interest involved an intrusion by a male Gyrfalcon. Both adults chased it. The female stopped chasing it after 100 m; but her mate continued the chase. He overtook the intruder and dived at him twice; in so doing he forced the intruder to roll over onto his back and to present his feet to the resident bird in order to ward off the attack. The chase was lost from view more than 500 m from the nest site. This was the only observation of an intrusion by a third Gyrfalcon.

Platt (1975) reported that the average distance from the nest at which Gyrfalcons would stop chasing intruding raptors or ravens was 516 m. With the exception of the above-mentioned conspecific encounter, Gyrfalcons in 1975 discontinued all territorial attacks within 500 m of their nest sites.

Gyrfalcons were also observed to attack a red fox (*Vulpes vulpes*) and a wolverine (*Gulo gulo*). These two attacks occurred at the same nest site--located under an overhang 30 m from the top of the cliff where it was inaccessible to mammalian predators. A female Gyrfalcon struck the wolverine repeatedly as she chased it from the top of the nest cliff to a point 250 m away from the nest. The fox was moving upriver on the opposite side of the river from the nest; both Gyrfalcons screamed at the fox and dived at it briefly as it passed in front of the eyrie.

Two instances in which the Gyrfalcons did not attack an intruding mammal were also observed at the same nest site. A timber wolf (*Canis lupus*) and later a porcupine (*Erethizon dorsatum*) walked above the nest along the same route that the wolverine had taken. Neither was attacked even though both falcons observed each of the mammals.

APPENDIX 2. Winter Overflights by Helicopter of Gyrfalcons at Nest Sites.

Nest #210 is located on a cliff along a small creek. On 17 January 1975, as the helicopter flew up the creek, a perched Gyrfalcon was sighted 200 m from the helicopter and approximately 50 m from the nest ledge. The helicopter passed approximately 100 m from the bird and 75 m above the level of the bird. The Gyrfalcon, a female, assumed a very alert perched position and then flushed without intention movements as the helicopter passed by her. She flew in a low weaving manner away from the helicopter and the nest site.

On 21 January the helicopter flew 300 m in front of and slightly above nest cliff #975. A male Gyrfalcon flushed as the helicopter passed approximately 40 m from his perch located in a crevice. He was unable to see the helicopter until the moment that he flushed. His flight was low and weaving away from the helicopter.

At site #747 a roost is located 300 m above the valley floor in a deep crevice in a rock outcropping. On 19 February the helicopter approached the roost from below. When it was 100 m from the roost, a male Gyrfalcon flushed from the roost and flew in a low weaving manner away from the helicopter.

On 19 February a pair of Gyrfalcons flushed from the face of a cliff near site #804 as the helicopter passed at about 100 m over the cliff from behind it. Their flight was low and weaving away from the helicopter.

On 19 February a male Gyrfalcon flushed from nest cliff #925 as the helicopter flew 30 m in front of, and just above, the cliff. The falcon flushed 100 m in front of the helicopter and flew away in a low weaving manner.

Two days later the helicopter flew over the same nest cliff at 150 m. Although unseen by the observers, a male Gyrfalcon was present and did not flush. The helicopter then approached the cliff at the level of the eyrie and the falcon flushed approximately 100 m in front of the aircraft.

On 20 February the helicopter approached nest #508 which is located in a deep twisting canyon. A pair of Gyrfalcons perched near the nest ledge flushed at the first sight of the helicopter when it was approximately 50 m from them. They gave no flight intention movements and flew down the canyon in a weaving manner.

S U P P L E M E N T

SUPPLEMENT. Observations During 1976.

Introduction

Gyrfalcon nest sites on the Yukon North Slope were visited during 1976 by D. Mossop of the Yukon Game Branch. Most sites were visited on 10-11 June 1976. Sites which could not be visited in June were visited on 9, 15, or 16 August 1976. A few sites that were visited in June were revisited in August.

Nest sites were examined to determine whether they were occupied and, if they were occupied, to determine the numbers of young produced at the sites. The young had already left the nests at many of the sites that were visited only in August. From the amount of droppings and other debris at these sites it was possible to determine which of the sites had been occupied and had probably produced young.

Results

The available evidence suggests that young Gyrfalcons were raised at 18 of the 30 nest sites that were visited during 1976 (Table 16). Because four nest sites that were visited in previous years were not visited during 1976, the number of active nests in the study area may have been slightly higher. The numbers of young produced in 1976 are known for 11 nest sites; the average productivity of these sites was 3.3 young/successful nest site. Differences in productivities of successful nests among the four years (1973, 1974, 1975, and 1976 [see Table 12])

TABLE 16. Gyrfalcon Nesting Success on Yukon North Slope, 1976.

NEST SITE		NEST SITE	
210	Young*	925	5 young
804	4 young	708	No activity
819	2 young	646	Young*
896	No activity	975	No activity
139	Young*	226	Adult
415	Not visited	496	Not visited
567	Not visited	870	No activity
788	No activity	558	No activity
479	3 young, 1 egg	579	Adults, nest site not found
954	5 young	091	At least 2 young
936	3 young	528	Adult
510	Adults	860	4 young
893	4 young	296	Not visited
915	Young*	401	1 young
508	Young*	942	3 young
747	Adults	871	No activity
280	Young*	873†	2 young
782	No activity		

*Evidence at the nest suggests that young were raised at these sites.

†New nest site (not occupied during 1974 or 1975).

were not significant (Kruskal-Wallis; H=3.1; df=3; n=26, 12, 12, 11; $P > 0.3$).

Ten of the 13 Gyrfalcon nest sites that were successfully occupied during 1975 were successfully occupied again during 1976.

During 1975 Gyrfalcons were disturbed by helicopter overflights or subjected to prolonged human presence at seven of the 13 successful nests. Five of these seven sites were successfully reoccupied in 1976 (Table 17). Five of the six successful 1975 nests that were neither disturbed by helicopter overflights nor subjected to human presence were successfully reoccupied in 1976. Disturbance of successful 1975 nest sites thus did not appear to be a factor in their successful reoccupation in 1976. (It is not known, however, how many of the sites that were reoccupied during 1976 were reoccupied by the same birds that were present during 1975.) This situation is in marked contrast to that of 1974-1975 when disturbance of successful 1974 nest sites appeared to be a significant factor in the successful reoccupation of these sites in 1975 (page 38). The difference between the 1975 and 1976 rates of reoccupancy of nest sites that were successful but disturbed during the previous year (0% vs 71%) was significant (two-tailed Fisher exact test; P=0.028).

The effect of disturbance of successful nest sites was not evident in the reoccupancy of such sites two years after the disturbance (Table 18). Thirteen nest sites were successfully occupied during 1974. Five of these sites have been omitted from the discussion of reoccupancy during

TABLE 17. Reoccupancy During 1976 of Successful 1975 Gyrfalcon Nests.

Status of Successful Nest in 1975	STATUS OF NEST SITE IN 1976		
	Produced Eggs or Young	No Eggs or Young	TOTAL
Disturbed by helicopter† and subjected to human presence††	1		1
Disturbed by helicopter but not subjected to human presence	2	2	4
Subjected to human presence and tested but not disturbed by helicopter	2		2
Tested but not disturbed by helicopter and not subjected to human presence	2		2
Not tested by helicopter or subjected to human presence	3	1	4
Total	10	3	13

† Bird either flushed from perch or assumed stress posture.

††Of a week or more in duration.

TABLE 18. Reoccupancy During 1976 of Successful 1974 Gyrfalcon Nests*.

Status of Successful Nest in 1975	STATUS OF NEST SITE IN 1976: Produced Eggs or Young	STATUS OF NEST SITE IN 1976: No Eggs or Young	TOTAL
Disturbed by helicopter† and subjected to human presence††	2**		2
Disturbed by helicopter but not subjected to human presence			0
Not disturbed by helicopter but subjected to human presence		1	1
Not disturbed by helicopter or subjected to human presence	3	2	5
Total	5	3	8

* Two sites that were not visited during 1976 and three sites that were successful in 1975 but that were disturbed during 1975 have been omitted.

**Lone birds were disturbed at both these sites during 1975.

† Bird either flushed from perch or assumed stress posture.

††Of a week or more in duration.

1976 either because they were not visited during 1976 or because disturbance occurred during the intervening year when the site was successfully occupied. Of the remaining eight nest sites, two of the three sites that were disturbed during 1974 (by helicopter overflights or by prolonged human presence) were successfully occupied during 1976. None of these three sites had been occupied during 1975. Three of the five sites that were not disturbed during 1974 were successfully occupied during 1976. All three of these sites had been occupied during 1975, but the two that were not occupied during 1976 had also not been occupied during 1975.

Discussion

There was a marked increase in the number of Gyrfalcons that bred successfully (eggs laid or young raised) on the Yukon North Slope during 1976 from the numbers that bred successfully during 1974 and 1975. The increase in the number of successful pairs of Gyrfalcons coincided with an increase in the numbers of ptarmigan, which were much more numerous on the Yukon North Slope during the summer of 1976 than they were during the summers of 1975 or 1974 (D. Mossop, pers. comm.). Numbers of ptarmigan were probably also high during late winter when the Gyrfalcons began the nesting cycle. It is possible that the increase in the number of pairs of successfully breeding Gyrfalcons was in response to an increase in the numbers of ptarmigan--their primary prey species.

The abundance of ptarmigan can be suggested as a possible cause of the fluctuations in the number of breeding Gyrfalcons, but it is only one of a number of possible causes. The data available are insufficient to ascertain the cause or causes of the observed fluctuations in the number of breeding pairs of Gyrfalcons.

Although the number of breeding pairs of Gyrfalcons in 1976 appears to have responded to the availability of ptarmigan, the average productivity of successful nests did not change. The average productivity of successful nests on the Yukon North Slope during the years 1973 to 1975 was already high in comparison with other areas where Gyrfalcons have been studied. The food available to feed young Gyrfalcons on the Yukon North Slope during the years 1973 to 1976 has been sufficient to maintain a high average productivity of successful nests. This average productivity is probably limited by some factor other than food supply.

The available data are also insufficient to determine the effect of disturbance to nesting Gyrfalcons on the reoccupancy of the nest site during the succeeding year. The failure to reoccupy nest sites during 1975 was significantly greater for sites disturbed during 1974 than for undisturbed sites but there was no such difference in reoccupancy rates during 1976 of sites disturbed during 1975. The reoccupancy of disturbed nest sites differed significantly between 1975 and 1976. Disturbance did not appear to be a factor in the reoccupancy of disturbed nest sites two years after the disturbance, but the difference between the 1975 and 1976 reoccupation rates one year after disturbance makes this conclusion less certain. Two years after the 1974 disturbance, however, Gyrfalcons did reoccupy two of the three disturbed nest sites that were not occupied the year following the disturbance.

Detailed conclusions concerning the effect of disturbance to Gyrfalcons on their reoccupancy of nest sites in the years following the disturbance must await further data. Until such data are available, disturbance at a comparatively low frequency should be considered as one possible factor leading to the failure of Gyrfalcons to reoccupy disturbed nest sites, particularly in the year following the disturbance.

CHAPTER II

A STUDY OF THE DISTRIBUTION AND MOVEMENTS OF SNOW GEESE, OTHER GEESE AND WHISTLING SWANS ON THE MACKENZIE DELTA, YUKON NORTH SLOPE, AND ALASKAN NORTH SLOPE IN AUGUST AND SEPTEMBER, 1975

W. R. KOSKI

ABSTRACT

Aerial transect surveys and reconnaissance surveys were flown of the outer Mackenzie Delta, Yukon North Slope, and eastern Alaskan North Slope from August 20 to September 25, 1975. The surveys were flown to determine (1) the numbers of geese and swans that used the study area during the fall staging period, (2) the concentration sites of these birds, (3) the chronology according to which the geese and swans used the study area, (4) the brood sizes and adult to juvenile ratios of these birds, and (5) the year-to-year variations in these variables.

In 1975, large numbers of Snow Geese used the study area between September 3 and September 24. The peak number of Snow Geese present was 375,000. Because of adverse weather conditions few Snow Geese used the North Slope; instead most were concentrated around Shallow Bay in the Mackenzie Delta. Production of young Snow Geese in 1975 was very good.

White-fronted Geese used the Mackenzie Delta from August 20 to September 19. A peak number of 23,700 was present on September 10. Between August 25 and 28, 12,200 Black Brant were sighted along the coast between Kittigazuit Bay and Camden Bay. The peak number of Whistling Swans present in the area was 3400 on August 20. Swans were present in the area until September 23. Production of young swans was similar to production in previous years.

ACKNOWLEDGEMENTS

The field portion of this study was carried out by W.R. Koski and L.D. Roy. Special thanks go to T.W. Barry, P.L. Sharp, and C.E. Tull who aided in the collection of data concerning family group size and adult to juvenile ratios.

W.W.H. Gunn, W.J. Richardson, and C.E. Tull made useful comments and assisted in the preparation of this report.

The Arctic Gas Biological Report Series, of which this report is a part, is a series of consultant project reports presenting data based on field and laboratory studies. The format and presentation vary among reports in accordance with the author's discretion.

The data for this work were obtained as a result of investigations carried out by LGL Limited for Alaskan Arctic Gas Study Company and Canadian Arctic Gas Study Limited. The text of this report may be quoted provided the usual credits are given.

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INTRODUCTION

Previous studies (Barry, 1967; Campbell, 1973a; Campbell, 1973b; Campbell and Weber, 1973; Koski and Gollop, 1974; Patterson, 1974; Schweinsburg, 1974; and Koski, 1975) indicate that the Yukon and eastern Alaskan North Slope and the Mackenzie Delta are important fall staging areas for large numbers of Snow Geese (*Chen caerulescens*) and lesser numbers of White-fronted Geese (*Anser albifrons*), Canada Geese (*Branta canadensis*), Black Brant (*Branta bernicla*), and Whistling Swans (*Olor columbianus*). Some of these studies further suggest that there is a large amount of year-to-year variation in the numbers of birds using each area, in the areas used, and in the duration of the period for which these areas are used by each of these species.

To further document this variation, aerial surveys were again conducted in 1975 along the Yukon North Slope and eastern Alaskan North Slope and in the outer Mackenzie Delta (Figures 1, 2, 3, and 4).

The objectives of this study were to determine the following:

1) the numbers of geese and swans that use the study area during the fall staging period;

2) the concentration sites of these birds;

3) the seasonal chronology according to which the geese and swans use the study area and the concentration sites;

4) the brood sizes and the adult to juvenile ratios of these birds; and

5) the year-to-year variation in each of the above variables.

Data gathered during this study and previous studies should contribute to a fund of baseline information that will be used to develop environmental recommendations pertinent to the proposed Arctic Gas pipeline and to assess the possible impact of the pipeline upon species of birds that use the Mackenzie Delta and the North Slope.

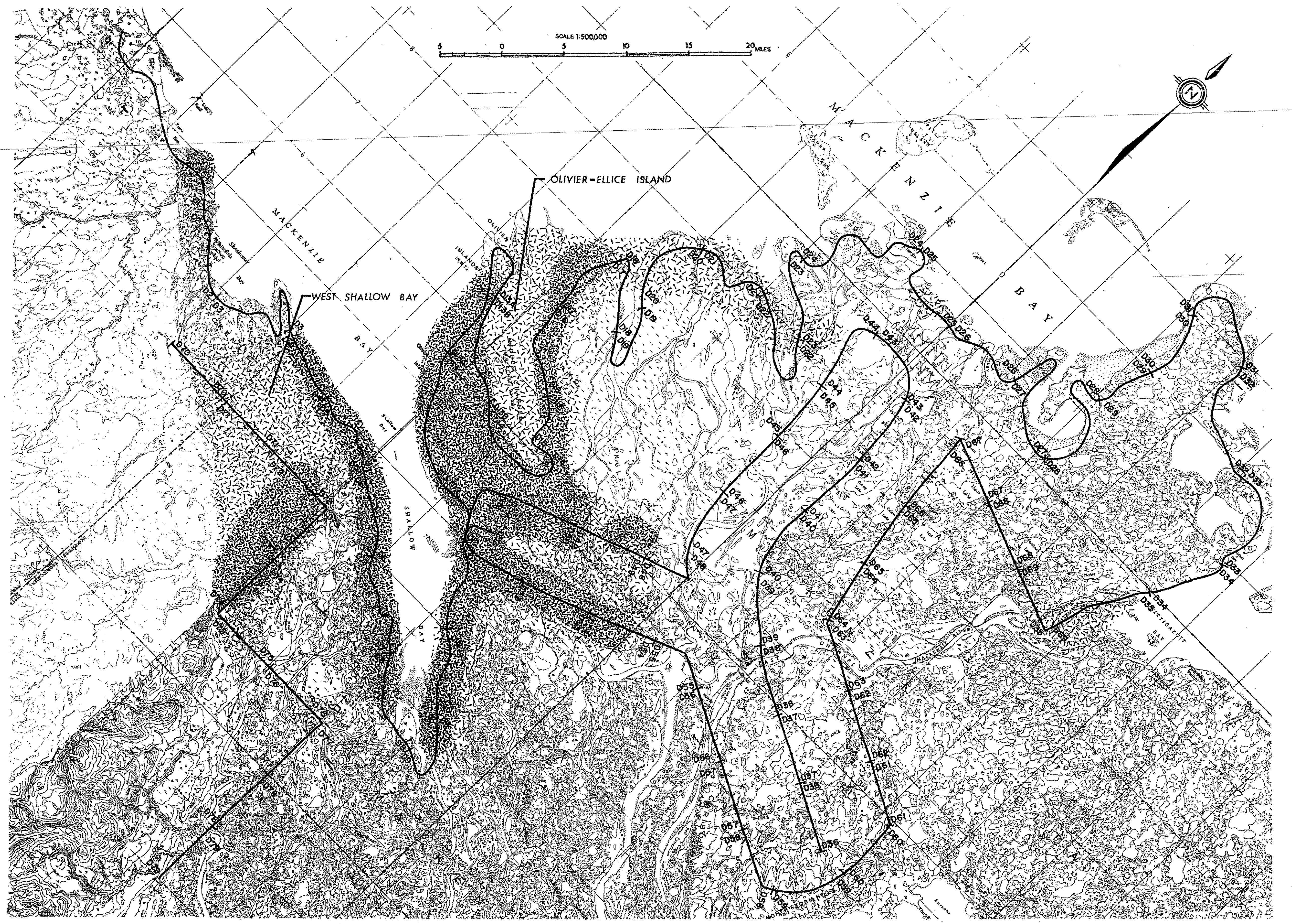


FIGURE 1
TRANSECTS FLOWN DURING AERIAL SURVEYS OF THE MACKENZIE DELTA AND CONCENTRATION SITES OF SNOW GEESE AS DETERMINED BY AERIAL SURVEYS: AUGUST & SEPTEMBER, 1975.

LEGEND

AREAS WHERE 1000+ SNOW GEESE WERE SIGHTED ON A TRANSECT ON A SINGLE OCCASION.

AREAS WHERE A MEAN OF 1500+ SNOW GEESE WERE SIGHTED ON A TRANSECT (SEPT. 5-23)

D1 — D2 TRANSECTS IDENTIFIED BY NUMBERS.

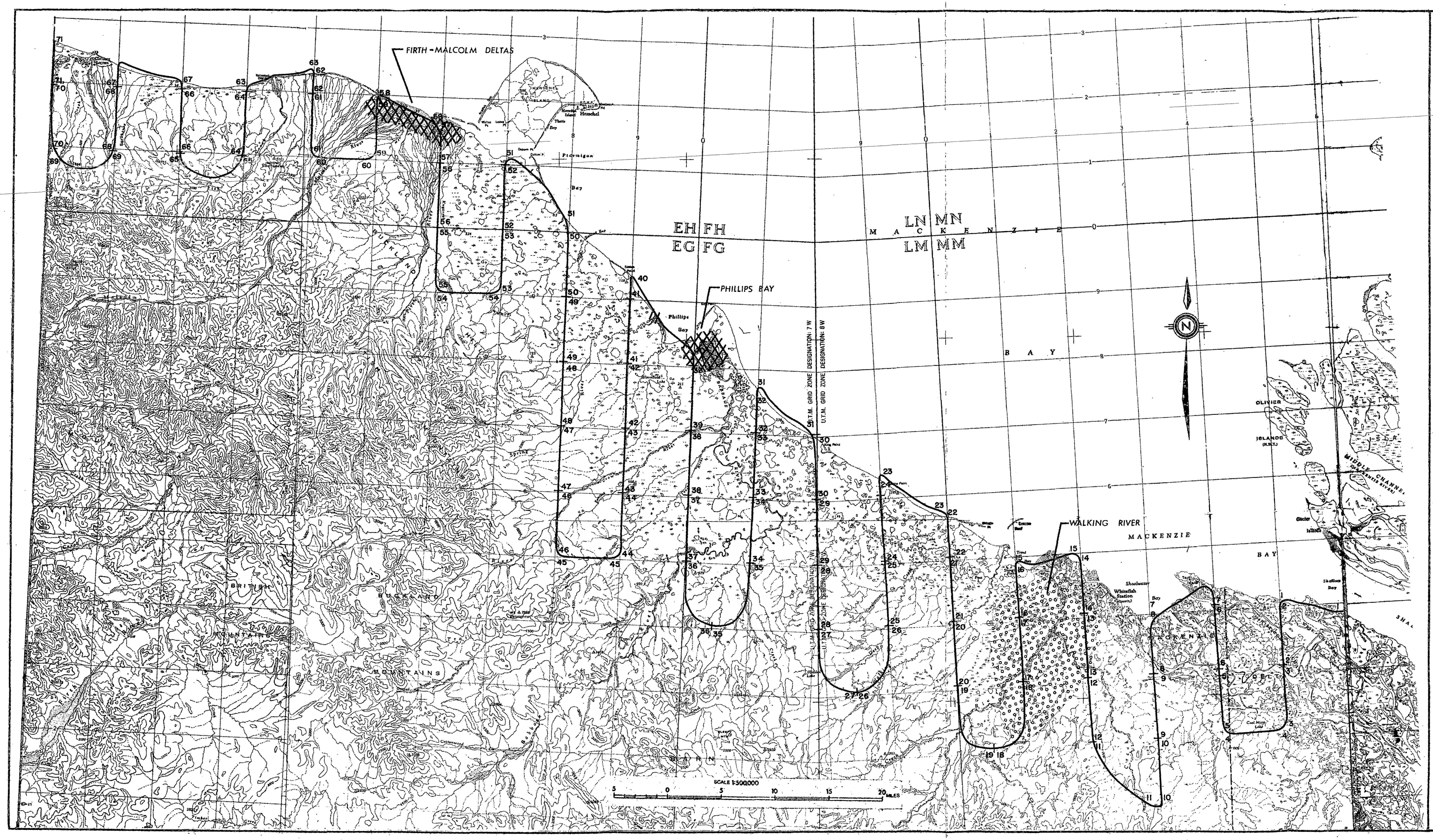


FIGURE 2.
TRANSECTS FLOWN DURING AERIAL SURVEYS OF THE YUKON NORTH SLOPE AND CONCENTRATION SITES OF SNOW GEESE, BLACK BRANT, WHITE-FRONTED GEESE, AND WHISTLING SWANS: AUGUST AND SEPTEMBER, 1975.

LEGEND

- WHITE-FRONTED GEESE.
- BLACK BRANT.
- SNOW GEESE.
- WHISTLING SWANS.
- UNIDENTIFIED DARK GEESE.
- D1 / D2 — TRANSECTS IDENTIFIED BY NUMBER.

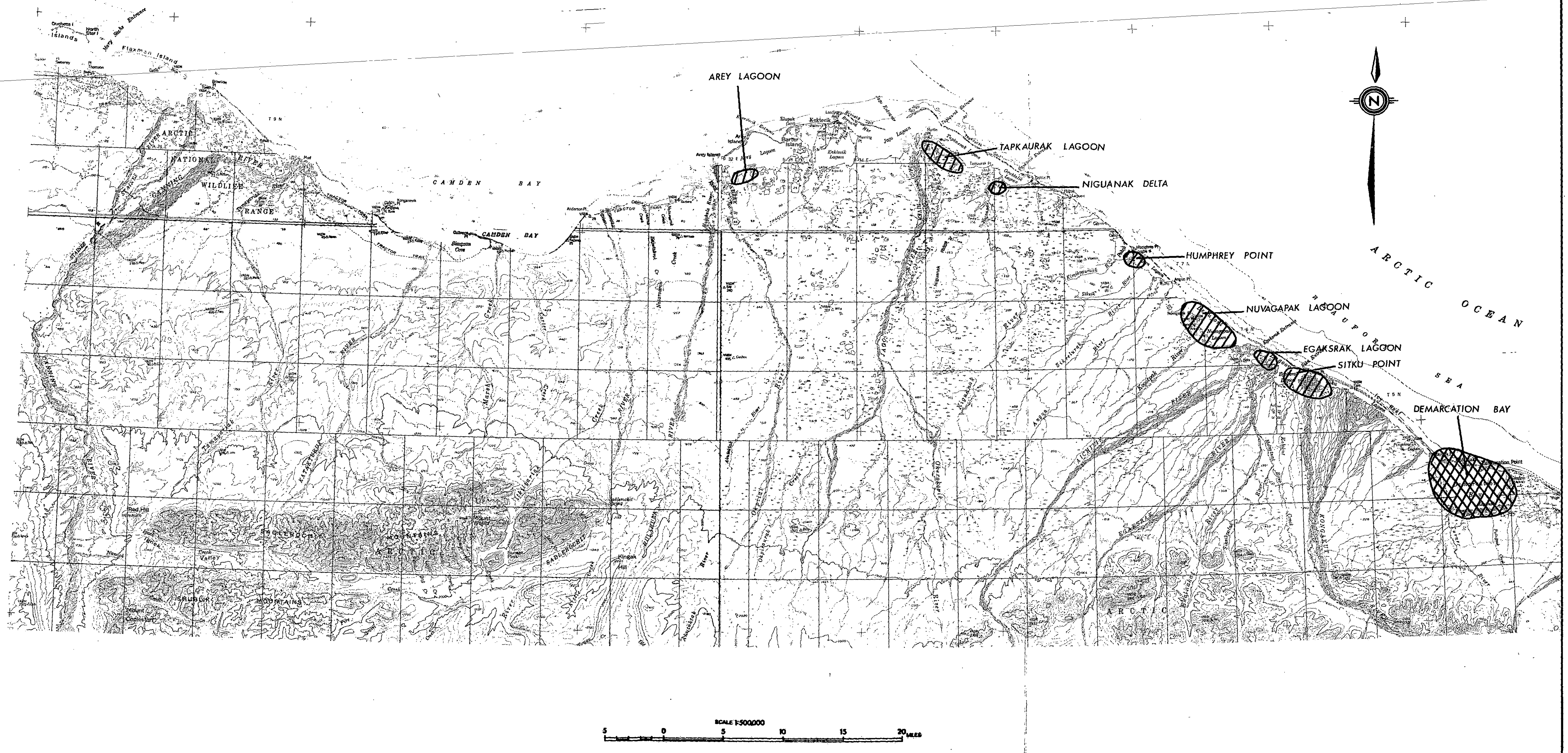
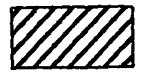
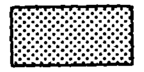


FIGURE 3
CONCENTRATION SITES OF WHITE-FRONTED GEESE, BLACK BRANT AND WHISTLING SWANS AS DETERMINED BY RECONNAISSANCE SURVEYS OF THE EASTERN ALASKAN NORTH SLOPE: AUGUST AND SEPTEMBER, 1975.

LEGEND


WHITE-FRONTED GEESE.


BLACK BRANT.


WHISTLING SWANS

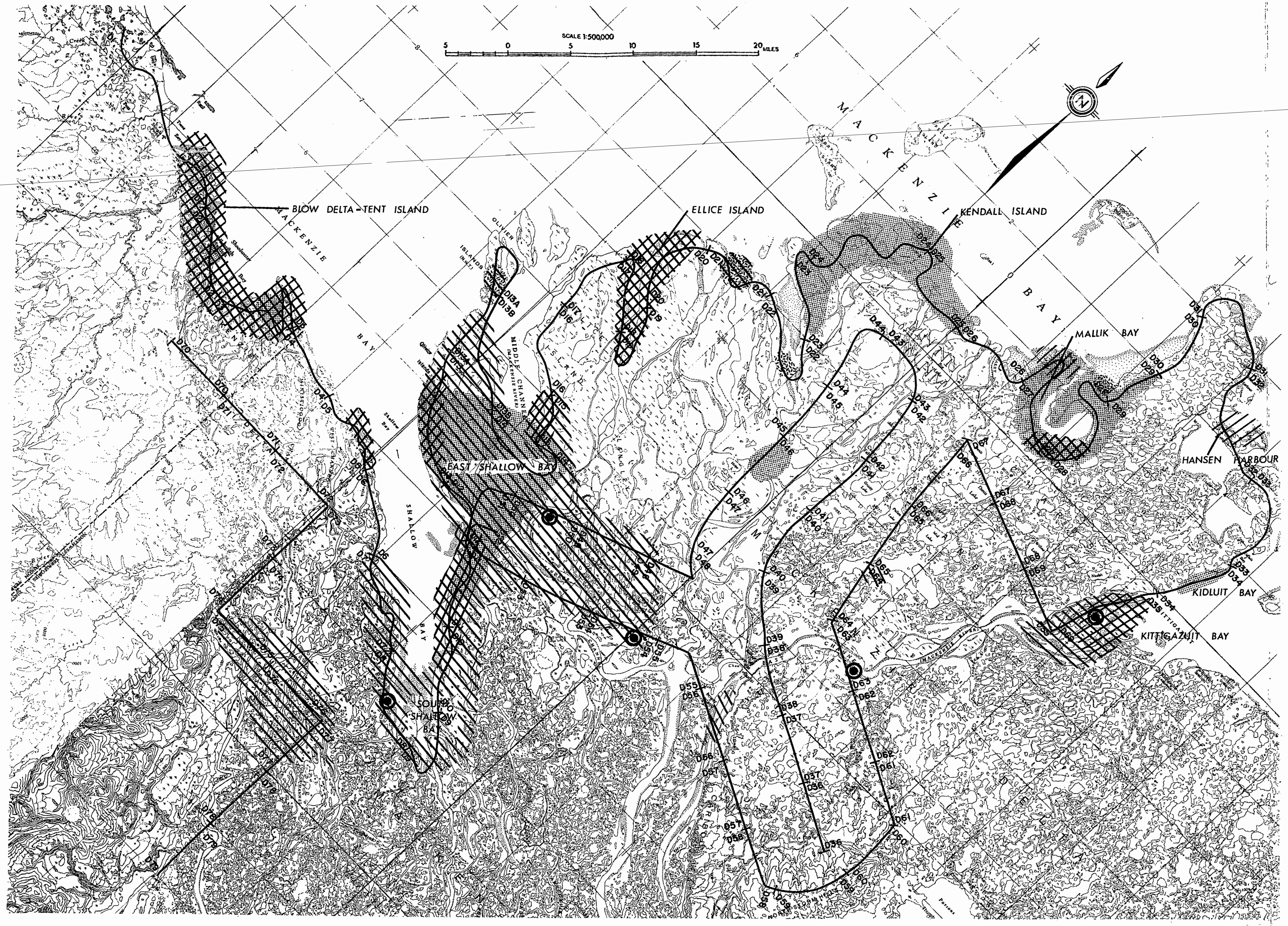


FIGURE 4
TRANSECTS FLOWN DURING AERIAL SURVEYS OF THE MACKENZIE DELTA AND CONCENTRATION SITES OF WHITE-FRONTED GEESE, BLACK BRANT, CANADA GEESE, AND WHISTLING SWANS: AUGUST AND SEPTEMBER, 1975.

LEGEND

- WHITE-FRONTED GEESE.
- BLACK BRANT.
- CANADA GEESE.
- WHISTLING SWANS.
- UNIDENTIFIED DARK GEESE.
- D1 / D2 TRANSECTS IDENTIFIED BY NUMBER.

METHODS

Between August 20 and September 25, 1975, both reconnaissance surveys and transect surveys of the study area were conducted. Transect surveys were flown along the prearranged transect grid that was flown in 1973 and 1974 (Koski and Gollop, 1974; Koski, 1975); these transects are shown in Figures 1 and 2. The prearranged transect route was flown in the Mackenzie Delta between August 20 and September 23. On the Yukon North Slope, only part of the transect grid was surveyed on September 14 and September 18. On the remainder of the Yukon North Slope and eastern Alaskan North Slope, the regular transect grid was not flown because Snow Geese used these areas only briefly in 1975. Ten additional transects were flown along the west side of the Mackenzie Delta after large numbers of geese had been sighted there on September 8 (Figure 1).

Reconnaissance surveys were flown both along the coast and over inland areas that geese or swans had used in previous years. On August 25 a reconnaissance survey was flown from Shallow Bay to Camden Bay to check for the arrival of Snow Geese and to count Black Brant along the Yukon North Slope and eastern Alaskan North Slope. Other reconnaissance surveys were flown to monitor the arrival of Snow Geese, their general movements within the study area, and their departure from the area.

Surveys were conducted from a Cessna 185 or Piper Aztec fixed-wing aircraft and at an altitude of 500 ft (150 m) AGL. Some reconnaissance surveys were conducted at lower altitudes because weather conditions did not permit flying at 500 ft.

Two observers, one stationed on each side of the aircraft, recorded all geese and swans that they sighted. Because Snow Geese were considered to be the most important species, the collection of other data was suspended for those periods during which numbers of Snow Geese were too large to permit recording of all other data. Wing struts were marked to allow the observers to estimate whether sightings were within or farther than 0.5 mi from the aircraft; birds that were sighted within 0.5 mi of the aircraft were recorded as on-transect, and birds that were sighted farther than 0.5 mi from the aircraft were recorded as off-transect. A third observer recorded the sizes of family groups and/or the adult to juvenile ratios of Snow Geese and of Whistling Swans, as well as any other pertinent data.

Additional data on the movements of the geese were collected from people camped on or flying over the study area.

The method of calculating the total number of geese or swans present on the study area during each survey period was the same as the method used by Koski (1975) with the following modification in the Mackenzie Delta: concentration transects were considered to be transects where 2000 or more Snow Geese (whether on or off-transect), 500 or more White-fronted Geese, or 50 or more Whistling Swans were sighted during any one survey. These concentration transects were treated according to the modification described by Koski (1975) for the Mackenzie Delta. The change in the definition of concentration transects from 1000 to 2000

Snow Geese for purposes of calculating total numbers of Snow Geese in the Mackenzie Delta was due to the extremely large concentrations of geese in the area in 1975. With such large numbers of birds to count, observers could easily miss off-transect flocks of up to 2000 Snow Geese. (Flocks of 1000 Snow Geese can be seen at 3 or 4 mi from a height of 500 ft AGL, and larger flocks can be seen at greater distances.)

Concentration transects were defined for White-fronted Geese and Whistling Swans in order to calculate total numbers present because the intensive surveys of 1975 indicated that large aggregations of these species also favoured certain areas in the Delta. The method used by Koski (1975) to make corrections for the concentrations of Snow Geese was also adopted for these species.

As in 1974 (Koski, 1975), unidentified dark geese were included with White-fronted Geese in order to calculate the total number of White-fronted Geese present. Because Black Brant can be easily differentiated from White-fronted and Canada Geese, geese that were recorded as dark geese were probably either White-fronted or Canada Geese. Canada Geese formed only slightly more than 1% (157 of 14,423) of the total number of identified Canada and White-fronted Geese in 1974 (Koski, 1975); therefore, the bias introduced by the consideration of all of the unidentified dark geese as White-fronted Geese was probably very small. As a result, the numbers of Canada Geese in the area may have been underestimated. However the small number of flocks of Canada Geese that were sighted suggests that any underestimation (if it did occur) was probably also small.

RESULTS

Snow Geese

Arrival, General Movements, and Departure

The first flock of Snow Geese was detected on the study area on August 18 (Appendix 1). Small numbers were seen as far west as Nuvagapak Lagoon during a reconnaissance survey of the North Slope that was conducted on August 25 (Appendix 2). During a regular transect survey of the Mackenzie Delta on August 28, 147 Snow Geese were sighted (Table 1). On September 3, large numbers of Snow Geese first started to appear in the Mackenzie Delta region (Appendix 1); and during a reconnaissance survey on September 4 of the Shallow Bay area and the section of the Yukon North Slope from Shingle Point to Phillips Bay, over 15,000 Snow Geese (Appendix 3) were detected. As only a small section of the North Slope could be surveyed because the visibility was severely reduced by fog and snow, there were probably several tens of thousands of Snow Geese present at this time. Despite snow storms on September 4, 5, and 6, a few thousand geese were seen flying and feeding behind the DEW site at Komakuk (Appendix 1).

On September 8, when the North Slope was 98% snow-covered, only 41 Snow Geese were sighted between Shingle Point and Demarcation Bay (Appendix 4); however, over 140,000 were sighted on-transect in the Mackenzie Delta (Table 1), where the snow cover varied from 50% around Shallow Bay to 98% on Richards Island. Large numbers of Snow Geese (284,000 to 375,000) remained in the Mackenzie Delta from September 8 to September 20.

TABLE 1. Numbers of Snow Geese Sighted On-Transect (During Each Aerial Survey Period) on the Mackenzie Delta, Yukon North Slope, and Eastern Alaskan North Slope: August 25 to September 23, 1975.

DATE	AUGUST 25-28			SEPTEMBER 8			SEPTEMBER 10			SEPTEMBER 11		
AREA	MACKENZIE DELTA	YUKON	ALASKA	MACKENZIE DELTA	YUKON	ALASKA	MACKENZIE DELTA	YUKON	ALASKA	MACKENZIE DELTA	YUKON	ALASKA
Number of Birds Seen On Transect	147	211	220	144267	34	7+	111621	N/A	N/A	89928	N/A	N/A
Number of Transects	32	-Recon. Survey--		52	-Recon. Survey--		21	0	0	30	0	0
Average Number of Birds Per Transect	4.59	*N/A	N/A	2774.37	N/A	N/A	5315.29	N/A	N/A	2997.60	N/A	N/A
Extrapolated Population	326	211+	220+	284039	34+	7+						
TOTAL		757+			**284080			≃300000			≃350000	

DATE	SEPTEMBER 13			SEPTEMBER 17-18			SEPTEMBER 20			SEPTEMBER 23		
AREA	MACKENZIE DELTA	YUKON	ALASKA	MACKENZIE DELTA	YUKON	ALASKA	MACKENZIE DELTA	YUKON	ALASKA	MACKENZIE DELTA	YUKON	ALASKA
Number of Birds Seen On Transect	95759	9675	N/A	123005	11297	N/A	80277	N/A	N/A	40301	N/A	N/A
Number of Transects	71	24	0	81	14	0	24	0	0	30	0	0
Average Number of Birds Per Transect	1348.72	403.13	N/A	1518.58	806.93	N/A	3344.88	N/A	N/A	1343.37	N/A	N/A
Extrapolated Population	**325981	48425	0	319561	56485	0						
TOTAL		**374406			376046			≃320000			≃120000	

*N/A No data were available for this date.

** This includes transects 70-79 from September 11, as they were not flown at this time.

≃ The number of transects surveyed was not sufficient to allow extrapolation as described in 'Methods'. The number present represents an estimation which compared transects on this date with the same transects on the nearest complete survey.

On September 13, 9675 Snow Geese were sighted on-transect in the Walking River concentration site, on the Yukon North Slope, At this time the Blow River and Walking River areas of the Slope were only 60% snow-covered. A total of 11,297 Snow Geese was seen in the Walking River concentration site on September 18. During a reconnaissance survey on September 20, no geese were detected in this area.

On September 19 several hundred Snow Geese were sighted flying south past Inuvik. By September 25 only about 1000 geese remained on the southeast edge of Shallow Bay.

Total Numbers

Between August 25 and September 23, 1975, a total of 706,277* Snow Geese was sighted on 379 transects--an average of 1864 Snow Geese per transect (Table 2). Table 1 gives the results of these surveys according to the study areas surveyed and the dates or periods when the surveys were conducted.

The peak number of Snow Geese sighted on the Alaskan North Slope was 220 on August 25.

The peak number of Snow Geese on the Yukon North Slope occurred on September 17-18, when 11,297 birds were sighted on-transect. At this time,

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*The total of 706,277 does not represent 706,277 different birds because many birds were counted on more than one survey.

TABLE 2. Total Numbers of Snow Geese Sighted On-Transect on the Mackenzie Delta, Yukon North Slope, and Eastern Alaskan North Slope: August and September, 1973, 1974, and 1975.

DATE	MACKENZIE DELTA			YUKON NORTH SLOPE			ALASKAN NORTH SLOPE			TOTAL		
	TRANSECTS FLOWN	GEESE SEEN	GEESE/ TRANSECT	TRANSECTS FLOWN	GEESE SEEN	GEESE/ TRANSECT	TRANSECTS FLOWN	GEESE SEEN	GEESE/ TRANSECT	TRANSECTS FLOWN	GEESE SEEN	GEESE/ TRANSECT
1973	148	86520	585	301	126960	422	197	44037	224	646	257517	399
1974	275	28913	105	286	37435	131	213	48591	228	774	114939	149
1975	341	685305	2010	38	20972	552	0	0	*N/A	379	706277	1864

*N/A- No data were available because only reconnaissance surveys were flown in Alaska.

the extrapolated population for the Yukon North Slope was 56,485 birds (Table 1).

The peak number of Snow Geese extrapolated for the Mackenzie Delta was 325,981 on September 13; this peak closely approximated the number that was extrapolated for September 17-18, which was 319,561 (Table 1).

The peak number of Snow Geese using the entire study area was present during the September 13 and the September 17-18 surveys; the population that was extrapolated for these dates was 375,000 (Table 1).

Concentration Sites

Figures 1 and 2 show the concentration sites that Snow Geese used during 1975. The only site used extensively on the North Slope was the Walking River site, where a large number of birds was sighted during a reconnaissance survey on September 4 (Appendix 3) and where approximately 48,000 birds were estimated to have been present on September 14 and September 18.

Snow Geese extensively used the concentration sites in the Mackenzie Delta during 1975 (Table 3). Mean numbers of 56,739 and 19,581 Snow Geese were present on the Olivier-Ellice Island concentration site and the West Shallow Bay concentration site, respectively (Table 3). The maximum numbers that used these sites were estimated to have been 233,000 on September 17 (Olivier-Ellice Island site) and 175,000 on September 8

TABLE 3. Numbers of Snow Geese Sighted On-Transect on Concentration Sites on the Yukon North Slope and Mackenzie Delta: August and September, 1975.

LOCATION	DATE									MEAN
	AUGUST	SEPTEMBER								
	28	8	10	11	13-14	17-18	20	23	25	
Blow Delta	N.S.*	105	528	786	1235	5452	2369	1775	N.S.	1750
West Shallow Bay	0	77578	30442	28507	11073	6805	2168	76	***0	19581
Olivier-Ellice Island	0	55961	80651***	41712***	80640	89643	75740	38450	≃1000***	56739
Kendall Island	142	0	N.S.	N.S.	730	2545	N.S.	N.S.	N.S.	854
Kittigazuit Bay	0	3350	N.S.	N.S.	1038	1965	N.S.	N.S.	N.S.	1588
Walking River	***0	**6	N.S.	N.S.	9510	9765	N.S.	N.S.	N.S.	6427

* N.S. This area was not surveyed on this date (not included in mean).

** This was a reconnaissance survey (included in mean because representative of numbers using the area).

*** This was an incomplete survey (not included in mean).

(West Shallow Bay site).

Adult to Juvenile Ratios and Brood Sizes

During the 1975 surveys, 25,861 Snow Geese were classified as either adults or juveniles; 12,223 were adults and 13,638 were juveniles (Table 4). These numbers give an adult to juvenile ratio of 1.00 to 1.12; the ratios were 1.00 to 1.19 in 1973 (Koski and Gollop, 1974) and 1.00 to .001 in 1974 (Koski, 1975). When the numbers of adults and juveniles in 1973 and 1975 were tested through use of a G test, they were found to be significantly different (G = 7.59, df = 1, $P < .01$).

In 1975, 831 family groups were counted; the mean number of young per brood was 3.10 ± .04 (Table 5). The difference from the mean brood size in 1973 (2.99 ± .04) was almost significant according to normal criteria (Student's t = 1.92, df = 1673, P = 0.063).

The distributions of brood sizes for 1973 and 1975 are presented in Table 5.

The percentage of the adult Snow Geese that were either non-breeders or unsuccessful breeders was calculated from data presented in Tables 4 and 5. In 1975, 28% of the adults were either non-breeders or unsuccessful breeders; this portion was 20% in 1973 and almost 100% in 1974.

TABLE 4. Adult to Juvenile Ratios of Snow Geese as Determined by Surveys of the Mackenzie Delta, Yukon North Slope, and Eastern Alaskan North Slope: August and September, 1973, 1974, and 1975.

YEAR	ADULTS	JUVENILES	RATIO ADULT/JUVENILE
1973	4533	5399	1.00/1.19
1974	28647	29	1.00/.001
1975	12223	13638	1.00/1.12

TABLE 5. Distribution of Brood Sizes of Snow Geese as Determined by Surveys of the Mackenzie Delta, Yukon North Slope, and Eastern Alaskan North Slope: September, 1973 and 1975.

DATE	NUMBER OF BROODS SIGHTED									TOTAL NUMBER OF BROODS	MEAN BROOD SIZE ± S.E.
	BROOD SIZE	1	2	3	4	5	6	7	8		
1973		84	219	257	210	57	12	3	2	844	2.99 ± .04
1975		52	205	295	196	58	18	6	1	831	3.10 ± .04

Dark Geese

In 1975 a total of 42,721* dark geese was sighted during surveys of 445 transects; the average number of geese sighted per transect was 96.00 (Table 6). As in 1973 and 1974, the highest densities of dark geese were sighted in the Mackenzie Delta, where 42,190 geese were sighted on 407 transects; the average number of geese per transect in the Mackenzie Delta was 103.66.

The number of dark geese sighted on-transect during each survey of the study area is given in Table 7. Peak numbers of dark geese were extrapolated for the August 25-28, September 8, and September 10 surveys, when 25,600, 24,400, and 24,900 birds, respectively, were estimated to have been present.

Table 8 gives the total numbers of White-fronted Geese, Black Brant, Canada Geese, and unidentified dark geese that were sighted on-transect each year in the Mackenzie Delta and the Yukon North Slope and eastern Alaskan North Slope. The most abundant species of dark goose was the White-fronted Goose, which formed 67% of the dark geese that were identified and virtually all of the unidentified geese (see methods). Black Brant formed 31% and Canada Geese formed 1.2% of the identified dark geese.

Figures 2, 3, and 4 show the concentration sites used by each species of dark goose.

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*See footnote on page 12.

TABLE 6. Total Numbers of Dark Geese Sighted On-Transect on the Mackenzie Delta, Yukon North Slope, and Eastern Alaskan North Slope: August and September, 1973, 1974, and 1975.

DATE	MACKENZIE DELTA			YUKON NORTH SLOPE			ALASKAN NORTH SLOPE			TOTAL		
	TRANSECTS FLOWN	GEESE SEEN	GEESE/ TRANSECT	TRANSECT FLOWN	GEESE SEEN	GEESE/ TRANSECT	TRANSECTS FLOWN	GEESE SEEN	GEESE/ TRANSECT	TRANSECTS FLOWN	GEESE SEEN	GEESE/ TRANSECT
1973	173	10557	61.02	291	793	2.73	227	675	2.97	691	12025	17.40
1974	219	8326	38.02	251	1791	7.14	213	550	2.58	683	10667	15.62
1975	407	42190	103.66	38	531	13.97	0	0	*N/A	445	42721	96.00

* N/A - No data were available because only reconnaisance surveys were flown in Alaska.

TABLE 7. Total Numbers of Dark Geese Sighted On-Transect (During Each Survey Period) on the Mackenzie Delta, Yukon North Slope, and Eastern Alaskan North Slope: August and September, 1975.

DATE	AUGUST 20			AUGUST 28 & 25			SEPTEMBER 8			SEPTEMBER 10		
AREA	MACKENZIE DELTA	YUKON	ALASKA	MACKENZIE DELTA	YUKON	ALASKA	MACKENZIE DELTA	YUKON	ALASKA	MACKENZIE DELTA	YUKON	ALASKA
Number of Birds Seen on Transect	4,495	N/A*	N/A	2,635	1,866	10,037	6,248	1,067	412	7,798	N/A	N/A
Number of Transects	66	0	0	32	-Recon.	Survey-	52	Recon.	Survey	21	0	0
Average Number of Birds Per Transect	68.11	N/A	N/A	82.34	N/A	N/A	120.15	N/A	N/A	371.33	N/A	N/A
Extrapolated Population	9,032	N/A	N/A	13,691	1,866+	10,037+	22,884	1,067+	412+	24,851	N/A	N/A
TOTAL		9,032+			25,594			24,363			24,851	

DATE	SEPTEMBER 11			SEPTEMBER 13			SEPTEMBER 17-18			SEPTEMBER 20	SEPTEMBER 23
AREA	MACKENZIE DELTA	YUKON	ALASKA	MACKENZIE DELTA	YUKON	ALASKA	MACKENZIE DELTA	YUKON	ALASKA	MACKENZIE DELTA	MACKENZIE DELTA
Number of Birds Seen on Transect	5,878	N/A	N/A	6,781	0	N/A	6,934	531	N/A	977	444
Number of Transects	30	0	0	71	24	0	81	14	0	24	30
Average Number of Birds Per Transect	195.93	N/A	N/A	95.51	0	N/A	85.60	37.93	N/A	40.71	14.80
Extrapolated Population	19,490	N/A	N/A	18,706	0+	N/A	12,469	1,095+	N/A	1,324	1,058
TOTAL		19,490			18,706			13,564		1,324	1,058

* N/A - No data were available for this date.

TABLE 8. Total Numbers of White-fronted Geese, Black Brant, Canada Geese, and Unidentified Dark Geese Sighted On-Transect on the Mackenzie Delta, Yukon North Slope, and Eastern Alaskan North Slope: August and September, 1973, 1974, and 1975.

SPECIES	DATE	MACKENZIE DELTA			YUKON NORTH SLOPE			ALASKAN NORTH SLOPE			TOTAL		
		TRANSECTS FLOWN	GEESE SEEN	GEESE/ TRANSECT	TRANSECTS FLOWN	GEESE SEEN	GEESE/ TRANSECT	TRANSECTS FLOWN	GEESE SEEN	GEESE/ TRANSECT	TRANSECTS FLOWN	GEESE SEEN	GEESE/ TRANSECT
White-fronted Geese	1973	173	6736	38.94	291	230	0.79	227	0	0.00	691	6966	10.08
	1974	219	7530	34.38	251	1791	7.14	213	550	2.58	683	9871	14.45
	1975	407	13126	32.25	38	71	1.87	0	0	*N/A	445	13197	29.66
Black Brant	1973	173	1575	9.10	291	437	1.50	227	375	1.65	691	2387	3.45
	1974	219	720	3.29	251	0	0.00	213	0	0.00	683	720	1.05
	1975	407	6112	15.02	38	390	10.26	0	0	N/A	445	6502	14.61
Canada Geese	1973	173	105	.61	291	1	0.00	227	0	0.00	691	106	.15
	1974	219	52	.24	251	0	0.00	213	0	0.00	683	52	.08
	1975	407	237	.58	38	0	0.00	0	0	N/A	445	237	.53
Unidentified dark geese	1973	173	2141	12.38	291	125	0.43	227	300	1.32	691	2566	3.71
	1974	219	24	.11	251	0	0.00	213	0	0.00	683	24	.04
	1975	407	22715	55.81	38	70	1.84	0	0	N/A	445	22785	51.20

*N/A- No data were available.

White-fronted Geese

Table 9 gives the numbers of White-fronted Geese seen on-transect during each survey period and the extrapolated populations for each period. Peak numbers used the study area from September 8 to 10, when approximately 23,700 White-fronted Geese were estimated to have been present. Appendix 5 presents the results of the surveys of transects D70 to D79, which were conducted only during 1975. These transects were not included in any of the above calculations in order to keep the data consistent with those collected during previous years.

During 1975, three family groups of White-fronted Geese were identified; they contained six, three, and one young.

Black Brant

Table 8 gives the numbers of Black Brant sighted on transects during aerial surveys in 1975, and Appendices 2, 3, and 4 give the numbers of Black Brant sighted during reconnaissance surveys. Largest numbers were sighted in the Mackenzie Delta on August 20 (1863), on the Yukon North Slope on August 25 (1866), and on the eastern Alaskan North Slope on August 28 (10,037). The highest number seen during one complete survey of the study area was 12,185 during the August 25-28 period. As in 1973 and 1974, numbers of Black Brant seen during September surveys were considerably lower than those seen during August surveys (Koski, 1975). However, unlike 1973 and 1974, a small number ($\simeq$ 1000) was present on the Blow River Delta until September 23.

TABLE 9. Numbers of White-fronted Geese Sighted On-Transect (During Each Survey Period) on the Mackenzie Delta, Yukon North Slope, and Eastern Alaskan North Slope: August and September, 1975.

DATE	AUGUST 20			AUGUST 25-28			SEPTEMBER 8			SEPTEMBER 10		
AREA	MACKENZIE DELTA	YUKON	ALASKA	MACKENZIE DELTA	YUKON	ALASKA	MACKENZIE DELTA	YUKON	ALASKA	MACKENZIE DELTA	YUKON	ALASKA
Number of Birds Seen on Transect	2,631	N/A*	N/A	2,328	25	0	5,922	832	343	6,702	N/A	N/A
Number of Transects	66	0	0	32	-Recon.	Survey-	52	-Recon.	Survey-	21	0	0
Average Number of Birds Per Transect	39.86	N/A	N/A	72.75	N/A	N/A	113.88	N/A	N/A	319.14	N/A	N/A
Extrapolated Population	7,164	N/A	N/A	13,384	25+	0+	22,558	832+	343+	23,743	N/A	N/A
TOTAL		7,164			13,409+			23,733+			23,743	

DATE	SEPTEMBER 11			SEPTEMBER 13			SEPTEMBER 17-18			SEPTEMBER 20	SEPTEMBER 23
AREA	MACKENZIE DELTA	YUKON	ALASKA	MACKENZIE DELTA	YUKON	ALASKA	MACKENZIE DELTA	YUKON	ALASKA	MACKENZIE DELTA	MACKENZIE DELTA
Number of Birds Seen on Transects	5,653	N/A	N/A	6,256	0	N/A	4,306	141	N/A	110	125
Number of Transects	30	0	0	71	24	0	81	14	0	24	30
Average Number of Birds Per Transect	188.43	N/A	N/A	88.11	0	N/A	53.16	10.07	N/A	4.58	4.17
Extrapolated Population	19,265	N/A	N/A	18,025	0+	N/A	10,797	705	N/A	550	625
TOTAL		19,265			18,025			11,502		550	625

* N/A - No data were available for this date.

Canada Geese

Only small numbers of Canada Geese were sighted during aerial surveys (Table 8). The peak number was seen on September 17-18, when the extrapolated number present was 1065. All of the Canada Geese sighted were in the Mackenzie Delta.

Whistling Swans

Numbers and Distribution

Table 10 gives the total numbers of Whistling Swans sighted on-transect in the Mackenzie Delta, Yukon North Slope, and eastern Alaskan North Slope during 1975 and compares these data with similar data for 1973 and 1974. In 1975, 1981* Whistling Swans were sighted on 289.5 transects--an average of 6.84 birds per transect. The peak number of swans in the Mackenzie Delta was sighted on August 20, at which time the number of Whistling Swans estimated to have been present was 3118 (Table 11). The number of Whistling Swans on the whole study area at this time was estimated to have been 3400. The highest density of swans (8.1/sq mi) was recorded on August 20, on 12 mi of transect around Mallik Bay, in the Mackenzie Delta.

Figures 2, 3, and 4 show the concentration sites for Whistling Swans during 1975.

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*See footnote on page 12.

TABLE 10. Numbers of Whistling Swans Sighted On-Transect on the Mackenzie Delta, Yukon North Slope, and Eastern Alaskan North Slope: August and September, 1973, 1974, and 1975.

DATE	MACKENZIE DELTA			YUKON NORTH SLOPE			ALASKAN NORTH SLOPE			TOTAL		
	TRANSECTS FLOWN	SWANS SEEN	SWANS/ TRANSECT	TRANSECTS FLOWN	SWANS SEEN	SWANS/ TRANSECT	TRANSECTS FLOWN	SWANS SEEN	SWANS/ TRANSECT	TRANSECTS FLOWN	SWANS SEEN	SWANS/ TRANSECT
1973	147	705	4.80	291	219	.75	227	39	.17	665	963	1.45
1974	100	524	5.24	0	*N/A	N/A	34	26	.76	134	550	4.10
1975	289.5	1981	6.84	38	5	.13	0	N/A	N/A	327.5	1986	6.06

*N/A- No data were available.

TABLE 11. Numbers of Whistling Swans Sighted On-Transect (During Each Survey Period) on the Mackenzie Delta, Yukon North Slope, and Eastern Alaskan North Slope: August and September, 1975.

DATE	AUGUST 20 & 25			AUGUST 28			SEPTEMBER 8			SEPTEMBER 11-14		
AREA	MACKENZIE DELTA	YUKON	ALASKA	MACKENZIE DELTA	YUKON	ALASKA	MACKENZIE DELTA	YUKON	ALASKA	MACKENZIE DELTA	YUKON	ALASKA
Number of Birds Seen on Transect	696	200	79	**421	N/A	N/A	129	35+	0	247	3	N/A
Number of Transects	66	-Recon.	Survey-	32	0	0	23.5	-Recon.	Survey-	61.5	24	0
Average Number of Birds Per Transect	10.55	*N/A	N/A	13.16	N/A	N/A	5.49	N/A	N/A	4.02	.13	N/A
Extrapolated Population	3,118	200+	79+	***2,400	35+	N/A	N/A	35+	0	1,427	15	N/A
TOTAL		3,397+			***2,435			N/A			1,442	

DATE	SEPTEMBER 17-18			SEPTEMBER 20			SEPTEMBER 23		
AREA	MACKENZIE DELTA	YUKON	ALASKA	MACKENZIE DELTA	YUKON	ALASKA	MACKENZIE DELTA	YUKON	ALASKA
Number of Birds Seen on Transect	333	2	N/A	42	N/A	N/A	113	N/A	N/A
Number of Transects	64.5	14	0	12	0	0	30	0	0
Average Number of Birds Per Transect	5.16	.14	N/A	3.50	N/A	N/A	3.77	N/A	N/A
Extrapolated Population	1,832	10	N/A	N/A	N/A	N/A	N/A	N/A	N/A
TOTAL		1,842			N/A			N/A	

* N/A - No data were available on this date.

** This compares with 547 for the same transects on August 20 (the highest density of swans was sighted on the outer Mackenzie Delta).

*** This was estimated by comparing the number of birds sighted on transects surveyed with the number sighted on the same transects flown on August 20 and multiplying by the extrapolated population for August 20.

Adult to Juvenile Ratios and Brood Sizes

In the Mackenzie Delta the mean brood size for 213 family groups of Whistling Swans was 2.22 ± .07 (Table 12). On the Yukon North Slope and eastern Alaskan North Slope the mean brood size for 21 family groups was 2.57 ± .24 (Table 12). There was no significant difference between brood sizes on the Mackenzie Delta and on the Yukon North Slope and eastern Alaskan North Slope (G test: $G = 2.71$, $df = 1$, $P > .50$).

On August 20, 554 Whistling Swans in the Mackenzie Delta were classified as either adults or juveniles; 438 were adults and 116 were juveniles. These numbers give an adult to juvenile ratio of 1.00 to .26 (Table 13). On August 25, 94 Whistling Swans on the Yukon North Slope and eastern Alaskan North Slope were aged; 68 were adults and 26 were juveniles. These numbers give an adult to juvenile ratio of 1.00 to .38.

On September 17, 18, and 20, 364 Whistling Swans in the Mackenzie Delta were aged; 229 were adults and 135 were juveniles. These numbers give an adult to juvenile ratio of 1.00 to .59 (Table 13). On September 23, 121 Whistling Swans in the Mackenzie Delta were aged; 77 were adults and 44 were juveniles (19 family groups). These numbers give an adult to juvenile ratio of 1.00 to .57.

There was a significant difference between the ratios of adults to juveniles present in mid-August and mid-September (G test: $G = 28.43$, $df = 1$, $P < .005$) in the Mackenzie Delta.

TABLE 12. Brood Sizes of Whistling Swans as Determined by Aerial Surveys of the Mackenzie Delta, Yukon North Slope, and Eastern Alaskan North Slope: August and September, 1974 and 1975.

LOCATION	DATE	NUMBER OF BROODS SIGHTED						MEAN BROOD SIZE ± S.E.
		BROOD SIZE 1	2	3	4	5	TOTAL	
Mackenzie Delta	1974	11	16	9	4	1	41	2.22 ± .16
Mackenzie Delta	1975	54	81	58	17	3	213	2.22 ± .07
Yukon North Slope and eastern Alaskan North Slope	1975	4	6	7	3	1	21	2.57 ± .24

TABLE 13. Adult to Juvenile Ratios of Whistling Swans as Determined by Aerial Surveys of the Mackenzie Delta, Yukon North Slope, and Eastern Alaskan North Slope: August and September, 1973, 1974, and 1975.

LOCATION	DATE	ADULTS	JUVENILES	ADULT/JUVENILE RATIO
Mackenzie Delta	August 20, 1975	438	116	1.00/.26
	September 17, 18, 20, 1975	229	135	1.00/.59
	September 23, 1975	77	44	1.00/.57
	*September 6, 1974	200	62	1.00/.31
Yukon North Slope and eastern Alaskan North Slope	August 25, 1975	68	26	1.00/.38
	*August 30, 1973	58	27	1.00/.47

* Taken from unpublished LGL data.

There was no significant difference between the adult to juvenile ratios in the Mackenzie Delta for August 20, 1975 and September 6, 1974 (G test: G = .767, df = 1, P > .10); or the adult to juvenile ratios on the Yukon North Slope and eastern Alaskan North Slope for August 30, 1973 and August 25, 1975 (G test: G = .360, df = 1, P > .50); these were the earliest dates for each year and each region for which such ratios were available.

The percentages of the adult population that were either non-breeders or unsuccessful breeders during the year were calculated from the adult to juvenile ratios and mean brood sizes. In the Delta (on the basis of the August 20 data) 76% of the adult Whistling Swans were either non-breeders or unsuccessful breeders; on the North Slope 71% were either non-breeders or unsuccessful breeders.

DISCUSSION

Snow Geese

Arrival, General Movements, and Departure

In 1975 the arrival of the first flock of Snow Geese on the Mackenzie Delta (August 18) coincided with the departure of the Snow Geese from the Anderson River breeding grounds (T.W. Barry[1], pers. comm.), and these birds probably originated from the Anderson River. Sightings of large numbers of Snow Geese on the Parry Peninsula and in the vicinity of the Horton River suggest that in 1975 the majority of the Anderson River birds flew east and mixed with the birds from Banks Island and that they staged in this general area for a short period of time before moving to the North Slope. T.W. Barry (pers. comm.) reports that he noted the same pattern of movement in 1973.

On September 2 the Snow Geese started to leave the eastern staging areas, and by September 3 large numbers of geese were seen flying westward past Tuktoyaktuk, on the east side of the Mackenzie Delta. On September 4 only small numbers of birds were seen in the Delta but large numbers were seen between Shingle Point and the Babbage River. It therefore appears that the birds flew directly from eastern staging areas to the Yukon North Slope. Despite snow storms on September 5, 6, and 7, several thousand Snow Geese moved as far west as Komakuk DEW site; but by September 8 virtually all Snow Geese had retreated to the Shallow Bay portion

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[1]Canadian Wildlife Service, Edmonton.

of the Mackenzie Delta. A few days of slightly warmer weather resulted in a partial thaw on the North Slope, and approximately 50,000 geese moved into the section of the Yukon North Slope southeast of Shingle Point and staged in this section until freezing conditions forced them from this area on or about September 19. The birds also started to leave the Mackenzie Delta at this time. Freezing weather and snow storms on September 22 hastened departure, and after similar weather on September 24 to 25 the study area was frozen over and completely snow-covered. By September 25 virtually all of the geese had departed from the study area.

The date of arrival of the first flock of Snow Geese (August 18) was intermediate among arrival dates from 1971 to 1975 (Table 14). The commencement of the major arrival (September 3 to 7) was later than in previous years, but the arrival period was shorter than in 1973; hence the major arrival was completed earlier than in 1973. The two years during which the greatest number of young were produced (1973 and 1975) had the latest dates of major arrival, and the two years during which virtually no young were produced (1972 and 1974) had the earliest dates of major arrival. These data suggest that adults with young possibly move more slowly from the breeding colonies and possibly stop longer at eastern staging areas to allow the young birds to build up strength.

The peak staging period in 1975 was 16 days (as compared with 13 days in 1971, 12 days in 1972, 17 days in 1973, and 26 days in 1974).

The movement of Snow Geese from eastern staging areas directly onto

TABLE 14. Dates of Arrival and Departure for Snow Geese on the Mackenzie Delta, Yukon North Slope, and Eastern Alaskan North Slope: August and September, 1971-1975*.

YEAR	DATE FIRST FLOCK SIGHTED	DATES OF MAJOR ARRIVAL	DATES OF MAJOR DEPARTURE	DATE LAST FLOCK SIGHTED
1971	August 15	August 31-September 2	September 12-16	September 17
1972	August 17	August 27-29	September 7-10	September 15
1973	August 23	September 1-12	September 22-25	October 4**
1974	August 21	August 22-25	September 17-21	September 30
1975	August 18	September 3-5, 6, or 7	September 19-24	September 25

* These dates were estimated from data presented on page 19, Koski and Gollop (1974) and from Koski (1975).

** Slaney (1974).

the North Slope (which was partially snow-covered) without first stopping in the Mackenzie Delta (which was snow-free) supports the premise that these birds traditionally use the North Slope as a staging area. Moreover, after having been forced into the Mackenzie Delta by adverse weather conditions, some geese returned to the Walking River concentration site on the Yukon North Slope although this area never became completely snow-free.

The dates of major departure in 1975 were comparable to those of 1973 and were later than those of 1971, 1972, and 1974. Because departure from the staging areas is determined by the onset of heavy snow-fall and adverse weather conditions (Barry, 1967; Gollop and Davis, 1974), the dates of major departure are less predictable than the dates of major arrival.

Peak Numbers

The peak number of Snow Geese that used the study area in 1975 was estimated to have been 375,000 (Table 15). This estimate compares with estimates of 200,000 to 300,000 in 1972 (Schweinsburg, 1974), 400,000 in 1973 (Koski and Gollop, 1974), and 163,000 in 1974 (Koski, 1975).

Concentration Sites

Despite the fact that snow persisted on the North Slope throughout the staging period, approximately 50,000 Snow Geese used the Walking River concentration site from September 12 to September 19. The Walking River concentration site was the only site on the North Slope that geese used for more than 3 or 4 days.

TABLE 15. Peak Numbers of Geese and Swans Extrapolated from Numbers Sighted During Transect and Reconnaissance Surveys: August and September, 1973, 1974, and 1975.

DATE	SNOW GEESE	WHITE-FRONTED GEESE	BLACK BRANT	CANADA GEESE	WHISTLING SWANS
1973	400000	25200	*4150	750	2000
1974	163000	22200	*2000	200	1900
1975	375000	23700	12200	1050	**3400 (2435)

* These values are known to be very low as only the last part of the migration was detected on surveys

* This value was obtained on a survey conducted on August 20 which was earlier than previous surveys were flown--2435 is the highest number during the period when surveys were flown in previous years (August 25-September 30).

The main concentration sites used by Snow Geese during 1975 were those bordering Shallow Bay, in the Mackenzie Delta. The West Shallow Bay concentration site was most heavily used by Snow Geese when they were first forced off the North Slope on September 8; at this time over 77,000 geese were sighted on-transect, and 175,000 geese were estimated to have been present. Table 3 shows that the number of Snow Geese that used this site gradually declined throughout the staging period and that birds from the West Shallow Bay site probably moved to both the Walking River and Olivier-Ellice Island sites.

The Olivier-Ellice Island site had the largest number of Snow Geese (56,739 on-transect Snow Geese per survey) and was used more continuously than any of the other concentration sites (September 8 to September 25). A peak number of 233,000 birds was estimated to have used this area on September 17-18. One flock of feeding birds sighted in this concentration site on September 17 was estimated to have contained over 60,000 Snow Geese.

The Blow Delta and Kittigazuit Bay concentration sites were both used continuously by small numbers of Snow Geese. The Kendall Island site received only a small amount of use in 1975. This was probably due to the presence of more snow in this area than around Shallow Bay.

The general staging pattern for Snow Geese in 1975 differed from the pattern noted from 1971 to 1974. In past years Snow Geese have staged primarily on the Yukon North Slope and eastern Alaskan North Slope. During these years the Mackenzie Delta served primarily as a late season staging area where lesser numbers of birds spent a few days after they had been forced from the North Slope by adverse weather conditions.

In 1975 severe weather conditions forced most of the Snow Geese to stage in the Mackenzie Delta. Extremely large numbers of Snow Geese were concentrated in a very small area as compared with the area that they used in previous years on the North Slope. It is unlikely that the small area that Snow Geese used during 1975 could support such numbers of birds every year. However, during years such as 1975 the Mackenzie Delta is extremely important as an area where Snow Geese can build up the energy reserves that they require for their southward migration.

Adult to Juvenile Ratios and Brood Sizes

The average brood size (3.10 ± .04) and the adult to juvenile ratio (1.00/1.12) both indicate that the production of young Snow Geese in 1975 was extremely high. The adult to juvenile ratio was significantly higher in 1975 than in 1973, but there was no significant difference in mean brood size. The difference in the adult to juvenile ratios is explained by the number of non-breeding and unsuccessfully breeding birds, which was probably higher in 1975 than in 1973. In both 1972 and 1974 virtually no young were produced. This lack of production meant that in 1973 and in 1975 almost all birds returning to the breeding colonies were potential breeders. However, in 1975 a considerably higher proportion of the adult birds were two-year-old birds because of the extremely high production in 1973. Many two-year-old birds may not nest even under ideal conditions (Barry, 1967), and the rate of nesting failure is higher among first time breeders (Cooch, 1958; Prevett, 1973). Therefore, a larger proportion of the 1975 population than of the 1973 population would be expected to have been non-breeding or unsuccessfully breeding birds, and, as the survey results show, there would have been a higher proportion of adults in the total population given the same average brood size for the two years. In 1976, because there was no recruitment in 1974, a reduction in the number of breeding pairs due to mortality between the 1975 and 1976 breeding seasons can be expected. Also, a large number of non-breeding birds can be expected because of the large number of young produced in 1975.

White-fronted Geese

The peak number of White-fronted Geese present in the study area occurred from September 8 to 10, when 23,700 were estimated to have been present. This number closely approximates the 25,200 (1973) and 22,200 (1974) White-fronted Geese that were estimated by Koski (1975) to have used the study area (Table 14). Approximately 7000 White-fronted Geese were present on the study area on August 20, when surveys were commenced. At this time migrants from areas such as Anderson River were probably already present (Barry, 1967). A large influx of White-fronted Geese arrived in the Mackenzie Delta shortly before September 9, and this influx probably coincided with a general migration from Alaska (as described by Barry [1967] and Koski [1975]). During a reconnaissance survey of the North Slope on September 8 (Appendix 4), several flocks of White-fronted Geese were sighted migrating southeastward along the coastal plain.

Throughout the study period White-fronted Geese were sighted south of the study area along the major river channels in the Mackenzie Delta. From this area many were seen moving farther southward. It is therefore probable that the peak number of White-fronted Geese that was present in the study area was considerably lower than the total number that used the study area throughout the staging period.

Data from transects 70 to 79 (Figure 1) were not included in the extrapolation for the study area in order that the results would be comparable with results from 1973 and 1974. Extrapolations for this area indicate that an additional 3150 and 3950 White-fronted Geese were present in this area on September 11 and September 17-18, respectively (Appendix 5). If it is assumed that the White-fronted Geese sighted on September 10 on the regular transect route did not move into this newly-surveyed area on September 11, then the peak number of geese in the area surveyed (including the additional transects 70 to 79) would have been approximately 27,000.

The major concentration sites used by White-fronted Geese were along the southern and eastern sections of Shallow Bay, on northern Ellice Island, on the islands in Kittigazuit Bay, and in the Blow River Delta-Tent Island area.

Black Brant

In 1975 the greatest number of Black Brant sighted during a single complete survey was 12,200 (August 25-28). The largest concentrations of

Black Brant were sighted at Demarcation Bay and Beaufort Lagoon. The figure of 12,200, though considerably higher than the numbers sighted in 1973 and 1974, represents a very minimal estimate of the total number of Black Brant using the study area. The distribution of these birds indicates that although the centre of their westward migration was in the Beaufort Lagoon-Demarcation Bay area (Appendix 2), several thousand Black Brant had probably passed through the study area previous to this first survey. Results of later surveys indicate that some birds still had not arrived on the study area at this time. Most of the birds were sighted in river deltas and lagoons, where they were probably resting and feeding. Godfrey (1966) and Schweinsburg (1974) report similar habitat usage by Black Brant.

A small concentration of approximately 1000 Black Brant was seen in the Blow River Delta during all surveys up to and including that of September 23. At this time the Beaufort Sea coast was frozen, and, if the birds had migrated along the coast, no open water areas would have existed until they reached the western coast of Alaska. It is therefore suspected that these birds may have migrated overland *via* the Blow River pass and down the Yukon River to the Yukon River Delta. Cade (1955) states that this route is used by Black Brant during spring migration, but there is no evidence that Black Brant use this route during fall migration.

Canada Geese

Only small numbers of Canada Geese were sighted during 1975. The largest number sighted in the Mackenzie Delta was on September 17-18, when 1065 were estimated to have been present. These data support other studies (Gollop and Davis, 1974; Koski, 1975), which have found that only small numbers of Canada Geese use the Yukon North Slope and eastern Alaskan North Slope and Mackenzie Delta during fall migration.

Whistling Swans

In 1975 a peak number of 3400 Whistling Swans was estimated to have been present on the study area during the period August 20 to 25. These surveys were earlier than comparable surveys conducted during previous years. On August 28, 2435 Whistling Swans were estimated to have been present; this number compares with 1900 and 2000 for 1973 and 1974. The peak density of swans (8.1 swans/sq mi) was recorded around the shore of Mallik Bay on August 20. Slaney (1974) reports a peak density of 16 birds/sq mi in the Mallik Bay area during mid-July but does not give a comparable figure for mid-August.

There was a significantly higher ratio of adults to juveniles on transects flown on August 20 than on the same transects on September 17, 18, and 20. This higher ratio supports the findings of Slaney (1974), which state that adult birds without broods leave the outer Delta before those with young. However, on September 23 approximately one-half of the adults sighted (39 of 77) were not associated with broods; therefore, not all non-breeding or unsuccessfully breeding adults left the Delta before adults with young.

The mean brood size on the Mackenzie Delta in 1975 was 2.22 ± .07, which was the same as in 1974 (2.22 ± .16; Koski, 1975). Slaney (1974) reports average brood sizes of 2.2 in 1972 and 2.5 in 1973 for part of this study area (Richards Island), and Campbell (1973a) reports average brood sizes of 1.8 (Moose Channel area) and 2.3 (Kittigazuit Bay) for other parts of this study area.

The mean brood size on the Yukon North Slope and eastern Alaskan North Slope was 2.57 ± .24, which compares with a figure of 2.2 for the Alaskan North Slope in 1966 (King, 1970).

In 1975 concentrations of Whistling Swans were present on Sitku Point, on the eastern Alaskan North Slope, and on the Babbage River Delta, on the Yukon North Slope. In the Mackenzie Delta major concentrations were found around Mallik Bay, the outer section of the Kendall Island Bird Sanctuary, and the east side of Shallow Bay. Smaller concentrations were found south of Kidluit Bay, north of Hope Lake, southwest of Tent Island, and at Whitefish Station.

In 1975, 76% of the adult Whistling Swans in the Mackenzie Delta were either non-breeders or unsuccessful breeders; in 1974, 72% were in this category (calculated from data in Table 13). Data presented by Campbell (1973) suggest that in 1972, 67% of the Whistling Swans in the Moose Channel and Kittigazuit Bay areas were non-breeders or unsuccessful breeders.

On the Yukon North Slope and eastern Alaskan North Slope 71% of Whistling Swans were non-breeders or unsuccessful breeders in 1975; this figure compares with 85% for Whistling Swans in Alaska during 1966 (from data presented in King, 1970).

Because Whistling Swans do not breed until their fifth or sixth season (Delacour, 1954), one would expect a high proportion of the adult birds to be non-breeders (as these data suggest). The high proportion of non-breeding birds and the long period of time required by the birds to become potential breeders suggest that a small increment in mortality rates could cause a substantial reduction in the number of birds that reach sexual maturity.

SUMMARY

In 1975 the major arrival of Snow Geese on the study area occurred from September 3 to 7, and the major departure was from September 19 to 24. The peak staging population was approximately 375,000 Snow Geese.

The pattern of usage of concentration sites differed from that of other years because of an early freeze-up on the North Slope. Most of the Snow Geese (up to 325,000) staged in the Mackenzie Delta--primarily on the east and west sides of Shallow Bay--but approximately 50,000 birds used the Walking River concentration site even though snow persisted in this area throughout the staging period.

An average brood size of 3.10 ± .04 and an adult to juvenile ratio of 1.00 to 1.12 indicated that 1975 was a high production year for Snow Geese.

White-fronted Geese used the Mackenzie Delta portion of the study area from August 20 to September 19. The peak number of 23,700, which used the area September 8 to 10, probably coincided with an influx of birds from Alaska. The most important area to White-fronted Geese was along the southern and eastern sections of Shallow Bay.

On August 25 and 28, 12,200 Black Brant were sighted between Kittigazuit Bay and Camden Bay; the largest concentrations of this species were detected on August 25 at Demarcation Bay and Beaufort

Lagoon. Approximately 1000 Black Brant were present on the Blow River Delta until September 23.

Only small numbers of Canada Geese were sighted during aerial surveys, and the peak number present was estimated to have been 1065.

Whistling Swans used the study area from the commencement of surveys on August 20 until freeze-up on September 23. The peak number of swans (3400) was present on August 20, and the largest concentrations of birds were sighted around Mallik Bay, on the outer fringe of the Kendall Island Bird Sanctuary, and along the eastern shore of Shallow Bay.

Non-breeding and unsuccessfully breeding Whistling Swans formed 76% of adult birds. These birds started to leave the study area before those with young. The average brood size of 2.22 ± .07 and the adult to juvenile ratio of 1.00 to .26 indicate that production in 1975 was similar to that in previous years.

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A P P E N D I C E S

APPENDIX 1. Important Sightings which Document Snow Goose Movements: August and September, 1975.

August 18:	Dirk DeGraaf (A.E.L.) sighted the first flock of Snow Geese in the Mackenzie Delta near West Channel.
September 2:	Willard Hagen (pilot for Corridor Air) sighted several tens of thousands of Snow Geese on the Parry Peninsula and in the vicinity of Horton River.
September 3:	Willard Hagen sighted several thousand Snow Geese flying westward near Tuktoyaktuk.
September 4, 5, and 6:	A few thousand Snow Geese were sighted both flying by and feeding near the DEW site at Komakuk Beach. Personnel working there report that this was the only time period during which they sighted Snow Geese in 1975.
September 19:	Several hundred Snow Geese were seen flying south past Inuvik.
September 23:	Several thousand Snow Geese were seen flying south from Shallow Bay area.
September 25:	A reconnaisance survey of Shallow Bay area detected approximately 1000 Snow Geese on the southeast edge of the bay.

APPENDIX 2. Coastal Survey from Shallow Bay to Camden Bay: August 25, 1975.

	BLACK BRANT	WHITE-FRONTED GEESE	UNIDENTIFIED DARK GEESE	SNOW GEESE	SWANS	SANDHILL CRANES
West Side of Shallow Bay	0	15	0	0	25	7
Tent Island & Vicinity	80	389	25	0	102	6
Blow River Delta	33	0	0	6	13	0
Shingle Point	6	0	0	0	2	0
Babbage River Delta	765	0	0	0	79	2
Spring River Delta	225	0	0	0	6	3
Stokes Point	140	0	0	0	11	0
Roland Bay	0	0	0	0	12	0
Catton Point	77	0	0	0	3	1
Firth River Delta	310	0	0	50	5	0
Malcolm River Delta	248	0	0	155	15	0
Vicinity of Komakuk	0	0	25	0	0	0
Clarence Lagoon	37	0	0	0	7	0
Demarcation Bay	2,435	0	0	0	0	0
Sitku Point	1,350	0	0	0	47	0
Egaksrak Lagoon	695	0	0	0	2	0
Nuvagapak Lagoon	2,335	0	0	220	5	0
Humphrey Point	700	0	0	0	0	0
Niguanak River Delta	675	0	0	0	0	0
Tapkaurak Lagoon	1,325	0	0	0	0	0
South of Barter Island	75	0	0	0	5	0
Hulahula River Delta	14	0	0	0	10	0
Arey Lagoon	415	0	0	0	0	0
Vicinity of Kajutakrok Creek	18	0	0	0	10	0
Return Inland Malcolm Delta to Shingle Point	0	0	0	0	47	0

APPENDIX 3. Reconnaissance Survey from Shallow Bay to Phillips Bay: September 4, 1975.

LOCATION	BLACK BRANT	WHITE-FRONTED GEESE	CANADA GEESE	UNIDENTIFIED DARK GEESE	SNOW GEESE	SANDHILL CRANES
Shallow Bay	269	108	0	78	0	2
Whitefish Station	600	20	0	300	28	0
Blow River Delta	359	92	0	85	126	0
Inland between Shingle Point and Babbage River	0	40	3	0	15,699	0

APPENDIX 4. Reconnaissance Survey from Aklavik to Demarcation Bay: September 8, 1975*.

LOCATION	SNOW GEESE	WHITE-FRONTED GEESE	CANADA GEESE	BLACK BRANT	UNIDENTIFIED DARK GEESE	SWANS
Aklavik to Shingle Point following the edge of the delta	8473	459	11	133	75	not recorded
Near Shingle Point	6	0	0	15	45	0
East of Phillips Bay	0	0	0	0	210	0
Phillips Bay	0	51	0	220	57	27
Firth and Malcolm river deltas	28	212	0	0	197	4
Clarence Lagoon	0	60	0	0	0	4
Demarcation Bay	7	278	0	69	65	0

* The Yukon North Slope and eastern Alaskan North Slope were 98% snow covered at this time.

APPENDIX 5. Numbers of White-fronted Geese and Unidentified Dark Geese Sighted on Transects D70-D79 in the Mackenzie Delta: September 11 and September 17-18, 1975.

TRANSECT NUMBER	SEPTEMBER 11	SEPTEMBER 17 AND 18
70	2 UD*	8 UD
71	18 WF** 8 UD	0
72	105 WF	100 UD
73	98 WF 3 UD	53 WF
74	100 UD	137 WF
75	0	238 WF
76	500 WF 425 UD	612 WF 100 UD
77	68 UD	110 WF 410 UD
78	0	0
79	0	0
EXTRAPOLATED NUMBER	3158	3957

* UD - Unidentified dark geese.

** WF - White-fronted Geese.

CHAPTER III

AERIAL SURVEYS OF BIRD POPULATIONS ALONG THE PROPOSED CROSS DELTA PIPELINE ROUTE, YUKON TERRITORY AND NORTHWEST TERRITORIES, JUNE-AUGUST, 1975

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ABSTRACT

Four aerial surveys of the cross delta route of the proposed Arctic Gas pipeline were flown during the period June-August, 1975. The surveys were flown in order (1) to determine the numbers of water birds along the route during the periods of nesting, of brood-rearing and moulting, and of spring and fall staging and migration; (2) to identify those areas along the route that are important to water birds; and (3) to compare the numbers of water birds along the cross delta route with the numbers along the circum-delta route.

Densities of water birds during the spring staging period and the nesting period were highest along the section of the route that traverses the outer Mackenzie Delta. Densities during the brood-rearing and moulting period and the fall staging period were highest along the section of the route to the southeast of the Mackenzie Delta. The density of broods of water birds was highest on that portion of the route to the east of the Mackenzie Delta. Scaup were the most numerous of the 31 species of birds that occurred along the route.

The outer Mackenzie Delta is probably the most important section of the cross delta route for water birds. For each of the major water bird groups, the highest density during a survey occurred at least once along the outer Mackenzie Delta section of the route.

The area traversed by the cross delta route appears to support more water birds than does the area traversed by the circum-delta route.

ACKNOWLEDGEMENTS

The field portion of this study was conducted by W.R. Koski and L.D. Roy. B. Bowes, L. Buckmaster, and W. Hagen, pilots with Corridor Air, Inuvik, flew the surveys. W.W.H. Gunn, S.R. Johnson, W.R. Koski, L.A. Patterson, W.J. Richardson, and G.F. Searing provided valuable comments on the content of the report.

The Arctic Gas Biological Report Series, of which this report is a part, is a series of consultant project reports presenting data based on field and laboratory studies. The format and presentation vary among reports in accordance with the authors' discretion.

The data for this work were obtained as a result of investigations carried out by LGL Limited for Canadian Arctic Gas Study Limited. The text of this report may be quoted provided the usual credits are given.

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INTRODUCTION

The cross delta route has recently been proposed to shorten the route of the Arctic Gas pipeline in the Mackenzie Delta area (CAGPL, 1975). This route diverges from the previously-planned circum-delta route on the Yukon North Slope (Figure 1). From there it crosses Shallow Bay and the outer Mackenzie Delta and then joins at the southwest corner of Richards Island with a supply line originating at the Taglu Field. The line proceeds from this junction southeast to Thunder River, where it rejoins the previously-planned route and follows it southeastward up the Mackenzie Valley.

The circum-delta route (Figure 1) runs from the Yukon North Slope along the coastal tundra until it approaches the Mackenzie Delta. It then turns southward, remaining to the west of the delta, and turns eastward at the south end of the delta. After crossing the Mackenzie River near Arctic Red River, this route proceeds to a point west of Travaillant Lake where it is joined by the Richards Island supply line from the north. It then proceeds eastward to Thunder River, then southeastward up the Mackenzie Valley. A supply line runs westward from the Parsons Lake field to join both the circum-delta and the cross delta routes.

A number of studies of water birds have been conducted in areas traversed by the proposed cross delta route. Calef and Lortie (1971), Schweinsburg (1974), and Sharp *et al.* (1974) have reported on the populations of water birds that breed on the Yukon North Slope.

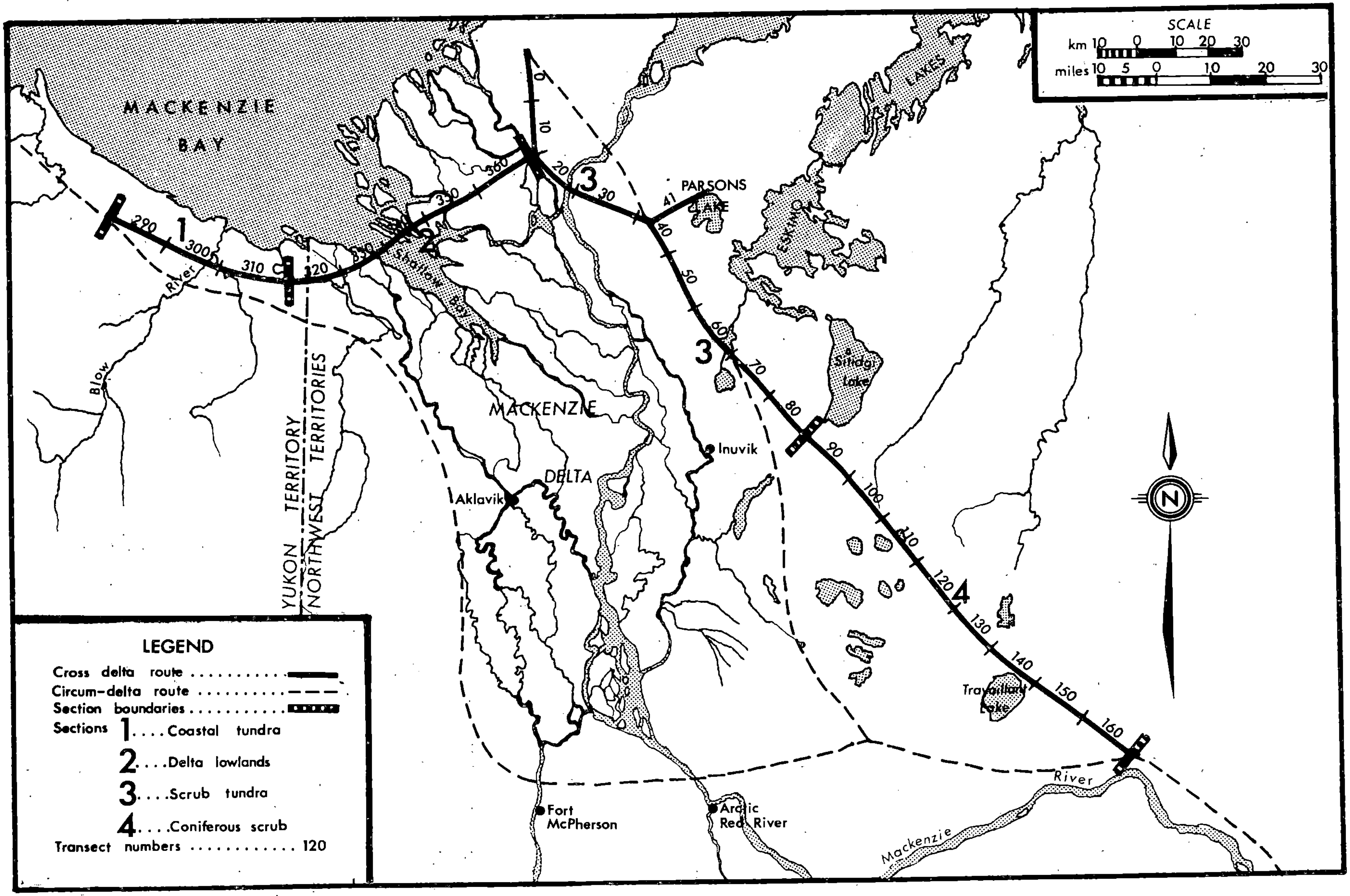

FIGURE 1. Habitat Sections and Aerial Transects along the Cross Delta Route.

Koski and Gollop (1974) and Koski (1975a, 1975b) have described the fall staging of Snow Geese, of other species of geese, and of Whistling Swans on the Yukon North Slope and in the Mackenzie Delta. The U.S. Fish and Wildlife Service (USFWS), in cooperation with the Canadian Wildlife Service, has conducted annual surveys of waterfowl breeding pairs and waterfowl production in the Mackenzie Delta, on Richards Island, and in areas to the southeast of the Mackenzie Delta (Martel, in prep.). Campbell (1973), Campbell and Weber (1973), and Slaney (1974) have conducted aerial and ground surveys of water birds in sections of the Mackenzie Delta and Richards Island. Salter (1974a) has studied water birds along portions of the circum-delta route on Richards Island and in the areas south and southeast of the delta. Jacobsen (1974) has provided a comprehensive literature review relevant to the water birds of the area.

These studies represent a sizeable quantity of ornithological information concerning areas traversed by the cross delta route. However, they have generally concentrated on specific parts of the area, on specific pipeline routes, or on particular groups of water birds. Consequently, some areas along the cross delta route have not been studied comprehensively with respect to all water bird populations.

Aerial surveys were conducted along the cross delta route in 1975 to gather information concerning water bird populations along the route. The specific objectives of the surveys were the following:

1) to determine the species and numbers of water birds that use the area along the proposed route during the periods of nesting, of brood-rearing and moulting, and of spring and fall staging and migration;
2) to identify the areas along the route that are important to water birds during these periods; and
3) to compare the cross delta route with the circum-delta route in terms of the importance of the areas along each route to water birds.

The data from this study, when combined with data from other studies, will provide baseline information that can be used to assess the potential impact of the proposed Arctic Gas pipeline on water bird populations and to develop environmental recommendations with respect to the pipeline.

METHODS

Four aerial surveys were conducted along the proposed cross delta route during the late spring and summer of 1975. These were flown on June 5, June 20, July 31, and August 30.

The dates were chosen to correspond to times when important seasonal activities of the birds were estimated to have occurred. The survey of June 5 corresponded to the period of spring arrival; the survey of June 20 to the nesting period; the survey of July 31 to the time of brood-rearing and moulting; and the survey of August 30 to the fall staging and migration period.

Surveys were flown in fixed-wing aircraft, either a twin-engine Piper Aztec or a single-engine Cessna 185. The pilot followed the pipeline route which had been drawn on topographic maps. The surveys were conducted at heights varying between 100 and 150 ft[1] AGL and at air speeds of 90 to 120 mph. Two observers, one at each side of the aircraft, identified and counted all water birds and other conspicuous birds that were seen within a 1/8 mi (200 m) strip on the observer's side of the plane.

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[1]British units of measurement have been used in this study to maintain consistency within the continuing series of aerial survey reports.

Observations were recorded on cassette tapes and were later transcribed to data sheets. The data were then transferred to a computer system for analysis.

The route was divided into 10-mi transects, according to the milepost designations shown on preliminary alignment sheets prepared by Canadian Arctic Gas Pipeline Limited (1975). The transects are shown in Figure 1. The data were recorded separately for each 10-mi transect. For purposes of analysis the transects were pooled into four sections according to their physical features and characteristic vegetation (Figure 1). These sections were the following:

1) coastal tundra--the Yukon North Slope (milepost 290 to milepost 320);
2) delta lowland--the outer Mackenzie Delta (milepost 320 to milepost 372);
3) scrub tundra--Richards Island to south end of Sitidgi Lake (milepost 0 to milepost 90); and
4) coniferous scrub--Sitidgi Lake to Thunder River (milepost 90 to milepost 172).

For the purposes of this study, water birds were defined to be those groups of birds that are attracted to or dependent on an aquatic or semi-aquatic habitat. These birds include the following: waterfowl such as swans, geese, and ducks; other diving ducks such as loons and grebes; and gulls, terns, and Sandhill Cranes.

RESULTS

Total Density Indices

Figure 2 presents the density indices for total water birds that were calculated for each section on each survey. Density indices during the spring staging and breeding periods were highest in the delta lowland section. Density indices during the brood-rearing and fall staging periods were highest in the coniferous scrub section. The highest density index for the entire period (62.9 water birds/sq mi) occurred in the coniferous scrub section on August 30--largely the result of one flock of 700 scaup on a single lake. The lowest density indices were found consistently on the coastal tundra section.

Despite the apparent differences in the density indices for the different sections, density indices did not differ significantly among sections on any of the four surveys.

Numbers and Density Indices of Water Bird Species

The numbers and density indices of the birds observed along each of the four sections of the cross delta route are presented in Tables 1 to 4. Density indices are given for water birds only, because of the difficulty of detecting most terrestrial birds from aircraft. A complete transect-by-transect summary of data from each survey is given in Appendix 1. The scientific names of the birds recorded are listed in Appendix 2.

TOTAL WATER BIRDS

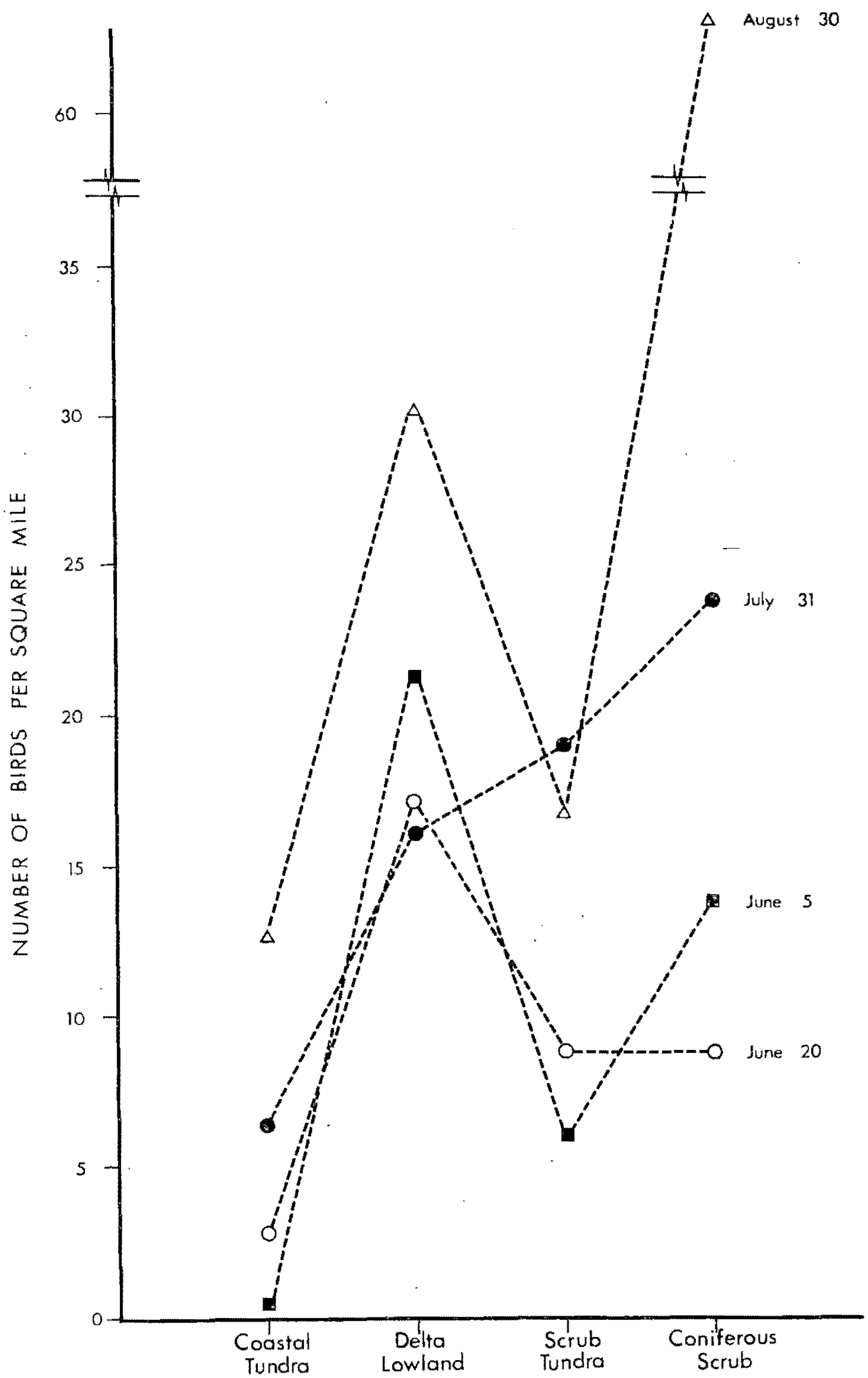

FIGURE 2. Density Indices of Total Water Birds along Sections of the Cross Delta Route.

TABLE 1. Numbers and Density Indices of Birds Observed During Aerial Surveys of the Coastal Tundra Section of the Cross Delta Route, 1975.

DATE SURVEYED / AREA SURVEYED	JUNE 5 7.5 mi^2		JUNE 20 6.3 mi^2		JULY 31 7.5 mi^2		AUGUST 30 3.8 mi^2	
	NO.	DENSITY*	NO.	DENSITY	NO.	DENSITY	NO.	DENSITY
WATER BIRDS								
Arctic Loon			2	0.3	9	1.2	1	0.3
Loon spp.							2	0.5
Loon, grebe or duck					8	1.1	1	0.3
Whistling Swan					2	0.3	2	0.5
Ducks:								
Mallard			1	0.2				
Pintail			3	0.5				
Scaup spp.			6	1.0	2	0.3		
Oldsquaw	2	0.3	2	0.3	15	2.0	36	9.6
King Eider			2	0.3				
White-winged Scoter			1	0.2				
Red-breasted Merganser	1	0.1						
Diving duck spp.			1	0.2	4	0.5		
Duck spp.					2	0.3		
Total Ducks	3	0.4	16	2.5	23	3.1	36	9.6
Sandhill Crane							5	1.3
Arctic Tern					6	0.8		
Total Water Birds	3	0.4	18	2.9	48	6.4	47	12.5
OTHER BIRDS†								
Willow Ptarmigan			4					
Parasitic Jaeger					3			
Long-tailed Jaeger			1		1			
Jaeger spp.	1				2			

* Density indices are in units of birds/mi^2.

† Density indices have only been calculated for water birds.

TABLE 2. Numbers and Density Indices of Birds Observed During Aerial Surveys of the Delta Lowland Section of the Cross Delta Route, 1975.

DATE SURVEYED / AREA SURVEYED	JUNE 5 13.1 mi² NO.	DENSITY*	JUNE 20 13.1 mi² NO.	DENSITY	JULY 31 13.1 mi² NO.	DENSITY	AUGUST 30 6.6 mi² NO.	DENSITY
WATER BIRDS								
Arctic Loon			7	0.5	28	2.1	5	0.8
Red-throated Loon					4	0.3		
Loon spp.					6	0.5	1	0.2
Loon, grebe or duck					2	0.2	2	0.3
Whistling Swan	54	4.1	13	1.0	48	3.7	8	1.2
Canada Goose	2	0.2	2	0.2				
White-fronted Goose	4	0.3	12	0.9			35	5.3
Dark goose spp.							22	3.3
Ducks:								
Mallard	2	0.2						
Pintail	30	2.3	24	1.8	5	0.4		
American Wigeon							64	9.7
Dabbling duck spp.	1	0.1			3	0.2	9	1.4
Scaup spp.	103	7.9	62	4.7	8	0.6	7	1.1
Oldsquaw			13	1.0	2	0.2		
White-winged Scoter	9	0.7	54	4.1				
Scoter spp.	2	0.2			2	0.2	14	2.1
Red-breasted Merganser	1	0.1			4	0.3		
Diving duck spp.	1	0.1	2	0.2				
Duck spp.					27	2.1	14	2.1
Total Ducks	149	11.4	155	11.8	51	3.9	108	16.4
Sandhill Crane	4	0.3	8	0.6	2	0.2	17	2.6
Glaucous Gull	52	4.0	2	0.2	2	0.2		
Mew Gull	1	0.1						
Gull spp.					1	0.1		
Arctic Tern	10	0.8	25	1.9	65	5.0		
Total Water Birds	276	21.1	224	17.1	209	16.0	198	30.2
OTHER BIRDS†								
Bald Eagle			1					
Marsh Hawk							2	
Pomarine Jaeger	15							
Parasitic Jaeger			1					
Jaeger spp.	71		5					
Short-eared Owl					1			
Common Raven							1	

* Density indices are in units of birds/mi².

† Density indices have only been calculated for water birds.

TABLE 3. Numbers and Density Indices of Birds Observed During Aerial Surveys of the Scrub Tundra Section of the Cross Delta Route, 1975.

DATE SURVEYED / AREA SURVEYED	JUNE 5 25 mi²		JUNE 20 25 mi²		JULY 31 25 mi²		AUGUST 30 22.5 mi²	
	NO.	DENSITY*	NO.	DENSITY	NO.	DENSITY	NO.	DENSITY
WATER BIRDS								
Arctic Loon			13	0.5	53	2.1	45	2.0
Red-throated Loon			3	0.1	4	0.2		
Loon spp.					5	0.2	11	0.5
Loon, grebe or duck			7	0.3	21	0.8	11	0.5
Whistling Swan	2	0.1	29	1.2	36	1.4	23	1.0
White-fronted Goose	20	0.8	10	0.4				
Dark goose spp.	4	0.2						
Ducks:								
Mallard			3	0.1	3	0.1		
Pintail	10	0.4	16	0.6	36	1.4	2	0.1
Green-winged Teal	2	0.1						
American Wigeon	1	0.0**	1	0.0			30	1.3
Dabbling duck spp.	1	0.0					9	0.4
Scaup spp.	12	0.5	53	2.1	18	0.7	156	6.9
Common Goldeneye			2	0.1				
Oldsquaw	35	1.4	38	1.5	53	2.1		
Common Eider			1	0.0				
White-winged Scoter	6	0.2	17	0.7	15	0.6		
Surf Scoter			8	0.3				
Scoter spp.			1	0.0	56	2.2	37	1.6
Diving duck spp.	37	1.5	10	0.4	11	0.4	8	0.4
Duck spp.	7	0.3	2	0.1	132	5.3	47	2.1
Total Ducks	111	4.4	152	6.1	324	13.0	289	12.8
Sandhill Crane	2	0.1	1	0.0	5	0.2		
Glaucous Gull	1	0.0	1	0.0	2	0.1		
Mew Gull			1	0.0				
Arctic Tern	5	0.2	5	0.2	26	1.0		
Total Water Birds	145	5.8	222	8.9	476	19.0	379	16.8
OTHER BIRDS†								
Marsh Hawk					1		1	
Willow Ptarmigan	1		11					
Rock Ptarmigan			1					
Ptarmigan spp.	17		1					
Pomarine Jaeger	1							
Parasitic Jaeger			3					
Long-tailed Jaeger			2		1			
Jaeger spp.			1					
Common Raven					2			

* Density indices are in units of birds/mi².

† Density indices have only been calculated for water birds.

** Less than 0.05.

TABLE 4. Numbers and Density Indices of Birds Observed During Aerial Surveys of the Coniferous Scrub Section of the Cross Delta Route, 1975.

DATE SURVEYED / AREA SURVEYED	JUNE 5 20.5 mi² NO.	DENSITY*	JUNE 20 20.5 mi² NO.	DENSITY	JULY 31 20.5 mi² NO.	DENSITY	AUGUST 30 20.5 mi² NO.	DENSITY
WATER BIRDS								
Arctic Loon	4	0.2	7	0.3	29	1.4	37	1.8
Loon spp.			2	0.1	2	0.1	13	0.6
Loon, grebe or duck	2	0.1	4	0.2	9	0.4	31	1.5
Whistling Swan	3	0.2	3	0.2	17	0.8	9	0.4
Ducks:								
Mallard	4	0.2	14	0.7	1	0.0	2	0.1
Pintail	6	0.3	12	0.6	8	0.4	2	0.1
Green-winged Teal					2	0.1		
American Wigeon	2	0.1	4	0.2				
Dabbling duck spp.	4	0.2	1	0.0**	24	1.2	20	1.0
Scaup spp.	142	6.9	82	4.0	225	11.0	714	34.8
Common Goldeneye	3	0.2	3	0.2				
Oldsquaw	7	0.3	3	0.2	3	0.2	1	0.0
White-winged Scoter	60	2.9	27	1.3			6	0.3
Surf Scoter			6	0.3				
Scoter spp.					32	1.6	24	1.2
Red-breasted Merganser	4	0.2	6	0.3				
Diving duck spp.	16	0.8	3	0.2	76	3.7	12	0.6
Duck spp.	10	0.5			38	1.9	421	20.5
Total Ducks	258	12.6	161	7.9	409	20.0	1202	58.6
Mew Gull	4	0.2						
Bonaparte's Gull			1	0.0				
Arctic Tern	16	0.8	3	0.2	23	1.1		
Total Water Birds	287	14.0	181	8.8	489	23.8	1292	63.0
OTHER BIRDS†								
Bald Eagle	1							
Willow Ptarmigan	3							
Rock Ptarmigan	1		2					

* Density indices are in units of birds/mi².

† Density indices have only been calculated for water birds.

** Less than 0.05.

Thirty-seven species of birds were identified during the course of the four surveys; 31 of these were recorded within the 1/4-mi transect width. The largest number of species in a section (25) was recorded for the scrub tundra section. The largest number of species on any of the four surveys (26) was recorded during the June 20 survey. During this survey, the scrub tundra section contained the largest number of those species (21).

The most numerous group of water birds was the diving ducks. The two species of scaup were the most abundant of these, comprising nearly 70% of the identified diving ducks. (From the air the two species of scaup could not be reliably separated.)

The short coastal tundra section consistently contained the fewest species and the lowest density indices along the route (Table 1). The Oldsquaw was the commonest species recorded here; it occurred in largest numbers on the August 30 survey.

The delta lowland section had the highest density indices of water birds during the two June surveys and high density indices during the July 31 and August 30 surveys (Table 2). The highest density indices of Whistling Swans, Sandhill Cranes, and Arctic Terns were found consistently on this section. Geese were also comparatively common along this section.

Density indices of water birds on the scrub tundra section, though often high, were rarely as high as those on the delta lowland or coniferous scrub sections (Table 3). There were two exceptions--the density indices of Arctic Loons and Oldsquaws were generally highest on the scrub tundra section.

The coniferous scrub section of the cross delta route had especially high density indices of water birds during the July 31 and August 30 surveys (Table 4). The totals for this section were influenced greatly by the large numbers of ducks. Scaup comprised more than 50% of the ducks that were identified.

Figures 3 and 4 show the density indices of each of the major groups of water birds for each of the surveys and each of the sections of the route. Loons, geese, dabbling ducks, diving ducks, and gulls each represent more than one species; swans, cranes, and terns each represent a single species.

Density indices on each transect in each section were compared for each water bird group on each survey. Density indices differed significantly among the four sections in only two cases (Kruskal-Wallis: terns June 20; $H = 13.4$; $df = 3$; $n = 26$; $P < 0.01$: diving ducks July 31; $H = 8.3$; $df = 3$; $n = 26$; $P < 0.05$). The density index for Arctic Terns on the June 20 survey was significantly higher in the delta lowland section than the density indices for the other sections (one-tailed Mann-Whitney: *vs* coastal tundra; $U = 0.0$; $n = 3, 5$; $P = 0.018$: *vs* scrub tundra; $U = 3.0$;

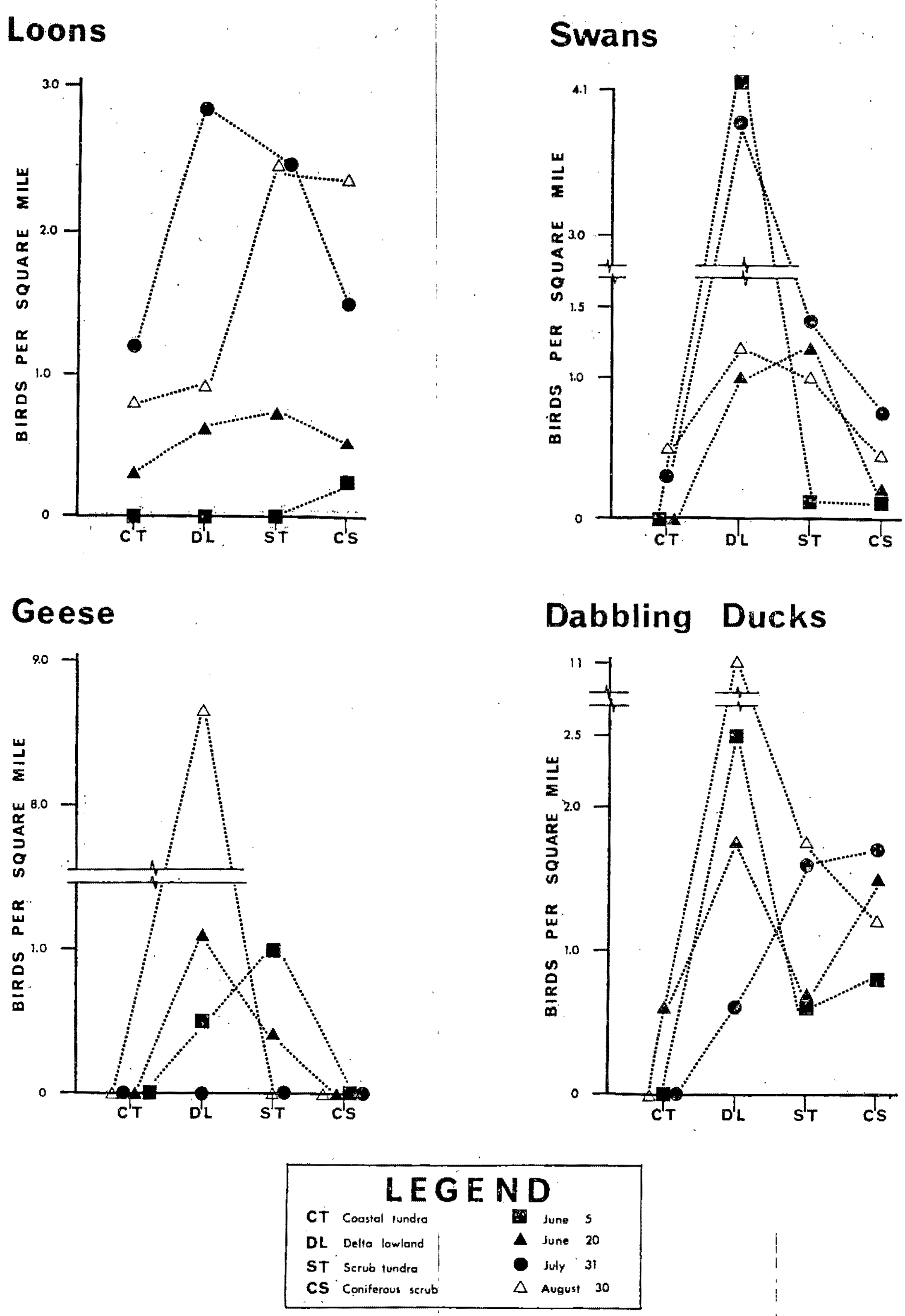

FIGURE 3. Density Indices of Loons, Swans, Geese, and Dabbling Ducks along Sections of the Cross Delta Route.

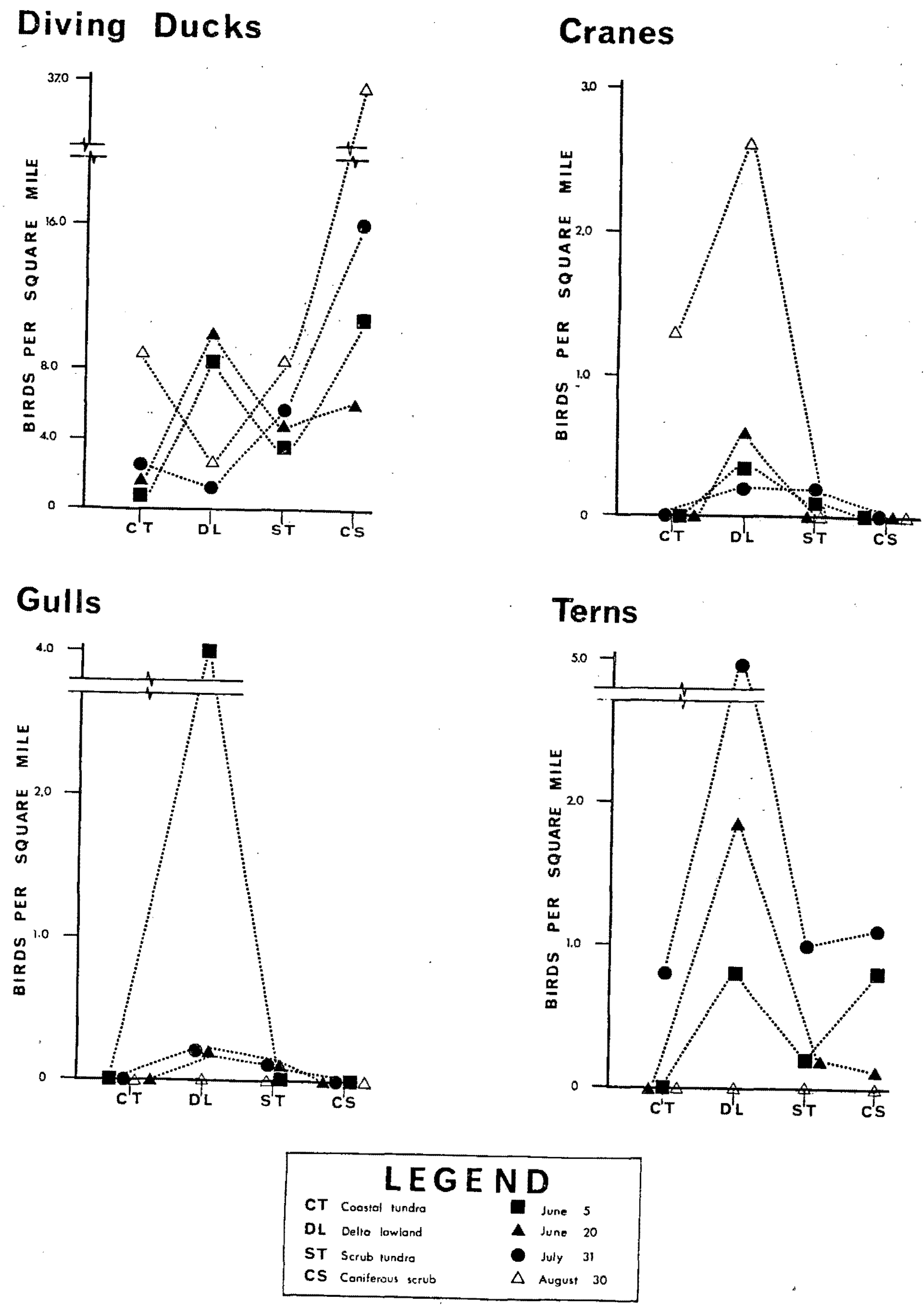

FIGURE 4. Density Indices of Diving Ducks, Cranes, Gulls, and Terns along Sections of the Cross Delta Route.

n = 5, 10; P < 0.01: *vs* coniferous scrub; U = 1.5; n = 5, 8; P < 0.003). The density index for diving ducks on the July 31 survey was significantly higher in the coniferous scrub section than the density indices for the other sections (one-tailed Mann-Whitney: *vs* coastal tundra; U = 3.0; n = 3, 8; P < 0.042: *vs* delta lowlands; U = 0.5; n = 5, 8; P < 0.002: *vs* scrub tundra; U = 19.5; n = 8, 10; P < 0.05).

Productivity

Table 5 presents the numbers of broods of water birds and the numbers of young birds that were recorded on each section of the route during the July 31 survey. These results have also been included in Tables 1 to 4. Density indices for the number of broods were higher on the coniferous scrub and the scrub tundra sections than they were on the delta lowland and the coastal tundra sections. Most of the observed broods were of diving ducks; of these, scaup broods were the most abundant.

Several Arctic Loons and Whistling Swans were observed on nests during the July 31 survey, suggesting that the survey was too early for an adequate determination of productivity for these birds. For this reason, brood counts for these species from the August 30 survey have been included in Table 5. The number of broods of Arctic Loons on the August 30 survey was greatest along the scrub tundra and coniferous scrub sections.

TABLE 5. Numbers of Broods of Water Birds, and Numbers of Young Birds on the July 31 Aerial Survey of the Cross Delta Route, 1975.

SECTION	COASTAL TUNDRA		DELTA LOWLAND		SCRUB TUNDRA		CONIFEROUS SCRUB	
AREA SURVEYED (SQ MI)	7.5		13.1		25.0		20.5	
	NUMBER OF BROODS	NUMBER OF YOUNG	NUMBER OF BROODS	NUMBER OF YOUNG	NUMBER OF BROODS	NUMBER OF YOUNG	NUMBER OF BROODS	NUMBER OF YOUNG
Arctic Loon	1	1	1	1	5	6	3	5
Arctic Loon**			1	1	9	12	7	8
Red-throated Loon					1	1		
Whistling Swan			1	1*	1	1	1	1*
Whistling Swan**					2	6		
Pintail							1	5
Dabbling duck spp.							3	18
Scaup spp.			1	3	2	15	11	51(75)
Oldsquaw	2	13				(50)		
White-winged Scoter					1	9		
Scoter spp.					2	14	1	4
Red-breasted Merganser			1	3				
Diving duck spp.					2	7	3	13
Duck spp.					13	75(12)	3	12
Loon, grebe or duck					1	2		
Sandhill Crane					1	1		
TOTAL	3	14	4	8	29	131	26	109
DENSITY INDEX(/SQ MI)	0.4	1.9	0.3	0.6	1.2	5.2	1.3	5.3

* Possibly more than one young.
** Brood results from August 30 survey.
( ) Denotes large flocks consisting of a mixture of adults and young. They have not been included in totals or densities.

Important Transects for Water Birds

Table 6 identifies for each of the four surveys and for each major water bird group those 10-mi transects on which relatively high density indices were recorded. Transect numbers correspond to the preceding milepost number of each transect (as taken from preliminary alignment sheets [Canadian Arctic Gas Pipeline Limited, 1975]). The locations of transects are shown in Figure 1.

The symbols used in Table 6 represent, for each water bird group during each survey, the comparative position of the density indices for each transect relative to the mean density index. In order to assess the relative importance of those transects on which a water bird group was recorded, they were the only transects included in the calculation of the mean. The important transects for a water bird group on a particular survey were considered to be those with density indices which were at least twice as large as this mean density index.

From Table 6 it is apparent that the important transects for swans and for terns were concentrated in the delta lowland section and the northern portion of the scrub tundra section. Geese and cranes were restricted mainly to this area.

The most widely dispersed groups of water birds were the ducks and the loons; they occurred virtually throughout the area. The dabbling ducks showed no trend towards a concentration of important transects in

TABLE 6. Comparative Density Rankings† of Water Bird Groups on Transects along the Cross Delta Route, 1975.

WATER BIRD GROUP	SURVEY	MEAN DENSITY INDEX*	COASTAL TUNDRA SECTION			DELTA LOWLAND SECTION					SCRUB TUNDRA SECTION										CONIFEROUS SCRUB SECTION							
			290	300	310	320	330	340	350	360	0	10	20	30	40	41	50	60	70	80	90	100	110	120	130	140	150	160
Loons	June 5	1.6																							•			
	June 20	1.0		•		•		•		∇	•		∇	∇		ϕ				•		•				•	•	∇
	July 31	2.2	•	•	•	•	•	•	∇	ϕ	ϕ	ϕ	ϕ	•	∇	•	•	•	•	•	•		∇	•	•	•	•	∇
	August 30	2.5		•	•	•	•		•	•	•	ϕ	∇	∇		N		•	•	∇		∇	ϕ	∇	∇	•	•	•
Swans	June 5	4.7				Φ		•		•						•								•				
	June 20	1.7				•	•		∇	•	ϕ	ϕ	•	•							•		•					
	July 31	3.2			•		•	Φ	•	•	∇	∇		•		•				•			•	∇		•		
	August 30	1.5			∇		∇	∇	∇		•	∇	•	•		N			∇	•			•		•	•	•	
Geese	June 5	2.4				•	•					•	•			ϕ												
	June 20	1.6				•		∇	•		•			∇		•												
	July 31	0.0																										
	August 30	21.1						∇		•						N												
Dabbling Ducks	June 5	2.5				Φ	•								•	∇			•		•		•	•	•			•
	June 20	1.5		•	•	∇		∇	ϕ	∇	∇	•	∇	•		•	•	•		•	∇	•	∇		∇	∇		∇
	July 31	2.9							•	•		Φ	•						•			•		•	•	•	•	∇
	August 30	9.3							•	Φ			•	∇		N					•	•	•		•			
Diving Ducks	June 5	9.9			•	•	•	ϕ	•					•	•	•	•		∇	∇		∇	•	ϕ	•		•	ϕ
	June 20	6.1	•	•	•	•	•		•	Φ	•	•	•	∇	•	∇	•	•	∇	∇	•	•	∇	•	∇	•		ϕ
	July 31	9.2		•	•	•	•	•	•	•	•		•	ϕ		•		•	•	ϕ	ϕ	∇	•	Φ	∇	•	•	Φ
	August 30	30.3			•	•			•				•			N		ϕ		•	•	•	•	Φ	•	•	•	•
Cranes	June 5	0.6				•		•	∇		∇																	
	June 20	0.8				•			•	∇			•															
	July 31	1.3								•	∇																	
	August 30	8.8			•	∇										N												
Gulls	June 5	3.9				Φ	•	•											•						•		•	
	June 20	0.5								∇		•						•								•		
	July 31	0.5					•	•		•						∇												
	August	0.0														N												
Terns	June 5	1.6						•	•	•			•						•						•			ϕ
	June 20	1.3				•	•	ϕ	ϕ	∇			•	•		•							•					•
	July 31	2.3			∇	•	•	∇	ϕ	Φ	•	•	ϕ	•		•		•	•		•		ϕ	•	•	•		
	August 30	0.0														N												

† Explanation of symbols

- • 0.0 < density index ≤ mean
- ∇ mean < density index ≤ 2 x mean
- ϕ 2 x mean < density index ≤ 4 x mean
- Φ 4 x mean < density index
- N transect not surveyed

†† See Figure 1 for the locations of the transects.

* Mean density index (in units of birds per square mile) of those transects on which the group was observed.

any section. The important transects for diving ducks were concentrated in the coniferous scrub section and the southern portion of the scrub tundra section. The important transects for loons were concentrated in two areas. The more important of these areas consisted of the northern portion of the scrub tundra section and the adjoining portion of the delta lowlands; the less important was the northern portion of the coniferous scrub section.

DISCUSSION

Limitations of Aerial Survey Data

Data collected on aerial surveys do not yield absolute densities of water bird populations; the data obtained do, however, yield indices of population density which can be used in comparisons of data.

Martinson and Kaczynski (1967) have shown that aerial survey results generally underestimate both the total number of waterfowl present and the number of different species present. Detectability of these birds varies according to species; it also varies with the observer and the location of the observer in the aircraft. The USFWS has devised means of calculating correction factors for counts of waterfowl species; but because the calculation of such factors requires counts of waterfowl on the ground in conjunction with the results of aerial surveys, these factors could not be obtained for this study. Accordingly, the results presented are probably underestimations of the actual numbers of birds that were present during the surveys. The amount of this underestimation is probably greater for some species than it is for others.

Data were gathered on only four days during the period June 5 to August 30, 1975. Survey times were chosen in order to coincide generally with the periods of spring staging, of nesting, of brood-rearing and moulting, and of fall staging and migration; it is felt that the data are representative of the general use made of the area by water birds during these periods. However, because the breeding cycles of different species of water birds are not in synchrony, the results are more representative of these periods for some species than they are for others. Important changes in the use of the areas by water birds may have occurred between the dates of the surveys. The nature and timing of these changes are not known.

Importance of Sections of the Route to Water Birds

Coastal Tundra Section

There was little apparent water bird activity along the coastal tundra section during the surveys of June 5, June 20, or July 31. Oldsquaws were the most regularly recorded species along this section. This finding agrees with that of Schweinsburg (1974) and Sharp *et al.* (1974) who reported that the Oldsquaw was the commonest water bird along the coastal pipeline route and on numerous tundra lakes on the Yukon North Slope. On June 5 most bodies of water were frozen along this section, which explains the very low numbers of water birds that were recorded at that time.

On August 30, the highest density of Oldsquaws on any survey was found on this section. Schweinsburg (1974) recorded large numbers of this species along nearby coastal areas on September 2, 1971, as well as on other surveys during the month of August. Moulting of large numbers of Oldsquaws takes place along the coast of the Beaufort Sea during July and August (Bartonek, 1969; Bartels, 1973) and migration westward peaks during early September (Gollop and Davis, 1974). It is probable that a small percentage of the Oldsquaws, such as the ones observed on the August 30 survey, use the inland lakes as well as the coastal waters for premigratory staging or as a stopping place during migration.

Delta Lowland Section

The highest density index of water birds on the June 5 survey was recorded in the delta lowlands, where the water areas opened earlier than in the other sections. The species that migrate early were relatively numerous in the delta lowlands; Whistling Swans, Glaucous Gulls, Pintail, and scaup were the most numerous of these species. Snow Geese may have arrived in the delta lowlands and departed by May 20 (when a partial reconnaissance survey was flown). Slaney (1974) indicated that the areas that were heavily used by arriving Snow Geese were located on the eastern edge of the delta lowland section.

Relatively high density indices of water birds on the delta lowland section were also found on the June 20 survey; however, changes were noticed in the relative abundances of many of the water bird groups. Numbers of Whistling Swans and Glaucous Gulls had decreased sharply; those of Pintail and scaup had also decreased, but to a lesser degree (scaup were still the commonest water birds on this section). Large increases occurred in the numbers of White-winged Scoters, and lesser increases occurred in the numbers of Arctic Terns and White-fronted Geese. The first Arctic Loons in this section were seen during the June 20 survey.

Few broods were recorded in the delta lowland section on the July 31 survey. Unusually high water levels in the delta lowlands during June may have delayed nesting so that eggs had not hatched at the time of the survey and broods were not evident (W.R. Koski, pers. comm.). In support of this premise, Koski sighted several broods of ducks along the western part of the delta lowlands section during the August 30 survey, but his data for this section were not recorded due to a tape recorder malfunction. These broods were not included in the results because of the incomplete nature of the data.

On June 20 the geese along the delta lowland section were recorded as pairs or as single birds; these were probably breeding birds. Slaney (1974) indicated that relatively high breeding densities of White-fronted Geese were found on the eastern edge of the delta lowland section. White-fronted Geese usually finish incubation in early July (Barry, 1967) and it is probable that they had moved to brood-rearing areas by the time of the survey.

The highest density indices of loons and of terns that were recorded on any survey were found in the delta lowland section on the July 31 survey. The density index for swans was also high during this survey. Because of the low productivity of loons and swans in this area, the high density indices of these birds probably resulted from an influx of unsuccessfully-breeding adults or of subadult birds. Slaney (1974) reported concentrations of subadult swans moulting in the Mackenzie Delta, and Koski (1975b) estimated that 76% of adult Whistling Swans in the outer Mackenzie Delta in 1975 were non-breeding or unsuccessfully-breeding birds.

The high density indices of terns indicate the importance of the delta lowland section to these birds. Campbell and Weber (1973) found their highest densities of terns in the treed portion of the delta. They found a mean density of 3.1 terns/sq mi there, somewhat lower than the density of 5.0 terns/sq mi recorded along the cross delta route on July 31.

The August 30 survey showed that water birds in the delta lowlands had increased in numbers from the previous three surveys. Sandhill Cranes, dark geese, and dabbling ducks had especially high densities--the highest densities recorded for these groups during the study. Three additional flocks of geese were recorded along this section but outside the aerial transect strip.

The large increase in the numbers of dabbling ducks in this area results from an increase in the numbers of American Wigeon. The increase in the numbers of Sandhill Cranes occurred to the west of Shallow Bay, within the area where Campbell and Weber (1973) observed a tenfold increase in the density of Sandhill Cranes in early September, 1972.

Late summer staging by large numbers of Black Brant, White-fronted Geese, and Snow Geese in the outer Mackenzie Delta is well known (Godfrey, 1966; Barry, 1967; Campbell and Weber, 1973; Slaney, 1974; Schweinsburg, 1974). Snow Geese had not arrived in the delta from their breeding areas on Banks Island and the Anderson River Delta by August 30, and the dark species of geese were the only geese sighted on the August 30 survey. Koski and Gollop (1974) and Koski (1975a, 1975b) indicated that concentration areas for Snow Geese and White-fronted Geese lie along the cross delta route. In September, 1975, the areas around Shallow Bay were extensively used by these birds (Koski, 1975b).

Based upon the results of the four surveys in 1975, the delta lowland section appears to be the most important section of the cross delta route for water birds. On at least one survey, each major group of water birds attained its highest density index along the delta lowland section. For this reason it is probably important to all water bird populations at some time during the summer season.

Scrub Tundra Section

Numbers of water birds along the scrub tundra section were low on the June 5 survey. Most of the larger lakes had extensive ice cover at this time, and only the smaller ponds were free of ice. At this time Oldsquaws and White-fronted Geese were the two commonest species present. Because most observations of White-fronted Geese were of pairs, densities of this species were probably representative of breeding densities along this section. The Oldsquaws were probably still in migration at this time--they were moving eastward past Komakuk on the Yukon coast on June 5, 1975 (Richardson *et al.*, 1976).

The number of Oldsquaws along this section on the June 20 survey was similar to that of the earlier survey, but the number of geese had decreased. Whistling Swans and loons (particularly Arctic Loons) showed the most marked increases on the June 20 survey. Density indices of both are probably representative of breeding densities (observations were mostly of paired or single birds). These density indices, and the number of broods recorded, both indicate the importance of the scrub tundra section to breeding loons and swans. The density index of swans (1.2/sq mi) is similar to the average breeding densities in the northern Mackenzie Delta area (1.2-1.6/sq mi) for the years 1948-1954 (Martel, in prep.). The density index of loons (0.6/sq mi) is similar to that reported by Campbell and Weber (1973) (0.5/sq mi) in their study area at Kittigazuit Bay.

The July 31 survey indicated the importance of the scrub tundra section for the production of young ducks. Many of the broods of ducks could not be identified; of those that could be identified, Oldsquaws were the most numerous, followed by scoters and scaup.

Swans were present in the scrub tundra section on the July 31 survey in numbers similar to those of the June 20 survey. Arctic Loons, Pintails, scoters, and Arctic Terns showed the greatest increases in abundance. The Pintails occurred as flocks of adult birds; they were probably in the process of moulting. The density index of Arctic Loons (for both this section and the delta lowland section)(2.1/sq mi) was approximately twice the maximum density recorded by Campbell and Weber (1973). This high density probably results from the appearance of adult birds with their young on the bodies of water; in June many of these adults would have been on nests where they could not readily be detected from the air.

Numbers of loons along the scrub tundra section were still high on the August 30 survey (unlike the delta lowlands, where the numbers decreased sharply). Numbers of swans also remained high, but Pintails and Oldsquaws showed marked decreases, presumably a result of southward migration by Pintails and a westward movement by Oldsquaws along the Beaufort Sea coast. Numbers of American Wigeon and scaup increased markedly, although American Wigeons were found at a much higher density in the delta lowland section and scaup were found at a much higher density in the coniferous scrub section.

Results of the four surveys indicate that the scrub tundra section is important as a nesting area for Arctic Loons, Whistling Swans, White-fronted Geese and some species of diving ducks. This section is also important during late summer for Arctic Loons, Whistling Swans, and some duck species. However, the importance of this area to the various water birds is often intermediate between that of the delta lowlands section and that of the coniferous scrub section.

Coniferous Scrub Section

During the June 5 survey, diving ducks were relatively numerous along the coniferous scrub section. The most numerous diving ducks were scaup and scoters. The coniferous scrub and delta lowland sections, which are the first sections to open in the spring, appear to be the most important sections of the cross delta route for diving ducks arriving in the vicinity of the Mackenzie Delta. Arctic Terns appeared to be in migration through the coniferous scrub section at this time.

Overall numbers of water birds had decreased by the June 20 survey because of a decrease in the numbers of scoters, scaup, and terns. Dabbling ducks (Mallards and Pintails) showed an increase in numbers at this time. Although their numbers were not large, their occurrence as pairs or single birds indicated that these birds probably nested along this section.

The number of broods recorded along the coniferous scrub section on the July 31 survey indicates the importance of this section as a nesting and brood-rearing area. Broods of diving ducks, particularly scaup, were the most numerous, but broods of dabbling ducks and Arctic Loons were also present. Numbers of adult or subadult Whistling Swans, Arctic Loons, and Arctic Terns in the coniferous scrub section showed a marked increase at this time.

Results of the August 30 survey showed a further large increase in the numbers of scaup in the coniferous scrub section, and hence in the total numbers of water birds present. This increase was caused by the sighting of a large flock of 700 scaup on an unnamed lake northwest of Travaillant Lake.

Numbers of loons also increased at this time. A simultaneous decrease in loons in the delta lowlands was noted, suggesting a net movement south. Salter (1974b) also reported a southerly autumn movement of loons in the Mackenzie Valley. A westward movement by loons along the Beaufort Sea coast has also been recorded (Gollop and Davis, 1974).

The coniferous scrub section is important primarily to diving ducks (particularly scaup). It is of particular importance during the periods of brood-rearing and moulting and of fall staging and migration, when the densities of scaup along this section were the greatest that were recorded for any species during this study.

Comparison of Cross Delta and Circum-Delta Routes

In 1973 Salter (1974a) conducted three aerial surveys along those parts of the circum-delta route that run from Fort McPherson to Thunder River and from Taglu Field on Richards Island to the junction of the Richards Island and Prudhoe Bay supply lines. These surveys covered that part of the circum-delta route that contains water bird habitat. It is thus possible to compare the water bird populations along the cross delta and circum-delta routes.

In comparing the two routes there are two possible sources of error for which corrections could not be made. It has been assumed that the abilities of the different observers were comparable and that the detectabilities of water birds in different areas were the same. In fact, however, the detectability of water birds in the delta lowlands is probably lower than other areas because of the large amount of emergent vegetation present (W.R. Koski, pers. comm.). The magnitudes of possible errors due to these assumptions are unknown.

Differences Between Years

Before the results from surveys of the two routes can be compared, annual variations in water bird numbers must be considered. The numbers of water birds, particularly ducks, in northern areas are known to fluctuate considerably from year to year (Hansen and McKnight, 1964). This fluctuation is to some extent correlated with drought conditions on the prairies. Martel (in prep.) supports this correlation with data from the Mackenzie Delta region.

The only data which are directly comparable between years are those of the USFWS, which conducted aerial surveys during early June of both 1973 and 1975 over the same series of transects in the Mackenzie Delta (Voelzer and Jensen, 1973, 1975). In 1973 they recorded density indices of 4.2 dabbling ducks/sq mi and 9.2 diving ducks/sq mi. In 1975 their density indices were 1.9 dabbling ducks/sq mi and 7.4 diving ducks/sq mi. The ratios of the numbers of birds recorded in 1975 to the numbers recorded in 1973 were thus 0.44 for dabbling ducks and 0.80 for diving ducks.

The USFWS data show that there were greater numbers of ducks present in their study area in the Mackenzie Delta during early June of 1973 than there were during early June of 1975. If it is assumed that these ratios can be applied to regions adjacent to the Mackenzie Delta for the early June period, then the 1973 data obtained by Salter for the circum-delta route can be multiplied by the above-mentioned ratios to correct for the differences in years.

Table 7 lists the density indices for ducks in early June along both routes and the results after corrections have been made for the differences between years. (The scrub tundra section for the circum-delta route is considered to be that portion of the Richards Island supply line that runs from Taglu Field to the south end of Sitidgi Lake. The coniferous scrub section of the route is considered to be the portion that runs from Fort McPherson to Thunder River and the portion that runs from the south end of Sitidgi Lake to a junction with the Fort McPherson-Thunder River section.) When the 1973 data have been corrected for differences between years, the results indicate that in early June the cross delta route supported slightly higher densities of ducks along the scrub tundra and the coniferous scrub sections than did the circum-delta route.

The assumption that the ratios of USFWS results for the Mackenzie Delta can be applied to areas near the delta has been made only for the numbers of ducks recorded on the early June surveys; comparable data for the overall numbers of water birds and for the later survey times are both lacking. However, the larger number of ducks recorded in the

TABLE 7. Density Indices of Ducks in Early June on Sections of the Circum-Delta and Cross Delta Routes.

	DENSITY INDEX (DUCKS/SQ MI)		
	CIRCUM-DELTA		CROSS DELTA
	1973†	1973 DATA CONVERTED TO 1975 VALUES††	1975
SCRUB TUNDRA			
Dabbling ducks	0.7	0.3	0.6
Diving ducks	3.7	3.0	3.6
CONIFEROUS SCRUB			
Dabbling ducks	0.7	0.3	0.8
Diving ducks	11.4	9.1	11.3

† From Salter (1974a).

†† 1973 results have been converted by multiplying them by the ratio of ducks recorded in 1975 to those in 1973 by USFWS for identical transects in the Mackenzie Delta.

delta in early June of 1973 suggests that the numbers of ducks (and presumably of total water birds) were larger in the vicinity of the delta throughout the summer of 1973 than they were in 1975. The presumed higher densities during 1973 should be borne in mind when comparing data which could not be corrected for differences between years in the numbers of birds present.

Diferences Between Routes

Table 8 lists the density indices of the major water bird groups that were recorded on surveys of the cross delta and circum-delta routes during three time periods: early June, mid- to late June, and early August. Results are presented for the scrub tundra and coniferous scrub sections--the only sections of the two routes which are directly comparable. Results have not been corrected for the known differences between years.

On the scrub tundra section, results from the two routes were similar for the early June surveys. However, for the mid- to late June surveys and the early August surveys, the density indices for the cross delta route were considerably higher than for the circum-delta route. The groups which contributed most to this difference were ducks and swans during both periods and loons during early August.

For the coniferous scrub section, density indices were similar on both routes for the two June survey periods. In early August, however,

TABLE 8. Density Indices* of Water Birds on Sections of the Circum-Delta Route During 1973† and the Cross Delta Route during 1975.

	JUNE 1-5		JUNE 20-JULY 2		JULY 31-AUGUST 2	
	CROSS DELTA 1975	CIRCUM-DELTA 1973	CROSS DELTA 1975	CIRCUM-DELTA 1973	CROSS DELTA 1975	CIRCUM-DELTA 1973
SCRUB TUNDRA SECTION						
Loons	-	0.1	0.6	0.5	2.5	0.3
Swans	0.1	0.1	1.2	0.5	1.4	0.3
Geese	1.0	0.6	0.4	-	-	0.4
Dabbling ducks	0.6	0.7	0.7	-	1.6	-
Diving ducks	3.6	3.7	5.2	1.6	5.9	1.5
Total ducks	4.4	4.5	6.1	1.9	13.0	6.2
Cranes	0.1	-	-	-	0.2	-
Gulls	0.0**	0.1	0.1	0.1	0.1	0.1
Terns	0.2	0.1	0.2	0.1	1.0	0.4
Total water birds	5.8	5.5	8.9	3.1	19.0	7.7
CONIFEROUS SCRUB SECTION						
Loons	0.2	1.0	0.4	1.1	1.5	1.3
Swans	0.1	0.2	0.2	0.2	0.8	0.4
Geese	-	-	-	-	-	-
Dabbling ducks	0.8	0.7	1.5	0.3	1.7	0.4
Diving ducks	11.3	11.4	6.3	7.6	16.4	2.8
Total ducks	12.6	13.6	7.9	9.6	20.0	7.2
Cranes	-	-	-	-	-	-
Gulls	0.2	0.9	0.0	0.3	-	0.5
Terns	0.8	0.1	0.2	0.0	1.1	-
Total water birds	13.9	15.9	8.8	11.3	23.8	10.5

* Density indices are in units of birds/mi^2.

† From Salter (1974a).

** Less than 0.05.

the density index of water birds for the cross delta route was twice as large as that of the circum-delta route. The major component of this increase was the large increase in the number of diving ducks present along the cross delta route in early August--a time when the numbers of diving ducks decreased along the circum-delta route.

Results of aerial surveys along a proposed pipeline route are greatly affected by areas of local concentrations within the 1/4 mi corridor that is surveyed. Minor route changes to avoid such concentration areas can cause considerable differences in the densities of water birds along a pipeline route. A notable example is a small unnamed lake northwest of Travaillant Lake on the cross delta route which was heavily utilized by diving ducks at the times of the July and August surveys. The numbers of water birds found on this lake served to raise considerably the importance to water birds of the coniferous scrub section of the cross delta route in comparison to the coniferous scrub section of the circum-delta route.

For the two sections of the two routes which are directly comparable, the cross delta route supports similar or greater numbers of water birds (according to season) than does the circum-delta route. The cross delta route also contains the delta lowlands section--an area that is important to water birds. Although the circum-delta route also contains a section to the west of the Mackenzie Delta, this section is well-drained with few lakes and contains little favourable water bird habitat (Poston *et al.*, 1973).

In order to compare the numbers of birds present along the two routes, the uncorrected density indices for each section have been averaged over the three time periods and multiplied by the number of miles of proposed pipeline in each section of the two routes (as given in Tull [1975]). This calculation indicates that 1.6 water birds were present along the cross delta route for every water bird present along the circum-delta route. There are two sources of bias in the above result which must be borne in mind--the data have not been corrected for the differences in numbers of water birds during the two years when the surveys were conducted (a bias that apparently tends to inflate the total numbers of birds along the circum-delta route in comparison with the cross delta route) and the section of the circum-delta route from Fort McPherson to the Yukon North Slope has been omitted from the overall results (a bias that tends to deflate the total numbers of birds along the circum-delta route in comparison with the cross delta route). (Water birds on the Yukon North Slope have been omitted from the calculations for both routes.) Of the two biases, the lack of a correction for the differences between years is probably the more important; this suggests that the calculated ratio of 1.6:1 is probably lower than the actual ratio.

The results suggest that there are more water birds present along the cross delta route than are present along the circum-delta route during the period from early June to early August. The large numbers of geese that are known to stage in the outer Mackenzie Delta during August and September (Koski, 1975b) have not been considered in reaching this conclusion. These numbers of geese further emphasize the importance of the cross delta route to water birds.

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A P P E N D I C E S

APPENDIX 1. Numbers and Densities of Birds Recorded on Each 10-Mile Transect During Aerial Surveys of the Cross Delta Pipeline Route, 1975.

This appendix consists of a computer printout which is stored in the library of the Edmonton branch office of LGL Limited. This appendix is available upon request.

APPENDIX 2. Scientific Names of Birds Identified During the 1975 Study.

Common Loon	*Gavia immer*
Arctic Loon	*Gavia arctica*
Red-throated Loon	*Gavia stellata*
Whistling Swan	*Olor columbianus*
Canada Goose	*Branta canadensis*
Black Brant	*Branta nigricans*
White-fronted Goose	*Anser albifrons*
Mallard	*Anas platyrhynchos*
Pintail	*Anas acuta*
Green-winged Teal	*Anas crecca*
American Wigeon	*Anas americana*
Greater Scaup	*Aythya marila*
Lesser Scaup	*Aythya affinis*
Common Goldeneye	*Bucephala clangula*
Oldsquaw	*Clangula hyemalis*
Common Eider	*Somateria mollissima*
King Eider	*Somateria spectabilis*
White-winged Scoter	*Melanitta deglandi*
Surf Scoter	*Melanitta perspicillata*
Black Scoter	*Melanitta nigra*
Red-breasted Merganser	*Mergus serrator*
Rough-legged Hawk	*Buteo lagopus*
Bald Eagle	*Haliaeetus leucocephalus*
Marsh Hawk	*Circus cyaneus*
Gyrfalcon	*Falco rusticolus*
Willow Ptarmigan	*Lagopus lagopus*
Rock Ptarmigan	*Lagopus mutus*
Sandhill Crane	*Grus canadensis*
Pomarine Jaeger	*Stercorarius pomarinus*
Parasitic Jaeger	*Stercorarius parasiticus*
Long-tailed Jaeger	*Stercorarius longicaudus*
Glaucous Gull	*Larus hyperboreus*
Mew Gull	*Larus canus*
Bonaparte's Gull	*Larus philadelphia*
Arctic Tern	*Sterna paradisaea*
Short-eared Owl	*Asio flammeus*
Common Raven	*Corvus corax*

CHAPTER IV

GROUND SURVEYS OF TERRESTRIAL BREEDING BIRD POPULATIONS ALONG THE CROSS DELTA GAS PIPELINE ROUTE, YUKON TERRITORY AND NORTHWEST TERRITORIES, JUNE AND JULY, 1975

L.A. PATTERSON
W.R. KOSKI
C. ERIC TULL

ABSTRACT

Ground transect surveys of terrestrial birds were conducted between June 8 and July 9, 1975 at nine sites located on the cross delta route of the proposed Arctic Gas pipeline.

The objectives of the study were (1) to survey samples of the major habitats that occur at sites along the cross delta route, (2) to determine for each habitat and each site sampled, the numbers and densities of the species of birds present, and (3) to determine habitat preferences of these species.

Twenty-one habitats were sampled; 14 had total samples greater than 1000 yd and six had total samples greater than 10,000 yd. Eleven habitats were combined into six habitat groups and habitat preferences of common species were determined for each of these groups.

Closed deciduous scrub contained the greatest density of terrestrial birds. Tree Sparrows, redpolls, and Savannah Sparrows were the commonest species in this habitat; Yellow Warblers and Fox Sparrows showed the greatest preference for this habitat.

Based on the densities of birds recorded in the habitat groups deciduous scrub is considered to be the most important habitat group along the cross delta route in terms of the numbers of terrestrial birds which it supports.

ACKNOWLEDGEMENTS

We would like to thank W.W.H. Gunn, W.J. Richardson, and A.N. Wiseley for their assistance in the preparation of this report. Special thanks also go to L.D. Roy who, together with W.R. Koski, conducted the ground surveys during which the data for this report were collected.

The Arctic Gas Biological Report Series, of which this report is a part, is a series of consultant project reports presenting data based on field and laboratory studies. The format and presentation vary among reports in accordance with the authors' discretion.

The data for this work were obtained as a result of investigations carried out by LGL Limited, Environmental Research Associates for Canadian Arctic Gas Study Limited. The text of this report may be quoted provided the usual credits are given.

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INTRODUCTION

The proposed Prudhoe Bay supply line of the Arctic Gas pipeline runs eastward along the Alaska and Yukon North Slope to Conglomerate Creek. At this point two alternative routes have been proposed. The circum-delta route turns southward along the west side of the Mackenzie Delta. Once south of the Mackenzie Delta, the route runs eastward, crosses the Mackenzie River near Arctic Red River, and proceeds to a point west of Travaillant Lake where it meets the proposed Richards Island supply line. The latter supply line originates at Taglu Field on Richards Island and proceeds southward along the east side of the Mackenzie Delta to the above-mentioned junction. From this junction the route runs eastward to Thunder River, then southeastward up the Mackenzie River valley (Figure 1).

The recently-proposed cross delta route is an alternative to the circum-delta route. This route proceeds eastward along the Yukon North Slope and then crosses Shallow Bay and the outer Mackenzie Delta. On the southeast corner of Richards Island the cross delta route joins with a supply line which originates at the Taglu field. From this junction, the proposed cross delta route runs southeastward to Thunder River and then follows the same route up the Mackenzie River as does the circum-delta route (Figure 1). Both routes include a spur which runs westward from the Parsons Lake field to the main route.

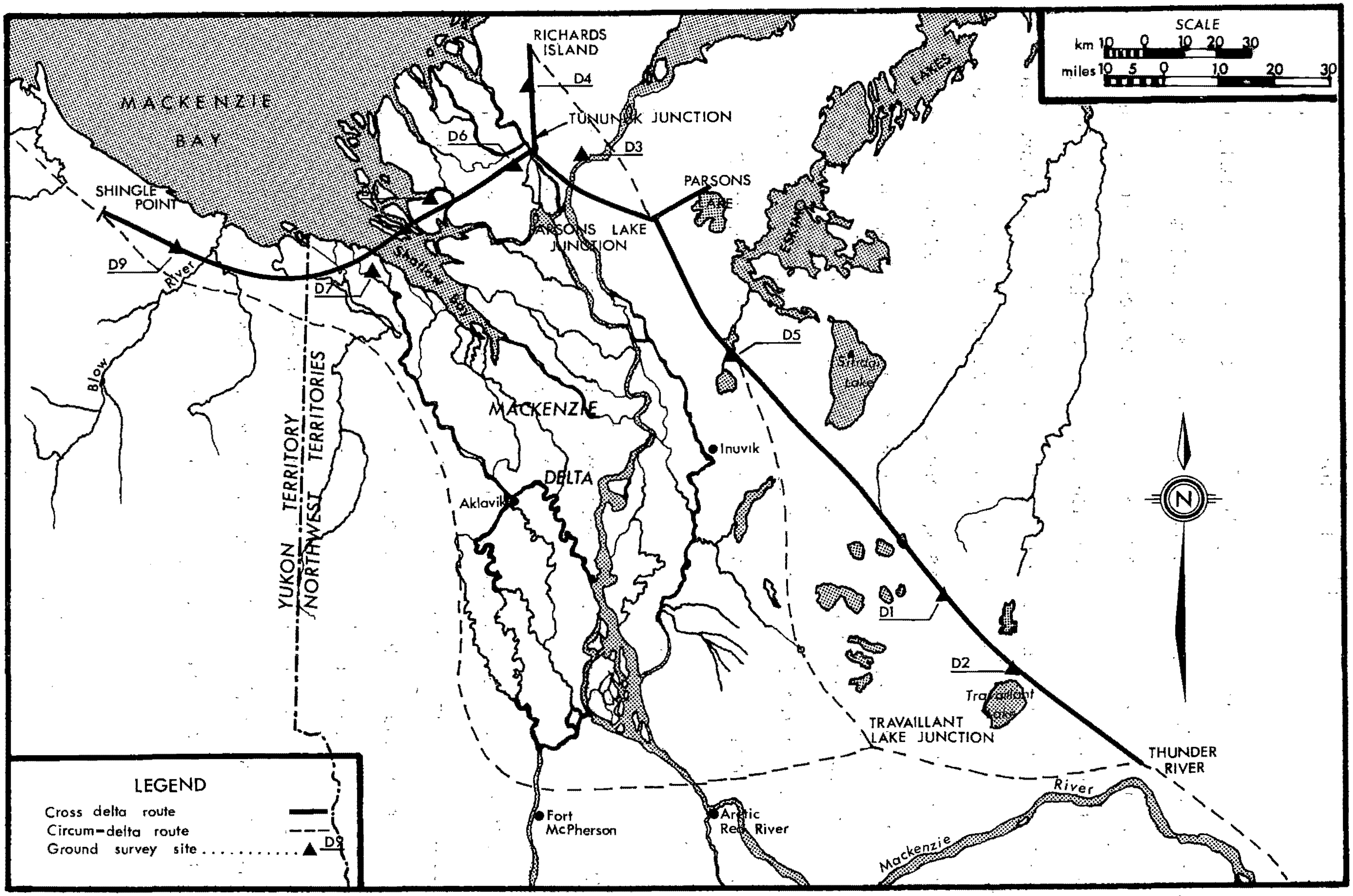

FIGURE 1. Cross Delta Route and Location of Ground Survey Sites, June 8 - July 9, 1975.

The cross delta route passes through two major vegetation zones, tundra and boreal forest (Rowe, 1972). The boreal forest zone along the route includes portions of the forest-tundra transition (Richards Island) and the lower Mackenzie (Travaillant Lake) subsections of the boreal forest zone, as defined by Rowe (1972).

From 1971 to 1974 LGL Limited has conducted a series of ornithological studies to collect both quantitative and qualitative data on populations of birds in habitats along the route of the proposed Mackenzie Valley gas pipeline. To date four studies have been conducted along the proposed route through Alaska and the Yukon Territory (Schweinsburg, 1974; Salter and Davis, 1974; Tull *et al.*, 1974; Koski, 1975) and three have been conducted along the proposed route through the Mackenzie Valley (Salter and Davis, 1974; Tull *et al.*, 1974; Ward, 1975).

These studies concentrated on the circum-delta route; as a result, only a small amount of data was available that pertained to the recently-proposed cross delta route. The purpose of the present study was to conduct surveys (similar to the above-mentioned studies) of the breeding bird populations in the major habitats along the cross delta route.

The specific objectives of this study were the following:

1) to conduct transect surveys at sites located on or adjacent to the proposed cross delta route in habitats considered to be representative of the area;

2) to determine for each survey site and for each habitat type:

   a) the numbers and density indices of all the birds present,

   b) the species of birds present, and

   c) the numbers and density indices of each species of bird present; and

3) to determine habitat preferences (if such preferences exist) of the more common species in the vicinity of the cross delta route.

The data from this study can be used to assess the potential impact of the proposed Arctic Gas pipeline upon populations of birds that use these habitats. The data, when combined with similar data from previous studies, will provide an information base that can be used to develop environmental recommendations with respect to the pipeline.

METHODS

Selection of Survey Sites

Transect surveys were conducted at sites that were distributed along the length of the proposed cross delta route (Figure 1). Individual sites were selected to meet the following criteria:

1. they were on or adjacent to the right-of-way of the proposed cross delta route,

2. they were accessible by float-equipped aircraft, and

3. they included portions of habitat that were considered to be representative of the area.

Scheduling of Transect Surveys

Transect surveys were conducted at a number of sites during June and early July--the breeding season for terrestrial birds. Unlike previous years when field crews of four observers were employed, the field crew in 1975 consisted of only two observers. Because only a limited amount of time in a day is available for optimal bird counts (early to mid-morning), this use of two observers reduced the amount of habitat that could be surveyed during a day. In order to ensure that the numbers of yards surveyed at each site were comparable to the numbers of yards surveyed at sites in previous studies, and in order to ensure that large samples of habitats characteristic of each site were surveyed, surveys were conducted for two to four days at each site.

Transect Survey Method

As in previous years a transect survey method (as described by Kendeigh [1944]; Udvardy [1957]; Enemar and Sjöstrand [1967, 1970]; and Emlen [1971]) was used to survey terrestrial birds in the study area. Such a method was used because it allowed the sampling of large sections of habitat over a large geographical area during a short period of time. The possible biases in the transect survey method are discussed in Richardson and Thompson (1974), Richardson and Gollop (1974), and Richardson and Courtney (1975).

The survey technique used by LGL Limited is outlined in detail by Salter and Davis (1974). The following gives a brief description of the technique and describes the modifications that were implemented in 1975.

Two field personnel surveyed transects that were 20 yd[1] in width and 1000 yd in length. As in previous years, most of the transects were straight lines but some were plotted to avoid bodies of water and

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[1]British units of measurement have been used in this study to maintain consistency within the continuing series of ground survey studies.

land forms. The survey crew walked 20 yd apart during the survey. One observer recorded information that pertained to each bird sighting; the other observer recorded information pertaining to habitat, to weather conditions, and to distance travelled along the transect.

All surveys were conducted between 04:45 and 11:30 MDT each day. This period corresponded with the period of peak activity of songbirds in the area (Richardson and Gollop, 1974; Richardson and Courtney, 1975). By conducting surveys during the period of peak activity, detectability was high, and the precision of the survey was increased (Enemar, 1959; Svensson, 1970).

Bird Data

During transect surveys, the following data pertinent to each individual bird or flock of birds that was detected were recorded:

1. the species,
2. the number of individuals detected,
3. the distance along the transect at which the bird was first detected,
4. the perpendicular distance from the centre of the transect to the bird when it was first detected,
5. the type of habitat in which the bird was first detected,
6. the manner by which the bird was first detected (i.e., detected by sight, song, or call),
7. any subsequent vocalization (i.e., a call note or song),
8. the behaviour of the bird (when first detected and subsequently),

9. when possible, the sex of each bird detected, and
10. when possible, the age of each bird detected.

All birds seen or heard on or over the transects were recorded. Those recorded within 10 yd of the centre of the transect were noted as being "on-transect"; the numbers of these birds were considered to be representative of the actual birds present and these numbers have hence been used to calculate density indices. Those birds recorded in the area from 10 to 40 yd from the centre of the transect, a distance within which habitats could be accurately classified, were noted as being "off-transect". The numbers of these birds were not considered to be as representative of the actual birds present as were the "on-transect" estimates, and the numbers have hence been used only for the calculation of habitat preferences where interspecific comparisons need not be made.

Habitat Classification

Habitats were classified according to the key designed by Fosberg (1967). Some of the basic terms used in the Fosberg key were redefined in 1974 to permit easier and clearer classification of habitat types (Koski, 1975) and these definitions were used in 1975.

Closed habitats were defined as those in which the dominant plant species either touched or had a crown cover value of at least 90%. Open habitats were defined as those in which the dominant species had a crown cover value of less than 90% but greater than 30%. Scattered habitats were defined as those in which the dominant species had a crown cover value of less than 30%.

In all classifications, the dominant species was defined as the tallest species of plant with a crown cover value of at least 20%. Woody plants greater than 15 ft in height were defined as trees, those 1.5 to 15 ft in height were defined as shrubs. The habitats that were dominated by shrubs greater than 1.5 ft in height were called scrub habitats; habitats that contained woody plants less than 1.5 ft in height were called dwarf scrub habitats.

The following data were recorded for each habitat encountered along the transects (that extended for at least 20 yd):

1. the number of yards of habitat,
2. the type of habitat,
3. the species of trees present,
4. the species of shrubs present,
5. the species of herbs present,
6. the average height of the highest layer of vegetation,
7. the average distance between trees (when applicable), and
8. the percentage of the ground covered by the shrub layer (when applicable).

Meteorological Data

At the beginning of each transect survey, the following information was recorded:

1. the time,
2. the temperature (°F),
3. the wind speed,
4. the cloud cover (in tenths),
5. the presence and type of any precipitation,
6. the percentage of snow cover on the ground, and
7. the percentage of ice cover on the nearby bodies of water.

Treatment of Data

Data were recorded in field books and were later transferred to data sheets for computer analysis.

Data collected solely through use of transect methods do not yield absolute densities of populations of breeding birds (Richardson and Courtney, 1975). If, however, large amounts of habitat are sampled, the data obtained during transect surveys do provide indices of population density which can be used in comparisons of data.

Both sitting and flying birds were included in the calculation of density indices. Because species such as Pectoral Sandpipers, Semipalmated Sandpipers, and Lapland Longspurs engage in aerial territorial displays, the true nature of bird densities in areas where such species occur can only be gained through the inclusion of flying birds in the calculation of density indices. However, Richardson and Thompson (1974) and Richardson and Courtney (1975) indicate that the inclusion of flying birds in the calculation of density indices for forest or scrub habitats may result in overestimates of the number of birds present, especially in the case of species that are highly mobile. It may also result in faulty habitat associations, e.g., when a bird is recorded flying over a habitat in which it does not normally land.

In calculating indices of density, flocks of five or more birds were omitted because such flocks were most probably composed of non-breeding birds.

Because a large number of the Common and Hoary Redpolls could not be identified to the species level but only to the species group--"unidentified redpolls"--all redpolls have been grouped to form the category "redpolls".

In calculating the number of species recorded in a habitat or at a site, a bird identified only to the "species group" level was counted only if no bird had been identified to the species level in that particular group of species.

Non-parametric statistical tests were used in comparing data in order to avoid assumptions concerning the distribution of the data. The Mann-Whitney U-test, the Kruskal-Wallis one-way analysis of variance, and the Spearman Rank correlation (Siegel, 1956) were used when appropriate. In applying these tests, the only samples of habitat that were used were those for which more than 500 yd had been surveyed at a given site on a given day. A further stipulation, that there be at least three such samples in each category to be tested, was also applied.

Habitat preferences of the more common species (those which formed more than 2% of the total number of birds seen "on-transect") were calculated using all sightings of sitting birds that were recorded both "on" and "off" transect in habitats that could be identified. Habitat preferences were calculated by taking the above density index for a given habitat as a percentage of the sum of the density indices for all of the habitats which satisfied the criteria for statistical testing. One of the "more common" species, the Northern Phalarope, was not included in the calculation of habitat preferences because of the small proportion of sitting birds to flying birds that was recorded for this species.

If a species of bird did not show a habitat preference, but was found in equal densities in each of N habitats, then the expected preference index for each habitat would be 100/N%. A preference index for a habitat of 200/N% was taken to indicate a preference by a species for that particular habitat.

RESULTS

Sites and Habitats Sampled

Between June 8 and July 9, 1975 a total of 134,348 yd of 22 habitat types was sampled at nine sites. The sites were located as far west as the Blow River, Yukon Territory, as far north as Richards Island, N.W.T., and as far south and east as Travaillant Lake, N.W.T. Table 1 lists the positions of the sites, the dates on which each site was surveyed, and the weather conditions during the surveys. Appendix 1 presents site maps which illustrate the routes of all transects at each site.

Table 2 lists the number of yards of each habitat that was sampled at each site. The number of yards of each habitat sampled during the study varied from a high of 18,736 yd of open deciduous scrub to a low of 21 yd of snow. Over 10,000 yd were surveyed in each of the following six habitats:

1. open deciduous scrub (080)--18,736 yd
2. closed deciduous scrub (035)--18,222 yd
3. open mixed scrub (306)--16,253 yd
4. open deciduous dwarf scrub (084)--15,094 yd
5. open dwarf scrub/dry sedge tundra (228)--14,148 yd
6. sedge marsh (127)--11,820 yd

TABLE 1. Ground Survey Site Locations, Survey Dates, and Weather Conditions† During Surveys, June 8-July 9, 1975.

SITE	LATITUDE N	LONGITUDE W	MONTH	DAY	TIME MDT	TEMPERATURE (°F)	WIND MPH	CLOUD COVER 10ths	% SNOW COVER	% ICE COVER
D1 Fish Trap Lake	67°58'	132°15'	6	8	05:00-09:28	40-45	5-12	0-1	0	80
				9	04:58-08:45	44-44	5	6-9	0	80
				10	05:06-08:30	37-40	3-8	1-7	0	75
D2 Travaillant Lake	67°46'	131°45'	6	12	04:52-08:57	39-40	2	10	0	35
				13	04:38-08:50	39-40	1-2	0	0	35
D3 Bar C	69°05'	134°34'	6	14	04:57-11:05	44	10	4-6	2	90
				15	04:50-08:15	40	15	2-10	2	85
				16	04:40-08:40	37-38	5	5-11*	2	85
				17	04:45-07:40	54	6-8	0-1	2	85
D4 Camp Farewell	69°26'	135°55'	6	25	06:43-10:00	45-46	3	0-11	2	60
				26	06:57-10:48	42-46	1	11	2	60
				27	05:34-08:35	51	2-3	7-10	2	50
D5 Noell Lake	68°33'	133°35'	6	28	05:35-10:32	54	4-10	7	1	35
				29	07:06-09:41	48-53	8-9	1-4	1	10
				30	05:32-08:32	62	1-2	8-10	1	0
D6 Langley Channel	69°04'	135°00'	7	1	05:15-09:42	55	4	2-5	0	0
				2	05:50-08:07	50	8	10	0	0
D7 West Channel	68°48'	136°00'	7	4	05:11-08:50	58	4-6	3-8	0	0
				5	06:50-11:10	52	4-5	5-9	0	0
D8 Middle Channel	68°58'	135°30'	7	6	05:28-10:52	42	1	10	0	0
				7	05:05-10:35	50-60	2	0	0	0
D9 Blow River	68°50'	137°20'	7	8	05:52-11:05	53-57	1-8	0-4	2	0
				9	05:07-09:17	51-60	5-8	1-8	2	0

† there was no precipitation during any of the surveys

* 11-indicates heavy fog

TABLE 2. Number of Yards of Each Habitat Type Surveyed at Each Site On the Cross Delta Route, June 8-July 9, 1975.

HABITAT	SITE									TOTAL
	D1	D2	D3	D4	D5	D6	D7	D8	D9	
304†--Open Mixed Forest		88								88
050 --Open Spruce-Lichen Muskeg		382								382
099 --Scattered Spruce-Lichen Muskeg	3089	1922			108					5119
100 --Scattered Spruce-Moss Muskeg	165	940								1105
305 --Closed Mixed Scrub	986	2055			22					3063
306 --Open Mixed Scrub	9980	5079			1194					16253
026 --Closed Evergreen Scrub		227								227
079 --Open Evergreen Scrub	4133	2831			484					7448
035 --Closed Deciduous Scrub	77	155	3751	785	1601	2869	3615	5369		18222
080 --Open Deciduous Scrub	455	186	6150	2447	4614		2188	2653	43	18736
047 --Closed Deciduous Dwarf Scrub			1370		469				38	1877
084 --Open Deciduous Dwarf Scrub			3316	2008	9700				70	15094
126 --Wet Sedge Tundra			1287	1108	86				3522	6003
127 --Sedge Marsh						5945	3163	2690	22	11820
144 --Broad-leaved Submerged Meadow								474		474
231 --High-Low Centre Polygons			1261	2888					2281	6430
137 --Moss Meadow									97	97
229 --Lichen-Heath Community			199		387					586
227 --Dry Sedge Tundra			1022	1561					4245	6828
228 --Open Dwarf Scrub/Dry Sedge Tundra			4636	6091	1937				1484	14148
301 --Water								327		327
308 --Snow			21							21
TOTAL	18885	13865	23013	16888	20602	8814	8966	11513	11802	134348

† habitat classification number

These habitats represent 70.1% of the total number of yards of habitat that was sampled during this study.

Appendix 2 contains a brief description of each habitat that was encountered during this study and Appendix 3 lists the species of plants that were identified within these habitats. No attempt was made to define plant communities beyond the Fosberg (1967) classification. Greater detail of the plant community structure in the study area can be obtained by referring to Hettinger *et al.* (1973), Reid and Janz (1974), Reid (1974), Slaney (1974), and Reid and Calder (1975).

Total Density Indices

Table 3 lists the total numbers of birds and the corresponding density indices that were recorded at each site. The greatest density index was recorded at Middle Channel (22.8 birds/1000 yd); the smallest was recorded at Noell Lake (4.9 birds/1000 yd).

Table 4 lists the total numbers of birds and the corresponding density indices that were recorded in each habitat type. The greatest density index (17.1 birds/1000 yards) was recorded in closed deciduous scrub (035); the smallest (4.8 birds/1000 yards) was recorded in open deciduous dwarf scrub (084).

Eleven habitats satisfied the criteria for statistical testing. The density indices from these 11 habitats showed significant heterogeneity (Kruskal-Wallis; $H = 25.1$; $P < 0.01$; $df = 10$; $N = 76$).

TABLE 3. Total Numbers and Density Indices of Birds Detected "On-Transect" at Survey Sites Along the Cross Delta Route, June 8-July 9, 1975.

SITE	TOTAL YARDS	NUMBER OF HABITATS*	NUMBER OF SPECIES	TOTAL BIRDS	DENSITY INDEX BIRDS/1000 YD
D1--Fish Trap Lake	18885	7	17	141	7.5
D2--Travaillant Lake	13865	10	11	74	5.3
D3--Bar C	23013	9	21	212	9.2
D4--Camp Farewell	16888	7	15	136	8.1
D5--Noell Lake	20602	10	12	100	4.9
D6--Langley Channel	8814	2	8	71	8.1
D7--West Channel	8966	3	12	106	11.8
D8--Middle Channel	11513	5	15	262	22.8
D9--Blow River	11802	6	9	108	9.2
TOTAL	134348	22	41	1210	9.0
MEAN					9.7
STANDARD DEVIATION (±)					5.3

* with total sample greater than 50 yd

TABLE 4. Total Numbers and Density Indices of Birds Detected "On-Transect" in Each Habitat Type During Ground Transect Surveys, June 8-July 9, 1975.

HABITAT	TOTAL YARDS	NUMBER OF SITES†	NUMBER OF SPECIES	TOTAL BIRDS	DENSITY INDEX BIRDS/1000 YD
304--Open Mixed Forest	88	1	1	1	*
050--Open Spruce-Lichen Muskeg	382	1	2	2	*
099--Scattered Spruce-Lichen Muskeg	5119	3	9	39	7.6
100--Scattered Spruce-Moss Muskeg	1105	2	3	7	6.3
305--Closed Mixed Scrub	3063	2	5	18	5.9
306--Open Mixed Scrub	16253	3	16	103	6.3
026--Closed Evergreen Scrub	227	1	3	3	*
079--Open Evergreen Scrub	7448	3	9	45	6.0
035--Closed Deciduous Scrub	18222	8	17	311	17.1
080--Open Deciduous Scrub	18736	7	18	204	10.9
047--Closed Deciduous Dwarf Scrub	1877	2	7	26	13.9
084--Open Deciduous Dwarf Scrub	15094	4	12	72	4.8
126--Wet Sedge Tundra	6003	4	9	34	5.7
127--Sedge Marsh	11820	3	10	96	8.1
144--Broad-leaved Submerged Meadow	474	1	2	16	*
231--High-Low Centre Polygons	6430	3	11	62	9.6
137--Moss Meadow	97	1	2	2	*
229--Lichen-Heath Community	586	2	1	1	*
227--Dry Sedge Tundra	6828	3	5	61	8.9
228--Open Dwarf Scrub/Dry Sedge Tundra	14148	4	14	93	6.6
301--Water	327	1	3	13	*
308--Snow	21	1	1	1	*
TOTAL	134348	9	41	1210	9.0
MEAN					8.4
STANDARD DEVIATION (±)					3.5

† with total sample greater than 50 yd

* densities were not calculated for habitats where less than 1000 yd were sampled

The density index that most differed from the other indices was that of closed deciduous scrub; when it was removed from the comparison, the density indices for the other 10 habitats were not significantly heterogeneous (Kruskal-Wallis; H = 13.6; P > 0.10; df = 9; N = 65). However, the difference in density indices was not sufficiently large that the density index for closed deciduous scrub differed significantly from the density indices of all of the other habitats. In fact, the density indices for closed and open deciduous scrub did not differ significantly (two-tailed Mann-Whitney; U = 42.5; P > 0.10; N = 11, 13).

In order to facilitate the later analysis of habitat preferences, the 11 habitats which met the criteria for statistical testing were combined into six habitat groups as follows:

Habitat Group	Habitat
Muskeg	099 Scattered Spruce-Lichen Muskeg
Mixed/Evergreen Scrub	306 Open Mixed Scrub 079 Open Evergreen Scrub
Deciduous Scrub	035 Closed Deciduous Scrub 080 Open Deciduous Scrub
Dry Tundra	084 Open Deciduous Dwarf Scrub 227 Dry Sedge Tundra 228 Open Dwarf Scrub/Dry Sedge Tundra
Polygonal Tundra	231 High-Low Centre Polygons
Wet Tundra	126 Wet Sedge Tundra 127 Sedge Marsh

The members of each habitat group are similar in profile (structure of canopy, understory, and herb layers) and frequently occurred in association with one another. Before these groups were established, the density indices for each habitat within a group were compared by means of the appropriate Mann-Whitney or Kruskal-Wallis test. No statistically significant differences of density indices were found within any of the habitat groups (Table 5), and these groups were consequently used in the analysis of habitat preferences.

The density indices of the six habitat groups were not found to differ significantly among themselves (Kruskal-Wallis; $H = 9.4$; $df = 5$; $P > 0.05$; $N = 53$).

Species Composition

Table 3 lists the total number of species that were recorded "on-transect" at each survey site. Although the greatest number of species (21) was recorded at the site with the second highest number of habitat types (Bar C) and the smallest number of species (seven) was recorded at the site with the smallest number of habitat types (Langley Channel), there was no statistically significant correlation between the number of habitats sampled at a site and the number of species recorded at the site (one-tailed Spearman rank correlation; $r_s = 0.33$; $P > 0.05$; $N = 9$). The number of yards sampled at a site, however, was significantly correlated with the number of species recorded at the site (one-tailed Spearman rank correlation; $r_s = 0.66$; $P < 0.05$; $N = 9$).

TABLE 5. Density Indices of Habitat Groups and Statistical Comparisons Within Groups, June 8-July 9, 1975.

HABITAT GROUP	HABITAT NUMBER[1]	NUMBER OF YARDS	DENSITY INDEX BIRDS/1000 YD	STATISTICAL RESULTS	GROUP DENSITY INDEX BIRDS/1000 YD
Muskeg	099	5119	7.6		7.6
Mixed/Evergreen Scrub	306	16253	6.3	$U^2 = 9.0$; $P = 0.31$; $n = 4,6$	6.2
	079	7448	6.0		
Deciduous Scrub	035	18222	17.1	$U^2 = 42.5$; $P > 0.10$; $n = 11,13$	13.9
	080	18736	10.9		
Dry Tundra	084	15094	4.8	$H^3 = 1.4$; $df = 2$; $P > 0.30$; $N = 23$	6.3
	227	6828	8.9		
	228	14148	6.6		
Polygonal Tundra	231	6430	9.6		9.6
Wet Tundra	126	6003	5.7	$U^2 = 5.0$; $P = 0.28$; $n = 4,5$	7.3
	127	11820	8.1		

[1] for the names corresponding to the habitat numbers see Table 2

[2] Two-tailed Mann-Whitney U-test

[3] Kruskal-Wallis One-way Analysis of Variance

Table 4 lists the total number of species that were recorded "on-transect" in each habitat type. The greatest number of species (18) was recorded in open deciduous scrub (080), the habitat with the greatest number of yards surveyed. The results indicate that, as expected, the number of species recorded increases as the area that is sampled increases.

Table 6 lists the 15 most common species sighted "on-transect" and the percentage of the total number of birds recorded "on-transect" that each represents. Of the 41 species that were recorded "on-transect", five species--Savannah Sparrows, Tree Sparrows, Lapland Longspurs, Yellow Warblers, and redpolls (which together represented 12.2% of the total number of species sighted "on-transect")--comprised 62.7% of the total number of birds sighted "on-transect".

Table 7 lists the density indices for each species that was recorded "on-transect" in habitats for which a total sample of greater than 1000 yd was surveyed. The highest density index (6.0 birds/1000 yd) was recorded for Lapland Longspurs in dry sedge tundra (227). Other density indices greater than 4.0 birds/1000 yd were recorded for Lapland Longspurs in high-low centre polygons (231), for Yellow Warblers in closed deciduous scrub (035), and for Savannah Sparrows in closed deciduous scrub (035), open deciduous scrub (080), closed deciduous dwarf scrub (084), and sedge marsh (127).

Table 8 lists the species of birds that were recorded at each site. Forty-one species of birds were recorded "on-transect", 54 species were

TABLE 6. Numbers of Each Species and Percentage of Total Birds Detected "On-Transect" for the 15 Most Common Species Detected During Ground Transect Surveys, June 8-July 9, 1975.

SPECIES	NUMBER	% OF TOTAL
Savannah Sparrow	224	18.5
Tree Sparrow	196	16.2
Lapland Longspur	144	11.9
Yellow Warbler	101	8.3
Redpolls	94	7.8
Gray-cheeked Thrush	46	3.8
Fox Sparrow	44	3.6
Northern Phalarope	42	3.5
Willow Ptarmigan	24	2.0
Blackpoll Warbler	21	1.7
White-crowned Sparrow	19	1.6
Semipalmated Sandpiper	16	1.3
Harris' Sparrow	14	1.2
Northern Waterthrush	12	1.0
American Robin	10	0.8
	1007	83.2
Other Species	203	16.8
TOTAL	1210	100.0

TABLE 7. Species Density Indices (Birds per 1000 Yd) for Each Habitat Type*, June 8-July 9, 1975.

HABITAT†	099	100	305	306	079	035	080	047	084	126	127	231	227	228
NUMBER OF YARDS	5119	1105	3063	16253	7448	18222	18736	1877	15094	6003	11820	6430	6828	14148
Arctic Loon										.2				
Whistling Swan							.1							
White-fronted Goose												.3		.1
Pintail						.1					.1			
Oldsquaw										.2				
White-winged Scoter				.1								.3		
Willow Ptarmigan						.3	.2		.3			.6	.4	.4
Sandhill Crane											.1			
American Golden Plover									.1					.1
Common Snipe											.3			
Whimbrel												.5		.1
Lesser Yellowlegs				.1										
Pectoral Sandpiper										.5		.3		
Semipalmated Sandpiper							.1			.8		.9	.4	
Stilt Sandpiper							.1			.2			.6	
Northern Phalarope						.4	.4			.2	.9	.5		.1
Long-tailed Jaeger														.1
Glaucous Gull														.1
Arctic Tern						.1					.1			
Tree Swallow				.1										
Gray Jay				.2										
American Robin	.2	2.7		.1		.1			.1					
Varied Thrush	.2				.1									
Gray-cheeked Thrush	1.2		.3	1.4	1.6	.2	.1							
Orange-crowned Warbler							.1							
Yellow Warbler				.2		4.8	.4		.1		.1			
Yellow-rumped Warbler	.6		.7	.2	.1									
Blackpoll Warbler				.4	.3	.4	.1		.1					
Northern Waterthrush						.7								
Wilson's Warbler				.1										
Redpolls	1.0		1.0	.4	.4	1.6	1.1	1.0	.4		.8	.2		.5
Savannah Sparrow	.4					4.4	4.6	4.8	1.1	1.2	5.2	1.2	1.5	1.9
Dark-eyed Junco	.2			.1										
Tree Sparrow	2.9	2.7	3.6	2.0	1.7	1.9	2.3	2.1	1.6	.2	.1	.6		.5
Harris' Sparrow	.8			.1	.3	.1	.1	.5	.1					.1
White-crowned Sparrow		.9		.1	.5	.2	.1	.5	.3					.2
Fox Sparrow			.3	.4	.1	1.5	.2		.2					
Lapland Longspur						.1	.9	2.1	.6	2.2	.3	4.2	6.0	2.0
Smith's Longspur							.1	.5						

* only habitats where 1000 yd or more were sampled are included in this table

† for the names corresponding to the habitat numbers see Table 2

TABLE 8. Species of Birds Detected at Each Ground Survey Site, June 8-July 9, 1975.

SPECIES	SITE								
	D1	D2	D3	D4	D5	D6	D7	D8	D9
Arctic Loon	0	0	0	x	+	0	0	0	0
Red-throated Loon	0	0							
Horned Grebe					0				
Whistling Swan	0	0	0	0	+	0	+	x	0
Canada Goose			0	0					0
White-fronted Goose			x	0	0	0			
Mallard	0					0			
Gadwall	0								
Pintail	+		x	0	0	+	x	x	+
Green-winged Teal						0		+	
American Wigeon	0	0		0				0	
Northern Shoveler								+	
Greater Scaup	0			0	0	0	+	x	0
Lesser Scaup		0		0					
Scaup spp.			+						
Common Goldeneye		0							
Oldsquaw	0	0	+	+	0			0	x
Common Eider		0							
White-winged Scoter	x	0	0	x	+	0		0	0
Surf Scoter	0	0		0	0				
Black Scoter				0					
Red-breasted Merganser	0	0	0	0	0		0		0
Golden Eagle									0
Bald Eagle		0							
Marsh Hawk			0	0		0			
Osprey		0							
Willow Ptarmigan			x	x	x				x
Sandhill Crane			0	+		0	x	+	
American Golden Plover			x	+					+
Common Snipe	0		0	0		0	x	x	
Whimbrel			x	x	0	0			0
Spotted Sandpiper		0							
Lesser Yellowlegs	x	0			0				
Pectoral Sandpiper			+	+					x
Semipalmated Sandpiper			x	x			+		x
Long-billed Dowitcher				0				0	+
Stilt Sandpiper			x	x					x
Hudsonian Godwit			0	+					
Red Phalarope									+
Northern Phalarope			x	x	0	x	x	x	x
Pomarine Jaeger			0						
Parasitic Jaeger		0	+	0		0		0	0
Long-tailed Jaeger			+	x		+			0
Glaucous Gull		0	x	+		0	0	0	0
Herring Gull		0	0			+			
Thayer's Gull				0		0			
Mew Gull	0	0	0	+	0	0	0	0	
Bonaparte's Gull	+				0				
Arctic Tern	0	0	+	0	0	x	+	x	0
Short-eared Owl			0	0	0	0			
Belted Kingfisher		0							
Common Flicker		0							
Tree Swallow	x	0							
Gray Jay	x	+			+				
Common Raven		0	+	0	0	0	0	0	

TABLE 8 (cont'd)

SPECIES	SITE								
	D1	D2	D3	D4	D5	D6	D7	D8	D9
Boreal Chickadee		0							
American Robin	x	x	x		x	x	+	0	
Varied Thrush		x					0		
Swainson's Thrush		0							
Gray-cheeked Thrush	x	x	x	+	x	0	x	x	
Bohemian Waxwing		+		0					
Orange-crowned Warbler			x			0			
Yellow Warbler	x	+	x	x	x	x	x	x	
Yellow-rumped Warbler	x	x	0						
Blackpoll Warbler	x	x	+		x	x	x	x	
Northern Waterthrush				+		+	x	x	
Wilson's Warbler	x								
Rusty Blackbird	+	0	0	0		0		+	
Pine Grosbeak	0	+							
Hoary Redpoll			x		0		x	x	+
Common Redpoll	x	0	x		0	0	0	x	0
Redpoll spp.				x					
Savannah Sparrow	x		x	x	x	x	x	x	x
Dark-eyed Junco	x	x							
Tree Sparrow	x	x	x	x	x	+	x	x	
Chipping Sparrow		0							
Harris' Sparrow	x	x	x		x				
White-crowned Sparrow	x	x	x	x	x	0	0		
Fox Sparrow	x	x	x	x	x	x	x	x	
Lapland Longspur			x	x					x
Smith's Longspur					x				

x "on-transect"

\+ "off-transect"

0 casual observation

recorded either "on" or "off" transect, and 79 species were recorded either in the course of transect surveys or by casual observations at the survey sites. Scientific names of the species of birds observed during this study are listed in Appendix 4.

Appendices 5 and 6 list the density indices of each species of bird that was recorded in each habitat at each site. These are arranged according to survey site in Appendix 5 and according to habitat type in Appendix 6.

Appendix 7 lists the records of nests that were found in the course of the study. Appendix 8 lists the flocks of birds that were recorded on the ground transect surveys.

Habitat Preferences

Table 9 lists the habitat preference indices for the more common species in the individual habitat types. The two most marked preference indices were both for closed deciduous scrub (035); they were shown by Yellow Warblers (77.1%) and by Fox Sparrows (64.6%). In contrast, Tree Sparrows showed little indication of habitat preference; although they occurred in each of the 11 habitats that were considered, their habitat preference indices did not exceed 20% in any of these habitats.

Table 10 lists the preference indices for the common species in the six habitat groups. The effect of grouping the individual habitats is to enhance the degree of habitat preference. The density indices for

TABLE 9. Habitat Preference Indices* of Common Species Observed During Ground Transect Surveys on the Cross Delta Route, June-July, 1975.

HABITAT NUMBERS†	099	306	079	035	080	084	227	228	231	126	127
NUMBER OF YARDS	5119	16253	7448	18222	18736	15094	6828	14148	6430	6003	11820
Willow Ptarmigan	-	-	-	9.4	12.3	9.7	21.4	24.6	22.6	-	-
Gray-cheeked Thrush	24.9	33.2	29.7	8.6	1.6	1.9	-	-	-	-	-
Yellow Warbler	-	2.0	-	77.1	11.6	2.2	-	-	-	-	7.0
Redpolls	-	4.6	-	33.0	18.1	6.0	18.1	7.6	2.3	-	10.3
Savannah Sparrow	2.2	0.2	-	18.9	18.9	3.9	8.3	8.6	8.3	6.6	24.2
Tree Sparrow	14.1	10.2	9.0	16.5	18.2	12.7	2.2	8.4	4.8	3.4	0.4
Fox Sparrow	-	9.6	-	64.6	8.3	10.5	4.5	-	-	-	2.5
Lapland Longspur	-	-	-	0.3	3.8	2.9	40.4	12.1	27.6	12.6	0.3

* density index in a given habitat as a percentage of the sum of the density indices in all 11 habitats

† see Table 2 for names of habitats that correspond to habitat numbers

TABLE 10. Habitat Preference Indices* of Common Species Occurring in Major Habitat Groups Surveyed on the Cross Delta Route, June-July, 1975.

HABITAT GROUP†	MUSKEG	MIXED EVERGREEN SCRUB	DECIDUOUS SCRUB	POLYGONAL TUNDRA	DRY TUNDRA	WET TUNDRA
NUMBER OF YARDS	5119	23701	36358	6430	36070	17823
Willow Ptarmigan	-	-	21.7	44.0	34.3	-
Gray-cheeked Thrush	39.6	51.3	8.1	-	1.0	-
Yellow Warbler	-	2.6	86.6	-	1.6	9.1
Redpolls	-	6.9	54.8	4.9	19.0	14.2
Savannah Sparrow	4.0	0.2	35.0	15.3	12.0	33.4
Tree Sparrow	24.9	17.2	31.1	8.5	15.8	2.6
Fox Sparrow	-	13.4	73.2	-	10.2	3.2
Lapland Longspur	-	-	4.2	57.9	28.6	9.3

* density index in a given habitat group as a percentage of the sum of the density indices in all six habitat groups

† see 'Results'--total density indices for the components of each habitat group

Yellow Warblers and Fox Sparrows in deciduous scrub were 86.6% and 73.2%, respectively, of the sum of the density indices in the six habitat groups. Other marked preferences were shown by Lapland Longspurs for polygonal tundra (57.9%), by redpolls for deciduous scrub (54.8%), and by Gray-cheeked Thrushes for mixed/evergreen scrub (51.3%).

DISCUSSION

Limitations in the Use of Transect Survey Data

Transect surveys are useful in order to determine the relative densities of birds present in an area during the breeding season. The major advantage of the transect survey method is that it allows large amounts of habitat to be sampled at sites distributed over a large geographical area in a short period of time.

The data collected during transect surveys are best used to compare populations at a site that has been surveyed in successive years. But the data can also be used, with less reliability, in comparing populations in a particular habitat type that has been surveyed at various sites, or, with lesser reliability, in comparing the populations in different habitat types.

Before any comparisons are made, the deficiencies of the transect survey method should be enumerated. The following factors may influence the accuracy of the results of transect surveys:

a) Time of Year

Surveys are conducted during the breeding season but the degree of advancement of the breeding season will in itself affect the results of the surveys. The number of migrants in the study area, the behaviour of territorial males and their subsequent detectability (the males of some species stop territorial behaviour after egg-laying is completed and incubation is underway), and the presence of fledglings during the latter part of the breeding season affect the numbers of birds detected.

b) Weather

Although surveys were not conducted during adverse weather conditions, the variation in conditions between surveys (in particular any major changes in weather fronts) can influence the number of birds detected.

c) Conspicuousness

Some species are more conspicuous than others, and a species may be more conspicuous in one habitat than it is in another.

d) Geographical Variation

The number of birds in a habitat type is known to vary with geographical factors such as latitude and the distance from bodies of water.

e) Time of Day

The conspicuousness of each species varies with the time of day the survey is conducted. Although most species of birds are most conspicuous during the early to mid-morning period, some species are more conspicuous at other times of the day.

f) Differences in Observer Ability

No two observers have the same ability to see, to hear, or to identify all species of birds.

Plot studies that have been conducted relatively close to the study area have indicated that transect surveys tend to underestimate the number of birds in closed habitats in the Mackenzie Valley (Richardson and Courtney, 1975) and to overestimate the number of birds in open habitats on the North Slope (Richardson and Gollop, 1974).

Important Habitats

Table 11 presents a comparison of the relative densities of birds within the major habitat groups as recorded during various studies conducted in the northern Mackenzie Valley, in the Mackenzie Delta (including Richards Island), and on the Yukon North Slope.

With the exception of 1972, which appears to have smaller density indices than the other years, there is a fair degree of similarity in the density indices between years and between regions. The major differences are for deciduous scrub, which had higher density indices in 1974 than in 1973 or 1975, and dry tundra, which had a higher density index in 1973 for sites in the Mackenzie Valley than for sites in other regions or in other years.

TABLE 11. Density Indices of Habitat Groups, Northern Mackenzie Valley, Mackenzie Delta, and Yukon North Slope, 1972-1975.

REGION SURVEYED†	A		A, B		A, B		A, B, C		C		C	
YEAR	1972[1]		1973[2]		1974[3]		1975[4]		1973[3]		1974[5]	
	NUMBER OF YARDS	DENSITY INDEX*	NUMBER OF YARDS	DENSITY INDEX	NUMBER OF YARDS	DENSITY INDEX	NUMBER OF YARDS	DENSITY INDEX	NUMBER OF YARDS	DENSITY INDEX	NUMBER OF YARDS	DENSITY INDEX
Muskeg	23350	4.1	21100	10.5	19684	11.4	6224	7.4	2850	8.4	3276	8.8
Mixed/Evergreen Scrub	-	-	8300	10.4	12160	9.6	26764	6.2	-	-	-	-
Deciduous Scrub	4850	5.6	3550	14.3	6023	14.1	36958	13.9	8225	21.4	7181	25.6
Dry Tundra	1100	5.5	5900	15.4	2487	9.2	36070	6.2	36950	8.6	57129	9.6
Polygonal Tundra	-	-	-	-	-	-	6430	9.6	6100	10.5	-	-
Wet Tundra	1950	10.8	-	-	1545	13.6	17823	7.3	23625	5.2	19399	14.4

* density index in birds/1000 yd

1 Salter and Davis (1974)

2 Tull, Thompson, and Taylor (1975)

3 Ward (1975)

4 this report

5 Koski (1975)

† A--Northern Mackenzie Valley

B--Mackenzie Delta

C--Yukon North Slope

Deciduous scrub had the highest overall density index of the six habitat groups. The commonest species recorded during these studies in deciduous scrub were Tree Sparrows, redpolls, and Savannah Sparrows, which were found throughout the area, and Yellow Warblers, which were found most commonly in the outer Mackenzie Delta. Yellow Warblers and Fox Sparrows showed the most marked preferences for this habitat.

The overall density indices of the other five habitat groups did not differ markedly among themselves.

Because of the high density recorded, deciduous scrub is considered to be the most important habitat in the study area. Because of the abundance of this habitat in the outer Mackenzie Delta, this section probably supports the highest overall density of terrestrial breeding birds along the cross delta route.

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A P P E N D I C E S

APPENDIX 1. Maps of Routes of Transect Surveys Conducted at Each Site, June-July, 1975.

This appendix consists of maps which are stored at the Edmonton branch of LGL Limited, and can be obtained upon request.

APPENDIX 2. Habitat Types Sampled During Ground Transect Surveys, June 8-July 9, 1975.

026--Closed Spruce Scrub 1B1-7

This habitat was found in small quantities in the southern-most section of the study area. It usually occurred near lakes and ponds.

The closed shrub layer consisted of *Picea mariana* 6 to 12 ft high and the ground layer consisted principally of *Sphagnum* spp. with *Vaccinium vitis-idaea* often present.

035--Closed Deciduous Scrub 1B2-1a

This was one of the most ubiquitous habitats encountered during transect surveys along the cross delta route. On the Mackenzie Delta it occurred along river channels and in areas of higher elevation; in other sections of the study area it occurred along the shores of lakes, ponds, and streams.

In low areas this habitat consisted of a shrub layer of willow, and sometimes alder, 3 to 8 ft high, and a ground layer of mosses, *Equisetum* spp., sedges, and grasses. In higher, better-drained areas this habitat consisted of a shrub layer of *Salix* spp. and/or *Betula glandulosa* 2 to 6 ft high, and a ground layer of mosses, sedges, *Ledum palustre*, and *Vaccinium* spp.

APPENDIX 2 (cont'd)

047--Closed Deciduous Dwarf Scrub 1C2-1b

On Richards Island this habitat was common but in other sections of the study area it formed only a minor part of the habitats present.

The dwarf scrub layer was composed of *Salix* spp., *Betula glandulosa*, and *Betula nana*. Ground cover consisted of sedges, mosses, lichens, *Arctostaphylos* spp., and *Vaccinium* spp.

050--Open Spruce-Lichen Muskeg 1D1-2a

This habitat occurred only at the southern-most sites in the study area. It was found in low-lying areas, usually near lakes.

The tree layer consisted of *Picea mariana* 15 to 25 ft high. The shrub layer, which was sometimes absent, consisted of *Salix* spp. and *Betula glandulosa*; the ground layer consisted of lichens with lesser amounts of *Ledum palustre*, *Vaccinium* spp., and mosses.

079--Open Evergreen Scrub 1G1-3

This was one of the most abundant habitats sampled at the site on Fish Trap Lake; it was also common at Travaillant Lake.

APPENDIX 2 (cont'd)

The shrub layer consisted of *Picea mariana* 5 to 15 ft high. The principal components of the ground layer were *Ledum palustre*, mosses, lichens, and *Vaccinium* spp.

<u>080--Open Deciduous Scrub 1G2-1</u>

This was a common habitat type throughout the study area. It occurred most commonly along the shores of lakes, ponds, or rivers, or on the sheltered side of hills.

The dominant layer was composed of *Alnus* spp., *Salix* spp., and *Betula glandulosa* and was 1.5 to 8 ft high. The ground layer was composed of sedges, grasses, mosses, lichens, *Vaccinium* spp., and *Ledum palustre*.

<u>084--Open Deciduous Dwarf Scrub 1H2-1</u>

This habitat, which was common on Richards Island, was characteristic of upland areas that were exposed to wind.

The dominant layer was 0.5 to 2 ft high and was composed principally of *Betula nana* with *Salix* spp., *Alnus* spp., and *Betula glandulosa* also present. The ground layer consisted of *Arctostaphylos* spp., *Dryas integrifolia*, *Vaccinium vitis-idaea*, sedges, mosses, and lichens.

APPENDIX 2 (cont'd)

099--Scattered Spruce-Lichen Muskeg 1J1-4

This habitat was encountered at the three southern-most sites and formed an important portion of the habitats at the two southern-most of these sites.

The tree layer consisted of scattered *Picea mariana* that ranged in height from 10 to 20 ft. The shrub layer was absent or scattered and consisted of *Picea mariana*, *Betula glandulosa*, *Alnus* spp., and *Salix* spp. The ground layer consisted of lichens (mostly *Cladonia* spp.) with small quantities of *Ledum palustre*, *Vaccinium* spp., and mosses.

100--Scattered Spruce-Moss Muskeg 1J1-5

This habitat was the same as scattered spruce-lichen muskeg except that the principal component of the ground layer was mosses instead of lichens. In a few instances the ground layer was composed of a mixture of sedges and mosses.

126--Wet Sedge Tundra--1M2-1

This habitat is one of the most abundant habitats on the North Slope (Site D9). Although it was present at most of the other sites, it was uncommon at these sites. It occurred in poorly-drained areas or areas of little or no relief.

APPENDIX 2 (cont'd)

The dominant species were *Carex* spp. and *Eriophorum* spp. Mosses were also usually present and grasses were present in slightly drier areas.

127--Sedge Marsh 1M2-2

Sedge marsh is one of the major habitat types found in the Mackenzie Delta. In this area it occurred in large flat areas that are flooded every spring and often remain flooded all summer. At the tundra and forest sites, sedge marsh occurred on the edge of lakes or ponds.

The dominant plant species in this habitat were *Carex aquatilis*, *Carex* spp., and *Equisetum* spp. In addition to the difference in species composition, sedge marsh was separated from wet sedge tundra by the height of the dominant layer (sedge marsh, 1.5 to 2.5 ft; wet sedge tundra, 0.5 to 2 ft), and by the density of the vegetation (sedge marsh had a much denser sedge layer).

137--Moss Meadow 101-2

This habitat formed only a minor portion of the habitats sampled. It was found in sheltered areas near lakes or streams.

The dominant vegetation was mosses. Scattered throughout this habitat was *Salix* spp. and *Rubus chamaemorus*.

APPENDIX 2 (cont'd)

144--Broad-leaved Submerged Meadow 1P2-2

This habitat type was sampled only on the Mackenzie Delta. It occurred in small pools that were found in Sedge Marsh areas.

Hippuris spp. and *Menyanthes trifoliata* were the major plant species present.

227--Dry Sedge Tundra 1M2-1

Dry sedge tundra was one of the major habitats found on the Yukon North Slope and occurred in small quantities at sites on Richard's Island and at Noell Lake. It was always found in well-drained areas.

The dominant vegetation was *Eriophorum vaginatum*. Other species of *Eriophorum*, *Carex* spp., *Ledum palustre*, *Empetrum nigrum*, *Vaccinium vitis-idaea*, mosses, lichens, and *Cassiope tetragona* were also present in smaller amounts.

228--Open Dwarf Scrub/Dry Sedge Tundra 1H2-1/1M2-1

This habitat was common on the North Slope and Richards Island. It occurred in areas of dry sedge tundra which were partly sheltered.

APPENDIX 2 (cont'd)

This habitat type was the same as dry sedge tundra except that scattered *Salix* spp., and *Betula nana* 0.5 to 1 ft in height were found between the *Eriophorum* hummocks.

229--Lichen Heath Community 102-2

This habitat type was found in very exposed areas and formed a minor part of the habitats sampled.

The dominant layer was 2 or 3 in high and consisted of *Dryas integrifolia*, *Empetrum nigrum*, *Cassiope tetragona*, and *Saxifraga oppositifolia* interspersed with *Cetraria* spp., *Cladonia* spp., and *Steriocaulon* spp.

304--Open Mixed Forest 1D1-4a/1D2-1

This habitat occurred only near lakes and in sheltered areas at the southern-most sites in the study area.

The tree component was 15 to 25 ft high and consisted of *Picea mariana*, *Betula papyrifera*, and *Populus tremuloides*. The shrub layer was usually open or scattered and consisted of saplings of the above, *Alnus* spp., and *Salix* spp. The ground layer consisted of grasses, *Vaccinium* spp., and mosses.

APPENDIX 2 (cont'd)

305--Closed Mixed Scrub 1B1-7/1B2-1a

This habitat occurred only at the two southern-most sites. Closed mixed scrub usually occurred along lake shores or streams.

The closed shrub layer (6 to 15 ft high) consisted of *Picea mariana*, *Betula glandulosa*, *Betula papyrifera*, and *Alnus* spp. The ground layer consisted of *Ledum palustre*, *Vaccinium* spp., mosses, and lichens.

306--Open Mixed Scrub 1G1-3/1G2-1

This habitat was found only in the two southern-most sites and was the most common habitat found at these sites.

The species were the same as for closed mixed scrub except that the shrub layer was open.

231--High-Low Centre Polygons 1M2-1/1H2-1

This habitat type occurred in low-lying areas of the North Slope and Richards Island. Both high and low centre polygons were grouped in this habitat type.

The only layer present was the ground layer. The raised areas of the polygons were characterized by *Betula nana*, *Salix* spp., *Ledum palustre*,

APPENDIX 2 (cont'd)

Vaccinium vitis-idaea, and *Eriophorum* spp. The depressed areas were characterized by *Carex* spp. and *Eriophorum* spp.

APPENDIX 3. List of Species of Plants Identified During Ground Transect Surveys, June 8-July 9, 1975. (Nomenclature follows Hultén [1968].)

Lichen	*Peltigera* spp.
Lichen	*Cetraria* spp.
Lichen	*Cladonia* spp.
Lichen	*Stericaulon* spp.
Moss	*Sphagnum* spp.
Moss	*Hylocomium splendens*
Horsetail	*Equisetum variegatum*
Horsetail	*Equisetum arvense*
Horsetail	*Equisetum* spp.
Black Spruce	*Picea mariana*
Bluejoint	*Calamagrostis canadensis*
Cottongrass	*Eriophorum vaginatum*
Cottongrass	*Eriophorum angustifolium*
Cottongrass	*Eriophorum scheuchzeri*
Sedge	*Carex aquatilis*
Sedge	*Carex* spp.
Trembling Aspen	*Populus tremuloides*
Willow	*Salix* spp.
Shrub Birch	*Betula glandulosa*
Dwarf Birch	*Betula nana*
Paper Birch	*Betula papyrifera*
Labrador Tea	*Ledum palustre*
Mountain Alder	*Alnus crispa*
Alder	*Alnus incana*
Purple Mountain Saxifrage	*Saxifraga oppositifolia*
Chickweed	*Stellaria* spp.
Moss Campion	*Silene acaulis*
Anemone	*Anemone* spp.
Alaska Spiraea	*Spiraea beauverdiana*
Cloudberry	*Rubus chamaemorus*
Cinquefoil	*Potentilla* spp.
Dryas	*Dryas integrifolia*
Lupine	*Lupinus arcticus*
Fireweed	*Epilobium augustifolium*
Mare's Tail	*Hippuris* spp.
Crowberry	*Empetrum nigrium*
Lapland Rosebay	*Rhododendron lapponicum*
Cassiope	*Cassiope tetragona*
Cassandra	*Chamaedaphne calyculata*
Bearberry	*Arctostaphylos alpina*
Lingonberry	*Vaccinium vitis-idaea*
Alpine Blueberry	*Vaccinium uliginosium*
Buckbean	*Menyanthes trifoliata*
Indian Paintbrush	*Castellija* spp.
Lousewort	*Pedicularis* spp.
Sweet Coltsfoot	*Petasites frigidus*

APPENDIX 4. Bird Species Sighted During Ground Transect Surveys, June 8-July 9, 1975. (Nomenclature follows A.O.U. Checklist [1957] and the Thirty-second Supplement [1973]).

Arctic Loon	*Gavia arctica*
Red-throated Loon	*Gavia stellata*
Horned Grebe	*Podiceps auritus*
Whistling Swan	*Olor columbianus*
Canada Goose	*Branta canadensis*
White-fronted Goose	*Anser albifrons*
Mallard	*Anas platyrhynchos*
Gadwall	*Anas strepera*
Pintail	*Anas acuta*
Green-winged Teal	*Anas crecca*
American Wigeon	*Anas americana*
Northern Shoveler	*Anas clypeata*
Greater Scaup	*Aythya marila*
Lesser Scaup	*Aythya affinis*
Common Goldeneye	*Bucephala clangula*
Oldsquaw	*Clangula hyemalis*
Common Eider	*Somateria mollissima*
White-winged Scoter	*Melanitta deglandi*
Surf Scoter	*Melanitta perspicillata*
Black Scoter	*Melanitta nigra*
Red-breasted Merganser	*Mergus serrator*
Rough-legged Hawk	*Buteo lagopus*
Golden Eagle	*Aquila chrysaetos*
Bald Eagle	*Haliaeetus leucocephalus*
Marsh Hawk	*Circus cyaneus*
Osprey	*Pandion haliaetus*
American Kestrel	*Falco sparverius*
Willow Ptarmigan	*Lagopus lagopus*
Sandhill Crane	*Grus canadensis*
Semipalmated Plover	*Charadrius semipalmatus*
Killdeer	*Charadrius vociferus*
American Golden Plover	*Pluvialis dominica*
Black-bellied Plover	*Pluvialis squatorola*
Ruddy Turnstone	*Arenaria interpres*
Common Snipe	*Capella gallinago*
Whimbrel	*Numenius phaeopus*
Upland Sandpiper	*Bartramia longicauda*
Spotted Sandpiper	*Actitis macularia*
Solitary Sandpiper	*Tringa solitaria*
Lesser Yellowlegs	*Tringa flavipes*
Pectoral Sandpiper	*Calidris melanotos*
Least Sandpiper	*Calidris minutilla*
Semipalmated Sandpiper	*Calidris pusilla*
Sanderling	*Calidris alba*
Long-billed Dowitcher	*Limnodromus scolopaceus*
Stilt Sandpiper	*Micropalama himantopus*
Hudsonian Godwit	*Limosa haemastica*

APPENDIX 4 (cont'd)

Red Phalarope	*Phalaropus fulicarius*
Northern Phalarope	*Lobipes lobatus*
Pomarine Jaeger	*Stercorarius pomarinus*
Parasitic Jaeger	*Stercorarius parasiticus*
Long-tailed Jaeger	*Stercorarius longicaudus*
Glaucous Gull	*Larus hyperboreus*
Herring Gull	*Larus argentatus*
Thayer's Gull	*Larus thayeri*
Mew Gull	*Larus canus*
Bonaparte's Gull	*Larus philadelphia*
Arctic Tern	*Sterna paradisaea*
Short-eared Owl	*Asio flammeus*
Belted Kingfisher	*Megaceryle alcyon*
Common Flicker	*Colaptes auratus*
Tree Swallow	*Iridoprocne bicolor*
Bank Swallow	*Riparia riparia*
Cliff Swallow	*Petrochelidon pyrrhonota*
Gray Jay	*Perisoreus canadensis*
Common Raven	*Corvus corax*
Boreal Chickadee	*Parus hudsonicus*
American Robin	*Turdus migratorius*
Varied Thrush	*Ixoreus naevius*
Swainson's Thrush	*Catharus ustulatus*
Gray-cheeked Thrush	*Catharus minimus*
Water Pipit	*Anthus spinoletta*
Bohemian Waxwing	*Bombycilla garrulus*
Orange-crowned Warbler	*Vermivora celata*
Yellow Warbler	*Dendroica petechia*
Yellow-rumped Warbler	*Dendroica coronata*
Blackpoll Warbler	*Dendroica striata*
Northern Waterthrush	*Seiurus noveboracensis*
Wilson's Warbler	*Wilsonia pusilla*
Rusty Blackbird	*Euphagus carolinus*
Pine Grosbeak	*Pinicola enucleator*
Hoary Redpoll	*Acanthis hornemanni*
Common Redpoll	*Acanthis flammea*
Savannah Sparrow	*Passerculus sandwichensis*
Dark-eyed Junco	*Junco hyemalis*
Tree Sparrow	*Spizella arborea*
Chipping Sparrow	*Spizella passerina*
Harris' Sparrow	*Zonotrichia querula*
White-crowned Sparrow	*Zonotrichia leucophrys*
Fox Sparrow	*Passerella iliaca*
Lapland Longspur	*Calcarius lapponicus*
Smith's Longspur	*Calcarius pictus*

APPENDIX 5. Numbers of Birds Observed in Each Habitat, by Survey Site, in 1975.

This appendix consists of a computer printout; this printout, which is stored in the library of the Edmonton branch office of LGL Limited, is available upon request.

APPENDIX 6. Numbers of Birds Observed at Each Survey Site, by Habitat Type, in 1975.

This appendix consists of a computer printout; this printout, which is stored in the library of the Edmonton branch of LGL Limited, is available upon request.

APPENDIX 7. Nests Found During Study, June 8-July 9, 1975.

SPECIES	SITE NUMBER	DATE MONTH	DATE DAY	EGGS	HEIGHT (FT)	HABITAT
Arctic Loon	D4	6	26	2	0	Semi-floating area edge of lake
Arctic Loon	D9	7	8	2	0	Edge of pond
Arctic Loon	D9	7	8	2	0	Edge of pond
Whistling Swan	D4	6	26	4	1	Push-up in flooded sedge marsh
Whistling Swan	D5	6	30	1	1.5	Push-up of moss in d[illegible] tundra
Whistling Swan	D7	7	4	4	2	Push-up of sedge and mud in flooded willow-sedge marsh
Whistling Swan	D8	7	7	4	1.5	Push-up of sedge leaves in scattered willow shrub
White-fronted Goose	D3	6	13	4	0	High centre polygon
White-fronted Goose	D3	6	16	6	0	Sedge hummock in wet sedge tundra
Pintail	D3	6	16	4	0	Under shrub birch
Pintail	D7	7	4	6	0	Under closed willow shrubs
Greater Scaup	D7	7	4	7	0	Flooded sedge marsh edge of large pond
Oldsquaw	D4	6	26	5	0	Under shrub willow
Red-breasted Merganser	D3	6	16	6	0	Under alder--3 ft from shore of small lake
Willow Ptarmigan	D3	6	16	12	0	Under shrub birch
Sandhill Crane	D4	6	25	1*	0	Low centre polygon
Semipalmated Sandpiper	D4	6	26	4	0	On sedge hummock
Stilt Sandpiper	D9	7	8	3*	0	High centre polygons
Northern Phalarope	D4	6	26	4	0	Edge of low centre polygon
Northern Phalarope	D9	7	9	2	0	Centre of clump of sedge
Parasitic Jaeger	D9	7	8	1	0	Raised edge of low centre polygon
Glaucous Gull	D9	7	9	2	0	Island on large pond
Arctic Tern	D9	7	8	2	0	Dry hummock in wet sedge tundra
Short-eared Owl	D4	6	26	5	0	Under shrub birch
American Robin	D2	6	11	4*	1.5	Shrub birch
Gray-cheeked Thrush	D2	6	11	4	0	Base of spruce tree

APPENDIX 7 (cont'd)

SPECIES	SITE NUMBER	DATE MONTH	DATE DAY	EGGS	HEIGHT (FT)	HABITAT
Gray-cheeked Thrush	D2	6	11	4	0	Base of shrub spruce
Gray-cheeked Thrush	D2	6	12	3	0	Under spruce tree
Yellow Warbler	D8	7	6	1+4*	2.5	Shrub alder
Blackpoll Warbler	D5	6	30	5	0	Under 1 ft high spruce shrub
Northern Waterthrush	D4	6	26	5	0	Base of willow
Hoary Redpoll	D3	6	14	1	.5	Shrub willow
Hoary Redpoll	D3	6	15	5	.3	Shrub alder
Common Redpoll	D9	7	9	5	2	Shrub alder
Redpoll sp.	D4	6	25	4*	.5	In shrub alder
Savannah Sparrow	D3	6	16	3	0	Under sedge hummock
Savannah Sparrow	D4	6	25	3	0	Hole in moss-lichen hummock
Savannah Sparrow	D4	6	26	5	0	Base of sedge hummock
Savannah Sparrow	D7	7	4	5	0	Top of sedge hummock
Savannah Sparrow	D8	7	7	0	1.5	Top of sedge leaves
Tree Sparrow	D1	6	8	4	0	Under sedge hummock
Tree Sparrow	D1	6	10	0	0	Under hummock of lichen and *Vaccinium uliginosium*
Tree Sparrow	D1	6	10	3	0	Under scrub birch and Labrador tea
Tree Sparrow	D2	6	12	6	0	Under grass hummock
Tree Sparrow	D3	6	14	5	0	Under shrub birch
Tree Sparrow	D4	6	26	3	0	Under *Carex* hummock
Tree Sparrow	D5	6	30	3*	0	Under shrub birch and Labrador tea
White-crowned Sparrow	D2	6	12	5	0	Under sedge hummock
White-crowned Sparrow	D5	6	28	4	0	Under shrub birch and Labrador tea
Fox Sparrow	D1	6	8	3	0	Under fallen spruce tree
Fox Sparrow	D3	6	14	4	0	Under willow

APPENDIX 7 (cont'd)

SPECIES	SITE NUMBER	DATE MONTH	DATE DAY	EGGS	HEIGHT (FT)	HABITAT
Fox Sparrow	D3	6	14	4	0	Under shrub alder
Fox Sparrow	D4	6	26	4*	0	Base of shrub alder
Lapland Longspur	D3	6	16	5	0	Under sedge hummock
Lapland Longspur	D4	6	25	3*	0	Under *Eriophorum* hummock

* signifies young, not eggs.

APPENDIX 8. Occurrence of Flocks (five or more birds) During Ground Transect Surveys of the Cross Delta Route, June 8-July 9, 1975.

SITE	SPECIES	HABITAT	NUMBER	ACTIVITY
D4--Camp Farewell	White-winged Scoter	Open Deciduous Dwarf Scrub	6	Flying
D6--Langley Channel	Northern Phalarope	Sedge Marsh	6	Flying
D6--Langley Channel	Northern Phalarope	Water	6	Sitting
D7--West Channel	Northern Phalarope	Sedge Marsh	5	Unknown
D8--Middle Channel	Northern Phalarope	Closed Deciduous Scrub	5	Sitting
D8--Middle Channel	Northern Phalarope	Open Deciduous Scrub	15	Unknown
D8--Middle Channel	Northern Phalarope	Broad-leaved Submerged Meadow	5	Sitting
D8--Middle Channel	Northern Phalarope	Broad-leaved Submerged Meadow	5	Sitting
D8--Middle Channel	Northern Phalarope	Closed Deciduous Scrub	5	Sitting
D9--Blow River	Northern Phalarope	Wet Sedge Tundra	12	Sitting

CHAPTER V

AERIAL SURVEYS OF WATER BIRD POPULATIONS ALONG THE FORT SIMPSON REALIGNMENT OF THE PROPOSED ARCTIC GAS PIPELINE ROUTE, ALBERTA AND NORTHWEST TERRITORIES, MAY-SEPTEMBER, 1975

L. A. PATTERSON
ALLEN N. WISELEY

ABSTRACT

Three aerial surveys of the Fort Simpson realignment of the proposed Arctic Gas pipeline route were flown during the period May-September, 1975. The study was conducted in order (1) to determine the numbers of water birds along the route during the periods of nesting, of brood-rearing and moulting, and of fall staging and migration; (2) to identify those areas along the route that are important to water birds; and (3) to compare the realigned route with the previously-proposed route in terms of their importance to water birds.

The route of the Fort Simpson realignment was little used by water birds at the times of the aerial surveys. Wetlands and lakes near the route were more heavily used by water birds than the route itself. Densities of breeding birds and of broods along the Fort Simpson realignment were low in comparison with densities for transects that are considered to be representative of the general area. Water bird numbers along the Fort Simpson realignment were highest (though still comparatively low) for the section between the Mackenzie River and Jean-Marie Creek. Although the Fort Simpson realignment has habitat with more potential for waterfowl utilization and production than the original route proposal, the major portions of both routes have severe limitations for utilization and production of waterfowl.

ACKNOWLEDGEMENTS

We wish to thank J.H. Eisenhauer who, together with A.N. Wiseley, conducted the aerial surveys. J. Bergeron and B. Pratt, pilots with Contact Airways Ltd., Fort McMurray, and R. Sprang, pilot with Arctic Air Ltd., Fort Simpson, flew the aerial surveys. W.W.H. Gunn and C.E. Tull each assisted on one of the surveys. P.M. Cary, W.W.H. Gunn, W.R. Koski, W.J. Richardson, C.E. Tull, and J.G. Ward assisted in the preparation of this report. J. Erwin prepared the typescript.

The Arctic Gas Biological Report Series, of which this report is a part, is a series of consultant project reports presenting data based on field and laboratory studies. The format and presentation vary among reports in accordance with the discretion of the authors.

The data for this work were obtained as a result of investigations carried out by LGL Limited, Environmental Research Associates, for Canadian Arctic Gas Study Limited. The text of this report may be quoted provided the usual credits are given.

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INTRODUCTION

The Fort Simpson realignment (CAGPL, 1975) is an eastward shift in location of an approximately 285 mi (455 km) section of the proposed Arctic Gas pipeline route in the upper Mackenzie Valley and northwestern Alberta (Figure 1). The realigned route diverges from the original route (CAGPL, 1974) 20 mi (32 km) south of Wrigley, N.W.T., crosses the Mackenzie River upstream from the confluence of the Mackenzie and Liard rivers, and rejoins the original route 25 mi (40 km) southwest of Bistcho Lake, Alberta.

A number of studies of water birds have been conducted in the general region of this realignment and several contain information of direct relevance to this study. Poston and Ambrock (1968) and Poston *et al.* (1973) have defined the potential of habitats and water bodies in this region with regard to their capabilities for waterfowl utilization and productivity. The U.S. Fish and Wildlife Service (USFWS) has conducted breeding pair and productivity surveys along specific representative transects in this region for many years (Voelzer and Jensen, 1969, 1970, 1971, 1972, 1973, 1974, 1975; Henny *et al.*, 1972). Studies by Soper (1957), Murdy (1964), Weller *et al.* (1969), Murdy *et al.* (1970), and Kemper *et al.* (1975) have investigated the waterfowl populations that occur in specific parts of the upper Mackenzie Valley-Great Slave Lake region. Water bird studies conducted by LGL Limited for the proposed Arctic Gas pipeline have provided information on the distribution of water birds along and in the vicinity of previously-proposed gas pipeline routes in this region (Davis,

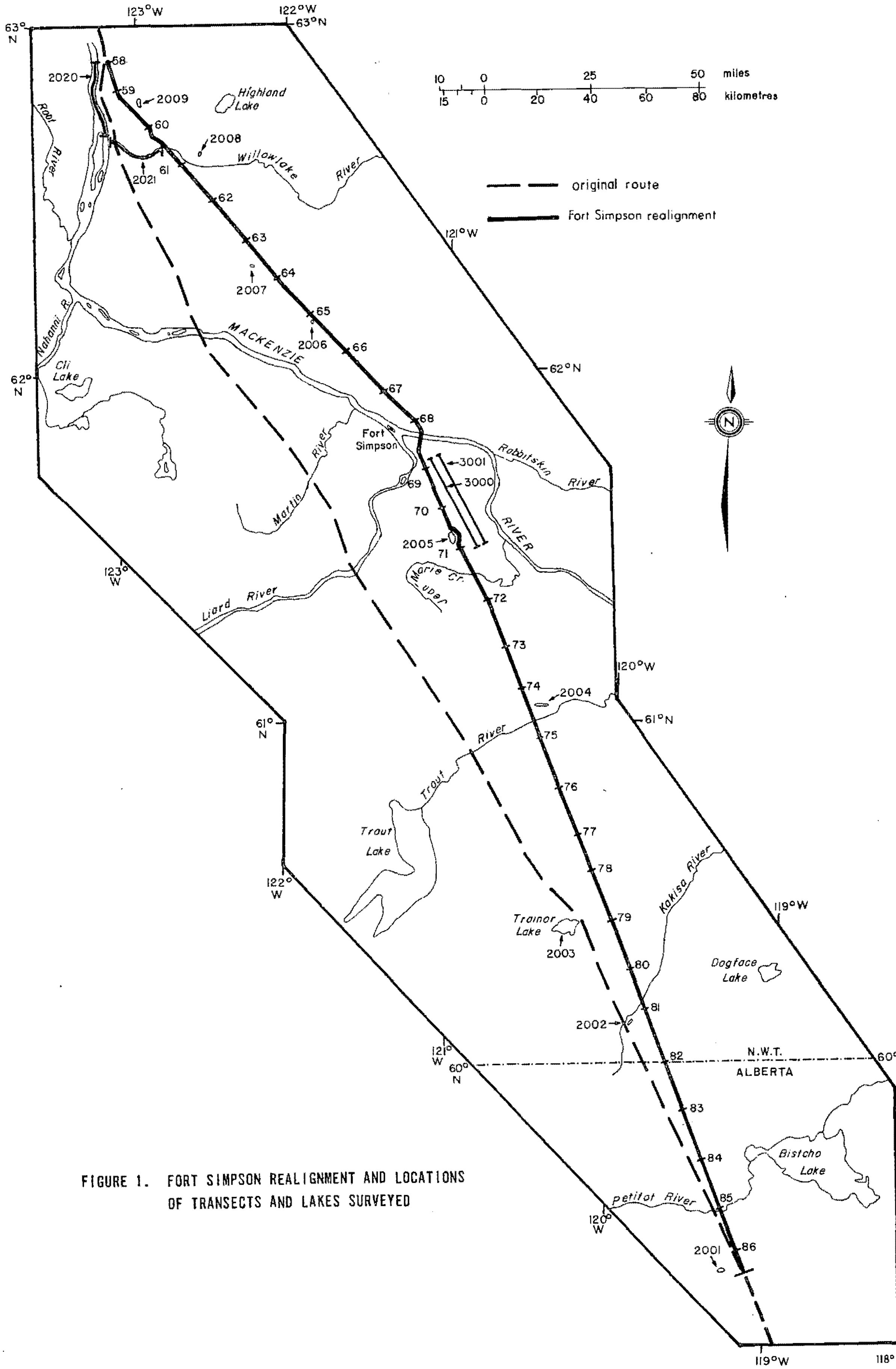

FIGURE 1. FORT SIMPSON REALIGNMENT AND LOCATIONS OF TRANSECTS AND LAKES SURVEYED

1974; Wiseley and Tull, 1975) and on the chronology of spring and fall migration of water birds in the upper Mackenzie Valley (Salter 1974a, 1974b; Salter *et al.*, 1974).

The above-mentioned studies indicate that portions of the upper Mackenzie Valley and northwestern Alberta are important to large numbers of water birds (particularly waterfowl) during spring and fall migration, when the birds form large concentrations in these areas, and are important to lesser numbers of water birds during the breeding season. Several additional studies indicate that the Mackenzie Valley is important to ducks that are displaced from the prairies during years of drought; many of these birds apparently move into or through the Mackenzie Valley (Hansen and McKnight, 1964; Smith, 1970).

There is little specific information, however, on the distribution of water birds along and in the vicinity of the Fort Simpson realignment. Aerial surveys were accordingly conducted along the realigned route in 1975 to gather such information. The specific objectives of this study were the following:

1) to determine the species and numbers of water birds that use the areas along and adjacent to the realigned route during the periods of nesting, of brood-rearing, and of fall staging and migration;
2) to identify the areas along the route that are important to water birds during these periods; and

3) to compare the realigned route with the original route in terms of their importance to water birds.

The results of this study, when combined with those of other studies, will provide baseline information that can be used both to assess the potential impacts of the proposed Arctic Gas pipeline on the bird populations of the area and to develop environmental recommendations to mitigate these impacts.

STUDY AREA

The Fort Simpson realignment passes through three forest sections of the Boreal Forest Region (Rowe, 1972):

1) Upper Mackenzie section--transects 58 through 63 and 66 through 76 (Figure 1),
2) Northwestern Transition section--transects 63 through 66, and
3) Hay River section--transects 76 through 86.

The realigned route crosses the portion of the Upper Mackenzie section that follows the Mackenzie River from Great Slave Lake downstream to Norman Wells. In this section white spruce (*Picea glauca*) and balsam poplar (*Populus balsamifera*) are the predominant tree species on the alluvial flats along the river, and black spruce (*Picea mariana*) is the most common species on the slopes and muskeg areas that border the alluvial flats. The realigned route crosses a small part of the western edge of the Northwestern Transition section, which borders the eastern side of the Upper Mackenzie section. Throughout this section, black spruce, which are generally dwarfed and sparsely distributed, are the most numerous trees. The Hay River section borders the southern side of the Upper Mackenzie section and extends southward into northwestern Alberta. Black spruce covers a large part of this section; white spruce and trembling aspen (*Populus tremuloides*) are less common. Reid (1974) and Reid and Janz (1974) describe the terrestrial habitats of the area in greater detail.

Much of the study area is relatively flat and poorly drained; such areas contain numerous ponds and wetlands. Because these boreal forest water bodies are relatively stable from year to year (Wellein and Lumsden, 1964) and do not show the large fluctuations in occurrence, size, and water level that are shown by water bodies on the prairies (Hansen and McKnight, 1964; Stoudt, 1969), many of them are important to water birds. Poston and Ambrock (1968), Poston *et al.* (1973), and Kemper *et al.* (1975) give more detailed descriptions of the habitats in the area that are of particular importance to waterfowl.

METHODS

Areas and Dates of Surveys

Aerial surveys of water birds in areas along or adjacent to the Fort Simpson realignment were conducted on 30-31 May, on 16 July, and on 4 September, 1975. The 30-31 May date was chosen to coincide with the early nesting period and with the time when the USFWS conducts its waterfowl breeding pair surveys. The 16 July date was chosen to coincide with the brood-rearing and early moulting period and with the time when the USFWS usually conducts its waterfowl productivity surveys. The 4 September date was chosen to coincide with the late moulting and early fall migration period.

On each of these dates aerial surveys were conducted of the following areas:

1) the entire route of the Fort Simpson realignment (divided into 10 mi* long transects numbered 58 to 86);
2) an area adjacent to the realigned route (transects 3000 and 3001) where the habitat was suspected to be particularly attractive to waterfowl (Poston *et al.*, 1973);

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*British units of measurement have been used in this study to maintain consistency within the continuing series of aerial survey reports.

3) a 15 mi section of the Willowlake River from its mouth to the point where the realigned route would cross the Willowlake River (transect 2021) and an 18 mi section of the east shore of the Mackenzie River between the mouth of the River-Between-Two-Mountains and the mouth of the Willowlake River (transect 2020); and
4) nine lakes (lakes 2001-2009) adjacent to the pipeline route.

The locations of these transects and lakes are shown on Figure 1. Appendix 1 gives the latitudes, longitudes, and areas of the transects and lakes that were surveyed.

Aerial Survey Techniques

Standard aerial survey techniques were used during this study. Detailed descriptions of the standard techniques for breeding pair and productivity surveys are given in Martinson and Kaczynski (1967), Henny *et al.* (1972), Davis (1974), and Salter (1974c).

The survey aircraft (Cessna 185) was flown at 95 mph and at an altitude of 100 ft AGL. Two observers, one on each side of the aircraft, recorded all water birds and any other conspicuous birds that were seen on 1/8 mi wide transects on each side of the aircraft. This technique was used to survey transects along and adjacent to the realigned route and along sections of rivers. For surveys of lakes, however, all birds seen at any distance from the aircraft were recorded in an attempt to obtain a total count of the birds on the lakes.

Observations were recorded on cassette tapes and were later transferred to data sheets. The data were then transferred to a computer system for analysis. Some data were lost due to malfunctioning of tape recorders. When this malfunctioning occurred during a linear transect, densities were calculated for the area of transect for which data were not lost. When malfunctioning occurred during a survey of a lake, however, the results for that lake were omitted from the analysis--a result of the bias that would be introduced into an attempted total count that was based on either the number of birds seen close to shore or the number seen in the middle of the lake because these two numbers are not necessarily comparable.

Bird densities that are derived through aerial surveys are meaningful only for the more conspicuous species of birds that occur in open habitats. Such birds are usually quite easy to detect and to identify from the air. In the present study densities are only meaningful for birds that occurred on bodies of water. In this study these water birds included loons, grebes, ducks, coots, gulls, and terns. Sightings of other species of birds can only be considered as incidental observations; these sightings have not been included in this report.

When observed from the air some species of water birds are virtually impossible to distinguish from one another. In this study such species included Greater Scaup and Lesser Scaup, which were recorded only as scaup, and Common Goldeneye and Barrow's Goldeneye, which were recorded only as goldeneyes. Also, because female Common Mergansers and female

Red-breasted Mergansers are difficult to identify from the air, these two species (both male and female) have been grouped as mergansers. Many other water birds could not be identified because they were seen only briefly (especially if part of a large flock of birds) or because they were in eclipse (moult) plumage. These birds could, however, be identified to some general water bird category and they are so listed in the results.

Limitations of Aerial Survey Data

Aerial surveys are useful to census water birds that are distributed over a wide area. The results, however, are subject to a number of sources of error. Rowinski (1958), Diem and Lu (1960), Martinson and Kaczynski (1967), and Henny *et al.* (1972) have shown that aerial surveys of waterfowl populations, such as those conducted by USFWS, could result in an underestimation of the total number of birds in an area by as much as 30-80%. The major factors that can cause such underestimations are as follows:

a) Species of Waterfowl

Some species of waterfowl are more colourful than other species or contrast more clearly with their habitats; they are hence more conspicuous and can be more easily counted. Other species have behaviour patterns that make them more visible to the observer. Diving ducks, for example, spend more of their time in open water where they are more visible to an aerial surveyor than are dabbling ducks.

b) Numbers of Birds

Large groups of water birds are generally easier to detect than small groups or solitary birds; but it is difficult to estimate the size of large flocks of birds and the tendency of most observers is to underestimate the numbers in such flocks.

c) Time of Year

The vegetation cover on water bodies, the behaviour of water birds, the plumage of water birds, and the numbers of water birds in an area all change with the time of year. Each of these factors may affect the results of the surveys. They are especially important when comparing results of surveys conducted at different times of the year.

d) Differential Timing of Seasonal Activities

The times when water birds breed, moult, and migrate vary among species. A survey to sample water birds during a certain activity (e.g., brood-rearing) may provide results that are more representative of this activity for one species than they are for another.

e) Time of Day

The amount of activity of water birds varies with the time of day. The intensity and direction of glare from the water (which frequently cause observers to miss some of the birds that are present) also vary with the time of day.

f) Weather Conditions

Activities of birds vary with the amount of wind, fog, and precipitation, with the light intensity, and with the temperature. Waves caused by wind make the detection and identification of water birds more difficult.

g) Ability of Observers

There can be substantial differences among observers in their abilities to detect birds and to identify species. Experienced observers usually estimate large numbers with greater accuracy and more quickly identify the birds that they sight.

h) Location of Observer in Aircraft

Observers in the front seats of aircraft have the advantage of being able to watch in front of the aircraft. They usually see more birds than do observers in other locations in the aircraft.

For waterfowl species, Diem and Lu (1960) and Martinson and Kaczynski (1967) have developed correction techniques that account for the variations caused by the different degree of conspicuousness of different species, by the difficulties of estimating large numbers of birds, and by the differences in observer abilities. These techniques require that ground observations be made on some parts of the survey area within a few days of the date of the aerial survey. The resulting ground to air ratios are then used to correct the aerial survey results. Because ground observations of water bird numbers were not conducted during the present study, the aerial survey results cannot be corrected for these biases. Densities from this study should thus be considered only as indices of density; they are probably underestimates of the actual numbers of water birds present in the study area.

RESULTS

Late May Survey

Twenty species of water birds were identified during the survey of 30-31 May. Table 1 gives the numbers and density indices of each species or species group of water birds for each of the four types of areas that were surveyed. The scientific names of the species are given in Appendix 2.

The lowest density index of total water birds occurred on the transects surveyed along the realigned route (3.0 birds/mi^2) and the highest occurred on the lakes (29 birds/mi^2). The density indices of total water birds on the river transects (5.8 birds/mi^2) and on the transects in the area adjacent to the realigned route (19 birds/mi^2) were intermediate in value.

Scaup were the most numerous of the water birds identified along the realigned route and in the area adjacent to the route; they comprised 36% of all water birds observed in these areas. Mergansers and Surf Scoters were the most numerous of the water birds identified on the river transects. Scaup, Surf Scoters, White-winged Scoters and goldeneyes were the most numerous water birds identified on the lakes that were surveyed.

TABLE 1. Numbers and Density Indices of Water Birds, 30-31 May 1975.

TYPE OF AREA* AREA SURVEYED (mi^2)	A 71.3		B 10.0		C 8.3		D 24.7	
	NO.	DENSITY†	NO.	DENSITY	NO.	DENSITY	NO.	DENSITY
Common Loon	2	0.03					3	0.12
Red-necked Grebe	4	0.06	9	0.9			4	0.16
Horned Grebe							1	0.04
Loon, grebe, or duck	3	0.04	3	0.3			6	0.24
Waterfowl								
Canada Goose	6	0.08					8	0.32
Mallard	5	0.07	6	0.6	4	0.5	7	0.28
Pintail							1	0.04
Green-winged Teal	2	0.03	2	0.2			2	0.08
Blue-winged Teal					1	0.1		
American Wigeon	1	0.01			4	0.5	5	0.20
Dabbling duck (spp)	1	0.01	1	0.1	2	0.2	1	0.04
Ring-necked Duck	3	0.04	5	0.5			3	0.12
Scaup (spp)	93	1.30	53	5.3	1	0.1	131	5.30
Goldeneye (spp)	16	0.22	3	0.3	6	0.7	86	3.48
Bufflehead	19	0.27	17	1.7			24	0.97
Oldsquaw							30	1.21
White-winged Scoter	5	0.07	20	2.0	1	0.1	112	4.53
Surf Scoter	6	0.08	5	0.5	9	1.1	129	5.22
Scoter (spp)			6	0.6			12	0.49
Merganser (spp)			1	0.1	11	1.3	8	0.32
Diving duck (spp)	7	0.10			2	0.2	71	2.87
Duck (spp)	18	0.25	43	4.3			28	1.13
Total Waterfowl	182	2.55	162	16.2	41	4.9	658	26.64
Sandhill Crane	3	0.04						
Bonaparte's Gull	6	0.08	12	1.2	1	0.1	11	0.44
Gull (spp)	9	0.13	2	0.2	6	0.7	36	1.46
Common/Arctic Tern	3	0.04	2	0.2			1	0.04
Total Water Birds	212	2.97	190	19.0	48	5.8	720	29.15

* A - Transects along realigned route.
B - Transects adjacent to realigned route.
C - Transects along rivers.
D - Lakes.

†Density indices are in units of birds/mi^2.

Mid-July Survey

Fifteen species of water birds were recorded on the survey of 16 July. Table 2 gives the numbers and density indices for the adults of each species or species group of water birds for each of the four types of areas that were surveyed.

The lowest and highest density indices of total adult water birds again occurred, respectively, on the transects along the realigned route (0.5 birds/mi^2) and on the lakes that were surveyed (98 birds/mi^2). The density indices of total adult water birds on the river transects (6.1 birds/mi^2) and on the transects in the area adjacent to the realigned route (11 birds/mi^2) were again intermediate in value.

The values of the density indices of total adult water birds for the various areas during the mid-July survey generally differed from those obtained during the late May survey. The mid-July density indices for the realigned route and for the area adjacent to the route were lower than the comparable late May density indices by factors of approximately six and two, respectively; the mid-July density index for the lakes was higher by a factor of approximately three than the comparable late May density index. There was little difference in the late May and mid-July density indices for the river transects. At the time of the mid-July survey many of the waterfowl were in eclipse plumage and were found in large flocks;

TABLE 2. Numbers and Density Indices of Adult* Water Birds, 16 July 1975.

TYPE OF AREA** AREA SURVEYED (mi²)	A 63.1		B 5.0		C 8.3		D 19.7	
	NO.	DENSITY†	NO.	DENSITY	NO.	DENSITY	NO.	DENSITY
Common Loon	2	0.03	2	0.4			20	1.02
Loon (spp)	1	0.02						
Red-necked Grebe							2	0.10
Loon, grebe, or duck	5	0.08	7	1.4			2	0.10
Waterfowl								
Mallard	2	0.03					4	0.20
Pintail							6	0.30
American Wigeon			1	0.2			5	0.25
Dabbling duck (spp)	5	0.08					3	0.15
Scaup (spp)	1	0.02					702	35.63
Goldeneye (spp)							13	0.66
Bufflehead							8	0.41
White-winged Scoter							31	1.57
Surf Scoter							10	0.51
Scoter (spp)							9	0.46
Merganser (spp)							25	1.27
Diving duck (spp)	1	0.02	1	0.2	3	0.4	94	4.77
Duck (spp)	6	0.10	36	7.2	46	5.5	912	46.29
Total Waterfowl	15	0.24	38	7.6	49	5.9	1822	92.49
Sandhill Crane	2	0.02						
Bonaparte's Gull			1	0.2			36	1.83
Gull (spp)	4	0.06	7	1.4	2	0.2	32	1.62
Common/Arctic Tern							3	0.15
Black Tern	2	0.03					10	0.51
Total Water Birds	31	0.49	55	11.0	51	6.1	1927	97.82

* Does not include broods.

** A - Transects along realigned route.
B - Transects adjacent to realigned route.
C - Transects along rivers.
D - Lakes.

† Density indices are in units of birds/mi².

they were, consequently, particularly difficult to identify to the species level. For this reason 54% of all the adult waterfowl observed during this survey were identified only as one of the general categories of ducks. Scaup were the most numerous of the water birds that could be identified; they comprised 34% of all adult water birds observed on the survey (78% of the water birds that could be identified to the species group level).

Table 3 lists the numbers and density indices of the broods of water birds that were recorded on the mid-July survey. Fifty-nine broods were recorded. Although most broods could not be assigned to a particular species, broods of six species of water birds were identified.

The total brood density index was comparatively low along the realigned route (0.2 broods/mi^2). It was quite high, however, in comparison with the density index for adult ducks along the realigned route. Of the adult ducks along the pipeline route, 73% were accompanied by broods. Although the total brood density indices were higher for the transects adjacent to the realigned route (0.6 broods/mi^2) and for the lakes (1.9 broods/mi^2), the proportions of adult ducks with broods were much lower for both types of area (8% for transects adjacent to the route and 2% for lakes). No broods were recorded on the river transects.

Early September Survey

Twelve species of water birds were identified on the survey of 4 September. Table 4 lists the numbers and density indices for each species

TABLE 3. Numbers and Density Indices of Broods of Water Birds, 16 July 1975.

TYPE OF AREA*	A		B		C		D	
AREA SURVEYED (mi^2)	63.1		5.0		8.3		19.7	
	NO.	DENSITY†	NO.	DENSITY	NO.	DENSITY	NO.	DENSITY
Common Loon	2	0.03					1	0.05
Mallard							2	0.10
Pintail							4	0.20
American Wigeon							5	0.25
Dabbling duck (spp)	3	0.05					2	0.10
Scaup (spp)							2	0.10
Merganser (spp)							1	0.05
Diving duck (spp)	1	0.02					11	0.56
Duck (spp)	5	0.08	3	0.6	—	—	9	0.46
Total Water Birds	11	0.17	3	0.6	0	0.0	37	1.88

* A - Transects along realigned route.
B - Transects adjacent to realigned route.
C - Transects along rivers.
D - Lakes.

†Density indices are in units of broods/mi^2.

TABLE 4. Numbers and Density Indices of Water Birds, 4 September 1975.

TYPE OF AREA* AREA SURVEYED (mi^2)	A 51.3		B 5.0		C 6.4		D 4.8	
	NO.	DENSITY†	NO.	DENSITY	NO.	DENSITY	NO.	DENSITY
Loon (spp)			2	0.4			1	0.2
Red-necked Grebe							10	2.1
Loon, grebe, or duck	1	0.02					411	85.6
Waterfowl								
White-fronted Goose					9	1.4		
Mallard	2	0.04	10	2.0				
Pintail	3	0.06	2	0.4			1	0.2
American Wigeon			2	0.4			4	0.8
Dabbling duck (spp)	25	0.49	37	7.4			20	4.2
Scaup (spp)	70	1.36	54	10.8	1	0.2	344	71.7
Goldeneye (spp)							26	5.4
Bufflehead							17	3.5
Surf Scoter							9	1.9
Scoter (spp)							75	15.6
Diving duck (spp)	39	0.76	14	2.8			529	110.2
Duck (spp)	14	0.27					313	65.2
Total Waterfowl	153	2.98	119	23.8	10	1.6	1338	278.8
American Coot							3	0.6
Gull (spp)	18	0.35			1	0.2		
Total Water Birds	172	3.35	121	24.2	11	1.7	1763	367.3

* A - Transects along realigned route.
B - Transects adjacent to realigned route.
C - Transects along rivers.
D - Lakes.

†Density indices are in units of birds/mi^2.

or species group of water birds for each of the four types of area surveyed.

The lowest density index of total water birds occurred on the river transects (1.7 broods/mi^2); the highest density index again ocurred on the lakes that were surveyed (367 birds/mi^2). The density indices of total water birds observed along the realigned route (3.4 birds/mi^2) and on the area adjacent to the route (24 birds/mi^2) were intermediate in value.

The total density index for the lakes in early September was larger than the indices for the lakes in mid-July or late May by factors of more than 3 and 12, respectively. The total density index for the river transects was lower than the indices for the river transects in late May or mid-July by a factor of more than three. The total density indices for the transects along and adjacent to the realigned route had increased from their mid-July values to values comparable to their values in late May.

Many of the water birds on the lakes (72%) could not be identified to the species or species group level because they occurred as large flocks in confined areas. Scaup were the most abundant water birds that could be identified during the survey. They comprised 23% of the water birds observed (73% of the water birds that could be indentified to the species group level).

Density Indices of Transects and Lakes

Table 5 lists the density indices of total waterfowl and of total water birds that were recorded on each transect during each of the three surveys. Table 6 lists the numbers and the density indices of total waterfowl and of total water birds that were observed on each of the lakes during each survey. Appendix 3 gives the numbers and density indices of each species of bird that was observed on each transect or lake during each survey.

Other Areas Surveyed

In addition to the surveys of the Fort Simpson realignment and adjacent areas, surveys were flown in early September to investigate the use made by water birds of Bistcho and Hay-Zama lakes in northwestern Alberta. The results of these surveys are given in Appendix 4.

TABLE 5. Density Indices* for Total Waterfowl and Total Water Birds on Individual Transects During the Three Surveys.

	30-31 MAY		16 JULY†		4 SEPTEMBER	
TRANSECT NUMBER**	TOTAL WATERFOWL	TOTAL WATER BIRDS	TOTAL WATERFOWL	TOTAL WATER BIRDS	TOTAL WATERFOWL	TOTAL WATER BIRDS
TRANSECTS ALONG REALIGNED ROUTE						
58	0.0	0.0	0.0	0.0	0.0	0.0
59	0.0	0.0	0.0	0.0	3.2	3.2
60	2.8	4.4	0.8	1.6	0.0	0.0
61	0.0	0.0	0.0	0.0	0.0	0.0
62	0.4	0.4	0.0	0.0	0.0	0.0
63	0.0	0.0	0.0	0.0	2.4	2.4
64	0.0	0.0	0.0	0.0	12.0	12.0
65	1.6	2.0	0.4	0.4	0.0	0.0
66	0.0	0.0	0.0	0.0	0.0	0.0
67	2.0	2.0	0.0	0.0	0.0	0.0
68	3.2	3.2	0.0	0.0	6.4	6.4
69	9.6	10.8	0.0	0.0	2.8	2.8
70	8.4	12.8	0.8	1.6	22.0	22.0
71	1.6	1.6	0.0	0.0	16.8	16.8
72	0.8	0.8	0.8	0.8	0.0	0.0
73	13.6	15.6	0.0	3.2	0.0	0.0
74	0.0	0.0	0.0	0.0	0.0	0.0
75	0.0	0.0	0.0	0.0	0.0	0.0
76	0.0	0.0	0.0	0.0	0.0	0.0
77	0.0	0.0	0.0	1.6	0.0	0.0
78	0.0	0.0	0.0	0.0	1.6	1.6
79	2.4	2.4	0.0	0.0	0.0	0.0
80	2.4	2.4	0.0	0.0	3.2	3.2
81	3.2	4.0	0.8	1.6	0.4	7.6
82	0.0	0.4	0.0	0.8	0.8	0.8
83	11.2	12.0	2.4	2.4	0.4	0.8
84	6.0	6.4	0.4	0.8	2.0	2.0
85	0.0	0.0	0.0	0.0	0.0	0.0
86	7.2	7.2	0.8	0.8	0.0	0.0
TRANSECTS ADJACENT TO REALIGNED ROUTE						
3000	21.2	25.2	1.2	6.4	17.6	18.4
3001	11.2	12.8	14.0	15.6	30.0	30.0
TRANSECTS ALONG RIVERS						
2020	3.1	4.7	10.0	10.2	0.0	0.2
2021	7.1	7.1	1.1	1.3	5.3	5.3

* Density indices are in units of birds/mi^2.

† Does not include broods.

** For the locations of the transects see Figure 1 and Appendix 1.

TABLE 6. Numbers and Density Indices* for Total Waterfowl and Total Water Birds on Lakes During the Three Surveys.

LAKE**	30-31 MAY		16 JULY†		4 SEPTEMBER	
	NUMBER	DENSITY	NUMBER	DENSITY	NUMBER	DENSITY
			TOTAL WATERFOWL			
2001	118	105.4	868	775.0	229	204.5
2002	0	0.0	2	3.0	20	29.9
2003	192	14.7	599	45.7	(105)	-
2004	73	36.5	(57)	-	(188)	-
2005	103	34.3	(514)	-	1089	363.0
2006	58	77.3	56	74.7	(77)	-
2007	10	14.9	66	98.5	(22)	-
2008	65	81.2	10	12.0	(31)	-
2009	39	15.6	221	88.4	(627)	-
			TOTAL WATER BIRDS			
2001	131	117.0	868	775.0	556	496.4
2002	3	4.5	26	38.8	22	32.8
2003	213	16.3	649	49.5	(127)	-
2004	76	38.0	(63)	-	(188)	-
2005	110	36.7	(520)	-	1185	395.0
2006	62	82.7	56	74.7	(78)	-
2007	12	17.9	76	113.4	(22)	-
2008	66	82.5	10	12.0	(31)	-
2009	47	18.8	242	96.8	(631)	-

* Density indices are in units of birds/mi^2.

† Does not include broods.

** For the locations of the lakes see Figure 1 and Appendix 1.

Bracketed figures are partial counts (of unknown fraction) of total on lake and cannot be used for density indices.

DISCUSSION

Distribution of Water Birds

By the time of the 30-31 May survey most species of water birds had probably completed spring migration into or through the upper Mackenzie Valley. Geese, most species of dabbling ducks, and some species of diving ducks (e.g., goldeneyes and mergansers) are early spring migrants; they begin to move into a region as soon as the ponds begin to thaw in spring (Bellrose, 1976). In 1973, for example, most species of these groups were present in the Fort Simpson area by late April (Salter *et al.*, 1974). Loons, grebes, and some species of the diving ducks (e.g., scaup and scoters) are later migrants that probably do not arrive until the larger lakes have started to thaw. In 1973, for example, these species arrived in the Fort Simpson area during early to mid-May (Salter *et al.*, 1974); during the years 1961 through 1965, the major influxes of these late-nesting species of diving ducks into the Yellowknife area occurred between 15 and 20 May (Murdy *et al.*, 1970).

The birds seen on the late May survey were thus mainly birds that would spend the early summer in the vicinity of the Fort Simpson realignment. Most of these birds probably bred in the area. Some of the scaup, goldeneyes, and Buffleheads, however, were probably subadult birds; these species do not breed until they are two or three years of age (Bellrose, 1976; Palmer, 1976).

The density index of breeding ducks (the predominant water birds observed on the surveys) along the Fort Simpson realignment was relatively small in comparison with breeding densities from USFWS surveys conducted in the same general region during 1975 and previous years. The USFWS has conducted surveys of ducks breeding in the southern Mackenzie Valley-Great Slave Lake area and in northern Alberta for many years. The transects that they survey in these areas are considered to be representative of the areas. In 1975 the USFWS surveys were conducted during the period 20-27 May; the density indices were 5.3 ducks/mi^2 in the southern Mackenzie Valley-Great Slave Lake area and 4.6 ducks/mi^2 in northern Alberta* (Voelzer and Jensen, 1975). The comparable value from the survey of 30-31 May of the Fort Simpson realignment was 2.5 ducks/mi^2--approximately half the values obtained from the 1975 USFWS data. During the years 1969 through 1974, the USFWS density indices of breeding ducks in northern Alberta ranged from a low of 2.7 ducks/mi^2 in 1969 to a high of 5.6 ducks/mi^2 in 1972 (average 3.9 ducks/mi^2); in the southern Mackenzie Valley-Great Slave Lake region they ranged from a low of 3.1 ducks/mi^2 in 1974 to a high of 13.9 ducks/mi^2 in 1972 (average 6.4 ducks/mi^2) (Voelzer and Jensen, 1969, 1970, 1971, 1972, 1973, 1974, 1975).

Davis (1974) conducted aerial surveys during the period 26 May-1 June 1972 along the preliminary Arctic Gas pipeline route under consideration at that time. For the section of this proposed route between Wrigley and

*The density indices presented for the USFWS surveys were calculated from the raw data supplied in reports by Voelzer and Jensen (1969, 1970, 1971, 1972, 1973, 1974, 1975) in the same manner as the density indices of the present study.

the Alberta-N.W.T. border (crossing the Mackenzie River east of Fort Simpson) he obtained a density index of 9.0 ducks/mi^2--more than three times the comparable value in 1975 for the Fort Simpson realignment. However, 1972 was a particularly good year for ducks in the southern Mackenzie Valley-Great Slave Lake region and the USFWS density index for this region in 1972 (13.9 ducks/mi^2) was more than twice the 1975 USFWS density index. The difference in breeding duck density indices between the preliminary 1972 route and the Fort Simpson realignment thus appears to be more a result of the large number of ducks present in the region during 1972 in comparison with 1975 than a result of differences between the two routes.

In both 1972 and 1975 the density indices of breeding ducks obtained along the pipeline routes were lower than the comparable density indices obtained from the USFWS surveys. This result is probably due to the fact that the pipeline routes were chosen wherever possible to avoid major water bodies. The USFWS transects, which are considered to be representative of the region, do not avoid water bodies.

The Fort Simpson realignment does not appear to be an important brood-rearing area for water birds. No comparable USFWS data are available for 1975, but comparisons can be made with USFWS brood survey data from 1970 and 1971--years when the USFWS breeding duck densities in the area were comparable to the 1975 values. The density index of duck broods along the Fort Simpson realignment (0.17 broods/mi^2) was considerably lower than the 1970 and 1971 density indices of duck broods in the upper Mackenzie Valley-Great Slave Lake region (1.04 broods/mi^2 in 1970, 0.84 broods/mi^2 in 1971) and in northern Alberta (0.96 broods/mi^2 in 1970, 0.45 broods/mi^2 in 1971) (Henny *et al.*, 1972).

By mid-July the majority of male ducks and the majority of the female ducks that did not breed or that failed in their breeding attempt congregate on water bodies where they moult their primaries (Bellrose, 1976). They become flightless for a short period at this time. The route of the Fort Simpson realignment was little used by moulting waterfowl. Very few ducks occurred along the pipeline route in mid-July and most of these were females with broods. Both the density indices and the percentage of ducks without broods were much higher on the lakes that were surveyed. The very high densities on the lakes probably resulted both from the tendency of moulting waterfowl to congregate on the water bodies and from the fact that areas included in the density calculations were entirely aquatic.

Fall migration was underway by the time of the 4 September survey, although some female ducks were probably still in the process of moulting. In 1975, migration of ducks in the Fort McMurray region of Alberta (approximately 350 mi [560 km] southeast of the Fort Simpson realignment) was already underway by the second half of August (J.G. Ward, LGL Limited, pers. comm.). In 1972 fall waterfowl migration was underway in the Fort Simpson area by late August although the peak of migration did not occur until 18-22 September (Salter, 1974b).

Most ducks occurred on the larger water bodies at the time of the early September survey. The density index for water birds along the Fort Simpson realignment was low in comparison with the density indices for the transects through more favourable habitat adjacent to the route (24.2 birds/mi^2) and for the lakes that were surveyed (367 birds/mi^2).

Among the most important autumn concentration areas of staging water birds in the general area of the Fort Simpson realignment are Mills Lake and Beaver Lake on the Mackenzie River (Salter, 1974b) and the Hay-Zama Lakes in northern Alberta. Densities of ducks on the Hay-Zama Lakes, for example, were 733 ducks/mi^2 on 26 September 1974 (Wiseley and Tull, 1975) and 865 ducks/mi^2 on 3 September 1975 (Appendix 4).

Areas Used by Water Birds

The route of the Fort Simpson realignment generally does not appear to be used by large numbers of water birds for the purposes of breeding, moulting, or fall migration. Densities of breeding birds and of broods along the route as a whole were low in comparison with densities on USFWS transects that are considered to be representative of the area. Densities along the route were not uniformly low, however; water birds were more numerous in some portions of the route than they were in others.

Of the transects along the realigned route, transect 70 had the highest average density index of 12.1 water birds/mi^2 (see Table 5). Transects

69 and 71 also had comparatively high densities on either the late May or the early September survey. Transects 69, 70 and 71 lie between the Mackenzie River and Jean-Marie Creek--an area where there are numerous small water bodies that lie very close to the realigned route (often within 1/8 mi of the route). The other transects where the average density indices were greater than 4.0 water birds/mi^2 (transects 64, 73, 81, and 83) also have small lakes or wetland areas adjacent to the pipeline route. Generally water bird density indices were quite low for the section of the Fort Simpson realignment north of the Mackenzie River and for the section between the Trout and Kakisa rivers.

Density indices of water birds were much higher for the lakes and water bodies near the Fort Simpson realignment than they were for the route itself. Although the comparatively high densities on the lakes reflect, in part, a bias that results from the presence only of aquatic areas in the sample, the high densities are probably also due to the tendency of non-breeding, moulting, or migrating waterfowl to concentrate on these lakes. The most heavily utilized lakes appeared to be lake 2001 (and probably lake 2005) during mid-July and lakes 2001 and 2005 (and probably lake 2009) during early September (see Table 6).

The importance of an area to water birds should be judged not only in terms of the density of birds in the area but also in terms of the total number of birds that occur in the area (i.e., in terms of the water bird density and the size of the area). In this respect the small water bodies near the Fort Simpson realignment are of relatively minor importance in comparison with large areas such as Mills Lake, Beaver Lake, and the Hay-Zama Lakes, all of which are major water bird concentration areas.

Comparison of Pipeline Routes

The Fort Simpson realignment was selected by Arctic Gas in 1975 to replace the original route alignment (CAGPL, 1974) to the west of Fort Simpson (see Figure 1). Aerial surveys of water birds have not been conducted along the original route and it is thus not possible to compare the populations of water birds along the two routes. It is possible, however, to compare the capabilities of the two routes for waterfowl utilization and production. These capabilities have been mapped for lands in the southern Mackenzie Valley by Poston *et al.* (1973) and for lands in northern Alberta by Poston and Ambrock (1968).

Each route is approximately 285 mi in length. Along the original route, approximately 0.5 mi (0.2%) are rated as Class 2 (slight limitations for utilization and production of waterfowl), approximately 21 mi (7%) are rated as Class 3 (moderate limitations for utilization and production of waterfowl), and approximately 263 mi (92%) are rated as Class 4 (severe limitations for utilization and production of waterfowl). The corresponding figures for the Fort Simpson realignment are 22 mi (8%) of Class 2, 33 mi (12%) of Class 3, and 230 mi (81%) of Class 4. Most of the Class 2 habitat on the Fort Simpson realignment occurs in the area between the Mackenzie River and Jean-Marie Creek. The Fort Simpson realignment thus has greater potential for waterfowl production than does the original route. However, the major portions of both routes have severe limitations for utilization and production of waterfowl. The numbers of birds recorded on the aerial surveys support this evaluation of the Fort Simpson realignment.

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APPENDICES

APPENDIX 1. Locations and Areas of Transects and Lakes Surveyed.

TRANSECT NUMBER	END POINTS 1		END POINTS 2		LENGTH (mi)	AREA (mi^2)	MAP SHEET* 1:250,000	DISTANCE FROM ROUTE (mi)
			TRANSECTS ALONG REALIGNED ROUTE					
58	62°59'N	123°12'W	62°51'N	123°06'W	10	2.5	95J	
59	62°51'N	123°06'W	62°44'N	122°53'W	10	2.5	95J	
60	62°44'N	122°53'W	62°38'N	122°40'W	10	2.5	95J	
61	62°38'N	122°40'W	62°32'N	122°27'W	10	2.5	95J	
62	62°32'N	122°27'W	62°25'N	122°16'W	10	2.5	95J	
63	62°25'N	122°16'W	62°18'N	122°03'W	10	2.5	95J	
64	62°18'N	122°03'W	62°12'N	121°52'W	10	2.5	95J/95I	
65	62°12'N	121°52'W	62°06'N	121°38'W	10	2.5	95I	
66	62°06'N	121°38'W	61°59'N	121°26'W	10	2.5	95I/95H	
67	61°59'N	121°26'W	61°53'N	121°14'W	10	2.5	95H	
68	61°53'N	121°14'W	61°45'N	121°08'W	10	2.5	95H	
69	61°45'N	121°08'W	61°37'N	121°03'W	10	2.5	95H	
70	61°37'N	121°03'W	61°30'N	120°53'W	10	2.5	95H	
71	61°30'N	120°53'W	61°22'N	120°46'W	10	2.5	95H	
72	61°22'N	120°46'W	61°13'N	120°37'W	10	2.5	95H	
73	61°13'N	120°37'W	61°05'N	120°33'W	10	2.5	95H	
74	61°05'N	120°33'W	60°57'N	120°26'W	10	2.5	95H/95A	
75	60°57'N	120°26'W	60°48'N	120°20'W	10	2.5	95A	
76	60°48'N	120°20'W	60°41'N	120°13'W	10	2.5	95A	
77	60°41'N	120°13'W	60°33'N	120°07'W	10	2.5	95A	
78	60°33'N	120°07'W	60°25'N	120°02'W	10	2.5	95A	
79	60°25'N	120°02'W	60°17'N	119°55'W	10	2.5	95A/85D	
80	60°17'N	119°55'W	60°09'N	119°48'W	10	2.5	85D	
81	60°09'N	119°48'W	60 01'N	119°42'W	10	2.5	85D	
82	60°01'N	119°42'W	59°53'N	119°35'W	10	2.5	85D/84M	
83	59°53'N	119°35'W	59°45'N	119°27'W	10	2.5	84M	
84	59°45'N	119°27'W	59°38'N	119°21'W	10	2.5	84M	
85	59°38'N	119°21'W	59°28'N	119°14'W	10	2.5	84M	
86	59°28'N	119°14'W	59°25'N	119°10'W	5	1.3	84M	
			TRANSECTS ADJACENT TO REALIGNED ROUTE					
3000	61°46'N	121°06'W	61°30'N	120°50'W	20	5.0	95H	2.3
3001	61°47'N	121°02'W	61°31'N	120°46'W	20	5.0	95H	4.6
			TRANSECTS ALONG RIVERS					
2020	62°56'N	123°13'W	62°42'N	123°08'W	18	4.5	95J	
2021	62°42'N		62°41'N	122°46'W	15	3.8	95J	
			LAKES					
2001	59°26'N	119°17'W - Wally Lake				1.1	84M	3
2002	60°07'N	119°54'W				0.7	85D	3
2003	60°25'N	120°17'W - Trainor Lake				13.1	95A	6
2004	61°03'N	120°26'W				2.0	95H	1
2005	61°32'N	120°58'W				3.0	95H	0.1
2006	62°11'N	121°49'W				0.8	95I	0.3
2007	62°21'N	122°12'W				0.7	95J	2
2008	62°39'N	122°31'W				0.8	95J	0.7
2009	62°48'N	122°57'W - Peekaya Lake				2.5	95J	3

*National Topographic System.

APPENDIX 2. Scientific Names of Water Birds Recorded. (Nomenclature follows A.O.U. Checklist [1957] and the Thirty-second Supplement [1973].)

Common Loon	-	*Gavia immer*
Red-necked Grebe	-	*Podiceps grisegena*
Horned Grebe	-	*Podiceps auritus*
Western Grebe	-	*Aechmophorus occidentalis*
Canada Goose	-	*Branta canadensis*
White-fronted Goose	-	*Anser albifrons*
Mallard	-	*Anas platyrhynchos*
Pintail	-	*Anas acuta*
Green-winged Teal	-	*Anas crecca*
Blue-winged Teal	-	*Anas discors*
American Wigeon	-	*Anas americana*
Ring-necked Duck	-	*Aythya collaris*
Greater Scaup*	-	*Aythya marila*
Lesser Scaup	-	*Aythya affinis*
Common Goldeneye	-	*Bucephala clangula*
Barrow's Goldeneye*	-	*Bucephala islandica*
Bufflehead	-	*Bucephala albeola*
Oldsquaw	-	*Clangula hyemalis*
White-winged Scoter	-	*Melanitta deglandi*
Surf Scoter	-	*Melanitta perspicillata*
Common Merganser	-	*Mergus merganser*
Red-breasted Merganser	-	*Mergus serrator*
Sandhill Crane	-	*Grus canadensis*
American Coot	-	*Fulica americana*
Bonaparte's Gull	-	*Larus philadelphia*
Common Tern*	-	*Sterna hirundo*
Arctic Tern*	-	*Sterna paradisaea*
Black Tern	-	*Chlidonias niger*

*Not identified to species level.

APPENDIX 3. Numbers of Each Species Observed on Each Transect or Lake During Each Survey.

This appendix consists of a computer printout; this printout, which is stored in the library of the Edmonton branch office of LGL Limited, is available upon request.

APPENDIX 4. Aerial Surveys of Bistcho and Hay-Zama Lakes.

In addition to the aerial survey of the Fort Simpson realignment in early September, surveys were also flown of Bistcho and Hay-Zama lakes in northern Alberta. The results of these surveys are given in Table 7.

The survey of Bistcho Lake was a partial survey around the shores of the lake. The numbers of water birds recorded are only partial counts (of unknown fractions) of the total birds present. Fifteen to seventeen Bald Eagles were seen during the survey; 14 of these birds were adults.

Ten transect lines, each 15 mi long, were surveyed on the Hay-Zama Lakes. The transects were 1 mi apart and covered one quarter of the area of the lakes. The number of water birds present on the lakes at this time was probably in the order of 150,000 birds.

TABLE 7. Water Birds Recorded on Bistcho and Hay-Zama Lakes, 3-4 September 1975.

	BISTCHO LAKE* 4 SEPTEMBER	HAY-ZAMA LAKES 3 SEPTEMBER 37.5 mi^2	
	NUMBER	NUMBER	DENSITY†
Loon (spp)	1	3	0.08
Red-necked Grebe	1		
Western Grebe		1	0.03
Grebe (spp)		1	0.03
Loon, grebe, or duck	186	5998	159.9
Waterfowl			
Canada Goose	46	38	1.01
White-fronted Goose		340	9.07
Dark goose (spp)	8	399	10.6
Snow Goose		1	0.03
Mallard	9	2909	77.6
Gadwall		41	1.09
Pintail	7	662	17.7
Green-winged Teal		60	1.60
Blue-winged Teal		2	0.05
American Wigeon	10	259	6.91
Northern Shoveler		123	3.28
Dabbling duck (spp)	11	9296	247.9
Redhead		15	0.40
Canvasback	550	82	2.19
Scaup (spp)	3110	293	7.81
Goldeneye (spp)	247	612	16.3
Bufflehead	38	129	3.44
White-winged Scoter		217	5.79
Surf Scoter	7		
Scoter (spp)	11	205	5.47
Ruddy Duck		18	0.48
Merganser (spp)	291	140	3.73
Diving duck (spp)	285	368	9.81
Duck (spp)	871	17021	453.9
Total Waterfowl	5501	33230	886.1
American Coot	65	593	15.8
Gull (spp)	23		
Total Water Birds	5777	39826	1062.0

*Reconnaissance survey--numbers are a partial count of total birds present.

†Density indices are in units of birds/mi^2.

CHAPTER VI

GROUND SURVEYS OF TERRESTRIAL BREEDING BIRD POPULATIONS ALONG THE FORT SIMPSON REALIGNMENT OF THE PROPOSED ARCTIC GAS PIPELINE ROUTE, ALBERTA AND NORTHWEST TERRITORIES, JUNE, 1975

ALLEN N. WISELEY
C. ERIC TULL

CHAPTER VI

ABSTRACT

Ground transect surveys of terrestrial birds were conducted between 1 June and 19 June 1975 at seven sites located along the route of the Fort Simpson realignment of the proposed Arctic Gas pipeline.

The objectives of the study were (1) to determine the species and numbers of birds that inhabit particular areas and particular habitats along the route and (2) to identify those habitats along the route that are particularly important to bird populations.

Twenty habitats were sampled; nine had total samples greater than 1000 yd and three had total samples greater than 5000 yd.

One hundred species of birds were recorded during the study. Tennessee Warblers were the most commonly recorded species. The density of terrestrial birds was greatest in closed deciduous scrub although the sample size for this habitat was quite small. The habitat with the next greatest density was open deciduous forest. The habitat with the largest sample, scattered spruce-lichen-moss muskeg, had one of the lowest densities of terrestrial birds.

Units of deciduous scrub and units of the taller mature forests appear to be the most important units of habitat along the Fort Simpson realignment in terms of the numbers of terrestrial breeding birds that they support. Units of scattered spruce muskeg appear to be the least important habitat units.

ACKNOWLEDGEMENTS

We wish to thank J.H. Eisenhauer who, together with A.N. Wiseley, formed the field crew for the study. R. Sprang, the pilot, and the other personnel of Arctic Air Ltd., Fort Simpson, provided transportation and logistical support. W.W.H. Gunn, W.R. Koski, L.A. Patterson, and W.J. Richardson made helpful comments on this report. J. Erwin and D. Sorochan prepared the typescript.

The Arctic Gas Biological Report Series, of which this report is a part, is a series of consultant project reports presenting data based on field and laboratory studies. The format and presentation vary among reports in accordance with the authors' discretion.

The data for this work were obtained as a result of investigations carried out by LGL Limited, Environmental Research Associates, for Canadian Arctic Gas Study Limited. The text of this report may be quoted provided the usual credits are given.

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INTRODUCTION

The Fort Simpson realignment (CAGPL, 1975) is an eastward shift of a 280 mi portion of the proposed Arctic Gas pipeline in the southern Mackenzie Valley. The realigned route diverges from the original route near the mouth of the River-Between-Two-Mountains in the foothills at the southern tip of the McConnell Range, traverses the plateau of the Ebbutt Hills and the broad southern Mackenzie River valley, and then rises gradually via the Redknife Hills to the Alberta Plateau, where it rejoins the original route in the upper drainage of the Petitot River (Figure 1).

Until recent proposals were made to use this generally remote area as a corridor for the transportation of natural gas, few studies of the terrestrial birds in the region had been conducted. Early work concentrated on birds along the rivers or near the towns and provided primarily distributional information; this information has been summarized by Godfrey (1966). Carbyn (1971) conducted plot census studies of birds in boreal forest habitats near Rae, N.W.T., approximately 150 mi east of the route.

From 1971 to 1974 LGL Limited has conducted a series of ornithological studies to collect both quantitative and qualitative data on the populations of terrestrial birds that breed along the route of the proposed Arctic Gas pipeline. To date two such studies have been conducted along previously-proposed routes in the southern Mackenzie Valley (Salter and

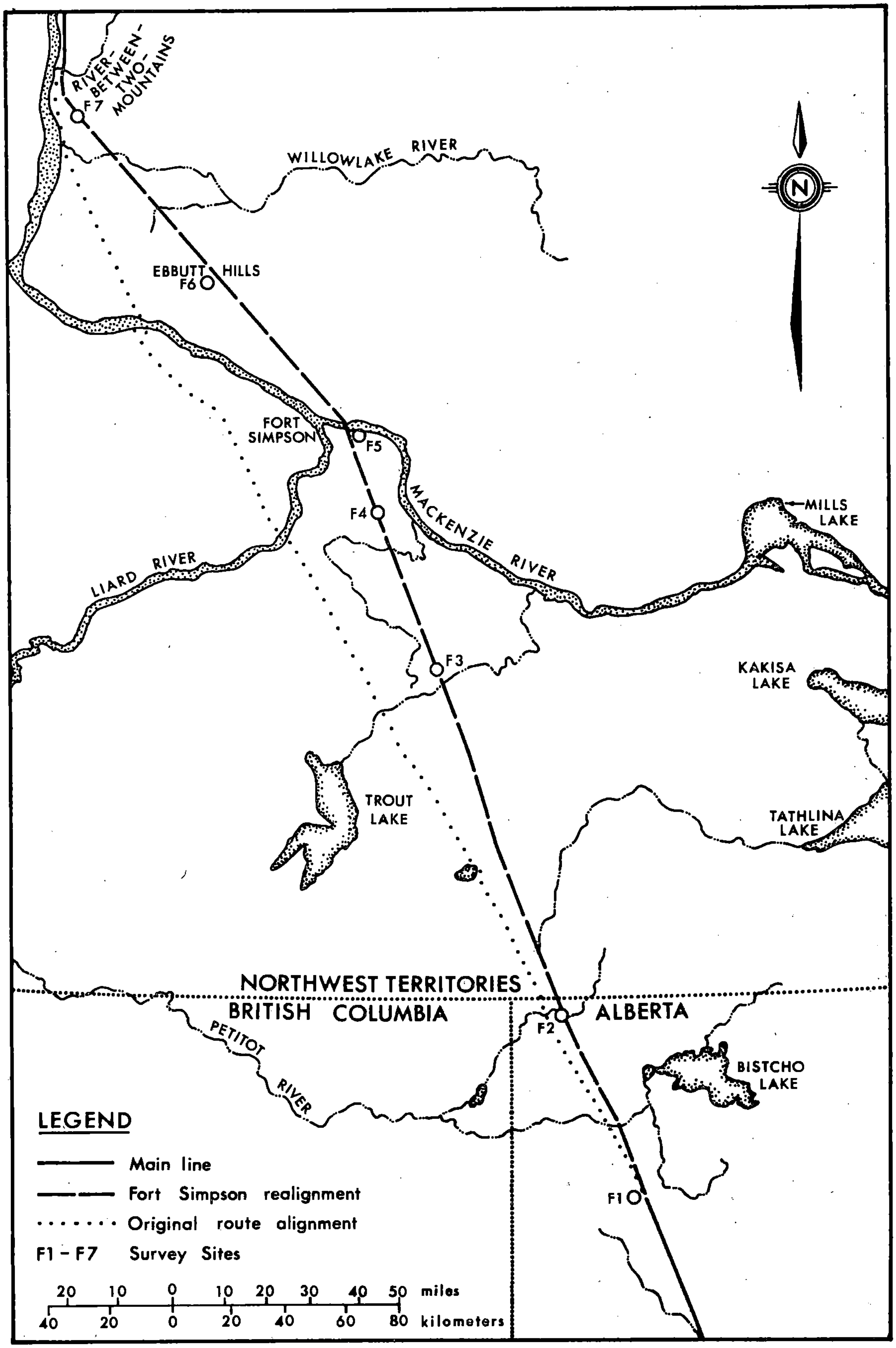

FIGURE 1. Fort Simpson Realignment and Location of Ground Survey Sites.

Davis, 1974; Ward, 1975) and one study has been conducted along the proposed route in northern Alberta (Tull, 1975).

Although these studies describe bird populations that may be typical of habitats or areas along the realigned route, no studies of terrestrial breeding bird populations had been conducted there. The purpose of the present study was to conduct surveys (similar to the above-mentioned studies) of the breeding bird populations in the major habitats along the Fort Simpson realignment.

The specific objectives of this study were the following:

1) to measure the number of species and the relative abundance of the birds that inhabit particular areas and particular habitats along the Fort Simpson realignment and
2) to identify those habitats along the route that are particularly important to bird populations.

The data gathered during this study, when combined with similar data from previous years, will provide an information base that can be used both to assess the impact of the proposed Arctic Gas pipeline on the bird populations of the area and to develop environmental recommendations to mitigate the impacts on the birds of the area.

STUDY AREA

The Fort Simpson realignment crosses three major forest zones of the Boreal Forest Region (Rowe, 1972). These zones are the following: 1) the Upper Mackenzie section--riparian forest that borders the major rivers of the Mackenzie River drainage; 2) the Northwestern Transition section--a small section of the route north of the Mackenzie River that is characterized by forest and muskeg of stunted, sparsely-distributed black spruce; and 3) the Hay River section--most of the area south of the Mackenzie Valley that forms a northern extension of mixed wood forest and that is largely dominated by black spruce, white spruce, and trembling aspen.

The vegetative patterns in the area are diverse; they depend upon many factors such as topography, drainage, soil type, soil structure, permafrost depth, direction of slope face, and history of fire and glaciation (Reid and Janz, 1974). Much of the area along the route is relatively flat and poorly drained. Few lakes are present but numerous ponds, fens, and bogs occur. Evidence of recent seismic exploration (cut lines) is present throughout most of the area.

Through use of aerial photographs, Wallace (1972) has mapped the vegetation of the Mackenzie corridor north of 60°N latitude. His maps indicate that a variable pattern of forested and non-forested vegetation occurs along the Fort Simpson realignment. Table 1 was prepared from measurements taken from these maps. It shows the estimated proportions of the route that are composed of each major habitat type, the species composition of the

TABLE 1. Approximate Vegetative Cover and Forest Composition Along the Fort Simpson Realignment North of 60°N.*

Vegetative Cover

1. Recent burns 9%
2. Forested 33%
   - riparian spruce-hardwood 1%
   - upland hardwood-pine-spruce 17%
   - upland spruce-feather moss 15%
3. Transition 45%
   - black spruce-sphagnum 40%
   - black spruce-lichen 4%
   - pioneer steep slope mixtures 1%
4. Non-forested 13%
   - sedge fens 11%
   - sphagnum bogs 2%
   - rock 0.1%
   - ponds 0.1%

Composition of Forested Habitat

	Dominant Species	Height Classes			
		1'-20'	21'-40'	41'-60'	61'-80'
Black spruce	56%	20%	36%	0%	0%
White spruce	16%	0.2%	7%	8%	1%
Hardwoods†	15%	0.2%	7%	7%	1%
Jack pine	11%	0.3%	8%	3%	0.3%
Larch	2%	2%	0%	0%	0%

* From Wallace (1972).

† Primarily aspen, balsam poplar, and white birch.

forested habitats, and the height classes of the tree species. The muskeg types of vegetation, chiefly black spruce-sphagnum, cover the greatest percentage (approximately 44%) of the route; forests cover only approximately 33% of the route. The dominant tree species along the route is black spruce.

METHODS

Site Selection

Seven possible sites were selected prior to the surveys. They were selected at approximately equal intervals along the route. Each site was chosen adjacent to a lake or river of size sufficient to permit a float-equipped plane to land and to take off. One site was relocated when it was discovered that the abundant emergent vegetation on the selected lake prevented the aircraft from landing there.

Survey Period

Ground transect surveys were conducted between 1 June 1975 and 19 June 1975. The surveys progressed from southerly to northerly sites. Surveys were conducted for two or three days at each location; the survey periods of three days occurred at sites F1 and F6.

Surveys were conducted each day between the hours of 0430 and 1100 MDT--a period when males of most species of birds were singing actively and could thus be easily detected and identified by sound as well as by sight. Surveys were not conducted during adverse weather conditions as changes in activity levels and hence the detectabilities of birds occur at these times.

Transect Survey Method

As in previous years a transect survey method (based on techniques described by Kendeigh [1944], Enemar and Sjöstrand [1967], and Emlen [1971]) was used to survey terrestrial birds in the study area. Such a method was used to study birds along the pipeline route because it allowed the sampling of large sections of habitat over a large geographical area during a short period of time. The survey technique used by LGL Limited is outlined in detail by Salter and Davis (1974). Patterson *et al.* (1976) describe the modifications that were implemented in the technique during 1975. Detailed assessments of the method are given in Richardson and Thompson (1974), Richardson and Gollop (1974), and Richardson and Courtney (1975).

Where possible the routes of transects were chosen to cross areas that are traversed by the pipeline route. Where the route was relatively inaccessible from suitable landing lakes, however, the transects were chosen to pass through adjacent areas of similar habitat types. Both aerial photos and visual impressions of each area from the air were used in an attempt to route the transects through habitat types that were typical of the pipeline route.

Treatment of Data

Field observations were recorded in notebooks during the transect surveys and were later coded on data sheets, key-punched and key-verified.

After the accuracy of the previous steps had been checked by means of a computer validation program, the results were tabulated by computer.

The bird data were tabulated in two forms--by habitat type and by survey site. The numbers and density indices of individual species, the numbers of species, and the total bird numbers and density indices were computed for each habitat type and for each survey site.

For calculations of indices of density, only those birds that were first seen or heard within 10 yd[1] of the centre of the transect ("on-transect" birds) were included. In order to be consistent with previous studies both sitting and flying birds were included in the calculations and flocks of five or more birds were excluded from the calculations.

Non-parametric statistical tests were used to compare data. The Kruskal-Wallis one-way analysis of variance and the Spearman rank correlation methods (Siegel, 1956) were employed where appropriate. Particular habitat types were considered in Kruskal-Wallis comparisons only if at least 500 yd of that habitat were encountered at each of at least three sites.

Habitat preference indices of the more common species (those which formed more than 4% of the total number of birds seen "on-transect") were calculated using records of sitting birds that were detected "on-transect". In contrast with previous studies, "off-transect" birds (those detected from 10 to 40 yd from the centre of the transect) were not included in these calculations

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[1] British units of measurement have been used in this study to maintain consistency within the continuing series of ground survey studies.

because it was felt that the habitats in which these birds were detected could not be classified with sufficient accuracy. Only those habitats with a total sample of at least 2500 yd were used in the calculations of habitat preference indices. A species was considered to show a preference for a habitat if the density index for that habitat exceeded twice the average of the density indices for that species in all the common habitats (see Patterson *et al.*, 1976).

RESULTS

Sites and Habitats Sampled

A total of 52,220 yd of transect in 20 habitat types was sampled at seven sites. Table 2 lists the latitudes and longitudes of the sites, the dates on which each site was surveyed, and the weather conditions during the surveys. Figure 1 shows the locations of each site and Appendix 1 presents maps of each site. The average distance between sites was approximately 38 mi, but distances ranged from 23 mi to 87 mi.

Table 3 presents the number of yards of each habitat type sampled at each site. The number of yards of each habitat encountered ranged from a high of 21,387 yd of scattered spruce-lichen-moss muskeg (41% of the total number of yards surveyed) to a low of 93 yd of open water. The only other habitats with samples of more than 5000 yd were open deciduous forest (5471 yd) and open evergreen forest (5173 yd). The greatest number of habitat types (13) was sampled at site F3; the smallest number (4) was sampled at site F2.

Most of the habitat types are based on a classification devised by Fosberg (1967); they have been described by Ward (1975) or Tull (1975). The habitat type "seismic line" was used to identify any cut line regardless of its vegetation, and thus indicated a disturbed area on a transect. Such cut lines occurred at every survey site. The only non-vegetated habitat encountered was open water.

TABLE 2. Ground Survey Site Locations, Survey Dates, and Weather Conditions* During Surveys, June, 1975.

SITE	LATITUDE	LONGITUDE	DATE JUNE	TIME MDT	WIND MPH	CLOUD TENTHS
F1 Wally Lake, Alta.	59°26'N	119°19'W	1-3	0437-1052	0-7	0-10
F2 Thinahtea Creek, Alta.	59°54'N	119°34'W	4-5	0441-0814	0	0-10
F3 Trout River, N.W.T.	61°04'N	120°29'W	8-9	0435-0909	0-9	4-10
F4 Red-neck Slough, N.W.T.	61°34'N	120°58'W	10-11	0455-1042	0-3	0-10
F5 Naylor's Landing, N.W.T.	61°50'N	121°07'W	12-13	0445-1009	0-4	0-10
F6 Ebbutt Hills, N.W.T.	62°21'N	122°12'W	16-17	0425-0920	0-3	2-4
F7 Peekaya Lake, N.W.T.	62°47'N	122°57'W	18-19	0427-1000	0	0-2

* There was no precipitation during any of the surveys.

TABLE 3. Number of Yards of Each Habitat Type Surveyed at Each Site on the Fort Simpson Realignment, June, 1975.

HABITAT	SITE							TOTAL
	F1	F2	F3	F4	F5	F6	F7	
11 Closed Evergreen Forest			141	1188			88	1417
55 Open Evergreen Forest	77	801	97	706	2272		1220	5173
15 Closed Deciduous Forest	1571		102				89	1762
58 Open Deciduous Forest	1270			198	950		3053	5471
303 Closed Mixed Forest	33		423				37	493
304 Open Mixed Forest			329	470	1995		761	3555
50 Open Spruce Muskeg			464	588	481		1463	2996
99 Scattered Spruce-Lichen Muskeg	97							97
100 Scattered Spruce-Moss Muskeg	1229		1783	119		835	108	4074
226 Scattered Spruce-Lichen-Moss Muskeg	5839	6260	881	902		6985	520	21387
26 Closed Evergreen Scrub			484					484
79 Open Evergreen Scrub			358			303		661
69 Closed Deciduous Scrub with Scattered Trees				221	72		71	364
35 Closed Deciduous Scrub	107		363	59	60		85	674
80 Open Deciduous Scrub				295	320		144	759
305 Closed Mixed Scrub	52		300					352
306 Open Mixed Scrub			424	25				449
127 Sedge Marsh				723		800		1523
256 Open Water		79		14				93
251 Seismic Line	85	57	27	147	21	78	21	436
TOTAL	10360	7197	6176	5655	6171	9001	7660	52220

Birds Recorded in Habitat Types

Table 4 lists the number of species of birds, the total number of birds, and the total density index of birds that were detected "on-transect" in each habitat type.

A total of 344 birds was recorded in 52,220 yd of transect--an overall density index of 6.6 birds/1000 yd. Of those habitats with samples of more than 500 yd, closed deciduous scrub supported the highest density index (17.8 birds/1000 yd) and scattered spruce-moss muskeg supported the lowest density index (2.9 birds/1000 yd). Four habitats (open evergreen forest, open deciduous forest, scattered spruce-moss muskeg, and scattered spruce-lichen-moss muskeg) satisfied the criteria for statistical testing. No significant heterogeneity was found among the density indices for these habitats (Kruskal-Wallis; H=2.4; P > 0.4; df=3; n=4,3,3,6).

Forty-three species of birds were recorded "on-transect" in the various habitats. The greatest number of species (17) was recorded in scattered spruce-lichen-moss muskeg--the habitat with the largest sample (21,387 yd). Almost as many species (14) were recorded in each of two habitats with much smaller samples--in 5173 yd of open evergreen forest and in 3555 yd of open mixed forest.

Table 5 lists the 10 species that exceeded 2% of the total birds that were identified "on-transect" and the percentage of the total birds that each species represented. Tennessee Warblers were the commonest species;

TABLE 4. Total Numbers and Density Indices of Birds Detected "On-Transect" in Each Habitat Type, June, 1975.

HABITAT	TOTAL YARDS	NUMBER OF SITES†	NUMBER OF SPECIES	TOTAL BIRDS	DENSITY INDEX BIRDS/1000 YD
11 Closed Evergreen Forest	1417	3	7	12	8.5
55 Open Evergreen Forest	5173	6	14	51	9.9
15 Closed Deciduous Forest	1762	3	3	12	6.8
58 Open Deciduous Forest	5471	4	11	59	10.8
303 Closed Mixed Forest	493	1	2	4	*
304 Open Mixed Forest	3555	4	14	23	6.5
50 Open Spruce Muskeg	2996	4	13	25	8.3
99 Scattered Spruce-Lichen Muskeg	97	1	0	0	*
100 Scattered Spruce-Moss Muskeg	4074	5	9	12	2.9
226 Scattered Spruce-Lichen-Moss Muskeg	21387	6	17	96	4.5
26 Closed Evergreen Scrub	484	1	0	0	*
79 Open Evergreen Scrub	661	2	2	2	3.0
69 Closed Deciduous Scrub with Scattered Trees	364	3	2	3	*
35 Closed Deciduous Scrub	674	5	7	12	17.8
80 Open Deciduous Scrub	759	3	5	6	7.9
305 Closed Mixed Scrub	352	2	1	1	*
306 Open Mixed Scrub	449	1	2	4	*
127 Sedge Marsh	1523	2	7	15	9.8
256 Open Water	93	1	2	2	*
251 Seismic Line	436	4	4	5	*
TOTAL	52220	7	43	344	6.6

† With total sample greater than 50 yd.

* Densities were not calculated for habitats where less than 500 yd were sampled.

TABLE 5. Numbers of the Commonest Species* and Percentages of Total Birds Identified "On-Transect", June, 1975.

SPECIES	NUMBER	% OF TOTAL
Tennessee Warbler	65	22.7
Gray Jay	30	10.5
Chipping Sparrow	30	10.5
Dark-eyed Junco	29	10.1
American Redstart	13	4.5
Yellow-rumped Warbler	12	4.2
Swainson's Thrush	12	4.2
Palm Warbler	11	3.8
Rusty Blackbird	11	3.8
Red-eyed Vireo	7	2.4
	220	76.9
Other Species	66	23.1
TOTAL IDENTIFIED	286	100.0

* Those species which comprised 2% or more of the total birds identified "on-transect".

they comprised 22.7% of all of the birds that were identified "on-transect".

Table 6 lists the density indices for each species of bird that was recorded in each of the major habitat types. Tennessee Warblers had the greatest density index of any species in any one habitat--6.0 birds/1000 yd in open deciduous forest.

Appendix 2 lists the scientific names of the species of birds recorded during this study. Appendix 3 lists the species that were recorded both "on-transect" and "off-transect" in each habitat type at each site. Appendix 4 lists the flocks of birds recorded during the transect surveys.

Habitat Preferences

Table 7 lists the habitat preferences of the species that represented more than 4% of the total birds recorded "on-transect". Gray Jays showed the most marked habitat preference. In open evergreen forest the density index for Gray Jays was 71% of the sum of the density indices for the six habitats with samples of more than 2500 yd. Other marked preferences were shown by Tennessee Warblers for open deciduous forest and by Swainson's Thrushes for open evergreen forest. Several of the species showed little or no preference for any of the habitats.

Birds Recorded at Survey Sites

Table 8 lists the number of species of birds, the total number of birds, and the density index of birds that were detected "on-transect" at each

TABLE 6. Species Density Indices (Birds/1000 yd) for Major Habitat Types†, June, 1975.

HABITAT††	11	55	15	58	304	50	100	226	79	35	80	127
NUMBER OF YARDS	1417	5173	1762	5471	3555	2996	4074	21387	661	674	759	1523
SPECIES												
American Wigeon								0.1				
Lesser Scaup						0.3						
White-winged Scoter								0.1				
Goshawk				0.2								
Common Snipe								*				0.7
Spotted Sandpiper							0.2					
Solitary Sandpiper								0.1				
Greater Yellowlegs									1.5			2.0
Lesser Yellowlegs								*				1.3
Yellowlegs spp.						0.7		*				
Yellow-bellied Sapsucker					0.3							
Alder Flycatcher										3.0		
Least Flycatcher		0.2			0.6							
Gray Jay	0.7	2.1		0.4		1.0	0.2	0.5				
Boreal Chickadee				0.4	0.3		0.2					
American Robin					0.3							0.7
Hermit Thrush				0.2	0.3		0.2					
Swainson's Thrush	1.4	1.0			0.6	0.3	0.2			1.5		
Thrush spp.	0.7											
Ruby-crowned Kinglet		0.4										
Solitary Vireo					0.3							
Red-eyed Vireo				0.7	0.3			*				
Vireo spp.		0.4										
Black-and-white Warbler											1.3	
Tennessee Warbler	0.7	2.1	3.4	6.0	1.4	1.0		*		1.5	2.6	
Magnolia Warbler			0.6									
Cape May Warbler		0.4										
Yellow-rumped Warbler		0.4	0.6	0.4	0.3	0.7	0.2				1.3	
Bay-breasted Warbler		0.2										
Palm Warbler	0.7					0.7		0.3		1.5		
Ovenbird				0.2								
Northern Waterthrush										1.5		
American Redstart		0.8		0.7	0.6	0.3					1.3	
Warbler spp.			0.6									
Red-winged Blackbird								0.1				
Rusty Blackbird	0.7							0.3				2.0
Common Grackle						0.3						
Blackbird spp.						0.3						
Western Tanager	0.7	0.2			0.6							
Pine Siskin											1.3	
White-winged Crossbill								0.1				
Crossbill spp.		0.4										
Savannah Sparrow								*				
Dark-eyed Junco		0.6		0.4		1.0	0.2	0.7				2.0
Chipping Sparrow	1.4	0.4		0.2	0.3	0.3	0.7	0.7		1.5		0.7
White-throated Sparrow					0.3	0.3						
Swamp Sparrow								0.1				
Lincoln's Sparrow						0.3	0.2	0.1		1.5		
Sparrow spp.		0.2										
Passerine spp.	1.4	0.2	1.7	1.1	0.3	0.7	0.2	0.9	1.5	5.9		0.7

† Only habitats where 500 yd or more were sampled are included in this table.

†† For the names corresponding to habitat numbers see Table 3.

* Trace--density index < 0.05 birds/1000 yd.

TABLE 7. Habitat Preferences* of Common Species** During Ground Transect Surveys, June, 1975.

HABITAT†	55	58	304	50	100	226
NUMBER OF YARDS	5173	5471	3555	2996	4074	21387
Gray Jay	71%	10%	0%	0%	0%	20%
Swainson's Thrush	46%	0%	27%	16%	12%	0%
Tennessee Warbler	22%	53%	15%	10%	0%	0.5%
Yellow-rumped Warbler	11%	21%	16%	38%	14%	0%
American Redstart	32%	31%	23%	14%	0%	0%
Dark-eyed Junco	21%	13%	0%	36%	9%	22%
Chipping Sparrow	22%	10%	16%	19%	0%	32%

* Density index of sitting birds in a given habitat as a percentage of sum of density indices in all six habitats with samples of more than 2500 yd.

** Those species that exceeded 4% of all birds detected "on-transect".

† 55 open evergreen forest
58 open deciduous forest
304 open mixed forest
50 open spruce muskeg
100 scattered spruce-moss muskeg
226 scattered spruce-moss-lichen muskeg

TABLE 8. Total Numbers and Density Indices of Birds Detected "On-Transect" at Each Survey Site, June, 1975.

	SITE	TOTAL YARDS	NUMBER OF HABITATS†	NUMBER OF SPECIES	TOTAL BIRDS	DENSITY INDEX BIRDS/1000 YD
F1	Wally Lake, Alta.	10360	9	16	84	8.1
F2	Thinahtea Creek, Alta.	7197	4	11	33	4.6
F3	Trout River, N.W.T.	6176	13	10	23	3.7
F4	Red-neck Slough, N.W.T.	5655	12	21	58	10.3
F5	Naylor's Landing, N.W.T.	6171	7	15	56	9.1
F6	Ebbutt Hills, N.W.T.	9001	5	9	23	2.6
F7	Peekaya Lake, N.W.	7660	11	12	67	8.7
	TOTAL	52220	20	43	344	6.6

† With total sample greater than 50 yd.

survey site.

The greatest density index (10.3 birds/1000 yd) was recorded at Red-neck Slough (site F4); the smallest (2.6 birds/1000 yd) was recorded at the Ebbutt Hills (site F6). The highest number of species (21) was also recorded at Red-neck Slough and the lowest (9) at the Ebbutt Hills. Although a high number of habitats were encountered in the Red-neck Slough area and a low number of habitats were encountered at the Ebbutt Hills, there was no significant correlation between the number of habitats at a site and either the number of species at the site (one-tailed Spearman rank correlation; r_s=0.25; P >> 0.05; n=7) or the density index at the site (one-tailed Spearman rank correlation; r_s=0.29; P >> 0.05; n=7).

Table 9 lists the species of birds that were detected at each survey site (and also at Fort Simpson).

The bird species composition varied considerably from site to site, largely a result of the different habitat types encountered at each site. Table 10 lists the four commonest birds that were recorded at each site. Although the Tennessee Warbler was the most abundant species encountered during the study, it was among the commonest species at only three of the seven sites--those sites where deciduous forest, open evergreen forest, or open mixed forest were commonly encountered. At two of these sites the density indices for Tennessee Warblers were almost twice the density index for any other species at any of the sites.

Table 9. Species of Birds Recorded* at Each Ground Survey Site, June, 1975.

Site	F1	F2	F3	F4	F5	F6	F7	Fort Simpson
Common Loon	0	0	0	0		0		
Red-necked Grebe	0	0		0		0		
Horned Grebe		0	0					
American Bittern		0						
Swan sp.				0				
Canada Goose						0		
Mallard	0	0	0	0			0	
Black Duck			0					
Pintail				0				
Green-winged Teal		0	+	0		0		
American Wigeon	x	x	+	0		0	0	
Lesser Scaup	0	+	0	x	0	0	0	
Common Goldeneye	0	0	0	0			0	0
Barrow's Goldeneye		0	0					
Bufflehead	0	0	0	0		0	0	
Oldsquaw	0	0		0		0		
White-winged Scoter	x	0	0	x		0	0	
Surf Scoter		0		0		0	0	
Red-breasted Merganser	0							
Goshawk	x							
Osprey			0					
Spruce Grouse		+					+	
Ruffed Grouse	0				0		+	
Sandhill Crane	0	0	0	0				
Common Snipe	+	x	0	x	0	+		
Spotted Sandpiper			0	x	0	0		
Solitary Sandpiper				+		x		
Greater Yellowlegs	0	+	+	x		x	0	
Lesser Yellowlegs	0	+	0	+		x		
Short-billed Dowitcher				+				
Wilson's Phalarope				0				
Herring Gull			0					
Mew Gull				0	0			0
Bonaparte's Gull	0	0	0	+		0		0
Common Tern				+				
Black Tern				0				
Great Horned Owl		0						
Common Nighthawk		0	0				0	0
Belted Kingfisher			0					
Common Flicker	0		x	+				0
Yellow-bellied Sapsucker				x				
Hairy Woodpecker			0					
Northern Three-toed Woodpecker							+	
Eastern Kingbird				0				
Alder Flycatcher			+		+		x	0
Least Flycatcher	+	0	x	+	x		+	0
Western Wood Pewee				0				
Olive-sided Flycatcher				0				
Tree Swallow	0		+	0		0		0
Bank Swallow	0	0						0

Table 9 (cont'd.)

Site	F1	F2	F3	F4	F5	F6	F7	Fort Simpson
Cliff Swallow								0
Gray Jay	x	x	x	x	x	x	x	0
Common Raven	0	0	0	0	0	0	0	0
Boreal Chickadee			x	+	x	+	x	
American Robin		0	+	x	+	+	+	0
Varied Thrush							+	
Hermit Thrush	x	+	x	x	+		0	
Swainson's Thrush	0		+	x	x		x	
Gray-cheeked Thrush						+		
Ruby-crowned Kinglet		+	+	+	x	+	+	
Bohemian Waxwing			+					
Starling								0
Solitary Vireo					x		+	
Red-eyed Vireo	x	0		x	0		x	0
Warbling Vireo	0				0			
Black-and-white Warbler				x	+		+	
Tennessee Warbler	x		x	x	x		x	
Orange-crowned Warbler			+					
Yellow Warbler								0
Magnolia Warbler	x		+					
Cape May Warbler				x	x			
Yellow-rumped Warbler	x	+	x	x	x	+	x	
Bay-breasted Warbler					x			
Blackpoll Warbler		+		0				
Palm Warbler	x	+	0	x			x	
Ovenbird	+				+		x	
Northern Waterthrush	0	0	0		x		+	0
Common Yellowthroat			0	0	+			
Wilson's Warbler		0						
American Redstart					x		x	0
Red-winged Blackbird	x	0		0				0
Rusty Blackbird	x	x	0	x		x		
Common Grackle				x				0
Brown-headed Cowbird								0
Western Tanager				x	x		0	0
Rose-breasted Grosbeak					+		+	
Pine Grosbeak							+	
Pine Siskin		+		x				
White-winged Crossbill		x						
Savannah Sparrow		x	0	0				0
Le Conte's Sparrow				0				
Sharp-tailed Sparrow		0						
Dark-eyed Junco	x	x	x	x	x	+	x	
Chipping Sparrow	x	x	+	x	x	x	+	0
White-crowned Sparrow	0	0				0		0
White-throated Sparrow			x	+	0		0	0
Fox Sparrow	0		+					
Lincoln's Sparrow	x	x	x	+		x	x	
Swamp Sparrow		x				x		
Song Sparrow		0						

* x Recorded "on transect" during surveys.
+ Recorded "off transect" but not "on transect" during surveys.
0 Recorded at site but not during transect surveys.

TABLE 10. Density Indices and Percentages of Total Birds Identified "On-Transect" for the Four Commonest Species at Each Site, June, 1975.

SITE	SPECIES	DENSITY INDEX BIRDS/1000 YD	% OF TOTAL
F1 Wally Lake, Alta.	1. Tennessee Warbler	1.4	25
	2. Chipping Sparrow	1.2	20
	3. Dark-eyed Junco	0.9	15
	4. Palm Warbler	0.7	12
F2 Thinahtea Creek, Alta.	1. Dark-eyed Junco	1.0	27
	2. Chipping Sparrow	0.8	23
	3. Gray Jay	0.4	12
	3. Rusty Blackbird	0.4	12
F3 Trout River, N.W.T.	1. Yellow-rumped Warbler	0.6	25
	2. Least Flycatcher	0.3	12
	2. Dark-eyed Junco	0.3	12
	2. White-throated Sparrow	0.3	12
F4 Red-neck Slough, N.W.T.	1. Dark-eyed Junco	1.2	15
	2. Rusty Blackbird	1.1	13
	3. Gray Jay	0.7	9
	3. Chipping Sparrow	0.7	9
F5 Naylor's Landing, N.W.T.	1. Tennessee Warbler	3.1	35
	2. American Redstart	1.8	20
	3. Gray Jay	1.1	13
	4. Chipping Sparrow	0.5	6
F6 Ebbutt Hills, N.W.T.	1. Gray Jay	0.6	24
	1. Chipping Sparrow	0.6	24
	2. Greater Yellowlegs	0.3	14
	2. Lesser Yellowlegs	0.3	14
F7 Peekaya Lake, N.W.T.	1. Tennessee Warbler	3.8	46
	2. Swainson's Thrush	1.2	14
	3. Gray Jay	0.9	11
	4. Red-eyed Vireo	0.4	5
	4. Dark-eyed Junco	0.4	5

Appendix 5 lists the records of nests that were found in the course of the study. Appendix 6 lists records of bird species that were found outside their known ranges.

DISCUSSION

Comparisons With Previous Studies

Table 11 lists the total density indices of birds that were found in various habitat types in the southern Mackenzie Valley during ground transect surveys in 1972, 1974, and 1975. Closed deciduous scrub appeared to support the highest density of birds (although the sample size in 1975 was quite small). The scattered spruce muskeg habitats generally supported the lowest densities of birds (but scattered spruce-moss muskeg in 1972 supported a comparatively high density). Densities for the forest habitats varied considerably both between years, and, for a given year, between the forest category types.

Three of the habitat types satisfied the criteria for statistical testing (at least three samples of 500 yd or more for each year). There was no significant difference for any of these three habitats among the density indices for the three years (Kruskal-Wallis: open and closed evergreen forest; H=0.05; df=2; n=5,5,4; P >> 0.1: open and closed mixed forest; H=1.9; df=2; n=5,4,3; P >> 0.1: scattered spruce-moss muskeg; H=3.8; df=2; n=4,3,3; P > 0.1). This lack of statistical significance probably results from the considerable variation from site to site in the density indices for a given habitat type in a given year.

There is considerable variation in the species that have been recorded during ground survey studies in the southern Mackenzie Valley (Appendix 7).

TABLE 11. Total Density Indices for Comparable Habitats in the Southern Mackenzie Valley During 1973, 1974, and 1975.

	HABITAT	1972[1] NO. OF YARDS	1972[1] DENSITY INDEX BIRDS/1000 YD	1974[2] NO. OF YARDS	1974[2] DENSITY INDEX BIRDS/1000 YD	1975[3] NO. OF YARDS	1975[3] DENSITY INDEX BIRDS/1000 YD
11/55	Open and closed evergreen forest	14550	4.1	9669	5.3	6590	9.6
15/58	Open and closed deciduous forest	6100	5.2	1683	11.9	7233	9.8
303/304	Open and closed mixed forest	11650	7.4	3191	10.3†	4048	6.7
50	Open spruce muskeg	9550	8.3	8475	8.5	2996	8.3
100	Scattered spruce-moss muskeg	9150	12.3	5401	3.5	4074	2.9
226	Scattered spruce-moss-lichen muskeg	1950	3.6	2016	3.0	21387	4.5
35	Closed deciduous scrub	2600	19.2	-	-	674	17.8
80	Open deciduous scrub	1250	13.6	-	-	759	7.9

[1] Salter and Davis (1974) (sites MV2-MV10)
[2] Ward (1975) (sites M1-M6)
[3] present study
† open forest only

One hundred species of birds were recorded in the course of the present study along the Fort Simpson realignment. Six of these species were not recorded during ground survey studies in the southern Mackenzie Valley in 1972 (Salter and Davis, 1974) or in 1974 (Ward, 1975). Twenty-eight additional species were recorded during the 1972 and/or 1974 studies that were not recorded during the present study. Godfrey (1966) shows a further 24 species that were not recorded on any of the ground survey studies but that probably breed in the southern Mackenzie Valley.

There are several reasons why some species were recorded infrequently or not at all in the southern Mackenzie Valley. Some species occur infrequently in the area because the species is rare throughout its range (e.g. Peregrine Falcon), because the area is near the edge of the preferred breeding range (e.g. Arctic and Red-throated Loons), or because the preferred habitat occurs infrequently in the area (e.g. buildings, caves etc. for Barn Swallow, cliffs for Peregrine Falcon). Other species are expected to occur more commonly in the area but were not detected because of their nocturnal habits (e.g. Boreal Owl) or their quiet secretive behaviour (e.g. Black-backed Three-toed Woodpecker).

It is difficult to compare habitat preferences for the three ground survey studies because few of the habitats were sampled in the various studies in amounts sufficient for comparisons. Some species, however, showed preferences for certain broad habitat types during the three studies. Tennessee Warblers generally showed a preference for forest habitats with a deciduous component. Gray Jays showed a preference for open evergreen forest habitats.

Swainson's Thrushes preferred forest habitats; their preference in 1974 and 1975 was for open forests with an evergreen component, whereas in 1972 it was for closed forests with a deciduous component. Dark-eyed Juncos and Chipping Sparrows both showed preferences for open to scattered evergreen habitats of either muskeg or forest. Yellow-rumped Warblers, however, showed different but not strongly marked habitat preferences each year (open spruce muskeg in 1975, open deciduous and open mixed forest in 1974, closed mixed forest in 1972).

Carbyn (1971) determined the species composition for a black spruce bog habitat near Rae, N.W.T. The four most abundant species on his plot--Dark-eyed Junco, Palm Warbler, Chipping Sparrow, and Yellow-rumped Warbler--were among the six most numerous species recorded in muskeg habitat during ground survey studies in the southern Mackenzie Valley in 1972, 1974, and 1975.

Relationship of Birds to Habitats

Bird populations cannot be considered separately from the habitats in which they are found. Several studies are cited by von Haartman (1971) to show that factors such as the abundance of food in a habitat or the number of nesting sites may enhance or restrict the numbers of birds that occur in the habitat. Another characteristic that can influence the numbers and the variety of birds in an area is the height and the degree of vertical stratification of the vegetation. MacArthur and MacArthur (1961) showed that both the height of the vegetation and the degree of vertical stratification were positively correlated with the bird species diversity. In the present study the density and number of species of birds were both comparatively high at site F5 where the height of the forest was greater than at the other sites.

Although the forested habitats have generally supported comparatively high densities of birds, these densities have usually been exceeded in the southern Mackenzie Valley by those found in closed deciduous scrub--a less stratified habitat. Deciduous scrub also supported high densities of birds in the boreal forest region of Alberta (Tull, 1975) and in the vicinity of the Mackenzie Delta (Patterson *et al.*, 1976). Deciduous scrub may be a comparatively productive habitat with more food available for birds than there is in forested habitat. But this may also be an artifact of the sampling technique as birds may be more easily detected in scrub habitat than in forest habitat.

Some species of birds depend upon two or more habitats to meet their ecological requirements. These species are often found near the transition between different habitats. The numbers of "edge" birds (both of individuals and of species) are often greater in the transition zone between two habitats than the numbers of the birds that are restricted to either of the adjoining habitats (Odum, 1971). Species such as Chipping Sparrows and Dark-eyed Juncos, which preferred open to scattered evergreen muskeg or forest, are probably edge species. The Yellow-rumped Warbler, which was found in comparable densities in a number of habitats and which seemed to show different but not strongly marked habitat preferences each year, may also be an example of an edge species. Pough (1949) lists edge habitats as being among the favoured habitats of these species.

Habitats can change markedly with the passage of time. Changes can occur in the height and the density of the vegetation and in the species composition. The changes may lead to a new habitat classification. In the early successional stages such changes in classification may occur within a short time period. As the habitat changes, so too will the bird population in that habitat. Johnston and Odum (1956) showed that bird populations went through several transitional stages during a sequence of successional changes from abandoned farmland to mature oak-hickory forest.

The boreal forest can be regarded as a dynamic system that is composed of a number of different habitat types. There are frequent changes and shifts in the amounts of the various habitat types as disturbances occur and as succession occurs in the habitat types following the disturbances.

Reid and Janz (1974) state that fire, floods, and the activities of man are the chief causes of major habitat disturbances in the southern Mackenzie Valley. Although some fires are caused by man, fire is a natural phenomenon that occurs regularly in the boreal forest (Lutz, 1960; LGL Limited, 1974).

Reid and Janz (1974) identified successional trends for habitats in the southern Mackenzie Valley. There are several mature forest types toward which habitats progress. Where the soil is well-drained, white spruce forest is the habitat type toward which other habitats progress under normal conditions. Where the soil is poorly-drained, habitats progress toward black spruce forest or muskeg under normal conditions. Other "edaphic climax" types prevail where conditions differ from normal conditions according to such factors as slope direction, soil type, drainage, or depth of permafrost layer.

The small songbirds of the southern Mackenzie Valley are well-adapted to the constantly changing habitat mosaic of the boreal forest. There is usually a surplus population of non-breeding adults in an area (Enemar, 1959); the birds have the potential to expand their populations rapidly under favourable breeding conditions (von Haartman, 1971); and the young birds often disperse to new breeding areas (Nice, 1937). The population of songbirds can thus respond quickly to any change in the habitat. Accompanying most changes in habitats there is an increase in the numbers of some species of songbirds and a decrease in the numbers of other species of songbirds.

The initial effect of a severe fire in a forested habitat, for example, is to reduce greatly the number of birds that occur in the area. Birds that prefer forested habitats, such as Gray Jays, Swainson's Thrushes, and Tennessee Warblers, are unable to utilize the area. Few birds utilize the area until the grasses or shrubs begin to regenerate--a process that usually occurs fairly rapidly. Birds that prefer scrub habitats and birds, such as Chipping Sparrows and Dark-eyed Juncos, that prefer open or edge habitats probably move into the area as the shrubs regenerate. If there is a heavy regeneration of deciduous shrubs, the area will probably support a higher density of birds than it did as a forest. As the habitat matures toward a forested type, the birds typical of transitional habitats gradually decrease in numbers to be replaced by birds typical of forested habitats.

Habitats Important to Birds

From the results of the three ground survey studies that have been conducted in the southern Mackenzie Valley, deciduous scrub (particularly closed deciduous scrub) appears to be the habitat type that supports the greatest density of breeding birds. It is not a common habitat in the area. Only small amounts of the habitat were encountered in the three ground survey reports. Reid (1974) indicates that this habitat occurs on "sand and gravel bars along the major rivers and streams where spring flooding occurs annually". It also occurs as a successional stage in some of the burned areas. The riparian scrub communities were encountered very little on the maps of Wallace (1972) along the Fort Simpson realignment, and the fire succession scrub communities are probably a part of the approximately 9% of the Fort Simpson realignment that Wallace categorizes as recent burns. Because of their scarcity in the area and because of the numbers of birds that they support, samples of deciduous scrub are among the most important habitat samples in the southern Mackenzie Valley from the overall point of view of numbers of terrestrial breeding birds.

Densities in the habitats classified as forest or as open spruce muskeg were generally intermediate in nature between the high densities found in deciduous scrub and the low densities found in the scattered spruce muskeg habitats. A number of species of birds, particularly some of the less common species, were restricted in their occurrence to the forested habitats. Wallace (1972) indicates that approximately 33% of the Fort Simpson realignment is forested (18% mixed forest, 15% coniferous forest). Approximately 20% of the forested habitat is composed of trees greater than 40 ft in height. In the present study, the taller forests with their greater vertical stratification (site F5) supported high numbers of species and of individual birds. From the point of view of numbers of birds, samples of forested habitat should be regarded as intermediate in importance. Samples of the taller forests are the most important of the forested habitat samples.

Because it is difficult to traverse on foot, sedge marsh (fen) has not been extensively sampled in the three ground survey studies. Wallace (1972) indicates that approximately 11% of the Fort Simpson realignment consists of sedge fens. The present study found a density of birds in sedge marsh comparable to that in forested habitats. Shorebirds occurred more commonly in sedge marsh than they did in any of the other habitats. Samples of sedge marsh are probably intermediate in importance in terms of the numbers of birds that they support.

The scattered spruce muskeg habitats have generally supported the lowest densities of terrestrial birds during the three ground survey studies. Wallace (1972) indicates that spruce muskeg is the commonest habitat type along the Fort Simpson realignment where it comprises approximately 44% of the route. Because of their abundance in the area and because of the low numbers of birds that they support, samples of scattered spruce muskeg are probably the least important habitat samples in the southern Mackenzie Valley from the overall point of view of numbers of terrestrial breeding birds.

In addition to the habitat type, there are several habitat characteristics that may affect the importance of a habitat sample to breeding terrestrial birds. Among these characteristics are height of vegetation, density of foliage in the various layers of vegetation, nearness to water (particularly rivers or lakes), and nearness to other habitat types. Sample sizes for the various habitat types are not sufficiently large to determine the effects of these additional factors on the densities of terrestrial birds.

Another factor that should be considered in evaluating the importance of samples of habitat to terrestrial birds is the vulnerability of the habitat. In this respect mature forests are perhaps the most vulnerable habitats. Severe disturbance to a habitat results in a more primary successional state. But, whereas scrub and other transitional stages may become established in a comparatively short period of time, mature forest may require more than a century to become established.

Before a unit of habitat at a particular location can be evaluated from an overall viewpoint in terms of its importance to breeding birds two further features must be considered. Ground survey transects reveal little with respect to the numbers of water birds that may nest in an area. Habitat samples would need to be evaluated in terms of their proximity to water bodies and in terms of the numbers of breeding pairs of water birds and the numbers of young produced in the area. The latter information is collected in the course of aerial surveys of water bird populations. Habitat samples should also be evaluated in terms of any rare species which breed in the area. Detailed knowledge of where such a species breeds is necessary for this evaluation, for it will breed in some tracts of a habitat but not in others.

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APPENDICES

APPENDIX 1. Maps of Sites.

All transect routes have been drawn to approximate scale and direction. The actual yardages and compass directions have not been included in this appendix but are available from LGL Limited upon request.

The following symbols have been used in the maps:

Lake ....

Major river...........................

Stream ....

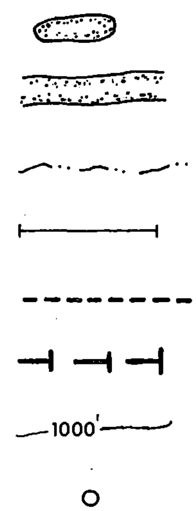
Transect ....

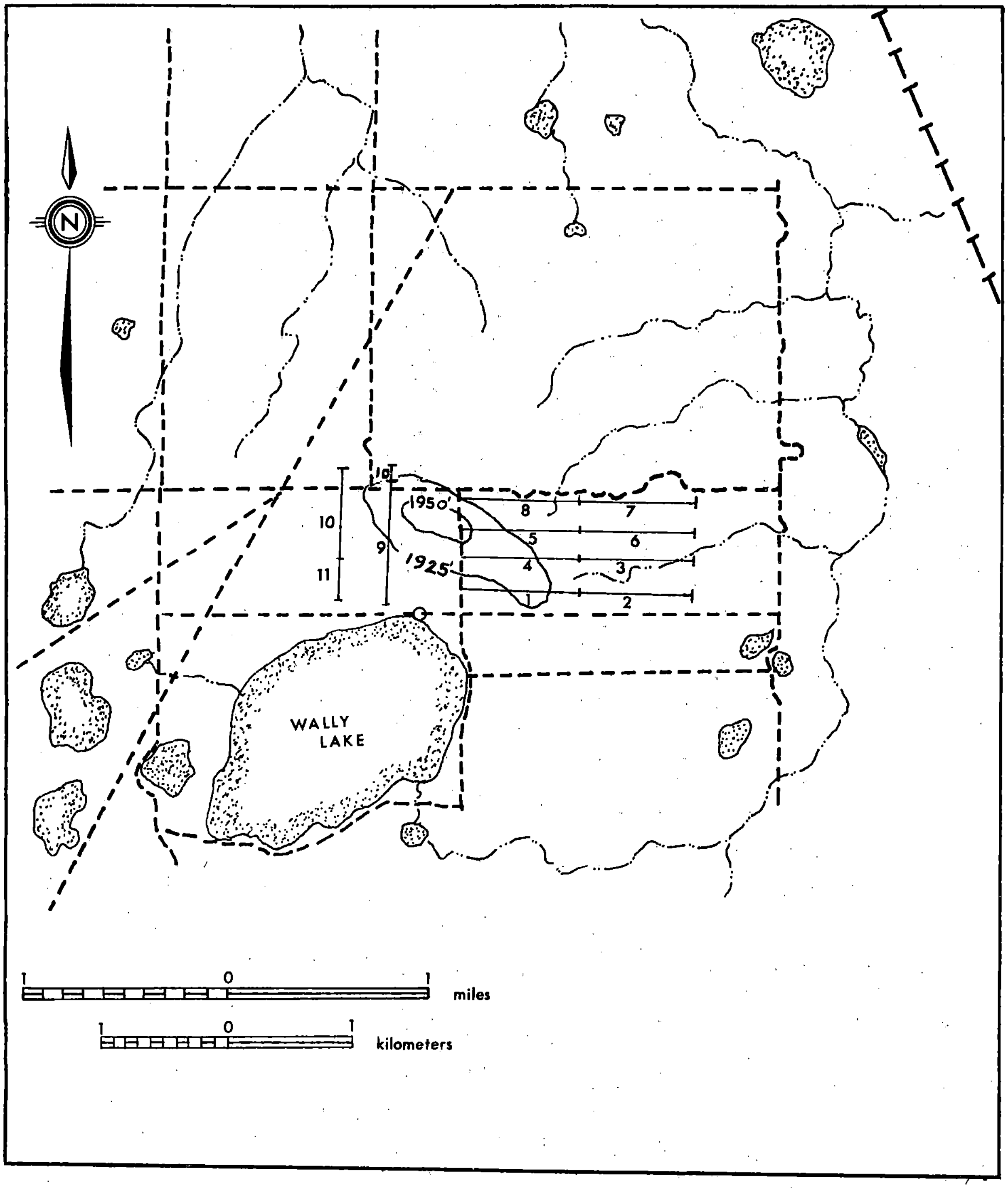
Cut line ....

Pipeline route ....

Contour line ....

Camp site ....





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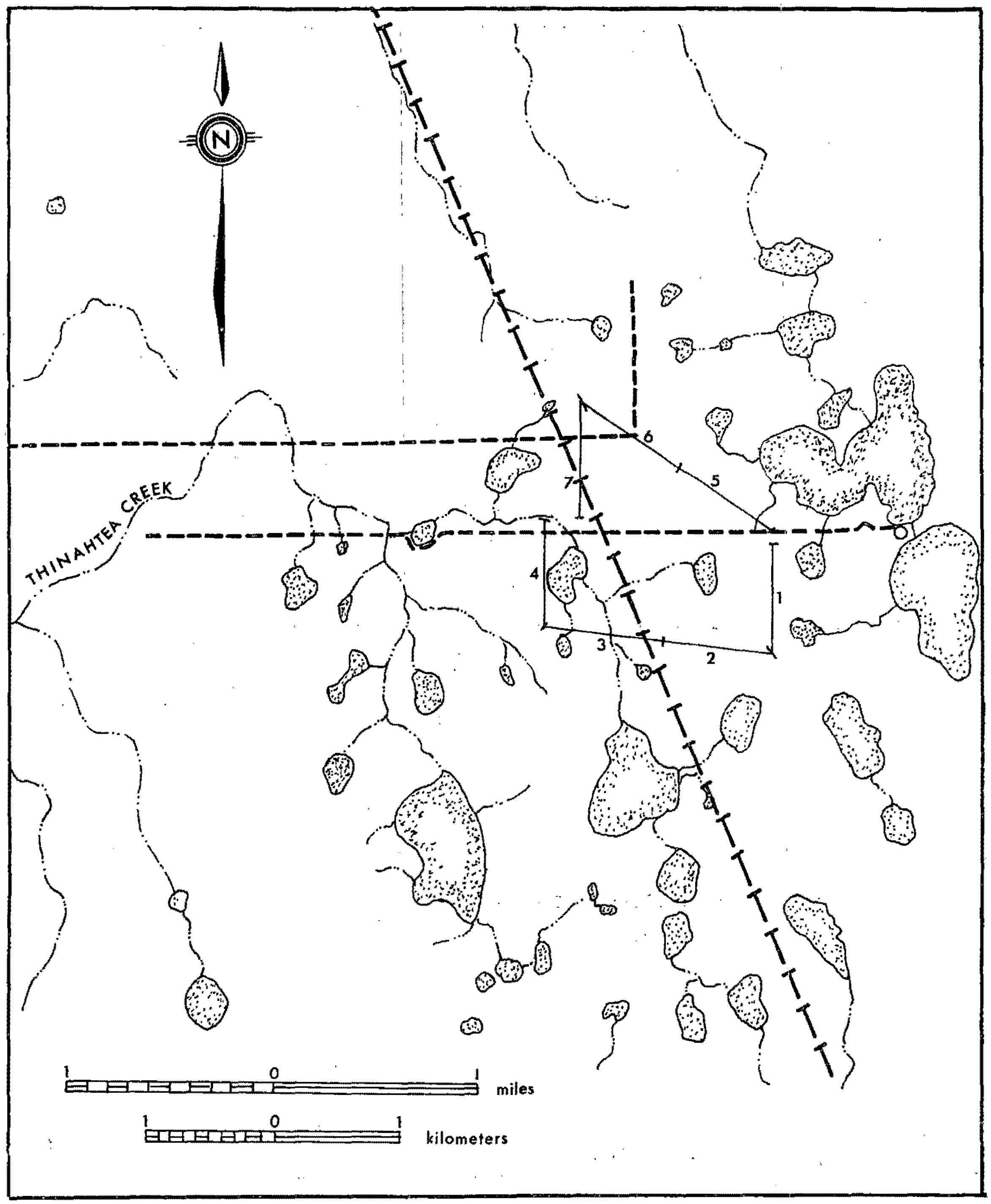
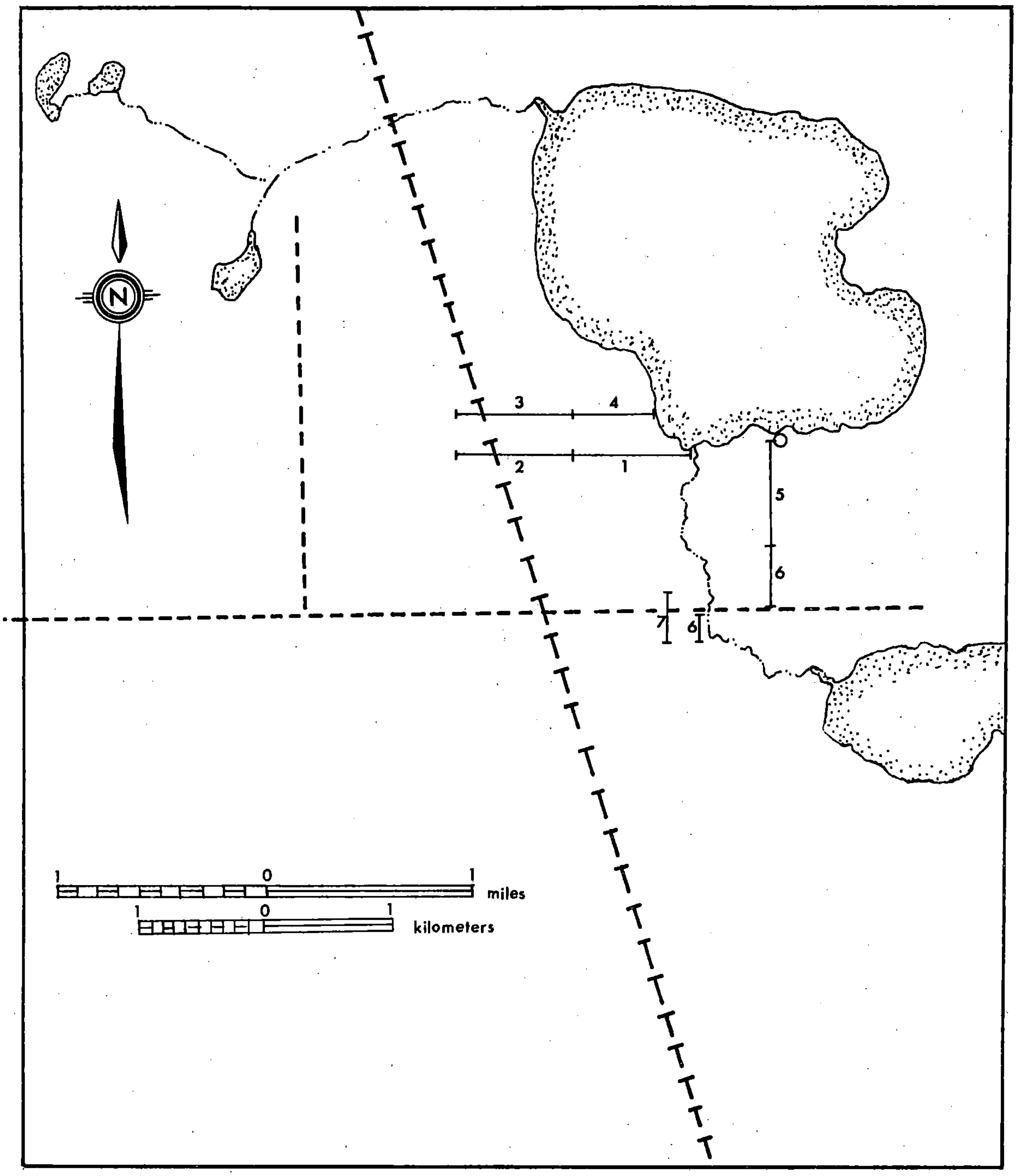
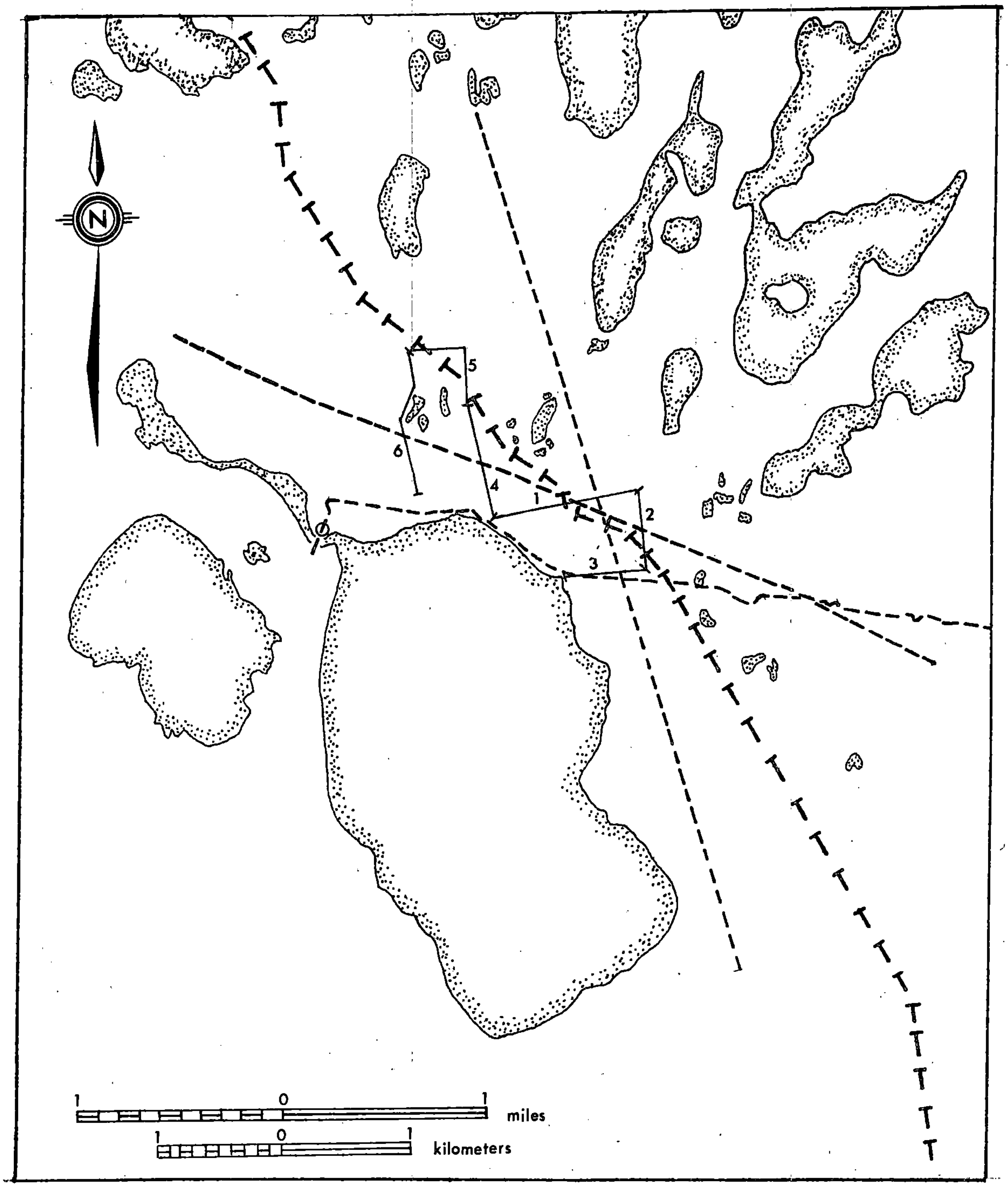


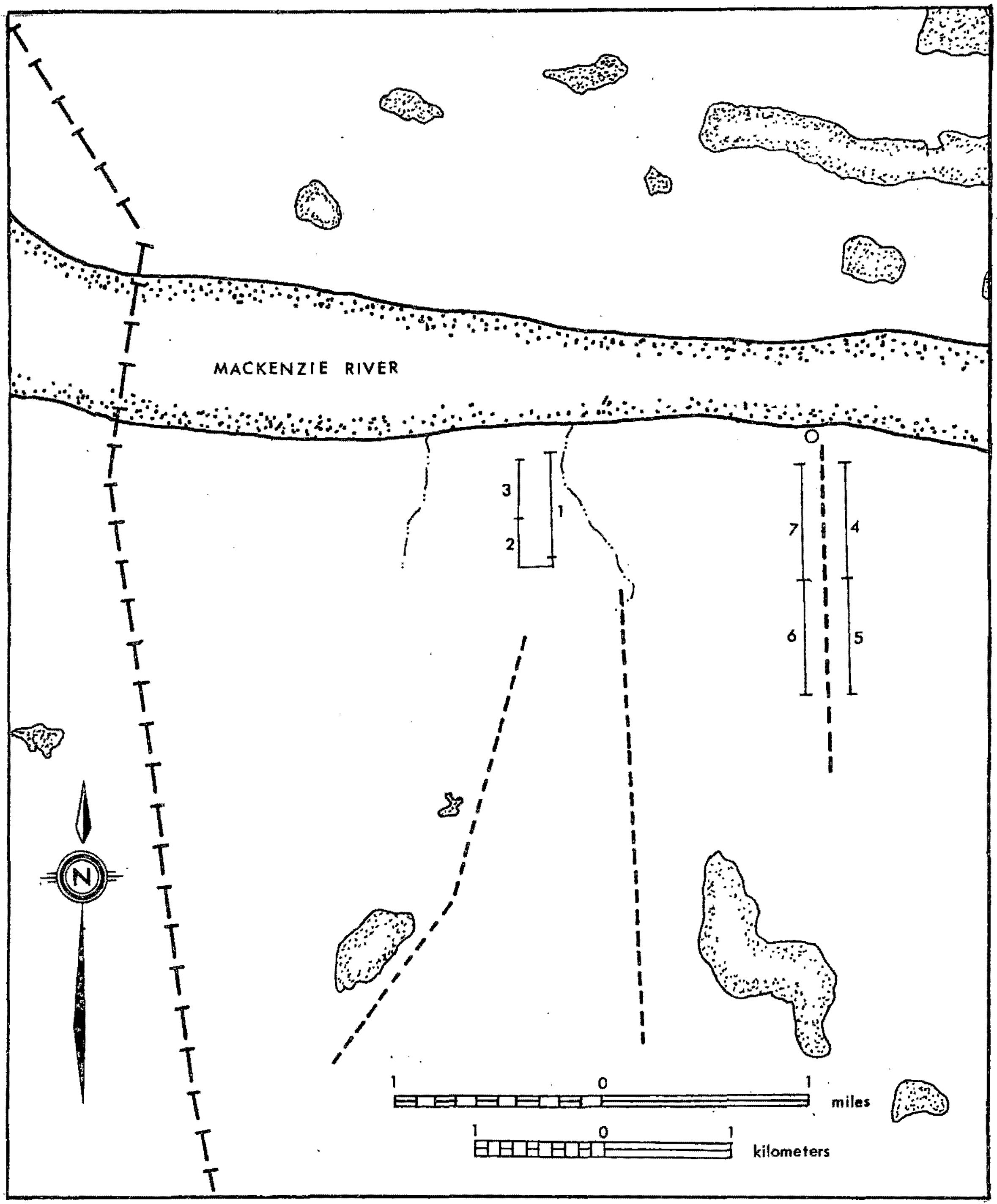
Site F2 Thinahtea Creek, Alta.



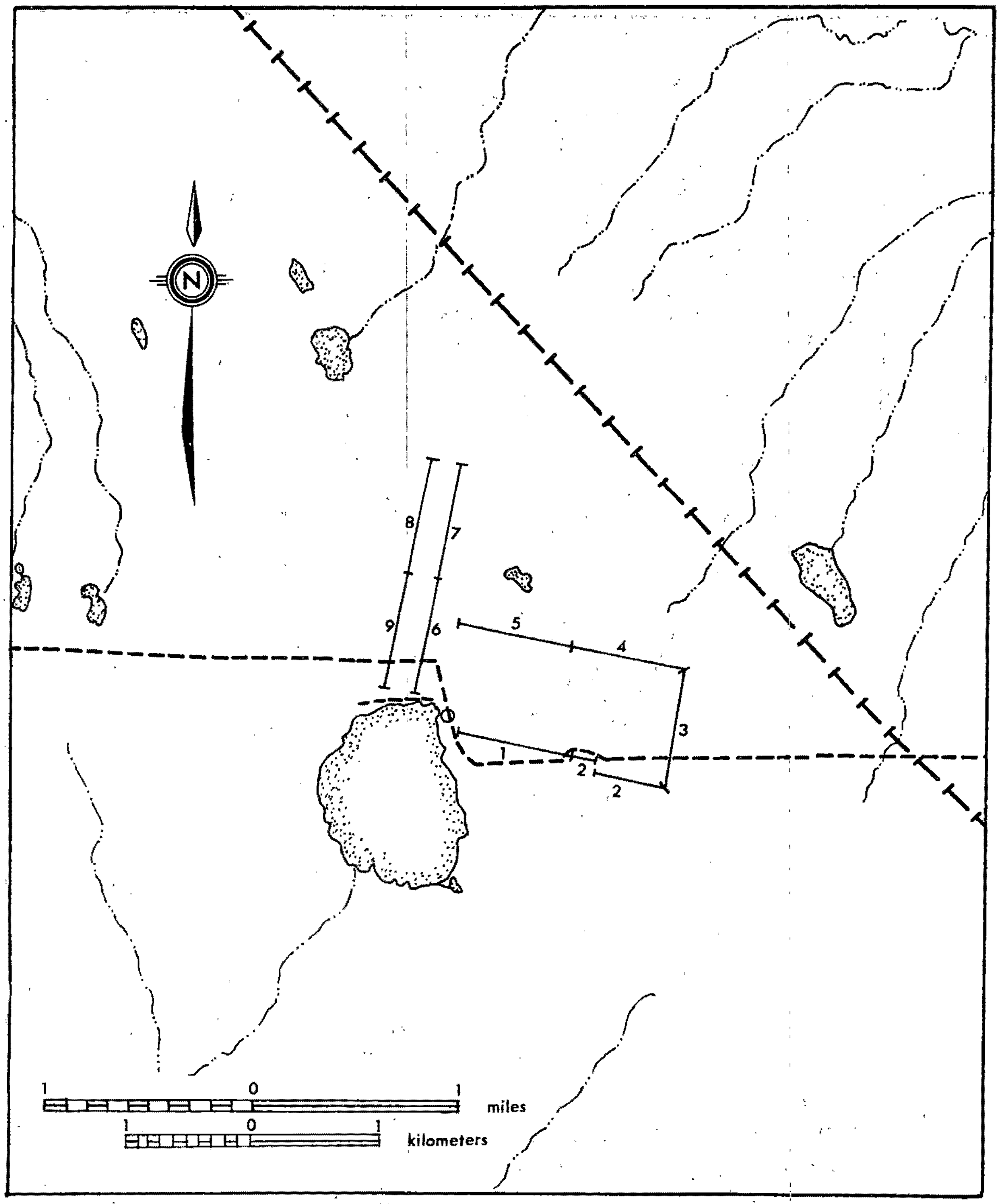
Site F3 Trout River, N.W.T.



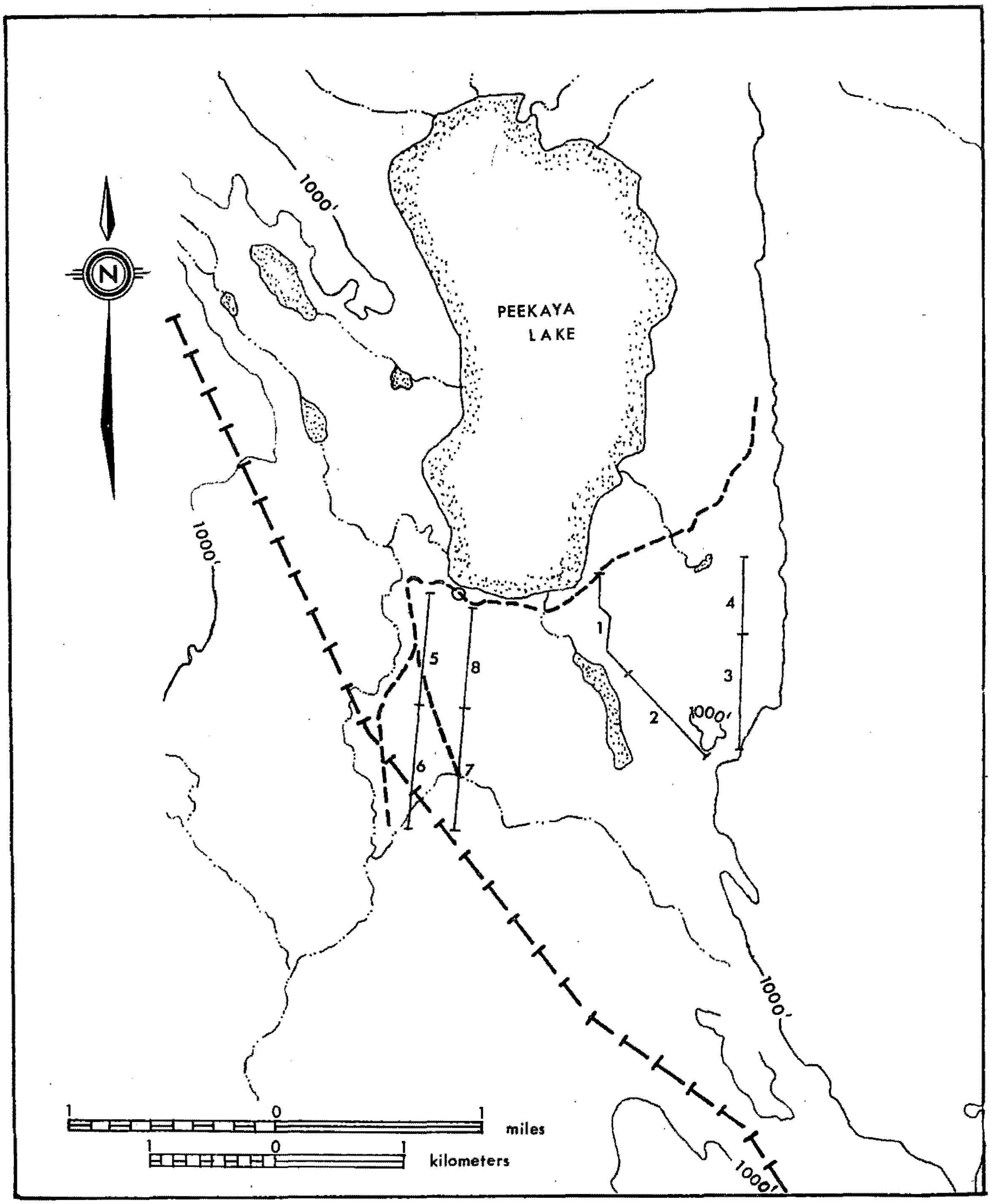
Site F4 Red-neck Slough, N.W.T.



Site F5 Naylor's Landing, N.W.T.



Site F6 Ebbutt Hills, N.W.T.



Site F7 Peekaya Lake, N.W.T.

APPENDIX 2. Scientific Names of Birds Recorded. (Nomenclature follows A.O.U. Checklist [1957] and the Thirty-second Supplement [1973].)

Common Loon	-	*Gavia immer*
Red-necked Grebe	-	*Podiceps grisegena*
Horned Grebe	-	*Podiceps auritus*
American Bittern	-	*Botaurus lentiginosus*
Swan sp.	-	*Olor* sp.
Canada Goose	-	*Branta canadensis*
Mallard	-	*Anas platyrhynchos*
Black Duck	-	*Anas rubripes*
Pintail	-	*Anas acuta*
Green-winged Teal	-	*Anas crecca*
American Wigeon	-	*Anas americana*
Lesser Scaup	-	*Aythya affinis*
Common Goldeneye	-	*Bucephala clangula*
Barrow's Goldeneye	-	*Bucephala islandica*
Bufflehead	-	*Bucephala albeola*
Oldsquaw	-	*Clangula hyemalis*
White-winged Scoter	-	*Melanitta deglandi*
Surf Scoter	-	*Melanitta perspicillata*
Red-breasted Merganser	-	*Mergus serrator*
Goshawk	-	*Accipiter gentilis*
Osprey	-	*Pandion haliaetus*
Spruce Grouse	-	*Canachites canadensis*
Ruffed Grouse	-	*Bonasa umbellus*
Sandhill Crane	-	*Grus canadensis*
Common Snipe	-	*Capella gallinago*
Spotted Sandpiper	-	*Actitis macularia*
Solitary Sandpiper	-	*Tringa solitaria*
Greater Yellowlegs	-	*Tringa melanoleuca*
Lesser Yellowlegs	-	*Tringa flavipes*
Short-billed Dowitcher	-	*Limnodromus griseus*
Wilson's Phalarope	-	*Steganopus tricolor*
Herring Gull	-	*Larus argentatus*
Mew Gull	-	*Larus canus*
Bonaparte's Gull	-	*Larus philadelphia*
Common Tern	-	*Sterna hirundo*
Black Tern	-	*Chlidonias niger*
Great Horned Owl	-	*Bubo virginianus*
Common Nighthawk	-	*Chordeiles minor*
Belted Kingfisher	-	*Megaceryle alcyon*
Common Flicker	-	*Colaptes auratus*
Yellow-bellied Sapsucker	-	*Sphyrapicus varius*
Hairy Woodpecker	-	*Dendrocopos villosus*
Northern Three-toed Woodpecker	-	*Picoides tridactylus*
Eastern Kingbird	-	*Tyrannus tyrannus*
Alder Flycatcher	-	*Empidonax alnorum*
Least Flycatcher	-	*Empidonax minimus*

APPENDIX 2 (cont'd)

Western Wood Pewee	-	*Contopus sordidulus*
Olive-sided Flycatcher	-	*Nuttallornis borealis*
Tree Swallow	-	*Iridoprocne bicolor*
Bank Swallow	-	*Riparia riparia*
Cliff Swallow	-	*Petrochelidon pyrrhonota*
Gray Jay	-	*Perisoreus canadensis*
Common Raven	-	*Corvus corax*
Boreal Chickadee	-	*Parus hudsonicus*
American Robin	-	*Turdus migratorius*
Varied Thrush	-	*Ixoreus naevius*
Hermit Thrush	-	*Catharus guttatus*
Swainson's Thrush	-	*Catharus ustulatus*
Gray-cheeked Thrush	-	*Catharus minimus*
Ruby-crowned Kinglet	-	*Regulus calendula*
Bohemian Waxwing	-	*Bombycilla garrulus*
Starling	-	*Sturnus vulgaris*
Solitary Vireo	-	*Vireo solitarius*
Red-eyed Vireo	-	*Vireo olivaceus*
Warbling Vireo	-	*Vireo gilvus*
Black-and-white Warbler	-	*Mniotilta varia*
Tennessee Warbler	-	*Vermivora peregrina*
Orange-crowned Warbler	-	*Vermivora celata*
Yellow Warbler	-	*Dendroica petechia*
Magnolia Warbler	-	*Dendroica magnolia*
Cape May Warbler	-	*Dendroica tigrina*
Yellow-rumped Warbler	-	*Dendroica coronata*
Bay-breasted Warbler	-	*Dendroica castanea*
Blackpoll Warbler	-	*Dendroica striata*
Palm Warbler	-	*Dendroica palmarum*
Ovenbird	-	*Seiurus aurocapillus*
Northern Waterthrush	-	*Seiurus noveboracensis*
Common Yellowthroat	-	*Geothlypis trichas*
Wilson's Warbler	-	*Wilsonia pusilla*
American Redstart	-	*Setophaga ruticilla*
Red-winged Blackbird	-	*Agelaius phoeniceus*
Rusty Blackbird	-	*Euphagus carolinus*
Common Grackle	-	*Quiscalus quiscula*
Brown-headed Cowbird	-	*Molothrus ater*
Western Tanager	-	*Piranga ludoviciana*
Rose-breasted Grosbeak	-	*Pheucticus ludovicianus*
Pine Grosbeak	-	*Pinicola enucleator*
Pine Siskin	-	*Spinus pinus*
White-winged Crossbill	-	*Loxia leucoptera*
Savannah Sparrow	-	*Passerculus sandwichensis*
Le Conte's Sparrow	-	*Ammospiza leconteii*
Sharp-tailed Sparrow	-	*Ammospiza caudacuta*
Dark-eyed Junco	-	*Junco hyemalis*
Chipping Sparrow	-	*Spizella passerina*
White-crowned Sparrow	-	*Zonotrichia leucophrys*

APPENDIX 2 (cont'd)

White-throated Sparrow	-	*Zonotrichia albicollis*
Fox Sparrow	-	*Passerella iliaca*
Lincoln's Sparrow	-	*Melospiza lincolnii*
Swamp Sparrow	-	*Melospiza georgiana*
Song Sparrow	-	*Melospiza melodia*

APPENDIX 3. Numbers of Birds Observed in Each Habitat and at Each Survey Site.

This appendix consists of a computer printout; this printout, which is stored in the library of the Edmonton branch office of LGL Limited, is available upon request.

APPENDIX 4. Occurrence of Flocks* of Birds† During Ground Surveys, June, 1975.

SITE			HABITAT	SPECIES	NUMBER	ACTIVITY
F1	Wally Lake, Alta.	226	Scattered spruce-lichen-moss muskeg	Gray Jay	5	Unknown
F2	Thinahtea Creek, Alta.	226	Scattered spruce-lichen-moss muskeg	Duck (sp.)	6	Unknown
F4	Red-neck Slough, N.W.T.	226	Scattered spruce-lichen-moss muskeg	Gray Jay	5	Sitting
F4	Red-neck Slough, N.W.T.	304	Open mixed forest	Crossbill(sp.)	?	Flying
F6	Ebbutt Hills, N.W.T.	226	Scattered spruce-lichen-moss muskeg	Crossbill(sp.)	?	Flying
F6	Ebbutt Hills, N.W.T.	226	Scattered spruce-lichen-moss muskeg	Crossbill(sp.)	?	Flying
F6	Ebbutt Hills, N.W.T.	127	Sedge marsh	Rusty Blackbird	10	Sitting
F6	Ebbutt Hills, N.W.T.	226	Scattered spruce-lichen-moss muskeg	Crossbill(sp.)	?	Flying

* of five or more birds

† all were recorded "off-transect"

APPENDIX 5. Breeding Records, June, 1975.

SPECIES	SITE		DATE JUNE	NUMBER OF EGGS	NUMBER OF YOUNG	HABITAT
Red-necked Grebe	F4	Red-neck Slough, N.W.T.	9	4	0	Inlet on lake
Red-necked Grebe	F4	Red-neck Slough, N.W.T.	9	4	0	Inlet on lake
Red-necked Grebe	F4	Red-neck Slough, N.W.T.	9	4	0	Inlet on lake
American Wigeon	F1	Wally Lake, Alta.	3	9	0	Scattered spruce muskeg
American Wigeon	F2	Thinahtea Creek, Alta.	5	7	0	Scattered spruce muskeg
Lesser Scaup	F4	Red-neck Slough, N.W.T.	11	10	0	Open spruce muskeg at pond edge
Spotted Sandpiper	F4	Red-neck Slough, N.W.T.	9	4	0	On cutline in sedge meadow
Yellow-rumped Warbler	F4	Red-neck Slough, N.W.T.	11	?	2	Open mixed forest
Chipping Sparrow	F6	Ebbutt Hills, N.W.T.	16	4	0	Scattered spruce muskeg
Chipping Sparrow	F7	Peekaya Lake, N.W.T.	18	2	0	On cutline in evergreen forest

APPENDIX 6. Range Extensions.

A few species were recorded outside their suggested breeding ranges as given by Godfrey (1966) and Salt and Wilk (1966).

Black Duck

One bird was seen on the lake near site F3 which is considerably west of the normal breeding range (eastward from Manitoba). This species has occasionally been seen in the Mackenzie district (Godfrey, 1966) and there are several sightings and a breeding record for Alberta (Salt and Wilk, 1966).

Greater Yellowlegs

This species was found at all of the sites except site F5. According to Godfrey (1966), the Fort Simpson realignment lies outside the breeding range of this species. Salt and Wilk (1966), however, suggest that this species occurs throughout northern Alberta.

Short-billed Dowitcher

This bird was seen frequently at Site F4. According to Salt and Wilk (1966) its status in northern Alberta is unknown. Godfrey (1966), however, gives a breeding range to the south and to the east of site F4, including much of northern Alberta and extending to the Great Slave Lake area.

APPENDIX 6 (cont'd)

Wilson's Phalarope

This species also occurred at site F4. According to both Salt and Wilk (1966) and Godfrey (1966) the breeding range of this species does not extend northward beyond the Peace River area of British Columbia and Alberta, more than 300 mi south of site F4. Tull (1975) found this species north of the Hay-Zama Lakes in northern Alberta.

Black Tern

Black Terns were seen at site F4, considerably northwest of their breeding range as given by Godfrey (1966). Salt and Wilk (1966), however, consider this species to be fairly common throughout the northern part of Alberta. Sightings of this species were also made from aircraft during aerial surveys of the Fort Simpson realignment as far north as the Ebbutt Hills (Patterson and Wiseley, 1976). Salter and Davis (1974) also found this species north of 60°N.

Common Yellowthroat

This species was recorded at sites F3, F4, and F5 in the southwestern Mackenzie District. These sites are north of the known breeding range according to both Godfrey (1966) and Salt and Wilk (1966). Salter and Davis (1974), Ward (1975), and Richardson and Thompson (1974) also reported this species throughout much of the Mackenzie Valley and as far north as Chick Lake.

APPENDIX 6 (cont'd)

Common Grackle

This species was recorded at site F4 and at Fort Simpson. Both areas lie to the northwest of the range given by Godfrey (1966). Ward (1975) encountered this species north of Wrigley.

Sharp-tailed Sparrow

A male of this species was singing at site F2--a location which lies slightly northwest of the range of this species according to both Godfrey (1966) and Salt and Wilk (1966). Although the bird was not seen, the song was unmistakably that of this species.

APPENDIX 7. Species Recorded Only During Present Study or During Previous Studies and Species Not Recorded During Any of the Studies but Expected to Breed in Study Area.

SPECIES RECORDED IN SOUTHERN MACKENZIE VALLEY DURING ONLY ONE OF THE THREE GROUND SURVEY STUDIES

	RECORDED ONLY DURING	
1972[1]	1974[2]	1975[3]
Blue-winged Teal	American Golden Plover†	Swan (sp.)
Northern Shoveler	Pectoral Sandpiper†	Goshawk
Greater Scaup	White-rumped Sandpiper†	Short-billed Dowitcher
Red-tailed Hawk	Pileated Woodpecker	Wilson's Phalarope
Bald Eagle	Common Crow	Common Tern
Killdeer	Water Pipit†	Sharp-tailed Sparrow
Parasitic Jaeger†	Evening Grosbeak	
Great Gray Owl	Purple Finch	
Vesper Sparrow	Common Redpoll	
	Harris' Sparrow†	
	Lapland Longspur†	

[1] Salter and Davis (1974)

[2] Ward (1975)

[3] present study

† probable migrant

APPENDIX 7 (cont'd)

SPECIES RECORDED DURING GROUND SURVEY STUDIES IN 1972[1] AND IN 1974[2] BUT NOT DURING PRESENT STUDY	
Sharp-shinned Hawk	Arctic Tern
Marsh Hawk	Eastern Phoebe
American Kestrel	Horned Lark†
Sora	Clay-colored Sparrow

[1]Salter and Davis (1974)

[2]Ward (1975)

†probable migrant

SPECIES EXPECTED TO BREED IN SOUTHERN MACKENZIE VALLEY* BUT NOT RECORDED ON ANY OF THE THREE GROUND SURVEY STUDIES	
Arctic Loon	Short-eared Owl
Red-throated Loon	Boreal Owl
Redhead	Downy Woodpecker
Ring-necked Duck	Black-backed Three-toed Woodpecker
Common Merganser	Yellow-bellied Flycatcher
Peregrine Falcon	Barn Swallow
Merlin	Black-capped Chickadee
Sharp-tailed Grouse	Red-breasted Nuthatch
Semipalmated Plover	Winter Wren
Upland Sandpiper	Golden-crowned Kinglet
Hawk Owl	Northern Shrike
Long-eared Owl	Red Crossbill

*from Godfrey (1966)