Assessment Of Impacts Of A Road To Izok Lake: Areview Of Exisitng Information And Recommendations For Research On Selected Species Of Wildlife

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ASSESSMENT OF IMPACTS OF A ROAD TO IZOK LAKE

A REVIEW OF EXISTING INFORMATION AND RECOMMENDATIONS

FOR RESEARCH ON SELECTED SPECIES OF WILDLIFE

by

G. F. Searing and [illegible]

LGL LIMITED

environmental research associates

Prepared for:

Northwest Territories
Fish and Wildlife Service
Yellowknife, N.W.T.

Funded by:

Northern Roads and Airstrips
[illegible]

LGL LIMITED
environmental research associates • BORDIGNON PLACE, 1200 WEST 73rd AVE., VANCOUVER, B.C. V6P 6G5
TELEPHONE (604) 263-092B

14 February 1980

Mr. Michael P.G. Hawkes
Supervisor, Habitat Management
Wildlife Service
Department of Renewable Resources
Government of the Northwest Territories
Yellowknife, N.W.T.
X1A 2L9

Dear Mr. Hawkes,

I am pleased to submit a revised copy of the report "Assessment of impacts of a road to Izok Lake: a review of existing information and recommendations for research on selected species of wildlife." You will note that current or planned studies by the N.W.T. Wildlife Service were not considered when defining research requirements. If those studies fulfill the research needs defined in this report, this should be taken into account when detailed impact assessment research is planned in the future.

Sincerely,

Gary F. Searing
Wildlife Biologist

GFS/meh

ASSESSMENT OF IMPACTS OF A ROAD TO IZOK LAKE: A REVIEW OF EXISTING INFORMATION AND RECONMENDATIONS FOR RESEARCH ON SELECTED SPECIES OF WILDLIFE

by

G.F. Searing and W.G. Alliston

LGL LIMITED
environmental research associates
Edmonton, Alberta

Prepared for

Northwest Territories
Fish and Wildlife Service
Yellowknife, N.W.T.

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INTRODUCTION

Mineral exploration and extraction is the major industry in the Northwest Territories (Padgham 1978). Eight mines are in operation in the N.W.T.; of these, five are located in the Great Slave Lake and Great Bear Lake areas (Department of Indian and Northern Affairs 1978). The region north of Yellowknife and east of Great Bear Lake is considered to have much mining potential, but the area presently lacks the necessary transportation facilities to transport ore. Because mine development will require the development of transportation facilities, the Department of Indian and Northern Affairs is undertaking a study of transportation alternatives for the mining regions of the northeast Mackenzie District. This report is the first stage in the process leading to assessment of the impacts of transportation developments on wildlife populations in this area.

The objectives of this study are as follows:

1. To identify, gather, review and assess the information that exists on the numbers, distribution and movements of certain wildlife populations (rare, endangered or threatened species, raptorial birds, waterfowl, grizzly bears, muskoxen, wolves, and caribou) within the study area and to prepare a reference list.

2. To develop a research plan that addresses the gaps in the available data base (as identified in objective 1) and to outline research that is required "to provide the information necessary to

   a. assess the impact of road development on wildlife populations;

   b. recommend alternatives that will minimize the impact of a road; and

   c. evaluate management alternatives and mitigative procedures that might be required if a road development proceeds.

We have interpreted objective 2 in a specific rather than a general way and have, therefore, limited the range of research plans to those that will provide basic information necessary for assessment of the *major* impacts of road construction and operation. For example, we have not included in the research plan studies of 'carrying capacity' and 'range utilization' that would be necessary to predict impacts related strictly to habitat loss, because the amount of habitat destroyed by road development is in most cases minor. Many additional studies would be required to predict the probable severity of a wide range of 'minor' impacts. The assessment of these lesser impacts would require detailed monitoring of basic biological and life history parameters and has not been addressed here.

The terms of reference limit this study to consideration of rare, threatened and endangered species, raptorial birds, waterfowl, and four species of mammals. The construction and operation of a road would affect many other species within the road development corridor. A more complete impact assessment would consider these other wildlife species, especially game and forage species of fish, furbearers (arctic fox, beaver, marten, river otter and others), and moose. If the transportation alternatives that are developed include a docking facility, then impact studies should also be extended to the marine environment.

It has been assumed that research will be initiated after selection of one or more general corridors. The corridor approach to impact assessment is common in dealing with linear developments; in this case, the corridor approach is the most economically feasible method because of the size of the area considered and a general lack of knowledge of most of its wildlife populations. At present, six different road and railroad corridors are being considered (Figure 1). Each of these corridors crosses a diversity of

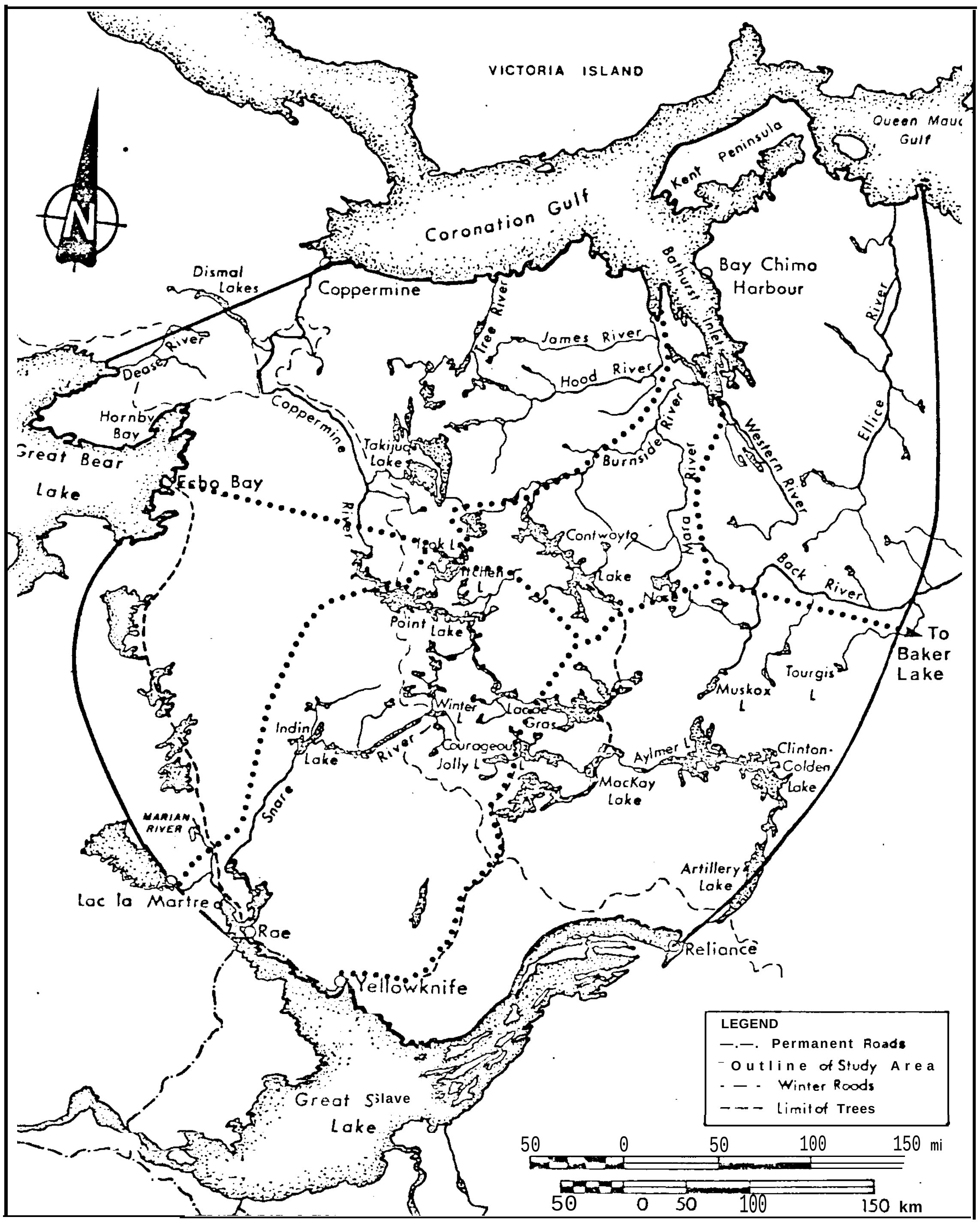


Figure 1. Some Currently Proposed Ground Transportation Corridors North of Yellowknife (Padgham 1978).

habitats. As a result, no single detailed research plan can be suitable for all corridors. Therefore, we have designed a general research plan that will provide data to address a wide range of highway - wildlife interactions; selection of some corridors may make parts of the research plan unnecessary. We have identified information gaps and designed a research plan that will provide a basis for impact assessment, subsequent monitoring, and evaluation of management alternatives.

STUDY AREA

The study area (Figure 2) extends from 62°00′ to 68°57'N and from 104°30′ to 120°30'W and encompasses a land area of approximately 356,000 km^2. The area is confined to the western extremity of the Precambrian shield and is predominantly a high (approximately 450 m ASL) rolling upland plateau (Mackenzie Uplands -- Bird and Bird 1961, citedby Kingsley 1979). The uplands are penetrated for a distance of about 220 km by a southern extension of the Coronation Gulf lowlands, forming Bathurst Inlet. The topography adjacent to the inlet is the most precipitous and varied in the study area. The uplands rise steeply from Coronation Gulf and only along Queen Maud Gulf, at the northeaster extremity of the study area, is there an extensive coastal lowland area of recent marine emergence (Bird 1963, cited by Ryder 1969). The area bordering the western arm of Great Slave Lake at the southeastern extremity of the study area has been influenced by deposition from Glacial Lake McConnell. This area is lower in elevation (approximately 150 m ASL) and in relief (approximately 10 m) than the highland areas to the north (Murdy 1965).

Lakes and ponds are generally numerous throughout most of the study area; they are generally infertile, deep, clear and have rocky shorelines. In both the Glacial Lake McConnell and Queen Maud Gulf lowland areas, lakes and ponds tend to be more turbid.

The study area encompasses a diversity of vegetation zones--from heavily wooded boreal forest to sparsely-vegetated tundra. About half of the study area is tundra and most of the remainder is forest-tundra transition and open forest. Jacobson (1978) has divided the study area into six wildlife zones based on the eco-regions of Tarnocai and Netterville (1976) in northern Keewatin; of Mills (1976) in northern Manitoba; and of Oswald (1’376) in the Yukon Territory (Figure 3).

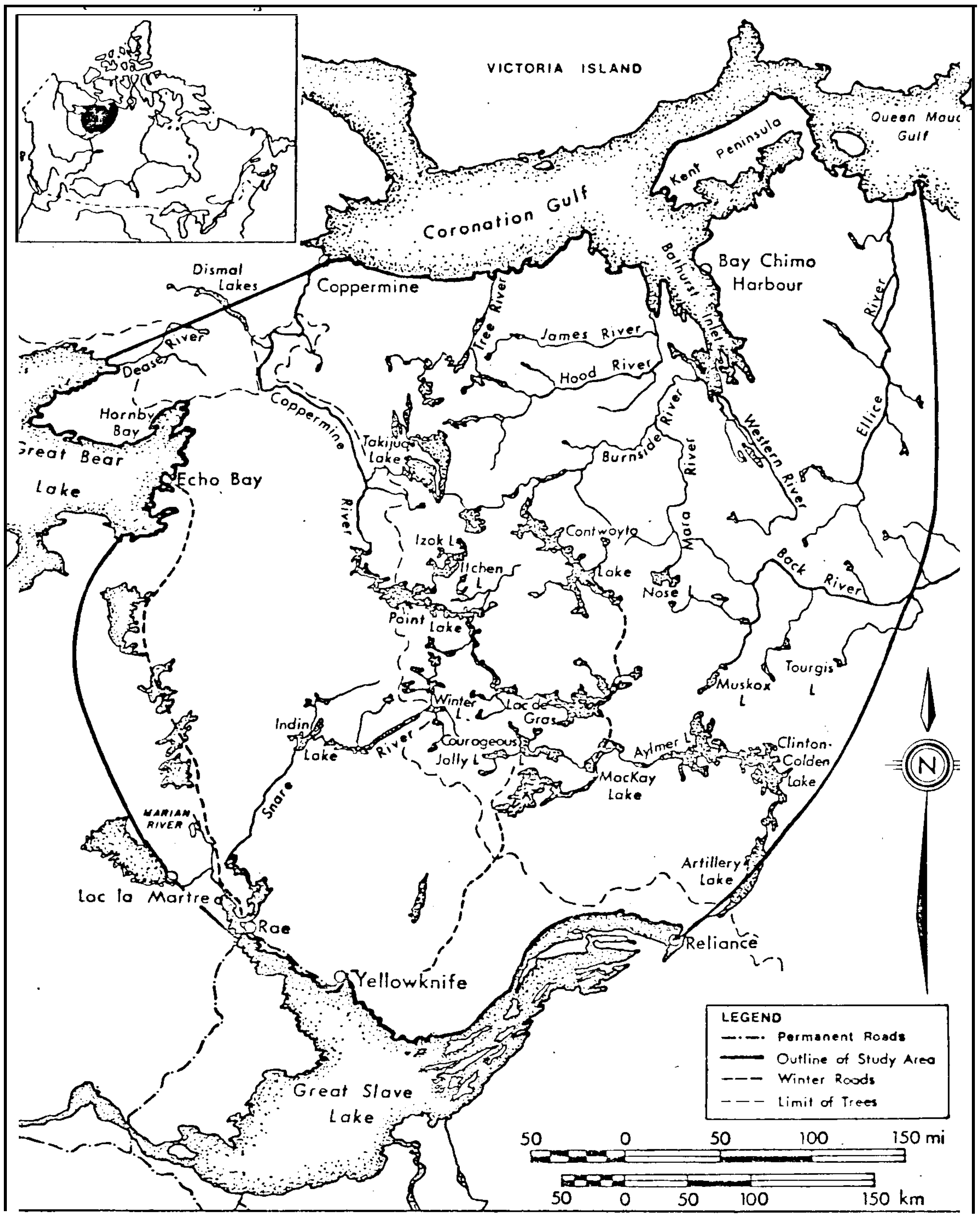


Figure 2. Map of the Study Area.

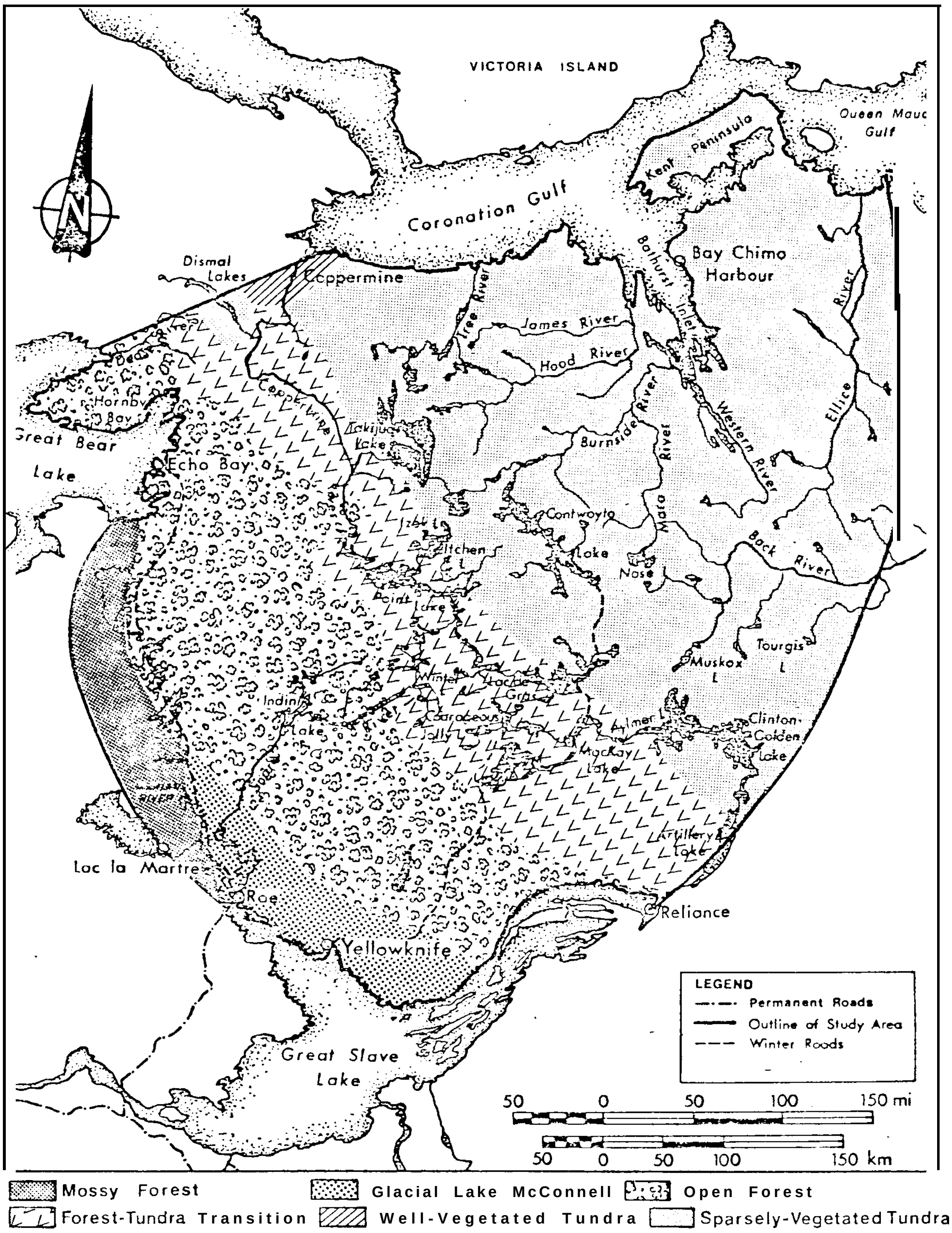
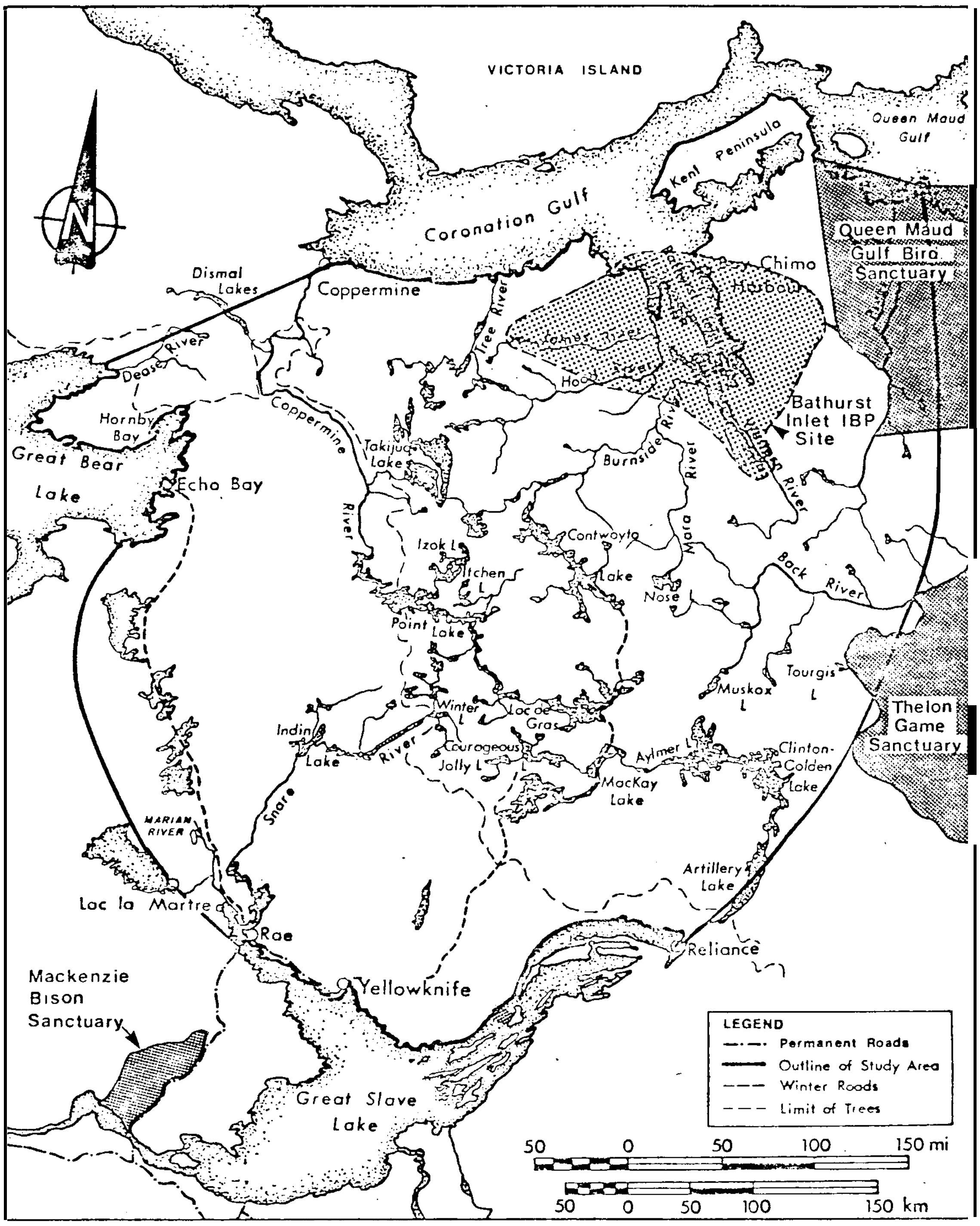


Figure 3. Major Wildlife Zones in the Study Area (Adapted from Jacobson 1978) .

The study area includes portions of the Queen Maud Gulf Migratory Bird Sanctuary (approximately 14,000 km^2), the Thelon Game Preserve (approximately 1,500 km^2) and the entire Bathurst Inlet IBP site (Nettleship and Smith 1975) (Figure 4). The Bathurst Inlet area is currently being considered as a possible National Park site (Kingsley 1979). The Reliance-Artillery Lake area has previously been considered as a possible National Park site (Kelsall *et aZ.* 1972) but is currently not under consideration.

Most of the study area is undisturbed wilderness. The small amount of settlement and development that has occurred is restricted primarily to the southwestern periphery of the area. Only small outposts exist along the northern periphery. The central and eastern portions of the study area are almost entirely undisturbed wilderness areas.

The study area has received little biological investigation. The only long-term systematic wildlife studies conducted in the area have been of the Bathurst caribou herd, of cliff-nesting raptors in the Bathurst Inlet" area, of nesting waterfowl in the Glacial Lake McConnell area and of goose populations (particularly Ross' goose) in the Queen Maud Gulf area. Information concerning other wildlife species and other parts of the study area is generally qualitative and fragmentary.



'igure 4. Wildlife Sanctuaries and IBP Site in the Study Area.

POTENTIAL IMPACTS OF ROAD DEVELOPMENT ON WILDLIFE

As a preliminary step in the development of an impact-related research plan, the nature and magnitude of potential impacts of road development must be assessed. The following paragraphs briefly review some of the impacts that are anticipated and the vulnerability of some of the species involved.

Wildlife may be affected by three major forms of impact associated with a road:

1. habitat alteration or loss,
2. disturbance, and
3. direct mortality.

These factors may act independently or in combination to cause impacts.

HABITAT ALTERATION

The direct destruction of habitat by road construction, though limited in extent, is the most evident form of impact. If an affected habitat is widely distributed (e.g. boreal forest), road construction would probably constitute only a minor impact. Destruction of uncommon or rare habitats That are important to wildlife (e.g. raptor nesting cliffs, certain wetlands) can, however, constitute a more serious impact. More subtle than the immediate and obvious effects of habitat destruction is long-term alteration, and perhaps [Instruction, resulting from such factors as altered drainage patterns or chemical pollution.

Effective habitat loss may also result from the exclusion of animals from areas surrounding the road as a result of disturbance caused by activities associated with a road. A most serious impact could result if a road acted as a barrier to migrating mammals (e.g. caribou) thus render.ing unavailable large blocks of habitat. The exclusion of a population from critical habitat can be equivalent to elimination of the entire range of the population.

DISTURBANCE

Disturbance of wildlife can cause stress that may alter normal behaviour and energy budgets. Animals under high natural stress because of environmental factors or the phase of their life cycle (nesting birds, migrating caribou) are particularly susceptible to added stress from disturbance. During such times the added stress from disturbance could result in increased mortality or decreased reproductive effort. Even when energy budgets are not critical, disturbance could produce behavioural responses that would decrease the productivity of the disturbed animals. Disturbance of animals can result from construction, operation, and maintenance of a road and from recreational and commercial activities that road access would permit and encourage.

DIRECT MORTALITY

Direct mortality of wildlife can result from collisions with Vehicles. Road kills can further attract scavengers (wolves, grizzly bears, bald eagles, golden eagles) and increase the likelihood of collisions with these species and further increase mortality. Roads, particularly the plowed surface of roads during winter, may also be used for travel by some wildlife, and thus the probability of collisions would be increased. More importantly, however, the increased access provided by these roads will open up wilderness areas to increased legal and illegal hunting and trapping pressure.

Distribution and mobility of wildlife populations influence their potential for impact from road development. Large segments of the populations of gregarious and highly migratory species (e.g. caribou) and species that concentrate in restricted habitats (e.g. staging, moulting or colonial-nesting waterfowl) are more likely to interact with road activities than are species that are widely dispersed and that occupy a variety of common habitats.

LITERATURE REVIEW AND RESEARCH REQUIREVENTS

BIRDS

Rare, Threatened and Endangered Species*

Three species of birds currently considered to be rare, threatened or endangered in Canada (D. Muir, pers. comm.) either inhabit, have inhabited, or have a high probability of occurring within the study area: peregrine falcon, eskimo curlew and whooping crane.

Peregrine Falcon

Status

The precipitous decline of peregrine falcon populations of North America and western Europe since the late 1940's has been well documented (Ratcliffe 1963, 1972; Hickey 1969; Cade and Fyfe 1970; Linberg 1975; Fyfe *et al.* 1976). A vast and convincing body of evidence has accumulated in recent years linking these declines with organochlorine contamination (for review see Peakall 1976).

There are three subspecies of peregrine falcon in Canada of which *Falco peregrinus anatum* is considered to be endangered, *F.p. tundrius* is threatened, and *F.p. pealei* is rare (D. Muir, pers. comm.). *F.p.tundrius* is found within the study area and *F.p.anatum* may inhabit (or has inhabited) parts of the area. *F.p.pealei* is a resident of the islands off the Pacific coast and does not occur within the study area.

*For definitions of these terms, see Appendix 1.

Knowledge of Peregrine Falcons in the Study Area

The distribution and abundance of nesting peregrine falcons in the study area are not well known. Fyfe (1969) has classified nesting habitat of peregrine falcons in northern North America into three categories: optimal, limited, and marginal. The study area contains a substantial proportion of the total amount of 'optimal' and 'limited' nesting habitat in northern continental North America (Figure 5). The Bathurst Inlet area is the only part of the present study area where nesting peregrine falcons have been monitored on a long-term systematic basis. McEwan (1'357) was the first to report peregrine falcons nesting near Bathurst Inlet, and subsequent repeated searches (by boat, aircraft, and on foot) of the coastal cliffs of the inlet and parts of Coronation Gulf and Melville Sound by the Canadian Wildlife Service have identified a total of 27 nesting territories (Fyfe *et aZ.* 1976). Only 4S% of these territories were occupied during 1975; Fyfe *et aZ.* (1976) have concluded that this population is declining.

Throughout the remainder of the study area, systematic peregrine falcon surveys have not been conducted and few nest sites have been confirmed (R. Fyfe, pers. comm.). During recent years, hcm'ever, a number of unconfirmed nest sites have been reported in various parts of the study area (L. Covello, R. Fyfe and R. McKillop, pers. comm.). In addition, nine historic sites were reported in the Yellowknife area by the late William MacDonald (R. Fyfe, pers. comm.). The recent unconfirmed reports of peregrine falcons nesting within the study area suggest that nesting populations may be larger than previously expected.

Potential Impacts of Road Development

Potential impacts of road construction and operation on nesting peregrine falcons could be caused by loss or degradation of nesting habitat, disturbances, or the removal of young to be sold to falconers.

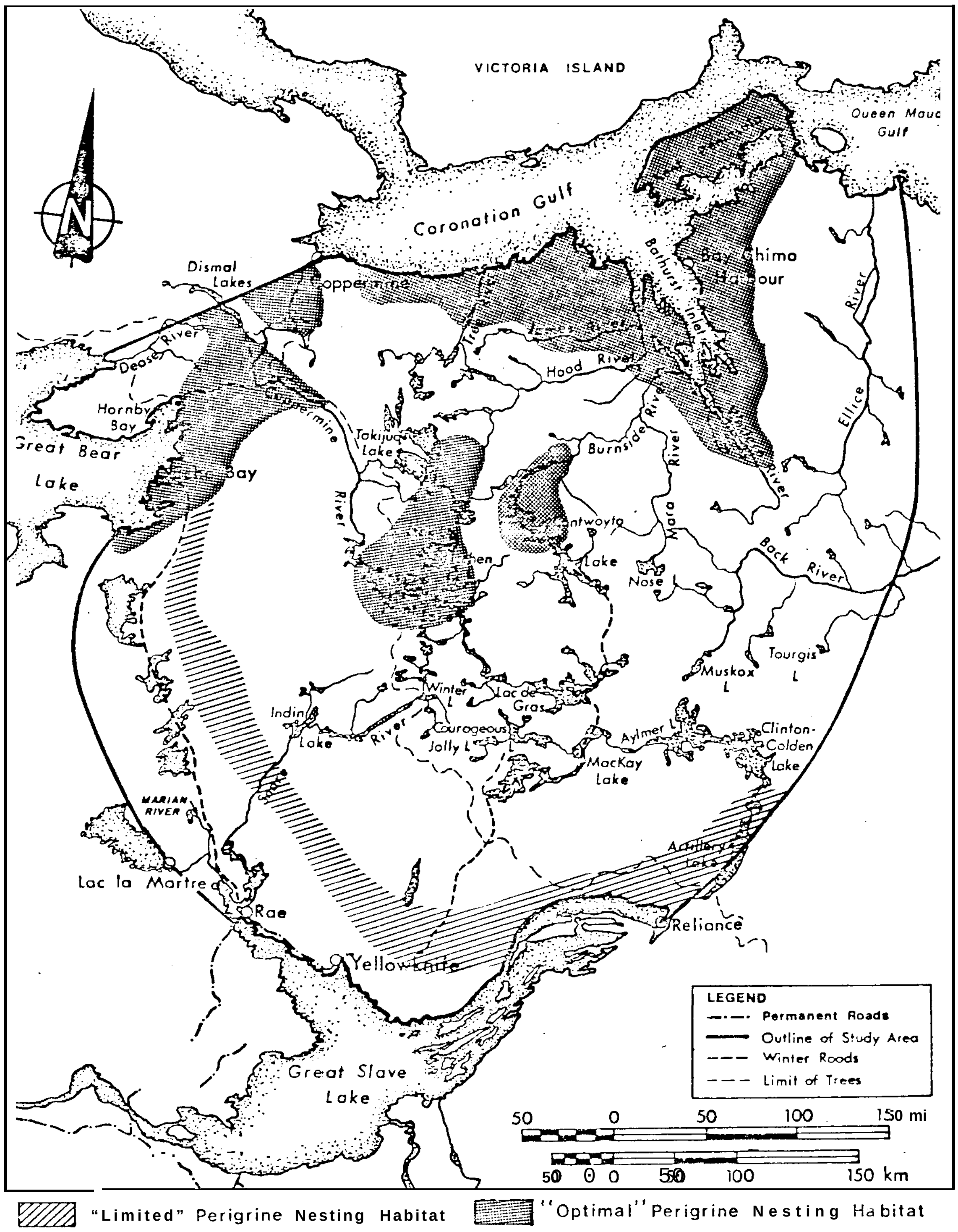


Figure 5. Potential Major Nesting Habitats for Peregrine Falcons in the Study Area (Adapted from Fyfe 1969).

Cliffs suitable for nesting peregrine falcons generally constitute a rare habitat (e.g., Hickey and Anderson 1969; Newton 1979:81). The destruction of active or historical eyries or the degradation of the area surrounding the site could render it unacceptable for nesting by peregrine falcons. Destruction or degradation of existing sites could prevent pairs from nesting or force birds to nest in inferior habitat where their chances of successfully reproducing would be decreased.

Nesting peregrine falcons are generally intolerant of disturbance within the nesting area (Herbert and Herbert 1969), but there is considerable variation among pairs (Fyfe and Oldendorff 1976; Windsor 1977; Alliston and Patterson 1978; Parker 1979). Intolerance to disturbance also varies within the nesting season; peregrine falcons are most sensitive to disturbance during the early phases of breeding (territory establishment, mating, egg-laying) (Fyfe and Oldendorff 1976). In addition to disturbance from road construction and operation, increased recreational activities near peregrine falcon nesting areas could be an additional source of disturbance. Such disturbance could result in abandonment of the nest site and/or increased mortality of eggs and young.

Captive peregrine falcons command very high prices on the black market. Access to peregrine falcon nesting areas for the purpose of capturing young falcons could have a serious impact upon peregrine falcon populations.

Peregrine falcon populations whose reproductive potential has been lowered by organochlorine contamination are probably less able to withstand development-related impacts than are healthy populations. Finney and Lang (1975, cited by Berger 1977) have stated "Due to the sensitivity of the peregrine population, clcl-elopers have to face the fact that the destruction of a single nest site or interference with nesting in a single year is a serious , unacceptable impact".

Research Requirements

To assess impact of road construction and operation on peregrine falcons, it is essential to locate active and, where possible, presently inactive peregrine falcon nest sites within the road corridor. Preliminary recommendations concerning routing within a corridor can be made by sampling habitats in various parts of the corridor. However, final road alignment cannot proceed until all potential peregrine nesting habitat along the proposed route is thoroughly searched.

Non-systematic surveys of peregrine falcon nesting habitat should be conducted from a helicopter by experienced surveyors and pilot (White and Sherrod 1974; Alliston and Patterson 1978). Resurveys, ground truthing of selected areas, or both are necessary to insure the accuracy of the surveys.

Whooping Crane

Status

Perhaps the best known of North America's rare and endangered species is the whooping crane. This species has never been abundant in historic times; during 1S50 Allen (1952) estimated that the population numbered approximately 1500 birds. By the 1920's the population had dropped to fewer than 100 birds and during 1941 the population had reached a low of 1S birds. Today there are approximately 74 wild whooping cranes (Toronto Globe and Mail, 18 April 1979).

Whooping cranes nest in a 500 km^2 area in Wood Buffalo National Park, approximately 90 km south of the study area. No confirmed sightings of whooping cranes have been made in the study area; however, two separate unconfirmed reports within a few days of each other from the Snare River area strongly suggest that non-breeding whooping cranes may occasionally enter the study area (E. Kuyt, pers. comm.).

Should non-breeding whooping cranes regularly use the study area, the glacial Lake McConnell and Moss Forest areas (Figure 3) would provide the most suitable habitat. These areas are close to the nesting grounds and are more characteristic of the normal habitat of whooping cranes (Novakowski 1966). The deep ponds and lakes of the Precambrian highlands (Jacobson 1978) would probably not provide favorable foraging habitat for this species.

Potential Impacts of Road Development

If parts of the study area are regularly used by non-breeding whooping cranes then displacement by either habitat destruction or disturbance could constitute a significant impact on this endangered species.

Research Requirements

It is not practical to conduct aerial surveys specifically to study the distribution of this species within the study area. During the course of surveys for other species, observers would record whooping cranes and map any sightings. Should whooping cranes be found, the areas used, their activities, and their duration of stay should be monitored as closely as possible without disturbance to the birds.

Eskimo Curlew

Status

Historic records indicate that Eskimo curlews were very numerous before the late 1800's. A rapid decline in Eskimo curlew populations occurred between 1870 and 1890. Most authors have suggested that excessive hunting pressure and the vulnerability of the large curlew flocks were primarily responsible for the decline of the species (Forbush 1912; Swenk 1'316; Bent 1929; Greenway 1958, cited by Banks 1977; Godfrey 1966; and others). however, Banks (1977) has speculated that climatic factors were also involved. The Eskimo curlew was protected by the Migratory Birds Convention Act of 1916; however, by 1916 its status was already precarious. At present this species is believed to be nearly extinct. Unconfirmed sightings are reported occasionally (e.g. Hagar and Anderson 1977) and a small remnant population may exist.

The first nest described for this species was found in the study area at Point Lake during the Franklin expedition (Richardson and Swainson 1831). There have been no other reports of this species in the study area, hut little subsequent biological work has been done in this area.

Potential Impacts of Road Development

If nesting Eskimo curlews were to occur in the immediate vicinity of a road, the impact of road construction and maintenance upon this nearly extinct species could be serious. 'Destruction of nest sites or nesting habitat during road construction may cause curlews to move to inferior habitats where they may have low survival or reproductive rates. Disturbance of nesting birds could also result in failure to nest or reduction of reproductive rates. If nesting Eskimo curlews were found within a read corridor, it would be necessary that road construction not be permitted within nesting areas and that the location of nesting areas be kept confidential to prevent disturbance by birdwatchers.

Research Requirements

The almost complete lack of knowledge of breeding areas or even of what constitutes Eskimo curlew nesting habitat, together with the extremely small population of this species, renders the development of specific research plans unrealistic. A practical approach would be for all biologists working in this area to be made aware of the potential presence of this species and for any sightings to be recorded and compiled. Areas from which breeding-season or repeated sightings are reported should be investigated by ornithologists.

Raptorial Birds

In addition to the peregrine falcon, 13 species of raptorial birds are known or believed to use the study area of which three species deserve special attention: bald eagles, golden eagles and gyrfalcons. All nest within the study area and are sensitive to disturbance while nesting (Fyfe and Olendorff 1976). The two eagle species are considered endangered in some parts of Canada and the bald eagle is considered to be endangered in the United States. The gyrfalcon has been included because it is the species most highly valued by falconers and increased access to nest sites could adversely affect the number of this uncommon species within a road corridor.

Knowledge of Raptorial Birds in the Study Area

Bald Eagle

Bald eagles build nests primarily in trees in riparian habitats, although in the study area they frequently nest on cliffs (Allen and Ealey 1979) and have been known to nest on the ground (Bromley and Trauger 1974). Nesting bald eagles are confined to the area south of treeline (Godfrey 1966; Jacobson 1978). In the study area, systematic surveys for bald eagle nests have been conducted only in the Yellowknife area and along the shores and islands of the east arm of Great Slave Lake (.Allen and Ealey 1979). These surveys were carried out only during one year (1978) and were conducted from aircraft, by boat and on foot. A total of 63 active bald eagle nests and 144 unoccupied stick nests were found. Twenty-two unoccupied nests were found late in the season after fledging had occurred; some of these nests may have been occupied during 1978. The highest densities of bald eagle nests were found on the islands of the east arm of Great Slave Lake. Whether densities are similar in other parts of the study area to those found in the Yellowknife area is not known; however these observations and those of R. Bromley (pers. con-m.) would suggest that relatively high densities of these birds may be encountered in portions of the study area.

Golden Eagle

The golden eagle is primarily a cliff-nesting species although occasionally it builds a stick nest in trees (Godfrey 1966). Golden eagles are known to nest throughout the study area (Jacobson 1978; Allen and Ealey 1979; R. Fyfe, pers. comm.). Although numbers are unknown, the species is thought to be uncommon in the study area. Surveys by R. Fyfe (pers. comm.) of the Bathurst Inlet area have revealed 10 nests; a boat and aircraft survey by Allen and Ealey (1979) along the east arm of Great Slave Lake produced only one active nest.

Gyrfalcon

Like the peregrine falcon, the gyrfalcon is a cliff-nesting species; however, it rarely nests south of treeline. Nests of gyrfalcons on the coastal cliffs of Bathurst Inlet have been surveyed repeatedly and monitored since the late 1950's. Systematic surveys have not been conducted in other parts of the study area (R. Fyfe, pers. comm.). Unconfirmed reports of gyrfalcon nests in the study area (L. Covello, R. Fyfe and R. McKillop, pers. comm.) suggest that this species nests in low numbers throughout the tundra portions of the study area.

Potential Impacts of Road Development

Road construction and operation would deleteriously affect these three species of raptors through destruction or degradation of nesting habitat, clisturb.ante, direct mortality, and in the case of gyrfalcons, removal of young for sale to falconers. Degradation of aquatic habitats could also influence the abundance of bald eagles by reducing the abundance or availability of prey species (fish).

Suitable cliff nest sites for gyrfalcons and golden eagles constitute a rare habitat; the destruction of nest ledges, disturbance, or degradation of the surrounding area may render these areas unacceptable as nesting habitat, Destruction or degradation of existing sites may prevent breeding or force birds into inferior habitats where their chances of successfully reproducing would be decreased. Nesting habitat of bald eagles is not believed to be limited, except possibly near treeline. Destruction of bald eagle nest sites could result in a temporary decrease in productivity.

All three species are known to be intolerant of disturbance within the nesting area, although the reactions of individual pairs may vary. As with peregrine falcons, intolerance to disturbance is greatest during the early phases of nesting (Fyfe and Olendorff 1976). In addition to the disturbance from road construction and operation, improved access to nesting areas by recreationists could be an additional source of disturbance.

Research Requirements

Locations of active nest sites near the road must be known in order to assess the impact of road construction and operation on these species of raptorial birds. Preliminary recommendations concerning routing within the corridor can be made by sampling within different areas or habitats; however, all potential nesting habitat along the route should be searched before final road alignment. Because gyrfalcons and golden eagles, like peregrine falcons, nest in cliff habitats, nest sites of these species would be recorded during peregrine falcon surveys. Separate surveys of riparian habitats south of treeline would be required to identify bald eagle nest sites.

Waterfowl

Knowledge of Waterfowl in the Study Area

Waterfowl are found throughout the study area during spring, summer and early fall. Various species use the study area for one or more of spring and autumn staging, migration, nesting and moulting. A total of 22 waterfowl species are known to nest in the study area (Table 1). Few of these species nest throughout the study area; many are limited by habitat preferences to specific parts of the study area.

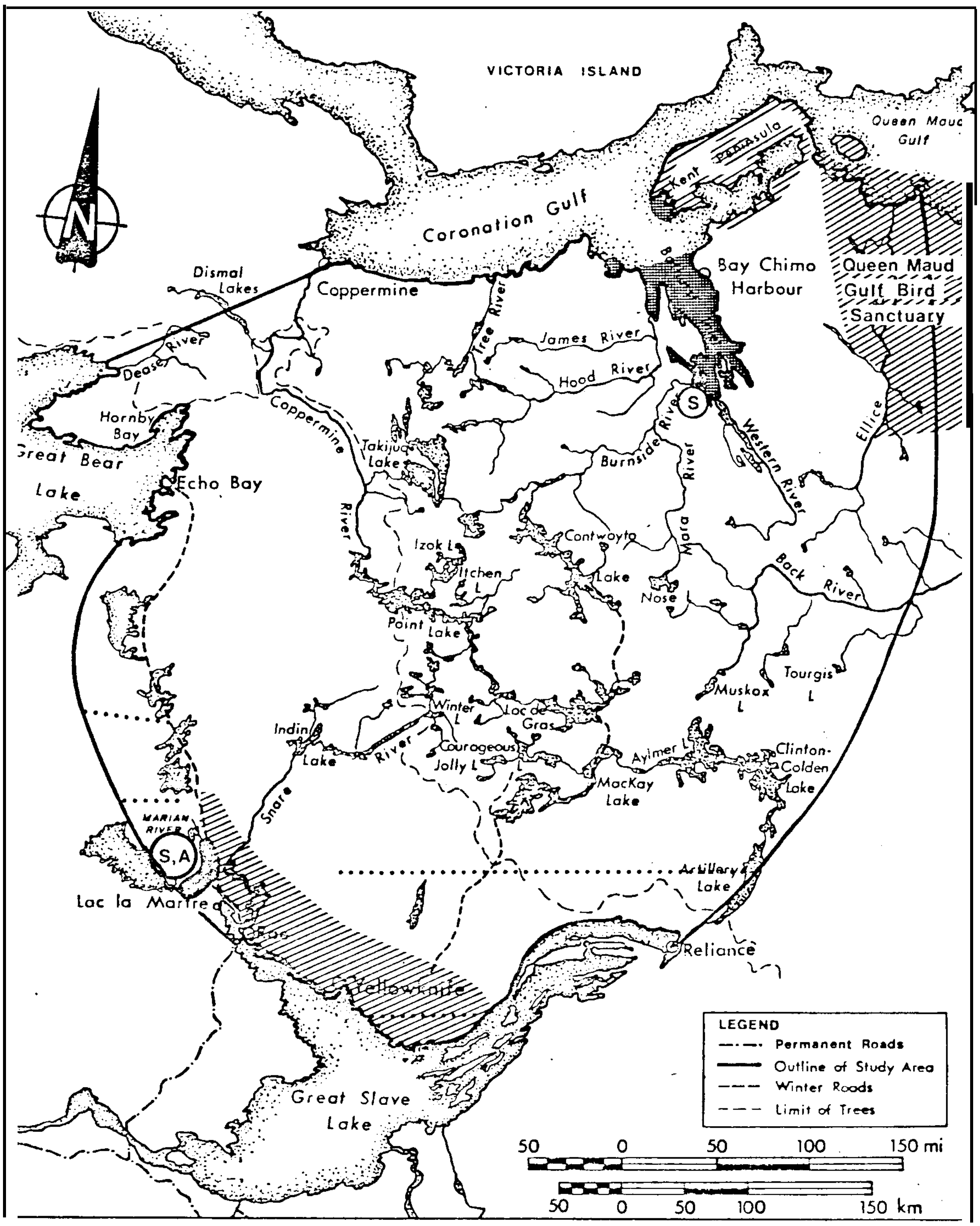
Knowledge of the distribution of waterfowl within the study area is based primarily on scattered, non-quantitative observations. Relative abundances of the various species that use the area are not well known.

Some quantitative data are available concerning the distribution and relative abundance of ducks in the southwestern extremity of the study area. Transects totalling approximately 230 km in length have been flown annually in this area since 1.956 by the U.S. Fish and Wildlife Service as part of the waterfowl breeding grounds survey (Figure 6). These surveys generally show that average or below average densities of nesting ducks use these areas.

Quantitative information concerning breeding chronologies, densities, and productivity of 12 species of nesting ducks is also available from intensive ground-based studies conducted on a 39 km^2 study area in the wetlands along the northwest arm of Great Slave Lake, between Yellowknife and Rae. The study area consisted of 400m strips on either side of the Yellowknife-Rae highway. This wetland is situated in the glacial Lake McConnell zone and is an above-average type of northern (transition boreal forest) waterfowl habitat (Murdy 1965; Murdy *et al.* 1970). Intensive studies were conducted in this area from 1962 through 1965 and general monitoring of the area was maintained from 1966 through 1970 during studies

Table 1. Known Distribution and Activities of Waterfowl that Regularly Occur in Study Area.

Species	Known Distribution and Activities in Study Area			
	Spring Staging	Breeding	Moulting	Fall Staging
Whistling swan	LaMarte and Marian Rivers	Throughout (scattered)	Throughout (scattered)	LaMarte and Marian Rivers
Canada goose	Delta of Burnside River	Throughout	Probably throughout	?
Brant	?	Coastal Kent Peninsula and adjacent mainland and islands	Same as breeding	?
White-fronted goose	Delta of Burnside River	Kent Peninsula and adjacent mainland	Same as breeding	?
Lesser snow goose	Delta of Burnside River	Colony near Ellice River	Ellice River	?
Ross' goose	?	Colony near Ellice River	Ellice River	?
Mallard	-	South of treeline	?	-
Pintail	-	Throughout	?	-
Green-winged teal	-	Mostly south of treeline	?	-
Blue-winged teal	-	South of treeline (uncommon)	?	-
American wigeon	-	Mostly south of treeline	?	-
Northern shoveler	-	South of treeline	?	-
Canvasback	-	Glacial Lake McConnell and Mossy Forest wildlife zones (uncommon)	?	-
Greater scaup		Restricted to islands in large lakes; mostly below treeline	Bathurst Inlet	
Common goldeneye		South of treeline	?	
Bufflehead		South of treeline	?	
Oldsquaw		North of treeline	Bathurst Inlet, Kent Peninsula, Queen Maud Gulf	
Common eider	-	Coastal areas of Coronation Gulf		Bathurst Inlet
King eider	-	Coastal areas throughout		Bathurst Inlet
White-winged scoter	-	South of treeline		
Surf scoter	-	South of treeline		
Red-breasted merganser	-	Throughout all but north-easterly tip of study area		



Important Nesting Areas

Molting Areas

Staging Areas S Spring A Autumn

. . . . Approximate Locations of Breeding Ground Survey Transects

Figure 6. Known Moulting and Staging Areas and Important Waterfowl Nesting Areas.

of the population ecology of the lesser scaup (Trauger 1971). The area studied by Murdy and Trauger is situated in a region that probably comprises some of the best nesting habitat for ducks in the study area and is quite unlike the Precambrian highlands that constitute most of our study area. Nevertheless, the detailed baseline data available from this highway-impacted area should be useful. Unfortunately, no comparable data were obtained from the Yellowknife Study Area previous to the development of the highway.

Quantitative information concerning the distribution and relative abundance of nesting waterfowl does not exist for the remainder of our study area. Reconnaissance surveys to identify concentrations (staging, nesting, moulting) of waterfowl have been few and limited in extent within the study area. Several surveys for nesting, brood-rearing and moulting geese have been conducted in the Queen Maud Gulf Migratory Bird Sanctuary (Hanson *et aZ.* 1956; Barry 1960; Ryder 1969; Kuyt *et al.* 1971; R. Kerbes, pers. comm.) at the north-eastern extremity of the study area. Survey flights by Ryder (1969) extended west to Bathurst Inlet and Kuyt *et aZ.* (1971) surveyed the eastern part of the Kent Peninsula. Of these surveys only Kerbes (pers. comm.) reported a major concentration of nesting waterfowl within the study area (see below). Barry (1960) made a single reconnaissance flight from Yellowknife to Bathurst Inlet *via* Contwoyto Lake during 1958 and did not report waterfowl concentrations in the study area. Jacobson (1978) reported a staging area for whistling swans after flying high level reconnaissance surveys over the southern and southwestern extremities of the study area. The information that exists concerning concentrations of waterfowl is derived largely from casual observations and is summarized in Figure 6.

The LaMarte and Marian rivers are spring and fall staging sites for whistling swans (Jacobson 1978; A. Goodman and S. Steffansen, pers. comm.). Counts of these birds have not been made but Steffansen estimates that more than 1000 birds may use this area at one time. A. Goodman will be conducting surveys of this area in 1979 to obtain counts of staging swans. Abrahamson (1964, cited by Kingsley 1979) stated that 'hundreds' of Canada geese, snow geese, and white-fronted geese stage in the delta of the Burnside River (Bathurst Inlet area) during spring migration.

According to the Land Use Information Series (LUIS) maps, coastal areas of the Kent Peninsula and Melbourne Island are designated as important nesting areas for black brant, white-fronted geese and eider ducks. However, Kuyt *et aZ.* (1971) found few waterfowl on the northwest coast of Kent Peninsula or on Melbourne Island. Lowland areas in the central Kent Peninsula are also reported to be important breeding areas for whistling swans and geese (R. McKillop, pers. comm.), and a nesting colony of Ross' geese and snow geese exists near the Ellice River (R. Kerbes, pers. comm.).

Waterfowl moulting areas have been reported along the southwest coast of the Kent Peninsula (Walker Bay) and in Daniel Moore Bay (R. Fyfe, pers. comm.). A. Hochbaum (pers. comm.) reported that coastal areas of Bathurst Inlet are used by moulting greater scaup, oldsquaws and autumn staging eiders. Canada geese moult along the Ellice River (R. Bromley, pers. comm.).

Potential Tmpacts

Impacts of road development upon waterfowl could result from loss of habitat, disturbance, or through increased hunting pressure created by improved access to the study area. The potential for impact is greatest where waterfowl are concentrated [staging, moulting, and colonial nesting) and when they are under physiological stress (staging, incubation, moulting).

Impacts caused by direct habitat destruction would probably not be significant. Serious impacts would only be likely if a major terrestrial staging area, colonial nesting site or an exceptionally favorable habitat were destroyed. Modification or destruction of extensive areas of wetland habitat resulting from interference by the road with normal drainage patterns could have an impact on dispersed nesting waterfowl.

Impacts caused by disturbance of concentrations of waterfowl by the construction and operation of a road and its auxiliary facilities are more likely to occur. Such disturbance could place added stress on groups of birds that are already energetically stressed. Increased stress might lead to decreased production, increased mortality rates, or both. Improved access may result in increased disturbance and increased hurting pressure on waterfowl in their staging, nesting, and moulting areas.

Research Requirements

To predict impacts of road construction and operation on waterfowl , information concerning the distribution, numbers and activities of waterfowl in the study corridor must be known. Of particular importance is the identification of areas used by concentrations Of waterfowl (staging, moulting, colonial nesting) and areas where high densities of dispersed-nesting waterfowl occur.

Aerial surveys of wetlands along the proposed corridor are the only feasible way to identify concentrations of waterfowl and to obtain estimates of numbers and species composition (estimation by experienced observers; photograph-s).

Density-indices of dispersed waterfowl on nesting territories are most accurately determined from surveys conducted by ground-based observers. However, to conduct such surveys over a large area would be v-cry manpower intensive. Surveys using fixed-wing aircraft permit economical and broad coverage at the cost of decreased accuracy. Such surveys are recommended for a preliminary overview of waterfowl distribution and numbers. If these surveys suggest that more precise information is required for certain areas, then surveys using a helicopter can be used, or, when necessary, surveys can be conducted by ground-based observers.

MAMMALS

Wolves

Knowledge of Wolves in the Study Area

Four different subspecies of wolf have been recognized as occurring within the study area (Hall and Kelson 1959). Although it is unrealistic that so many distinct subspecies occur in our study area, two noticeably different forms--the tundra wolf and the timber wolf--are found in this region (J. Kelsall, pers. comm.).

Wolves are distributed throughout the study area (LUIS maps; G. Calef and R. McKillop, pers. comm.); however, there is little quantitative information on their distribution, abundance, or movements.

Denning sites of wolves have been recorded frequently in eskers near treeline and in several river valleys of the barrens (Figure 7). Den sites have also been located on the calving and post-calving grounds of the Bathurst caribou herd (R. Bromley, J. Kelsall and R. McKillop, pers. comm.). It has been suggested that areas near the coast of Coronation Gulf are infrequently used for denning by wolves (.Jacobson 1978; G. Calef and R. McKillop, pers. comm.). The primary wintering areas of wolves are within tree line (LUIS maps) .

Interrelated movements of wolves and caribou have been documented for a large portion of northern Canada east of the study area (Parker 1973). Wolves are regularly observed near herds of the Bathurst caribou throughout the year (J. Kelsall, pers. comm.). It has been hypothesized that non-breeding wolves are the primary component of the wolf population that follows the caribou migrations whereas most adults den in areas away from the caribou calving and post-calving grounds (Walters *et al.* 1979). However, the presence of dens and family groups (with adolescent wolves) on the calving and post-calving grounds of the Bathurst caribou herd conflicts

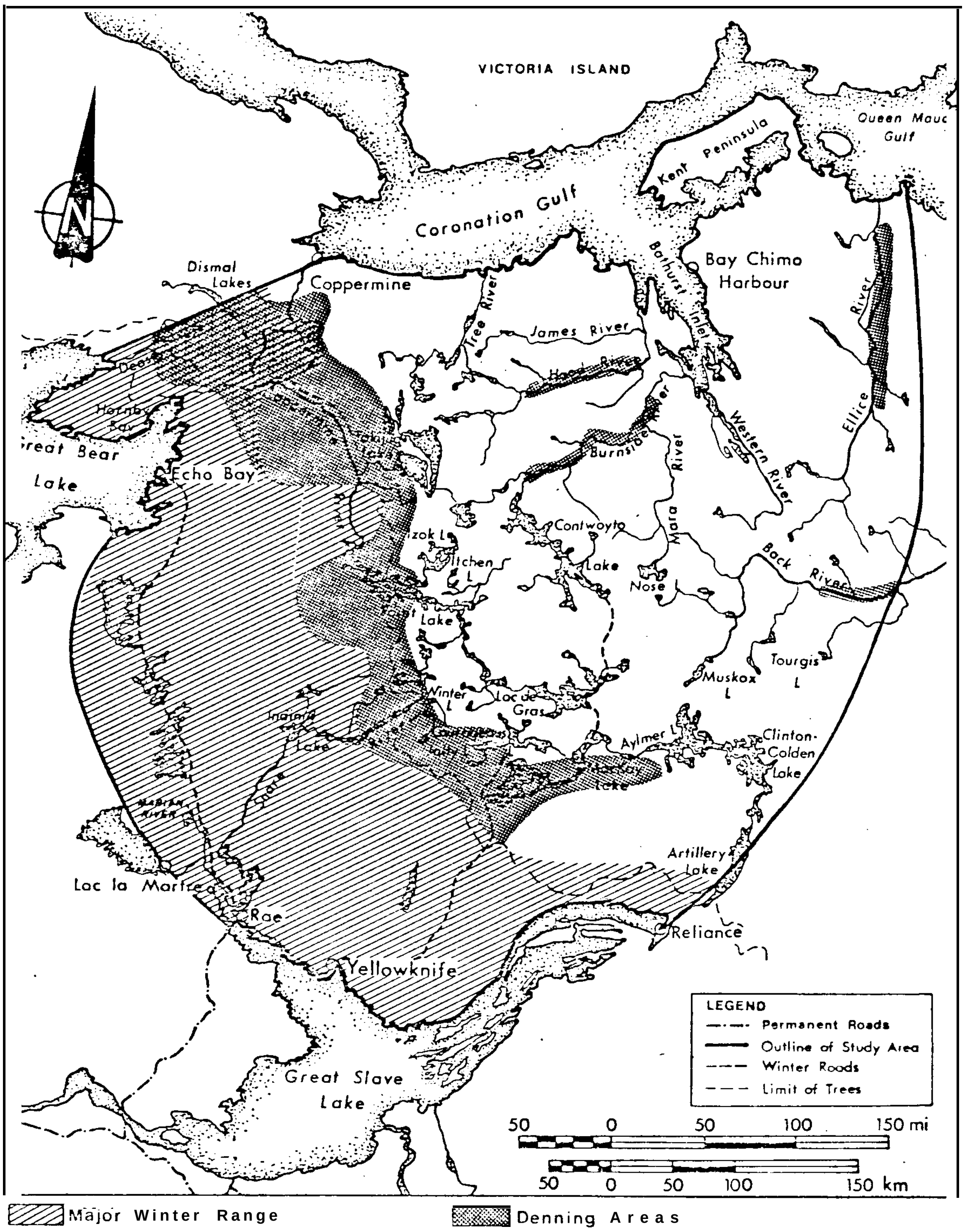


Figure 7. Principal Winter Ranges and Denning Areas of Wolves in the Study "Area (as Shown on LUIS Maps).

with this hypothesis. At present, the seasonal movements of the various portions of wolf populations in the study area are not well known. Radio-tagging studies of wolves to be initiated during *1979* by the Northwest Territories Fish and Wildlife Service (D. Heard, per-s. comm.) should provide information on the movements of various age groups and family groups of wolves relative to the movements of caribou herds.

Potential Impacts of Road Development

Little is known about the effects of road construction and operation on wolves. Road development may affect wolves by altering their distribution as a result of avoidance of a road, by loss of denning habitat, by disturbance leading to the subsequent abandonment of den sites, by increased mortality because of increased hunting and trapping pressure, and by changes in the distribution and abundance of potential prey species of wolves.

Road development may destroy some den sites and the disturbance associated with the construction and operation of a road may prevent wolves from denning at other sites. If denning habitats are limited, then the use of inferior denning habitats could result in decreased breeding success.

Increased hunting and trapping of wolves resulting from improved access could substantially reduce the wolf populations, especially within the road corridor. Effects of road development on the d"istribution, abundance and movements of prey species (particularly caribou) may also affect the distribution, abundance and movements of wolves that are dependent upon this prey species. Decreases in the abundance of prey could potentially decrease the numbers of wolves.

Research Requirements

Data on the distribution and abundance of wolves and wolf dens within the development corridor(s) are necessary to assess the potential impacts of road development on wolf populations. These data are also required to evaluate various corridors and to recommend specific routes through a particular corridor.

There are three major ways in which information on the distribution and abundance of wolves can be obtained:

1. Population size, distribution and movements of wolves in the corridor can be determined most accurately by radio-tagging one or more members of each pack that occurs within the corridor (e. g. , Kolenosky and Johnston 1967; Van Ballenberghe *et al.* 1975). The accuracy of population estimates would depend on the correct determination of pack size and the integrity of packs. Although this type of study can provide excellent and detailed information, this level of detail and effort may not be necessary for the prediction of major impacts.

2. Population indices and distributional information can be obtained through intensive systematic aerial surveys of the road corridor; these surveys can be multi-purpose in nature (i.e. to assess the distribution and relative abundance of wolves, muskoxen and caribou). During winter, surveys should concentrate on locating and following tracks of wolves rather than solely on locating animals along transects because the detectability of wolves during each survey is low and variable (depending upon vegetation characteristics). Information obtained from 'this technique may be improved when combined with track counts from the ground.

3. A series of winter track counts in the road corridor would provide an index of use that can be related to the results of aerial surveys. Aerial surveys for wolves are subject to major problems in interpretation of the data (Miller and Russell 1977) . Track counts in protected (wooded) habitats can be used to improve the reliability of aerial surveys conducted in those areas. A major disadvantage of the track-count method is that it is not useful in open, wind-blown areas.

Information on the distribution and abundance of wolf dens is best obtained by

1. interpretation of aerial photos and preliminary mapping of suitable wolf deming habitat along the road corridor;

2. location and mapping of known wolf den sites in the corridor; and

3. intensive surveys by helicopter of the corridor to locate additional den sites and to further assess the suitability of derming habitats.

Effects of development on the interactions of caribou and wolves are difficult to predict or to monitor. Changes in caribou movement patterns may change rates of wolf predation on caribou, but such changes cannot be measured reliably without a massive expenditure of time, manpower and money. However, knowledge of the seasonal changes in the segment of the wolf population that preys on caribou will permit a more accurate assessment of the effects of altered distribution and abundance of wolves and/or caribou on the population dynamics of these two species. Present radio-collaring studies of wolves by the Northwest Territories Fish and Wildlife Service (D. Heard, pers. comm.) are considered to be adequate as an initial phase of study. Additional information on predation of caribou by denning adults in the calving and post-calving grounds of the Bathurst caribou herd would also be useful.

Grizzly Bears

Knowledge of Grizzly Bears in the Study Area

Grizzly bears occur throughout the study area (Banfield 1959; Kelsall *et aZ.* 1972; S. Miller, G. Calef and R. McKillop, pers. Comm.). Recorded observations of bears in the study area date back to 1771. Sightings of grizzly bears have been made throughout the barrens, and recent observations summarized by Barichello and Miller (1978) include several sightings of grizzly bears in the forest-tundra ecotone at the limits of treeline. Kelsall et *aZ.* (1972) also observed signs of grizzly bears at treeline in the vicinity of Artillery Lake. Bears have been reported from Snare Lake (Miller 1978) and well into the forested regions near Great Slave Lake (J. Kelsall, pers. comm.).

No quantitative information exists on the numbers of grizzly bears east of Great Bear Lake (Barichello and Miller 1978). Harrington *et al.* (1962) show that grizzly bears are numerous in the Thelon Game Sanctuary. Very high densities of grizzly bears have recently been recorded on the calving grounds of the Bathurst caribou herd (Barichello and Miller 1978; D. Heard and G. Calef, pers. comm.) and in several of the major river valleys in the tundra and treeline areas (Figure 8). Bloody Falls on the Coppermine River is reported to be a well-used fishing site by grizzly bears (MacPherson 1965). Concentrations of grizzly bear dens have been reported to occur in eskers in the Burnside River valley (G. Warner, pers. comm.). Numerous eskers occur throughout the study area and undoubtedly provide denning habitat for bears, but these features have not been extensively examined for dens. Banfield (195'3) suggested that grizzly bears are becoming more common in the barren-lands because this species is spreading eastward from a glacial refugium. However, Harrington *et al.* (1962) and J. Kelsall (pers. comm.) consider that the increase is more likely the result of a natural population fluctuation rather than a range expansion.

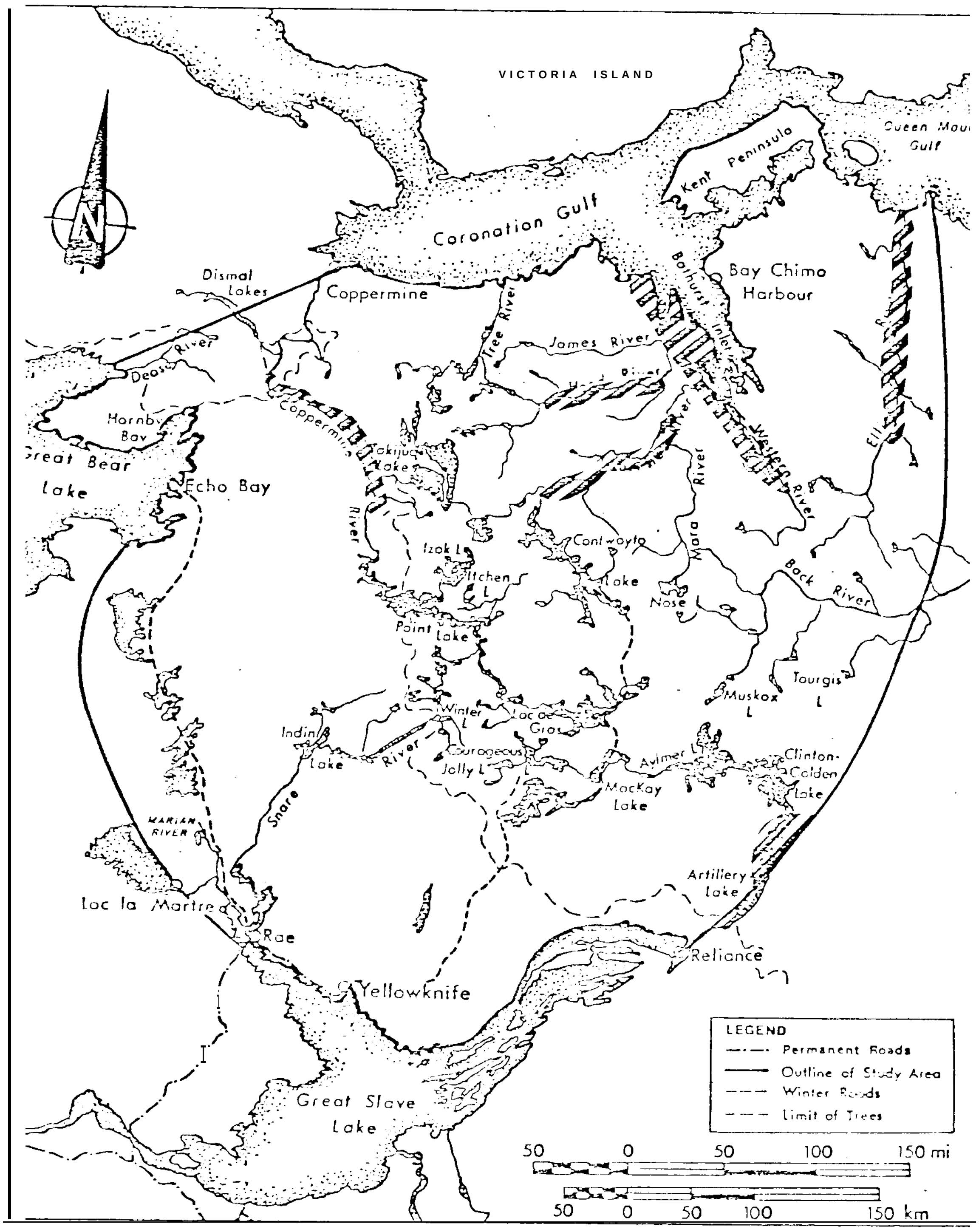


Figure 8'. Areas l','here Gri zzly Bears are Reported to be Abundant (as Shown on LUIS Maps) .

The seasonal habitat requirements and movement patterns of grizzly bears have not been documented in the study area. Investigations have been conducted further west, near Tuktoyaktuk, in conjunction with a proposed road development from Inuvik (Pearson and Nagy 1975). Because of the very different habitats between the areas studiedby Pearson andNagy (1975) and our study area, it is not possible to extrapolate the results from one area to the other without some basic information on grizzly bears in the study area.

Potential Impacts of Road Development

Little is known of the effects of road construction and operation on grizzly bears. Road development may affect grizzly bears by destruction of den sites, by exclusion of bears from denning habitats, by displacement of bears from critical feeding areas, by direct mortality resulting from increased bear-man interactions and by increased hunting pressure resulting from increased access provided by a road.

In areas where denning habitats are limited, destruction of optimal denning areas by road development, or exclusion of grizzly bears from such areas, could result in reduced survival of adults and/or young. Similarly, destruction of critical feeding areas, or exclusion of bears from these areas, could affect the condition of bears entering dens, and thus could increase mortality of adults and/or lower production of young (Reynolds 1378).

Increased bear-man interactions could result from attraction of bears to garbage and hand-outs at construction camps (Craighead *et al.* 1969; Marsh 1972). Such interactions can result in injury or mortality to man, bears, or both.

Increased access to wilderness areas by hunters and poachers could cause increased bear mortality. Road kills and the remains from hunter kills in the vicinity of the road might further attract bears to a road corridor and increase their vulnerability to hunting and interactions with man.

Research Requirements

Data on the distribution and abundance of grizzly bears and their dens within the road corridor are necessary to assess the impact of road development on grizzly bear populations and to recommend specific routes through the corridor that will minimize the impact of a road. Methods of obtaining these data are similar to the methods described for wolves.

1. Detailed data on population distribution, abundance and seasonal movements can be obtained through radio-tagging studies (Pearson 1975; Pearson and Nagy 1975) (see 'Research Requirements' for wolves, above). This level of detail is probably not necessary for the prediction of major impacts.

2. Distribution, seasonal habitat use and abundance indices can also be obtained through intensive and systematic aerial surveys of the road corridor. Unfortunately, because grizzly bears tend to be associated with dense shrub cover, bears often are not visible from the air, even in comparatively open habitats. Thus it is necessary to combine extensive ground work with aerial surveys in order to record bear sign and sightings in areas that cannot be adequately surveyed from the air. Ground surveys alone are not adequate to assess the abundance and distribution of grizzly bears throughout a corridor; however, ground surveys are very useful in locating seasonal feeding areas of grizzly bears.

3. Grizzly bear denning sites should be identified using the same methods described for wolf denning studies, except that both spring and fall surveys can be employed for grizzly bears. The timing of surveys during both seasons is critical; fall surveys are most difficult to conduct successfully because denning occurs over a shorter period than emergence and often occurs during inclement weather. If fall surveys can be conducted at an optimal time, they provide many data in a short period.

Muskoxen

Knowledge of Muskoxen in the Study 'Area

The distribution and abundance of muskoxen on the mainland north of Great Slave Lake have been well summarized by Kingsley (1979). Muskoxen are generally distributed northeast of a line running from Coppermine through Contwoyto Lake to Artillery Lake (Clarke 1940; Kuyt 1971; Kelsall *et* aZ. 1972; G. Calef, pers. comm.), but also can be found north of Great Bear Lake (Kelsall et *aZ.* 1971; D. Boxer, pers. comm.). Clarke (1940) reported that muskoxen were hunted in the Clinton-Colden Lake and Aylmer Lake areas at least until 1900 and that muskoxen were still present there during 1936. Clarke (1940) also reported muskoxen at Tourgis Lake (40 animals), Muskox Lake (occasional individuals), MacKay Lake (*7* animals) and Providence Lake (20 animals). During the 1930's, natives reported muskoxen to be numerous between Contwoyto Lake and the Burnside River with herds numbering up to 80 animals. Muskoxen were also present along the Dease River at the northwestern edge of the study area (Clarke 1940).

Clarke (1940) estimated that there were approximately 1200 muskoxen on the mainland of Canada. Only 300 of these were thought to be present in the Thelon Game Sanctuary and fewer still were located west of the Thelon River (i.e. in the study area). Recent estimates of the number of muskoxen west of Bathurst Inlet range from 108 (Monaghan 1970) to 450 (Tener 1958). A total of 98 muskoxen were seen during caribou surveys in 1967 in the Bathurst Inlet areaby Thomas (1967). During a survey of the Bathurst Inlet area in late February 1979, M. Kingsley and D. Boxer (pers. comm.) saw 76 muskoxen west and south of Bathurst Inlet--primarily in the Hood andMara River regions. D. Boxer (pers. comm.) thought that considerably more muskoxen were present in this region than his survey indicated. During August 1978, a single herd of 48 muskoxen was seen near the headwaters of the Hiukitak River and about 15 more muskoxen were observed along the lower reaches of this river (R. Bromley, pers. comm.). These areas and the portion of the study area bordering the TheIon Game Sanctuary from Tourgis Lake to Artillery Lake have been identified as key areas for muskoxen (Figure 9). Larger numbers of muskoxen are present outside the study area in the TheIon Game Sanctuary (Clarke 1940; J. Kelsall, pers. comm.), east of the Ellice River (D. Boxer 1974; G. Calef, pers. comm.) and in the Rae River area (D. Boxer, pers. comm.). Within the study area, the only calving area identified on the LUIS maps is located on the south shore of Melville Sound (Figure 9).

Muskoxen generally move to low elevations during summer (Clarke 1940; Wilkinson *et aZ.* 1976; and others), but little is known about the specific movements of muskoxen in our study area. Jacobson (1978) stated that muskoxen may make seasonal movements of up to 100 miles. Summer and winter ranges of muskoxen in the Bathurst Inlet area have been delimited (Renewable Resources Consulting Services Limited 1972) but the fidelity of muskoxen to these areas is not known.

Potential Impacts of Road Development

The responses of muskoxen to road construction and operation are not well known. Recent studies of the effects of seismic operations on muskoxen (Riewe 1973; F.F. Slaney and Co. 1975; Russell 1977) and observations of their sensitivity to disturbance by aircraft (Riewe 1974; Renewable Resources Consulting Services Ltd. 1975; F.F. Slaney and Co. 1975) suggest that this species might be particularly susceptible to impact by road construction and development activities.

Disturbance could exclude muskoxen from habitats along the road. If such habitats were limited, the impact on the herd(s) could be severe. Disturbance could also cause additional stress in these animals. If they were already heavily stressed by

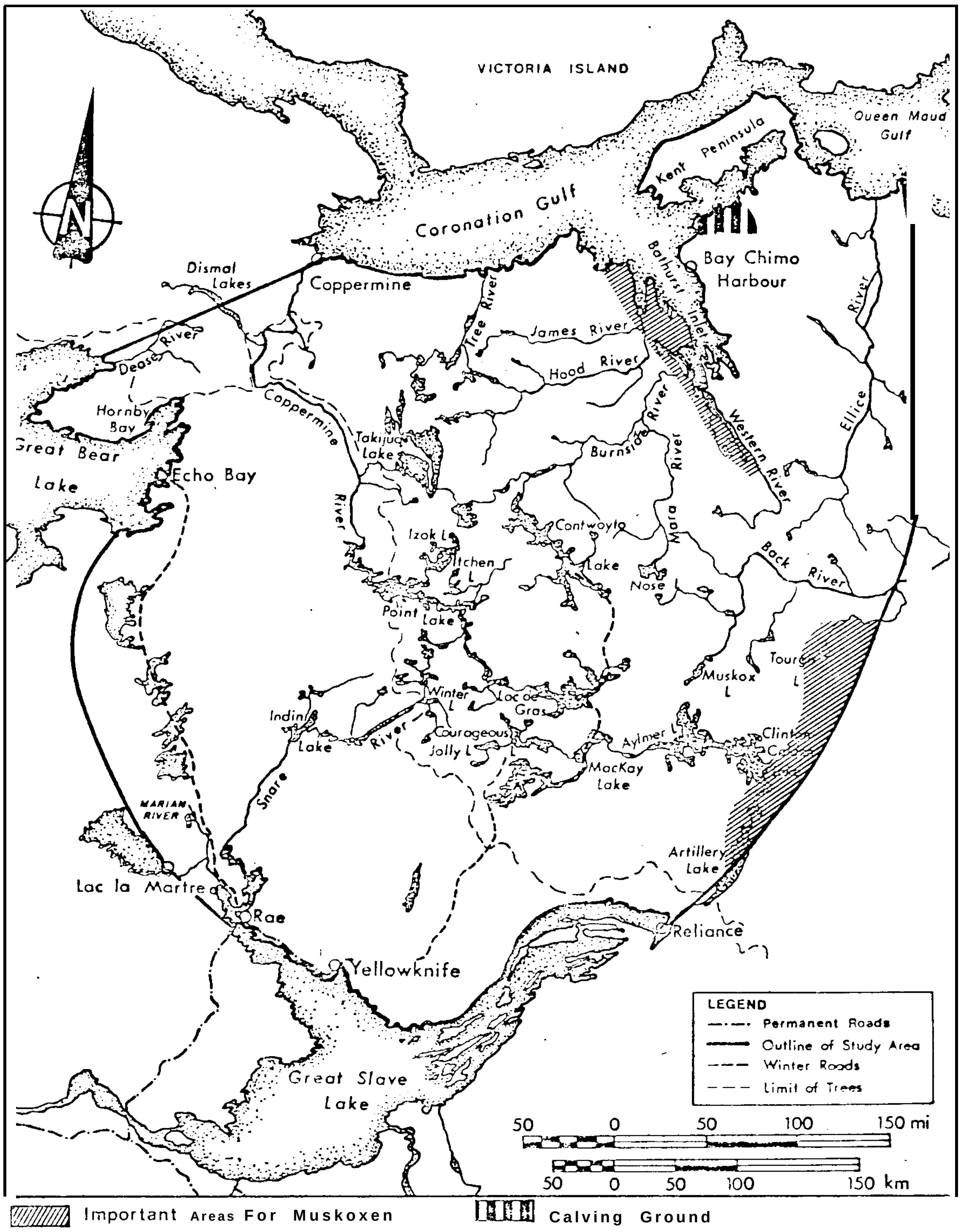


Figure 9. Known Calving Ground and Areas Where Muskoxen are Reported to be Abundant (as Shown on LUIS Maps) .

environmental conditions, additional stress could lead to increased mortality of adults and/or decreased production of young. Disturbante on the calving grounds could lead to stampedes, which Can result in death of or injury to calves. Although seasonal migrations by muskoxen may not be long, blockage of migration paths between highland wintering areas and lowland summering areas could result in serious impacts.

Access provided by roads could also lead to increased disturbance from human recreational activities, and to direct mortality of muskoxen from hunting and poaching.

Research Requirements

The major information gaps can be addressed by conducting a series of aerial surveys to determine the seasonal distribution and abundance of muskoxen within the road corridor. These surveys will identify some of the seasonal feeding areas and other habitats used by muskoxen; the road alignment can be chosen to avoid these areas. Because of the daily movements of muskoxen to and from feeding areas, ground level studies will be needed to locate critical feeding areas within the corridor.

Identification of critical muskoxen range is complicated by the facts that muskoxen may not be present in critical areas for portions of the year and that they may not use an area for an entire year or more. Studies over a period of several years are required to locate the majority of critical habitats for muskoxen in a road corridor.

Caribou

As specified in the terms of reference, emphasis has been placed on information about the Bathurst Caribou herd. Although portions of the Bluenose and Beverly caribou herds may enter the study area for part of the year, the Bathurst herd normally spends the entire year within or near the borders of the study area. Therefore, this section deals specifically with the Bathurst herd.

Knowledge of the Bathurst Caribou Herd in the Study Area

Considerably more information has been gathered on the Bathurst caribou herd than on any other species in the study area. Blanchet (1930, cited by Clarke 1940) conducted aerial surveys of the area north of Great Slave Lake as early as the late 1920's and Clarke (1940) conducted some aerial surveys of the herd during 1936. Systematic surveys of the Bathurst herd were initiated during 1949 by the Canadian Wildlife Service. Systematic caribou surveys have continued to the present and are currently being conducted by the Northwest Territories Fish and Wildlife Service.

Caribou range throughout the study area. They migrate between winter and summer ranges and regularly move through corridors between these ranges. Although range use and movement patterns of caribou are very complex, a simplified approach to the distribution and movements of caribou has been used here.

The winter distributions and calving grounds of the Bathurst caribou herd for 17 years between 1936 and 1977 are presented in Figures 10 to 13. The Bathurst caribou herd normally winters within the limits of trees in the southern and western portions of the study area, migrates northeast or east during spring, and calves in the Bathurst Inlet region. Kelsall (1968) attributed the frequent use of winter ranges between the north shore of Great Bear Lake and Conjurer Bay, between Indin and Mattberry Lake, and north of Gordon Lake to the excellent patches of spruce-lichen forest that are found

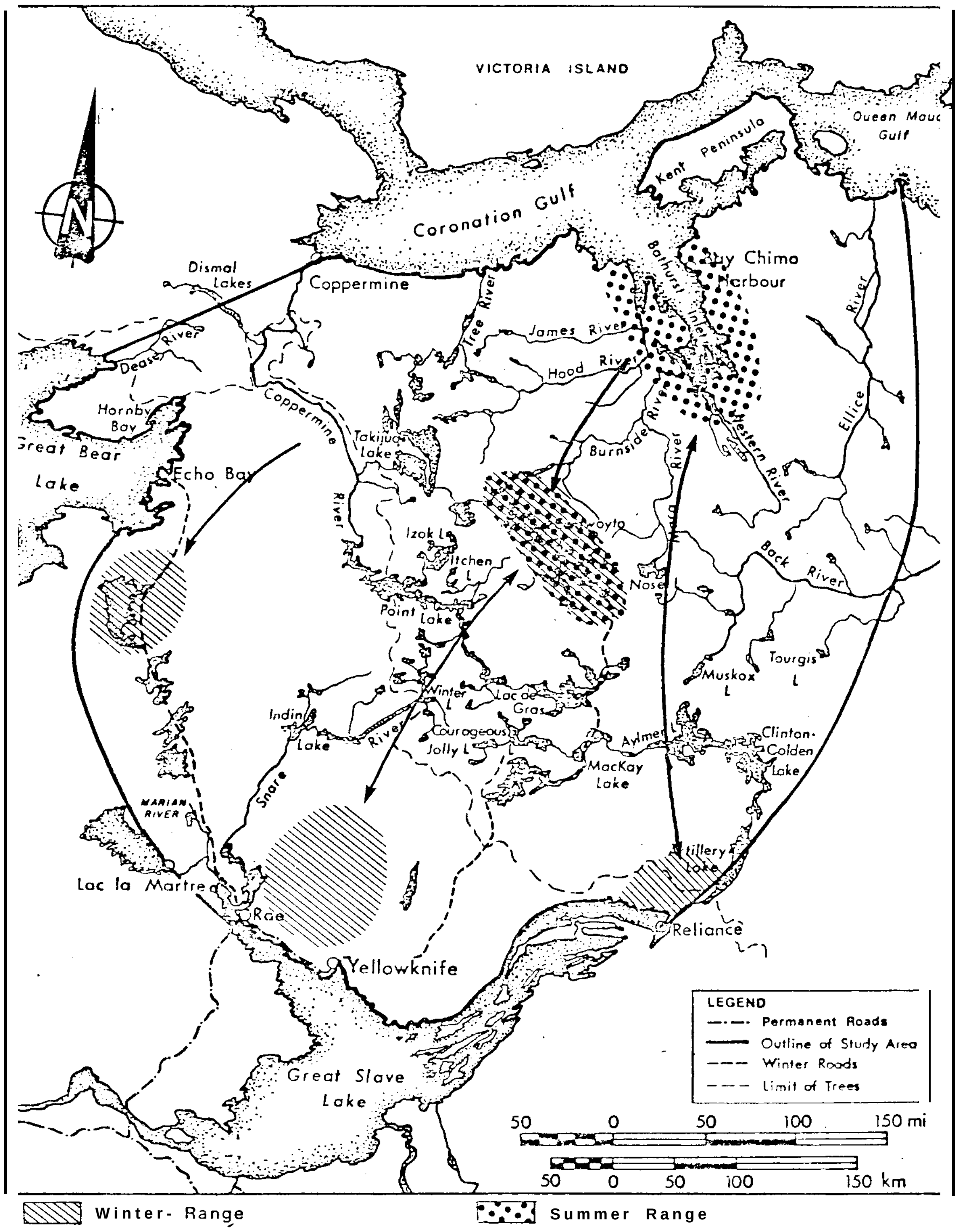


Figure 10. Approximate Locations of Major Known Winter and Summer Ranges of" the Bathurst Caribou Herd During 1936 (Clarke 1940).

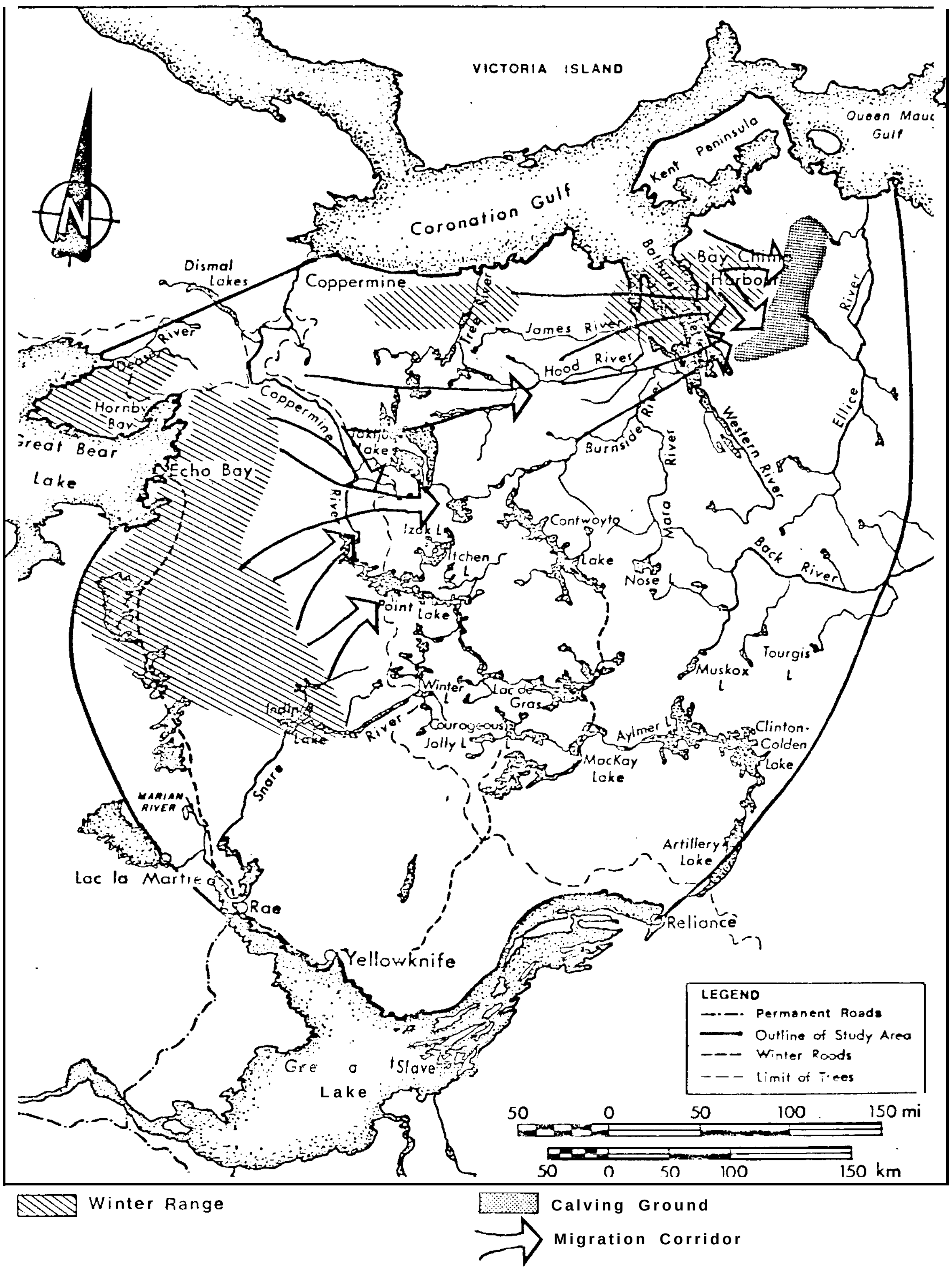


Figure 11. Maj or I\Tinter Ranges, Migrat ion Routes and Calving Grounds Used by the Bathurst Caribou Herd During 1967 (adapted from Thomas 1969) .

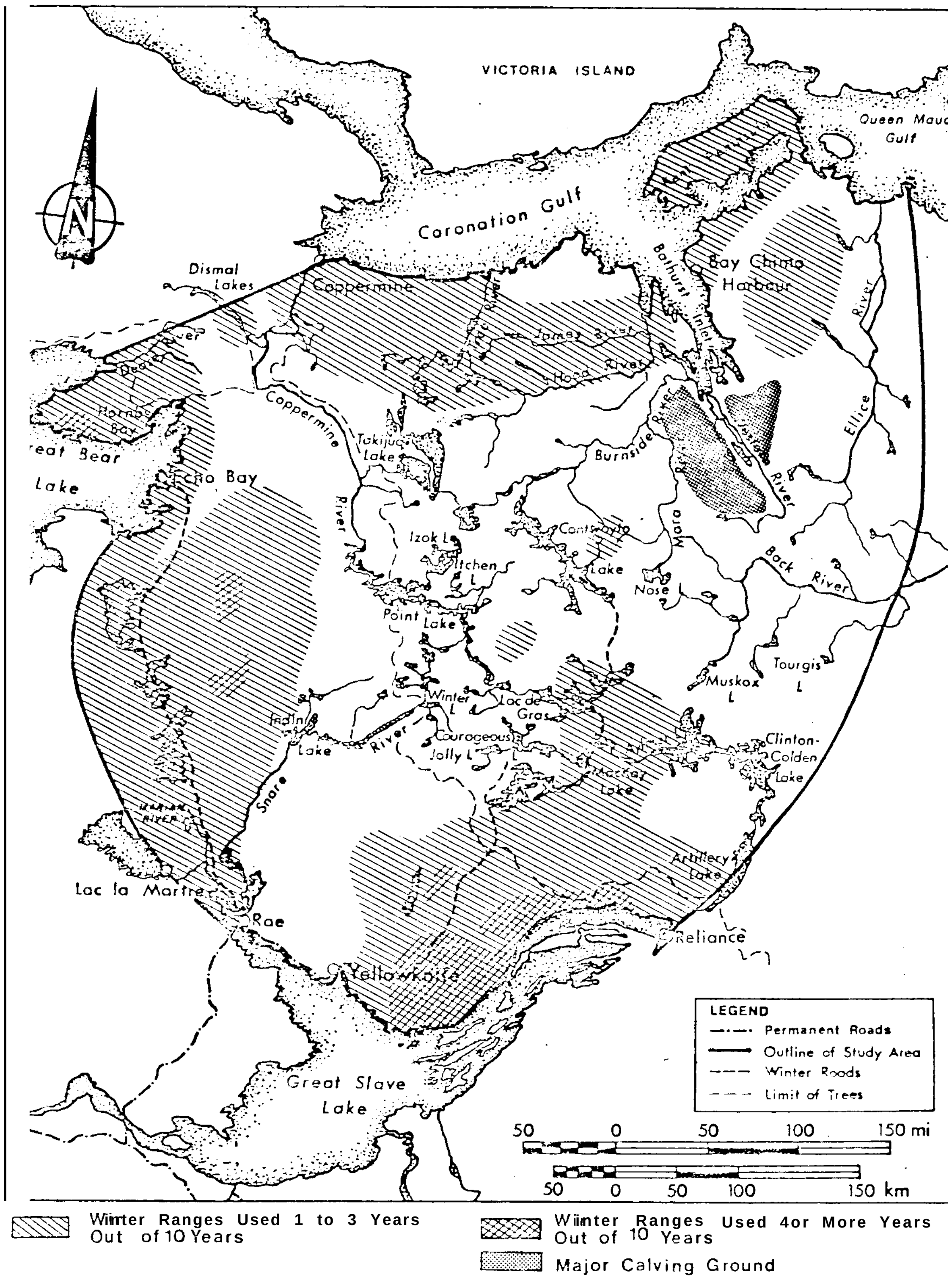
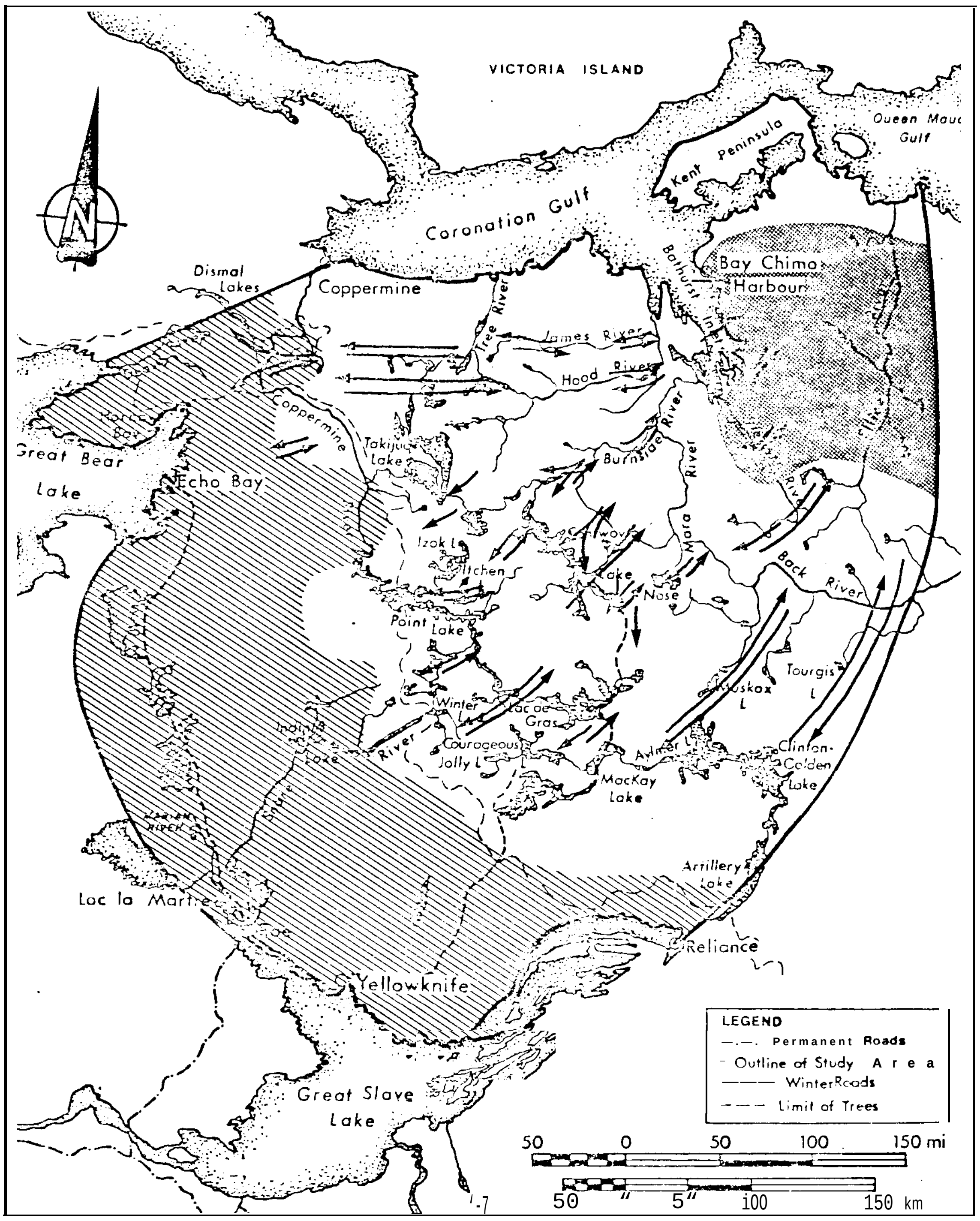


Figure 12. Major Winter Ranges and Calving Grounds Used by the Bathurst Caribou Herd from 1949 to 1960 (adapted from Kelsall 1968).



Winter Range

Calving Ground

Migration Corridor

Figure 13. Approximate Locations of Known Winter Range, Calving Ground and Migration Routes of the Bathurst Caribou Herd (compiled from LUIS Maps).

there. Caribou regularly winter in the Hidden Lake area east of Yellowknife (near the winter road) since at least 1973 (R. Bromley, pers. comm.). Of interest is the mention by Clarke (1940) of a caribou herd that summered in the Contwoyto Lake area (possibly herds of males that stopped short of the calving grounds [Kelsall 1968]) and of another herd that wintered there. At present, few caribou use the Contwoyto Lake area except during migration. Also of interest is the well documented shift in the calving grounds from an area south of Bathurst Inlet (Kelsall 1968) to the presently used calving grounds east of the inlet (LUIS maps).

According to the LUIS maps, caribou migration may occur across the entire central portion of the study area. The particular migration route used during spring depends to a large extent on the late winter (March) distribution of caribou. Caribou that winter near Great Bear Lake can be expected to migrate across the Takijuq Lake area, along the major river valleys leading to Bathurst Inlet (parallel to the coast), and finally across tile ice of Bathurst Inlet to the calving grounds (Figure 13). Caribou that winter north of Great Slave Lake have been shorn to migrate to the Bathurst Inlet area in a more dispersed pattern across a larger portion of the study area (Figure 13).

Summer movements of caribou are best described as nomadic. After calving, caribou move to (areas where suitable forage exists and where some relief from insect harassment can be found. Large post-calving herds form in suitable areas near the coast or on high ground exposed to the wind. During August, caribou tend to disperse over a wide area and are no longer found in dense aggregations (Kelsall 1968).

The routes taken by caribou during fall migration are nearly as unpredictable as during the spring migration with the exception of movements near Contwoyto Lake. Typically, a large number of caribou move southwest to Contwoyto Lake, separate, and move around either side of the lake (G. Calef, pers. comm.). A major water crossing exists at Pellatt Lake (Calef and Boxer 1977).

Movements on winter range are more restricted than the summer wanderings of caribou, but the herd remains basically nomadic. Shifts of caribou from one part of the range to another may occur throughout the winter, but movements on the winter range are most noticeable during February and March, immediately before the initiation of spring migration (Kelsall 1968).

Historically, barren ground caribou populations have been subject to large numerical fluctuations (Kelsall 1968). The Bathurst caribou herd has been surveyed since 1.949 and, although it is apparent that estimates of herd size are subject to considerable error (*viz.*, estimate of 94,000 caribou during 1966 and 145,000 caribou one year later--an improbable increase without massive immigration and undoubtedly the result of error), the herd has apparently undergone a major population fluctuation since the inception of systematic surveys (Table *2).* Presently, the Bathurst herd, which numbers about 150,000 animals, is the largest caribou herd in the Northwest Territories (Calef 1977, Calef and Boxer 1977). The calving herd now numbers between approximately 60,000 and 100,000 breeding cows (Boxer 1974; Calef and Boxer 1977).

During the fall of 1977, calves were estimated to comprise about 23% of the nerd (D. Heard, pers. comm.) which is considerably higher than previously reported fall calf percentages of other North American caribou herds (see Calef and Boxer 1977). Calf percentages during the fall of 1978 were lower (17.5%; D. Heard, pers. comm.), but were still comparable to or higher than most previously reported ratios.

Human harvest of the Bathurst caribou herd is estimated to be between 4% and 5% annually, of which 4000-6000 animals are taken by native hunters (Calef and Boxer 1977). Wintering caribou north of Yellowknife are heavily hunted as a result of access from the winter road (R. Bromley, pers. comm.). Little is known about the extent of other mortality factors such as predation. In fact, the population dynamics of the Bathurst caribou herd have not been studied.

Table *2.* Estimates of Calving Herd and Total Herd Sizes of the Bathurst Caribou Herd, 1949-1977.

Year	Estimate		Source
	Breeding Cows	Total nerd	
1949		*219,000*	Banfield 1954
1951		*143,000*	Kelsall 1955
1960		*95,000*	McEwan 1960
1966	*65,000*	*94,000*	Williams 1966
1967	*73,000*	*145,000*	Thomas 1969
1970	*100,000*	*163,000*	Boxer 1970
1971	81,000	*159,000*	Boxer 1971
1974	*101,000*	*174,000*	Boxer 1974
1977	*62,000*	*152,000*	Calef and Boxer 1977

Potential Impacts of Road Development

Because caribou are migratory, an entire herd can be exposed to a road that bisects the region between summer and winter ranges. The potential impacts of linear developments on caribou have received considerable study since the inception of the Trans-Alaska Pipeline and the associated haul road.

Reduction of the available range and increased hunting pressures are the major potential effects of highway development on caribou populations. The following is a summary of potential impacts of road development on caribou.

1. Habitat loss caused by road construction activities, by avoidance of the corridor by caribou, and by the disruption of traditional migration routes of caribou poses a serious threat. Although the amount of habitat actually destroyed by road construction would be small, indirect loss of blocks of prime habitat caused by caribou avoiding the road corridor and by the road acting as a barrier to caribou migrations could be critical. The potential for caribou to be excluded from a portion of their normal range by the road is largely unknown. However, failure of caribou to cross the Trans-Alaska Pipeline haul road (Cameron and Whitten 1978) and of reindeer to cross a railroad in Norway (Klein 1971) have been documented.

2. Increased disturbance and particularly increased hunting pressure associated with improved access could have serious impacts on caribou populations. These aspects have not been studied, but have been identified as a major concern (Walters *et aZ.* 1979). In view of the fact that the sizes of nest caribou populations, including the Bathurst herd (Calef and Boxer 1978), appear to be stable or declining, increased mortality from hunting may have severe consequences.

3. Mortality from collisions with vehicles would probably be low in open tundra areas but could be substantial in wooded areas, especially during winter when the snow-plowed road may attract animals because of the ease of travel along the road. Snowbanks along the road may make escape from the road difficult.

4. It has been speculated that non-breeding wolves follow caribou onto their summer range whereas most adults normally den away from the caribou calving and post-calving grounds. If this is true, then developments that affect the distribution and seasonal movements of caribou would also have a pronounced affect on the distribution and movements of wolves. These changes could have severe consequences for the Bathurst caribou herd (e.g. exposing calving and post-calving herds to predation both by breeding and by non-breeding wolves).

5. Caribou that are forced to cross a road or to find suitable range near the road may suffer increased levels of stress from frequent disturbance (Geist 1975; Villmo 1975). The effects of such stress are unknown. It is also unknown whether caribou would habituate to the road and associated traffic.

Research Requirements

Data on seasonal distribution and densities of caribou in the portions of their summer and winter ranges affected by the corridor are needed in order to assess the potential impact of a specific road development on caribou and to recommend road alignment. Because of the large annual variability in caribou distribution and movements, studies must be conducted over several years and must consider the distribution and movements of the entire herd. Such broad-scale studies would encompass much of the study area.

Movements of migrating caribou across the road corridor must be documented over a period of several years. The general migration routes of the Bathurst herd are known, but specific data on the proposed corridor are necessary. Data from within the corridor should be compared to overall distribution and densities and to the pattern of movement documented during previous years. Aerial surveys along the corridor would be necessary to assess the migration through the area during a short period of time.

Because of the potential of road development to increase mortality rates of caribou, it is critical to understand the population dynamics of the herd. Studies to determine the crude annual natality rate and the survival rate (including mortality attributed to predators, hunting and other causes) should be conducted. Studies should be initiated to determine the number of caribou that are killed by predators, by hunting and the total annual mortality. The ratio of caribou killed by hunters *versus* the number used should be derived to accurately reflect mortality caused by hunting and to design management plans accordingly.

Aerial surveys of the calving grounds of the Bathurst caribou herd presently being conducted by the Northwest Territories Fish and Wildlife Service should be continued. Fall segregation counts should also be continued and expanded (sufficiently large sample sizes in more areas).

The most critical research need in order to assess impacts of caribou is a long-term study of the response of caribou to disturbance. In order to mitigate the impacts and improve on the environmental aspects of road design in the north, it is necessary to know how the distribution and abundance of caribou are affected by existing reeds (i.e. was the populat ion affected through stress, loss of habitat, change in natural predation and/or harvest rates) . Often, these parameters can only be measured in indi rect ways (e.g. changes in migration patterns, composition counts).

SUMMARY OF AVAILABLE DATA

BIRDS

Previous studies of birds in the study area have usually been both short-term and limited in scope. Portions of the study area have not even received cursory surveys for birds and as a result, the distribution, movements and abundance of birds in the study area are poorly known.

Information concerning the presence and activities of birds has been recorded by explorers (e.g. Richardson and Swainson 1831; Seton 1908; Wheeler 1912), by biologists involved primarily in other fields of research (Clarke 1940; Ellis 1956; Tener 1956; McEwan 1957; Kelsall 1966, 1970), during opportunistic visits to specific areas (e.g. Rising and Schueler 1975), and during compilation of faunal inventories of specific areas (Kelsall *et al.* 1972). Most of the recent information is contained in field notes of professional and non-professional observers.

Intensive surveys for peregrine falcons have been conducted only in the Bathurst Inlet area. Nest sites of golden eagles and gyrfalcons were also recorded during these surveys. A relatively accurate estimate of the abundance of peregrine falcons, golden eagles and gyrfalcons exists for the coastal area of Bathurst Inlet. Raptorial birds have not been intensively surveyed elsewhere in the study area with the exception of an intensive survey of bald eagle nest sites on the east arm of Great Slave Lake during 1978.

There have been no surveys for whooping cranes or Eskimo curlews in the study area, but the existing information strongly suggests that the probability of these species occuring near a road would be low.

Waterfowl studies have been conducted in two general regions of the study area. Breeding bird transects and an intensive study of ducks were conducted in the southwestern portion of the study area, near the highway to Yellowknife. This area has been identified as above average habitat for waterfowl. Several staging areas for waterfowl have been identified within the study area, but, with the exception of a survey by Jacobson (1978), only small portions of the area have been intensively surveyed for staging waterfowl (i.e. Queen Maud Gulf Bird Sanctuary, Bathurst Inlet and portions of the Glacial Lake McConnell region).

MAMMALS

Considerably more information exists for mammals in the study area than for birds. Nevertheless, only caribou and muskoxen have been intensively surveyed. Numerous casual observations of wolves and grizzly bears, long-term studies of caribou and shorter-term surveys of muskoxen provide a general knowledge of the distribution, abundance and movements of these species of mammals in the study area. Still, many areas have not been surveyed and specific information necessary for impact studies of road development is lacking.

There have been no quantitative studies of wolves or grizzly bears in the study area. Most recent information on wolves, bears and their dens is from casual observations. These observations give an indication of some key areas for wolves and grizzly bears, but our knowledge of these species in the study area is still rudimentary.

Caribou and muskoxen have received more study in the study area than wolves and grizzly bears. Surveys of muskoxen in a large area centred around Bathurst Inlet have recently been conducted and much of the study area was surveyed for both muskoxen and caribou in order to compile the LUIS maps. However, the recent distribution and abundance of muskoxen away from the coast is poorly known.

The most intensive and longest-term research in the study area has been conducted on the Bathurst caribou herd. These studies were initiated during 1949 and have continued intermittently to the present. Recently, surveys of the calving grounds and fall composition counts of segments of the caribou herd have been conducted on almost an annual basis. The abundance, distribution and movements of the Bathurst caribou herd have been well documented within the study area; however, because of the annual variability in these parameters, dependence on past data is not adequate for studies of specific corridors.

RESEARCH PLANNING

RESEARCH INITIATION

This project is unusual in that ample lead-time exists before development so that a properly designed research program can be implemented. In this section, we discuss a number of guidelines that we believe should be considered during research planning.

The specifics of development of a road in the study area have not been defined. It is our experience that without clear definition of the probable development activities, data collected by researchers in specialized fields may not be applicable to the problem of impact assessment and mitigation. In order to define [Development activities and to ensure the relel-ante of the data that are collected, a short meeting should be held previous to the first field season. This meeting should include government managers, highway engineers and a wide selection of biologists. Such a meeting should result in:

1. a clearer understanding of the problems that need to be addressed, and

2. modification of research plans to meet 'interdisciplinary' data requirements.

Based upon the revised research plan from the workshop a limited field study should he conducted during the first year. Many of the necessary data can be collected during the first year of limited field research. More importantly, additional insights and questions will a rise from the first year's work. There fore it is most efficient to carry out the major field effort during a second year when data requirements and methods are better de fined and the relevant data can be obtained more efficiently.

PROJECT INTEGRATION AND IMPACT ASSESSMENT

As discussed above, we believe it is important to avoid a characteristic of almost all major impact studies--the tendency to expend all the effort and funds during the first year of research. This leaves little opportunity for recovery from errors in research design and allows little chance to study important factors identified during the first field season. We also believe that conventional impact assessments have unnecessarily suffered from the almost complete separation of the various disciplines. 'This independence is a result of the historical development of ecological research. 'The lack of integration of the disciplines is a problem not only between the biological and physical scientists, but also between biological disciplines (e.g. botany and zoology) and even within a fairly narrow field (e. g. vertebrate ecology).

The isolation of disciplines is especially significant with respect to impact-related research, because many of the most important impacts are on processes that link trophic levels or on interspecific processes that operate at the population level (e.g. predator-prey relati oships) . Traditional 'baseline' impact assessment research is often inadequate as a basis for recognition of these impacts or evaluation of their significance. In order to evaluate these impacts, both the research design and the impact assessment process should be carried out on an interdisciplinary basis.

Maintenance of an interdisciplinary (rather than multidisciplinary) research and impact assessment program is extremely difficult. There is a constant tendency for scientists to fall backon traditional data collection methods that do not provide relevant information for impact assessment. In order to counteract this tendency, we would make the following reccmendati.ens:

1. The research should be preceded by a planning workshop and should include a relatively small field effort during the first season.

2. Research should be tightly managed; it should not be unduly sub-divided among a large number or agencies and organizations. This approach also leads to savings in field costs because many phases of the field studies can often be conducted by a single field crew.

3. The research programs should be regularly reviewed in conjunction with reviews of proposed development plans in order to ensure that research design and analyses are relevant to impact prediction and assessment.

SPECIFIC CONSIDERATIONS FOR SURVEY DESIGN

This section describes some of the survey variables that must be considered before initiation of studies and some of the data collection requirements that must be incorporated into the survey methodology.

1. Identification of Corridors. Presently, 13 different transportation alternatives have been proposed for the study area. Seven of these alternatives involve road construction through a portion of the study area and two alternatives require the construction of a rail line. It is not feasible to study the entire study area or even to study all six transportation corridors. Selection of corridors that are most likely to be considered for development is an essential first step in the impact assessment process.

2. Corridor Width. The corridor must be sufficiently wide so that most impacts of road development and operation fall within the corridor. Any spur developments (e.g. borrow sites) should also be incorporated within the corridor. Because of the variable range of potential impacts, it is not possible to designate a uniform cm-rider width. The corridor width should be largely dictated by natural features (e.g. valleys) and should be narrower in heavily wooded areas than in open tundra regions.

3. Coverage of Aerial Surveys. During the first year of studies, coverage should be extensive and designed to obtain an overall perspective on wildlife use of the entire corridor rather than to obtain detailed information through intensive coverage. Coverage during the first year should sample all of the various habi- "tats along the corridor. During the second year, intensive surveys (e.g. 25+% coverage) of habitats identified as key areas can be undertaken with less intensive coverage (e.g. 15-20%) of less well used areas.

4. Coverage of Ground Surveys. Coverage of ground surveys should be limited and should concentrate on potential key areas identified from aerial surveys.

5. Aerial Survey Design and Timing.

a. Mammal Surveys. With the exception of surveys for grizzly bears and summer distribution surveys for caribou and muskoxen, these surveys are best conducted during the late fall to early spring. Grizzly bear surveys can be conducted from late spring to early fall; valuable seasonal distribution, abundance and habitat use information on other species can be gained during these survey periods as well. The corridor should be stratified and systematic linear surveys should be conducted within each stratum.

b. Denning Surveys. Aerial denning surveys for wolves are best conducted during the period previous to whelping (about late April) when females are excavating den sites. Additional information can also be gained from surveys conducted after the pups emerge from the den and are-visible at the den entrance. Surveys for grizzly bear dens are most effective during the peak emergence period (usually during early May) or during the fall denning period (mid to late October). Denning surveys should (1) non-systematically search the entire corridor for likely denning areas and (2) systematically investigate these areas thoroughly for den sites. These surveys should be conducted by helicopter so that investigators are able to freely vary the survey height and speed as warranted by conditions and to land at den sites (where no or limited disturbance would result) to more accurately determine den site characteristics.

c. Nesting Raptors. Non-systematic surveys using fixed-wing aircraft can be effectively employed to establish indices of abundance of tree-nesting bald eagles (and ospreys); however, nests are invariably overlooked during such surveys (Grier 1977). For a complete count of tree-nesting bald eagles either a single intensive search of riparian habitat using a helicopter or repeated searches using fixed-wing aircraft would be necessary. Surveys for cliff-nesting raptors should be conducted at the optimal time for studying the peregrine falcon because of its status (endangered or threatened) and because its nests are more difficult to detect than those of other cliff-nesting raptors being considered. The identification of peregrine eyries by helicopter surveys relies to a large degree on flushing the adult(s) from the eyrie. To assure that an adult is present at the eyrie (Cade 1960; Harris and Clement 1975), and that the disturbance created by the survey does not lead to desertion (Fyfe and Olendorff 1976), the optimal survey period would be during the two weeks following hatching of eggs (early to mid-July). The nesting schedule of the golden eagle is similar to, although somewhat earlier than, that of the peregrine falcon. Gyrfalcon nesting schedules are considerably earlier (Platt 1976) and young would be well developed at the time of the surveys.

d. Nesting Waterfowl. Surveys should be conducted from fixed-wing aircraft and should employ standard strip transect methods developed by the U.S. Fish and Wildlife Service (Anonymous 1968). Should potentially important nesting areas be identified by these surveys, more detailed information may be gathered during subsequent years. Aerial surveys along the corridor should be coordinated with the U.S. Fish and Wildlife Service surveys so that, for surveys conducted in similar habitats, comparisons may be made.

e. Waterfowl Concentrations. Non-systematic surveys of selected wetland habitats should be flown during spring and fall to locate major moulting or staging sites within the corridor. Although the timing of seasonal events varies from year to year, during most years surveys for spring staging waterfowl can be conducted from late April to late June. Fall staging surveys should be conducted between mid-August and mid-October. The periods of moulting vary from one species to another. A non-systematic survey conducted once during July and once during August would be adequate to identify any moulting or brood rearing areas within the corridor.

6. Ground Survey Design and Timing. The timing and design of ground surveys for grizzly bears, muskoxen and caribou should be determined from information needs identified from aerial surveys. I\Tinter track counts should be conducted at least three times during the winter along linear transects located through a variety of habitats. Ground observers should search selected cliff areas for cliff-nesting raptors to ground truth results of the aerial survey. Ground searches should be conducted during the same period of time as the aerial survey.

LITERATURE CITED

Abrahamson, G. 1964. The Copper Eskimos: an area economic survey 1963. Industrial Division, Dep. of Northern Affairs and Nat. Res., Ottawa.

Allen, D.L. and D.M. Ealey. 1979. Raptors and colonial birds of the Yellowknife area and east arm of Great Slave Lake, N.W.T. Unpubl. Rep., Can. Wildl. Serv. 58 p.

Allen, R.P. 1952. The whooping crane. Nat. Audubon Sot. Res. Rep. N9. 3. 246 p.

Alliston, W.G. and L.A. Patterson. 1978. A preliminary study of peregrine falcon populations in the Polar Gas area, Districts of Franklin and Keewatin, N.W.T. Unpubl. Rep., prepared by LGL Ltd. for Polar Gas Project. 112 p.

Anonymous. 1969. Standard procedures for waterfowl populations and habitat surveys, the bush (revised). U.S. Dep. of Interior, Bureau of Sport Fish. and Wildl.

Banfield, A.W.F. 1954. Preliminary investigations of the barren-ground caribou. Part 1. Former and present distribution, migrations and status. Can. Wildl. Serv. Wildl. Manage. Bull ., Ser. 1, No. 10A. 79 p.

Banfield, A.W.F. 1959. The distribution of the barren-ground grizzly bear in northern Canada. Nat. Mus Can. Bull. No. 166.

Banks, R.A. 1977. 'he decline and fall of the Eskimo curlew, or why did the curlew go extaille? Am. Birds. 31:127-134.

Barichello, N. and S. Miller. 1978. Status report of the barren-ground grizzly bear along a proposed road corridor between Great Slave and Izoks [sic] lakes. Unpubl. Rep., Northwest Territories Fish and Wildl. Serv. , Yellowknife. 13 p.

Barry, T.W. 1960. Waterfowl reconnaissance in the western Arctic. Arct. Circ. 13:193-202.

Bent, A.C. 1929. Life histories of North American shorebirds. Part II. U.S. Nat. Mus. Bull. No. 146.

Berger, T.R. 1977. Northern frontier northern homeland: The report of the Mackenzie Valley pipeline inquiry. vol. 2. Minister of Supply and Services Canada, Ottawa. 268 p.

Bird, J.B. 1963. A report on the physical environment of the Thelon River area Northwest Territories, Canada. U.S. Air Force Res. Mem. No. RM-1903-1-PR. 307 p.

Bird, J.B. and M.B. Bird. 1961. Bathurst Inlet, Northwest Territories. Geographical Branch, Dep. Mines and Tech. Surveys. Memoir 7. 66 p. + maps.

Blanchet, G.H. 1930. Keewatin and Northeastern Mackenzie. Dep. of Interior, Ottawa.

Boxer, D.D. 1970. Report on Bathurst Inlet calving herd population estimate. Unpubl. Rep., Northwest Territories Fish and Wildl. Serv., Yellowknife. 18 p.

Boxer, D.D. 1971. Report on Bathurst Inlet calving herd population estimate. Unpubl. Rep., Northwest Territories Fish and Wildl. Serv., Yellowknife. 15 p.

Boxer, D.D. 1974. Report on Bathurst Inlet calving herd population estimate. Unpubl. Rep., Northwest Territories Fish and Wildl. Serv., Yellowknife. 14 p.

Bromley, R.G. and D.L. Trauger. 1974. Ground nesting of bald eagles near Yellowknife, Northwest Territories. Can. Field-Nat. 88:73-75.

Cade, T.J. 1960. Ecology of the peregrine falcon populations in Alaska. Univ. California Publ. Zool. 63:151-290.

Cade, T.J. and R. Fyfe. 1970. The North American peregrine falcon survey, 1970. Can. Field-Nat. 84:231-245.

Calef, G.W. 1977. The population status of caribou in the Northwest Territories. Unpubl. Rep., Northwest Territories Fish and Wildl. Serv., Yellowknife. 24 p.

Calef, G.W. and D.D. Boxer. 1977. A population estimate for the Bathurst caribou herd 1977. Unpubl. Rep., Northwest Territories Fish and Wildl. Serv., Yellowknife. 17 p.

Cameron, R.D. and K.R. Whitten. 1978. Third interim report on the effects of the Trans-Alaska Pipeline on caribou movements. Joint State/Federal Fish and Wildl. Advisory Team, Anchorage, Alaska. Spec. Rep. No. 22. 29 p.

Clarke, C. D.H. 1940. A biological investigation of the Thelon Game Sanctuary. Nat. Mus. Can. Bull. No. 96. 135 p.

Craighead, J. J., M.G. Hornocker and F.C. Craighead. 1969. Reproductive biology of young female grizzly bears. J. Repro. Fert. Suppl. 6:447-475.

Department of Indian and Northern Affairs. 1978. North of 60°: Mines and minerals activities 1977. Mining Div., Dep. Indian and Northern Affairs. 32 p.

Ellis, D. *1956.* Observations on the migration, distribution and breeding of birds in the Canadian arctic during 1954 and 1955. Dansk Ornithologist Forenings Tidsskrift. 50:207-229.

Finney, G. and V. Lang. 1975. Eagles, hawks and falcons of the Mackenzie Valley and their relation to pipeline development. 51 p. *In:* Biological field program report: 1975, Vol. 4. Unpubl. Rep., prepared by the Lombard North Group Limited for Foothills Pipelines Limited.

F.F. Slaney and Company. 1975. Peary caribou and muskoxen and Panarctic's seismic operations on Bathurst Island, N.W.T., 1974. Unpubl. Rep., prepared for Panarctic Oils Ltd.

Forbush, E.H. 1912. A history of the game birds, wildfowl and shore birds of Massachusetts and adjacent states. Mass. State Board Agric., Boston. 622 p.

Fyfe, R. 1969. The peregrine falcon in northern Canada. *In:* J.J. Hickey (ed.). Peregrine falcon populations; their biology and decline. Univ. Wisc. Press. 596 p.

Fyfe, R.W. and R.R. Olendorff. 1976. Minimizing the dangers of nesting studies to raptors and other sensitive species. Can. Wildl. Serv., Occasional Paper No. 23. 17 p.

Fyfe, R.W., S.A. Temple and T.J. Cade. 1976. The 1975 North American peregrine falcon survey. Can. Field-Nat. 90:228-274.

Geist, V. 1975. Harassment of large mammals and birds. Unpubl. Rep., to Berger Commission. 62 p.

Godfrey, W.E. 1966. The birds of Canada. Nat. Mus. Can. Bull. No. 203. 428 p.

Greenway, J.C. Jr. 1958. Extinct and vanishing birds of the world. Amer. Comm. Internat. Wildl. Protection, New York. Spec. Publ. No. 13. 518 p.

Grier, J.W. 1977. Quadrat sampling of a nesting population of bald eagles. J. Wildl. Manage. 41:4 S-497.

Hagar, J.A. and K.S. Anderson. 1977. Sight record of Eskimo curlew *(Numenius borealis)* on the west coast of James Bay, Canada. Am. Birds. 31:135-136.

Hall, E.R. and K.R. Kelson. 1959. The mammals of North America. Ronald Press, New York. 2 Vol.

Hanson, H.C., P. Queneau and P. Scott. 1956. The geography, birds and mammals of the Parry River region. Arctic Inst. N. Am., Spec. Publ. No. 3. 96 p.

Harrington, C.R., A.H. Macpherson and J.P. Kelsall. 1962. The barren-ground grizzly bear in north Canada. Arctic 15:294-298.

Harris, J.T. and D.M. Clement. 1975. Greenland peregrine at their eyries: A behavioral study of the peregrine falcon. Medd. om Groenl. 205:1-28.

Haugh, J.R. 1976. Population and reproductive changes in Alaskan arctic peregrine. Can. Field-Nat. 90:359-361.

Herbert, R.A. and K.G.S. Herbert. 1969. The extirpation of the Hudson River peregrine falcon population. Pages 133-154. *In:* J.J. Hickey (cd.). Peregrine falcon populations; their biology and decline. Univ. Wisc. Press. 596 p.

Hickey, J.J. (ed.). ?969. Peregrine falcon population; their biology and decline. Univ. Wisc. Press. 596 p.

Hickey, J.J. and D.W. Anderson. 1969. The peregrine falcon: life history and population literature. *In:* J.J. Hickey (ed.) Peregrine falcon populations; their biology and decline. Univ. Wisc. Press. 596 p.

Jacobson, R. 1978. Wildlife and wildlife habitat in the Great Slave and Great Bear Lake regions, 1.974-1977. Unpubl. Rep. prepared for Can. Wildl. Serv.

Kelsall, J.P. 1955. Continued barren-ground caribou studies. Unpubl. Rep., Can. Wildl. Serv. CWSC 715. 202 p.

Kelsall, J.P. 1966. Additional bird observations at Bathurst Inlet, N.W.T. Can. Field-Nat. 80:178-179.

Kelsall, J.P. 1968. The migratory barren-ground caribou of Canada. Can. Wildl. Serv. Monogr. No. 3. Queen's Printer, Ottawa. 340 p.

Kelsall, J.P. 1970. Some breeding records for birds of the central Coppermine River. Can. Field-Nat. 84:306-307.

Kelsall, J.P., V.D. Hawley and D.C. Thomas. 1971. Distribution and abundance of muskoxen north of Great Rear Lake. Arctic 24:157-161.

Kelsall, J.P., E. Kuyt and S.C. Zoltai. 1972. Ecology of Fort Reliance - Artillery Lake area. Unpubl. Rep., prepared by Can. Wildl. Serv., Edmonton for Parks Canada. 99 p.

Kingsley, M.C.S. 1979. Wildlife of Bathurst Inlet, Northwest Territories. Unpubl. Rep., prepared by Can. Wildl. Serv., Edmonton for Parks Canada. 65 p.

Klein, D.R. 1971. Reaction of reindeer to obstructions and disturbances. Science 173:393-398.

Kolenosky, G.B. and D.H. Johnston. 1967. Radio tracking timber wolves in Ontario. Amer. Zool. 7:289-303.

Kuyt, E. 1971. An observation of muskoxen near tree-line at Artillery Lake, N.W.T. Can. Field-Nat. 84:405.

Kuyt, E., C.H. Schroeder and A.R. Brazda. 1971. Aerial waterfowl survey, Queen Maud Gulf, N. W. T., July-August, 1971. Unpubl. Rep., Can. Wildl. Serv. 33 p.

Linberg, P. 1975. Peregrine falcon in Sweden. Pages 2-94. *In:* Svenska Naturskyddkso Reningen, Stockholm.

MacPherson, A.H. 1965. The barren-ground grizzly bear and its survival in northern Canada. Can. Audubon 27:2-8.

Marsh, J.S. 1972. Bears and man in Glacier National Park, British Columbia, 1880-1980. Pages 289-296. *In:* S. Herrero (ed.). Bears-Their Biology and Management. IUCN New Series No. 23. 371 p.

McEwan, E.H. 1957. Birds observed at Bathurst Inlet, Northwest Territories. Can. Field-Nat. 71:109-115.

McEwan, E.H. 1960. Barren-ground caribou studies, July 1959 to August 1960. Unpubl. Rep., Can. Wildl. Serv. CWSC S37. 61 p.

Miller, F.L. and R.H. Russell. 1977. Unreliability of strip aerial surveys for estimating numbers of wolves on western Queen Elizabeth Islands, Northwest Territories. Can. Field-Nat. 91:77-81.

Miller, S. 1978. Inspection visit to Snare Lake, N.W. T. on 13 May, 1978 concerning reported bear-man interactions. Unpubl. Rep., Northwest Territories Fish and Wildl. Serv., Yellowknife. 4 p.

hills, G.F. 1976. Biophysical land classification of northern Manitoba. Pages 201-219. *In:* J. Thie and G. Ironside (cd.). Proc. 1st Meeting Can. Comm. on Ecological (Biophysical) Land Class., May 25-28, 1976. Ecol. Land Class. Ser. No. 1. Petawawa, Ont.

Monoghan, H.J. 1970. Preliminary report - muskoxen survey Bathurst Inlet area 1970. Unpubl. Rep., Northwest Territories Fish and Wildl. Serv.

Murdy, H.W. 1965. 1965 progress repel-t on the Yellowknife waterfowl study area, Northwest Territories. Unpubl. Rep., Northern Prairie Wildlife Research Center. 11 p.

Murdy, H.We,, D.L. Trauger and H.K. Nelson. 1970. Waterfowl research on the Yellowknife study area, 1961-70. Transactions of Federal-Provincial Wildlife Conference. 34:26-29.

Nettleship, D.N. and P.A. Smith (cd.). 1975. Ecological sites in northern Canada. Canadian Committee for the International Biological Programme. Conservation Terrestrial--Panel 9. 330 p.

Newton, I. ?.979. Population ecology of raptors. Butec Books, Vermillion, South Dakota. 399 p.

Novakowski, N.S. 1966. Whooping crane population dynamics on the nesting grounds, Wood Buffalo National Park, Northwest Territories, Canada. Can. Wildl. Serv. Rep. Ser. No. 1. 19 p.

Oswald, E.T. 1976. Biophysical analysis of the Yukon Territory. Pages 230-243. *In:* J. Thie and G. Ironside (cd.). Proc. 1st Meeting Can. Comm. on Ecological (Biophysical) Land Class., May 25-28, 1976. Ecol. Land Class. Ser. No. 1. Petawawa Ont.

Padgham, N.A. 1978. Mineral Exploration Northwest Territories, 1978. Unpubl. Rep., prepared by Dep. Indian and Northern Affairs, Yellowknife. 10 p.

Parker, G.R. 1'373. Distribution and densities of wolves within barren-ground caribou range in northern mainland Canada. J. Mammal. 54:341-348.

Parker, A. 1979. Peregrines at a Welsh coastal eyrie. Brit. Birds 72:104-114.

Peakall, D.B. 1976. The peregrine falcon *(Falco peregrinus)* and pesticides. Can. Field-Nat. 90:301-307.

Pearson, A.M. 1975. The northern interior grizzly bear *Ursus arctos L.* Can. Wildl. Serv., Rep. Ser. No. 34. 84 p.

Pearson, A.M. and J.G. Nagy. 1975. The arctic coastal grizzly bear and the potential impact of the proposed Inuvik-Tuktoyaktuk Highway. Unpubl. Rep., Can. Wildl. Serv., Edmonton. 9 p.

Platt, J.B. 1976. Gyrfalcon nest site selection and winter activity in the western Canadian Arctic. Can. Field-Nat. 90:338-345.

Ratcliffe, D.A. 1963. The status of the peregrine in Great Britain. Bird Study 10:56-90.

Ratcliffe, D.A. 1972. The peregrine population in Great Britain in 1971. Bird Study 19:117-156.

Riewe, R.R. 1973. Final report on a survey of ungulate populations on the Bjorne Peninsula, Ellesmere Island. Determination of numbers and distribution and assessment of the effects of seismic activities on the behaviour of the populations. Unpubl. Rep., prepared by Univ. Man., Winnipeg for Dep. Indian Affairs and Northern Development. 59 p.

Renewable Resources Consulting Services Limited. 1972. Arctic ecology map series. Unpubl. Rep., prepared for Can. Wildl. Serv., Edmonton.

Renewable Resources Consulting Services Limited. 1975. A study of land mammals in the high Arctic, 1974. Unpubl. Rep. prepared for the Polar Gas Project. 60 p.

Reynolds, H.V. 1978. Structure, status, reproductive biology, movement, distribution and habitat utilization of a grizzly bear population in NPR-A. Unpubl. Rep., Alaska Dep. Fish and (Me.

Richardson, J. and W. Swainson. 1831. Fauna Boreali-Americana. Vol. 2, The Birds. John Murray, London.

Rising, J.D. and F.W. Schueler. 1976. Observations on birds from northern Canada - 1975. Blue Jay 34:211-214.

Russell, J. *1977.* Some overt responses of muskox and caribou to seismic activities, northeastern Banks Island, March and April, 1977. Unpubl. Rep., Northwest Territories Fish and Wildl. Serv. , Yellowknife. 85 p.

Ryder, J.P. 1969. Nesting colonies of ross' goose. Auk 86:282-292.

Seton, E.T. 1908. Bird records from the Great Slave Lake region. Auk 25:68-74.

Swenk, M.H. 1916. The Eskimo curlew and its disappearance. Pages 325-340. *In:* Smithsonian Rep. for 191S, Washington, D.C.

Tamocai, C. and J. A. Netterville. 1976. Biophysical land classification in Boothia Peninsula and northeast Keewatin N.W.T. Pages 159-171. *In:* J. Thie and G. Ironside (cd.). Proc. 1st Meeting Can. Comm. on Ecological (Biophysical) Land Class., May 25-28, 1976. Ecol. Land Class. Ser. No. 1., Petawawa, Ont.

Tener, J.S. 1956. Annotated list of birds of the Back River, N.W.T. Can. Field-Nat. 70:138-141.

Tener, J.S. 1958. The distribution of muskoxen in Canada. J. Mammal. 39:398-408.

Thomas, D.C. 1967. Muskoxen *(Ovibos moschatus)* observed on a caribou survey March to May 1967. Unpubl. Rep., Can. Wildl. Serv. CWSC 113. 8 p.

Thomas, D.C. 1969. Population estimates and distribution of barren-ground caribou in Mackenzie District, N.W.T., Saskatchewan, and Alberta - March to May, 1967. Can. Wildl. Serv. Rep. Ser. No. 9. 44 p.

Trauger, D.L. 1971. Population ecology of lesser scaup *(Aythya affinis)* in subarctic taiga. Ph.D. Thesis. 118 p.

Van Ballenberghe, V., A.W. Erickson and D. Byman. 1975. Ecology of the timber wolf in northeastern Minnesota. Wildl. Monogr. 43. 43 p.

Vilmo, L. 1975. The Scandinavian viewpoint. Pages 4-9. *In:* J.R. Luick, P.C. Lent, D.R. Klein and R.G. White (cd.). Proceedings of the First International Reindeer and Caribou Symposium. Biol. Pap. Univ. Alaska. Spec. Rep. No. 1. 551 p.

Walters, C., R. Hilborn, R. Peterman, M. Jones and B. Everitt. 1979. Porcupine caribou workshop. Unpubl. Rep., Inst. Anim. Res. Ecol., Univ. B.C. 32 p.

Wheeler, D.E. 1912. Notes on the spring migration at timberline. Auk 29:198-207.

White, C.M. and S.K. Sherrod. 1974. Advantages and disadvantages in the use of a rotary-winged aircraft for raptor research. Raptor Res. 7:97-104.

Wilkinson, P.F., C.C. Shank and D.F. Penner. 1976. Muskox-caribou summer range relations on Bank-s Island, N.W.T. J. Wildl. Manage. 40;151-162.

Williams, R.W. 1966. An aerial census of the Bathurst caribou calving herd. Unpubl. Rep., Northwest Territories Fish and Wildl. Serv., Yellowknife. 9 p.

Windsor, J. 1977. The response of peregrine falcons to aircraft and human disturbance. Unpubl. Rep., preparedby Can. Wildl. Serv. for Mackenzie Valley Pipeline Investigations. 86 p.

APPENDIX I

The following definitions are those currently used by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

species - any species, subspecies, or geographically separate population.

rare species - any indigenous species of flora or fauna that, because of its biological characteristics or because it occurs at the fringe of its range or for some other reason, exists in low numbers or in a very restricted area of Canada but is not a threatened species.

threatened species - any indigenous species of flora or fauna that is likely to become endangered in Canada if the factors affecting its vulnerability do not become reversed.

endangered species - any indigenous species of flora or fauna whose existence in Canada is threatened with immediate extinction through all or a significant portion of its range owing to the action of man.

extirpated - any species of flora or fauna no longer existing in the wild in Canada but existing elsewhere.

extinct - any species of flora or fauna formerly existing in Canada but now no longer existing anywhere.