WEST KITIKMEOT / SLAVE STUDY SOCIETY

Re: Esker Habitat Studies in the Slave Geological Province: Movements and Habitat Use of Wolves Denning in the Central Arctic, Northwest Territories and Nunavut, Canada

STUDY DIRECTOR RELEASE FORM

The above publication is the result of a project conducted under the West Kitikmeot / Slave Study. I have reviewed the report and advise that it has fulfilled the requirements of the approved proposal and can be subjected to independent expert review and be considered for release to the public.

[signature] Feb 18/02

Study Director Date

INDEPENDENT EXPERT REVIEW FORM

I have reviewed this publication for scientific content and scientific practices and find the report is acceptable given the specific purposes of this project and subject to the field conditions encountered.

[signature] MAR. 13, '02

Reviewer Date

INDEPENDENT EXPERT REVIEW FORM

I have reviewed this publication for scientific content and scientific practices and find the report is acceptable given the specific purposes of this project and subject to the field conditions encountered.

ALASDAIR VEITCH 3 APRIL '02

Reviewer Date

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WEST KITIKMEOT / SLAVE STUDY SOCIETY

BOARD RELEASE FORM

The Study Board is satisfied that this final report has been reviewed for scientific content and approves it for release to the public.

Chair West Kitikmeot/Slave Society

April 13/02

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ESKER HABITAT STUDIES in the SLAVE GEOLOGICAL PROVINCE

Movements and habitat use of wolves denning in the central Arctic, Northwest Territories and Nunavut, Canada

Final Report to the

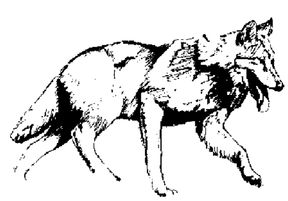
West Kitikmeot / Slave Study Society

Yellowknife, NT Canada

07 February 2002

Submitted by:

H. Dean Cluff
Lyle R. Walton
Paul C. Paquet



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SUMMARY

We studied wolves that den on the central tundra in the Northwest Territories and Nunavut. While these wolves are migratory in that they follow the caribou to the winter ranges south of the tree-line, these wolves return to the tundra in the spring to raise their pups. While wolves are mobile animals, they become much less so when they must return to a den site each day until their pups can travel and leave the den by early fall. Therefore, wolves are thought to be most vulnerable to disturbance during denning because they routinely abandon a den site for another when disturbed.

Den site selection for wolves is not random. While several factors may contribute to the selection process, the most important are likely a place to dig and reasonable access to caribou, their main food source. The need for a diggable site is important because the central tundra region is dominated by bedrock associated with the Precambrian Shield. What is not rock, tends to be large water bodies, standing water, or permafrost, and therefore cannot be dug. Wolves take advantage of eskers, ridges of gravel and sand formed by melting glaciers, to dig dens or take over dens from other wildlife such as foxes or ground squirrels. Therefore, we searched for active wolf dens in May and June on and off eskers but found that most wolves do indeed den on or near eskers. Those dens not associated with a prominent esker were still located in a mound of glacial-fluvial sediment that facilitated digging. While den site characteristics were recorded for some of the dens we found, more of these sites still need to be sampled to establish trends.

We captured wolves from 1997 to 1999 inclusive by net-gunning them from a helicopter and fitted radio-collars to most of them. We deployed 25 satellite radio-collars to track wolf movements mostly during summer. Twenty-four conventional (VHF) radio-collars were also used to facilitate tracking individuals. Although satellite collars were deployed on both sexes, we favored females because we expected them to reveal den sites better

than males. Our approach was to monitor the breeding pair in a wolf pack with a satellite and VHF radio-collar. We generally obtained one complete year of monitoring before exhausting the power supply of the satellite collar. If the wolf was not harvested then we removed the satellite collar the following spring and replace it with a VHF radio-collar to extend the monitoring. Two females were fitted with a satellite collar for a second year, but then a VHF collar was used thereafter.

We analyzed the movement and habitat use of satellite radio-collared wolves. We examined habitat use at two scales. Our coarse scale considered the entire study area as the habitat available to wolves to establish a home range. We then used the habitat types contained within this home range as what the wolf used. At this scale, wolves showed a preference for eskers relative to other habitat types. That is, wolves were apparently selecting areas to live that increased the availability of esker habitat to them. We then looked for patterns of habitat preference at a finer scale. For this second analysis we considered each wolf location as the habitat used and the home range of the wolf as what habitat was available. We used a circle buffer for each wolf location to minimize errors of using point locations for determining the proportion of habitat used. The circle buffer ensured that the true location of the wolf was included. Habitat preference at this finer scale disappeared. This is consistent with wolf ecology in that wolves are not tied to specific vegetation types for feeding. The selection for eskers occurs when wolves choose an area to live. Other factors might also be important such as proximity of caribou as wolf pups grow. Our data were insufficient to identify specific areas of preference or quantify den site density. However, because wolves show a general preference for eskers during denning, we believe eskers are an important resource for them. While den sites may not be limiting at this time, we encourage minimal disturbance of this resource.

We make four recommendations for monitoring wolf den activity for environmental impact assessments of economic development activity. Initially, the arrival times of wolves to their natal or whelping den site in the spring should be determined. Second, we recommend that wolf den sites in a given area of interest be mapped because which den sites are selected will help quantify a potential Zone of Influence from the proposed activity. Third, count of adults and pups and the timing of these counts can provide useful information on recruitment and den site re-location, should it occur, especially with non-radio-collared wolves. Fourth, documenting precisely when den site abandonment occurs will help determine if disturbance has occurred and its possible significance.

ACKNOWLEDGMENTS

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We appreciate the effort and advice of François Messier and Gary Wobeser as graduate committee members for Lyle Walton. Phil McLoughlin assisted us with the habitat data analysis while staff at the NWT Centre for Remote Sensing provided the habitat classification images from their field work, which was supported by WKSS. We also thank Ludwig Carbyn, Patty Hogg, Jason Bantle, and Reid Walton for assisting with the den-site observations. We thank Serge Larivière and anonymous reviewers who made helpful suggestions on earlier drafts of this manuscript. We are saddened by the tragic loss of Dr. Malcolm Ramsay, Lyle Walton's graduate supervisor at the University of Saskatchewan, Saskatoon. Malcolm was a dear friend and colleague to all of us and his valuable insight, input, and genuine positive energy will be dearly missed.

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1.0 OBJECTIVES

One of the biggest threats to the long-term persistence of gray wolves (*Canis lupus*) has been the presence of humans and their associated activity (Hummel and Pettigrew 1991). Colonization and settlement by people, large-scale industrial development, and human population growth have led to the reduction or extirpation of wolves throughout most of their southern range (Mech 1995, Clark et al. 1996). Historically, direct persecution of wolves has been the primary limiting factor for this species (Paquet and Hackman 1995). However, habitat alteration and exploitation as well as disturbance from humans are now the major factors threatening the long-term survival of wolves and other large carnivores (Paquet and Hackman 1995, Clark et al. 1996).

While the Northwest Territories (NWT) and Nunavut have vast areas of undeveloped land, there has been unprecedented resource exploration in the area recently, and this has raised concerns about the welfare of wildlife in the region. The Central Arctic region contains much of the Slave Geological Province (SGP), a geological formation rich in mineral deposits, extending from Great Slave Lake to the Coronation Gulf (Fig. 1-1). Diamond, gold, and base metal deposits have been discovered within this region and some now exist as producing mines. The pace of exploration and the perceived development potential have raised public concern because there is dearth of ecological information for the area. The need for baseline data is paramount because this information is required for the assessment of impacts from development and how they may be mitigated.

Relatively little research has been carried out on wolves that inhabit the tundra regions of the west-central arctic, NWT. As development proceeds in the SGP, we also need to assess the possible cumulative effects that further development may have on the long-term survival of these wolves (Mueller 1995). Wolves tend to avoid human settlements (Thurber et al. 1994), and appear to avoid exploiting prey near clusters of human habitation and development (Paquet 1993). However, wolves in the Northwest

Territories occasionally conflict with people in northern communities where property damage may occur, or pets killed. Nevertheless, wolves remain especially sensitive to human disturbance near active den sites (Weaver et al. 1996).

Many wolves in the Northwest Territories are migratory and follow the barren-ground caribou herds as they move from the boreal forests in winter to the tundra in spring and summer. Few breeding wolves actually den on the caribou calving grounds, preferring instead to den in areas closer to the treeline, likely as a strategy to optimize access to caribou for rearing pups (Clark 1940, Kelsall 1968, Kuyt 1972, Parker 1972, 1973, Heard & Williams 1992). However, den sites could be limiting given that the rocky terrain and the permafrost of the tundra shield may seriously restrict the availability of suitable habitats for denning (Mech and Packard 1990).

Wolves that den on the tundra are thought to do so almost exclusively in eskers and other glacial formations that resulted from retreating glaciers (Williams 1990, Mueller 1995). Eskers, composed of coarse gravel and sand (Goldthwait 1975, Traynor and Atkinson 1999), are important habitat for wolves given a lack of suitable den-digging material elsewhere. Repeated use of these dens is common and many such sites qualify as traditional dens because of their historical use by wolves. In addition to providing den sites, eskers are useful to wolves for travel routes, feeding, and resting. An understanding of the natural history and general ecological requirements of tundra wolves are important concerns for managers ensuring the long-term persistence of these populations (Paquet and Hackman 1995).

Therefore, we began a study in May 1996 to examine the extent of esker use by wolves denning on the tundra. Eskers were considered a Valued Ecosystem Component (VEC) in the 1995/96 scoping sessions and the public hearings that followed for Broken Hill Propriety's Ltd. (BHP) Ekati™ diamond mine proposal in Canada's central arctic (BHP Diamonds Inc. 1995a). Because eskers are comprised of coarse sand and gravel, they are excellent sources of construction material for quarries, airstrips, camps, and roads. Given that eskers are also important for wildlife, their use or removal has potential for land use conflicts.

Although considered as a wildlife VEC in the BHP scoping sessions, wolves were named a VEC in BHP's Wildlife Effects Monitoring Program. Wolves were specifically chosen in this study because of their apparent selection of eskers for denning. Previous work in the area found that carnivores (wolves, foxes, and grizzly bears) made extensive use of eskers, although some upland habitat was also used (Mueller 1995). Given that eskers comprise a small fraction (2-3%) of the arctic tundra ecosystem, Mueller (1995) thought that loss of some eskers could reduce the reproductive success of those species that use them for denning. Consequently, we wanted to determine the use of eskers by wolves and document their denning patterns. This meant searching for active den sites on the tundra in May and June. We also wanted to capture and radio-collar some wolves so we could follow individual wolves. We could then follow these individuals to locate their den sites, track their movements, and determine any preference they may have for specific sites.

We realized that we knew little on the potential impact to wolves from economic development in the area. A recent World Wildlife Fund (Canada) review (Paquet and Hackman 1995) acknowledged that wolves are sensitive to habitat loss and that they do react to human activity but in a variety of ways. The BHP Diamonds Project (now known as Ekati™ mine) predicted that their mine development may have some effect on wildlife such as barren-ground caribou, grizzly bears and wolves but that BHP could mitigate these impacts (BHP Diamonds Inc. 1995a,b). Nevertheless, we rationalized that if wolves are directly impacted by industrial development, it will likely occur during denning. We wanted to get baseline data with which we could compare with future studies and to help in monitoring programs that would be used to assess mitigation efforts.

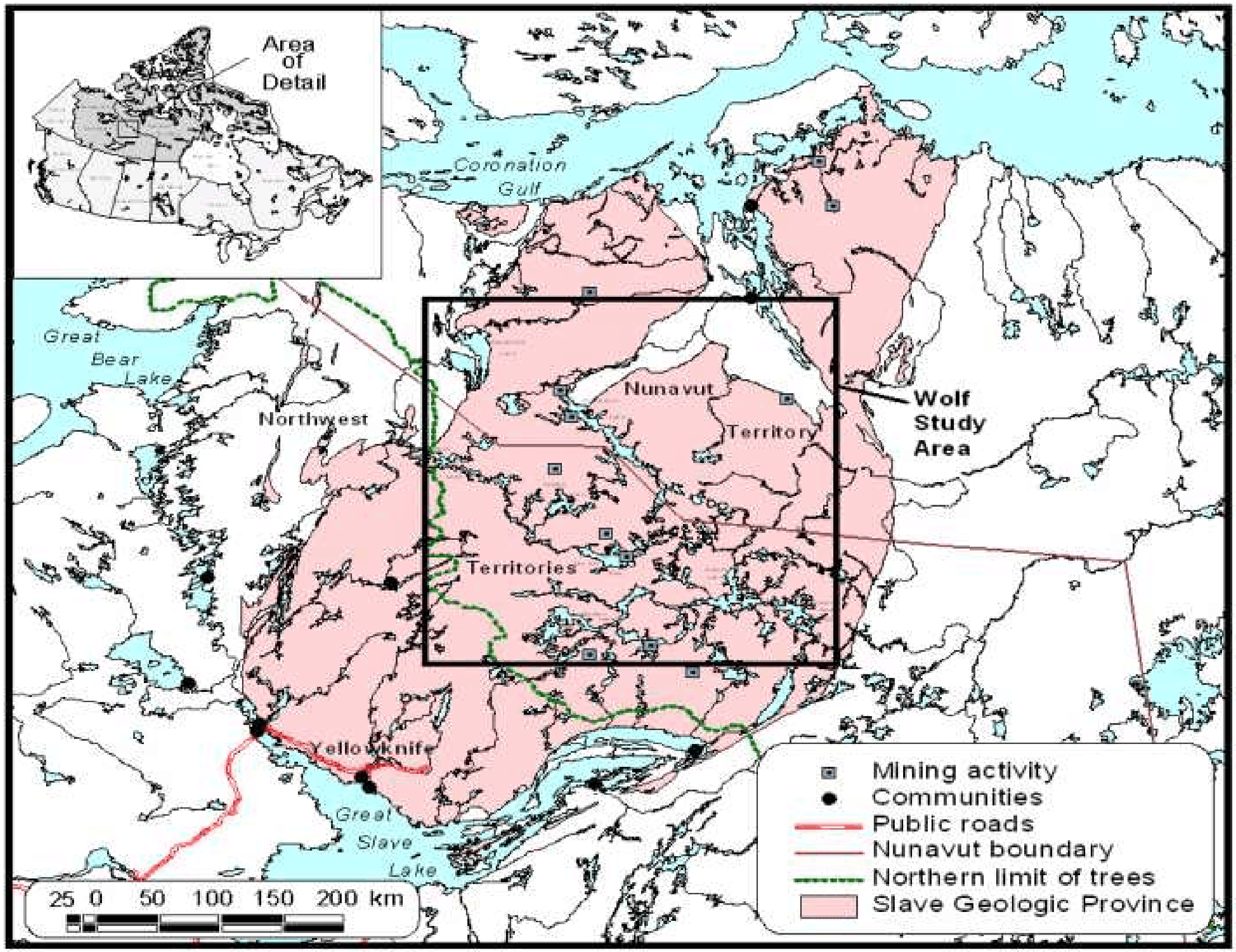
1.1 Study Objectives

This study was conducted to provide baseline information on wolf den site locations and movements of wolves that den on the tundra region of mainland Canada. Our ultimate aim was to identify important habitat areas for wolves that may also be sensitive to economic development.

The original objectives were to:

1. Inventory eskers and other glacial formations in the Slave Geological Province (SGP) for wolf den sites and update the current den site database.
2. Determine the spatial distribution of wolf denning sites within the SGP relative to the distribution of eskers using previously collected data, Traditional Ecological Knowledge (TEK), and new information.
3. Document movements of wolves denning in an area having potential for mining development.
4. Contribute baseline data for a GIS-based Spatial Decision Support System for large carnivores which will resolve or mitigate land use conflicts with wildlife.

Figure 1-1. The wolf study area within the Slave Geological Province, Northwest Territories and Nunavut, Canada.



2.0 DESCRIPTION

2.1 Study Area

The study area included much of the SGP above the treeline but west of Bathurst Inlet. The effective area was about 125,000 km^2 although the wolf capture effort was dispersed over a 30,000 km^2 area and centered around Lac de Gras (64E 27' N. 110E 35' W.). The main study area included Aylmer and Clinton-Colden lakes to the east, Contwoyto Lake to the north, Point Lake and Jolly Lake to the west, and Mackay and Munn lakes to the south (Fig. 1-1, 2.1-1). Although active wolf dens were occasionally located outside of this area, logistics prevented their regular monitoring. The study area straddled the NWT-Nunavut boundary when the new Nunavut territory became official in April 1999.

The regional climate is semi-arid and is characterized by short cool summers and long cold winters. Annual precipitation averages 300 mm, about half of which falls as snow. Summer temperatures average 10E C, with winter temperatures often less than -30E C. (Walton 2000). The study area consists of Low Arctic tundra. Dwarf shrubs such as *Salix* spp., and *Betula glandulosa* occur in drainages and may grow to 2-5 m. Other common shrubs include *Vaccinium uliginosum*, *V. vitis-idaea* and *Empetrum nigrum*, although they rarely reach 0.5 m tall. Heath tundra is common throughout the area. Many lakes occur throughout the area as is characteristic of the rocky upland regions of the Canadian Shield. Topography is gently rolling with numerous rock outcrops and glacial-fluvial features such as eskers, kames, drumlins, and raised beaches. The permafrost layer is discontinuous.

The Bathurst caribou herd, estimated at 349,000 ± 95,000 caribou more than one year of age in 1996 (Williams 1995), migrates annually through the area, leaving the northern boreal forest in April and reaching the calving grounds near Bathurst Inlet by early June. The herd disperses south by late June and reaches tree-line by late fall or early winter. The Beverly herd, estimated at 276,000 caribou (Gunn et al. 1997) and the Ahiak (Queen Maud Gulf) caribou herd at 200,000 individuals (Gunn et al. 2000) also contribute to the caribou presence in the area, but are also migratory (Fig. 2.1-2). Muskoxen (*Ovibos* *moschatus*) occur sporadically in the northern and eastern part of the study area. Other potential prey include the Arctic hare (*Lepus arcticus*), Arctic ground squirrel (*Spermophilus parryii*), lemmings (e.g., *Lemmus sibiricus*, *Dicrostonyx torquatus*), voles (e.g., *Microtus oeconomus*, *Clethrionymus rutilus, Synaptomys borealis*) and other small mammals (Sly et al. 1999). The barren-ground grizzly bear (*Ursus arctos*) is the only other large terrestrial predator on the tundra. Wolverine (*Gulo gulo*) and foxes (*Vulpes vulpes* and *Alopex alopex*) are also present.

This study focussed on areas where the potential for mine development appeared greatest. However, we extended beyond this area to inventory other esker systems and monitor wolves in areas likely receiving little or no economic activity. Consequently, the study area included much of the southern tundra portion of the SGP.

2.2 Wolf Den Site Database

Since 1972, the Government of the Northwest Territories (GNWT) has maintained a database of wolf den sites in the Northwest Territories (and much of the area now known as Nunavut). Former Departmental biologists Doug Heard and Mark Williams managed the database with sightings from many individuals. Most of these den sites were located incidentally while conducting caribou surveys or wolf studies. Other researchers, outfitters, and individuals also contributing sightings. The GNWT Caribou Project retained the database when D. Heard and M. Williams left the north by the mid-1990s. We were given control of the database soon thereafter because we were engaged in wolf studies involving dens.

The database records the latitude and longitude of reported den sites in the north, the year the den was active, its physical description, and the number of wolves seen. The source and reliability of the information is also given. All the locations are in degrees and minutes. The minutes are given only as integers presumably because locations were determined by plotting sightings on map sheets. Global Positioning System (GPS) satellites and receivers were either not available then or still prohibitively expensive and bulky. Consequently, the precision of the den sites vary given that the error in the co-ordinates could be at least one minute each in latitude and longitude. At these latitudes, the combined error in latitude and longitude could be about 1.5 km^2. This amount of error could be significant if one visits the area while the den site is inactive.

The database originally existed as a flat-file database, meaning that there was much redundancy as the status of a den site was updated because some information was repeated, or empty fields were carried forward. We believed that a relational database structure would improve the efficiency of database, especially in data entry, searching, and file size. The relational format follows the analogy of a 'customer' database linked with a customer's orders. The parent table provides all the relevant information about the site in terms of documenting its location. The second, or 'child', table documents the activity recorded at a given site.

We exported the records into dBase® (DBF file format) from SAS® (Statistics for the Applied Sciences) and re-organized the data into two tables, one for the den site itself (WOLFDENS.DBF), and the other for the status of the den at any given time (WDSTATUS.DBF). We used a unique alphanumeric identification code for each den site listed in the WOLFDENS table and entered all the relevant information about the site location and description. The alphanumeric identification code was based on the 1:250,000 NTS (National Topographic System) map sheet where the den occurred and consecutively numbered with a 3-digit integer thereafter. We thought this method would be the most appropriate because one need not know the number sequences for den sites elsewhere in the NWT or Nunavut, as was done previously. Rather, one need only consult the applicable NTS map sheet of den sites and maintain a count of those. This den site identification format also gives some information about the den location.

The wolf den site database was revised from its older format, but some errors may have been introduced by misinterpreting the data while doing so. While we were careful not to do this, we could not be certain. A copy of the database was sent to Nunavut planners to integrate this information in a GIS database which can then be compared to the distribution of eskers. The database is also included in the Databases for Environmental Analysis registry maintained by the National Accounts and Environment Division of Statistics Canada in Ottawa. The database has since been imported to a Microsoft® Access® database and a number of entry, query, and report forms have been created.

Each of the two dBase® files (*.DBF) made use of memo fields and thus each has an associated memo file (*.DBT). Memo fields are variable length fields and therefore avoid the problems of (1) wasted space or (2) not enough space for comments with a fixed length format.

We revisited many of these den sites to update their co-ordinates and determine their activity status. Some dens sites we could not find, or more often, we found a den that we thought could be the same one. Given the disparity in the old and updated co-ordinates we could not always confirm that we found the den as originally identified in the database.

2.3 Esker Inventory

Fieldwork was restricted to the inventory of eskers with the intent of locating den sites of large carnivores, primarily wolves. The inventory was assisted by combining search effort with other studies and revisiting previous den sites listed in a wolf den database (Fig. 2.3-1). Combining logistics with other projects such as the Grizzly Bear Project and the Esker Habitat Study facilitated searching for and monitoring active wolf dens.

We took advantage of our participation with the barren-ground Grizzly Bear Project to record our flight path while we searched for bears (Fig. 2.3-2). We recorded all sightings of wolves. While we flew by some eskers during these flights for bears, much of our search effort included off-esker areas. This allowed us the possibility to see if some wolves may have denned in habitat other than eskers.

2.4 Seasonal Movement of Radio-collared Wolves

Movement patterns of gray wolves (*Canis lupus*) have been studied in much of their current range in North America (Ballard et al. 1997, Fritts and Mech 1981, Messier 1985a). Most studies were of territorial wolves that prey on ungulates including deer (*Odocoileus*), elk (*Cervus elaphus*), moose (*Alces alces*), and sheep (*Ovis*). Although some of these ungulates may undergo seasonal migrations, they are of lesser magnitude than the migrations of barren-ground caribou (*Rangifer tarandus groenlandicus*). Consequently, most studies have concluded that wolves maintain relatively stable annual territories.

In the Northwest Territories, Nunavut, Yukon Territory, Alaska, and northern Quebec, caribou herds are not sedentary but migrate between the boreal forest where they winter to calving grounds on the tundra (Hemming 1971, Kelsall 1968, Messier et al. 1988). In many of these northern habitats, caribou are the only ungulates that occur at densities sufficient to support wolves, so wolves occupying these areas prey primarily on caribou (Kuyt 1972, Stephenson and James 1982). Wolves associated with these herds are not thought to be territorial but move seasonally with the caribou. However, from parturition (mid to late May) until pups can travel with the adults (September to October), movements of wolves are restricted to the area near their den sites. Furthermore, most wolves den near tree-line and do not follow caribou to their calving grounds (Heard and Williams 1992, Kuyt 1972, Parker 1973). Thus, during the denning period and when least mobile, wolves may be forced to search large areas for prey. Little information is available on the movement patterns of wolves inhabiting ranges of migratory caribou herds (Ballard et al. 1997, Kuyt 1962). Spurred by the recent discovery and development of a diamond-resource industry, we used satellite-tracking methods to collect information on annual and seasonal movements of wolves associated with the largest contiguous wilderness area on the continent.

2.4.1 Wolf captures

Wolves were captured in the summers of 1997, 1998, and 1999 to mark and radio-collar wolves at den sites. Deployment of satellite radio-collars (Telonics Inc., Mesa, Arizona, USA) occurred in 1997 and 1998 but conventional VHF (very high frequency) radio-collars (Telonics Inc., Mesa, Arizona, USA) were deployed in all three capture sessions. Conventional radio-collars were used to facilitate monitoring mated pairs. We attempted to place a satellite collar on one breeding adult in each captured pack while its mate would be fitted with a VHF collar. Although satellite collars were deployed on both sexes, breeding females were prioritized. While we wanted to track the movements of both sexes, we chose to deploy more satellite collars on breeding females because we thought it would best reveal den site location, especially if a den site was subsequently moved.

We located denning wolves for capture in early June with a small fixed-wing aircraft teamed with an experienced pilot and observer. Once located, wolves were captured with net-guns launched from a Hughes 500D helicopter (Helicopter Wildlife Management Inc., Salt Lake City, Utah, USA, and Great Slave Helicopters, Yellowknife, NT, Canada), and immobilized with a hand injection of Zoletil® or Telazol® at a dosage of 10 mg/kg (e.g., Ballard et al. 1991). If a wolf eluded capture via nets, an immobilizing dart (Palmer Cap-Chur Equipment Inc., Douglasville, Georgia, USA) was used. The capture process was approved by a University of Saskatchewan animal care committee (Protocol number 980031).

Each immobilized wolf was sexed, weighed, measured, ear-tagged and tattooed on the left and right buccal margins of the upper lip. The ear-tag and lip-tattoo contained a unique identifying number to which the wolf was subsequently referred. The identifying number consisted of an uppercase “W” signifying “wolf” followed by a 3 digit number. A lower-case “m” or “f” was added afterwards (in print) to identify the wolf's gender as male or female, respectively. Ear-tags were placed in both ears of all wolves captured in 1997 but we later decided this was unnecessary and we then ear-tagged only one ear in

1998 and 1999 to reduce possible infection in the ears. We ear-tagged the right ear for females and the left ear for males. Blood samples were taken to determine the prevalence of parasites and disease and also for genetic (DNA) analysis. Wolves were aged as adults, yearlings and 2-year-olds based on tooth wear and condition. We selected breeding females by the development of mammary glands, however a more subjective method had to be used on males (i.e., body size and condition) relative to other wolves within the pack. Thus, compared with females, we are less certain whether all males collared were dominant.

Satellite radio-collars were removed after one year because battery failure afterward was imminent. Transmission duty cycles of these collars were optimized to maximize locations (Service Argos Inc., Landover, Maryland, USA) during the denning period but still allow for recovery the following year. Wolves were often re-fitted with a VHF collar when the satellite collar was removed to extend monitoring. Conventional radio-collars have not been removed because their operational life is expected to be at least five years.

2.4.2 Monitoring radio-collared wolves.--Two different models of satellite collars were deployed on wolves (ST-10 and ST-14, Walton et al. 2001). All collars contained a conventional VHF (very high frequency) transmitter to permit aerial locations. Both collar types were programmed to operate for one year and transmit more frequently during summer than winter. The collars had a 7-hour transmitting period set for the time of day when satellite overpasses occurred most frequently (Burger 1995, Fancy et al. 1988). The interval between transmitting periods differed between collar types due to the lower power demand of the ST-10 collars. In summer 1997, the ST-14 collars had a transmitting period every 48 hours during the first 83 days, whereas ST-10 collars had a transmitting period every 24 hours during the first 97 days post-deployment. Following that, transmission periods occurred every 14 days for the ST-14 collar and every five days for the ST-10 collars. In early May 1998, both collar types deployed in 1997 reverted to their original duty cycles until they were removed (early June 1998). In 1998, only ST-10 collars were deployed, and they had one transmitting period every 24 hours for the first 122 days post-deployment, changing to one period every four days in winter, before reverting to the original duty cycle in early May 1999.

Locations for all satellite collars were obtained monthly from Service Argos Inc. (Landover, Maryland). Wolves were also located with small fixed-wing aircraft or helicopters occasionally throughout summer and autumn to document use of den sites. Because only one pack received more than one satellite collar, we used data from only one satellite-collared wolf/pack for the following analyses. Therefore, reported estimates of range size for each individual wolf are not synonymous with pack territory sizes. We considered each wolf-year to be independent and, therefore, included range sizes for two wolves we tracked during both years. Data on all other wolves spanned only one year. Locations received from Service Argos Inc. were used in analyses if they were of location class 1 or better (ca. #1 km accuracy --- Argos 1996, cf. Ballard et al. 1995, Keating et al. 1991).

2.4.3 Home range size and excursions.--For each wolf, size of annual ranges were estimated from collar deployment (early June) to 31 May the following year. Summer was defined as the period from arrival at the denning area until departure from the summer range in autumn. Winter included locations from the time of departure from the summer range until the wolf returned to a denning area the following spring. We estimated time of departure from the summer range as the mid-date between the last location known to be within the summer range and the first date in which the wolf had moved more than 50 km from the den site (and did not return to the denning area until the following year). We assessed precision of this method by plotting distance from the den for each location throughout the year and chose the mid-date between the two locations in which there was a distinct departure from the den site. In all situations, mid-dates were similar. Timing of return to the summer range was estimated by taking the mid-date from the first location less than 50 km from that year's den site (arrival) and in which the individual continued to show fidelity to the den site, to the last location more than 50 km (departure). In early May, the duty cycle program in the satellite collars helped us refine arrival times when we plotted the daily movements of wolves returning to their spring denning areas.

Annual and seasonal range sizes were calculated using the minimum-convex polygon method (MCP), modified to include 95% of the points closest to the median location for each wolf (Tracker, Version 1.1, Radio Location Systems AB, Huddinge, Sweden; Hovey, F. 1999, The Home Ranger, Version 1.5, Ursus Software, Revelstoke, British Columbia, Canada) and the 95% fixed kernel method (Worton 1989) using least squares cross validation to estimate the smoothing parameter (Hooge et al.1999). The fixed kernel method was considered less biased and more accurate than the adaptive kernel method (Seaman and Powell 1996, Seaman et al. 1999). We selected the best quality locations from each transmission period that were more than 18 hours apart to include in the analyses. Locations obtained over 18 hours apart were considered independent because wolves can move large distances and could potentially move anywhere within the seasonal home range in 18 hours. For example, during summer, we documented one satellite-collared female that moved 92 km in less than 22 hours.

Many investigators suggest that 30-120 locations are necessary to adequately describe annual territory sizes of wolves (Ballard et al. 1998, Carbyn 1983, Messier 1985a). Furthermore, when using kernel methods, more than 50 locations are preferred (Seaman et al. 1999). Using a subsample of wolves (n = 8), we plotted summer range size (95% MCP) versus sample size and found that it required 25-27 locations to reach an asymptote. Because we were only describing range sizes and not defining a territory, we selected all wolves for which we had 28 locations or more.

Excursion movements were observed during a short period during summer. We defined an excursion as any location that was more than 10 km from the 95% MCP boundary. The approximate duration of those excursions was calculated from the mid-date between the last location within the boundary and the first location over 10 km outside the boundary to the mid-date of the last location of the excursion and the first location in which the wolf had moved back inside the boundary. Duration of an excursion was only calculated for trips when there was a pre- and post excursion location less than 5 days (Messier 1985b). The average straight-line distance for each excursion was calculated by determining the distance between each excursion location and the closest segment of the home range boundary and then calculating the mean distance for those locations.

We compared home range size, excursions and winter migration distances between years and sexes using 2-way analyses of variance (Sokal and Rohlf 1995). The logarithmic transformation was used when unequal variances among groups was detected. We compared range size estimates from the two home range estimators (MCP vs fixed kernel) for each wolf with the paired t-test when groups were pooled. Circular statistics were used to calculate mean direction of travel for all excursions (Batschelet 1981). All statistical tests were 2-tailed, and *P*-values #0.05 were considered significant. Values are reported as mean ± *SE*.

2.5 Hierarchical Habitat Use By Tundra Wolves

Large carnivores are vulnerable to human disturbance, habitat alteration and exploitation (Paquet and Hackman 1995, Clark et al. 1996). One of the largest threats to the long-term persistence of wolves (*Canis lupus*) is the presence of humans and their associated activity (Hummel and Pettigrew 1991, Woodroffe 2000). Wolves tend to avoid human settlements (Thurber et al. 1994), and exploiting prey near clusters of human habitation and development (Paquet 1993). Human colonization, settlement, large-scale industrial development, and population growth and immigration have led to the reduction or extirpation of wolves throughout most of their southern North American range (Mech 1995, Clark et al. 1996). Historically, direct persecution of wolves has been an important limiting factor for this species (Paquet and Hackman 1995). Currently, human related mortality is still the leading cause of mortality in many populations of wolves (Fuller 1989, Boyd and Pletscher 1999, Larivière et al. 2000).

Wolves occupying Canada's central Arctic (Fig. 2.3-1) are threatened by exploration and development of a growing diamond resource. Wolves in this area are migratory and follow the Bathurst caribou herd (*Rangifer tarandus groenlandicus*) for most of the year (Walton et al. 2001a). However, the mining area is also the region where these migratory wolves den and raise their young (May-September). Because wolves are sensitive to human disturbance near active den sites (Weaver et al. 1996), the potential impacts to wolves by continued development is of concern.

The rocky terrain and permafrost of the tundra shield region may limit the availability of suitable denning habitats (Mech and Packard 1990). Wolves in the area are thought to den on glacial-fluvial habitats such as eskers (Heard and Williams 1982, Mueller 1995). As industrial development in the region proceeds, eskers will become an important source of granular material for road and mine construction. Because eskers make up only about 1-2% of the tundra landscape, a potential conflict may occur. As natural resource extraction accelerates in these northern regions, determining specific habitat requirements for wolves during the denning period will be important for the conservation of wolves in the area. In this chapter, we examine the habitat use patterns of a previously unstudied population of wolves inhabiting Canada's central Arctic. We adopt the use-availability design method although we are aware of recent controversies regarding the assumptions inherent in these and other habitat evaluation methods (Garshelis 2000). We assess habitat use during the wolf denning period at two scales, using Johnson's (1980) second and third orders of selection.

At the second order of selection we compare the availability of habitat types in the summer ranges of study animals with the availability of habitat types in the entire study area (Roy and Dorrance 1985, Thomas and Taylor 1990). At the third order of selection we compare the proportional use of habitat types determined from satellite telemetry locations with the availability of habitat types within the summer ranges of study animals. Here, buffers around individual telemetry locations are used to determine proportional use of habitat types (Rettie and McLoughlin 1999, McLoughlin 2000, Rettie and Messier 2000).

We based our analysis on the barren-grounds of the central Canadian Arctic, 300 km northeast of Yellowknife, Northwest Territories (Fig. 1-1). The region has recently been the site of intense exploration and mining activity largely associated with the diamond industry.

2.5.1 Capture and monitoring – In early June of 1997 and 1998, wolves were located for capture using a small fixed-wing aircraft. Once located, wolves were captured from a helicopter using net-guns (Helicopter Wildlife Management Inc., Salt Lake City, UT), and immobilized with a hand injection of Telazol® (10mg/kg - Ballard et al. 1991). The capture process was approved by a University of Saskatchewan animal care committee (Protocol No. 980031). Standard measurements and body weight were determined for each immobilized wolf. Gender was determined and a unique identifying number was applied using ear-tags and a tattoo applied on the left and right buccal margins of the upper lip. We attempted to place a satellite collar (UHF) on one breeding adult in each pack handled. Collars were manufactured by Telonics Inc. (Mesa, AZ). We distinguished breeding females from others by development of their mammary glands, specifically showing current lactation. We fitted satellite collars to these females and assumed them to be the breeding females in their pack. Males that received satellite collars, however, were selected on large size and better body condition relative to other captured males within the pack. Thus, compared with females, we were less certain whether all males collared were breeding males.

Two different models of satellite collars were deployed, the ST-10 and the ST-14 (Walton et al. 2001b). Locations for all of the satellite collars were obtained from Service Argos Inc. at the end of each month. We considered each wolf-year to be independent and, therefore, included data from two wolves during both years. Data on all other wolves only spanned one year.

2.5.2 Habitat maps – A combination of three LANDSAT Thematic Mapper (TM) scenes (ca. 75,000 km^2) classified by the Northwest Territories Centre for Remote Sensing were used to determine the availability of habitat types to wolves in the study area (Fig. 2.5-1, Epp and Matthews 1998). A complete accuracy assessment was not available at this time but will be soon after the vegetation classification study is completes later in 2001 (Epp and Matthews 2000). However, preliminary accuracy assessments suggest that there is confusion between some of the classes. Therefore, refinement of either the classification process or the identification of training areas is needed (Epp and Matthews 2000).

Twelve discrete habitat types excluding water and ice are represented in the maps (Table 2.5-1), including: esker habitat, wetlands, tussock/hummock successional tundra, lichen veneer, spruce forest, boulder fields, exposed bedrock, riparian tall shrub areas, birch seep, typical heath tundra, heath tundra with >30% boulder content, and heath tundra with >30% bedrock content (Epp and Matthews 1998). All spatial analyses described herein were conducted using SPANS® Explorer™ 7.0 (Tydac Research Inc., Nepean, Ontario, Canada).

2.5.3 Second order selection – Analysis of second order selection patterns (Johnson 1980) followed Manly et al. (1993) and considered the study area as what was available habitat and each summer range as the habitat area actually used by our study animals. We estimated summer ranges for wolves using the 95% minimum convex polygon method (Tracker, Version 1.1, Camponotus AB, Sweden). The summer season was defined as the period from arrival to the denning area (late April/early May) until the departure from the summer range in the fall (late October/early November, Walton et al. 2001a). Radio locations used in calculating summer ranges were a minimum of 18 hours apart, and included locations only of Service Argos classes 1, 2, and 3 (ca. < 1 km accuracy – Argos, 1996, see also Keating et al. 1991, Ballard et al. 1995).

For both habitat availability and use we divided the area of each of the 12 habitat types by the total study area. The resulting sets of used and available habitat ratios, which always totaled 1.0, were used to calculate a resource selection index for each habitat type for each wolf (Manly et al. 1993). The resource selection function (the set of b_i's, the standardized resource selection indices; Manly et al. 1993) for an individual wolf was considered the basic datum for subsequent statistical analyses.

2.5.4 Third order selection – For analysis of third order selection patterns (Johnson 1980), the proportional availability of habitats used by an animal was compared with the proportional availability of habitats contained in the 95% summer range of that animal. We defined habitat use as the contents of a circle 2.0 km in radius, centered on a telemetry location (Rettie and McLoughlin 1999, McLoughlin 2000, Rettie and Messier 2000). For both use and availability we divided the area of each habitat type within a buffer by the total area of the buffer. The resulting sets of used or available habitat ratios totalled 1.0 for each telemetry location. Data were processed with a program written in C^{++} to determine the resource selection probability function (RSPF, the set of H resource selection indices (b_i) where i = 1 to H and H is the number of habitat types). The RSPF for a single animal summer was considered the basic datum for subsequent analyses at the third order of selection.

2.5.5 Statistical analysis – Friedman's non-parametric two-way analysis of variance (Zar 1999) was used to compare differences in the bi-values for each habitat type used by wolves at each level of selection. All post-hoc multiple comparisons were conducted using the Student-Newman-Keuls procedure (Zar 1999). An experiment-wise alpha value of 0.05 was used to test for significance in all tests.

2.6 Graduate Student

Mr. Lyle Walton became affiliated with the Esker-Wolf Project soon after the project got underway. Mr. Walton began his graduate studies with course work at the University of Saskatchewan in Saskatoon in 1996. His field work began in the spring of 1997 when he participated in the wolf capture effort. Mr. Walton also assisted in community meetings that we held during the winter. While we informed and updated communities with our research at this time, we had also hoped to identify individuals who were interested in assisting us observe and record wolf behaviour at den sites during the summer.

Table 2.5-1. Land habitat types identified in the three LANDSAT TM images by the NWT Centre for Remote Sensing and used in the analysis of habitat selection by wolves (adapted from Epp and Matthews 1998).

Lichen Veneer	This ecosystem unit characterizes areas covered with continuous mats of lichen that appears as a "veneer". These sites are windswept and dry, allowing for little other plant growth. Lichen veneer consists mainly of Iceland moss, several species of *Certraria*, green and black hair lichens, grey mealy lichen, worm lichens, and others. Saxifrages and heath plants become more common in sites where growing conditions are more favourable.
Esker Complex	Esker complexes include all communities occurring on esker landforms. Esker tops are usually sparsely vegetated; common species include three-toothed saxifrage and moss-campion with lesser amounts of crowberry and bearberry. Lee slopes support bands of dwarf birch and willow that may reach heights of 1 m.
Wetland	This ecosystem unit is made up of sedge meadows, and occasionally sedge fens and emergent plant communities.
Tussock/Hummock	This ecosystem unit occurs on moist to sub-hygric lower slopes and depressions where tussocks (and hummocks) form. Tussocks are composed primarily of mounds of sheathed cotton-grass; later stage hummocks are typified by dwarf birch. Labrador tea, cloudberry, and Labrador lousewort are also common.
Heath Tundra	This ecosystem unit delineates the typical mesic tundra habitat. Boulder and bedrock content is below 30%. Vegetation is dominated by a well-developed mat of low shrubs including dwarf birch, Arctic willow, northern Labrador teat, crowberry, cranberry, black and read bearberry, and blueberry. Herb and moss layers are not well developed.
Heath Boulder	Heath tundra in which boulder content ranges from 30-80% coverage.
Heath Bedrock	Heath tundra in which exposed bedrock content ranges from 30-80% coverage.
Spruce Forest	Localized to the southern part of the study area, where the transition between boreal forest and tundra is more pronounced. Species include white spruce, jack pine, and white birch. Where

	conditions re more favourable, spruce-lichen woodlands exits.
Tall Shrub Riparian	This ecosystem unit occurs in active stream channels on fluvial veneers of fine-textured materials overlying boulders. The productive soil medium and constant availability of flowing water supports a tall shrub community (up to 4 m in height) of dwarf birch, diamond-leafed willow, green alder, and occasionally white or black spruce (in southern portions of the study area). The herb layer is also well developed with bluejoint, dwarf raspberry, dwarf march-violet, and horsetail as common species.
Birch seep	This ecosystem unit occurs in areas of active seepage through boulder fields. Typical vegetation is relatively well-developed dwarf birch (1 to 3 m tall) with a herb layer of bluejoint. Fine-textured fluvial deposits may occur in boulder crevices but rooting is primarily in the flowing water.
Bedrock Field	Exposed bedrock with a coverage in excess of 80%.
Boulder Field	Boulder fields with a coverage in excess of 80%. Boulders support a community of rock lichens of *Umbicullaria* and other species.

Figure 2.1-1. Esker-Wolf study area north of Great Slave Lake, Canada.

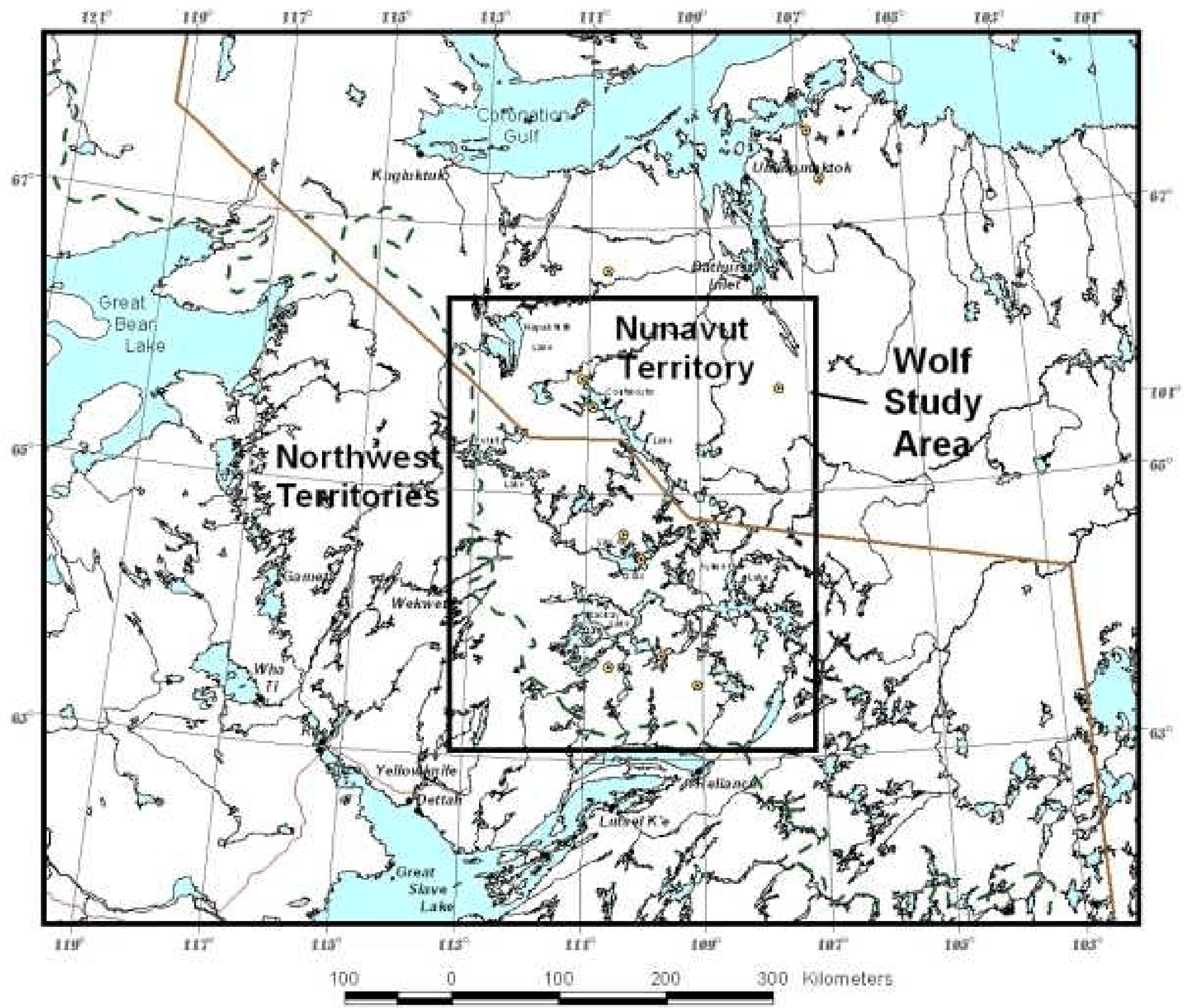


Figure 2.1-2. Barren-ground caribou herds on Canada's mainland that encompass the Esker-Wolf Project study area.

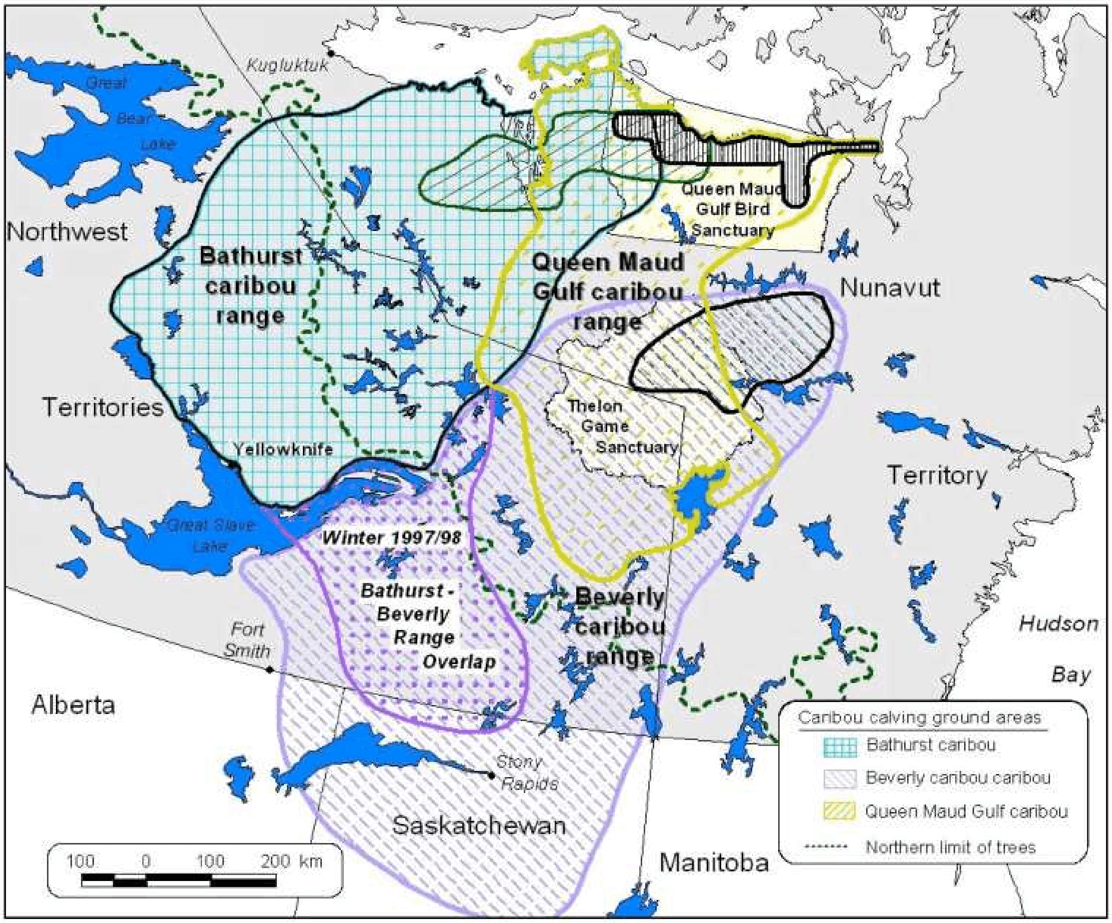


Figure 2.3-1. Wolf study area showing the distribution of eskers (NTS 1:250,000) and current mines and advanced exploration activity. The wolf den sites recorded in a database maintained by the Government of the Northwest Territories are also shown for the mapped area.

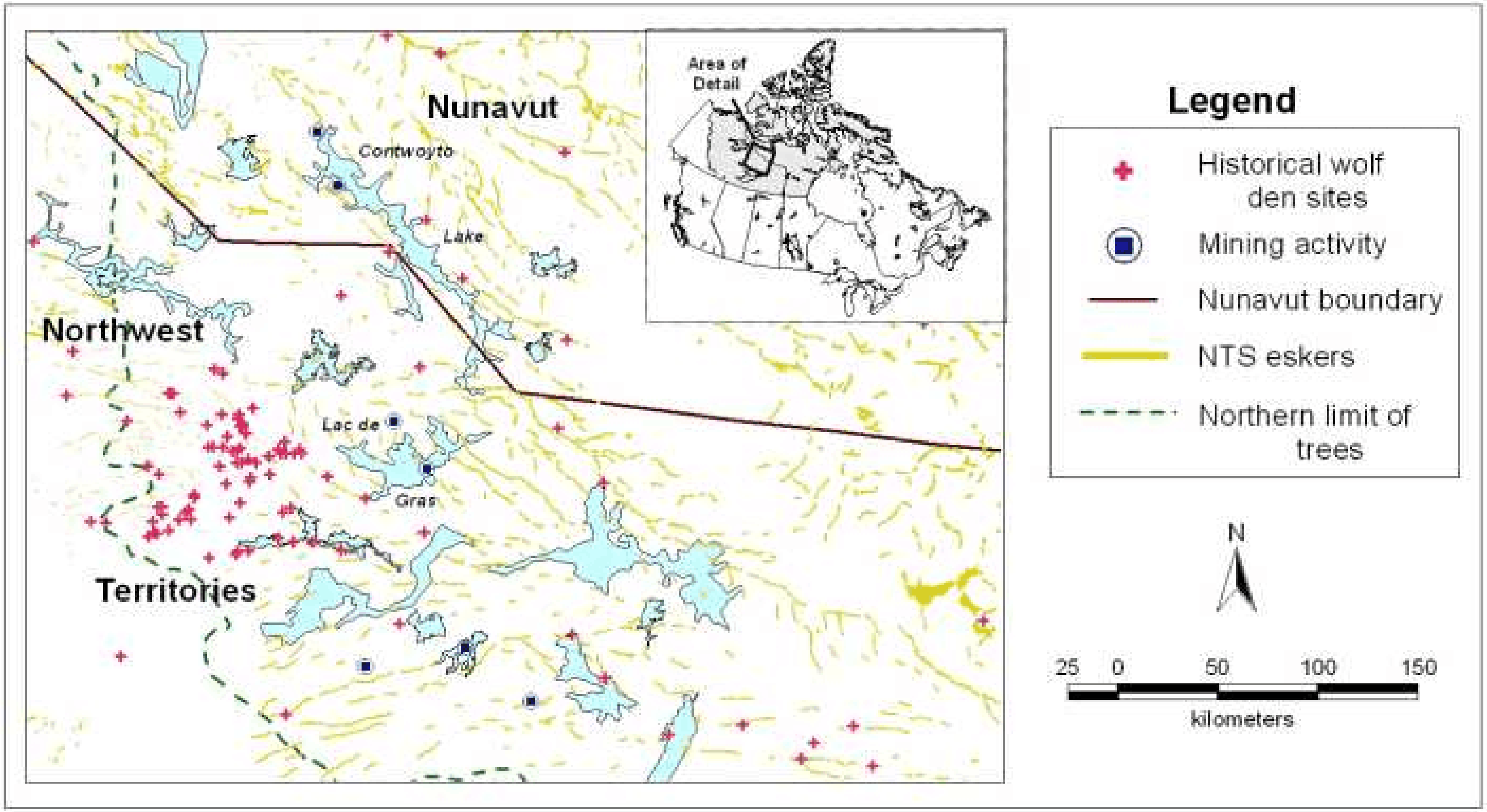


Figure 2.3-2. Flight line coverage taken in 1996 and 1998 in the study area while searching for wolves and grizzly bears. Flight lines were on and off esker habitat.

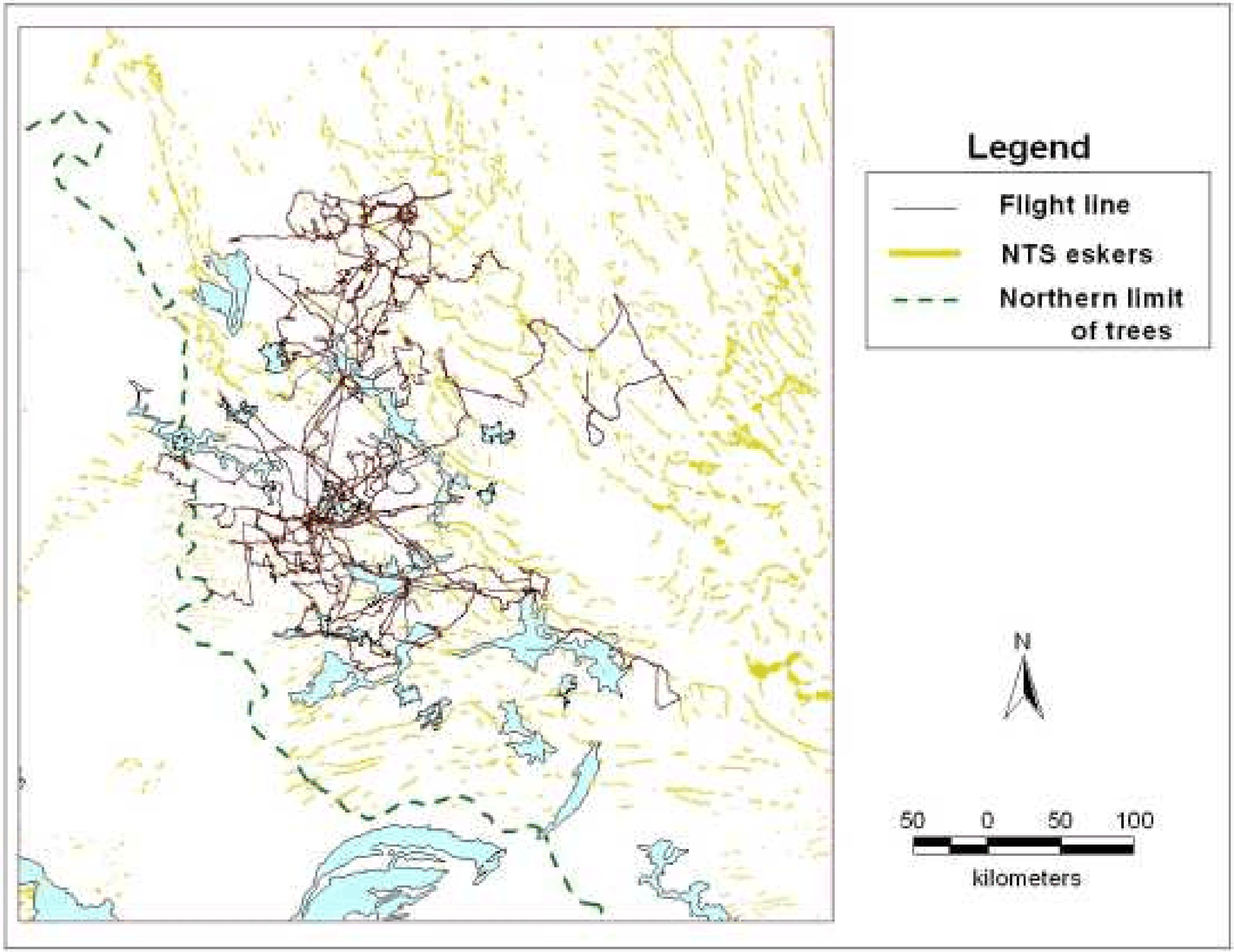
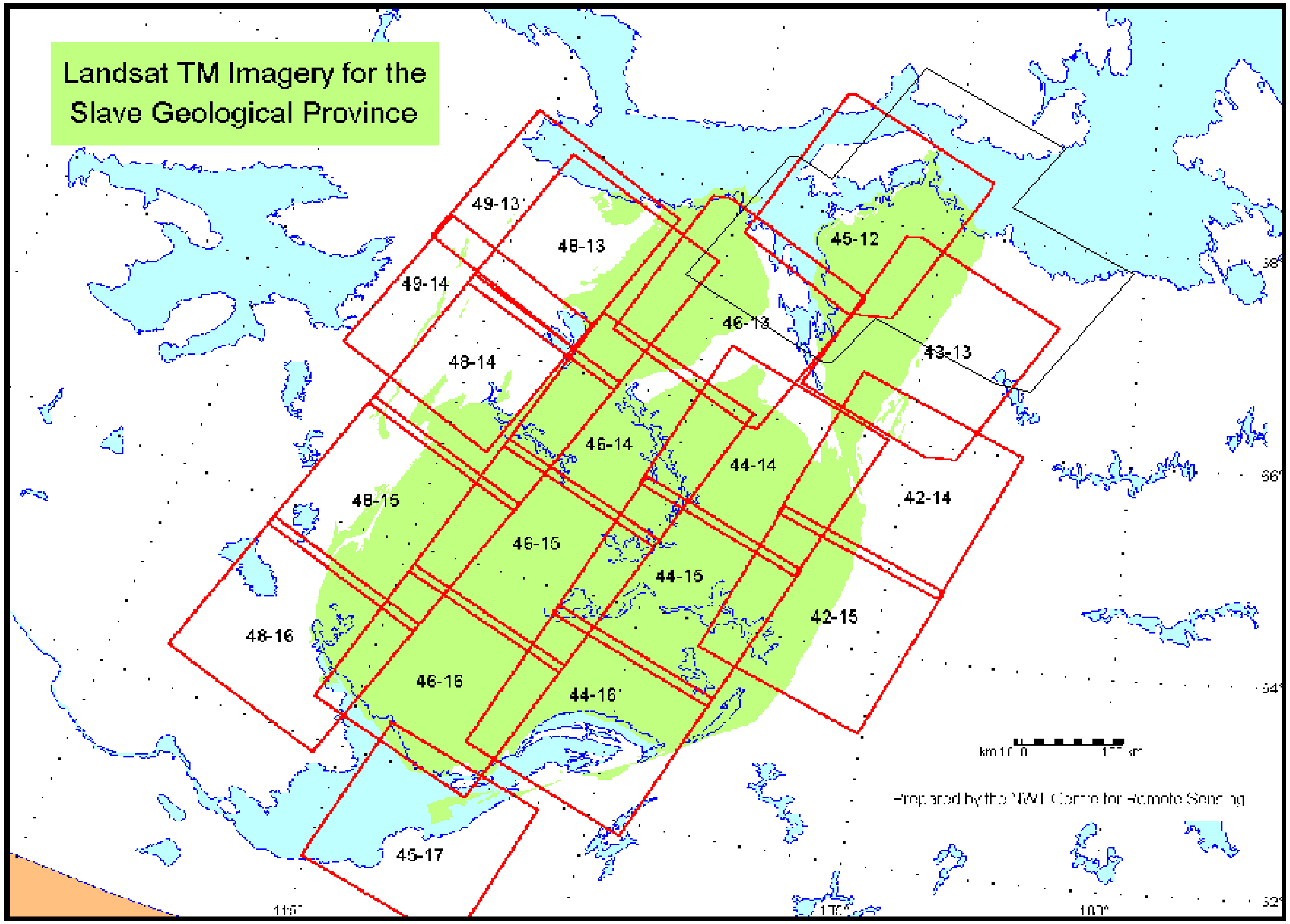


Figure 2.5-1. Landsat Thematic Mapper (TM) imagery used to classify habitat in the Slave Geological Province, Northwest Territories and Nunavut. Images used were scenes 46-14, 46-14, and the Lac de Gras regions of 46-15 and 44-15.



3.0 ACTIVITIES FOR THE YEAR

A search for wolf dens in the Slave Geological Province began in May 1996 and continued each year thereafter in late May or early June. We were in the field in May assisting with grizzly bear capture efforts and this provided an opportunity to inventory esker habitat and search these areas for wolf dens and record sightings of wolves. Wolf captures occurred in mid-June to avoid impacting newborn pups in May. Remote den site observations occurred in July and August whenever logistics allowed. Radio-tracking flights occurred during the den site reconnaissance effort in June, early August, and late March. Occasionally, a fall flight was conducted when funding allowed.

4.0 RESULTS

4.1 Wolf Den Database

The WOLFDENS.DBF (Table 4.1-1) contains the unique identity of each known wolf den site location. The WDSTATUS.DBF table (Table 4.1-2) contains specific information about when wolf activity was observed at the site, whether it was active, and the number of adults or pups that were observed. It was linked to the WOLFDENS.DBF table by the same alphanumeric identification code used there. Consequently, the den site description is not repeated when another year of activity data for a den site was entered, as was the case in the flat-file system. Rather, only the identification code is required. The total number of den sites listed in the revised database is 372, down from 390 in the original file. This is because we deleted those entries without a location (i.e., latitude and longitude).

Table 4.1-1. Parent table structure for WOLFDENS.DBF of the revised wolf den site database maintained by the Government of the Northwest Territories since 1972. This table records data on the den site location and physical description.

Field	Field Name	Data Type	Field Length	Decimals	Index
1	Den	Character	7		Y
2	Lat	Character	8		N
3	Long	Character	9		N
4	GPS	Character	3		N
5	dLat	Numeric	6	3	N
6	dLong	Numeric	7	3	N
7	Discovered	Character	11		N
8	Reliab	Character	1		N
9	Source	Memo	10		N
10	Description	Memo	10		N
11	Map	Character	4		N
12	Datum	Character	15		N
13	Photo	Character	1		N

Table 4.1-2. Child table structure for WDSTATUS.DBF of the revised wolf den site database maintained by Government of the Northwest Territories since 1972. This table records data on the wolf activity at a specific den site.

Field	Field Name	Data Type	Field Length	Decimals	Index
1	Den	Character	7		N
2	Lat	Character	8		N
3	Long	Character	9		N
4	Date	Character	11		N
5	Discovered	Character	11		N
6	YRactive	Memo	10		N
7	Active	Character	10		N
8	Notes	Memo	10		N
9	Reliab	Character	1		N
10	Confirm	Character	3		N
11	Prec	Character	1		N
12	BGCR	Character	1		N
13	Observer	Memo	10		N

4.2 Esker Inventory

During the spring and summers of 1996 to 2000, sightings of wolves varied from 8, 17, 11, 2, and 9 (Table 4.2-1). Although no den sites were observed in these cases, some could be nearby. Locations where pups were observed could either be rendezvous sites or near an unknown den site. From May to August 1996, 27 active wolf dens were found (Table 4.2-2). Some of these may have been from wolves abandoning one den for another. We could not distinguish individuals that year because none were uniquely marked or radio-collared then. All the 27 active wolf dens were found on or near eskers or other glacio-fluvial habitat such as kames. We found no active wolf dens associated with the grizzly bear reconnaissance flights in 1996 and 1998 that were not significantly distant from eskers.

We recorded 21, 18, 16, and 26 active wolf dens in 1997, 1998, 1999, and 2000, respectively (Table 4.2-2). All dens were associated with glacial-fluvial material, likely because it is easy to dig there. However, sometimes the esker material was not extensive. In six instances, active wolf den sites were located in slightly raised mounds of sand and gravel. No clear pattern was evident for these dens essentially “off-esker”. One of these dens was discovered in 2000 but had an uncollared wolf present, so we have no history on this. Of the other five dens, three of them were occupied by wolves that had used other dens located on eskers, either in previous years or earlier in a given year. The distribution of these wolf sightings and active wolf den sites from 1996 to 2000 is shown (Fig. 4.2-1).

Table 4.2-1. List of wolf sightings observed during spring and summer 1996 to 2000. Although no den sites were observed in these cases, some could be nearby. Locations where pups were observed could either be rendezvous sites or near an unknown den site.

1996

Location	Latitude	Longitude	Adults	Pups	Date	Source
E of Point L	65E 17.91'	111E 38.59'	2?		36711	D. Cluff
E Kathawachaga L	66E 14.20'	110E 43.47'	2		36711	D. Cluff
E Contwoyto L	65E 45.31'	110E 19.74'	2		36712	D. Cluff
SE Ursula L	64E 46.77'	110E 18.61'	1		36712	D. Cluff
N Kathawachaga L	66E 15.93'	111E 04.08'	1		36713	D. Cluff
W Melville Cr	67E 15.56'	115E 25.91'	1		10 July	D. Cluff
SW Providence L	64E 39.58'	112E 09.89'	1		14 August	D. Cluff
S Contwoyto L	65E 18.28'	109E 45.13'	1		36754	D. Cluff

1997

Location	Latitude	Longitude	Adults	Pups	Date	Source
Burnside River	66E 29'	109E 07'	1		36677	P. McLoughlin
mid Hood River	66E 48.07'	110E 56.30'	2		36679	D. Cluff
George Lake area	65E 59.57'	107E 38.40'	5		36713	D. Cluff
Western River	66E 12.26'	106E 56.28'	5		36713	D. Cluff
NW Lac de Gras	64E35.38'	111E 07.46'	3		36718	L. Walton
SW Lac de Gras	64E 31.69'	111E 13.08'	4		16 July	Walton/Cluff
Jericho portal	65E 59.76'	111E 28.79'	1		36726	L. Walton
George Lake camp	65E 55.42'	107E 26.58'	1		36726	D. Cluff
N Mara River	66E 11.85'	108E 32.66'	2		36726	R. Mulders
Mara River	65E 48.12'	108E 47.05'	4		36727	D. Cluff
NE Mackay L.	64E 10.53'	110E 14.78'	1		36751	Axys Consulting
Misery esker	64E 41.44'	110E 13.92'	3	4	36751	L. Walton
E Contwoyto L	65E 28.47'	109E 49.49'	1		36760	L. Walton
Mackay L. pack	64E 13.99'	109E 59.66'	3	5	36029	L. Walton
near Thonokeid	64E 28.81'	109E 32.44'	1		36029	L. Walton
SW Lac de Gras	64E 29.27'	111E 06.47'	6	1?	36030	L. Walton
Misery esker	64E 41.44'	110E 13.92'	5	1	36030	L. Walton

Table 4.2-1 (continued)

1998

Location	Latitude	Longitude	Adults	Pups	Date	Source
Nose Lake camp	65E 31.05'	109E 19.68'	2		35930	D. Cluff
Contwoyto River	64E 55.20'	108E 19.55'	2		35929	P. McLoughlin
SW Aylmer Lake	64E 00.73'	108E 50.27'	1		35928	P. McLoughlin
Mara River esker	65E 45.44'	108E 40.94'	6		35931	D. Cluff
Western River	66E 15.95'	107E 02.99'	2		35931	P. McLoughlin
NW Wilberforce Falls	67E 09.74'	109E 55.03'	1		35936	P. McLoughlin
NE Mackay Lake	64E 05.31'	110E 04.30'	1		35951	L. Walton
W Jolly Lake	64E 05.28'	112E 13.97'	1		35951	D. Oleson
NC Point L. (DC7)	65E 19.71'	112E 52.81'	1	3+	36018	L. Walton
NE Wilberforce Falls	67E 11.37'	108E 45.71'	1	21 July to 04 August		A. Desjarlais
Ellice River	66E 55.27'	104E 16.84'	4		35943	Mulders/Gau

1999

Location	Latitude	Longitude	Adults	Pups	Date	Source
T-Lake area	64E 24.35'	109E 58.23'	2		36330	M. Musiani
E. Clinton-Colden L.	63E 59.20'	107E 59.72'	W348 +1		36402	D. Cluff

2000

Location	Latitude	Longitude	Adults	Pups	Date	Source
SE Daring L	64E 50.377'	111E 27.352'	1		36675	D. Cluff
NE Lac de Gras	64E 34.013'	110E 20.919'	1		36675	D. Cluff
E Lac du Sauvage	64E 34.870'	110E 05.360'	1		36676	D. Cluff
near esker	64E 34.170'	110E 09.300'	1		36676	R. Mulders
limp - favors leftpaw	64E 38.110'	111E 01.450'	1		36678	R. Mulders
on Daring L. esker	64E 52.030'	111E 35.500'	4		36678	K. Hiscocks
suspected den area	65E 05.191'	109E 50.879'	2		36679	D. Cluff
running	64E 58.089'	109E 42.833'			36679	D. Cluff
previous den area	64E 40.090'	109E 58.450'	1		36677	R. Mulders

Table 4.2-2. List of active wolf den sites observed during spring and summer 1996 to 2000.

Suspected rendezvous sites are not included. Exact locations of wolf den site coordinates have been rounded off in order to protect the wolves. Questions phone Dean Cliff (867) 873-7783.

1996

Den Site	Latitude	Longitude	# Adults	# Pups	Date	Source
86A059	64E **.75'	112E **.03'	3		23 May	R. Case
86A060	64E **.28'	112E **.97'	2	3	23 May	R. Case
75M003	63E **.12'	110E **.47'	2	0	23 May	R. Case
RC4	64E **.28'	112E **.73'	1	1	26 May?	R. Case
	(64E **.19')	(112E **.83')	2	3	14 Aug	D. Cluff
RC5	64E **.88'	112E **.73'	3	0	26 May?	R. Case
RC6	64E **.65'	112E **.17'	1	0	26 May?	R. Case
DC1	65E **.70'	111E **.69'	5	0	26 May	D. Cluff
	(64E **.79')	(111E **.68')	1	0	04 July	D. Cluff
			2	2	14 August	D. Cluff
			1	2	22 August	D. Cluff
unnamed	64E **.28'	110E **.17'	2		29 June	D. Cluff
K1	64E **.00'	110E **.25'			<25 June	D. Penner
K2	64E **.11'	111E **.50'			<25 June	D. Penner
K3	64E **.10'	111E **.38'			<25 June	D. Penner
K4	64E **.25'	109E **.95'			<25 June	D. Penner
K5	64E **.35'	109E **.04'			<25 June	D. Penner
	(64E **.85')	(109E **.41')	1	0	01 July	D. Cluff
K6	64E **.48'	109E **.08'			25 June	D. Penner
DC3	64E **.65'	111E **.56'	2		02 July	D. Cluff
DC2	64E **.63'	111E **.82'	1		03 July	D. Cluff
DC6	64E **.50'	112E **.69'	1		03 July	D. Cluff
DC7	65E **.71'	112E **.81'	1		03 July	D. Cluff
RG1	65E **.33'	110E **.19'	1	0	06 July	R. Gau
DC8	66E **.82'	110E **.21'	2	0	06 July	D. Cluff
RG2	66E **.45'	112E **.89'	1	1	07 July	R. Gau
DC5	66E **.38'	110E **.80'	3		08 July	D. Cluff
DC4	64E **.93'	111E **.03'	4	4	09 August	D. Cluff
			1	2	22 August	D. Cluff
DC9	65E **.56'	109E **.92'	2	4	12 August	D. Cluff
			0	1	30 August	A. McMullen
JL1	65E **.04'	111E **.43'	4	2	14 August	J. Lee
DC10	65E **.64'	111E **.31'	2	4	15 August	D. Cluff
			0	7	22 August	D. Cluff
DC11	65E **.06'	109E **.14'	4	0	17 August	D. Cluff

Table 4.2-2 (continued)

1997

Den Site	Latitude	Longitude	# Adults	# Pups	Date	Source
SE Box Lake	63E **.88'	109E **.41'	1		21 May	D. Cluff
Snap Lake	63E **.22'	110E **.00'	35920		21 May	P. McLoughlin
Thonokeid Lake	64E **.94'	109E **.35'	2		21 May	D. Cluff
	64E **.74'	109E **.21'	4		13 June	Penner/Cluff
	64E **.38'	109E **.65'	5	2	13 August	L. Walton
Starvation Lake	64E **.83'	112E **.19'	1		22 May	D. Cluff
E. Point Lake	65E **.58'	111E **.80'	3		22 May	D. Cluff
	65E **.58'	111E **.80'	6+		12 June	Cluff/Walton
	65E **.92'	111E **.67'	6	3	07 August	L. Walton
	65E **.74'	111E **.24'	5	1	22 August	L. Walton
Daring Lake	64E **.00'	111E **.24'	3		22 May	D. Cluff
	64E **.00'	111E **.24'	3		12 June	Cluff/Walton
	64E **.61'	111E **.44'	4	7	16 July	L. Walton
E. Coronation	68E **.25'	107E **.45'	2		31 May	D. Cluff
	68E **.28'	107E **.66'	1		19 July	D. Cluff
N Hood River	67E **.83'	108E **.35'	2		03 June	D. Cluff
Jericho	66E **.33'	111E **.56'	2		10 June	Cluff/Walton
	66E **.49'	111E **.82'	1		09 August	D. Cluff
E. Lupin	65E **.50'	111E **.56'	2		11 June	D. Cluff
Pelonquin L.	65E **.35'	111E **.63'	4		11 June	Cluff/Walton
	65E **.23'	111E **.26'	2	2	18 July	L. Walton
NW Lac de Gras	64E **.06'	111E **.93'	2		12 June	D. Penner
	64E **.75'	111E **.62'	1	4	14 July	L. Walton
T-Lake	64E **.70'	110E **.50'	2		13 June	D. Penner
	64E **.06'	109E **.02'	1	2	13 August	L. Walton
NE Mackay Lake	64E **.83'	109E **.23'	3		13 June	D. Penner
SW Lac de Gras	64E **.86'	111E **.86'	1		13 June	D. Penner
S Mackay Lake	64E **.38'	110E **.70'	2		09 July	D. Penner
	64E **.74'	110E **.81'	3	3	10 July	L. Walton
	64E **.06'	110E **.68'	3	2	14 August	L. Walton
N. Providence L.	64E **.41'	112E **.37'	1	1	16 July	Cluff/Walton
S. Providence L.	64E **.32'	112E **.09'	1	5	16 July	Cluff/Walton
	64E **.19'	112E **.83'	1		31 July	D. Cluff
Snare River	64E **.68'	112E **.73'	1	2	08 August	Epp/Matthews
E Horseshoe L.	64E **.41'	112E **.37'	2	2	12 August	S. Traynor
Paul Lake	64E **.76'	110E **.59'	3	5	09 Sep	L. Buckland

Table 4.2-2 (continued)

1998

Den Site	Latitude	Longitude	# Adults	# Pups	Date	Source
SW Laverty Lake	63E **.72'	108E **.69'	2		11 June	D. Cluff
Afridi Lake	64E **.45'	109E **.87'	2		09 June	Cluff/Walton
N. Thonokeid Lake	64E **.74'	109E **.21'	3		09 June	Cluff/Walton
	64E **.35'	109E **.73'	1		15 July	D. Cluff
NE Starvation	64E **.86'	112E **.20'	2		10 June	D. Cluff
Ursula esker	64E **.09'	110E **.77'	6		xx May	S. Moore
	(same)	(same)	2		09 June	Cluff/Walton
	(same)	(same)	4		15 July	D. Cluff
	64E **.08'	110E **.91'	2		16 July	D. Cluff
	64E **.13'	110E **.28'	3		29 August	D. Cluff
Daring Lake	64E **.95'	111E **.98'	3		late May	J. Obst
	64E **.03'	111E **.41'	1		12 June	L. Walton
	64E **.19'	111E **.93'	3		09 Sep	D. Cluff
Ghurka Lake	65E **.68'	109E **.52'	7		15 May	D. Cluff
N Yamba Lake	65E **.70'	111E **.69'	2		10 June	Cluff/Walton
E. Lupin	65E **.32'	109E **.74'	1		12 June	L. Walton
W. Pelonquin L.	65E **.06'	111E **.86'	2		10 June	Cluff/Walton
NE Mackay Lake	64E **.74'	110E **.93'	2		12 June	L. Walton
Rocknest Bay (Aylmer Lake)	64E **.71'	108E **.18'	4		11 June	Cluff/Walton
S Mackay Lake	64E **.25'	109E **.95'	2		09 June	L. Walton
E. Hardy L.	64E **.17'	109E **.23'	2		12 June	L. Walton
Clinton-Colden L.	63E **.88'	107E **.12'	3		11 June	D. Cluff
	63E **.82'	107E **.43'	3		29 July	D. Cluff
SE Contwoyto L. -76000	65E **.90'	110E **.25'	1		21 July to 04 August	A. Desjarlais
NE Aylmer L.	64E **.93'	108E **.90'	6		12 June	Walton/Cluff
E Gordon Bay (Bathurst Inlet)	66E **.12'	107E **.06' -exposed pit	2	6	23 May	Mulders/Gau

1999

Den Site	Latitude	Longitude	# Adults	# Pups	Date	Source
NE Starvation	64E **.86'	112E **.20'	3		19 June	M. Musiani
	64E **.86'	112E **.20'	3		23 June	D. Cluff
Eda Lake	64E **.65'	112E **.17'	3		19 June	M. Musiani
	64E **.65'	112E **.17'	3		23 June	D. Cluff
Daring Lake *	64E **.00'	111E **20'			23 June	D. Cluff
N Yamba Lake	65E **.70'	111E **.69'	2	2*		D. Cluff

Table 4.2-2 (continued)

Den Site	Latitude	Longitude	# Adults	# Pups	Date	Source
Sable Lake area	64E **.01'	110E **.07	3		19 June	M. Musiani
	64E **.01'	110E **.07'	4		23 June	D. Cluff
	64E **.01'	110E **.07'	2	5+2	29 Aug	D. Cluff
	64E **.01'	110E **.07'	3	4	30 Aug	D. Cluff
E. Hardy Lake	64E **.17'	109E **.23'	3		24 June	D. Cluff
Ghurka Lake	65E **.68'	109E **.52'	36286		20 June	M. Musiani
W. Pelonquin Lake	65E **.06'	111E **.86'	36222		24 June	D. Cluff
	65E **.06'	111E **.86'	2	4	29 Aug	D. Cluff
Lac du Savage	64E **.01'	109E **.03'	2		20 June	M. Musiani
NW Lac de Gras	64E **.75'	111E **.62'	0		19 June	M. Musiani
	64E **.76'	111E **.62	3	2	19 June	D. Cluff
SE Providence L (RC4)	64E **.19'	112E **.83	2		19 June	M. Musiani
NE Mackay Lake	64E **.19'	109E **.46'	4		19 June	M. Musiani
NW Mackay Lake	64E **.83'	109E **.34'	2		19 June	M. Musiani
N. Thonokeid L.	64E **.74'	109E **.21	3		19 June	M. Musiani
	64E **.74'	109E **.21'	2	3	29 Aug	B. Goski
	64E **.28'	109E **.56'	W322	3-4	30 Aug	D. Cluff
	64E **.37'	109E **.66'	W358c		31 Aug	D. Cluff
NE Aylmer Lake	64E **.93'	108E **.90'	7		19 June	M. Musiani
	64E **.65'	108E **.73'	3		30 Aug	D. Cluff
Rocknest Bay Lake	64E **.71'	108E **.18'	3	5	30 Aug	D. Cluff
(Aylmer Lake)	64E**.90'	107E **.19'	W344c		30 Aug	D. Cluff

2000

Den Site	Latitude	Longitude	Adults	Pups	Date	Source
d1	64E **.000'	110E **.272'	2		31 May	D. Cluff
d2,d4	64E **.110'	110E **.393'	2		31 May	D. Cluff
Sable L area	64E **.913'	110E **.678'	4		03,06 June	D. Cluff
W315	64E **.268'	111E **.796'	2		02 June	D. Cluff
d3	64E **.100'	109E **.980'	2		03 June	R. Mulders
N Yamba L	65E **.700'	111E **.690'	4		04 June	D. Cluff
W Pelonquin L	65E **.118'	111E **.900'	5		04 June	D. Cluff
E Point L	65E **.656'	111E **.900'	1		04 June	D. Cluff
NE Starvation L	64E **.860'	112E **.200'	2		04 June	D. Cluff
Eda L	64E **.650'	112E **.170'	2		04 June	D. Cluff
N Thonokeid L	64E **.740'	109E **.210'	2		04 June	D. Cluff
d5	64E **.142'	109E **.280'	2		04 June	D. Cluff
Clinton-Colden L	63E **.706'	107E **.840'	1		04 June	D. Cluff
W Vodka L	64E **.425'	107E **.458'	1		04 June	D. Cluff

Table 4.2-2 (continued)

Den Site	Latitude	Longitude	Adults	Pups	Date	Source
Rocknest Bay	64E **.710'	108E **.180'	3		04 June	D. Cluff
d6	64E **.853'	108E **.119'	3		04 June	D. Cluff
E Hardy L	64E **.170'	109E **.230'	3		05 June	D. Cluff
d7	65E **.603'	108E **.558'	4		05 June	D. Cluff
d8	65E **.671'	110E **.252'	1		05 June	D. Cluff
E Lupin 2	65E **.320'	109E **.740'	2		06 June	D. Cluff
d9	65E **.780'	111E **.530'	2		05 June	D. Cluff
N Providence 1	64E **.400'	112E **.121'	3		05 June	D. Cluff
N Providence 2	64E **.258'	112E **.153'	1		05 June	D. Cluff
d10	64E **.309'	110E **.337'	1		06 June	D. Cluff
d11	64E **.364'	110E **.734'	1		06 June	D. Cluff
d12	64E **.492'	110E **.055'	5	6	25 June	P. Hogg

4.3 Seasonal Movement of Radio-Collared Wolves

Thirty-two wolves (15 female, 17 male) were captured in June 1997 and 28 (15 female, 12 male) in June 1998 (Table 4.3-1, Fig. 4.3-1). We fitted 12 wolves (7 female, 5 male) in 10 packs with satellite-collars in 1997, and 11 wolves (8 female, 3 male) in 11 packs in 1998. Two female wolves were recollared in 1998. Thus, 23 wolves in 19 different packs were monitored during this study. We experimented with 2 GPS radio-collars on 2 male wolves (Fig. 4.3-2) but with disappointing results. We received 3 transmitted locations from one GPS collar and 10 from the second collar. Because of the low sample sizes, these collars were omitted from further analysis. We recorded four mortalities of 11 satellite-collared wolves during this analysis. Hunters killed 3 wolves (W300m, W301f, W318f) while the cause of death of another (W320f) could not be determined. The latter three of these mortalities occurred below treeline during winter.

4.3.1 Home range size.-- When the mid-date procedure was used for wolves returning to the den in the spring, mean summer range sizes estimated using the 95% fixed kernel method were generally larger than the 95% MCP for all sexes and years, except for males in 1997. However, this difference between home range estimators disappeared when we determined den site return dates by plotting individual movements of wolves (Table 4.3-1, Table 4.3-3). We did not estimate wolf range sizes for the winter season using the fixed kernel estimator due to the limited numbers of locations obtained then (cf. Seaman et al. 1999). While average annual range sizes using the fixed kernel method were generally smaller than those calculated by the 95% MCP for all sexes and both years, this trend was not significant (paired $t = 1.925$, $d.f.=14$, $P = 0.075$). Therefore, we generally report overall range sizes as fixed kernel estimates except for the winter season where only 95% MCP estimates were possible.

Wolf summer ranges (Table 4.3-2) differed significantly between sex ($F = 7.60$, $d.f.=1$, $P = 0.013$) over both years. No year effect was detected for summer ranges ($F = 0.09$, $d.f. = 1$, $P = 0.769$) and no significant interaction between year and sex occurred ($F = 0.001$, $d.f. = 1, 11$, $P = 0.973$. Therefore, average summer range sizes (95% fixed kernel) pooled for both years was 589 ± 152 km^2 for females while males averaged 2,273 ± 953 km^2 (Table 4.3-3). One male wolf ranged widely and its summer range (10,232 km^2 - MCP; 7,720 km^2 - fixed kernel) was about 3-4 times larger than the other males (Table 4.3-3) and perhaps could be considered an outlier. Summer movements of satellite collared wolves are shown for 1997 (Fig. 4.3-3.) and 1998 (Fig. 4.3-4).

Wolf winter ranges were larger than summer ranges (Table 4.3-3) and showed a clear seasonal separation from denning areas in summer. Because transmitters operated less frequently during winter, fewer locations were received so we only estimated winter range size for wolves that had 10 or more independent locations. We realized that these ranges likely would be inadequately defined given the small samples. However, based on the 95% MCP method, winter range sizes (Table 4.3-3) did not differ between years (F = 0.007, *d.f.* = 1, P = 0.937) or sex (F = 0.148, P = 0.709), and no interaction was detected between year and sex (F = 0.043, *d.f.* = 1,9, P = 0.841). Average wolf winter range size was 40,507 ± 7,860 km^2 when pooled for sex and year.

Geographically, areas used by marked wolves varied seasonally and seemed to correspond to movements of migratory caribou. However, annual home range size of wolves did not differ between years (F = 0.09, *d.f.* = 1, P = 0.77) or sex (F = 1.94, *d.f.* = 1, P = 0.191), and no interaction was detected between year and sex (F = 0.009, *d.f.* = 1,11, P = 0.92). Our calculations of annual range size included all seasonal movements and averaged 43,691 ± 5,743 km^2 (Table 4.3-3).

Wolves wintered just north of the Northwest Territories - Saskatchewan border in 1997-1998 and north of Great Slave Lake during winter 1998-1999. Straight-line distances calculated from the den site of wolves to the most-distant location during winter averaged 454 ± 33 km for 11 wolves in 1997-1998 and 260 ± 15 km for 12 wolves in 1998-1999 (Table 4.3-4). There was no interaction between sex and year (F = 0.003, *d.f.* = 1,19, P= 0.96), and no difference between sexes (F = 8.98, *d.f.* = 1, P= 0.21). However, during the 1997-1998 winter, wolves were located further away from summer den sites than in

1998-1999 (F = 6927, $d.f.$ = 1, P= 0.008).

The median date (range) of departure from summer ranges for nine wolves in 1997 was 26 October (20 to 29 October), and for 12 wolves in 1998, it was 03 November (11 October to 6 December). The median date (range) of arrival back to summer ranges for six and nine wolves was 01 May (8 April to 11 May) in 1998 and 18 April (31 March to 12 May) in 1999 respectively, with most (13 of 15) wolves returning to the same denning area (<25 km). Calculating precise return dates to a den were more problematic than those for broad summer ranges because of the uncertainty in the location of the natal or whelping den site, and that prior to 01 May, no daily satellite locations were available. Therefore, average return date for 15 wolves was conservatively estimated at 11 May ± 3.6 days (95% confidence interval). Returns dates for these wolves are indicated in (Table 4.3-2) except for wolves W349f and W351m, who were thought to arrive at their den site by 19 and 20 May respectively. The average return rate would be slightly earlier in May if wolves W327m, W344f, and W351m returned to the den prior to 01 May. However, given the range in dates, one can still assume that wolves return to their den site in mid-May, and likely most have done so by the end of the second week in May.

In 1998, two satellite-collared wolves denned within 7 and 12 km of the previous year's den. Two wolves returned and used the same den as the previous year. Two male wolves, however, did not return to the same denning area and became associated with different packs than they were initially observed with. Straight-line distance from the previous years' den site to the new den site was 217 and 117 km for those wolves. In 1999, wolves returned to within 25 km of their previous dens, although we were unable to determine exact locations of the new den sites.

4.3.3 Excursions.--Fifteen summer excursions were observed in 3 (2 female, 1 male) of 8 wolves in 1997 (Fig. 4.3-3.) and 8 (6 female, 2 male) of 10 wolves in 1998 (Fig. 4.3-4). The median date (range) of all excursions was 10 July (04 to12 July) in 1997 and 01 July (19 June to 08 July) in 1998. No other excursions were observed outside of that 3-4 week period.

The average straight-line distance from the summer-range boundary for each excursion was similar between years ($F = 0.08$, *d.f.* = 1, $P = 0.78$), and averaged (range) 41.7 ± 14.3 km (17 to 67) and 40.9 ± 8.1 km (10 to 101) in 1997 and 1998, respectively (Fig. 4.3-5). We did not detect any difference in average excursion distance between males (52.0 ± 6.4 km) or females (38.3 ± 8.4 km; $F = 0.21$, *d.f.* = 1, $P = 0.66$), and there was no interaction between year and sex ($F = 0.23$, *d.f.* = 1, 11, $P = 0.64$).

Table 4.3-1. Summary of wolf captures in 1997 to 1999 inclusive. Lines separate the various packs encountered where more than one wolf was captured.

1997

wolf	sex	date	latitude	longitude	age class	collar type[1]	PTT[2] No.	VHF freq.	capture/den location
W300m[3]	M	10/Jun/1997	66 25.10	110 55.90	2-yr?	ST-10	29333	152.0797	NE of Jericho camp
W301f	F	10/Jun/1997	66 04.33	111 27.56	adult	ST-14	29341	152.3594	N of Jericho camp
W302m	M	10/Jun/1997	66 04.33	111 27.56	adult	VHF only		153.2598	N of Jericho camp
W303f	F	11/Jun/1997	65 44.50	110 02.28	adult	ST-14	29337	152.2398	E of Lupin mine
W304m	M	11/Jun/1997	65 44.50	110 02.28	adult	VHF only		153.3009	E of Lupin mine
W305f	F	11/Jun/1997	65 18.35	111 21.63	adult	ST-10	29334	152.1202	W of Pelonquin Lake
W306f	F	11/Jun/1997	65 18.35	111 21.63	adult	VHF only		153.3798	W of Pelonquin Lake
W307m	M	11/Jun/1997	65 18.35	111 21.63	adult	ST-14	29343	152.5205	W of Pelonquin Lake
W308m	M	11/Jun/1997	65 18.35	111 21.63	adult	ST-14	29336	152.4400	W of Pelonquin Lake
W309m	M	12/Jun/1997	65 18.58	111 51.80	yrlg?	no collar			E of Point Lake
W310m	M	12/Jun/1997	65 18.58	111 51.80	yrlg?	no collar			E of Point Lake
W311m	M	12/Jun/1997	65 18.58	111 51.80	2-yr?	ST-14	29339	152.2002	E of Point Lake
W312m	M	12/Jun/1997	65 18.58	111 51.80	yrlg?	no collar			E of Point Lake
W313f	F	12/Jun/1997	65 18.58	111 51.80	yrlg?	VHF only		153.4205	E of Point Lake
W314m	M	12/Jun/1997	65 18.58	111 51.80	yrlg?	no collar			E of Point Lake
W315f	F	12/Jun/1997	64 52.00	111 30.24	adult	ST-14	29342	152.2797	Daring Lake
W316m	M	12/Jun/1997	64 52.00	111 30.24	adult	VHF only		153.1805	Daring Lake
W317f	F	12/Jun/1997	64 52.00	111 30.24	yrlg?	no collar			Daring Lake
W318f	F	12/Jun/1997	64 38.06	111 15.93	adult	ST-14	29338	152.4001	NW of Lac de Gras
W330m	M	12/Jun/1997	64 38.06	111 15.93	adult	VHF only		153.0201	NW of Lac de Gras
W319m	M	12/Jun/1997	64 56.40	111 38.96	adult	VHF only		153.0607	W Yamba Lake
W320f	F	13/Jun/1997	64 28.70	110 10.50	adult	ST-10	29332	152.0397	T-Lake across from Diavik

wolf	sex	date	latitude	longitude	age class	collar type[1]	PTT[2] No.	VHF freq.	capture/den location
W321m	M	13/Jun/1997	64 28.70	110 10.50	adult	VHF only		153.0997	T-Lake across from Diavik
W322f	F	13/Jun/1997	64 28.74	109 33.21	adult	ST-14	29340	152.4800	N of Thonokeil Lake
W323f	F	13/Jun/1997	64 28.74	109 33.21	2-yr?	no collar			N of Thonokeil Lake
W324m	M	13/Jun/1997	64 28.74	109 33.21	adult	VHF only		153.2204	N of Thonokeil Lake
W325f	F	13/Jun/1997	64 28.74	109 33.21	2-yr?	VHF only		153.1398	N of Thonokeil Lake
W326f	F	13/Jun/1997	64 12.83	109 58.23	adult	VHF only		153.4603	NE Mackay Lake
W327m	M	13/Jun/1997	64 12.83	109 58.23	2-yr?	ST-10	29335	152.1603	NE Mackay Lake
W328m	M	13/Jun/1997	64 12.83	109 58.23	2-yr?	no collar			NE Mackay Lake
W329f	F	13/Jun/1997	64 29.86	111 19.86	adult	VHF only		153.3404	SW of Lac de Gras
W331f	F	09/Sep/1997	64 41.76	110 13.59	2-yr	VHF only		153.3009	E Paul Lake

1998

wolf	sex	date	latitude	longitude	age class	collar type	PTT No.	VHF freq.	capture/den location
W332m	M	09/Jun/1998	64 54.86	112 30.20	adult	VHF only		153.7000	NE Starvation Lake
W341f	F	11/Jun/1998	64 54.86	112 30.20	adult	ST-10	15661	152.9685	NE Starvation Lake
W333m	M	09/Jun/1998	64 49.27	110 35.97	adult	GPS	12853		Ursula Lake
W334m	M	09/Jun/1998	64 49.27	110 35.97	adult	VHF only		153.4800	Ursula Lake
W335m	M	09/Jun/1998	64 28.74	109 33.21	adult	GPS	12854		N. Thonokeid Lake
W336m	M	09/Jun/1998	64 28.74	109 33.21	adult	none			N. Thonokeid Lake
W322f	F	09/Jun/1998	64 28.74	109 33.21	adult	VHF only		153.5203	N. Thonokeid Lake
W337f	F	09/Jun/1998	64 18.45	109 23.87	adult	VHF only		153.6200	Afridi Lake
W338m	M	09/Jun/1998	64 18.45	109 23.87	adult	ST-10	15658	152.8407	Afridi Lake
W339f	F	10/Jun/1998	65 06.70	111 13.69	adult	ST-10	15659	152.9001	N. Yamba Lake
W340m	M	10/Jun/1998	65 06.70	111 13.69	adult	VHF only		153.6400	N. Yamba Lake

wolf	sex	date	latitude	longitude	age class	collar type[1]	PTT[2] No.	VHF freq.	capture/den location
W307m	M	10/Jun/1998	65 18.06	111 22.86	adult	VHF only		153.3800	W. Pelonquin Lake
W305f	F	12/Jun/1998	65 18.06	111 22.86	adult	ST-10	15660	152.9394	W. Pelonquin Lake
W311m	M	11/Jun/1998	63 52.72	108 47.69	adult	VHF only		153.8000	SW Laverty Lake
W342f	F	11/Jun/1998	63 52.72	108 47.69	adult	ST-10	15564	152.7600	SW Laverty Lake
W343f	F	11/Jun/1998	64 11.71	108 11.18	2-yr	none			Rocknest Bay (Aylmer L)
W344f	F	11/Jun/1998	64 11.71	108 11.18	adult	ST-10	15561	152.5998	Rocknest Bay (Aylmer L)
W345f	F	11/Jun/1998	64 11.71	108 11.18	2-yr	VHF only		153.5000	Rocknest Bay (Aylmer L)
W346f	F	11/Jun/1998	64 11.71	108 11.18	adult	VHF only		153.6600	Rocknest Bay (Aylmer L)
W347m	M	11/Jun/1998	63 58.88	107 38.12	adult	ST-10	15560	152.5601	Clinton-Colden Lake
W327m	M	11/Jun/1998	63 58.88	107 38.12	adult	none			Clinton-Colden Lake
W348f	F	11/Jun/1998	63 58.88	107 38.12	adult	VHF only		153.7800	Clinton-Colden Lake
W349f	F	11/Jun/1998	64 13.93	108 45.90	adult	ST-10	15559	152.3000	NE Aylmer Lake
W350m	M	11/Jun/1998	64 13.93	108 45.90	adult	VHF only		153.7200	NE Aylmer Lake
W351m	M	12/Jun/1998	64 04.74	110 03.93	adult	ST-10	15563	152.7201	NE MacKay Lake
W352f	F	12/Jun/1998	64 04.74	110 03.93	yrlg	VHF only		153.5400	NE MacKay Lake
W353f	F	12/Jun/1998	64 51.41	109 35.67	adult	ST-10	15562	152.6800	E. Hardy Lake
W315f	F	12/Jun/1998	64 47.03	111 20.41	adult	ST-10	15662	152.9899	Daring Lake

1999

wolf	sex	date	latitude	longitude	age class	collar type	PTT No.	VHF freq.	den/capture location
W341f	F	24/Jun/1999	64 54.86	112 30.20	adult	VHF only		153.4002	NE Starvation Lake
W355f	F	24/Jun/1999	64 51.65	112 06.17	2-yr	VHF only		153.4695	Eda Lake
W315f	F	24/Jun/1999	64 52.00	111 30.20	adult	VHF only		153.0401	Daring Lake
W339f	F	25/Jun/1999	65 06.70	111 13.69	adult	VHF only		153.8796	N. Yamba Lake

W353f	F	25/Jun/1999	64 51.41	109 35.67	adult	none		E. Hardy Lake
W305f	F	30/Aug/1999	65 18.06	111 22.86	adult	VHF only	153.1299	W. Pelonquin Lake
W338m	M	31/Aug/1999	64 22.49	109 23.32	adult	VHF only	153.5498	Afridi Lake
W349f	F	31/Aug/1999	64 11.65	108 41.73	adult	VHF only	153.8890	NE Aylmer Lake
W344f	F	31/Aug/1999	64 05.90	107 56.19	adult	VHF only	153.0103	Rocknest Bay (Aylmer L)
W356f	F	31/Aug/1999	64 53.01	110 38.07	adult	VHF only	153.5803	Sable Lake
W357m	M	01/Sep/1999	64 39.76	111 17.62	adult	VHF only	153.7401	NW Lac de Gras
W358m	M	01/Sep/1999	64 28.74	109 33.21	adult	VHF only	153.6804	N. Thonokeid Lake

Notes:

[1] ST-10 and ST-14 are Argos-type (Doppler shift) satellite radio-collars.

[2] Platform Terminal Transmitter as defined by Service Argos, Inc.

[3] Wolf W300m was not captured near a den site.

Table 4.3-2. Summer range areas of radio-collared wolves tracked by satellite during summer (01 May to 15 September inclusive), 1997 to 1999. Locations of wolves used to determine home range areas were restricted to their capture location, Argos satellite locations with error estimate <1 km (location classes 1, 2, 3) and *ad hoc* aerial and ground tracking. Successive locations for each wolf were at least 18 hours apart to reduce potential autocorrelation effects. In 4 cases, the wolf had not returned to the den site by 01 May so a second estimate was calculated from the date that the den was reached. Movements are plotted in Appendix 2 for each wolf with 10 locations or more.

Wolf	Year	Start Date	No. of locations	Duration (days)	Fixed Kernel (km^2)			MCP (km^2)
					60%	80%	95%	95%
Females								
W301f	1997	10 Jun	38	94	80.9	164.1	445.3	417
W303f	1997	11 Jun	2729	92120	743.0	194.6	523.0	401.8
	1998	12 May			37.9	70.2	219.4	172.5
W305f	1997	11 Jun	53685852	9.61e+10	76.3	171.6	488.5	504.8
	1998a	01 May			801.7	1250.7	2853.5	8003.2
	1998b	13 May			65.0	106.1	315.0	833.3
	1999	04 May			50.1	80.4	284.2	877.0
W315f	1997	12 Jun	311412	929139	155.3	286.9	914.9	846.1
	1998	11 Jun			–	–	–	83.1
	1999	19 May			--	--	--	692.2
W318f	1997	12 Jun	14	92	–	–	–	25.7
W320f	1997	13 Jun	34	91	124.4	248.1	469	542.3
W322f	1997	13 Jun	42143	9112473	19.5	33.8	54.6	77.6
	1998	13 May			--	--	--	9.9
	1999	20 Jun			–	–	–	–
W339f	1998	10 Jun	391711	935543	113.2	179.5	622.9	736.9
	1999a	01 May			–	–	–	2115.4
	1999b	13 May			–	–	–	71.3
W341f	1998	11 Jun	272	924	7.1	12.5	62.0	68.9
	1999	20 Jun			–	–	–	–
W342f	1998	11 Jun	71	95	597.4	1224	2343	2112.8
W344f	1998	11 Jun	6949	96121	116.2	186.0	406.7	1769.7
	1999	02 May			83.9	184.1	884.9	838.0
W349f	1998	11 Jun	5924	96121	180.9	341.7	957.6	793.8
	1999	02 May			135.9	332.9	829.7	585.0
W353f	1998	12 Jun	605042	957561	134.0	224.8	426.9	546.4
	1999a	01 May			1148.8	1795.5	2835.4	6804.9
	1999b	15 May			16.2	33.8	162.0	244.5

Table 4.3-2. (continued)

Wolf	Year	Start Date	No. of locations	Duration (days)	Fixed Kernel (km^2)			MCP (km^2)
					60%	80%	95%	95%
Males								
W300m	1997	10 Jun	21	90	–	–	–	–
	1998	19 Jun		--	--	--	--	--
W307m	1997	11 Jun	3516	96118	125.1	245.3	772.1	654.4
	1998	14 May			--	--	–	52.4
W308m	1997	11 Jun	38	83	350	633.1	1997	2354.4
W311m	1997	12 Jun	2916	91119	147.2	337.8	933.2	753.3
	1998	13 May			–	–	–	1597.6
W327m	1997	13 Jun	2918	9141	759.8	1160.1	2624.4	3287.9
	1998	01 May			–	–	–	300.1
W333m[1]	1998	09 Jun	10	93	–	–	–	336.2
W335m[1]	1998	09 Jun	3		–	–	–	--
W338m	1998	09 Jun	72102	98122	106.3	178.1	381.9	626.9
	1999	01 May			141.2	225.1	398.6	2925.3
W347m	1998	11 Jun	494340	967266	2006.1	3140.2	7719.8	10232.2
	1999a	02 May			1331.5	2122.9	5551.7	12571.0
	1999b	08 May			1275.0	2033.2	4542.4	7600.5
W351m	1998	12 Jun	3732	95121	494.1	864.2	1483.5	2107.8
	1999	01 May			354.1	656.9	1533.5	918.5

[1] experimental GPS radio-collar that failed prematurely, likely because of antenna design.

Table 4.3-3. Seasonal and annual home range sizes for individual satellite-collared wolves in the central Arctic, NWT, 1997-99.

		Summer			Winter[a,b]		Annual		
Sex Year	Wolf	95% MCP (km^2)	No. of locations	95% Fixed Kernel (km^2)	95% MCP (km^2)	No. of locations	95% MCP (km^2)	No. of locations	95% Fixed Kernel (km^2)
Females									
1997-98	W301f	417	38	445	–	–	–	–	–
(n=7)	W303f	402	27	523	–	–	31343	35	28746
	W305f	505	53	488	59699	27	63619	94	35201
	W315f	846	31	915	–	–	45491	37	45875
	W318f	26	14	–	–	–	–	–	--
	W320f	542	34	469	17736	14	21802	46	37744
	W322f	78	42	55	44826	12	43486	59	28118
	$\bar{x}$	402	34.1	482	40754	17.7	41148	54.2	35137
	SE	106.2	4.6	111.5	12284	4.7	7070	10.8	3257
1998-99									
(n=9)	W303f	172	29	219	–	–	–	–	–
	W305f	833	58	315	25441	26	31949	121	36080
	W315f	83	14	–	–	–	–	–	–
	W339f	737	39	623	20617	16	39483	82	43 359
	W341f	69	27	62	–	–	–	–	–
	W342f	2113	71	2343	–	–	–	–	–
	W344f	1770	69	407	27590	30	29031	149	18875
	W349f	794	59	958	27825	30	38358	119	16774
	W353f	546	60	427	75 ,42	48	104793	155	86200
	$\bar{x}$	791	47.3	669	35323	30	48723	125.2	40257
	SE	240.8	6.8	257.4	10039	5.2	14152	13	12543
Both Years	$\bar{x}$	621	41.6	589	37360	25.4	44936	89.7	37697

		Summer			Winter[a,b]		Annual		
Sex Year	Wolf	95% MCP (km^2)	No. of locations	95% Fixed Kernel (km^2)	95% MCP (km^2)	No. of locations	95% MCP (km^2)	No. of locations	95% Fixed Kernel (km^2)
	SE	147.8	4.5	152	7290	4.1	7564	14.3	6168
Males									
1997-98	W307m	654	35	772	–	–	–	–	–
(n=4)	W308m	2354	38	1997	–	--	–	–	–
	W311m	753	29	933	83095	12	84085	51	81137
	W327m	3288	29	2624	5144	11	34776	54	27053
	$\bar{x}$	1762	32.8	1582	44120	11.5	59430	52.5	54095
	SE	640.6	2.3	441.1	38976	0.5	24655	1.5	27042
1998-99									
(n=7)	W307m	52	16	–	–	–	–	–	–
	W311m	1598	16	–	–	–	–	–	–
	W327m	300	18	–	–	–	–	–	–
	W333m	336	10	–	–	–	–	–	–
	W338m	627	72	382	12163	23	43368	145	31524
	W347m	10232	49	7720	34986	43	51010	126	68714
	W351m	2108	37	1484	92327	25	102050	84	69970
	$\bar{x}$	2179	31.1	3195	46492	30.3	65476	118.3	56736
	SE	1371.9	8.6	2284.6	23846	6.4	18420	18	12611
Both Years	$\bar{x}$	2027	31.7	2273	45543	22.8	63058	92	55680
	SE	876	5.4	952.6	17968	5.8	12836	18.9	11012

[a] Winter home ranges were likely inadequately defined (see text).

[b] Fixed kernel estimates not calculated because of low sample size (see text).

Table 4.3-4. Distances between natal den site of radio-collared wolves and their furthest recorded winter location.

Winter 1997/98

Wolf	Date	Distance (km)	Comments
W300m	22 Jan 1998	453	
W301f	26 Nov 1997	373	mortality site
W303f	23 Dec 1997	584	
W305f	09 Dec 1997	573	
W308m	19 Mar 1998	415	collar failure >22 Oct. 1997
W311m	10 Dec 1997	556	did not return to same den site
W315f	25 Nov 1997	513	
W318f	~ 15 Dec 1997	196	mortality site
W320f	22 Nov 1997	454	
W322f	26 Nov 1997	472	
W327m	22 Nov 1997	403	
n = 11		0 = 453.8 km	± 33.4 km (± S.E.)

Winter 1998/99

Wolf[2]	Date	Distance (km)	Comments
W303f	09 Dec 1998	258	battery failure-last known location
W305f	19 Dec 1998	237	
W315f	16 Jan 1999	229	den site uncertain; capture site used
W338m	06 Feb 1999	298	
W339f	10 Mar 1999	250	
W341f	24 Dec 1998	156	
W342f	04 Dec 1998	326	sat. collar failure >08 Dec 1998
W344f	05 Dec 1998	293	
W347m	19 Feb 1999	241	
W349f	23 Feb 1999	215	
W351m	22 Feb 1999	262	
W353f	26 Nov 1998	356	
n = 12		0= 260.1 km	± 15.3 km (± S.E.)

Notes:

1 Wolf W307m was excluded because he was paired with wolf W305f

2 Wolf W300m was excluded from the Winter 1998/99 analysis because only an 1997 capture site location is available.

Figure 4.2-1. Distribution of wolf sightings and active wolf den sites in the central arctic tundra, Northwest Territories and Nunavut, from 1996 to 2000, inclusive.

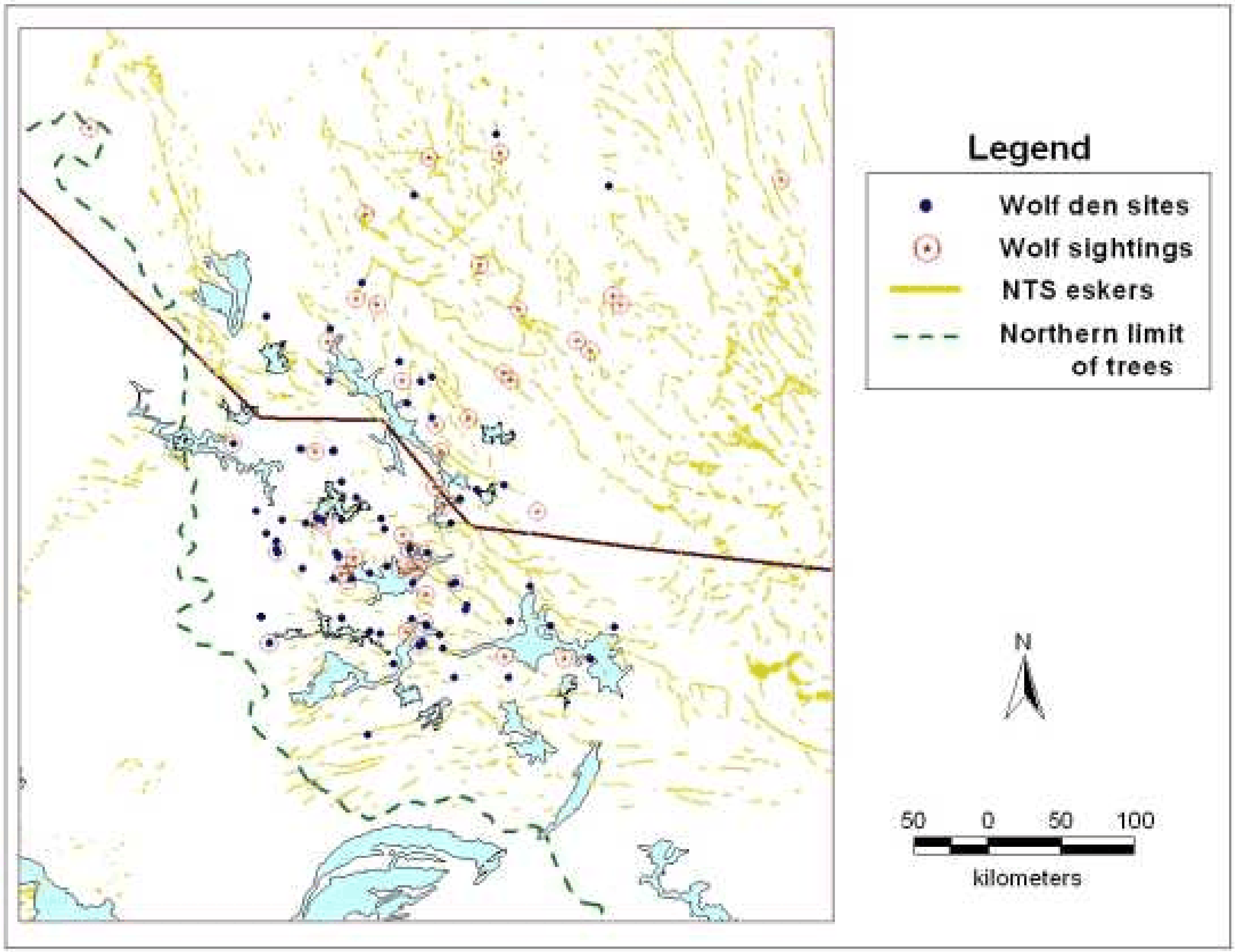


Figure 4.3-1. Capture sites of 58 wolves caught from 1997 to 1999 inclusive in the central arctic region of the Northwest Territories and Nunavut, Canada.

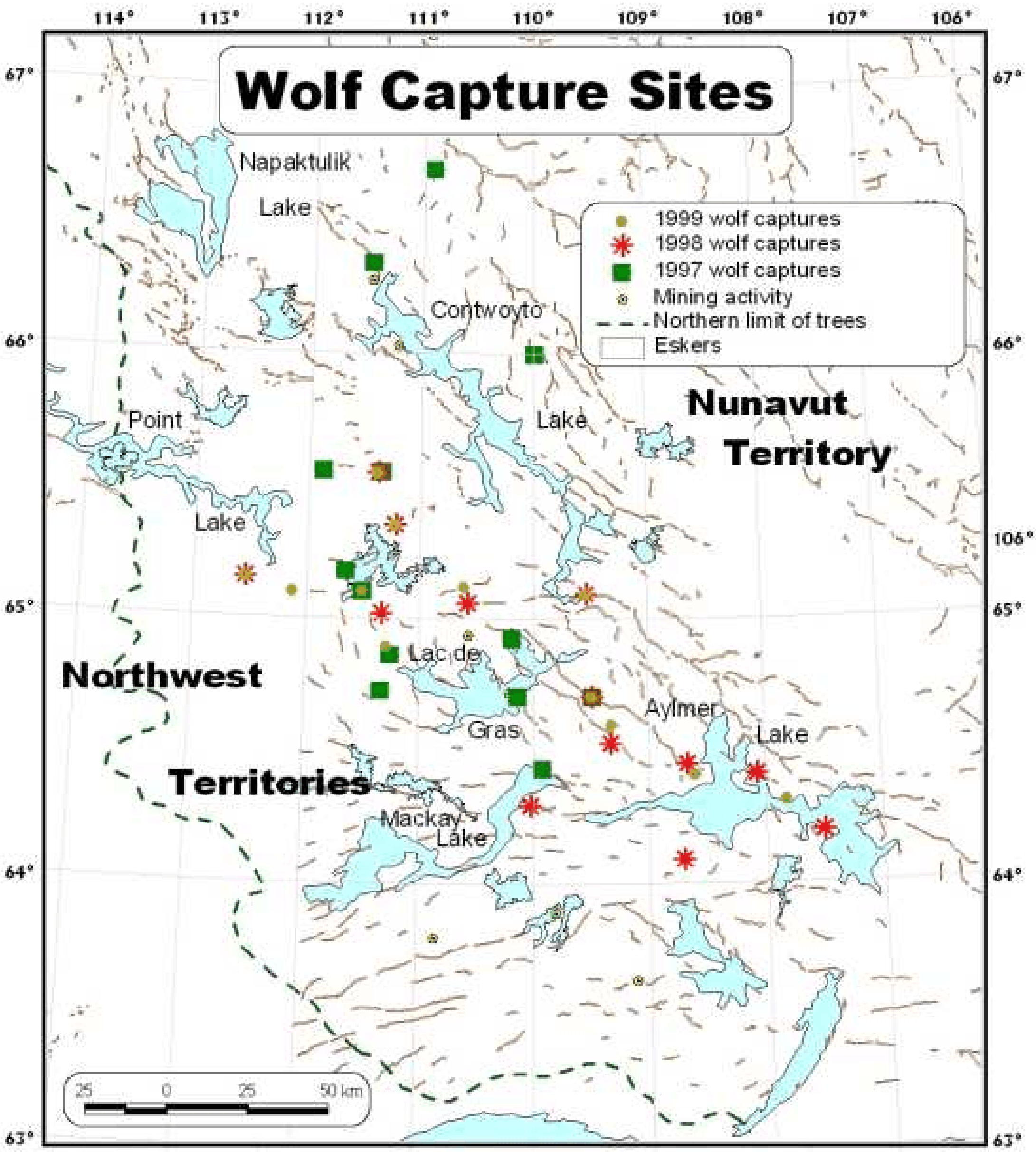
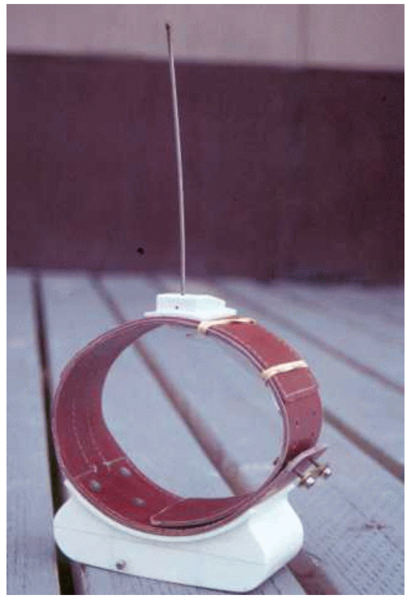


Figure 4.3-2. Experimental Global Positioning System (GPS) radio-collar (a) deployed on two wolves in 1998. Wolves W333m and W335m (b) were fitted with these collars.

(a)



(b)

Figure 4.3-3. Summer 1997 movements of wolves captured in the central Canadian Arctic.

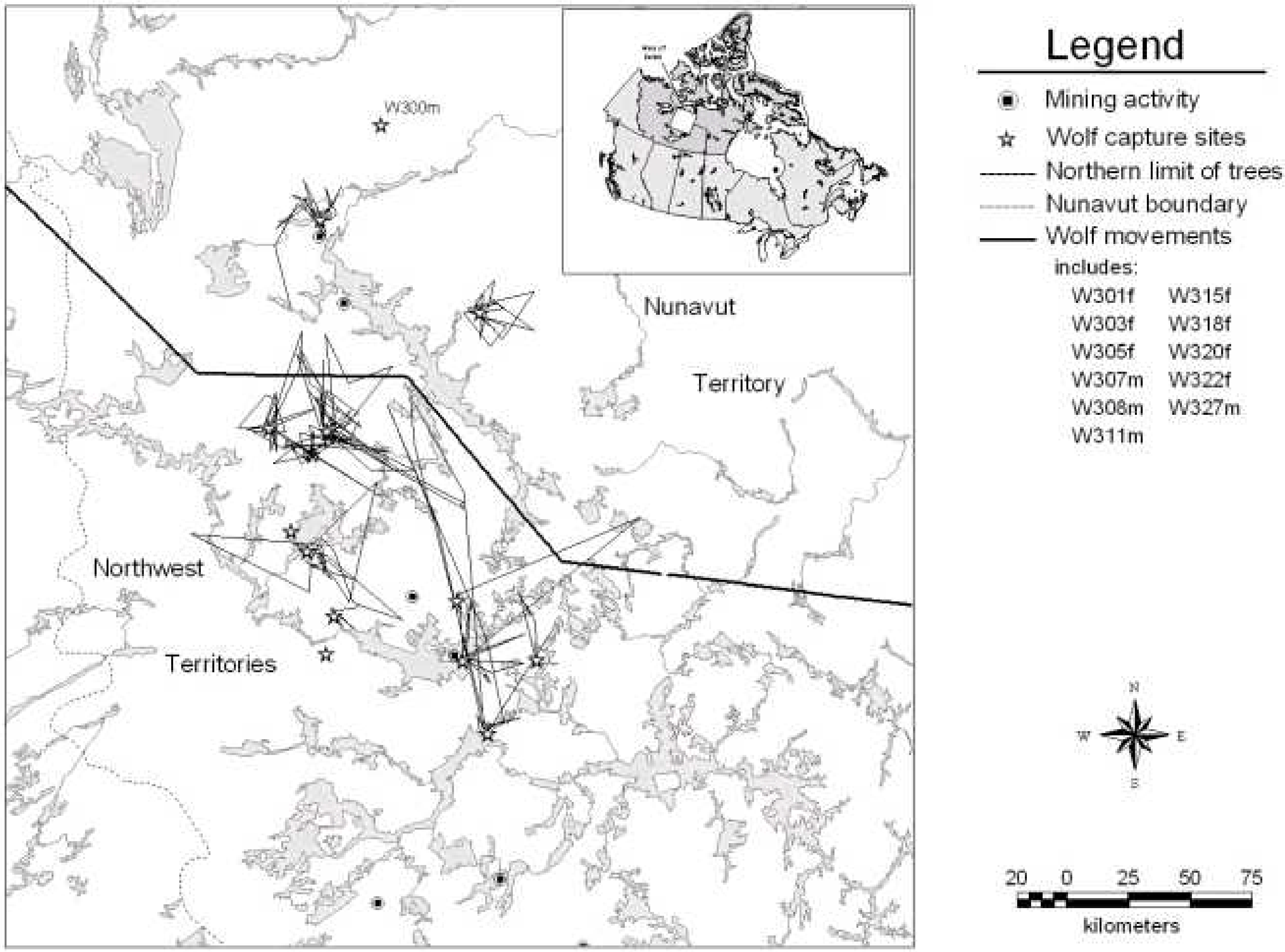


Figure 4.3-4. Summer 1998 movements of wolves captured in the central Canadian Arctic.

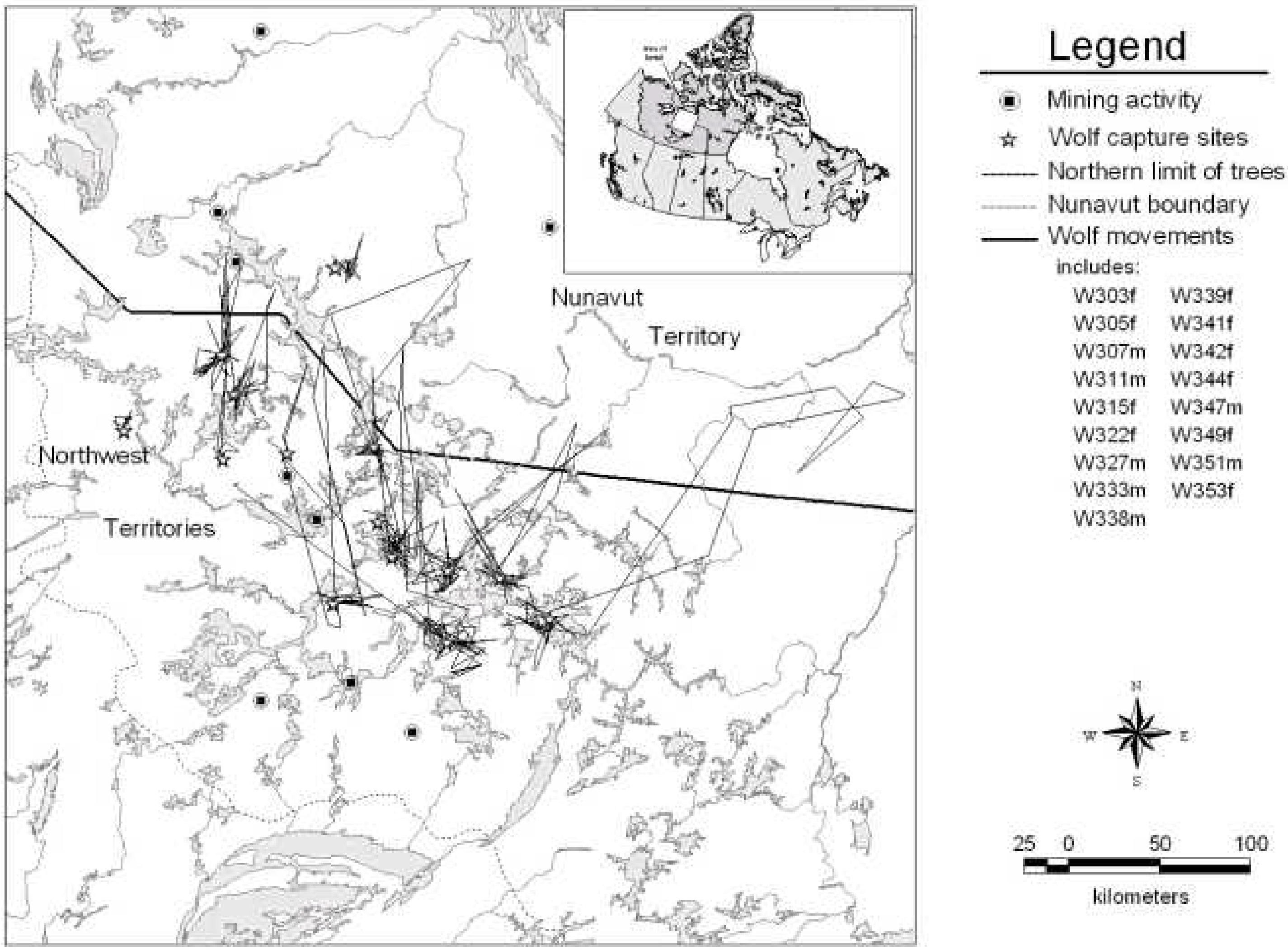
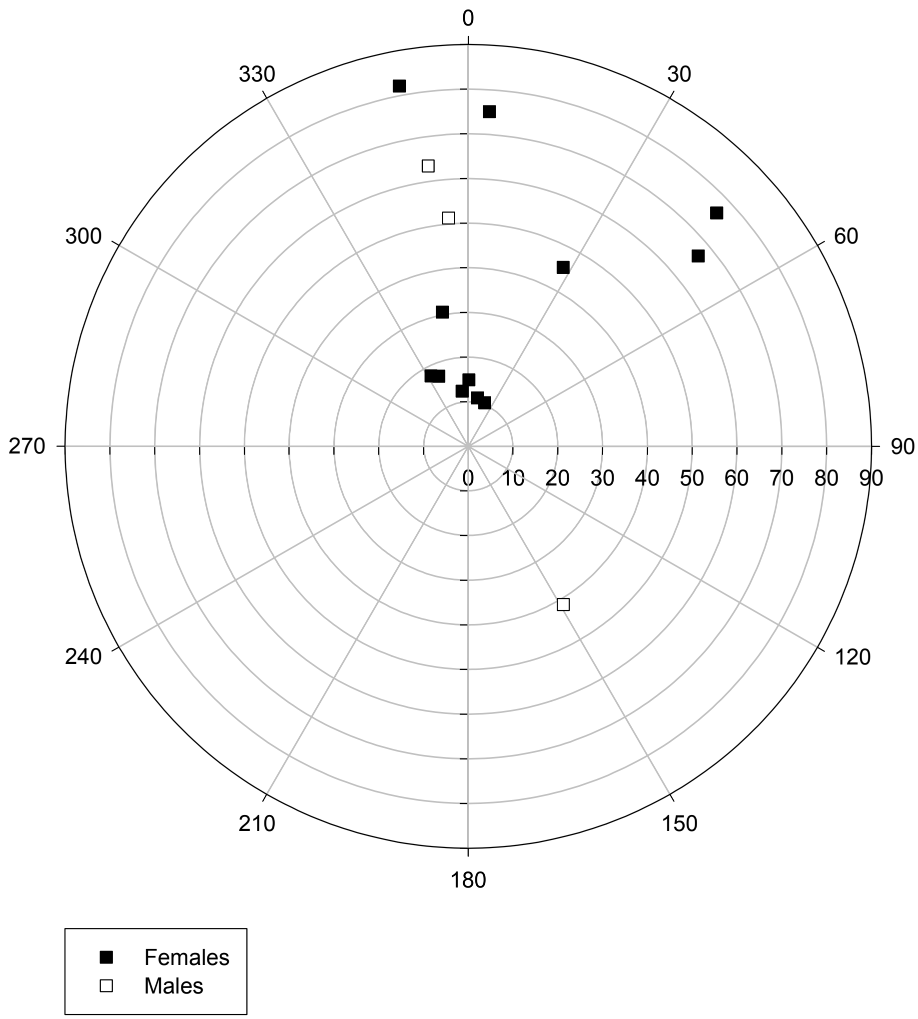


Figure 4.3-5. Mean direction (degrees) from den site and average distance (km) from the closest segment of the summer range boundary for 8 female (closed squares) and 3 male (open squares) wolves during 15 excursions, 19 June - 12 July 1997 and 1998 in the central Canadian Arctic.



4.4 Hierarchical Habitat Use By Tundra Wolves

Thirty-two wolves (15 female, 17 male) were captured in June 1997 and 28 (15 female, 12 male) in June 1998. We fitted 12 wolves (7 female, 5 male) in 10 packs with satellite-collars in 1997, and 11 wolves (8 female, 3 male) in 11 packs in 1998. Two female wolves were re-collared in 1998. Thus, 23 wolves in 19 different packs were monitored during this study (Fig. 2.3-1). We recorded 4 deaths of satellite-collared wolves. Three wolves were killed by hunters (2 female, 1 male), and cause of death of 1 female could not be determined. Three of the four mortalities occurred below tree-line during winter.

4.4.1 Second Order Selection – Summer ranges were available for 8 wolves (6 F, 2 M) during 1997 and 6 (4 F, 2 M) in 1998 (Walton et al. 2001a). Median selection index values and significant differences among habitat types as determined from multiple comparison tests are presented (Fig. 4.4-1). The most preferred habitat relative to other habitats was esker habitat. That is, when compared with the habitat types available in the study area, the home ranges of study animals contained preferentially more esker habitat when compared with other habitats. Following esker habitat, heath tundra was preferentially used. Heath boulder, heath bedrock, bedrock, tussock/hummock, wetland, lichen, tall shrub, birch seep and spruce followed esker and heath tundra as preferred habitats. Boulder fields were significantly less preferred when compared with all other habitat types.

4.4.2 Third Order Selection – Third order selection patterns were analysed for 10 female and 4 male wolves, using 261 class one, 229 class two, and 129 class three locations. Median selection index values and significant differences among habitat types as determined from multiple comparison tests are shown in Figure 4.4-2. The most preferred habitat relative to other habitats was bedrock. Following bedrock, no significant differences could be detected for the remaining 11 habitat types. When we removed all wolf locations that occurred around the den site (#2 km), the relative preferences for bedrock disappeared (Fig. 4.4-3).

Table 4.4-1. Manly-Beta values for each of 14 wolf-years for second order habitat use patterns among satellite radio-collared wolves during summers 1997 and 1998. Values are calculated from the summer range use for each wolf-year (habitat use) and the availability of the various habitat types within the entire mapped study area (habitat availability).

	Habitat Type*											
Wolf	lichen	esker	wetland	tussock	ht	spruce	bedrock	tall shrub	birch seep	ht bould	ht bed	boulder
W301f-97	0.01	0.13	0.114	0.237	0	0	0.036	0.009	0.012	0.071	0.253	0
W303f-97	0	0.12	0.051	0.074	0.14	0	0.014	0.009	0	0.177	0.15	0.3
W303f-98	0	0.14	0.056	0.069	0.17	0	0.015	0.005	0	0.19	0.09	0.3
W305f-97	0.126	0.24	0.049	0.04	0.11	0	0.097	0.003	0.004	0.189	0.12	0
W305f-98	0.137	0.24	0.06	0.036	0.12	0	0.087	0.003	0.004	0.173	0.116	0
W311m-97	0.124	0.37	0.029	0.061	0.1	0.01	0.071	0.028	0.036	0.118	0.04	0
W315f-97	0.167	0.2	0.034	0.127	0.1	0.04	0.087	0.043	0.033	0.106	0.07	0
W320f-97	0.02	0.12	0.024	0.064	0.11	0.07	0.044	0.359	0.121	0.032	0.03	0
W322f-97	0	0.15	0.029	0.064	0.13	0.07	0.045	0.261	0.174	0.018	0.05	0
W327m-97	0.04	0.14	0.039	0.096	0.13	0.07	0.079	0.157	0.089	0.082	0.07	0
W338m-98	0.02	0.07	0.035	0.09	0.1	0.338	0.064	0.129	0.141	0.017	0.02	0
W339f-98	0.139	0.25	0.053	0.056	0.13	0.03	0.079	0.023	0.017	0.118	0.08	0
W351m-98	0.08	0.06	0.071	0.115	0.1	0.218	0.104	0.067	0.08	0.062	0.05	0
W353f-98	0.03	0.15	0.034	0.13	0.13	0.04	0.089	0.149	0.081	0.066	0.09	0

* Habitat types are as follows: lichen veneer, esker complex, wetland, tussock/hummock, heath tundra, spruce forest, bedrock field, tall shrub riparian, birch seep, heath boulder, heath bedrock, and boulder field. See Table 5-1 for a description of each habitat type.

Table 4.4-2. Manly-Beta values for each of 14 wolf-years for third order habitat use patterns among satellite radio-collared wolves during summers 1997 and 1998. Values are calculated from 2 km diameter buffers centered about each wolf's point location (habitat use) and the boundaries of the summer range for each wolf (habitat availability).

	Habitat Type*											
Wolf†	lichen	esker	wetland	tussock	ht	spruce	bedrock	tall shrub	birch seep	ht bould	ht bed	boulder
W301f-97	0.114	0.196	0.072	0.072	0.05	0.042	0.133	0.076	0.048	0.074	0.062	0.055
W303f-97	0.07	0.151	0.085	0.107	0.09	0.000	0.103	0.161	0.000	0.096	0.077	0.059
W303f-98	0.09	0.057	0.078	0.107	0.07	0.005	0.109	0.142	0.027	0.091	0.145	0.076
W305f-97	0.08	0.102	0.091	0.106	0.07	0.057	0.108	0.037	0.059	0.087	0.095	0.105
W305f-98	0.093	0.09	0.103	0.091	0.08	0.089	0.093	0.108	0.050	0.082	0.062	0.058
W311m-97	0.091	0.080	0.067	0.072	0.05	0.108	0.083	0.073	0.102	0.079	0.075	0.11
W315f-97	0.130	0.085	0.133	0.07	0.08	0.092	0.079	0.080	0.098	0.072	0.032	0.049
W320f-97	0.139	0.068	0.087	0.096	0.1	0.078	0.099	0.066	0.040	0.106	0.057	0.087
W322f-97	0.094	0.102	0.132	0.065	0.1	0.09	0.096	0.065	0.061	0.073	0.085	0.071
W327m-97	0.121	0.026	0.132	0.059	0.09	0.265	0.058	0.043	0.130	0.043	0.018	0.015
W338m-98	0.108	0.020	0.081	0.121	0.05	0.097	0.109	0.033	0.075	0.071	0.164	0.067
W339f-98	0.060	0.083	0.025	0.138	0.06	0.076	0.108	0.157	0.092	0.093	0.069	0.038
W351m-98	0.060	0.047	0.095	0.096	0.04	0.150	0.111	0.050	0.136	0.067	0.080	0.06
W353f-98	0.085	0.096	0.115	0.098	0.08	0.062	0.093	0.045	0.092	0.095	0.07	0

* Habitat types are as follows: lichen veneer, esker complex, wetland, tussock/hummock, heath tundra, spruce forest, bedrock field, tall shrub riparian, birch seep, heath boulder, heath bedrock, and boulder field. See Table 5-1 for a description of each habitat type.

† The number of locations for each wolf is as follows: 35, 27, 31, 56, 81, 29, 29, 31, 39, 27, 95, 51, 48, and 83 (in list order, respectively).

Figure 4.4-1. Median Manly beta indices (b_i) for wolves (n = 14) at the second order of selection. Homogeneous subsets of data are indicated at right for medians that are not significantly different ($P < 0.05$, Student-Newman-Keuls test).

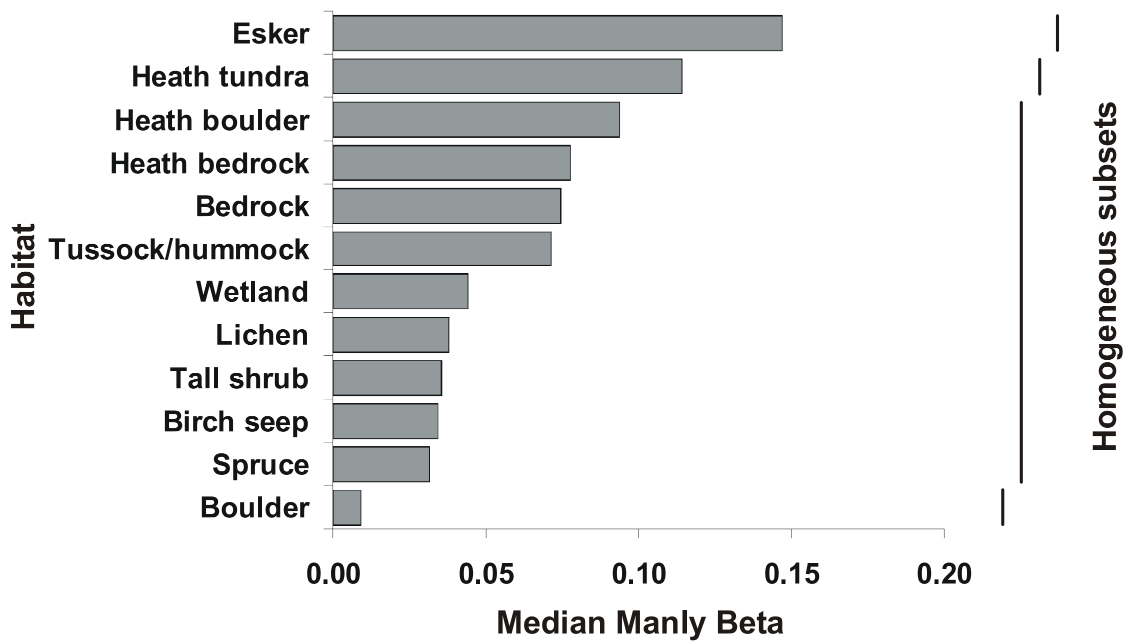


Figure 4.4-2. Median Manly beta indices (b_i) for wolves (n = 14) at the third order of selection, including all den sites. Homogeneous subsets of data are indicated at right for medians that are not significantly different ($P < 0.05$, Student-Newman-Keuls test).

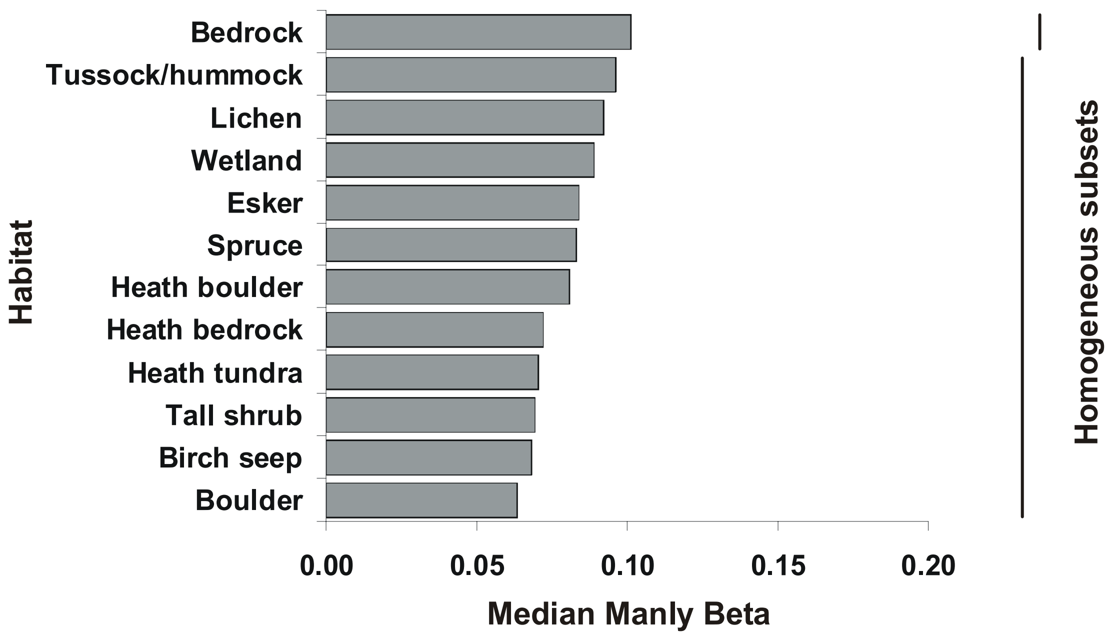
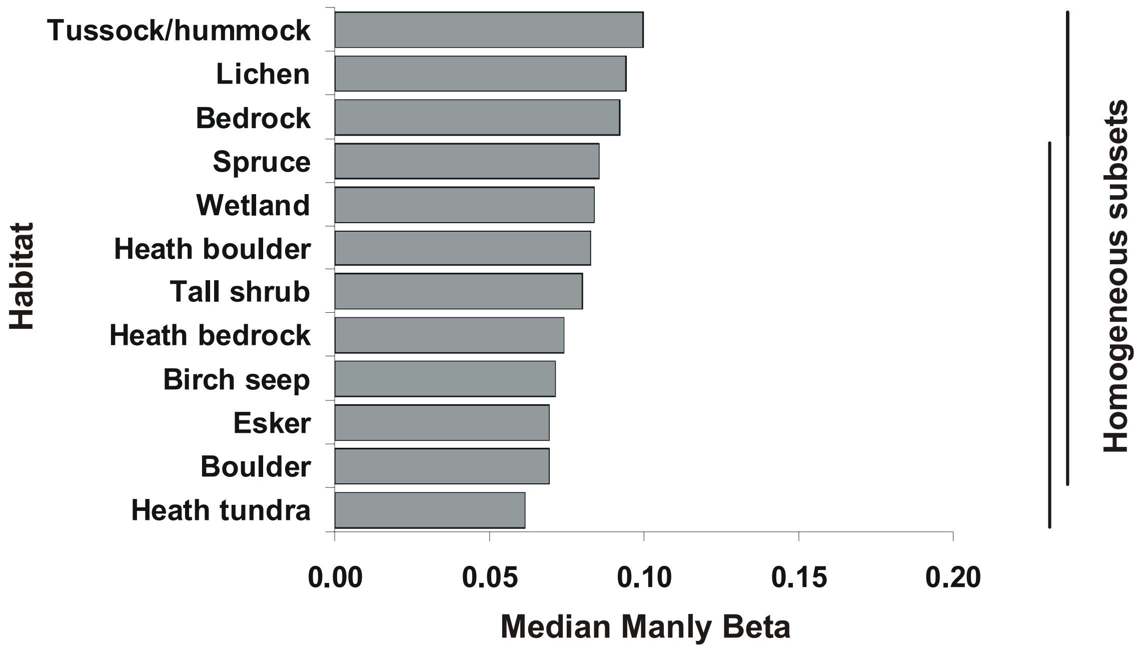


Figure 4.4-3. Median Manly beta indices (b_i) for wolves (n = 14) at the third order of selection, using only those locations that are at least 2.0 km away from known den sites. Homogeneous subsets of data are indicated at right for medians that are not significantly different ($P < 0.05$, Student-Newman-Keuls test).


Tussock/hummock
Lichen
Bedrock
Spruce
Wetland
Heath boulder
Tall shrub
Heath bedrock
Birch seep
Esker
Boulder
Heath tundra
Habitat
0.00
0.05
0.10
0.15
0.20
Median Manly Beta
Homogeneous subsets

5.0 DISCUSSION

5.1 Wolf Den Database

Some redundancy is maintained in the location coordinates because we chose to accommodate different formats. This was in anticipation of when this database is merged with updated information. Therefore, latitude and longitude co-ordinates may be entered as degrees and minutes, or degrees, minutes and decimal minutes, or just decimal degrees. The latter format is useful for importing the data into a Geographic Information System (GIS) such as ArcView®. The degrees and minutes allow for backward compatibility with the older data. We chose to have GPS co-ordinates entered as degrees, minutes, and decimal minutes because we believe decimal minutes are more intuitive for people than “seconds”. For example, maps often indicate degrees and minutes of latitude and longitude, but often not seconds. Once one locates the minute component of the location co-ordinate, dividing the rest of the area into units of ten is likely easier than doing so in units of six or sixty. Macro program code is included to easily convert between the various formats.

We introduced some new fields in the new database and revised others (Tables 4.3-1, 4.3-2). We added the field DATUM because GPS locations in NAD 27 and NAD83 can differ within several hundred metres. This might be a concern for some when a precise GPS location is indicated. GPS locations prior to 02 May 2000 were also subject to “Selective Availability”, an intentional timing error imposed on the civilian channel by the United States government who established and maintain the GPS satellite network. After 02 May 2000, “Selective Availability” was removed. The difference in location error is now 10 to 20 metres from the true location with “Selectively Availability” off compared to 70 to 100 metres before.

The DATE field is a character field (c.f., a date format field) because the date entry information varies beyond the capabilities of the date field format. The ACTIVE field in the WDSTATUS table is an attempt to determine if the den has been used or not.

The ACTIVITY field seeks to identify who was actually there (by specifying numbers). More general assessments of attendance (e.g., “pups present”) are placed in the NOTES field.

Next steps for the den site database should include adapting it for a Geographic Information System (GIS) such as ArcView or ArcGIS (Environmental Systems Research Institute, Redlands, CA USA) and publish metadata for it. Given disparities exist between old co-ordinates of previously recorded den sites and more precise co-ordinates for active dens found nearby since, a more thorough inventory and assessment would be required before the older database could be merged with our recent findings. We hope to do this in the near future.

5.2 Esker Inventory

Wolves often relocate their pups from the ‘natal’ den after 3-4 weeks. However, not all natal den sites found this spring were relocated as some were used throughout the summer. Den site relocation by wolves might also be related to caribou movements but sorting this out is difficult without monitoring marked individuals

Some of these esker systems were not mapped on the 1:250,000 NTS map sheets and may have been missed if an inventory survey was based only on these maps. Therefore, co-ordinating search effort with other projects played an important part in the success of this fieldwork.

5.3 Seasonal Movements Of Radio-Collared Wolves.

Although we obtained fewer locations during winter, it was apparent that wolves ranged over relatively large areas. The large size of winter ranges suggested that wolves were not territorial during that season but moved extensively searching for, and following, prey. Our findings concur with others who have documented this apparent shift in territorial behavior as density of prey decreased due to seasonal movements or migration (Ballard et al. 1997, Forbes and Theberge 1995).

Annual ranges of wolves we studied were much larger than annual territories used by wolves relying primarily on resident prey. Range sizes of that magnitude appear to be unique to populations preying exclusively on barren-ground caribou. Annual wolf territories in northwestern Alaska averaged 3,375 ± 1,973 km^2 (Ballard et al. 1998) and were the largest reported previously (cf., Ballard et al. 1997, Forbes and Theberge 1995, Messier 1985a). However, in most of these studies, wolves remained in relatively stable territories throughout the year.

Our range size results concur with Mech (1970) and Ballard et al. (1997), suggesting that wolves denning on the tundra and relying on migratory caribou range over larger areas than wolves occupying forested areas and relying on resident prey. Overall, summer ranges calculated in our study were similar to or larger than those reported in other North American populations (621 km^2, n = 14, Ballard et al. 1997, 1040 km^2, n = 12, Ballard et al. 1998, 110 km^2, n = 20, Fuller 1989). In northwestern Alaska (Ballard et al. 1997, 1998), wolves also prey on migratory caribou, although not all wolves migrate with the caribou. Differing migratory strategies of those wolves may be related to the availability of moose as an alternative prey (Ballard 1997).

Our data show that male and female wolves differ in their movements in summer but not at other times. We suspect this difference is because of differing parental roles with the male allocating more time than the female searching for food away from the den. The female, in part because of lactation requirements of the pups, remains at the den longer than the male but when the she does leave the den, she travels less. This difference in male and female movements disappears when the pack leaves the den and travels together, presumably following caribou in the fall and winter.

5.3.1 Migration.-- All satellite-collared wolves showed a distinct migratory pattern, leaving the tundra denning areas in autumn and moving over large areas throughout the winter, before returning to the tundra to whelp in early spring. Hence, they did not exhibit territorial behavior typical of other wolf populations in North America. In northwestern Alaska, wolves only migrated with the western Arctic caribou herd in years when alternate ungulate prey densities were too low to sustain wolf packs (Ballard et al. 1997, Stephenson and James 1982).

In Alaska, Stephenson and James (1982) speculated that seasonal migrations of wolves to wintering areas of caribou may be a traditional pattern, in which wolves migrate to the same general area. However, during our study, wolves collared during both years wintered in different areas (Walton 2000). Thus, movements of wolves may depend on distribution of wintering caribou, not on traditional wintering areas. Further research is required to discern if wolves follow a given caribou herd throughout winter or encounter caribou in a more peripatetic manner.

The site fidelity we observed strongly suggests that wolves in our study region use traditional denning areas. The two satellite-collared wolves that did not return to the same denning area were adult males. Neither male was observed during the second summer to associate with members of the pack they were initially affiliated with. Hence, both animals likely dispersed from their natal packs.

In territorial wolves, these excursions are referred to as extraterritorial movements and are explained as responses to changing prey availability, pre-dispersal forays, or migratory movements (Forbes and Theberge 1995, Messier 1985b, Van Ballenberghe 1983).

Therefore, given that male summer ranges were significantly larger than females, but average excursion distances between the sexes was not different, males must then range over a wider area than females, but not necessarily always further away from the den. Indeed, the duration of excursions averaged 2.4 ± 0.3 days for 12 females and 4.0 ± 0.0 days for two males (albeit a small sample for males). Alternatively, a gender difference in excursion distance could be lost in our method of using the home range boundary to detect and measure an excursion. Nevertheless, most excursions occurred in a northerly direction from the den site, with a mean direction (± angular deviation) of 7< ± 36< (Fig. 4.3-5).

Most wolves that inhabit ranges of migratory caribou do not den near calving grounds (Heard and Williams 1992, Parker 1973). Instead, they often select den sites near treeline, south of the calving grounds, in areas that may maximize availability of caribou throughout the denning season (Heard and Williams 1992). Caribou remain on the calving grounds until late June before dispersing south (Fancy et al. 1989, Kelsall 1968, Parker 1973). When at calving grounds, caribou may not be readily available to wolves. Therefore, wolves may have to extend their search areas to find prey. In our study, mean direction of travel for all excursions was northerly, which was toward the caribou calving grounds. Given the short duration of excursions, the direction most wolves traveled, and that this behavior also was observed in breeding females, we suggest these excursions were in response to low availability of caribou in the summer range.

Currently, diamond mining and road construction are occurring in the area used by these migratory wolves for denning. Because movements of wolves are localized while denning, they may be most susceptible to disturbance at this time. Developments that disturb or displace denning wolves or alter distribution or timing of caribou movements may have significant effects on the reproductive success of wolves. Given the large area barren-ground wolves occupy throughout the year, industrial developments that affect wolves may generate local and regional disturbances. Monitoring wolf den sites for annual occupancy can also be confounded by human-caused mortality during their long distance winter movements. Thus, we believe that the scale of assessing cumulative effects on these migratory wolves must be broadened in both space and time to incorporate these extensive movements and the harvest for wolf fur.

5.4 Hierarchical Habitat Use By Tundra Wolves

Wolves are top carnivores and as such, are not normally considered habitat specialists. With sufficient prey densities and minimized human disturbance, wolves are able to persist in a variety of ecosystems (Mech 1970, Fuller et al. 1992). However, in Arctic or sub-Arctic regions, suitable denning habitat may be important (BHP Diamonds Inc. 1995c, Mech and Packard 1990, Mueller 1995). Rettie and Messier (2000) suggest that factors most limiting to a population should drive selection patterns at coarser scales. For example, caribou are most likely limited by predation. Thus, selection of habitats to avoid wolf predation should occur at coarser scales and selection patterns driven by foraging decisions should only occur at finer scales (Rettie and Messier 2000). Thus, we predicted that denning habitats (eskers) would be selected at the coarser scale for tundra wolves. Because wolves are not tied to specific vegetation types for feeding, we predicted that at finer scales, wolves should not show strong preferences for specific habitats.

Our data concur with these predictions. At the second order of selection, wolves appeared to select their home ranges in areas that maximized the availability of esker habitat and at the third order of selection (daily movements), wolves did not appear to preferentially use any habitat type, except perhaps bedrock. Bedrock habitat may be used preferentially by wolves because it is a suitable resting habitat to seek relief from insects, and also facilitates travel.

The higher likelihood of esker habitat occurring in wolf summer ranges than other habitat types, suggests that eskers are important to wolves. Furthermore, the analysis focussed on wolf summer ranges, a time when wolves raise their pups. The composition of esker habitat supports the digging of dens where many other areas are dominated by bedrock, boulders, standing water, or permafrost, and wolves simply cannot dig there.

Most wolves den in esker habitat. Even in the exceptions, small sandy glacial deposits are used that allow digging in an elevated and well-drained platform. Therefore, we believe that eskers are an important habitat type for wolves, but we cannot accurately quantify that importance.

The use of esker habitat in coarse (second order) and fine (third order) habitat selection may be confounded somewhat by wolves selecting home ranges that optimize their availability to migrating caribou. Wolves denning in this region, do not show preference for denning near the caribou calving grounds. Instead, most wolves locate their dens near tree-line (Heard and Williams 1992). This strategy likely maximizes the proportion of time that caribou are available to wolves during the 3-4 month denning period. Post-calving movements usually bring the caribou back to the denning wolves at a time when nutritional demands of the pups are greatest (Heard and Williams 1992). Selecting a den site that maximizes the availability of caribou should maximize pup survival.

Using areas of use (i.e., circular buffers) as opposed to point locations to assess habitat selection is a conservative approach to habitat selection. However, it eliminates many of the biases associated with using point locations (Rettie and McLoughlin 1999). Given the inaccuracies associated with the Argos system transmitters, radii of 2 km ensured that the wolf's true location was included in each buffer. Further, results of habitat selection analyses appear to be insensitive to buffer size over a range of radii (Rettie and McLoughin 2000). The fact that wolves showed little selective behavior of habitat types at the finer order of selection was not surprising, as wolves are strict carnivores that rely on the presence of mobile prey. The high availability of eskers within wolf summer ranges in effect cancels the use of eskers at the fine scale of selection, therefore we do not find high Manly beta values for eskers here. Nonetheless, documenting a significant preference for esker habitat, relative to other habitat types at the coarse order of selection highlights the importance of eskers to denning wolves. Therefore, this is an example where it is important to view habitat selection on more than one scale of study. Without the two-scaled approach used here, we may not have realized that eskers are selected by wolves at the level of home range, rather than at lower levels of habitat selection.

5.5 Management Implications

We know little about the denning ecology of wolves in tundra regions, and the role of eskers as denning habitat. Our data clearly illustrate that wolves have an association with eskers, and that eskers are an important landscape component within the home ranges of denning wolves. We know that traditional den sites in the Arctic and sub-Arctic may be used annually or intermittently for centuries (Mech and Packard 1990), and that the permafrost and rocky terrain may limit suitable den sites. Our results indicate that eskers may be a limiting resource to wolves, possibly as denning habitat. Because of a growing threat to eskers from the development of non-renewable resource industries, we suggest that the loss of eskers be minimized.

Currently, mitigation for loss of esker habitat does not occur. Therefore, eskers should be identified as ecologically sensitive areas and should be surveyed for the presence of wolf dens. Existing wolf dens should be monitored and disturbance should not occur within 2-3 km of den sites (Chapman 1977). Disturbance of wolf den sites prior to whelping can affect site selection preferences by forcing the relocation of pregnant females (Stephenson 1974). Future monitoring should include a detailed investigation into the specific denning habitat requirements of wolves inhabiting the tundra regions of Canada’s central Arctic.

5.6 Study Contributions and Recommendations

This study has provided baseline data on wolves denning on the central arctic tundra which can help assess impacts of economic development on wolves and possible options for their mitigation. Our inventory of eskers for den sites will help document which habitat areas are sensitive to development by identifying traditional den sites. The importance of some eskers over others for wolves is currently less clear because of uncertainties remaining with den site fidelity. However, further research currently underway as an extension of this study should clarify this. At the time of our analysis, there were only three Landsat TM scenes classified and ground-truthed. Imagery for the remainder of the Slave Geological Province has been acquired and most of the scenes have since been classified and ground-truthed. Error assessments in the vegetation classification by Remote Sensing will be completed once all the scenes are classified, likely later in 2001. At this time refinements in the classification process can occur and classification can re-occur to yield improved results. We hope that this ecological information will help wildlife managers and industry implement socially beneficial development plans but limit adverse effects of habitat fragmentation, especially within ecologically sensitive areas.

Our study was also helpful in initially evaluating the sustainability of the Rennie Lake wolf hunt. Through the use of satellite collars, we were able to document that wolves associated with the Bathurst caribou herd were wintering together with the wolves associated with the Beverly caribou herd. Thus, we suspect that wolf density was unusually high and the harvest was drawn from three different sub-populations of wolves. Further assessment of this wolf hunt is underway and involves the genetic analysis of wolf tissue samples collected from the impact area and beyond.

Summer movements of wolves were variable with notable excursions during the time period when caribou were at the calving grounds and presumably not abundant in the wolves' denning area. Such movements are common in other wolf studies during times when prey are scarce (Mech 1977, Messier 1985b, Forbes and Theberge 1995).

Little is known about the movements of wolves associated with migratory caribou herds (Ballard et al. 1997). Wolves that occupy the Bathurst caribou range prey primarily on caribou, as there is not alternative ungulate prey available (Williams 1990). We believe that wolves follow the migrating caribou herds during the winter and then as the caribou move north to the calving grounds in early summer, wolves stop following the migrating herd and den near the treeline (Heard and Williams 1992). During the pup rearing period (late May - September), the movements of adult wolves are constrained to the area near the den site and are unable to move as extensively as at other times of the year (Fritts and Mech 1981, Heard and Williams 1992, Kuyt 1972). Thus, while the caribou are at the calving grounds, the availability of caribou may be limited and this may explain the excursions that we observed. Through the use of satellite collars, we have been able to document, for the first time, these large scale movements of wolves associated with the Bathurst caribou herd.

Further analysis and monitoring of satellite and VHF collars will lead to a spatial analysis of active wolf dens, their relationship to eskers, movement patterns and habitat associations during denning and when they follow the migrating caribou herd. A snapshot inventory of active wolf dens is being considered as a possible technique to estimate the number of wolves in the area.

5.6.1 Recommendations for monitoring wolf dens for environment impact assessment

The following monitoring procedure outlined here is an attempt to document potential impacts of a proposed development in the central arctic where wolves are known to have dens. The following procedures and rationale are presented here in chronological order for a given year.

5.6.1a Determine arrival times of wolves to den sites. Many wolves are present at their den sites by May 1st, so monitoring 1-2 weeks before then would be needed. Previously active den sites can be revisited. Although den sites may not be limiting to wolves, selecting the natal or whelping den site appears important. Den sites preferred by wolves should be selected first. If dens in the Zone of Influence of a proposed development are selected at all, they may be occupied at somewhat later dates, assuming constant road activity.

5.6.1b Map wolf den site selection. Mapping den sites that wolves use will help quantify the Zone of Influence of all-weather haul roads and related infrastructure. The frequency of specific den site selection by wolves on a yearly basis will also help measure their site fidelity. Given that the number of active wolf dens in a claim block will likely be low in any given year and that wolves are subject to mortality elsewhere, only major disturbances are likely to be documented (e.g., repeated occurrences of no active den sites).

5.6.1c Counts of pups and adults. If counted at set time intervals, estimates of pup production and wolf density on a claim block can be obtained. An early July pup count would allow an estimate of pup production while an early September pup count would be best to estimate recruitment of pups to the pack. However, it may be difficult to locate the wolf pack at this time, so an early to mid-August pup count would be a reasonable alternative. Demonstrating that wolves can successfully raise pups on the claim block would indicate any potential impacts of mine development and operation are likely minimal. Although only 2 parents are generally required for successful pup rearing, the presence of additional adult wolves at den sites is common in the central arctic and would lend support to a claim of a healthy environment in a claim block area. Keeping track of numbers of adults and coat colors also helps in identifying packs should they re-locate to another den.

5.6.1d Determine den site abandonment. This is difficult to do, especially for unmarked individuals, because the presence of wolves in late summer is related to the occurrence of caribou in the area. However, recent research on wolves in the Lac de Gras area indicates that wolves often occupy the same den until early September. Documenting an early den site re-location or perhaps 2 or more re-locations in a single season would suggest disturbance.

If radio-collared wolves are present on a claim block then greater certainty can be obtained in the data. Industry can capitalize on this in their monitoring for den site re-locations and documenting rendezvous sites. A bi-weekly radio-tracking effort should be sufficient when these conditions exist. Locating radio-collared wolves will reveal a spatial distribution of wolf dens on the claim block that can be monitored or surveyed as in items (1) & (2) once the radio-collars are no longer present. Radio-collared wolves on ae claim block and later legally harvested elsewhere can help elucidate inactive dens in successive years.

5.6.2 Mitigation of possible impacts

It is unknown whether esker surrogates suitable for denning by wolves can be created. Consequently, impact mitigation might be problematic in this instance of supplanting wolves from their den sites unless some new information becomes available. However, mitigation in terms of possible road and quarry selection can be applied should future development on a claim block continue.

5.6.3 Future Research

Because of the current and proposed development of resources in the Slave Geological Province and adjoining areas, public concern is growing towards the cumulative impacts that may occur in this fragile ecosystem. Initial concerns led to the creation of the West Kitikmeot/Slave Study Society and the baseline studies it supported to address the dearth of information for this region. While baseline studies need to continue, there is the added need now for studies that address cumulative effects assessment.

The den site fidelity monitoring effort from the Esker-Wolf study should be continued. Doing so will extend the activity database for a given set of wolf dens. From this multi-year data set, a probability of activity for specific wolf dens can be estimated where mining activity will not likely occur ("control"), is ongoing, or likely to occur in the near future. An inclusive GIS-based land-use planning tool is still needed to resolve or mitigate land use conflicts with wildlife and suggest potential candidate sites for the Protected Areas Strategy.

6.0 LINKS WITH PARALLEL STUDIES

This study complemented several existing studies in the West Kitikmeot/Slave area. The biological information collected will benefit baseline studies for industry and the NWT's Protected Areas Strategy. This study contributed to a Master of Science degree program at the University of Saskatchewan (Walton 2000).

The esker/wolf study worked in conjunction with two concurrent studies - the grizzly bear and wolverine projects - and shared logistics during field work. In addition, having radio-collared caribou track the migration of the Bathurst caribou herd from their calving grounds also helped interpret our wolf movements. A companion esker study that examined the physical characteristics of eskers was also helpful (Traynor and Atkinson 1999). A component of this study was a subproject in 1998 by April Desjarlais (1999) to evaluate wolf den habitat on eskers in the Slave Geological Province. Co-operation between the two projects complemented the data collection and minimized overlap.

We are collaborating with Anne Gunn and have shared our datasets of wolf and caribou movements to investigate patterns of association between predator and prey.

7.0 TRAINING ACTIVITIES AND RESULTS

Training activities included having volunteers accompany L. Walton and D. Cluff in the field to monitor wolves and wolf dens. Tom Lockhart from Lutsel K'e and Noel Doctor from N'Dilo served as observers during radio-tracking efforts in 1997. Only when a Cessna 185 aircraft was used could a second observer participate. Normally, an Aviat Husky aircraft was used because of its slow speed and quiet operation, an important consideration when monitoring active wolf dens. However, this aircraft only accommodated one passenger (behind the pilot), who must also be the radio-signal tracker.

Jason Bantle assisted with den site observations during July 1997 while Martin Catholique, Billy Enzoe, Jonas Lafferty, and Louis Whane assisted in August 1997. In 1999, we tried to involve some elders with the wolf capture operation. Elders were flown by BHP from Yellowknife to the Ekati™ mine site where BHP's helicopter would transport the elders to capture sites that occurred in the BHP claim block area. Unfortunately, BHP's helicopter was not involved because bad weather from high winds prevented the capture team in the second helicopter from safely and efficiently capturing wolves. When the weather improved, the elders had returned to Yellowknife as originally scheduled. Planning field work is complicated especially when many people are involved. When the weather doesn't co-operate, it delays plans and causes frustration or disappointment among participants. We hope the elders understood. We thank BHP and the respective Band Councils for still allowing us to try.

8.0 EXPENDITURES AND SOURCE OF FUNDS

A summary of expenditures and sources of funds is detailed in a separate document.

9.0 SCHEDULES AND ANY CHANGES

Circumstances forced a shift in emphasis of some objectives within the time frame of the WKSS mandate. These circumstances included levels of funding, loss of some collared wolves to the winter fur harvest, and the late availability of habitat classification data from other WKSS projects. However, the shift in emphasis will not preclude achieving the original objectives, but simply delay some of them. The spatial distribution of wolf denning sites (Objective #2) is not as complete as we had hoped, although we are committed to re-visiting this objective. We had hoped to perform a cluster analysis on the spatial distribution of wolf dens but this has been postponed for a year or two. We trust that the additional data we collected in their stead will serve to strengthen the other objectives.

The NWT Wolf Project has taken on another graduate student (Paul Frame) based at the University of Alberta, Edmonton. Mr. Frame will continue the den ecology component of these tundra wolves, with an emphasis on examining factors contributing to den site disturbance by people, mines, and their activities. The spatial distribution of den sites will be examined further here.

We have contributed summary map of our analysis of wolf movement patterns to the NWT Protected AreasStrategy as baseline data for consideration in the protected areas proposal by Lutsel K'e.

Although we are not the holders of TEK, we thought we could collect some important information by hosting a workshop with Aboriginal elders. However, in consultation with the WKSS directorate, we concluded we could not achieve this with available funding, and we agreed with WKSS to drop this component of the study from the outset.

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