Effects of snow depths on seasonal movements and home range distributions of wolves, moose, and woodland caribou in and around Pukaskwa National Park, Ontario, Canada

Graham K. Neale
The University of Montana

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AFFECTS OF SNOW DEPTHS ON SEASONAL MOVEMENTS AND
HOMERANGE DISTRIBUTIONS OF WOLVES, MOOSE, AND
WOODLAND CARIBOU IN AND AROUND PUKASKWA NATIONAL
PARK, ONTARIO, CANADA.

by

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B.A. Warren Wilson College, N.C., 1987

presented in partial fulfillment of the requirements
for the degree of

Master of Science

The University of Montana

2000

Approved by:

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Date
Abstract

The large mammal predator-prey system of the Greater Pukaskwa Ecosystem consists of wolf (Canis lupus), moose (Alces alces), and caribou (Rangifer tarandus caribou). Moose and wolf numbers have increased while woodland caribou numbers have decreased since the late 1800's. Pukaskwa National Park has conducted several studies to determine predator-prey dynamics. Park caribou are clustered mainly along the coastline of the north coast of Lake Superior, and seem to be spatially separated from higher densities of moose and wolves inland. A.T. Bergerud hypothesized that "deep snow" years force inland moose to move to the coast of Lake Superior to take advantage of lower snow depths caused by the "lake effect" and inland wolves follow them. In this scenario caribou would no longer be spatially separated. I found mean distances of moose from the coast of Lake Superior to be significantly shorter in winter ranges (P=0.003), with correspondingly significant movement to lower snow depth zones (P=0.000). However, these results were confounded by the fact that movement in the coastal direction also corresponded with lowering elevation, which also affect snow depths. Analysis of winter range polygons lying outside summer range showed no trends in winter and summer home range overlap (p=0.15) or directional movement in winter home range polygons lying outside summer home ranges (p=0.5). I hypothesize that localized inland habitat offers the same refugia characteristics as the lower snow zones along Lake Superior, and that moose select for low snow depth characteristics closer to summer range. Snow depth surveys support models of snow depth accumulation patterns in the park. Snow depth totals from 1996 and 1997 were two times higher than average, indicating "deep snow" conditions during the study. Aerial surveys, ground tracking and pellet-group count results indicate that densities of all three species are very low. Scat analysis of wolf, lynx, and black bear samples indicate that all three predators consumed adult and juvenile caribou. Relative black bear densities were considerably higher than previously reported, and they were likely a significant predator in this system. White-tailed deer and coyote remains were also found in wolf scats, some in the interior of the park, indicating these animals to be residents.

Woodland caribou (Rangifer tarandus caribou) densities and distributions have declined since 1900 in the southern portion of their range in North America. This decline is due to a complex suite of environmental and anthropogenic factors. Survey methods for caribou in Pukaskwa National Park (PNP) were only recently standardized so comparisons to earlier estimates are difficult. The 1997 PNP caribou survey estimated 20 animals living along the coastal region of the park. Where caribou are declining, wolves (Canis lupus), black bears (Ursus americanus), disease, and poor habitat conditions may all contribute to decreasing densities. The north shore population structure (the Greater Pukaskwa Ecosystem) meets the definition of a metapopulation. This may be due to both poor habitat quality and anthropogenic causes. I documented long-distance migrations across Pukaskwa National Park boundaries to Provincial government lands, connecting habitats managed by different government agencies. Resource extraction activities outside of Pukaskwa National Park should be planned and mediated to minimize negative impacts on extant subpopulations and maximize contiguous habitat between critical areas.
Acknowledgements

As usual in a project of this type there are many people who contribute to its success. I’d like to begin by thanking my parents, Russ and Nancy Neale, and my sisters Erica and Leda, and brother-in-law Robert Yeager for their unending and enthusiastic support of my many endeavors. They have provided wisdom, support, and humor, and helped me understand the way people, and some of the rest of the animals, work. To my niece Isabella, I dedicate this body of work in hopes that it is interesting, inspiring, and actually helps make the world of your future a place filled with the wondrous animals you so love. I want to thank Karmann, my constant canine companion of 12 years, who died in July 1999. Her patience, Zen-like attitude, and surprising sense of humor taught me much about canines, and how to look at life. I will miss her dearly. Thank you to my committee, Drs. Bob Ream, Dan Pletscher, Colin Henderson, and Paul Paquet, for sharing your knowledge, expertise, thoughts, guidance, and passion for wildlife conservation with me throughout this process. To Pat Tucker & Bruce Weide, more thanks than I could ever put to paper. Ever since we met because of Koani coming into our lives, they have been family on this journey through school, career, life, and wolf-dog-people behavior and politics. Their contribution to wolf recovery and human understanding is immense, and they are a constant source of inspiration and guidance to me. And, they know how to laugh! Elise Lawson has been a great friend and helpful colleague for years, beginning in the Kananaskis Country of Alberta and following through to the waters of Lake Superior. Thank you for your help and friendship. Lori Schmidt has been a source of knowledge and strength for me since my beginnings in wolf research. Her understanding of wolf ecology is immense, and her passion for teaching and research is unsurpassed. Our time spent with the captive packs of the International Wolf Center and the Wolf Education and Research Center was exciting, instructive, and inspirational. Wayne Roberts of Air Superior was an excellent pilot and good friend, and provided invaluable skills and intuition without which I couldn’t have completed my field research. My life felt safe in his hands, and we caught a few fish, to boot. The staff of Pukaskwa National Park was very helpful in all aspects of my work, and I certainly couldn’t have completed the project without them. A special thanks to Aunt Bob and Cathy for all the care packages and for sticking by the radio in bad weather; Weideman’s is a long way from the A&W! Dr. Mike Nelson and Dr. Rolf Peterson both provided friendship and many hours of fascinating discussions
about wolf and ungulate relationships. Thank you for the opportunity to work with you and to participate on your individual projects. Dr. Harold Cumming and Gord Eason were very helpful in gaining insight into the woodland caribou of Ontario, and provided constructive ideas as I strove to interpret my research findings. Anne Forshner, fellow grad student and instigator at Pukaskwa, was great to work with and has become a good friend. If only you’d gotten there three years earlier! This type of project requires an immense amount of work, and help from technicians is vital to getting anything done. Technicians Paul Wolf, Monica Pokorny, Nathalie Espuno and Stephanie Schmitz stuck with it through bugs, ice, snow, bugs, rain, heat, bugs, and many, many kilometers of transects. Thank you all for your interest, energy, humor, determination, good ideas, and baking abilities! Paul, I’m still going to get you an Ontario bug suit to replace your Minnesota cheesecloth! Thanks to Mark Johnson, DVM, for the help with blood protocol. Thanks to all who I have neglected to mention that helped make this project a success. And finally, heartfelt thanks go to the wolves, moose and woodland caribou of Pukaskwa National Park and beyond. May our work help us to understand our place in our world, and allow you to keep a healthy home ad infinitum.
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INTRODUCTION

Pukaskwa Predator Prey Process Project background

Pukaskwa National Park (PNP) was created in 1983, and is comprised of 187,800 ha of boreal forest on the north shore of Lake Superior (Fig. 1). Forests surrounding PNP belong to the provincial government (Ontario Ministry of Natural Resources) and contain large stands of hardwoods and conifers, as well as extensive gold and mineral deposits.

PNP Resource Specialists considered resource extraction activities surrounding the park extensive enough to warrant further study of the effects in the park ecosystem and its biotic components. In addition to habitat concerns, predator-prey dynamics among wolves, moose, and caribou were also identified as needing further study (Bergerud et al. 1983; Bergerud and Snyder 1988; Thompson and Peterson 1988). Woodland caribou inhabiting the north shore of Lake Superior had been identified as a species of concern before Pukaskwa National Park was created (Bergerud 1974).

Concern about lack of knowledge regarding ecosystem dynamics and cumulative effects of resource extraction outside PNP and vegetation management in the park led to changes in the park's management plan. The park's first two management plans called for monitoring and collaring caribou (Parks Canada 1982; Parks Canada 1996). Projects followed to attempt to estimate numbers and distribution over time. A Greater Park Area (GPA) was designated and encompasses 10,000 km², including the Park. This term was later changed to Greater Park Ecosystem (GPE, Skibicki 1994) to reflect an ecological focus on management of the area. Nearby mines, timber harvest activities in the Black River and White River forests, and associated road systems are included in this area (Fig. 2).

The park hired Geomatics International to formulate an Ecosystem Conservation Plan (1996), in which "insularization" of the park was identified as a threat to long-term ecosystem integrity. A partnership was formed with the Ontario Ministry of Natural Resources (OMNR), Hemlo Mining, Heron Bay Band of the First Nations, Domtar, and Parks Canada to initiate cooperative management of the GPE. PNP then developed a 5-year research program to study the cumulative effects of resource extraction outside the park and ecosystem processes in the GPE. Dr. Paul Paquet, of John/Paul & Associates Consulting is the Principle Investigator. Masters of Science students came from the University of Montana, Acadia...
University in Nova Scotia and Lakehead University in Thunder Bay, ON. PNP provided housing and logistical support.

The goals of the project (Burrows and Cherepak 1994) seek to identify the potential impacts of land-use and wildlife management activities inside and outside the park on the Pukaskwa predator and prey relationships. The predator and prey process chosen was primarily that of the wolf, moose and caribou system. Specific questions addressed were:

1. What are the natural and human land-use features that facilitate or impede predator and prey movements e.g. roads, snow depths, corridors?
2. How do the altered dynamics of patch-size, geometry and juxtaposition of habitats affect predator and prey relationships (e.g. clearcut size, habitat quality, stand/age condition).
3. How do wildlife population management objectives in and outside of the park affect predator and prey relationships?
4. What are the interactions between 1, 2 and 3?

Thesis organization

This thesis is organized as chapters covering discreet topics. In Chapter 1, Introduction, I provide a brief account of the initiation of the Pukaskwa Predator Prey Process Project (P5). In Chapter 1, Testing the Spatial Separation Hypothesis with Wolf, Moose and Caribou Seasonal Home Ranges and Variable Snow Depths I describe 3 types of wolf, moose and caribou systems and how they relate to the PNP system. I describe hypotheses to test these relationships and perform seasonal range analyses are relative to the spatial separation hypothesis (SSH), snow depths and habitat. In Chapter 2, Caribou Demographics and Spatial Organization, I present evidence from my research results and previous studies for an existing caribou metapopulation structure. Predation, disease, and management implications are discussed.
Location of Pukaskwa National Park, Ontario, Canada

a) Greater Ecosystem
Boreal Forest and Lake Superior Basin

b) Greater Park Ecosystem

b) Superior Algoma Central Railway

Pukaskwa National Park

Lake Superior
Road and Trail Network, Historical Logging, and Mining Activities in the Greater Pukaskwa Ecosystem

Peninsula Road

Marathon

White Lake Provincial Park

Hemlo Gold Mine (Williams Operating Corporation, Battle Mountain Gold, and Teck Resources Ltd.)

Metastation Provincial Park

Leased Harvested Pre 1960

Ifrevest 1960-69

Active or Former Mining Sites

Aggregate Pit

Major Highway

Transmission lines, trails, secondary roads and logging roads (up to and including 1994)

Pukaskwa National Park

Obatanjo Provincial Park

Eagle River Mine (River Gold Mines Ltd.)

George W. MacLeod Mine (Algoma Steel Corp.), Surtuga and Jubilee Mines (Clayton Gold Mines Ltd.)

& Wawa Gold Mines Gold Mines Ltd.

Prepared by: Parks Canada

Pukaskwa National Park

1998

L. Parent
Chapter One: Testing the Spatial Separation Hypothesis with Wolf, Moose and Caribou Seasonal Home ranges and Variable Snow Depths in Pukaskwa National Park, Ontario

ABSTRACT

The large mammal predator-prey system of the Greater Pukaskwa Ecosystem consists of wolf (*Canis lupus*), moose (*Alces alces*), and caribou (*Rangifer tarandus caribou*). Moose and wolf numbers have increased while woodland caribou numbers have decreased since the late 1800’s. Pukaskwa National Park has conducted several studies to determine predator-prey dynamics. Park caribou are clustered mainly along the coastline of the north coast of Lake Superior, and seem to be spatially separated from higher densities of moose and wolves inland. A.T. Bergerud hypothesized that “deep snow” years force inland moose to move to the coast of Lake Superior to take advantage of lower snow depths caused by the “lake effect” and inland wolves follow them. In this scenario caribou would no longer be spatially separated. I found mean distances of moose from the coast of Lake Superior to be significantly shorter in winter ranges than summer ranges (P=0.003), with correspondingly significant movement to lower snow depth zones (P=0.000). However, these results were confounded by the fact that movement in the coastal direction also corresponded with lowering elevation, which also affect snow depths. Analysis of winter range polygons lying outside summer range showed no trends in winter and summer home range overlap (p=0.15) or directional movement in winter home range polygons lying outside summer home ranges (p=0.5). I hypothesize that localized inland habitat offers the same refugia characteristics as the lower snow zones along Lake Superior, and that moose select for low snow depth characteristics closer to summer range. Snow depth surveys support models of snow depth accumulation patterns in the park. Snow depth totals from 1996 and 1997 were 40% – 50% higher than average, indicating “deep snow” conditions during the study. Aerial surveys, ground tracking and pellet-group count results indicate that densities of all three species are very low. Scat analysis of wolf, lynx, and black bear samples indicate that all three predators consumed adult and juvenile caribou. Relative black bear densities were considerably higher than previously reported, and they were likely a significant predator in this system. White-tailed deer and coyote remains were also found in wolf scats, some in the interior of the park, indicating these animals to be residents.
INTRODUCTION

Prior to 1900, the primary large mammal predator-prey system along the north coast of Lake Superior was wolf and woodland caribou (Clarke 1938, Snyder 1938, Snyder et al. 1942, deVos and Peterson 1951). That began to change around the end of the 1800's as forest resource extraction gained importance to an expanding human population. Due to a combination of a dramatic increase in availability of early-successional forage and natural range expansion, moose began to colonize the north coast boreal forest at the end of the 1800's (Bergerud 1974a, Peterson 1955). This provided an increase in available biomass to wolves, and their numbers began to increase (Bergerud et al. 1983; Bergerud 1988; Cumming et al. 1996).

Habitat changes that benefited the wolves and moose were detrimental to the woodland caribou (Cummings 1992). First railways, then later highways began to penetrate the northern forests and increased hunting and poaching (Ontario protected woodland caribou in 1928) to feed labor camps severely reduced local populations of caribou. Habitat fragmentation from roads, settlements, and timber harvest reduced winter range and associated lichen forage (Cummings 1992). This type of habitat attracted white-tailed deer (*Odocoileus virginianus*) and an associated parasite, *Parelaphostrongylus tenuis*. This meningal nematode adversely affected both caribou and moose populations, and is considered a factor in woodland caribou decline throughout the deer/caribou interface (Cumming and Beange 1993). Wolf predation continued to be a factor in caribou decline as wolf numbers increased in response to an increase in moose density. Habitat alteration on a large scale may have increased black bear (*Ursus americana*) populations and predation, particularly on calves. The combination of these factors contributed to a rapid decline in range and distribution of woodland caribou in the Great Lakes region (Darby et al. 1989).

Parks Canada created Pukaskwa National Park (PNP) in 1973, although front country infrastructure wasn’t completed until 1983. The park planned to develop over 400-km of hiking trails, a hotel, and a road into the center of the park to access planned campgrounds. Construction of the Coastal Hiking Trail began and 40 km of trail was constructed from Hattie Cove to the North Swallow River. During construction, concerns were raised about increasing both human and wolf access to the bands of caribou that lived along the coast and within the park (F. Burrows, pers. comm.). Construction was halted and research begun to gather more information. Attention focused on the wolf-moose-caribou system as a
way of exploring the habitat fragmentation and trans-boundary issues facing the park. These mammals utilized large areas and were of economic and conservation interest to both Parks Canada and to the Ontario Ministry of Natural Resources (OMNR). See Appendix A for PNP Faunal Investigations bibliography.

Bergerud (1974, 1989) began gathering data on wolf, moose, and caribou distribution, densities, and population dynamics in Pukaskwa National Park. He also postulated that snow depths in PNP, with the highest snow levels in Ontario (Findlay 1973), played an important role in predation by wolves. Bergerud (1985) believed that caribou avoided inland areas of the park and stayed within the rugged coast region, with moderate quality forage, to avoid wolf predation. Moose densities were highest in the northeastern section of the park/OMNR land where fires and cutovers provided substantial amounts of early-successional forage. Wolves were attracted to these high moose density areas and thereby created low wolf densities along the coast, thus reducing predation pressure on the caribou. Bergerud postulated that this spatial separation, effectively a result of caribou anti-predator behavior, and the rough terrain of the peninsulas and islands reduced predation pressure on the caribou.

Bergerud believed that this spatial separation changed in winters of heavy snow accumulation. The combination of the “lake effect” and the rapid increase in height of land created lower snow depths nearer the coast of Lake Superior and higher depths farther inland. Wolves, moose, and caribou have different snow loading ratios and are variably affected by snow depth and snow pack and characteristics. When snow depths are greater than 67 cm, movement is inhibited and moose can become more vulnerable to predation (Kelsall and Telfer 1971). Moose could reduce this risk by moving to the coast in heavy snow years to take advantage of the lower snow depths there. Wolves in turn would follow their main prey base. The three species are then no longer spatially or temporally separated, and caribou become vulnerable to wolf predation (Haber 1977; Holleman and Stephenson 1981; Bergerud 1985; Bergerud and Elliot 1986; Seip 1992). Search times would decrease greatly and under these conditions, Bergerud (1985) predicted that caribou could become extinct in Pukaskwa National Park. Bergerud (1985) stated that an initial condition for this scenario was high caribou densities, although he did not define “high”.

Three mechanisms seem to contribute to reduction of caribou associated with moose. First, in systems where caribou are more abundant than moose, wolves will opportunistically prey on caribou (Bergerud and Elliot 1986). Second, in systems where moose densities are high and caribou numbers low,
wolves will opportunistically prey on caribou and possibly drive them to extinction or suppress population growth. This situation is sometimes referred to as a “predator pit” (Seip 1992). Thirdly, in systems where moose and caribou densities are low, opportunistic predation on caribou will eventually eliminate caribou (Bergerud 1989).

Many aspects of predator-prey dynamics, population dynamics, and animal behaviour effect this system. Other important aspects are seasonal forage availability and quality for both moose and caribou, home range and migration route philopatry, and the importance of other predators such as lynx (*Felis canadensis*), black bear, and coyote (*Canis latrans*).

I formulated my hypotheses by building on information from previous studies relating to animal distribution and snow depths. Bergerud (1989) provided data on animal distribution and behaviour. Findlay (1973) designed a model for total snow fall zones based on topography and distance from the coast. This model had not been tested, however, so I designed a sampling scheme to test the zone delineation and the general robustness of the model. I then used this model to test for effects of snow depths on seasonal moose movements.

**HYPOTHESES**

**H1**: Moose migrate to the coastal zone in winters of heavy snowfall.

**H2**: Wolves migrate to the coastal zone in winters of heavy snowfall.

**H3**: Caribou and moose are spatially and/or temporally separated along the coast in winters of heavy snowfall.

**H4**: Wolves are selecting for caribou in the coastal zone in winters of heavy snowfall.

**STUDY AREA**

*Land use*

The Greater Pukaskwa Ecosystem (GPE) (including Pukaskwa National Park) is on the northeastern coast of Lake Superior and is classified as Central Boreal Uplands (Poitevin *et al.* 1989). Ontario Ministry of Natural Resources administers Wildlife Management Unit (WMU) #33, which surrounds the park to the north and east. The Wawa Crown Unit is a roadless area abutting the park to the
east. It forms a coast corridor 10 km wide that has been unofficially protected in the last two 5-year timber management cycles for caribou habitat, and as a travel corridor between Pukaskwa National Park and Lake Superior Provincial Park.

Land use north and northeast of the park is dominated by timber and mineral extraction. Road systems and cutovers are extensive, and provide access into many remote areas near the park boundary. A hydroline corridor bisects the northeastern corner of the park.

**Topography**

The elevation of Lake Superior is approximately 200 meters. The highest land in the park is Tip Top Mountain, at 640 meters. The Coast Hills regional topography is characterized by mountains interspersed with creeks, rivers, bogs, muskegs and lakes (Skibicki 1994). Cliffs and escarpments are present throughout this region. This area is usually the first to receive snowfall and the last to lose snow cover and have ice-free lakes. The Coast Hills ecodistrict gives way to the Bremner Uplands to the northeast. This area has some sharp relief, but is characterized by rolling hills, meandering creeks, river plains, meadows and the largest lakes in the park. The Bremner Uplands give way further inland to the Widgeon Uplands region in the northeast section of the GPE.

**Climate**

The north coast climate is an interface between maritime weather patterns along the coast and continental weather patterns inland. Maritime weather influences roughly a 15-km strip inland. In the winter this combination produces the highest snowfall in Ontario (Thomas 1964). Mean annual precipitation along the coast is 737 mm and 644-mm inland. Average winter and summer temperatures range from -13°C to 14.6°C, respectively for the coast area and -17°C and 15.9°C, respectively, inland (Poitevin et al. 1989).

Annual precipitation ranges from 74 to 109 cm, with the lowest amounts measured at the lakecoast and at distances of 64 km or more inland, the highest values being measured short distances inland on steeply rising ground.
Snow Cover

Findlay (1973) described three main principles when assessing the precipitation regime of Pukaskwa National Park. First, a general pattern holds that precipitation increases as the land surface rises and moist maritime air masses are forced upwards as they move inland. Second, winter precipitation from maritime air masses generally increases when it comes into contact with the coastline, but decreases at greater distances inland from the lake. Thirdly, very heavy precipitation may be expected on progressively rising land surfaces, particularly at abrupt elevation rises. Shadow effects are common on leeward sides of ridges, with turbulent airflow creating spillover zones of snowfall into valleys.

Ice cover on Lake Superior can range from 5% to 100% from year to year (Skibicki 1994).

Environment Canada collected snow depth data at Terrace Bay and Wawa, Ontario (Environment Canada database 1999). These data were used to compare the study winters' snow depths to average measurements for the study area.

Biotic Components

Two distinct regions exist in the GPE; the rugged coast topography and the flatter inland plateau that is higher in elevation. Vegetation in both areas is mixed with associations of balsam fir (Abies balsamea), black spruce (Picea mariana), white spruce (P. glauca), jack pine (Pinus banksiana), white birch (Betula papyrifera), and quaking aspen (Populus tremuloides) (Poitevin et al. 1989). Jack pine, white birch, white spruce, and black spruce with occasional red maple (Acer rubrum) dominate the coast region.

Wolves are the primary large carnivores in the GPE. The size of the black bear population is unknown, but bears are omnipresent throughout the GPE. Lynx (Felis canadensis) occur at low densities throughout the study area. Coyotes (Canis latrans) are becoming common near population centres.

Several unconfirmed sightings of mountain lions (Felis concolor) have been recently reported in the Wawa district to the east of the GPE (Eason, pers. comm.), and several confirmed sightings have been reported in northern Minnesota (L. Schmidt, pers. comm.). No mountain lion sightings have been reported in the GPE.
Potential prey species for wolves inhabiting the study area are moose (*Alces alces*), caribou (*Rangifer tarandus caribou*), snowshoe hare (*Lepus americanus*), and beaver (*Castor canadensis*). Whitetail deer (*Odocoileus virginianus*) occur occasionally.

Small mammals include southern red-backed vole (*Clethrionomys gapperi*), meadow vole (*Microtus pensylvanicus*), deer mouse (*Peromyscus maniculatus*), southern bog lemming (*Synaptomys cooperi*), and red squirrel (*Tamiasciurus hudsonicus*).

Other species include American marten (*Martes americana*), fisher (*M. pennanti*), mink (*Mustela vison*), river otter (*Lutra canadensis*), red fox (*Vulpes vulpes*), and weasels (*Mustela spp.*)

**METHODS**

*Hypotheses Overview*

**H1:** Are moose migrating to the coast zone in winters of heavy snowfall? Twenty-five moose were radio-collared in the Greater Pukaskwa Ecosystem (GPE) in March 1995. Four of these were captured within 3 km of Lake Superior, and were used in my study. An additional 10 moose were collared in the Otter Cove area within 3 km of Lake Superior in February 1996. Telemetry data were analyzed to test for migration to the coast, and for movement between snow zones.

**H2:** Do wolves migrate to coast zones in winters of heavy snowfall? P5 radio-collared wolves in 5 packs between 1994 and 1997 ranging from the coast to approximately 200 km inland. I compared coastal packs’ and inland packs’ seasonal homeranges to test for wolf pack migration towards Lake Superior.

**H3:** Are caribou and moose spatially separated along the coast in winter? I analyzed data from aerial telemetry, winter snow transect surveys, and spring/fall pellet group counts along the coastal zone to determine presence or absence and distributions of moose and caribou.
If wolves follow moose to the coast zone in winter, do they then select for caribou? I planned to compare relative densities of moose and caribou to percentages of prey species found in scats (as identified by hair) and kills.

Capture and handling

Wolves

Fourteen wolves representing 5 packs were collared between 1994 and 1997. Pack size, distribution, kills and travel routes were recorded during flights. Homeranges were estimated using Ranges V® software (Kenward and Hoddar 1996). I organized packs into two categories, inland and coastal. I documented visual wolf sightings and travel routes for the Swallow River pack prior to collaring. Ground searches during summer trapping efforts documented presence of wolves and pack numbers by tracks and scats.

The White River pack was monitored from 1994 to 1996, the Rein Lake pack from 1994 to February 1996, the Black River pack in 1994 and 1995, the Cascade pack for six months in 1995, and the Swallow River pack from April 1997 to October 1997. I used telemetry data gathered during the 1.5 years that I participated in monitoring all wolf packs.

All capture and handling operations were approved by a Parks Canada Animal Care Committee prior to field operations. We used either Helicopter Wildlife Management (575 E. 4500 S, Salt Lake City, UT 84107), or formed our own team comprised of PNP and WMCEP personnel to net-gun wolves. We used a Hughes 500 helicopter, and a 30-06 gun configuration firing blanks with cup-mounted nets. A spotting plane was used for reconnaissance when possible.

We trapped wolves along roads and trails in areas closed to public access or posted with appropriate signs. Wolves were captured in Newhouse® or McBride Number 14 OS traps (Woodstream® Corp.) in blind sets, with lures or bait. To reduce injuries, traps were modified with 1.8 cm offset jaws, rubber jaws, drag chain spring, and a swivel attachment of the drag chain. We used spring tensioned pans (M-Y Enterprises) to limit the capture of smaller, non-target species.

I immobilized wolves with Telazol® [teletamine hydrochloride (HCL) and zolzepam HCL, A.H. Robbins Co., Richmond, Va.]. I administered the drugs intramuscularly by jab stick. Captured animals
were examined for injuries, sexed, weighed, measured, and a blood and fecal sample were taken. Colored plastic ear tags were placed in the left ear of females and the right ear of males. We estimated age from tooth eruption, tooth replacement, and tooth wear (Bekoff and Jamieson 1975). All wolves were equipped with conventional VHF collars (Lotec®, Aurora, ON).

Blood serum and fecal material (Appendix B) will be used for virological, parasitological, and genetic analysis. Whole blood samples were forwarded after each capture to K. Strobeck, University of Alberta, Department of Zoology. Serology analysis is being performed by Ian Barker, Canadian Cooperative Wildlife Health Centre (CCWHC), University of Guelph. Doug Campbell, also of the CCWHC, performed necropsies on wolves that died or carcasses collected during the study.

**Moose and Caribou**

Ten female moose were radio collared near Otter Cove, PNP in January 1995. Females were selected for their smaller size and therefore greater sensitivity to snow depths, and to estimate fecundity. Helicopter Wildlife Management (HWM) performed capture operations using net guns. Blood, hair, and fecal samples were collected from captured animals. All animals received appropriate dosages of Liquamycin LA (1cc/10 kg, maximum 7cc/injection site) and Selenium/Vitamin E (1cc/90 kg). We restrained animals immediately upon capture with leg ties, blindfolded them, and attached the radio collar (Appendix C for methods used on both moose and caribou).

In 1995, salt-baited corral traps were used to capture caribou. We affixed radio transmitters to trap doors, which allowed remote monitoring of corrals. Each frequency represented a different trap so we could identify individual corrals. This system worked well and reduced trap time for captured animals and down time for prematurely released doors. No caribou suitable for collaring were captured.

Five caribou were radio collared near Otter Cove, PNP, in February 1996. Handling methods were the same as in moose capture (Appendix C).

**Biotelemetry data**

I collected information about caribou, moose, and wolf travel patterns, spatial relationships, and food habits by aerial radio-telemetry and snow tracking. Radio-collared animals were located from the air.
using a portable receiver (Lotek® SRX-400), a right-left switchbox, and paired 3-element Yagi antennae attached to a helicopter or fixed-wing aircraft.

All marked animals were located at least once per week, with an average of 4.5 flights per month. I attempted to get a visual confirmation of the animal both to confirm the location as well as to identify individuals, young, and wolf kill species.

A Garmin® aviation GPS was used to record the Universal Transverse Mercator (UTM, North American Datum 1927) coordinate, date and time, number of pack or herd members, any young present and for wolves the color of pack members observed.

Seasonal home range movements

Wolves

I divided location data into seasons using 1 May through 31 October and 1 November through 30 April as summer and winter partitions, respectively. These partitions were based on seasonal wolf activity patterns, which were greatly influenced by the pup-rearing season in summer. Partitions were compared using Ranges V® software (Kenward and Hoddar 1996) to identify seasonal home ranges. I used fixed kernel for a conservative estimate of home range size (Kenward, pers. comm.) with a grid cell size of 40 x 40 and Least Squares Cross Validation as the smoothing factor (Kenward and Hoddar 1996:40).

Moose

I treated each moose as a replicate. Telemetry data points were stratified into summer and winter seasons the same as wolves. I used moose movements to define when each animal moved to or from winter or summer range. Seasonal partitions were compared using Ranges V® homerange software (Kenward and Hoddar 1996). I used fixed kernel for a conservative estimate of home range size (Kenward, pers. comm.) with a grid cell size of 40 x 40 and Least Squares Cross Validation as the smoothing factor (see Kenward and Hoddar 1996:40).

Only one collared moose winter range overlapped the Otter Island collared caribou winter range (4 of 5 collared caribou wintered on or near Otter Island). I plotted the results of moose m9522’s home range
analysis (using the method described for wolves) over the Otter Island locations and position relative to the mainland to determine its relation to the Otter Island winter range.

*Caribou*

I treated each caribou as a replicate. Caribou seasonal home ranges were calculated in the same manner as the moose.

**Snow depth zones**

Findlay’s snow depth model (Fig. 1.1) had never been tested. I devised a sampling scheme to measure snow depths for the first 8 zones running inland from the coast (Fig. 1.2). The first three were accessed in the Hattie Cove area (Section One) and the last five in the Otter Cove area (Section Two). Transects were laid out with sampling plots every 100 m. I determined transects by drawing a compass line through all zones, perpendicular to the coastline, and placed plots every 100 m. I sampled each transect the same day when possible.

I recorded plot locations using a Garmin® rover unit. Sampling occurred between late January and early February of each winter, and every effort was made to collect the 1997 data on the same date as the previous year. Values for each plot were an average of four samples, taken at arm’s reach in the four cardinal directions as determined by a hand-held compass. Canopy cover affected snow depth on the ground. I reduced this variation by stratifying each plot into Open (0%-33%), Moderate (34%-66%) or Closed (67%-100) categories, sampling each category equally within each zone. Canopy categories were determined by estimating the amount of closure within a five-meter radius of plot center. The same person sampled within each transect to reduce observer variation.

I sampled 7 plots per zone in the 1996 field season for a total of 56 plots per transect. This low sample size resulted in a high standard deviation. I addressed this in 1997 by increasing the sampling size to 21 plots per zone for a total of 168 samples per transect.
Snow Track Survey Routes in the Otter Cove Study Site

Legend
Total Annual Snowfall (mm)
- 2800 - 3000 mm
- 3000 - 3200 mm
- 3200 - 3400 mm
- 3400 - 3600 mm
- 3600 - 3800 mm
- 3800 - 4000 mm
- 4000 - 4200 mm

Transects surveyed in 1996
Transects surveyed in 1996 and 1997

Prepared by: Parks Canada
Pukaskwa National Park
1998 L. Parent
Spatial Separation Analysis

Seasonal home range relative to coastline and snow depth analysis

A general linear model (GLM) ANOVA was used to analyze seasonal differences in moose locations relative to the coastline and snow depth zones. The study design was a fully nested block design with Years (random) within Seasons (fixed) within Moose Number (random). I normalized the distance data using the square root transformation, but did not need to transform the data for the snow zone analysis. I used alpha = 0.05 for analysis. This design tests for differences between seasons and between seasons within years. I ran the analysis using the DISTCST (distance from coast) and SNOWRNGE (snow depth zone) variables with values calculated using SPANS GIS and weekly telemetry locations.

Winter and Summer Range Overlap

A total of 24 moose seasons (12 moose, 2 seasons) were analyzed using a binomial table. I compared the number of winter ranges lying within summer range to the number that was outside the summer range boundary. At least 75% percent of the winter locations had to be inside the polygon formed by 100% of the summer range locations to be considered in. I chose 75% because I felt that 50% was not concentrated either in or out, and 100% was too stringent to account for a smaller number of locations outside the summer range polygon. I then used the same technique to test those winter ranges lying outside summer range for a significant number moving to the coast. I used a binomial test to determine the significance of the number of non-overlapping seasonal ranges among moose, and the direction of movement between seasonal ranges (towards the Lake Superior coast or away).

Relative use index track-intersect surveys

Woodland caribou in Pukaskwa National Park live in small bands characterized by a clumped distribution (Bergerud 1989), and can be difficult to detect. I designed a sampling scheme to search systematically for tracks of wolves, moose, and caribou in the Otter Cove region of the study area to augment aerial surveys (Figure 1.2).
I found very few tracks in 1996 (n=12) and none in 1997, so no analysis was possible for relative use. These surveys confirmed very low densities of these species in the study area. See Appendix D for details on the sampling methods.

Scat analysis

I collected 55 scat samples in the coast area during field seasons between 1995 and 1997 (Appendix E for complete database). I also collected approximately 150 samples inland. I identified and collected each sample, and labeled it with an identification number, date, UTM coordinates, species, and general location. Coast samples were of wolf (n=44), black bear (n=3) and lynx (n=8). Big Sky Laboratories (PO 0776, Florence, MT 59833-0776) completed the analyses. Each scat was autoclaved, washed and then sorted to identify contents. Hair, teeth, claws and hooves were identified to species. Ungulates were identified as adult or juvenile. Tally categories were moose, caribou, deer, beaver, snowshoe hare, coyote, bear, wolf, small mammal and other.

RESULTS

Hypotheses 3 and 4 were discarded after it became apparent that the majority of moose and caribou were spatially separated in the coastal zone during winter. One collared moose (8%) overlapped the winter range of caribou on Otter Island, and statistical spatial analysis was not applicable. One wolf passed through the study area in the two winter field seasons, and no wolf predation on caribou was documented during that time.

Wolves

Capture results

Individuals in 5 packs were radio collared within the GPE between 1994 and 1997 (Table 1.1). The packs were named after prominent geographic features in their territories. They were: the Black River pack, the White River pack, the Rein Lake pack, the Cascade Lake pack, and the Swallow River pack. Where applicable, the names were chosen to match those that Bergerud cited in his study (Appendix F for description of trapping effort in park interior). Due to mortalities and access difficulties, some gaps exist in concurrent databases where packs were not collared for a period of time or disappeared altogether (Cascade pack).
Trapping began for the inland packs in August of 1994. Three packs were identified: the Black River pack, the White River pack, and the Rein Lake pack. Two adult females in the Cascade Lake pack were fitted with radio collars in June of 1995 and followed as per the weekly sampling regime. They were dead by January 1996, one (w9577) from starvation, and the other (w9576) from unknown causes. W9576 died at a remote drilling camp (590624 E, 5322224 N) that was inhabited at the time. No carcass was found, only large quantities of hair and some bone. Well-used wolf trails and large quantities of scat indicated this was a high use area, and because garbage was present and this was the eastern-most boundary of the Cascade pack’s territory, more than one pack may have been using the area. The collar was recovered and was heavily chewed. The collar was found about 0.5 km outside the eastern park boundary.

No further pack activity was observed in the area for the remainder of the winter, and extensive sign searches the next summer and fall failed to turn up evidence of wolves using the area.

Visuals of five animals were made near the Swallow River on two occasions during routine telemetry flights in the winter of 1996/1997. On April 8th, we captured an adult male wolf (w9738, black), and upon relocation the next day captured two more males (w9739, light gray adult, and w9740, black subadult) in the Swallow River pack. W9740 went off the air in May 1997.

Table 1.1 Data on radio collared wolves of the P5 project, in order of capture date. Data shared by subprojects.

<table>
<thead>
<tr>
<th>Wolf Name</th>
<th>ID Number</th>
<th>Sex</th>
<th>Weight in kg</th>
<th>Age in Years</th>
<th>Pack Affiliation</th>
<th>Capture Date</th>
<th>Color</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aldo</td>
<td>W9402</td>
<td>M</td>
<td>36.5</td>
<td>3</td>
<td>Black River</td>
<td>26 Aug 94</td>
<td>Tan</td>
<td>Dispersed/Living</td>
</tr>
<tr>
<td>Nelie</td>
<td>W94269</td>
<td>F (breeding)</td>
<td>29.0</td>
<td>8</td>
<td>Black River</td>
<td>20 Aug 94</td>
<td>Grey</td>
<td>Died Oct 94</td>
</tr>
<tr>
<td>Sam</td>
<td>W94371</td>
<td>M</td>
<td>12.5</td>
<td>YOY</td>
<td>Black River</td>
<td>22 Aug 94</td>
<td>Grey</td>
<td>Dispersed/Living</td>
</tr>
<tr>
<td>Paulina</td>
<td>W9452</td>
<td>F</td>
<td>28.0</td>
<td>2-4</td>
<td>White River</td>
<td>16 Aug 94</td>
<td>Tan</td>
<td>Dispersed/Died</td>
</tr>
<tr>
<td>Cassidy</td>
<td>W9453</td>
<td>F (breeding)</td>
<td>32.0</td>
<td>4-6</td>
<td>Rein Lake</td>
<td>30 Sept 94</td>
<td>Grey</td>
<td>Dead Feb 97</td>
</tr>
<tr>
<td>Mojo</td>
<td>W9405</td>
<td>M</td>
<td>32.0</td>
<td>2-4</td>
<td>Rein Lake</td>
<td>3 Oct 94</td>
<td>Tan</td>
<td>Dispersed/Died</td>
</tr>
<tr>
<td>Solita</td>
<td>W9576</td>
<td>F</td>
<td>25.0</td>
<td>4-6</td>
<td>Cascade Lake</td>
<td>15 Jul 95</td>
<td>Black</td>
<td>Died Dec 95</td>
</tr>
<tr>
<td>Mika</td>
<td>W9577</td>
<td>F</td>
<td>25.0</td>
<td>4-6</td>
<td>Cascade Lake</td>
<td>20 Jul 95</td>
<td>Black</td>
<td>Died Feb 96</td>
</tr>
<tr>
<td>Ana</td>
<td>W9587</td>
<td>F</td>
<td>35.0</td>
<td>4-6</td>
<td>White River</td>
<td>29 Aug 95</td>
<td>Tan</td>
<td>Dispersed/Died</td>
</tr>
<tr>
<td>Star</td>
<td>W96**</td>
<td>M</td>
<td>*</td>
<td>6-8</td>
<td>Rein Lake</td>
<td>16 Feb 96</td>
<td>Tan</td>
<td>Died Feb 97</td>
</tr>
<tr>
<td>Moon</td>
<td>W96**</td>
<td>F</td>
<td>37.0</td>
<td>7-9</td>
<td>White River</td>
<td>18 Feb 96</td>
<td>Silver</td>
<td>Alive</td>
</tr>
<tr>
<td>Mk</td>
<td>W9738</td>
<td>M</td>
<td>Est. 57.0</td>
<td>5-7</td>
<td>Swallow R.</td>
<td>8 Apr 97</td>
<td>Black</td>
<td>Alive</td>
</tr>
<tr>
<td>Hale</td>
<td>W9740</td>
<td>M</td>
<td>Est. 36.0</td>
<td>2-3</td>
<td>Swallow R.</td>
<td>9 Apr 97</td>
<td>Tan</td>
<td>Unknown</td>
</tr>
<tr>
<td>Luz</td>
<td>W9739</td>
<td>M</td>
<td>Est. 40.0</td>
<td>5-7</td>
<td>Swallow R.</td>
<td>9 Apr 97</td>
<td>Black</td>
<td>Alive</td>
</tr>
</tbody>
</table>
Mortality

P5 wolves died from many causes, both natural and human-caused (Table 1.2). As would be expected, mortality was higher outside the park where human-caused deaths from automobiles, trains, trapping, and shooting occurred.

Table 1.2 P5 cause-specific wolf mortalities by pack

<table>
<thead>
<tr>
<th>Wolf Name</th>
<th>ID Number</th>
<th>Sex</th>
<th>Age at Death</th>
<th>Pack Affiliation</th>
<th>Date of Death</th>
<th>Disperser (Y or N)</th>
<th>Cause of Death</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nelie</td>
<td>W94269</td>
<td>F</td>
<td>~8.5</td>
<td>Black River</td>
<td>Oct 94</td>
<td>N</td>
<td>Starvation</td>
</tr>
<tr>
<td>Paulina</td>
<td>W9452</td>
<td>F</td>
<td>~3.9</td>
<td>White River</td>
<td>Mar 95</td>
<td>Y</td>
<td>Train</td>
</tr>
<tr>
<td>Cassidy</td>
<td>W9453</td>
<td>F</td>
<td>~5.8</td>
<td>Rein Lake</td>
<td>Feb 97</td>
<td>N</td>
<td>Unknown</td>
</tr>
<tr>
<td>Mojo</td>
<td>W9405</td>
<td>M</td>
<td>~3.8</td>
<td>Rein Lake</td>
<td>Feb 95</td>
<td>Y</td>
<td>Blastomycosis</td>
</tr>
<tr>
<td>Sotila</td>
<td>W9576</td>
<td>F</td>
<td>~5.5</td>
<td>Cascade Lake</td>
<td>Dec 95</td>
<td>N</td>
<td>Unknown</td>
</tr>
<tr>
<td>Mika</td>
<td>W9577</td>
<td>F</td>
<td>~5.7</td>
<td>Cascade Lake</td>
<td>Feb 95</td>
<td>N</td>
<td>Starvation</td>
</tr>
<tr>
<td>Ana</td>
<td>W9578</td>
<td>F</td>
<td>~6.5</td>
<td>White River</td>
<td>Nov 96</td>
<td>N</td>
<td>Trapped</td>
</tr>
<tr>
<td>Star</td>
<td>W9607</td>
<td>M</td>
<td>~8.8</td>
<td>Rein Lake</td>
<td>Feb 97</td>
<td>N</td>
<td>Injury, UK</td>
</tr>
</tbody>
</table>

Spatial Separation Analysis

Since one pack disappeared and I could not collar animals in the Swallow pack until late in my study, I do not have telemetry data to use for analysis. I do have presence or absence data from observations made during weekly moose and caribou telemetry flights and the moose and caribou survey flights. Wolf activity along the coast was non-existent or very limited during the winter months when tracks were visible. One set of tracks was found in Otter Cove in February 1996, and one set was documented on Oiseau Creek in January 1996. An adult collared male (w9607) from the Rein Lake pack made two short-term excursions to the Oiseau Bay area and then returned to the Rein Lake territory.

In 1997 I made many observations of tracks in the Swallow pack’s territory, and had two visual sightings of the entire pack. They traveled almost exclusively on rivers and lakes at a distance of at least 5 km inland from the coast.

Population estimates

Wolf population estimates were derived from non-systematic observations made during aerial surveys. Faunal surveys identified areas of wolf presence, but could not be used to calculate densities for
the park. Bergerud (1985) calculated densities and identified specific packs, but did not describe methods or time frame of observations, thus making repeat estimations of actual numbers from his data difficult.

I estimate 10-15 wolves within PNP and 15-20 wolves in the study area outside or trans-boundary with the park during the course of my study in 1996 and 1997. Using the lower of the two estimates, this gives density estimates of 1 wolf/200 km² in the park (1,878 km²), or 1 wolf/200 km² for the study area (25 wolves in 5000 km²).

**Testing H₂: Seasonal homeranges**

Due to the mortalities and difficulty in collaring wolves in the park interior, I do not have a wolf telemetry data set that is concurrent with the moose and caribou data. Therefore, I analyzed homeranges for the inland packs to test whether they significantly shifted their winter range to the coast. Presence or absence of wolves in the coast zone was determined by observations made during weekly telemetry flights for moose and caribou.

Average homerange size inland and coast packs were 628 km² and 245 km², respectively (Tables 1.3 and 1.4). None of the inland packs showed a movement to the coast between seasonal ranges. One wolf, Star (adult male Rein Lake pack), was located near Oiseau Bay, on the coast, on 10/19/96, and on two subsequent flights on 11/12/96 and 11/20/96. This was a movement of approximately 35 km towards the coast. He returned to the Rein Lake area after each excursion.

<table>
<thead>
<tr>
<th>Pack Name</th>
<th>Summer/n</th>
<th>Winter/n</th>
<th>Annual/n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black River</td>
<td>231 / 24</td>
<td>382 / 11</td>
<td>692 / 35</td>
</tr>
<tr>
<td>White River</td>
<td>207 / 51</td>
<td>209 / 52</td>
<td>632 / 103</td>
</tr>
<tr>
<td>Rein Lake</td>
<td>596 / 49</td>
<td>431 / 55</td>
<td>561 / 104</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pack Name</th>
<th>Annual/n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swallow</td>
<td>457 / 72</td>
</tr>
<tr>
<td>Cascade</td>
<td>33 / 57</td>
</tr>
</tbody>
</table>

Table 1.3 Annual and seasonal home range sizes, in km², for inland wolf packs using Fixed Kernel estimator and 95% of locations. Partition entry depicts range size (km²) / sample size.

Table 1.4 Annual home range sizes, in km², for coast wolf packs using Fixed Kernel estimator and 95% of locations. Partition entry depicts range size (km²) / sample size. Seasonal omitted due to small sample.
Moose

Capture results

Ten female moose were radio collared within 3 kilometers of the coast. Two died during the study, leaving 8 captured within 3 km (my study) and the remaining two within 10 km of the coast for F. Burrow's study (Table 1.5). All moose were healthy with good fat stores, coats, and few ticks. Four moose captured in 1995 by F. Burrows were used for coast moose analysis.

Table 1.5 Moose capture data February 1996, and status as of October 1997

<table>
<thead>
<tr>
<th>Animal Number</th>
<th>Sex</th>
<th>Age</th>
<th>Capture Date</th>
<th>Calf at Capture?</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>m9505</td>
<td>F</td>
<td>AD</td>
<td>16 Feb 96</td>
<td>N</td>
<td>Alive</td>
</tr>
<tr>
<td>m9506</td>
<td>F</td>
<td>AD</td>
<td>16 Feb 96</td>
<td>Y, Female</td>
<td>Alive</td>
</tr>
<tr>
<td>m9508</td>
<td>F</td>
<td>AD</td>
<td>16 Feb 96</td>
<td>N</td>
<td>Alive</td>
</tr>
<tr>
<td>m9511</td>
<td>F</td>
<td>AD</td>
<td>17 Feb 96</td>
<td>Y, Twin Fem</td>
<td>Alive</td>
</tr>
<tr>
<td>m9512</td>
<td>F</td>
<td>AD</td>
<td>17 Feb 96</td>
<td>N</td>
<td>Alive</td>
</tr>
<tr>
<td>m9514</td>
<td>F</td>
<td>AD</td>
<td>17 Feb 96</td>
<td>Y</td>
<td>Alive</td>
</tr>
<tr>
<td>m9516</td>
<td>F</td>
<td>AD</td>
<td>15 Feb 96</td>
<td>Y</td>
<td>Dead - predation</td>
</tr>
<tr>
<td>m9518</td>
<td>F</td>
<td>AD</td>
<td>15 Feb 96</td>
<td>N</td>
<td>Dead - predation</td>
</tr>
<tr>
<td>m9521</td>
<td>F</td>
<td>AD</td>
<td>16 Feb 96</td>
<td>Y, Female</td>
<td>Alive</td>
</tr>
<tr>
<td>m9522</td>
<td>F</td>
<td>AD</td>
<td>15 Feb 96</td>
<td>N</td>
<td>Alive</td>
</tr>
</tbody>
</table>

Collared moose with calves

Numbers are from the two years that the calving period was observed (Table 1.6) during my study. Fecundity was estimated by visual sightings. Visuals of calves from the air were often obtained shortly after birth, though this technique cannot account for calves dying within the first few weeks. Cause of death of calves was not determined. Fecundity was estimated by visual sightings. Visuals of calves from the air were often obtained shortly after birth, though this technique cannot account for calves dying within the first few weeks. Cause of death of calves was not determined.

Table 1.6 Coastal moose fecundity history for 1996 and 1997 (call/year)

<table>
<thead>
<tr>
<th>Animal ID</th>
<th>1996</th>
<th>1997</th>
</tr>
</thead>
<tbody>
<tr>
<td>m9505</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>m9506</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>m9508</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>m9511</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>m9512</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>m9514</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>m9516</td>
<td>Y</td>
<td>Died</td>
</tr>
<tr>
<td>m9518</td>
<td>Died</td>
<td>-</td>
</tr>
<tr>
<td>m9521</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>m9522</td>
<td>Y</td>
<td>Y</td>
</tr>
</tbody>
</table>
Recruitment is defined as a cow bringing a calf to approximately 10 months of age, through March or the end of snow cover. In 1995, 5 of 10 moose had calves while in 1996 that number rose to 6 out of 9 moose with calves.

**Mortality**

Four of twelve radio-collared moose died, and were designated as probable wolf kills. Two were collared in 1996 for the WMCEP (Appendix G). Cause of death was determined by aerial detection of wolves or by physical evidence at the scene.

**Seasonal Home Ranges**

Annual moose homeranges were characterized by clumped winter range within or near highly dispersed summer range. In a total of 24 moose seasons (12 moose, two seasons/year), 11 winter ranges (WR) were inside the 100% polygons of the summer range (SR), 13 were outside. Of the 13 WR’s that were outside the SR’s, 6 (46%) moved towards the coast of Lake Superior (Table 1.8).

<table>
<thead>
<tr>
<th>Moose #</th>
<th>1996 - WR In/Out of SR</th>
<th>Direction</th>
<th>1997 - WR In/Out of SR</th>
<th>Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>M107</td>
<td>Out</td>
<td>Coast</td>
<td>Out</td>
<td>Coast</td>
</tr>
<tr>
<td>M157</td>
<td>Out</td>
<td>Inland</td>
<td>Out</td>
<td>Inland</td>
</tr>
<tr>
<td>M211</td>
<td>In</td>
<td>N/A</td>
<td>In</td>
<td>N/A</td>
</tr>
<tr>
<td>M291</td>
<td>In</td>
<td>N/A</td>
<td>Out</td>
<td>Coast</td>
</tr>
<tr>
<td>M312</td>
<td>Out</td>
<td>Parallel</td>
<td>Out</td>
<td>N/A dispersed</td>
</tr>
<tr>
<td>M322</td>
<td>In</td>
<td>N/A</td>
<td>In</td>
<td>N/A</td>
</tr>
<tr>
<td>M580</td>
<td>Out</td>
<td>Coast</td>
<td>In</td>
<td>N/A</td>
</tr>
<tr>
<td>M591</td>
<td>Out</td>
<td>Coast</td>
<td>In</td>
<td>N/A</td>
</tr>
<tr>
<td>M611</td>
<td>Out</td>
<td>Coast</td>
<td>Out</td>
<td>Coast</td>
</tr>
<tr>
<td>M636</td>
<td>In</td>
<td>N/A</td>
<td>In</td>
<td>N/A</td>
</tr>
<tr>
<td>M646</td>
<td>In</td>
<td>N/A</td>
<td>In</td>
<td>N/A</td>
</tr>
<tr>
<td>M677</td>
<td>Out</td>
<td>Parallel</td>
<td>Out</td>
<td>Parallel</td>
</tr>
</tbody>
</table>

Fifty percent of collared moose occupied different winter ranges in 1997 than 1996. Of the four moose collared in 1995, 50% changed winter range between years once during the succeeding two winters (Table 1.9). Winter ranges were deemed different if their minimum convex polygons were non-overlapping.
Table 1.8 Yearly shifts in moose winter range.

<table>
<thead>
<tr>
<th>Moose</th>
<th>m107</th>
<th>m157</th>
<th>m211</th>
<th>m291</th>
<th>m9505</th>
<th>m9506</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>range</td>
<td>95=96=97</td>
<td>95=96=97</td>
<td>95=96=97</td>
<td>95=96=97</td>
<td>96=97</td>
<td>96=97</td>
</tr>
<tr>
<td>Moose</td>
<td>m9508</td>
<td>m9511</td>
<td>m9512</td>
<td>m9514</td>
<td>m9521</td>
<td>m9522</td>
</tr>
<tr>
<td>Winter</td>
<td>96=97</td>
<td>96=97</td>
<td>96=97</td>
<td>96=97</td>
<td>96=97</td>
<td>96=97</td>
</tr>
</tbody>
</table>

Only one marked moose, m9522, was determined to have a range overlap with marked caribou on Otter Island. This may be a factor both of the low density of animals as well as the small sample size.

Testing $H_1$: Distance from coast

The mean distance of seasonal home ranges (winter 1996, 1997 by summer 1996, 1997) differed significantly between summer and winter (df=1, $P=0.003$), with winter being closer to the coast of Lake Superior.

There was not a significant difference (df=1, $P=0.985$) between seasonal ranges between years (winter 1996, summer 1996 by winter 1997, summer 1997) indicating seasonal migration behavior was consistent year to year.

Snow depth effect

Snow depth zones were used as a way to compare moose movements between summer and winter. Location of seasonal ranges within snow depth zones between years (winter 1996, summer 1996 by winter 1997, summer 1997) was not significant (df=1, $P=0.399$) indicating seasonal migration behavior was consistent year to year.

The difference between Seasons (winter 1996, 1997 and summer 1996, 1997) was significant (df=1, $P=0.000$). Moose moved to shallower snow zones in winter. Residuals showed some trends in seasonal overlap between snow zones. Constricted winter ranges were sometimes located in corners of or adjacent to summer range, and summer ranges encompassed several snow zones.
Winter and Summer Range Overlap

Moose showed no trend in homerange relocation between summer and winter ranges, indicating selected homeranges provided year around habitat needs. Within a total of 24 moose seasons (one moose for one season), 13 (54%) winter ranges were outside the boundary of the summer range. The expected range lies between 6 and 18. The binomial test required <6 winter range polygons to be out of summer range polygons for overlap to be significant. Therefore, neither overlap nor non-overlap was significant (p=0.15).

Non-overlapping winter movement

From a total of 13 winter ranges that did not lie within summer ranges, 6 (46%) moved towards the coast, and 7 (54%) moved either parallel or away from the coast of Lake Superior. The binomial table requires >9 polygons to move towards the coast of Lake Superior to have significant directional movement, therefore there was not significant movement towards the coast (p=0.5), indicating snow depths relative to the coast were not a factor in the direction of movement.

Caribou

See Chapter Two for capture results.

Seasonal Home Ranges and Migration

I collected 409 locations for 1996 through 1997. Four of the five marked caribou had summer ranges distinct from winter ranges, and 60% migrated ≥ 50 km between seasonal ranges. Four of the five marked caribou used Otter Island for winter range, with c9521 rutting on Otter Island then moving north to One Lake Island for winter range. One female, c9502, remained on Otter Island during the entire study period. The other female, c9501, migrated ≥ 50 km out of PNP and into the Wawa Crown Unit (WWC) in 1996 but remained on Otter Island in 1997. All migratory caribou returned to Otter Island for the rutting season.

The two that migrated south out of PNP and into the WWC associated with another herd at Floating Heart Bay. This herd was first identified by Bergerud and Dalton (1989) in 1985 and still persisted during my study.
Testing $H_1$: moose and caribou spatial separation

Four of five marked caribou used Otter Island for winter range. Only one collared moose overlapped ranges with collared caribou on winter range. She lived in the Scapula Lake/Otter Creek area both winters, on the coast adjacent to Otter Island. The homerange estimates encompassed Otter Island, although the moose was never located on the island during winter.

Findlay total snowfall model

Snow pack profiles differed between years, mainly in early season accumulation. Snow depths increased by zone moving inland as predicted (Table 1.13). Snow depth range varied during the two winters of the study (Fig. 1.3 and 1.4).

<table>
<thead>
<tr>
<th>Zone</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td>292.5</td>
<td>318.0</td>
<td>355.0</td>
<td>588.1</td>
<td>829.9</td>
<td>924.5</td>
<td>1122.6</td>
<td>1083.5</td>
</tr>
<tr>
<td>1997</td>
<td>723.0</td>
<td>824.2</td>
<td>733.6</td>
<td>797.5</td>
<td>901.5</td>
<td>938.6</td>
<td>973.6</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Scat analysis

Beaver and caribou hair were most common in scats from wolf, bear and coyote most common in scats from bear, and beaver and hare most common in scats from lynx (Table 1.14). Collection times ranged between 1995 and 1997. Sites ranged from Oiseau Bay to the center of the Swallow pack territory to the mine site where w9576 was killed. The majority of the scats were collected along the linear Coastal Hiking Trail, which may account for the higher incidence of caribou hair over moose. All three predators consumed caribou, while only wolf scat contained moose hair. Thirty-four percent of wolf scats ($n=44$), 20% of black bear scats ($n=3$), and 18% of lynx scats ($n=8$) contained caribou hair. At least one scat from each predator contained juvenile caribou hair. Wolf scats contained more caribou than moose hair. Juvenile deer hair was found in a wolf scat in Deep Harbour, indicating the possibility of resident deer far inside the PNP boundary. Coyote hair was also found near Otter Head.
Twenty percent (n=10) of the wolf scats, collected in different areas, contained black bear hair. This is fairly unusual; Paquet and Carbyn (1986) examined 2000 wolf scats over a nine-year period and found no evidence of bear remains, although these authors did report wolves killing denning bears. Methods between studies were not compared.

### Table 1.10 Presence of animal hair, by percentage, in scats from that predator

<table>
<thead>
<tr>
<th>Pred</th>
<th>Moose</th>
<th>Caribou</th>
<th>Deer</th>
<th>Beaver</th>
<th>Hare</th>
<th>Coyote</th>
<th>Bear</th>
<th>Wolf</th>
<th>Sm. mamm.</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wolf (n=44)</td>
<td>18</td>
<td>34</td>
<td>18</td>
<td>41</td>
<td>0</td>
<td>14</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>16</td>
</tr>
<tr>
<td>Bear (n=3)</td>
<td>0</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>33</td>
<td>33</td>
<td>0</td>
<td>0</td>
<td>14</td>
</tr>
<tr>
<td>Lynx (n=8)</td>
<td>0</td>
<td>18</td>
<td>25</td>
<td>37</td>
<td>37</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>75</td>
</tr>
</tbody>
</table>

### DISCUSSION

#### Spatial separation hypothesis analysis

I did not detect the predator-prey-snow depth dynamics described by Bergerud (1989). Bergerud stated that an initial condition for this scenario was high caribou densities, although he did not define “high”. Caribou densities in PNP seem to have decreased since 1973 but during my study did not differ greatly from the time of Bergerud’s study (Bergerud 1989). Long-term monitoring is required to detect increases in caribou densities, and to discern whether the dynamics he described apply at those higher densities.

Bergerud (1989) stated that an increase in moose densities to > 0.20 moose / km² seems to reduce predation rates on caribou and allows caribou populations to increase for a time (Bergerud 1989). Park moose densities, calculated at 0.22 moose / km² and thought to be declining, are decreasing below this threshold (moose densities outside the park are 0.33 moose / km² and increasing (G. Eason, pers. comm.)). Caribou densities should have been increasing throughout the GPE for some time, having predation pressure reduced by the higher moose densities. However, caribou numbers have remained stable, which could be due to black bear predation on calves.

#### Wolves

Mid and late winter snow conditions (January and February) may have hindered wolf travel to the coast hill area. The temperatures remained well below zero for several weeks at a time, sometimes reaching...
-40°C to -50°C. The snow pack was very deep and not cohesive, and possibly made travel for wolves more
difficult than for longer legged ungulates. Travel on rivers and lakes was easier due to low snow depths, but
no wolf activity was observed in the coast area until March. Throughout the spring and summer months the
Swallow pack was well inland and did not visit the coast area.

The data sets from the inland packs are sufficient to demonstrate that no migration towards the
cost occurred. This supports the result that moose did not migrate to the coast of Lake Superior.

Moose

Marked moose winter ranges differed significantly from summer range with winter mean distances
being closer to Lake Superior. Moose moved towards the coast, but not all the way there. Instead, they
seemed to select for low snow depth areas within their winter home range. Topographically, a move towards
the coast also resulted in a move to lower elevation, also reducing snow depths.

There was a statistically significant movement across snow depth zones to lower snow depths.
Individual moose behavior varied however, and my results reveal irregular patterns of movement, in which
individuals achieved the same result of moving to lower snow depths while not following the original
hypothesis of long-distance movement to the coast. This analysis was not very useful however, since
breadth of the snow depth zone is a function of topography. A short movement in one area could result in
crossing several zones, while the same movement in another might remain in the same zone.

The spatial separation analysis results are that there is no trend in seasonal range overlap, and no
trend in direction of movement to winter range once a moose has left the summer range polygon. While
there was a significant movement in the direction of Lake Superior, moose did not move all the way to the
cost. These results support my observations that moose moved to habitat types that provided the same
characteristics for refugia that the lake effect along the coast of Lake Superior would, e.g. edge habitat,
larger rivers and inland lakes, dense timber stands, and to shallow snow. Kelsall and Telfer (1971) found
that moose tend to avoid snow depths of more than 67 cm in winter range. Few of the snow depth zones
were less than this depth, indicating moose were selecting for localized lower snow depths.

All of these landscape features reduce snow depths and could provide better foraging opportunities
and escape terrain. Moose occupied lakes for extended periods of time in the deep snow months, I observed
as many as 22 moose congregating on one lake at a time. Snow depths averaged 22 cm on inland lake ice during both winters. This analysis of movement somewhat cancels out the significance of comparison of mean seasonal distances from the coast of Lake Superior and emphasizes snow depth selection as a primary factor in moose winter range selection.

Late winter is the season of interest for testing Bergerud’s spatial separation hypothesis. Snow accumulation reaches its peak then, and would define shallow versus deep snow winters. Late winter habitat is defined as those areas used by moose once movements are restricted by snow conditions (OMNR Timber Management Guidelines for the Provision of Moose Habitat 1988). Snow accumulation is at its greatest during late January and February (Findlay 1973). A key factor in the moose migration hypothesis was “deep snow” winters, presumably meaning deeper than average snow depths. Depth data recorded at Wawa (east of PNP) shows that the two winters during the study were characterized by higher than average snow depths (Table 1.15).

### Table 1.11. Total snow accumulation on last day of month, in cm., Wawa, Ontario

<table>
<thead>
<tr>
<th>Year</th>
<th>January</th>
<th>February</th>
<th>Year</th>
<th>January</th>
<th>February</th>
</tr>
</thead>
<tbody>
<tr>
<td>1977</td>
<td>64</td>
<td>80</td>
<td>1991</td>
<td>60</td>
<td>47</td>
</tr>
<tr>
<td>1978</td>
<td>46</td>
<td>58</td>
<td>1992</td>
<td>46</td>
<td>58</td>
</tr>
<tr>
<td>1979</td>
<td>68</td>
<td>76</td>
<td>1993</td>
<td>83</td>
<td>76</td>
</tr>
<tr>
<td>1980</td>
<td>31</td>
<td>44</td>
<td>1994</td>
<td>56</td>
<td>37</td>
</tr>
<tr>
<td>1981</td>
<td>20</td>
<td>17</td>
<td>1995</td>
<td>16</td>
<td>30</td>
</tr>
<tr>
<td>1982</td>
<td>92</td>
<td>92</td>
<td>MEAN</td>
<td>56.57</td>
<td>60.5</td>
</tr>
<tr>
<td>1983</td>
<td>60</td>
<td>62</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1984</td>
<td>80</td>
<td>48</td>
<td>1996</td>
<td>130</td>
<td>120</td>
</tr>
<tr>
<td>1985</td>
<td>54</td>
<td>54</td>
<td>1997</td>
<td>130</td>
<td>121</td>
</tr>
<tr>
<td>1986</td>
<td>83</td>
<td>69</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1987</td>
<td>50</td>
<td>35</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1988</td>
<td>45</td>
<td>68</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1989</td>
<td>61</td>
<td>101</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1990</td>
<td>60</td>
<td>79</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1991</td>
<td>60</td>
<td>47</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Coady (1974) reported gradual movement of moose from summer to winter range between October and March in response to a wide range of snow conditions and abrupt migrations to winter range (shallower snow) in response to early and deep snow. He reported that hardness of snow in summer range might be related to altitudinal movements of moose in Alaska, and that local movement and activity of moose during winter were generally limited, particularly during periods of deep snow.
Peterson and Allen (1974) reported that increased snow depths on Isle Royale in late winter emphasized the important influence of snow conditions on moose-wolf relationships. Despite low weight loading ratios, wolves are hampered by deep snow of low density. However, they often benefit from increased density and crusting conditions associated with older snow packs. Moose have a much higher snow-loading ratio, but are aided in snow by their long legs. On Isle Royale, increased snow depths resulted in a concentration of moose in conifer cover along the coast of Lake Superior (lower snow depths from both conifer cover and lake effect), which are primary travel routes for wolves. Reduced availability of forage due to reduced mobility in deep snow created a higher incidence of malnutrition, especially in calves, resulting in greater vulnerability to wolf predation. In years of deep snow, wolves have generally increased their kill rate of calves and "prime-age" moose.

Seip (1992) stated that calving season was at least as important for spatial separation to remove calves from higher alternative prey density areas. Although I do not have a sufficient sample size to test this, collared moose and caribou were not spatially separated at calving time during my study. Moose m9522 calved on Otter Head in 1996 and on Otter Island in 1997. She remained on the island for almost six weeks, from 5/14/97 to 6/29/97. During this time both female caribou had calves. I recorded no wolf activity involving moose m9522 during my study.

Bergerud noted that moose had colonized the coast area in mid-1980, and he stated that if wolves weren’t managed aggressively then caribou could become extinct in a few years of heavy snow. I documented several instances of moose overlapping caribou range at different times of year. In September 1995 we caught a female moose in the south corral trap on Otter Island. She had a calf with her, and I suspect it may have been moose m9522 in the trap. In July 1996 I noted an adult male moose leaving Otter Island and swimming to the mainland. We also found moose pellets, new and old, in several cedar swamps on the island.

Caribou

Despite the fact that moose didn’t migrate all the way to the coast, moose and caribou are not completely spatially separated during the late winter months in heavy snow years. In spite of this overlap, there seemed to be no concentration of wolf hunting activity in the coastal hills area. During the winters of
1996 and 1997 the environmental conditions met Bergerud’s criteria for deep snow, yet the spatial and
temporal patterns predicted for wolves, moose, and caribou did not occur. Shorefast ice, thought to
facilitate wolf access to caribou refugia, formed in late January in both winters and was strong enough to
hold humans throughout much of the coastline. Lake Superior was mainly ice-covered in February and
early March of both winters. One possibility is that densities of all three species are very low, and predation
dynamics may differ in this situation. My study was limited to two winters, and was concurrent with the
disappearance of an entire wolf pack (Cascade Lake), so further study is recommended to confirm my
findings.

Wolves, moose and caribou have more highly adapted physiological and behavioural traits for
living in snow (Kelsall 1969, Kelsall and Telfer 1971, Telfer 1979). Between the ungulates, caribou have a
higher snow-coping index value than do moose (Telfer and Kelsall 1984). This is derived from calculating
an average of the sum of a morphological adaptation index and a behavioural adaptation index. Two
reasons have been given for selection by caribou of lower snow zones; less energy required for cratering for
ground lichens, and wolf avoidance. In Pukaskwa I never observed visually nor found sign of caribou
cratering for ground lichens, although I found evidence of foraging for ground lichen during the snow free
months. Their primary lichen source was arboreal lichen and lichens found on cliffs melted free of snow.

Three possible explanations exist for the caribou seasonal movements I observed. First, I may
have missed the cratering behaviour, although with many aerial visuals and the foraging survey conducted
on Otter Island, I believe I would have detected some sign over the course of the study. Second, the caribou
may not move inland because the moose/wolf migration phenomenon does not occur, creating higher
densities of wolves inland which are thus avoided. Although the moose responded to snow depths, they did
not move to the coast, nor did the wolves. If caribou were selecting the coast to avoid moose and wolves
inland, and this was disrupted in heavy snow years as Bergerud suggested, then it would make sense for the
caribou to reverse the spatial separation. By moving inland to higher snow depth zones where they have an
advantage with a higher snow-coping index value, they could avoid the wolves and moose seeking the
lower zones near the coast. The third possibility is that the critical late winter forage, arboreal lichen, drops
off significantly only a short distance from the coast. I was not able to measure this quantitatively, but
observations made during track transects seemed to support this hypothesis. The river valleys, which
facilitated the inland movement of fog and moister air during summer months, appeared to have higher lichen biomass available further inland but at still a relatively short distance from the coast. I raise this possibility as a factor in the winter coast distribution of the Pukaskwa caribou herds. Inland caribou obviously find a source for lichen, but these coastal caribou may either learn to forage on the arboreal lichen, or it may be of superior quality to the ground lichen available.

Snow depth, refugia, capture displacement

Snow depth accumulation patterns were different each year, with higher levels accumulating faster in 1997. Snow depth and snow pack conditions are important factors in wolf-prey relationships (Bergerud 1988; Bobek 1992; Gasaway et al. 1992; Seip 1992; Dale 1993; Huggard 1993a, 1993b and others). Snow conditions can alternately aid or hinder wolves and ungulates. At times during the winter the combination of deep snow accumulation and rugged terrain render some areas impassible to both ungulates and wolves. For this reason areas that have characteristically low snow levels become important travel corridors and refugia.

In the GPE, these areas are water bodies and the coast of Lake Superior. Moose used lakes and rivers as apparent refugia, often for several weeks at a time. During early February 1996, I observed as many as 22 moose on South Soldier Lake. Both collared and uncollared moose were observed using lakes and rivers for extended periods of time. In March 1997, tracks from the Swallow pack were seen for several kilometers along the Swallow River, at one point intercepting moose m9505 and two others, then bypassing them and continuing down river. On 26 February 1996 moose m9518 was found dead on the river ice amidst wolf trails, beds and scat. She had left her capture site and traveled over 9 km up the Pukaskwa River where she was apparently intercepted and killed by wolves. Her carcass was mostly consumed, and the site had signs (blood, broken branches etc.) consistent with characteristics of a wolf kill.

Although not a part of my thesis, I want to mention that, out of ten captures along the coast, seven moose (70%) showed moderate (2 km) to high (3+ km) displacement. Since they were captured in February, I believe that they were already on their late winter range and that the capture experience displaced them. Five out of the surviving eight (63%) did not use the same winter range the second winter, with three of those (60%) returning to the area of the previous winters’ capture. One curious aspect is that
all of the post-capture moves were either parallel to the snow zone they were captured in, or, more
interestingly, inland to deeper snow level zones. Five of the seven (71%) moved inland. This capture
displacement phenomenon was also seen with moose captured in the same manner for the OMNR study in
western Ontario (E. Lawson, pers. comm.).

One possible explanation is that the lower snow levels as defined by the snow depth zones are not
of sufficient benefit to the moose for predator avoidance to make them stay in the same or lower snow
zone.
Chapter Two: Spatial organization, demographics, and predation of woodland caribou in and around Pukaskwa National Park, Ontario

ABSTRACT

Woodland caribou (*Rangifer tarandus caribou*) densities and distributions have declined since 1900 in the southern portion of their range in North America. This decline is due to a complex suite of environmental and anthropogenic factors. Survey methods for caribou in Pukaskwa National Park (PNP) were only recently standardized so comparisons to earlier estimates are difficult. The 1997 PNP caribou survey estimated 20 animals living along the coastal region of the park. Where caribou are declining, wolves (*Canis lupus*), black bears (*Ursus americana*), disease, and poor habitat conditions may all contribute to decreasing densities. The north shore population structure (the Greater Pukaskwa Ecosystem) meets the definition of a metapopulation. This may be due to both poor habitat quality and anthropogenic causes. I documented long-distance migrations across Pukaskwa National Park boundaries to Provincial government lands, connecting habitats managed by different government agencies. Resource extraction activities outside of Pukaskwa National Park should be planned and mediated to minimize negative impacts on extant subpopulations and maximize contiguous habitat between critical areas.

INTRODUCTION

Woodland caribou once inhabited Ontario south to Lake Nipissing and into the northern United States, but their range has steadily receded northward to its present-day southern limit of approximately 50 degrees latitude (Darby *et al.* 1989). Historically, woodland caribou have continuously occupied the north shore of Lake Superior (Clarke 1938, Snyder 1938, Snyder *et al.* 1942, deVos and Peterson 1951). Since the turn of the century, however, they have declined steadily in numbers and distribution [deVos and Peterson 1951, Cringan 1956. (Fig.2.1)]. This decrease has largely been attributed to a combination of factors such as hunting, poaching, fire, habitat fragmentation, logging, disease, relative distributions of predators, wolf predation due to an increase in moose (*Alces alces andersoni*) and deer (*Odocoileus virginianus*) numbers, human disturbance, and global warming (Klein 1968, Anderson 1971, 1972,
Past and Present Woodland Caribou Range in Ontario

Legend
- Red: Caribou Range
- Green: Parks with caribou

(Map not drawn to scale)

From H. G. Cumming & D. B. Beange, 1993

Prepared by: Parks Canada
Pukaskwa National Park
1998 L. Parent
Bergerud 1974a, Geist 1978, Bergerud et al. 1984a, Darby et al. 1989). Increases in moose and deer numbers are associated with landscape changes such as logging and road corridors (Cumming and Walden 1970). This northward expansion of deer and moose is well documented by Snyder (1938), Peterson (1955), and Cumming and Walden (1970).

Habitat surveys by Ahti and Hepburn (1967) estimated that northern Ontario could support approximately 700,000 woodland caribou. Combined Ontario Ministry of Natural Resources (OMNR) and provincial and national park estimates were far below this amount, and appeared to be declining (deVos and Peterson 1951; Cringan 1956; Cumming and Beange 1993).

Woodland caribou are listed as a Species of Concern by Parks Canada, and have been monitored in Pukaskwa National Park (PNP) since 1972. Population estimates for the Province and the region have varied, although the OMNR states that numbers continue to decline from historical levels (G. Eason, pers. commun.) The OMNR is developing a Caribou Management Plan that will address habitat fragmentation, anthropogenic effects, and predation as causes of decline. PNP contains several bands of caribou.

**Caribou spatial organization in the GPE**

The Greater Park Ecosystem (GPE, Skibicki 1994) encompasses 10,000 km$^2$, including PNP. Nearby mines, timber harvest activities in the Black River and White River forests, and associated road systems are included in this area (Introduction, Fig. 2).

Prior to 1900, northern Ontario may have had a largely panmictic woodland caribou population. Suitable seasonal habitat was likely distributed in a matrix regulated by fire events (Schiefer and Pruitt 1991, Cumming 1992), with areas of relatively poor habitat having correspondingly patchy caribou populations. Ahti and Hepburn (1967) rated the north shore region containing the GPE among the poorest for lichen habitat. Although Cumming and Beange (1993) indicate caribou have inhabited this area for centuries, small, isolated herds seem to have been the predominant population structure from the earliest recorded time to present (Bergerud 1989). Thus, the historic north shore caribou population may have been comprised of spatially disjunct herds forming a metapopulation within a larger, regional population in the GPE. This condition may have existed prior to the disruptions of the early 1900’s, with herd isolation and low densities exacerbated later by the suite of disturbances mentioned above.
One of the primary goals of the Pukaskwa Predator Prey Process Project (P5) was to accurately estimate wolf, moose, and caribou densities and distributions, and to better understand the large mammal system within the GPE. In part, increased “insularization” of the park prompted this effort. Newmark (1987) tested the land-bridge island hypothesis on 14 western parks in the United States. This hypothesis stated that land-bridge island parks would be supersaturated with species; the ratio of island to mainland species would be higher than expected from the area of the island. If this hypothesis were true, the rate of extinction should exceed the rate of colonization on a land-bridge island, resulting in a loss of species that is thought to be related to the size and degree of isolation of the island. He found the natural post-establishment loss of mammalian species to be consistent with the hypothesis and that all but the largest of western North American national parks were too small to retain intact mammalian fauna. There is a high probability that this also applies to PNP.

METHODS

Capture and handling

All capture and handling operations were approved by a Parks Canada Animal Care Committee prior to field operations; permits were renewed on an annual basis. My research design called for marking caribou in the Otter Cove region of PNP. All adult animals caught were collared because densities were low. In 1996, 5 caribou were radio collared near Otter Cove, PNP. Helicopter Wildlife Management (HWM) performed capture operations using net guns. Immediately upon capture we restrained animals with leg ties and placed a mask over their face (Appendix C). Blood, hair, and feces were collected from captured animals. All animals received appropriate dosages of Liquamycin LA (1cc/10 kg, maximum 7cc/injection site) and Selenium/Vitamin E (1cc/90 kg).

Population Estimates

Biologists have conducted surveys several times to estimate caribou numbers in Ontario, and numbers estimated have varied widely (deVos and Peterson 1951; Cringan 1956; Simkin 1965a; Darby et al. 1989). PNP has used different methods ranging from flights in areas of known or suspected caribou to more recent attempts at systematic line transect sampling along the coast. Methods were standardized in 1990. Estimates of caribou numbers are a combination of observations of animals plus an estimate of
additional animals present in the survey area as determined by track interpretation. Caribou recruitment was based solely on observed numbers of adults and calves.

Systematic surveys ranged from 1-3 km inland, with transects at 1 km apart. The majority of surveys designed specifically for caribou were conducted within 3 km of the coast as a result of Bergerud's hypothesis that caribou selected coastal rather than inland habitat to avoid wolf predation (Wade, pers. commun.). Differences in survey coverage were due mainly to funding limitations. In addition, resource managers assumed that moose surveys would identify caribou in other regions of the park.

To better measure presence, herd size and distribution of caribou, I investigated sightings in several parts of the study area and tallied estimates from public or warden sighting reports. Track presence and size was recorded on the Coastal Hiking Trail in May/June 1996, and compared to other observations in the same areas to best estimate the minimum number of animals in the area at that time.

OMNR's methods followed Gasaway (1986), and tallied caribou sightings along with moose. Other sightings were confirmed based on visual identification of tracks or animals by experienced observers. Anecdotal reports from the general public were evaluated by the descriptions given and experience of the reporter. When possible, follow-up investigations were made to confirm tracks or other sign. These data were used to describe and support a general interpretation of caribou densities and distribution.

RESULTS

Capture Results

Three males and two females were radio-collared and one calf was ear-tagged for the WMCEP in 1996 F (Table 1.10). All animals were captured on or near Otter Island. Biologists observed 11 caribou along the PNP coast during the 1997 aerial survey. Wade (1997) estimated there to be 20 caribou from this observed number. If this estimate is accurate then the marked sample 30% of the PNP population.
**Table 2.1 Caribou capture data 1996.**

<table>
<thead>
<tr>
<th>Animal Number</th>
<th>Name</th>
<th>Sex</th>
<th>Age</th>
<th>Capture Date</th>
<th>Calf</th>
<th>Status</th>
</tr>
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<tbody>
<tr>
<td>c9501</td>
<td>Kester</td>
<td>F</td>
<td>AD</td>
<td>17 Feb 96</td>
<td>N</td>
<td>Alive</td>
</tr>
<tr>
<td>c9503</td>
<td>Paul</td>
<td>M</td>
<td>AD</td>
<td>17 Feb 96</td>
<td>N/A</td>
<td>Dead</td>
</tr>
<tr>
<td>c9522</td>
<td>Russell</td>
<td>M</td>
<td>AD</td>
<td>18 Feb 96</td>
<td>N/A</td>
<td>Dead</td>
</tr>
<tr>
<td>c9502</td>
<td>Isabella</td>
<td>F</td>
<td>AD</td>
<td>18 Feb 96</td>
<td>Y (Elise)</td>
<td>Alive</td>
</tr>
<tr>
<td>c9521</td>
<td>Traveler</td>
<td>M</td>
<td>AD</td>
<td>18 Feb 96</td>
<td>N/A</td>
<td>Alive</td>
</tr>
<tr>
<td>Orange1(L)</td>
<td>Elise</td>
<td>F</td>
<td>YOY</td>
<td>2 Oct 95</td>
<td>N/A</td>
<td>UK</td>
</tr>
</tbody>
</table>

**Telemetry and Seasonal Movements**

I collected 409 locations for 1996 through 1997. Four of the five marked caribou had summer ranges distinct from winter ranges, and 60% migrated ≥ 50 km between seasonal ranges. Four of the five marked caribou used Otter Island for winter range, with c9521 rutting on Otter Island then moving north to One Lake Island for winter range. One female, c9502, remained on Otter Island during the entire study period. The other female, c9501, migrated ≥ 50 km out of PNP and into the Wawa Crown Unit (WWC) in 1996 but remained on Otter Island in 1997. All migratory caribou returned to Otter Island for the rutting season.

The two that migrated south out of PNP and into the WWC associated with another herd at Floating Heart Bay. This herd was first identified by Bergerud and Dalton (1989) in 1985 and still persisted during my study.

**Collared Caribou with Calves**

C9501 successfully recruited calves in 1995, 1996, and 1997. She remained on Otter Island and nearby smaller islands since her capture. C9502 did not have a calf in 1995, did not bring one to recruitment age in 1996, and had a calf on Otter Island that was alive as of December 1997. Fecundity was estimated by visual sightings. Visuals of calves from the air were often obtained shortly after birth, though this technique cannot account for calves dying within the first few weeks. Cause of death of calves was not determined.
Mortality

Two caribou, c9522 and c9503, died since the 1996 capture. Both were adult males and died on Otter Island during the rutting season. No sign of predation was evident. C9522 was between 10 and 13 years, and c9503 was about 10 years old.

GPE Population Estimates

Bergerud thought the PNP herd was declining, although inconsistent methods and effort makes survey comparisons difficult (Table 2.4).

I confirmed caribou on Pic Island during the 1996 and 1997 winters (n=10+, winter), on Yser Point in Marathon harbor in 1996 (n=5+; winter, probably part of the Pic Island herd), Neys Provincial Park in 1997 (n=5; spring, one stag, 2 cow/calf pairs), near Floating Heart Bay in the Wawa Crown Unit in 1996 (n=5+; summer) and on the 1997 caribou survey (n=5+; winter). The number of animals can be difficult to estimate; numbers are based on discernable tracks and/or individuals sighted and are approximations.

Reports made by the general public accounted for confirmed sightings at Ruffle Lake (1 male, 1 cow/calf pair), Michepocoten River (1 male), White River (1 male) and Jarvey Lake (6 mixed sex).

Table 2.2 Caribou survey data 1972 through 1997

<table>
<thead>
<tr>
<th>Year</th>
<th>Number Estimated</th>
<th>Number Observed</th>
<th>Recruitment</th>
<th>Comments</th>
<th>Year</th>
<th>Number Estimated</th>
<th>#Obs'd</th>
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<tr>
<td>1973</td>
<td>14</td>
<td>8</td>
<td>12.5%</td>
<td>Revised</td>
<td>1986</td>
<td>12</td>
<td>12.5%</td>
<td>Bergerud</td>
<td></td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>1987</td>
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<td></td>
<td>Bergerud</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td>Bergerud</td>
</tr>
<tr>
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<td></td>
<td>33.0%</td>
<td></td>
<td>1989</td>
<td>14</td>
<td>12.5%</td>
<td></td>
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</tr>
<tr>
<td>1976</td>
<td>21</td>
<td></td>
<td>14.3%</td>
<td></td>
<td>1990</td>
<td>14</td>
<td>21.0%</td>
<td>Monitoring</td>
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<tr>
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<td>21</td>
<td></td>
<td>10.7%</td>
<td></td>
<td>1991</td>
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<td>25.0%</td>
<td></td>
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</tr>
<tr>
<td>1978</td>
<td>26</td>
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<td></td>
<td>1992</td>
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</tr>
<tr>
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<td>16</td>
<td>18.8%</td>
<td></td>
<td>1993</td>
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<td>14</td>
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<tr>
<td>1980</td>
<td>19</td>
<td>16</td>
<td>28.6%</td>
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<td>1994</td>
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<td>6.7%</td>
<td></td>
<td>1995</td>
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<td>1</td>
<td>0.0%</td>
<td>Telemetry</td>
</tr>
<tr>
<td>1982</td>
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<td></td>
<td>22.7%</td>
<td></td>
<td>1996</td>
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<td>8</td>
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<td></td>
</tr>
<tr>
<td>1983</td>
<td>22</td>
<td>13</td>
<td>19.3%</td>
<td>Bergerud</td>
<td>1997</td>
<td>11</td>
<td>8</td>
<td>27.0%</td>
<td>Trax/survey</td>
</tr>
</tbody>
</table>
DISCUSSION

Metapopulation characteristics

McCullough (1996) contrasted a metapopulation from a continuous population as distributed over spatially disjunct patches of suitable habitat. These ‘patches’, separated by intervening unsuitable habitat, create a matrix. The matrix, then, restricts dispersal. He stated that “a metapopulation’s persistence depends on the combined dynamics of extinction within given patches and recolonization among patches by dispersal. So long as the rate of recolonization exceeds the rate of extinction, the metapopulation can persist even though no given subpopulation in a patch may survive continuously over time.”

Wells and Richmond (1995) use three characteristics that can describe groups of individuals at the organismal level: (1) spatial structure, (2) genetic structure, and (3) demographic structure. They state that a population should be defined by a discontinuity or disjunction in one of these characteristics. They define metapopulation as “a set of spatially disjunct groups of individuals with some demographic or genetic connection among them”. They differ from McCullough in their definition of part of the term, stating that the “probability of extinction of a group should not be an issue in deciding whether a set of groups is a metapopulation because metapopulations should be defined largely by spatial structure”.

Both views could describe the structure of the GPE caribou herds and arguments for both the demographic and spatial definitions can be made. The issue of localized extinction, however, and the rate of recolonization is especially important when addressing the park’s ability to protect and perpetuate caribou herds in PNP and the GPE. The genetic definition should be further explored, building on the samples gathered by the Wolf, Moose and Caribou Ecology Project (WMCEP) and other regional studies.

Bergerud (1989) stated that an increase in moose densities to > 0.20 moose / km² seemed to reduce predation rates on caribou and allows the caribou population to increase for a time. Park moose densities, calculated at 0.22 moose / km² and declining, are decreasing below this threshold (moose densities outside the park are 0.33 moose / km² and increasing (G. Eason, pers. commun.)). If this were the case, then the herd should have been on the increase for some time as moose densities increased above 0.22 moose / km², with the decline yet to come as moose densities dip below 0.2 moose/km².

C9501 successfully recruited calves in 1995 and 1996, and as of December 1997 will do so for this year as well. C9502 did not have a calf in 1995, but probably had one in 1996 and lost it somewhere.
between reaching summer range and the end of the summer period. Her restricted movements around calving time on Otter Head and her slow progress in reaching summer range near Floating Heart Bay (three weeks) relative to her return trip to Otter Island for the rut (one week) indicated that she may have been slowed down with a calf. She was still tending her 1997 calf as of December 1997.

**Population estimates, caribou distribution, and seasonal ranges**

Caribou conservation has been a priority for PNP since the park's inception. PNP personnel estimated population trends, anthropogenic effects on coastal habitat use, and the role of predation in limiting caribou numbers in the park. Differences in survey methods make year to year comparisons difficult, and line transect survey techniques do not always pick up small, disjunct populations. Gross trends are that numbers have been dropping over time, although estimates of historical densities differ. In 1997 biologists estimated 20 (extrapolated from 11 seen in the survey) animals living along the coastal region of the park. I estimated recruitment (although the sample was too small to statistically analyze) to be 33% in 1996 and 27% in 1997. PNP herds have persisted, and calf production seems to be fairly constant, so why isn't the PNP herd growing?

Darby *et al.* (1989) published distinct population estimates based on empirical data for the Terrace Bay and Wawa districts. The Terrace Bay district estimate is 476 animals; this district is composed of the Caramat, Coldwell Peninsula, Flanders Township, Hagarty Rd., Pic Island, and Slate Island populations. The Wawa district estimate is 52 animals; this district is composed of Lake Superior Provincial Park, Michipicoten Island, Pukaskwa National Park, and Montreal Island populations.

In 1967 Ahti's (Ahti 1967) estimate for this area (the Nipigon-Superior Region, covering 14,000 mi² or 36,257.2 km²) was 500 animals. This is an average of 0.01 caribou/km² or one caribou/100 km², for an estimate of 19 caribou in PNP. Bergerud (1989) estimated an average of 0.1 caribou/km² or one caribou/10 km² for an estimate of 200 caribou in PNP (he uses this as an historic figure, implying pre-1900 numbers), although he did not state the method by which he derived this number. Bergerud's historical estimate for PNP is 10 times that of Ahti's. Our current estimate of 0.01 caribou/km² or one caribou/100 km² for an estimate of 20 caribou in PNP matches that of Ahti's. Assuming that fire suppression has not significantly altered the vegetation characteristics of PNP (see discussion below) Ahti's estimate is still accurate, and is consistent with P5 estimates.
Estimating animal densities from available habitat assumes that the habitat is occupied and that the required seasonal mix of habitat is available within any given home range of an animal. Caribou live in clumped distributions at low densities indicating that the habitat is not homogeneously distributed (not considering anti-predator behaviour). Ahti stated that the province was well below his estimate of carrying capacity at the time of the survey. However, this comparison of estimates raises the possibility that, if historical densities were actually closer to Ahti's habitat-based number than Bergerud's, then present day densities are close to expected historical values. This means caribou densities have actually been maintaining rather than dropping precipitously as Bergerud suggests. If this is true, then PNP may still be characteristic of historical undisturbed coastal caribou densities and distribution.

Cumming and Beange (1993) state that woodland caribou numbers are declining across the southern portion of their range in Ontario. My recent aerial surveys and documented sighting inquiries indicate that small, remnant herds continue to exist in the GPE (Fig. 2.2). Downward regional population trends and consistent anecdotal accounts of herds dwindling after timber harvest indicate that these remaining herds are at risk today. These downward trends may be due to characteristics of population dynamics such as demographics, low encounter rates, mortality and slow reproductive characteristics, and anthropogenic influences such as poaching, legitimate aboriginal hunting, destruction of winter range and habitat fragmentation. These negative effects ultimately result in the cumulative removal of critical interdependent herds that form the metapopulation of caribou in and around the GPE.

I used telemetry locations to document continuous caribou distribution and movement from Oiseau Bay in PNP to Floating Heart Bay in the Wawa Crown Unit. Confirmed reports extend that range to Pic Island and Neys Provincial Park to the northwest.

Caribou in PNP use primarily the coastal hills area, at least since the early 1970's (Bergerud 1989). Mean inland distance for 136 radiolocations on the mainland was $1.3 \pm 0.1$ km, and mean inland distance for 221 aggregations or tracks seen on winter surveys was $0.55 \pm 0.05$ km during Bergerud's study. Bergerud's farthest radiolocation inland was 8.7 km, although anecdotal reports occasionally placed them much farther inland such as Louie Lake in the northeast corner of the park. The WMCEP found the distribution to be approximately the same within the park, and documented additional herds to the north.
Concentration Areas (□) and Location of Confirmed Sightings (△) of Woodland Caribou in the Greater Park Ecosystem.
near Neys Provincial Park and to the south at Floating Heart Bay. Other animals were sighted along the
park coast north of Otter Cove during the aerial caribou survey.

Otter Island and Otter Head were the focal points for both early and late winter ranges for males
and females. The females used Otter Island exclusively both winters, and two of three males (c9522 and
c9503) used Otter Head in the winter of 1996. C9522 was the exception the winter of 1997. He returned
from Floating Heart Bay summer range to Otter Island for the rut, and then moved north approximately 20
km to the One Lake Island area for winter range. The remaining two males, c9521 and c9503, stayed on
Otter Island for the entire winter of 1997.

Reports made by the general public accounted for confirmed sightings at Ruffle Lake,
Michepocoten River, White River, and Jarvey Lake. These are encouraging data and indicate that there is
still time to design conservation measures to protect these small groups. The Jarvey Lake group of 6
animals is the largest aggregation reported (Otter Cove herd has four animals remaining, Floating Heart a
minimum of five) as of March 1998.

Two alternative explanations, besides wolf predation, may explain caribou coastal distributions.
One is the availability of forage (winter arboreal lichen and availability of diverse summer browse species
in the complex topography along the coastal corridor), and the other is philopatry to seasonal and migration
ranges. Both sexes migrated relatively long distances, and two of the three males repeated these migrations
for 2 years of the study. Bergerud's (1989) description of philopatry to the coastal range is still applicable.

Disease

All three caribou collared by park personnel in PNP in 1993 died in March of that year. Two were
officially attributed to wolf predation, and one was of an unknown cause. The head from the latter carcass
was sent to the Canadian Cooperative Wildlife Health Centre (CCWHC), University of Guelph to look for
the brain worm, *Parelaphostrongylus tenuis* (*P. tenuis*). This parasite is contracted by caribou from white-
tailed deer, via a snail, and is deadly to caribou. No evidence of *P. tenuis* was found. Bone marrow analysis
indicated starvation (Wade, pers. commun.). This was the only carcass to have been examined for *P. tenuis
as of December 1997.

Deer hair comprised 18% of wolf and 25% of lynx scat contents. This is significant to caribou
conservation because of the threat of the brain parasite *P. tenuis*. These scats were collected at sites
Predation

Wolves

Bergerud (1989) stated that caribou were selecting coastal habitat with inferior forage to avoid higher densities of wolves and moose inland. Over the course of my study I documented wolf use of the coastal habitat during two winters of heavy snow. One pack disappeared in 1996, and certainly affected wolf distribution and densities for the second year of my study. This lack of wolf presence may help explain the caribou distribution, although the lack of coastal moose and wolf migration during heavy snow years does not support the hypothesis that heavy predation pressure on caribou occurs when snow conditions are optimal for wolves to move to the coast. Weekly aerial telemetry surveys did not reveal any wolf sign during winter months along the entire coastal corridor. OMNR surveys (one to two per winter) begun in the late 1970’s have never picked up coastal wolf activity in the Wawa Crown Unit (G. Eason, pers. commun.)

Wolves (likely the Swallow pack) seemed to first travel to the coast in mid-March when the snow pack forms a crust and travel improves. This pattern was seen in 1996 and 1997. Snow pack conditions in mid to late winter would inhibit wolf travel with low temperatures and light, low-density snow usually greater than 60 cm.

Predation in general and wolf predation on caribou in particular is not well documented in the GPE. Records from the 1970’s and 1980’s are not complete enough to determine confirmed causes of death. Three cases seem to be possible wolf predation. Dan Couchie, park assistant superintendent, observed one
on 19 March 1984. A wolf was seen running from a caribou carcass at the base of a cliff near the lighthouse on Otter Island. The carcass was partially consumed and wolf scat was abundant in the area. The possibility exists that the caribou fell off the cliff and was scavenged. Bergerud and Krysl (1989) documented a similar accident. No necropsy was conducted on the animal. Two other carcasses were observed in March of 1994 (Paquet pers. comm.)

The two caribou mortalities attributed to wolf predation in 1993 were not closely examined and, judging from descriptions and photos by the wardens reporting the carcasses, I do not believe they were killed by wolves. In both instances, the head was missing and fairly cleanly severed, with the radio collars lying 5 to 20 meters away. In one photo, it appears that the left rear haunch and leg are missing from the carcass. A wolf was seen on nearby Otter Island, but photos taken at that time clearly showed no signs of wolf predation. The carcass was gone within a short time, and later scavenging by wolves was likely. The remoteness of the site in March would seem to preclude poaching, but the ice cover would have made landing in a helicopter or a plane equipped with skis possible. Female caribou do have antlers, and they may have been killed for trophies and/or meat. There is no physical evidence to support this hypothesis however, and the cause of death for all three (two attributed to wolf predation, one undetermined) remains unknown.

Wolf predation has occurred, but based on photographs, descriptions and data from collared animals, more mortalities have been attributed to wolf predation than can be confirmed. Wolves are scavengers as well as predators, and carcasses must be carefully examined (e.g. skinned to inspect for trauma characteristic of predator kills) to determine cause of death. Wolf presence at a carcass does not confirm predation. I emphasize this point because accurate interpretation of wolf-caribou interactions and effects of predation depend greatly on correctly identifying sources of mortality.

Lynx and Black Bear

Two other predators should be considered. Bergerud (1989) mentioned lynx predation on calves as a possible mortality source, but dismissed black bear as being at very low densities and therefore not a significant source of mortality. I found lynx tracks in the coastal zone only once during the course of my study. This could be explained by observing during the low point of their ten-year population cycle
Of eight lynx scats I examined, two contained caribou hair (both juvenile and adult).

Pukaskwa has long been thought of as a one-predator system. Wolves are considered the primary predator on moose and caribou, and Bergerud hypothesized that they create a “predator pit” effect keeping caribou numbers very low. Bergerud et al. (1983) postulated that wolves were a limiting factor for moose in PNP.

I believe that black bears are of a sufficiently high density in the park to be considered significant predators on both moose and caribou calves. Habitat conditions surrounding PNP have changed over time, mainly due to logging activities. This has created vegetative conditions favorable to black bears by creating more browse species for foraging. The habitat matrix of the GPE contains many known bear foods, such as graminoids, and fleshy berries such as blueberries (*Vaccinium* spp.) and mountain ash berries (*Sorbus americana*). I observed animals or found sign of black bears in every significant drainage system in the Otter Cove study area, at the Pukaskwa Depot, and along the Coastal Hiking Trail (CHT) (Fig. 2.3). In the White Gravel River corridor and Oiseau Bay I observed overlapping tracks of several different individuals (based on track size). I found black bear scat on Otter Island (containing mountain ash berries), and sighted a bear on Weideman’s Island. Bear numbers are high enough outside PNP that bear baiting and hunting in WMU#33 is a significant economic enterprise (G. Eason, pers. commun.).

Estimates of black bear densities nearest to PNP are 1 bear/4.1-6.3 km² from Superior National Forest in northeastern Minnesota (Rogers 1986), 1 bear/1.65 to 5 km² in east central Ontario (Yodzis and Kolenosky 1986), and 1 bear/10 km² for Michigan (Erickson and Petrides 1964). There are no black bear density estimates for PNP. Scat analysis results indicate bear presence in the coastal zone as well.

Messier (1994) analyzed 27 moose studies over a broad range of moose densities to test whether wolf predation can regulate moose numbers. He found that wolf predation rate was density dependent between 0 – 0.65 moose/km², which he classified as a low-density population. The GPE study area falls in the middle of this range with densities between 0.22 and 0.33 moose/km² inside and outside the park, respectively. Messier’s empirical model based on these results suggested that moose densities would stabilize at 1.3 moose/km² in the presence of a single predator, the wolf. He stated that if moose productivity were diminished through either deteriorating habitat quality or through bear-induced calf
Black Bear Observations Within the Greater Park Ecosystem 1975 - 1994

confirmed black bear sightings (reports from visitors and park staff)
Pukaskwa National Park boundary

*Data taken from the mammal observation database of Pukaskwa National Park

Prepared by: Parks Canada
Pukaskwa National Park
1998 L. Parent
mortality, then a low-density equilibrium, very similar to that of the GPE, (0.2-0.4 moose/km²) was predicted. With regard to the “predator pit” hypothesis, his model predicted that when a low equilibrium develops, a "predator pit" is absent or extremely shallow.

Ballard et al. (1992), Van Ballenberghe (1987), and Ballard (1994) documented bear predation on moose and woodland caribou. Ballard (1994) reviewed several case histories and drew inferences from several black bear-moose (Alces alces) studies. He concluded that black bear predation on woodland caribou in the proposed re-introduction area in Minnesota would likely be a secondary source of caribou mortality and that between 6-30% of the calves and 0-5% of the adults might be killed annually by black bears.

If black bears are significant predators on cervids in the GPE, they will potentially affect moose as well as caribou densities. Van Ballenberghe (1987) reviewed empirical evidence from available case histories that suggested that naturally regulated bear/moose/wolf systems where alternative prey is scarce might produce stable short-term equilibria that occur far below carrying capacities set by moose/forage interactions. F. Burrows is currently investigating characteristics of moose forage. Moose densities in PNP are thought to be declining, and continued monitoring is necessary to define longer-term trends.

I present this comparison as an argument for further research on cause-specific calf mortality for both moose and caribou. Scat analysis indicated that wolves, lynx, and black bear consumed juvenile and adult caribou. This is not direct evidence of predation, of course, since wolves, bears and lynx also scavenge.

**Scat analysis**

All 3 predators (wolves, black bear and lynx) consumed caribou, while only wolf scat contained moose hair. At least one scat from each predator contained juvenile caribou hair. Deer and coyote showed up more often than I expected given the distance from disturbed areas outside the park that had frequent sightings. Samples containing deer hair were from the Otter Cove area, well within the park.

Scats from both wolf and bear, collected in different areas, contained bear hair, indicating a relative abundance of bear. Twenty percent (n=10) of the wolf scats contained black bear hair. This is fairly unusual; Paquet and Carbyn (1986) examined 2000 wolf scats over a nine-year period and found no
evidence of bear remains, although these authors did report wolves killing denning bears. Methods between studies were not compared.

Habitat

Caribou distribution in PNP may be affected by the pronounced patchiness that occurs along the coastal region. Caribou favour complex habitats that have different plant and cover types juxtaposed in close proximity to each other (Antoniak 1993; Rominger et al. 1994, 1996). Wind events and the broken cliffs and narrow valleys between them create many small microclimates. Forest Ecosystem Classification (FEC) surveys conducted by park personnel confirmed that many stand and soil types occur within short distances of each other (L. Nabigon pers. commun.) in this area.

Farther inland, stands are protected from the severe winds of Lake Superior. They also may have changed more over time due to fire suppression than the coastal hills, which are far less susceptible to fire due to much higher moisture during the summer months [M. Crofts and A. Promaine pers. commun.(Fig. 9)]. The coastal hills region may not have changed significantly during the period of fire suppression. Schaefer and Pruitt (1991) discussed the short and long-term effects of fire on woodland caribou and their habitat, stating that it is basically bad in the short term and good in the long term. The coastal hills have a very long fire cycle with very small, patchy fires limited primarily to ridge tops. Lighting strikes ignite pines or spruce on exposed ridges, and trees and duff burn downhill until they meet moist vegetation or contact creeks, bogs or muskeg. This produces excellent jackpine/lichen ridge top habitat over the long term, and contributes to the patchwork of habitat types.

Woodland caribou are generalist herbivores in the summer and lichen specialists in the winter (Cringan 1956; Cumming 1992). I could not find any citations regarding exclusive use of arboreal over ground lichen species or visa versa. If coastal herds favored arboreal lichen, it could be another explanation for coastal distribution.

Late winter ground surveys revealed some interesting foraging behaviour. Caribou moved from clump to clump of spruce snags which had fallen into a teepee shape. They would thrust their head and shoulders into the teepees and eat whatever lichens were in reach. Once finished, they would leave that clump and find another like it, rather than browse the outside of the structure. This seemed an efficient
technique for minimizing effort and maximizing food intake. I found 3 caribou repeating this pattern, and one cow/calf pair in which the calf followed the cow and browsed the same trees she did. This type of older forest structure may be an important factor in foraging stand selection and energy conservation.

Land use

Darby et al. (1989), Cumming (1992) and Cumming and Beange (1993) documented the local decline of caribou after timber harvesting activities fragmented forest habitat. Efforts to protect the coastal corridor between PNP and Lake Superior Provincial Park (LSPP) have been successful so far mainly due to its inaccessibility and the abundance of merchantable timber closer to road systems.

Other types of resource extraction activities may negatively affect caribou. New technologies have increased the efficiency of mining gold in the greenstone belt along the coast and PNP boundary. River Gold Mines, Ltd. is therefore very interested in any restrictions that may be applied to above ground exploration and road building for caribou conservation. These concerns are valid and satisfactory solutions regarding road building and use, extent of above ground buildings and tree clearing, and control of access should be negotiated. The OMNR continues to be very interested in supporting conservation efforts for this critical strip of coastal habitat (G. Eason, pers. commun.).

Potential disturbances from mining activity within the WCU should be considered. Mahoney et al. (1991) documented a decrease in caribou densities within a 0-3 km zone during mine construction, suggesting that noise and disturbance at the mine site resulted in caribou avoiding the area. Klein (1971) argued that human activity and installations have the capacity to disrupt the normal patterns of range use and activity of caribou and thus impair energy assimilation. Such influences have not been shown to affect caribou mortality patterns specifically nor population dynamics in general (Bergerud et al. 1984)

North shore woodland caribou conservation

Seasonal and long-distance movements and connectivity with other known herds

Within the Otter Island herd (n=5) four of five migrated in the summer of 1996, and three of four migrated in the summer of 1997. Seasonal ranges varied from one female staying on Otter Island for 3 years, while another female and two males made seasonal migrations over 50 km. The summer range of the migrating female and one of the males overlapped with that of the Floating Heart Bay herd. This herd was
last documented in 1985 (Bergerud and Dalton 1989). This seasonal migration illustrates that spatially disjunct groups make repeated annual contact over long distances. This occurred in non-fragmented habitat, and indicates that connectivity may be important to metapopulation persistence by enabling spatially disjunct herds to associate with each other more successfully than if they had to cross habitat patches embedded within a matrix of human-altered habitat.

Mech and Nelson (1981) listed 9 observations of caribou in northern Minnesota in 1980 and 1981. All but one was of single animals, and appeared to be males. A pair was observed 15 January 1981, one with large, one with small antlers. The observations were all made in the same general area, which was approximately 240 km from the nearest known established population at Lake Nipigon, ON. Some observations noted behaviour characteristics similar to symptoms caused by *P. tenuis* infection (Mech and Nelson 1981). None of the animals apparently survived, though no carcasses were recovered.

One interesting WMCEP result was that both male and female caribou that migrated to Floating Heart Bay returned to Otter Island at the beginning of the rutting season in early September. This indicates a philopatry to the breeding herd, and may illustrate a “behaviourally disjunct” population.

**Wawa Crown Forest Management Unit**

The Wawa Crown Forest Management Unit (WCU) has long been considered an important haven for caribou living along the coastal strip. A strip of land from the PNP to the LSPP boundary and 5-km inland has been excluded from the last 2, five-year timber management plans at the behest of the OMNR. The forest resources within this strip are of minimal value (OMNR timber inventory documents, 1996), and River Gold Mine operations have had little impact on surface features. The topography is rugged, and forest harvesting and road building are not yet considered economically feasible.

Changes in forest management practices may affect this moratorium, however. With major cutbacks in budgets and personnel, the OMNR and forestry companies are changing the administrative structure governing land and resource management. Under the new Sustainable Forestry License agreements, forest companies take on the majority of the responsibility for following harvest prescriptions and overseeing post-harvest rehabilitation. Negotiations are now underway for the cutting boundaries and harvest quotas within the WCU.
Urban centers and protected areas

The towns of Terrace Bay, Marathon, and Wawa lie within the north shore coastal corridor, as well as the Trans Canada Highway #17, Canadian Pacific railway, and secondary and logging roads. Part of this range is already protected by Provincial parks (Slate Islands, Neys, and Lake Superior), Pukaskwa National Park, and a small wilderness area, Ganley Harbour Provincial Wilderness Area. Farther inland are White Lake and Obatanga Provincial Parks. These latter 2 parks are not in the coastal zone and are quite small, but have had recent or historical sightings of caribou in their vicinity.

Cumming (1996) recommended that a sound management strategy for caribou survival in northern Ontario should begin with “virtual refuges” that allow caribou to survive apparent competition with moose. These areas, with at least 3-km buffers, should be identified and reserved from forest harvesting and from road use during winter. The coastal area from PNP to LSPP could provide a large virtual refuge.

Contiguous coastal habitat also provides caribou with more options should large-scale landscape disturbances occur in inland forests. These stands will become increasingly important to caribou survival when large-scale fires occur, and as logging continues to move towards the coast from inland cutting units.

Pukaskwa National Park coastal corridor and human use

Caribou have continually occupied the coastal corridor of PNP since the 1970’s. Wyett and Keesey (1977) and Krysl (1985) indicated the potential negative impact of human activities in critical habitat areas. An important management issue is campgrounds. Pitt and Jordan (1996) identified black bear influence at campgrounds as a potentially significant mortality source for reintroduced caribou in Minnesota. Twelve designated campsites and a potentially unlimited number of non-designated sites exist within the coastal corridor. The recent addition to designated campsites of bear-proof food boxes has greatly reduced the attraction of bears to food, although food preparation, fishing refuse, and careless storage continues to attract bears. The visitor center should adopt a “bear safe camping” campaign to educate campers and further reduce the potential for attracting and feeding bears. Explaining the problems of attracting bears to the endangered caribou would most likely increase camper’s participation in such program.
Management recommendations

The PNP fire management plan (Heathcott and Crofts 1997) incorporates data from other caribou studies to enhance caribou habitat through controlled burning programs (Fig. 2.4). The coastal habitat in particular appears to still be within the range of variation for fire occurrence and management should continue as per the Fire Plan. The issue of greatest concern to the GPE caribou metapopulation is the continued harvest of large tracts of forest outside of the park boundary. Every effort should be made to use the best science available to avoid habitat degradation and to enhance habitat connectivity between geographic areas of known caribou herds and consistent sightings of individuals. Mediation techniques such as adaptive management zones surrounding the park, road density reduction and use restriction, and selective harvesting techniques used where appropriate should be designed and strictly followed.

Connectivity issues to the east of the park should be addressed. Urban, road, and industrial development along the lakeshore could choke off exchange with herds on Pic Island/Neys Provincial Park and further east to the Slate Islands. A unique opportunity exists to create a permanent coastal corridor connecting PNP herds with the Floating Heart Bay and Lake Superior Provincial Park herds. My data confirms continued caribou use of this corridor, and highlights the importance of this area in perpetuating caribou on the north shore. Protecting this area would create the longest continuous stretch of protected habitat on the shores of Lake Superior, and provide a vital connection between the southern herds in the mixed boreal forest type with those in the boreal forests of PNP.

Plans to increase ecotourism along the coastal corridor should be carefully designed and should consider critical season (calving) and sensitive island and coastal areas of known caribou use. An increase in human use could severely disrupt caribou distribution and reduce the probability of survival along the coastal corridor (Krysl 1985).

We do not have enough data on immigration, emigration, or adult or neonate mortality to understand the population trends of these disjunct herds. I documented calf recruitment, non-predatory mortality, trans-boundary migration, and associations with other herds. Long-term monitoring is needed to better understand the rate of exchange between herds, and to identify cause-specific mortality factors. Genetic relatedness among herds should be investigated with samples collected by the WMCEP, the Slate Islands (OMNR), and other regional projects.
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Appendix A

Complete listing of Pukaskwa National Park internal reports regarding Faunal Investigations and other information regarding wolves, moose and caribou.

Appendix B

20 September, 1995

Wolf Blood Handling Protocol - Pukaskwa National Park Wolf Ecology Project

Blood samples are taken in the field at time of capture. Blood is collected from one of two sites on the wolf. The most commonly used is the dorsal branch of the lateral saphenous vein in either hindlimb (Mech 1974), Alternatives are the cephalic vein on either forelimb, or the femoral vein in the inguinal region (M. Johnson, pers. comm.).

- DO NOT LET TUBES FREEZE
- MAKE SURE TUBES ARE WARM WHEN USED

Draw blood by first occluding the vein (an additional person can do this, or it can be done by using a veterinary tube or a plastic glove), then inserting a 1", 18 ga needle, bevel facing upwards, into the swollen vein. The Vacutainer Blood Collection System® system (Becton Dickenson, New York, New York) works very well for this; it greatly facilitates filling several Vacutainer tubes. The system uses a needle, holder, and Vacutainer tubes which fit into the holder. Blood will flow into the container when the vein is properly punctured, and the tubes can then be filled sequentially. When the sample has been taken, release the occluded vein before withdrawing the needle to prevent hematomas. Then apply pressure or rub the point of insertion for 30 seconds.

An alternative method is to use a 30 ml syringe with a 1", 18 ga needle. Blood is then inserted into the red tops.

- LABEL EACH VIAL WITH DATE, WOLF NUMBER, TIME COLLECTED.

Collect THREE RED TOP tubes from each wolf. Each tube will hold approximately 10 ml of blood. Fill each tube with about 8 ml. Transport the blood carefully: place in Styrofoam container or in foam filled cooler. Do not let the vials vibrate.

Handle as follows:
- Keep one vial as whole blood, and freeze ASAP.
- Place the remaining two vials in an upright position in a cool place (not freezing) to let the serum separate. Ideally have the blood spun in a centrifuge within 12 hours after collection. In the field, this is often not possible, so settling will work fine if the vials are handled carefully.
- Once the serum has separated from the red blood cells (not longer than 12 hours) carefully draw off the serum from both vials with a pipette. Place serum in two new red top vials. They can be the 5 ml size. LABEL EACH ADDITIONAL VIAL CAREFULLY WITH DATE AND WOLF NUMBER.
- Freeze remaining blood and serum vials immediately.

**PROJECT DESCRIPTION:**
Five (5) woodland caribou (Rangifer tarandus caribou) cows are to be fitted with Lotek Engineering Inc. conventional VHF radio collars as part of the Pukaskwa National Park (PNP) Wolf Ecology Project component. Trapping will be conducted in the Otter Island / Otter Cove area of the park between September 23 and October 10, 1995. Capturing may be continued during the fall of 1996 depending upon capture success or animal replacement.

**OBJECTIVE:**
The objective of the proposed project is to obtain data on caribou aggregation densities, dispersal, mortality, predation by wolves (Canis lupus), recruitment, use of islands and coastline as refugia, calving areas, and recapture of previously tagged animals. These animals will be integrated into the ongoing P5 research program, and will be located weekly via aerial and ground telemetry. These data will be analyzed in conjunction with wolf, moose, and weather data gathered concurrently. Caribou have been identified as a species of concern by PNP and have been studied periodically in the past. Results will be used to meet management and conservation goals set by PNP.

**CAPTURE TECHNIQUES:**
The following procedures are used by permission from Bill Dalton, Terrestrial Projects Biologist, MNR, Northwest Region Science and Technology. They are taken from his Animal Care Protocol for the Northwestern Ontario Woodland Caribou Migration Study. He has developed and used this protocol for many years with proven success. Mr. Dalton assisted the park in caribou capture in 1992. NOTE:ALTHOUGH MENTIONED IN THE PROTOCOL BELOW, NO IMMOBILIZATION DRUGS WILL BE USED FOR THIS PROJECT.

**Corrals:**
Corrals approximately 3m X 3m constructed with roundwood available at the site are baited with feed store salt blocks and or ground lichen. Traps are constructed so that holes are smaller than an animal’s nose so that a head cannot be forced between the bars. Traps are left in place year-round and bait is provided ad-lib. When animals habituate to the traps a trap door is set. Animals entering the trap trigger the door automatically. Traps are to be set only where they can be accessed within 30 minutes by trained animal handlers. Radio telemetry will be used to monitor door position while a trap is set. Traps will not be set for automatic capture in seasons when either sex of caribou has antlers in velvet. Traps will not be constructed where moose are likely to be trapped.

**Water Capture:**
Sit and Wait:
Handlers wait at known caribou crossing points between islands for caribou to swim. Caribou are allowed to proceed 1/3 of the way across the channel before the handlers assume pursuit with outboard motorboats (open aluminum or zodiac rubber). Caribou are turned back from the shore they were swimming to and when they settle into a return swim they are approached from behind. One of two courses of action will follow: a) remote full processing, or b) collaring only. Caribou handling procedures are described in full later.

**Island Drives:**
Small islands will be driven by people with whistles, staying in voice contact. The caribou will be pushed off into the water near locations where boats are waiting (hidden from sight). Once caribou are swimming, water capture as per sit and wait can proceed.
PROCESSING:

Swimming Caribou:
On approach from behind, the caribou tail is grasped by the handler in the bow of the boat, and held at its base. This process takes 10 - 45 seconds after engaging in close pursuit. If unsuccessful after three attempts, or if the caribou’s nose is submersed at any time, or the caribou’s mouth opens for panting the caribou is released from pursuit. The outboard motor is stopped as soon as the tail grip is attained. Processing can proceed in two ways at this point: collaring only or remote processing, the latter being preferred to maximize the value of the capture opportunity and to be in a strong position for interpreting subsequent behaviour of the animal (age, condition, reproductive status, comparative studies).

Remote Processing:
Handler #2 moves in behind #1 (the bow person) and secures a better grip on the tail as close to the body as possible. This then puts the caribou swimming at 90° to the boat’s long axis. Caribou restrained in this way swim strongly but do not fight or thrash. Handler #2 then reaches for the animal’s ears and lifts the head to the side of the boat (this manoeuver takes skill, strength, and confidence but is usually accomplished without the animal’s nose entering the water). Handler #1 and #3 tie the two front legs together, then #1 and #2 standing with a wide stance (one foot on the gunnel, one centred in the boat on a seat) tip the boat until the gunnel is low in the water. The caribou is lifted straight up (using good leg lifting technique) until the rib cage clears the gunnel and then is laid into the boat in a sweeping motion. #3 ties the back legs, the animal is blindfolded and earplugged and is transported at low speed to a predetermined handling site and removed from the boat.

Caribou in Traps:
No animal with velvet antlers will have a trap triggered on them. Spring/summer trapping will occur only with attended traps, and operator triggers. Fall captures in traps will only be carried out with personnel stationed in the immediate vicinity (30 minutes access time maximum) and trap doors will be monitored by radio-telemetry to minimize time between capture and handling. Muggers will enter the trap and physically restrain and hog-tie caribou. Antlered caribou will have a rope loop dropped over their antlers. They are drawn to the side of the trap allowing muggers to enter from behind them and lower them to the ground.

Animal processing:
The following procedures apply to caribou immobilized for collaring and measurements. They apply to drug and no-drug immobilization (except where noted).

At intervals during handling a rectal thermometer will be used to monitor for temperature elevation above 40.0°C. In addition the caribou is monitored visually for muscle tremors which correlate well with temperature and stress. When either or both symptoms of stress are noted the procedures below are minimized (collar and tags) and the animal released as soon as possible. Depressed respiration (less than 10 per minute (1 breath per 6 seconds)) will be addressed by immediate reversal/antagonism of drugged animals and release of non-drugged animals. Dopram (1.0 mg/kg IV) will be administered when regular respirations are below 6 per minute (1 breath per 10 seconds). Elevated respiration is expected, but prolonged high respiration is a possible sign of capture myopathy, and/or hyperthermia. When restrained animals respiration rate does not moderate after 10 minutes of immobilization, it will be reversed/released.

Animals will be monitored and handled with a minimum amount of noise and disturbance. Handling Steps (steps specific to immobilizing drugs have been ommitted, as have procedures such as tooth pulling which will not be used):

1) apply a blindfold (cloth in a band 4 layers thick).
2) insert earplugs (foam rubber).
3) re-orient animal into head-up and sternal recumbancy (do not roll him over).
4) inject vitamin E/selenium to reduce chance of capture myopathy (MU-SE).
5) record respirations.
6) take anal temperature.
7) affix telemetry collar - loose enough to prevent choking/irritation but so that it will not pull off over the ears. Remove excess collar length (rule of thumb: a fist inserted sideways between neck and collar).
8) record respirations.
9) take anal temperature.
10) take linear body measurements with tape measure (ear, head, neck, shoulder height, heart girth, total length, tail, hind foot, antlers, rump patch, neck mane extent).
11) collect a pinch of hair, including root, from the rump.
12) collect fecal sample from the anus using plastic glove.
13) affix Allflex maxi-tags to the right and left ears hanging down and inserted between the two prominent cartilage ridges 1/3 fro the ear base. Affix metal clips to tears on the ventral surface between two cartilage ridges there (for long term marking because the Allflex maxi-tags are prone to breaking after 2 years).
14) record respirations.
15) take anal temperature.
16) collect blood samples (red top #3 (condition, pregnancy) and purple top #2 (genetics)) using the standard Vacutainer system (saphenous venipuncture) drawing from the top of the metacarpal.
17) administer Liquimycin (long acting antibiotic) IM to prevent infection.
18) face the caribou towards an escape route and untie knots on legs, massage legs and tuck under body, remove earplugs, remove blindfold and prevent the animal from falling backwards as it stands to depart.
Note: Handling times, time at recording of respirations, recovery times, and vigour of the animal are recorded.
Note: In the event that an animal is injured or succumbs to stress beyond recovery, it will be dispatched with a bullet to the head.

ANIMAL HANDLING TRAINING:
Graham Neale has trained with Bill Dalton in the Slate Islands, ON, in addition to handling over 40 whitetailed deer working with Dr. L. David Mech in Minnesota, 10 elk in Glacier National Park, Montana, as well as trapping and/or processing over 50 wolves on several research projects in the U.S. and Canada. Keith Wade and several of the park personnel involved with this capture project have been trained by and involved in captures with Bill Dalton. Volunteers will be trained by these personnel and moved up in rank of complexity as they gain experience and demonstrate ability.
Appendix D – Relative use index track intersect survey methods and results

Route Configurations

The survey routes, running perpendicular to the coast or following drainages, were designed to sample each habitat type in the vicinity of that route. The transects (1.5 km in 1996, 3 km in 1997) were run perpendicular to the line of survey for the route. Habitat types consist of river/creek systems, riparian zones, meadow areas, deciduous, mixed and conifer stands, rocky ridges, lakes, and coastline (Skibicki 1994).

I assigned numbers to routes in a clockwise direction North to South. A random number generator then determined the order in which the routes were surveyed. Critical locations such as route starting point, ending point, transect intersections and ending points, and track intersections were all plotted using a Trimble® or Garmin® GPS unit. Map and compass were also used for verification and route finding. The intersections of transects with the main route were referred to as nodes.

I designed two types of routes to survey both coast-to-inland areas and other geographical features such as peninsulas and islands. Using a systematic survey sampling method, each route was approximately 2 kilometers apart, and 1.5 km (1996) to 3 km (1997) long. Ninety-five percent of all telemetry locations and historical sightings were within this distance. Allowances have been made for impassable topographical features. These were bypassed where necessary, and then the route bearing was returned to at the next possible point.

Transect nodes were identified every 0.5 kilometers, starting with the inland terminus of the route. A transect of 300 m was laid out on each side, and was followed using a compass bearing. Each route had 7 transects. Each transect consisted of 3 data collection points; an intersection with the route, and two endpoints. Each transect survey was standardized by running the western most leg first. Individual surveyor bias was minimized by requiring the same surveyor to complete each transect.

Data Collection

Data were collected at each data point on each transect, at Null stations determined by a 10 minute watch alarm, and where tracks were found crossing the route or transect survey line. The GPS location, average snow depth at that point and degree of canopy cover (1 = 0%-33%, 2 = 34% - 66%, 3 = 67% - 100% canopy coverage over the 15 meter area.), and an ocular survey of all tree or shrub species within 15 m of the point were collected. Other features such as rock or lake were included. The ocular survey consisted of sighting through a tube, a PVC pipe section measuring 31cm x 3.5 cm., on 8 compass points, beginning with north and proceeding clockwise (0°, 45°, 90°, 135°, 180°, 225°, 270°, 315°).

One person measured snow depths and performed the ocular survey while the other recorded the UTM’s and the tree and shrub species called out by the surveyor. Each species was recorded by using the 3-letter code for the species’ binomen. A Stand Composition evaluation was also included to help characterize the stand. The ocular survey may be weighted towards large trees, for example, in an area that is predominated by saplings.

Track Data

When tracks were encountered, the point of intersection was noted (i.e. on Route or Transect) and the UTM location was fixed from the GPS. An ocular survey, as described above, was conducted. If possible, data were collected on species, direction of travel, number of animals, snow depth of the track (penetration), and snow depth one meter off track (average for location), track size, and approximate age of tracks (as indicated by previous snowfall, weather conditions, tracks on top of tracks etc.). Other habitat variables are also noted, such as the proximity of streams, rocky outcrops, trails etc. Notes were kept on the presence of lynx, snowshoe hare, and fox and marten.

Optimization:

Based on justification of limit of search; 99% of past 3 surveys sighted animals only within 3 km of coastline. 1996 surveys recorded all tracks within 1.5 km; all telemetry is within 1.5 km of coastline.
Plateau of Detection:

Several days were required to assess accessibility and sampling frequency required. We walked several transects of 500 m to see how far we would have to walk to detect “all” tracks, that is, when the cumulative count of tracks tapers off. Since densities of wolves, moose and caribou are low, we also factored in terrain and overall distance relative to being able to sample the whole transect in a day.

Track transect survey data results
February/March 1996

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<tr>
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Snow Depths

**8.2**

**TOTAL FOR ALL CATEGORIES:** **166.6 KM / 99.96 MI.**

Field season results for the winter of 1996 resulted in an additional 8.2-KM walked for snow depth surveys. Most snow depth surveys were performed in tandem with track routes and transects. Route configuration varied between 3km inland routes which ran perpendicular to the coast with 1 transect (600m, 300m/side) every .5 km, to routes crossing Otter Head and Otter Island, also with 1 transect every .5 km. The threshold of detectability for track encounters was tested on the Holly Creek (Route #5) using 500m transects/side, with no additional tracks detected. Thus 300m transects were used throughout the rest of the survey.

February/March 1997

These totals represent two surveys cycles conducted during field season

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**TOTAL FOR ALL CATEGORIES:** **167.6 KM / 104.75 MI.**

Field season results for the winter of 1997 resulted in an additional 21 KM for Otter Creek, 26.8 KM for the White River transect, and 4 KM surveyed for snow depths on Otter Island. Caribou foraging surveys totaled 21 KM walked. Route configuration was modified for the second field season to reflect results from 1996. Each route was shortened to survey the first four transects inland from the coast (1.5 km) to facilitate the increase of surveying frequency to two times/season. Routes 1, 2, were not surveyed due to insufficient ice formation and time constraints, and 8 and 9 because of other survey activity on Otter Island.
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Note: AD = Adult, JUV = Juvenile, Y = Yes, N = No, MUS = Muscled, FEAT = Feathered, pass = passed, porc = pork, vege = vegetation.
Appendix E-Coastal predator scat analysis

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Appendix F-Wolf, Moose, and Ecology Project wolf trapping effort/other mortalities

Detailed account of search effort and wolf sign documented in park interior 1995 through 1996.

The Cascade Pack - June 1995 through January 1996

Study design for the WMCEP called for collection of telemetry data from two wolf packs living along the coastal zone and overlapping radio-collared moose and caribou home ranges. Reconnaissance began in the summer of 1994, and built upon information gathered by other PNP field personnel. Remote access was facilitated by cost sharing with other park projects. Tracks were found on numerous occasions throughout the summer of 1995, frequently near the river mouths on the sandy beaches in Imogene Cove, Bonamie Cove, Tagouche and Holly Creeks.

On June 6th, 1995, while scouting a creek adjacent to Otter Creek, an adult wolf, light silver in color, was observed at close range. With this sighting, wolf presence had been documented in this area for the past 3 years (G. Felbaum, pers. com.). On June 14th, G. Neale scouted area and documented tracks from multiple animals using well-worn trails. Trapping commenced on 9 July and finished 20 July with 2 captures. Both wolves were adult females; Solita, approximately 4-6 yrs., 25 kgs., black, non-breeder, and; Mika, approximately 4-6 yrs., 27 kgs., black, non-breeder. No injuries were recorded. One non-target black bear was handled and released.

The silver wolf was observed from the aircraft, standing about 10 m away from Solita as she was recovering from that morning’s capture. She was not observed again.

Telemetry indicated that both animals were from the same pack, and although they were not always in the same place at the same time, they occupied the same general area. In addition to the two collared wolves we observed 5 wolves, for a total of 7 animals in the Cascade Pack. In mid-October it became evident that Mika had separated from the main pack. Thereafter she was always observed alone, traveling in the vicinity of Otter Cove. The last location with both animals together was on a kill of a yearling male moose in Otter Cove on 28 November 1995. Four wolves were seen on the kill. This was the last location of Mika with the Cascade Pack.

Solita traveled widely, ranging roughly from the coast inland to Cascade Lake and from the Pukaskwa River north to the Cascade River. Homerange estimators can vary considerably, but using the harmonic mean method and 95% of her locations gave us a result of 167 km² for Solita. Mika’s movements became quite constricted in early winter, and she was located repeatedly near the old kill in Otter Cove or nearby on Otter Creek. Using the same software program and also 95% of Mika’s locations gave a homerange calculation of 73.15 km². Note: These are preliminary analysis results, and may not be chosen for the final analysis.

Solita was last seen with 5 wolves on the ice of the Pukaskwa River on 22 December 1995. On 1 January 1996, her collar was located on mortality mode in a mining exploration camp approximately 2 km away. This camp is located within 500 m of the PNP boundary. Upon investigation the collar was mostly chewed away, although the antenna was still intact and bolted in a circular shape. It was located on a small rise above the camp, with several well-worn wolf trails (in snow) running nearby. No carcass could be found, although large amounts of black hair and many scats were present. Prospectors had been occupying the site at the time of her mortality, and repeated attempts to contact workers present have not produced any information. The evidence seems to indicate interpack mortality; our 6 months of telemetry data indicate that the Pukaskwa River formed the southern boundary of the Cascade Pack’s homerange, and wolf sign had been observed to the south. After this incident, no further sign of the Cascade pack was observed on weekly telemetry flights throughout their former homerange.

Mika continued to remain in or near Otter Cove, until her collar was found on mortality mode on 29 January 1996 on the North Cascade River. She was found curled up under the protection of a small cliff (P. Krizan, per. com.). Necropsy results show no specific cause of death, although she was experiencing gastric hemorrhaging, typical of an ulcerated stomach, at the time of her death. No discrete ulcers were found in her case, but this sort of trauma is also associated with acute stress (D. Campbell, pers. com.).

Winter Flight Observations, Ground Surveys, and Marked Moose Kills - January through May, 1996

Aerial observation for wolf sign throughout most of PNP was facilitated by weekly telemetry flights for collared caribou along the coast, moose along the coast and in the interior, and wolves in the north and northeastern section of the park. This enabled us to conduct non-systematic surveys for wolves in areas where no packs were radio-collared. Wolf tracks were seen several times after snowfall, indicating
presence and movement within the park and along its boundaries. Observations were classified by the following areas:

1) **Northwest corner of PNP at Pic River to Oiseau Bay.**
   - Tracks of a single wolf were seen repeatedly near Willow River and along Oiseau Creek. No pack activity was noted.
   - Aldo, a collared wolf from the Black River Pack, was located near the Willow River before his disappearance on 8 November 1995.

2) **Oiseau Bay south to Cascade River; inland to Hook Lake.**
   - Tracks of 3 to 4 wolves were seen at least 4 times traveling along lake and river systems near the coast in this region. Twice wolves traveled from lake to lake along the coast, then turned northward up the Cascade River. No excursions south of this river were observed.
   - Two wolves were sighted on Swallow River ice approximately 12 km inland from the coast during the moose survey in early February.

3) **Cascade River south to the East Pukaskwa River; inland to Cascade Lake, Frappier Lake, and north to Gornupkagama Lake.**
   - Tracks of one wolf were observed on 20 February in Otter Cove. It traveled down Holly Creek and traversed the Cove around 12 p.m., traveling northwest (These tracks were also confirmed during ground surveys).
   - Possible wolf tracks on Otter Island 16 February but not confirmed on the ground.
   - No other wolf activity was recorded in this area all winter; there was no sign of the Cascade Pack throughout their former territory.
   - Five wolves were sighted 7 km east of Frappier Lake on the Pukaskwa River during the moose survey.

**Summer Reconnaissance and Trapping Effort - May through September, 1996**

Reconnaissance for wolf sign along the coast in general and in the Otter Cove study site in particular began May 30th with a hike along the entire length of the Coastal Hiking Trail (CHT). Results of this survey are contained in the CHT 1996 report.

Efforts then shifted to the Cascade Pack’s territory. The previous year’s trapline was revisited and capture sites were checked for sign several times. No sign, old or new, was found. The search was expanded to surrounding drainages and to core use areas identified by Mika and Solita’s telemetry points. Otter, Holly, Tagouche, and Imogene Creeks were systematically searched using boat, fixed wing, rotary, and foot access. The search area covered likely drainages, travel routes, and lake systems which had previously been used or likely would be for travel routes. The search area went from the Pukaskwa River north to the Cascade River and from the coast inland to Cascade and McDougall Lakes. No wolf sign whatsoever was found within the bounds of last year’s pack territory as defined by telemetry data. Fresh tracks of a single animal were recorded on a small lakeshore 2 km east of McDougall Lake and on a small creek system approximately 4 km NE of Camp Lake. No evidence of pack reproduction or activity was found.

The search area was then broadened to include the area north of the Cascade River. Wolf tracks had been seen repeatedly in this area over the previous winter. Tracks of 2 to 3 animals were found near the mouth of the White Gravel River; two were traveling together, one alone. Further searching upstream indicated the two animals had traveled at least 6-km inland.

On 24 June 1996, moose #657 (frequency #) was found on mortality at Elizabeth Lake (5336220 N, 576900 E). Wolf tracks and scat were plentiful, and obvious signs of struggle were found in the sweet gale (*Myrica gale*) clumps on the edge of the lake. Bear sign was also present. Tracks indicated at least two wolves present. An extensive search of the lake and connecting drainages indicated the wolves had traveled to and from the lake only from the west, northwest and north. Tracks were also found in the Swallow River drainage 5 km to the northwest.

During the pup-rearing phase of late spring and summer, adult wolves essentially become central place foragers surrounding the den or rendezvous site. An extensive trapline was set in the Elizabeth Lake area to take advantage of this behaviour. The trapline was run from 27 June to 17 July. Budget and personnel constraints limited the duration of the trapping effort. However, during this time, no wolf sign or activity was found in the area. Searches were made throughout the area during the trapping effort, and after the line was pulled. Two black bears and one porcupine were captured and either escaped or were released.
Search efforts continued through September. Tracks of 2 to 3 wolves were found consistently throughout the Swallow River area to the west, but track and howling surveys turned up no sign of rendezvous sites or larger pack activity. The animals seemed to be hunting throughout a larger territory without the constraint of rendezvous site responsibilities.

PNP conducted extensive vegetation surveys during the summer of 1996. These teams were trained in identifying wolf sign and howling, and reported the following observations for August. Tracks were found approximately 30-km inland NE of Tip Top mountain, and a single animal howled near Lake Elizabeth during a 3 day stay there.

In late September, a PNP General Works crew stopped to change fuel tanks at Trapper Harbour, approximately 10 km north of Otter Cove near the mouth of the Swallow River. They reported hearing howling and barking. Barking vocalizations in wolves is a fear or warning response, and can indicate the presence of pups or a den or rendezvous site nearby. I investigated this report, and found tracks of 2 to 3 animals along a stretch of sandy beach. Trails were evident in a nearby cedar swamp. No response was heard from howling. Deteriorating lake and weather conditions over the next several weeks prohibited further investigation, so no further sign was found.

Despite intensive efforts, no wolves were collared in the Otter Cove study site in the summer of 1996. Detailed data were gathered however, on presence and absence of wolves in this area of the park.
Appendix G - Wolf, Moose, and Caribou Ecology Project moose mortalities

- Moose 150.667, was collared on 15 February 1996, 4 km inland on the Pukaskwa River. She was missed on the two flights subsequent to capture, and was relocated for the first time on 26 February, 9 km inland from her capture point, on the Pukaskwa River. She was dead on the river ice. The kill site exhibited characteristics of a wolf kill with signs of struggle, dismemberment of the body, and many tracks, trails, and beds on the river nearby. Because she was killed such a short period after her capture, she may have been experiencing complications due to capture stress. Her movement of 9 km, however, suggests she was quite mobile. It may be that in moving away from the point of her traumatic capture experience she ran into the wolves using the often-shared travel route. Her physical condition at time of death can only be guessed at, and it may well have been a combination of the two. As a side note, several moose moved varying distances immediately after the 1996 capture operations, sometimes several drainages away. Number 667’s movement was the farthest of all the moose.

- Moose #150.657 was found on mortality 24 June 1996. She had moved to summer range and had a calf, whose fate is unknown. Signs of struggle in the shoreline vegetation and wolf scat, tracks, and kill characteristics indicated wolf predation. Black bear sign was also in the area. This was near the center of the Swallow River pack’s territory.