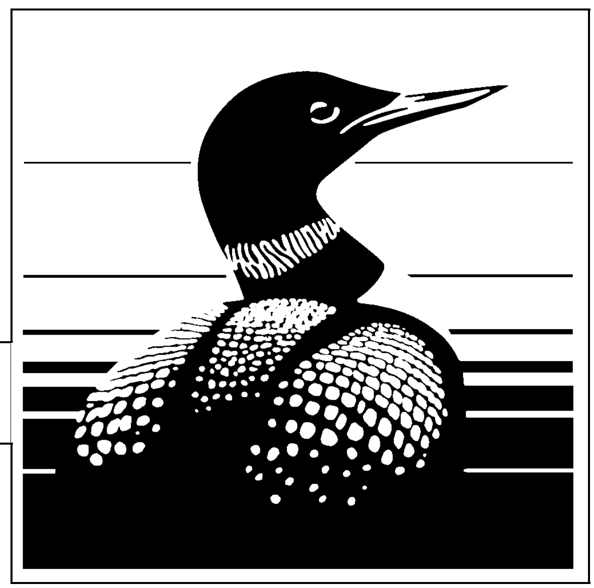
Barren-Ground Caribou Calving Ground Workshop Report of Proceedings

D. E. Russell, G. Kofinas and B. Griffith

Pacific and Yukon Region 2002
Canadian Wildlife Service
Environmental Conservation Branch



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Barren-Ground Caribou Calving Ground Workshop
Report of Proceedings

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Abstract

This report details the proceedings of the Barren-ground Caribou Calving Ground Workshop, held in Vancouver, November 18-20, 2001. Scientists from across North America gathered to discuss the current knowledge and issues facing calving grounds of northern mainland caribou. The similarities and differences between herds from Alaska through to Labrador were discussed. Attention was focused on defining calving grounds consistently across the continent.

Potential impacts of climate change and development were presented and discussed. Participants began work on a comparative matrix to evaluate the importance of calving grounds to the different herds. Finally, research gaps and needs were discussed by all participants.

Résumé

Ce rapport précise le contenu de l'atelier des terrains de vêlage des grands troupeaux de caribou migrateurs, ayant eu lieu à Vancouver le 18 au 20 novembre, 2001. De divers scientistes d'à travers le continent se sont rassemblés afin de discuter leurs connaissances et les défis auxquels les troupeaux de caribou devront faire face. Les similitudes et différences entre les troupeaux d'Alaska jusqu'au Labrador ont également été analysées. Les participants ont mis l'emphase sur l'ouvrage d'une définition des terrains de vêlage qu'on puisse appuyer à travers l'Amérique du Nord.

Les impacts potentiels des changements climatiques et du développement industriel ont été présentés et discutés durant l'atelier. De plus, les participants ont commencé à formuler un système comparatif d'évaluation de l'importance des terrains de vêlage à chaque troupeau. Enfin, les scientistes ont noté les directions éventuelles vers lesquelles la recherche pourrait être dirigée.

Acknowledgements

This workshop was part of the "Comparative assessment of North American caribou herds" project funded by the Environment Canada's ***Northern Ecosystem Initiative***. Specific funding for the workshop came from ***Northern Program, Indian and Northern Affairs Canada***. Support was also received from the Human Role in Reindeer/Caribou Systems initiative funded by the ***International Arctic Science Committee (IASC)*** and the Sustainability of Arctic Communities project funded by the ***U. S. National Science Foundation***. The authors would like to thank all those that participated and especially Diana Abraham and Philippa McNeil for their work on the production of the report.

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Introduction

Over the past 15 years, the organizers of this workshop have focused their caribou research on calving grounds, the impact of oil development on barren-ground caribou, and the local communities that depend on caribou. This work has enjoyed multi-agency co-operation among universities and the governments of the Northwest and Yukon Territories, Alaska, Canada and the United States - all participating in an effort to develop tools with which the effects of development and other factors, such as climate change, can be assessed. The pressure for future industrial development in the Arctic is high, and there has been unprecedented climate warming in some parts of the polar region. There is a need to look at the extent to which these impacts affect migratory caribou across the continent, and to share what has been learned about each herd.

This report documents the proceedings of a 3-day workshop organized and convened by the Canadian Wildlife Service (Yukon), The Institute of Arctic Studies at Dartmouth College (New Hampshire) and the United States Geological Survey, University of Alaska Fairbanks (Alaska). The objective of the workshop was to bring together North America's expertise on northern mainland caribou to review the current state of scientific knowledge of the importance of calving grounds to caribou across North America's Arctic (Figure 1), and to discuss the implications of industrial development and climate change on herd growth and survival. The workshop was held at St. John's College on the campus of the University of British Columbia in Vancouver, B.C., from Sunday November 18th to Tuesday, November 20th, 2001. A list of the participants is provided in Appendix A. Proceedings were facilitated and recorded by ESSA Technologies Ltd.

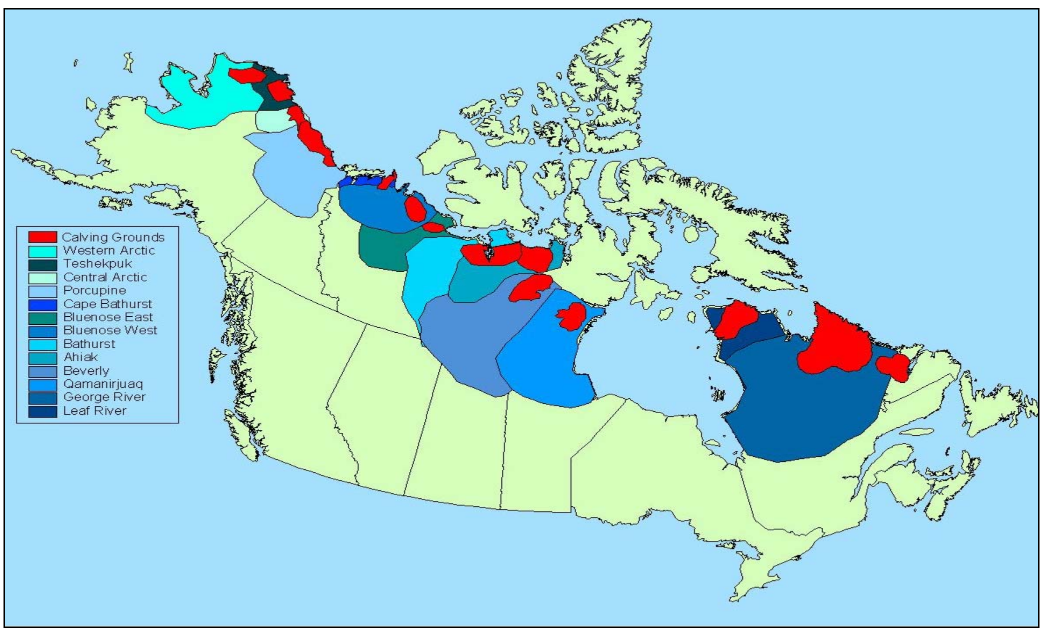

Figure 1 Map of North American migratory caribou herds and calving grounds

A series of questions was posed by the organizers at the outset of the workshop to guide the discussions and presentations over the 3-day meeting:

- What is the extent of knowledge about caribou calving grounds and where are the information gaps?
- Is everyone talking the same language?; i.e., How are calving grounds defined?, How is the peak of calving defined?, How are these things measured?
- Is a cross-herd comparison worth doing?; Are there herd characteristics and calving ground characteristics that are common among herds?
- Are all calving grounds created equal?
- Is there a systematic way to look at and assess impacts on caribou calving grounds across the North? What are the development pressures now and in the foreseeable future? How is climate change impacting caribou?
- Is all development bad?; Are impacts of a particular development equal for all herds?
- Is there potential for synergy in current and proposed research?

Workshop Agenda

Day 1
Expectations – what do participants want to get from this workshop?
Issues with Defining Calving Grounds – Where and when are calving grounds? How are they defined?
Herd Profiles and Initial Comparisons

Day 2
Factors Affecting the Location of Calving Grounds
Forces of Change
Herd Characterization

Day 3
Definition of Calving Grounds
Ecological Contribution of Calving Grounds by Herd
Synthesis and Discussion of Herd Characterization
Management Implications
Ongoing and Proposed Caribou Research
Action Items

Expectations

Participants were asked to describe what they expected / hoped to learn at the workshop. Responses varied, but some common goals emerged.

Information Management

- Identify existing data sets and their quality; identify gaps in data so future research can be directed to fill them.
- Develop some common standards and protocols to facilitate data collection and analysis across herds.
- Evaluate the quality of existing information; ensure a sound link between biology and policy.
- Move forward on studies of the challenges facing caribou across the continent.
- Develop a common language to describe the characteristics of calving grounds.
- Share information about individual herds to increase collective knowledge base.
- Gain perspective on individual herds by looking outward at what is known about other herds; obtain feedback (peer review) on the patterns observed in individual herds; how do other herds cope with environmental changes (e.g., the past two years) and with development?
- Refine ideas for a Central Arctic calving grounds project and identify potential collaborators.

Policy Issues

- Learn from the experience of others about how to transfer knowledge at the basic biology level into better decision-making at the government level.
- Understand the downstream management implications of the research being done.
- Understand the importance of the link between biology and policy-making; develop a framework for evaluating conflicts between conservation and development.
- Learn how to bring local people's traditional knowledge into decision-making processes.

Caribou Biology

- Gain a better understanding of the movements of animals at the landscape scale.
- Understand the importance of habitat and forage quality on and off the calving grounds.
- Understand the impact of predation on caribou bioenergetics and calving ground location for each herd.
- Understand the importance of access corridors into calving grounds.
- Evaluate the importance of calving grounds to northern mainland caribou. Fidelity of caribou to calving grounds has been interpreted as indicative of the importance of these areas in the life cycle of caribou, but do we really know this?
- Learn about how herds cope with different environments across the continent in order to help identify how an individual herd might cope with changes in its own environment over time.
- Understand the ecological contribution of calving grounds to the annual performance of caribou, relative to other parts of their range. Is it the same across all herds? If not, why not?
- Develop a better understanding of the diversity of strategies caribou use to increase fitness; broaden the inventory of ideas about the importance of calving grounds (not just predation vs. forage); How do large changes in herd size relate to calving grounds?
- Look at the broader picture; can't look at calving grounds in isolation from other factors that affect caribou success, e.g., conditions on the winter range, disturbances, climate change.

Current State of Knowledge

Issues Relating to the Definition of Caribou Calving Grounds

The content for this section of the report is based on a presentation made by Brad Griffith (US Geological Survey, University of Alaska Fairbanks). At the end of the workshop, the group revisited the definition presented by Brad and refined it based on the discussions generated by this and other presentations made over the course of the workshop. See the section "Definition of Caribou Calving Grounds" for the final group consensus on a definition for calving grounds (pg. 31).

The presentation focused on how to "delineate", rather than how to "define", calving grounds. At its most fundamental level, delineation of calving grounds must be based on calving sites. There are several methods currently being used across the continent to estimate the location of calving sites and calving areas. These are:

- aerial surveys at peak of calving - The locations of cows with newborn calves are depicted on topographic maps; concentrated calving areas may be delineated on field maps.
- VHF radio collared cows - Cows are repeatedly located during the calving season and the first sighting of a cow with a calf is the estimated calving site; to accept the first sighting as the calving site, no more than 3 days may elapse between seeing a cow without a calf and subsequently seeing the cow with a calf.
- satellite collared cows - Changes in movement rates over the calving period may identify calving cows and their calving sites. Our experience is that movement decreases dramatically at birth for some herds (e.g. Porcupine and Bathurst herds) while reduced movement rates are less obvious in other herds (e.g. Western Arctic, and Teshekpuk Lake herds).

For many herds, however, calving sites are simply not known and the location of the calving grounds must be estimated based on the distribution of cows during the calving period. Although this is a less refined data set than those that focus on calves, it was considered by the group to be a reasonable compromise that would make it possible to use existing data sets to delineate calving grounds for these herds.

The delineation of calving grounds for the Porcupine and Central Arctic herds is based on a fixed-kernel analysis of calving sites obtained from repeated aerial surveys, and results in contour lines that encompass four different types of distributions (Figure 2):

1. **annual calving ground:** the 99% fixed-kernel utilization distribution based on estimated calving sites for a single year.
2. **annual concentrated calving area:** the area that includes all documented calving sites with greater than average fixed-kernel density; on average this area includes about 50% of the annual calving sites in an area that encompasses only about 10% of the annual calving ground.
3. **extent of calving:** the aggregate extent of all known annual calving grounds
4. **extent of concentrated calving**: the aggregate extent of all known annual concentrated calving areas.

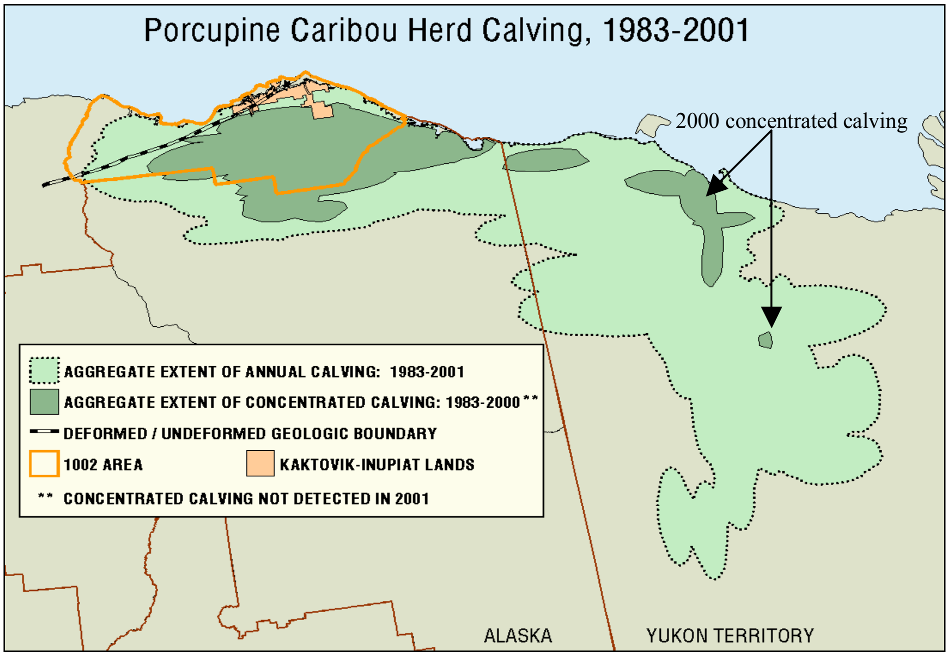

Figure 2 Porcupine caribou calving distribution, showing extent of concentrated calving and extent of annual calving for 1983-2001

The Arctic environment is highly variable, so the size and location of calving areas tends to be dynamic over the long term. For example, when environmental conditions (e.g. extensive snow cover in 2000 and 2001) prevented Porcupine Caribou herd cows from reaching their usual calving grounds in Alaska, they dropped their calves wherever they were at the time (Figure 2). Survival of these calves was reduced. Such outliers result in an ever-expanding aggregate extent of annual and concentrated calving.

Calf survival appears to be related to the location and properties of the annual calving grounds and concentrated calving areas. For the Porcupine Caribou herd, calf survival within the extent of calving is influenced by predators, forage quality, and forage availability. Annual calving grounds tend to be in places where forage greens up quickly within the extent of calving. Annual concentrated calving areas tend to be in places with fewer predators and with higher forage biomass than elsewhere within the annual calving ground. Although calf survival was enhanced in the annual concentrated calving areas for the Porcupine Caribou herd, the frequency of use of an area for concentrated calving was not related to calf survival. Industrial development has the potential to displace parturient cows from traditionally used areas of concentrated calving. In the western segment of the Central Arctic herd, the area of concentrated calving has shifted to the south away from the infrastructure associated with the oil fields along the coast (Wolfe et al. 2000).

Herd Profiles and Initial Comparisons of Familiar Populations

This section of the report documents presentations by participants that compared and contrasted pairs of herds familiar to the presenter. The following comparison criteria were given to presenters before the workshop as a guideline to content:

- time of arrival, time of departure
- peak of calving
- calf:cow ratios
- condition of animals
- hunting activities
- patterns of use, shifts, density, etc.
- diet
- vegetation phenology (when do first willows unfurl)
- calf mortality observations

This exercise later evolved into the development of a matrix of standardized criteria (including those listed above) to characterize each herd. This matrix was then used near the end of workshop to compare and contrast herds across the continent (see pg. 35). The matrix will be further developed and refined over the coming weeks with input from participants.

The material reported in the following subsections is summarized and contains the core information from each presentation as well as points of discussion that are relevant to the topic.

Western Arctic vs. Teshekpuk Lake – Jim Dau (Alaska Department of Fish & Game)

Surveys for the Western Arctic (Figure 3) and Teshekpuk Lake (Figure 4) herds rely primarily on conventionally collared animals, and begin each year on about June 3rd. Typically, weather is poor at that time of the year and it often takes up to two weeks to get the four days of flying required to locate each of the 120-125 collared animals once.

Figure 3 Typical calving landscape for the Western Arctic Herd

Figure 4 Typical calving landscape for the Teshekpuk Lake Herd

The years of 2000 and 2001 both saw unusual calving distributions in the Western Arctic caribou herd. In the period 1987-99, 98% of collared cows calved on the traditionally used calving grounds. In 2000, 17% of parturient cows calved about 1 day's travel south of the traditional area, and in 2001, 59% of cows calved outside the usual area. Most of these cows were well over 100 miles to the south. Even so, the June calf:cow ratio for the Western Arctic herd for 2001 was 66 per 100 cows, so calf parturition was not notably reduced by the departure from tradition. For the Teshekpuk Lake herd, however, 2001 saw very unusual calving distributions, with a large number of calves born off the traditionally used calving areas, and the lowest calf:cow ratio ever recorded.

Criterion	**Western Arctic**	**Teshekpuk**
Topography	Upland tussock tundra (Kuropat 1984)	Lowland moist graminoid/prostrate shrub tundra (Kelleyhouse 2001)
Arrival/departure	Arrive: early May Depart: late June *information based on 40 years of annual surveys, with locations since 1987	Arrive: late May Depart: mid to late June
Peak calving	June 3-10	June 4-12
Body condition	Unknown for parturient cows	Unknown for parturient cows, but appears to be poor in June
Hunting	None on calving grounds	Harvest occurs year-round; up to 8% annual harvest rate
Patterns of use, shifts, density	Maternal cows early May to late June Entire herd (diffuse) mid July – early October *aggregations of >200,000 caribou seen during insect season	Maternal cows mid May – late June Entire herd mid July – early October *occasionally, some caribou winter in calving area
Diet	*Eriophorum vaginatum* & *Dryas/Carex* Emergent forbs, e.g., *Lupinus arcticus*	Lichens, mosses, sedges Grasses, forbs and shrubs <18% of diet

Criterion	Western Arctic	Teshekpuk
	Emergent *Salix spp. pulchra* (Kuropat 1984)	(kelleyhouse 2001)
Vegetation phenology	June 4 *E. vaginatum* in flower June 10 *L. arcticus* in flower June 14 *Salix spp.* leaf buds opening (Kuropat 1984)	Unknown
Calf mortality	Neonatal mortality unknown Recruitment more dependent on summer survival than calf production *insect relief is terribly important (cow-calf separation, not eating, burning calories running)	High neonatal mortality 2001: 37 collared cows 4 nonparturient 17 neonatal deaths 16 calves survived Fall composition - ~20 calves per 100 cows (lowest ever recorded)
Adult mortality	Average annual cow mortality is 15% and ranges between 7% and 20% (sample of ~100 functional collars per year) Mortality for bulls is higher; try to keep 15 bulls collared, but sample is very unreliable	
Population size	430,000 (1999) census	25,000 – 28,000
Carry-over effects	Lack of correlation between spring parturition and subsequent fall calf:cow ratios suggests summer mortality is more important than factors on the winter range	

Central Arctic vs. Porcupine Caribou – Steve Arthur (Alaska Department of Fish & Game)

The data on Central Arctic caribou (Figure 5) distribution come almost entirely from conventional VHF radiotracking. Very little satellite tracking has been done on this herd. The Central Arctic herd winters in the Brooks Range, in recent years south of the crest. In late March or early April, the caribou begin drifting northward toward two distinct areas of concentrated calving on either side of the Sagavanirktok River (Figure 6). In 2001, snowmelt was late and the low-lying terrain was quite wet. Calves were dropped either in icy water or deep snow. During June, there is not much movement. In July, after snowmelt, caribou move up to the coast. By August there is notably more movement, and this is accompanied by higher mortality. By September, the eastern and western groups become almost indistinguishable in terms of their range. In the fall, Central Arctic caribou move rapidly south through narrow mountain passes toward their winter range.

Figure 5 Typical calving landscape of the Central Arctic Herd

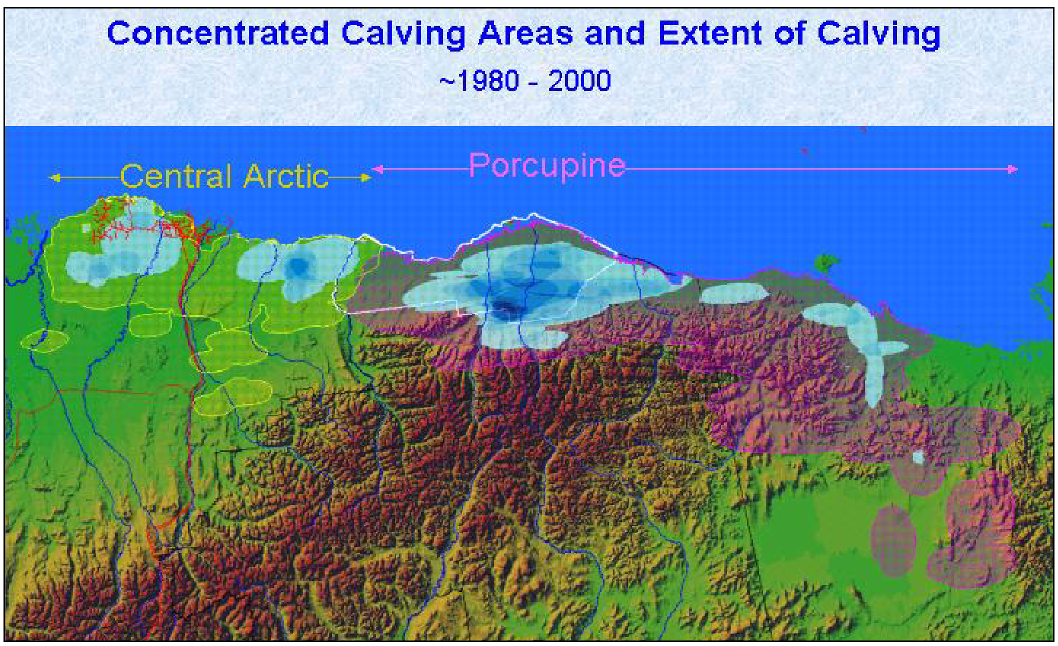

Figure 6 Calving distribution of the Central Arctic Herd and Porcupine Caribou Herd

In contrast to the Central Arctic herd, the Porcupine Caribou herd (Figure 7) has been monitored with both conventional and satellite tracking. The Porcupine Caribou herd winters in the Ogilvie, Richardson, and Brooks mountain ranges of Alaska, and the Yukon and Northwest Territories. Spring migration begins as early as March (mild winter) to as late as mid-May (severe winter). The caribou migrate north and northeast to the coast, and then travel west along the coast where they spend much of the summer. The first bare ground typically appears on the eastern coastal plain and moves west as the season progresses. Over the last two years, caribou did not reach the coastal plain in time for calving.

Figure 7 Typical calving landscape for the Porcupine Caribou Herd

Criterion	Central Arctic	Porcupine
Topography	Mostly low and wet; some high ridges and bluffs, dwarf shrubs, *Dryas*	Tussock tundra meadows, riparian uplands, drier heath in foothills
Arrival/departure	Early June	Arrive a few days earlier than the central arctic caribou
Peak calving	June 8-9	June 1-2 *when snow melts early, cows tend to calve further north; these conditions bring in early fog
Body condition		Cows arrive in poor physical condition ~ 5% body fat
Hunting	Some CAH taken by Kaktovik in June	Kaktovik and Aklavik may take some animals in june, depending on distribution
Patterns of use, shifts, density	During June there isn't much movement. When snow melt is early, calving is closer to the coast; when melt is later, calving is further south in the foothills. From 1987-92, there was 70% fidelity by parturient cows to their traditional side of the river	Caribou arrive along the foothills of the Brooks range from the east as snow melts. In years when snowmelt is late calving occurs in Canada or in the foothills. Normal years calving occurs in Alaskan coastal plain
Diet		Lichen and moss prior to green-up, diet shifts from *Eriophorum* flowers, to willow and forbs as spring progresses
Vegetation phenology		Green-up occurs from the foothills to the coast
Calf mortality		Long-term average is 25% mortality in first month; in late years of 2000 and 2001, mortality about 40%. Total annual mortality is 50%
Adult mortality		Based on radio-collars, adult cow

Criterion	Central Arctic	Porcupine
		mortality is 16% and adult bulls 17%. Yearling mortality is 6%
Population size	Herd increased from 5,000 in 1993 to 27,000 in 1999 despite the presence of oil development activity on the coastal range	Herd increased from ~100,000 in 1976 to 178,000 in 1989 and then declined to 123,000 in 2001.
Carry-over effects	Caribou in good condition are less likely to be impacted by stress associated with development activities than those in poorer condition	Strong correlation between late June condition and fall condition – little compensatory gain over summer. This holds for cows and calves

Cape Bathurst vs. Bluenose West vs. Bluenose East – John Nagy (Department of Resources, Wildlife & Economic Development, NWT)

The primary focus of research over the past 10 years has been to differentiate the herds in the area. What was initially thought to be a single Bluenose herd appears now to be two separate herds. This conclusion is based on the discovery in 1994 of two distinct areas of concentrated calving. Satellite collars were deployed in March 1996, some of which are still operational on caribou from the Cape Bathurst and Bluenose West herds. Work on the Bluenose East herd has been suspended.

The Cape Bathurst herd (Figure 8) winters on the Tuktoyaktuk Peninsula, moving east to calve in the spring. Little movement occurs over the summer months. For the Bluenose West (Figure 9) herd, there are three winter concentrations north of Great Bear Lake, and individual caribou appear to show little fidelity to any one of these from year to year. Calving distribution appears to be related to where the caribou winter as these caribou tend to calve close to their winter range. Some caribou stay on the calving grounds throughout the summer. The Bluenose East herd winters on the northeast and southern shores of Great Bear Lake, and move east and north to the coast for calving.

Figure 8 Typical calving landscape for the Cape Bathurst Herd

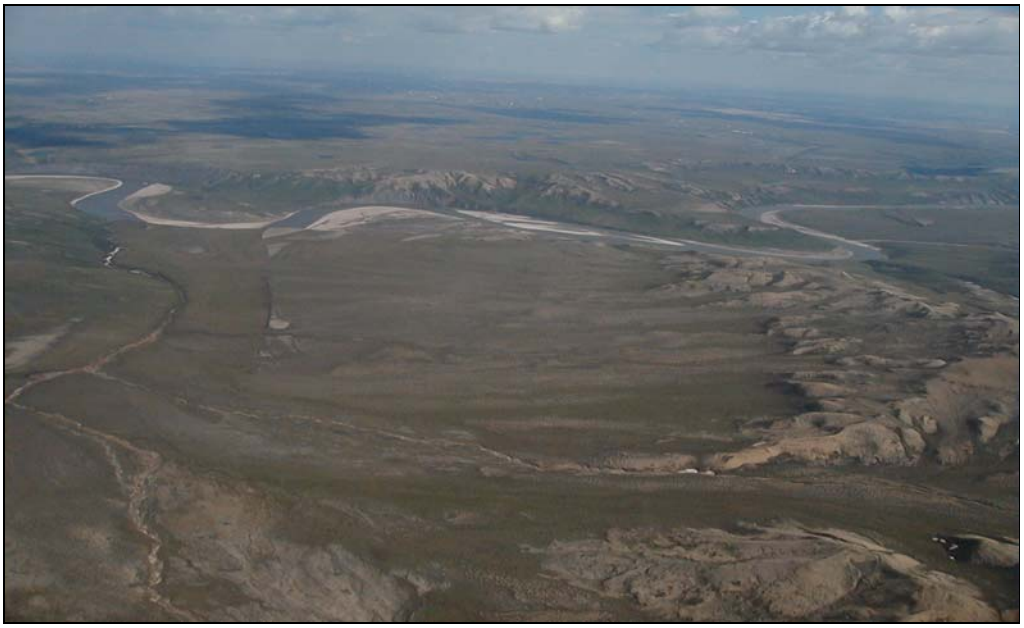

Figure 9 Typical calving landscape for the Bluenose West Herd

There is relatively little movement by caribou in all three of these herds. The location of calving grounds has been based on an analysis of daily distances travelled from mid-May to mid-July (Figure 10).

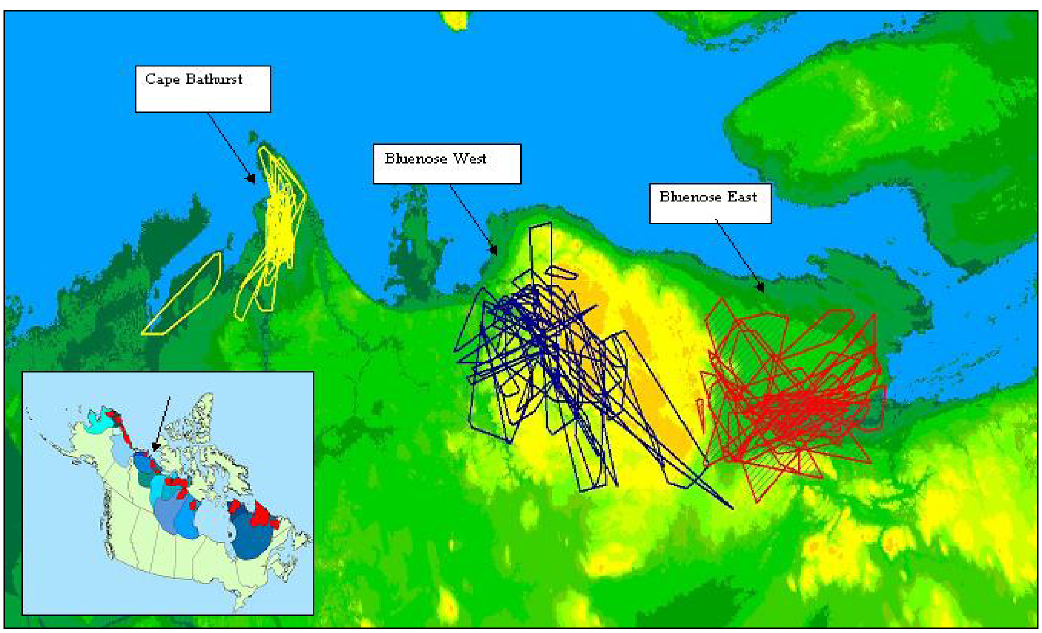

Figure 10 Calving distributions for the Cape Bathurst, Bluenose West, and Bluenose East Caribou Herds (Nagy et al., in prep.)

Most development in the area has been on the winter ranges of these caribou. Over the past 20 years there has been a tremendous amount of seismic activity (mines), as well as oil and gas exploration activity in the southern portion of the winter range. There is also a possibility of as much as $700 million available for oil and gas exploration in the Cape Bathurst area. Displacement of caribou from key winter range by development activities, combined with climatic factors and insect disturbance, influence caribou condition and calf survival.

Criterion	**Cape Bathurst**	**Bluenose West**	**Bluenose East**
Topography	*Eriophorum*, *Salix*	High elevation at coast	*Eriophorum*, tussock, shrub (*Betula, Salix*)
Arrival/departure		May 28 -	May 28 – June 25
Peak calving		June 6-7	
Body condition		Skinny bulls; insect harassment into late Sept.	
Hunting			
Patterns of use, shifts, density		This year, cows with calves tended to be further south than usual	
Diet	Late June: 88% willow July: 80-90% willow Winter: 90% lichen		
Vegetation phenology		Nearly 100% snow cover this year in early June (14th)	
Calf mortality			
Adult mortality		Unknown	
Population size	20,000	80,000	100,000
Carry-over effects			

Bathurst vs. Ahiak – Anne Gunn (Wildlife & Fisheries, Government of the Northwest Territories)

Systematic aerial surveys of the Bathurst herd (Figure 11) were conducted periodically from 1965-1996 using visual monitoring (pre-1980) and high-level photography (1980-1996) during peak calving whenever possible. To ensure full coverage of the area used for calving, surveyors fly for 10 minutes beyond the last cow sighted. Since 1996, a satellite collaring program has allowed the tracking of up to 16 cows on the calving grounds. The calving ground for this herd is considered to be the area used by cows, both pre- and post-calving, between May 25th and June 5th, and is located at the northern extent of the annual range (Figure 12). Over the years, the annual calving ground of the Bathurst herd has moved from the western side of Bathurst Inlet in the 1950s (based on information from the local Inuit) to the east (1960s-mid-80s), then in recent years back into the west. Reasons for this rotational use of calving areas may include the need to find fresh forage, or to escape from parasite-infested pasture. However, it appears that Ahiak herd may have moved into the abandoned area in the east, which contradicts both possible reasons.

Figure 11 Typical calving landscape for the Bathurst Caribou Herd

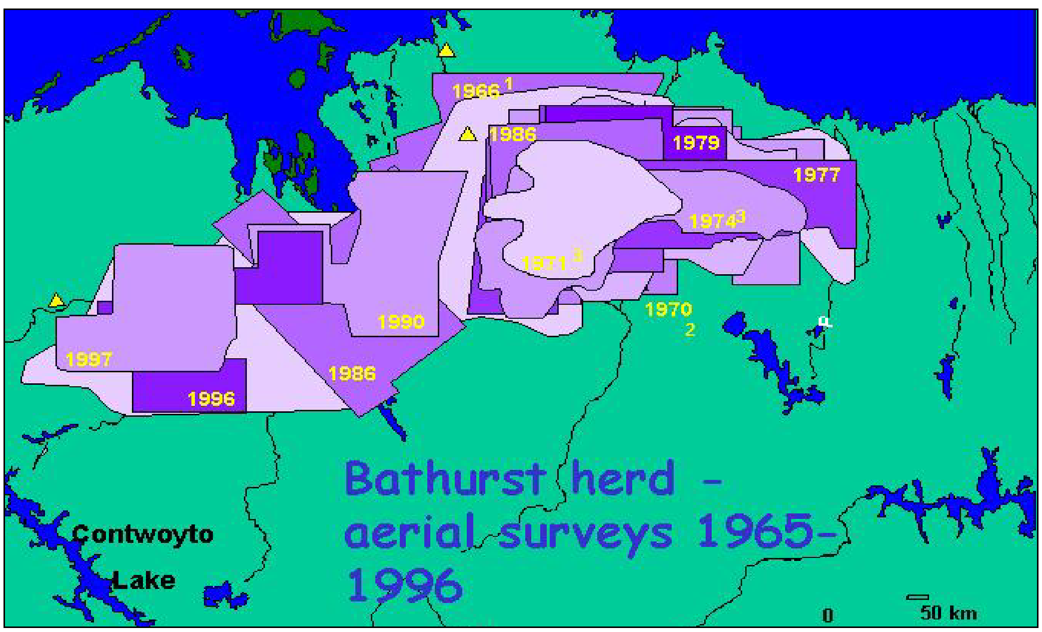

Figure 12 Calving distributions of the Bathurst Caribou Herd

For the Ahiak herd (Figure 13), also known as the Queen Maud herd, aerial surveys were flown in 1986 and 1996. In 1996, a satellite-collaring program began with 5 cows and annual telemetry through to 1998. The movements of collared cows show there is overlap in the areas previously used for calving by the Bathurst herd and currently, in some years the Ahiak herd shares its winter range with both the Bathurst and Beverly herds. Unfortunately, observations of this herd have not been systematic over the years, and it is not yet very well understood.

Figure 13 Typical calving landscape for the Ahiak Caribou Herd

There is a strong social element associated with the calving grounds, at least for the Bathurst herd. Does gregariousness at calving offer opportunities to evaluate the performance of others and use this information to determine a suitable place to calve? Also, escape from insects and parasites may play a role in choosing where to calve. Norwegian researchers postulate that a key function of the calving grounds is to escape harassment by warbles flies and mosquitoes, and to minimize exposure to nematodes. Caribou typically leave the calving grounds soon after calving, and the Norwegians speculate that this rapid departure reflects a strategy to minimize the gastro-intestinal build-up of nematode eggs and a cycle of re-infection. However, not all caribou herds follow the immediate departure model (e.g., Ahiak cows tend to stay on the calving grounds into the post-calving period).

Criterion	Bathurst	Ahiak (Queen Maud)
Topography	Granitic outcrops, marine deposits, glacial landforms lower elevation than winter range	
Arrival/departure	1996-2000 (west of Bathurst Inlet): Arrive - first cows May 16-29, all May 21-June 3 Depart - June 12-28 (5-15 days after peak of calving) * there is no overlap with post-calving range *50-100 caribou/km^2	No data, but arrive early June and some stay on into post-calving phase
Peak calving	Median dates (east of Bathurst Inlet): June 5-9 In late years (1969, 1979, 1986) June 11-15	
Body condition	No data	No data
Hunting	Some harvest levels are documented, but not all; no comprehensive data set available	No data
Patterns of use, shifts, density	Individual fidelity is strong (±10 km between consecutive years) Calving concentration has shifted 300 km to the west over the past 15 years; Inuit say calving occurred west of Bathurst Inlet in the 1950s	Show fidelity to calving grounds There is overlap in areas used for calving and post-calving

Criterion	Bathurst	Ahiak (Queen Maud)
Diet	Lichens up to calving Large annual variation in other foods used - 1998 (early green-up) rel. High use of sedges 1999 rel. High use of mosses 1997 rel. High use of forbs *corrected fecal/rumen analysis	No data
Vegetation phenology	*Eriophorum* – very few flowering stems; caribou seen biting into tussocks to get greening shoots Flowering begin May 31 (1998, 1999) to June 4 (1997) Dwarf birch buds break by June 5 in early years (1998), but not seen by June 9 in 1999 or June 13 in 1997	No direct data, but very strong west to east >0^{o}c temperature gradient in spring
Calf mortality		No data
Adult mortality		
Population size		1986: 40-60,000 1996: 200,000
Carry-over effects		Overlap with Beverly and Bathurst winter ranges

Beverly vs. Qamanirjuaq – Mitch Campbell (Department of Sustainable Development, Nunavut)

Very little is known as yet about the Beverly herd (Figure 14) as few animals have been collared and none have been satellite collared; the priorities of the local communities currently lie with the Qamanirjuaq herd, based on the harvested proportion. There is a rotational quality to the Beverly calving grounds. In the late 1950s, calving occurred in the south, then moved northward and is now coming south again.

Figure 14 Typical calving landscape for the Beverly Caribou Herd

Recent research on the Qamanirjuaq herd (Figure 15) is based on satellite-collared animals. From 1993-95, 5 collars were deployed; from 1995-1997, 7 more collars were deployed; and since 1997, 10 collars have been deployed that will be used for six years. Only adult animals, about 4-5 years of age, have been collared. Spring migration for the Qamanirjuaq herd occurs from March 16 – May 25; onset may be delayed if the snow is deep on the winter range. Calving occurs from May 26 – June 25 at the northern extent of the annual range, with the peak at 5-15 June. The post-calving period is June 26-July 31, and the late summer period is August 1 – September 15. Rut and fall migration occur from September 16 – October 31, and by November 1st most caribou in this herd are rapidly moving toward the winter range below the tree line. There is a clear distinction between the Qamanirjuaq herd and the Beverly herd ranges in the summer, but these caribou overlap on their winter ranges.

Figure 15 Typical calving landscape for the Qamanirjuaq Caribou Herd

Typically, Qamanirjuaq caribou can be found just north of Meultin Lake, and in recent years, the Seal River in March. Historically, they begin their spring migration toward the calving grounds by May 2nd although migration has begun in late May in recent years. In 2000, animals were just leaving their winter range in northern Manitoba and Saskatchewan May 18-25, and many cows did not reach the calving grounds to calve; calf mortality was high that year. In the spring of 2001, animals started migrating through the Seal River again (not used since the 1950s). It is speculated that one of the reasons for this shift in travel patterns could be predators. Over the years, harvesting has culled about 600 wolves every year from caribou range. Both 2000 and 2001, however, were characterized by severe winters and the wolf harvest was reduced.

Criterion	Beverly	Qamanirjuaq
Topography	Sandstone outcrops, glacial landforms Relatively flat; less rock toward the west North of Baker Lake, there are eskers, grading into undulating topography with frost boils, shrub tundra, *Arctagrostis* and *Vaccinium*	Granitic outcrops, marine deposits, glacial landforms Gravel and boulders over bedrock; lichen on outcrops with *Eriophorum*, *Carex*, *Betula*, *Salix* ~ 10% sedge meadow
Arrival/departure		Arrive: May 26 -
Peak calving		June 5-15
Body condition	Variable	
Hunting	9% of harvest in Nunavut; almost all of those caribou taken by Baker Lake	Extensively harvested
Patterns of use, shifts, density	Seems rotational from the south to the north and back to the south	May be a spatial shift, but not clear
Diet	Lichens (winter), grass/sedge (summer)	Lichens (winter), grass/sedge with seaweed as mineral licks (summer)
Vegetation phenology		
Calf mortality		Can be high (e.g., 2000); there are lots of wolves, and hunting
Adult mortality	Unknown	Unknown
Population size		~ 500,000 to 600,000
Carry-over effects		

Leaf River vs. George River – Micheline Manseau (Parks Canada, Winnipeg)

The range of the Leaf River caribou herd (Figure 16) is west of Ungava Bay, and overlaps in the winter with that of the George River herd. The calving ground traditionally used by the Leaf River herd is quite large relative to the size of the annual range and is distinct from that of the George River herd.

The George River caribou herd (Figure 18) ranges throughout far northern Quebec and Labrador, with some degree of concentration in Labrador. These caribou winter in the boreal forest and east into the Mealy mountain range of Labrador. There is high fidelity among George River caribou to the calving ground at the northeastern extent of the annual range and overgrazing there and on the summer range has been observed.

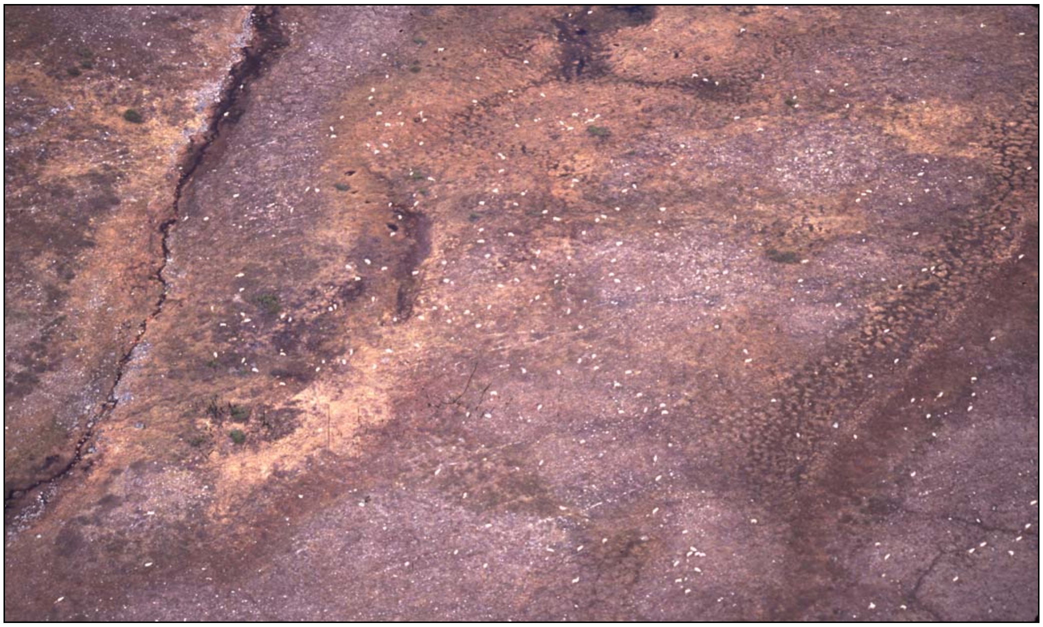

Figure 16 Typical calving landscape for the George River Caribou Herd

Satellite telemetry work (10 km^2 pixels) has been done on the George River caribou herd from 1986 to present. Poor physical condition of cows in spring and summer, as well as low growth rates of calves during their first summer, were documented in 1988 and 1993. Significant reductions in forage biomass were documented for the summer range. Experiments on the impacts of grazing pressure on vegetation quality were also conducted. Although there was no significant correlation with nutritive value, biomass declined. This response suggests that forage species have little resilience to grazing. Aggregation size was also thought to be a contributing factor to the poor condition of the cows. Animals in large aggregations tend to spend more time moving and less time feeding than animals in small aggregations. These observations were corroborated by local hunters. There is speculation that such large aggregations move quickly because the available forage is rapidly consumed and there is a need to continue moving in search of food. For the George River herd, peak aggregation size corresponds with peak biomass. Insect-driven aggregations tend to be smaller and more tightly packed than feeding aggregations.

Development impacts occur primarily on the winter ranges of these caribou herds, and include low-level flying, hydroelectric, and mining activities. Additionally, range expansion is bringing the herds into contact with sport hunters from communities to the south in areas where there is road access.

Criterion	Leaf River	George River
Topography		Rocky, spruce-lichen forest; rolling; high plateaus
Arrival/departure		
Peak calving	A few days earlier than the GRH	2nd week of June
Body condition	Poor condition upon arrival (1993, 1994) June to July : no loss of fat; protein same as for GRH; calf growth rates higher than for GRH Calf weights: calves larger in June than GRH	Poor condition upon arrival (1993, 1994) June to July: fat loss; protein same as for LRH; calf growth rates lower than for LRH because these cows were losing weight; even so, GRH cows were not lighter than LRH cows Calf weights at 1 week and 4/5 weeks of age: no difference between 1988 and 1993
Hunting		
Patterns of use, shifts, density		
Diet	June: lichens, standing dead grass July: *Betula glandulosa,* some *Salix* *based on rumen content	June: standing dead grass and twigs July: *Betula glandulosa*, grass *based on rumen content
Vegetation phenology		Shrub leaf-out occurs up to 2 weeks after peak calving (1993 late spring) Good high N but also high phenolic content
Calf mortality		
Adult mortality		
Population size	~550,000 (2001) (260,000 in 1991 census)	~440,000 (2001) (780,000 in 1993 census Couturier et al. 1996)
Carry-over effects		

Factors Affecting Calving Ground Location

This section of the report documents a series of presentations by participants describing the role of various factors thought to influence the location of calving grounds. Each subsection contains a summary of the core information from each presentation.

Landscape – Don Russell (Canadian Wildlife Service, Whitehorse)

The question explored by this presentation was whether landscape-level trends exist across the continent and, if so, are they biologically meaningful? Can we categorize herds by the land or vegetation types they use? Is a comparison of herds across the continent a valuable exercise?

On a very crude level, there is a trend in vegetation type from relatively dense shrub tundra on mesic or moist sites in the west to more barren sites with lichens in central North America and trees east of Hudson Bay. Additionally, there is a general trend to larger calving grounds from west to east, but there appears to be no trend in the density of cows on calving grounds. Note, however, that the cow density data are preliminary and will be refined as more data become available. In terms of climate, the number of growing degree days up to 10 days after peak calving tends to increase from west to east (Figures 18 and 19). This trend persisted even when the data were corrected (by imposing a cut-off date of June 15) to account for later calving in the east. There is no clear west to east trend in caribou body weight, although caribou in areas with the highest number of growing degree days appear to be larger (i.e. Bluenose and George River).

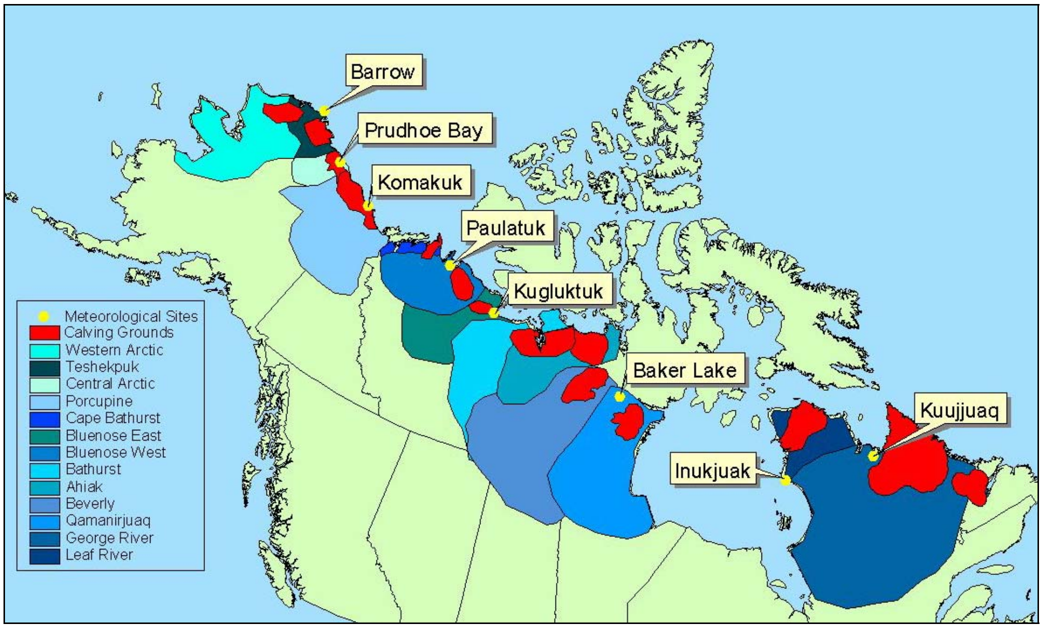

Figure 17 Selected weather stations across North America

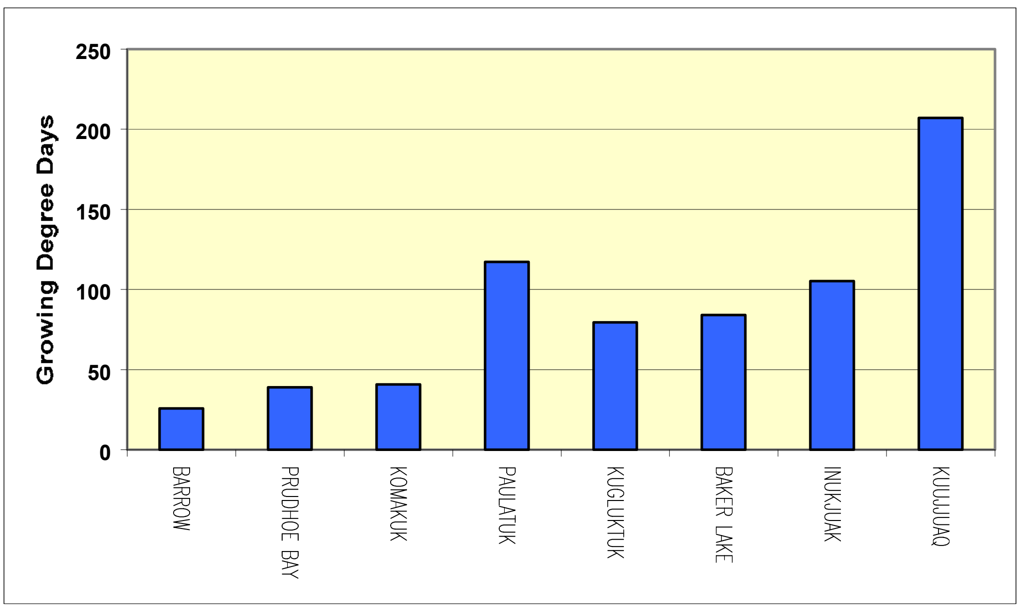

Figure 18 Growing degree days to 10 days after peak of calving for selected weather stations

Discussion focused on the validity of looking at cross-continental trends with currently available data. As it stands now, the analysis could be misleading because there is no standardization of methods from herd to herd; data are collected differently for each herd, the definition of calving grounds is not uniform for all herds, and the quantity and quality of data also differs. Care must be taken to avoid drawing conclusions regarding these trends until the data can be refined.

Green-up – Brad Griffith (US Geological Survey, University of Alaska Fairbanks)

This presentation focused on forage habitat selection and its impact on calf performance.

Estimating forage abundance using traditional sampling methods is not feasible given the very large scale of barren-ground caribou calving grounds and annual ranges. The satellite-based Normalized Difference Vegetative Index (NDVI) was employed to overcome this problem. NDVI estimates the relative total green biomass (i.e., not lichens) with a 1 km resolution. NDVI assumes that caribou forage is correlated with total green biomass. The following terms were defined:

NDVI_calving	=	median NDVI as close to median calving date as cloud cover conditions allow (NDVI not obtainable when cloudy); this value varies among years and among herds because calving dates vary among herds
NDVI_peak-lactation	=	median NDVI 3 weeks post-calving (peak lactation demand); higher values reflect earlier green-up, not necessarily greater maximum biomass (dates vary among herds, ~ June 21- July 5, because calving dates vary among herds)
NDVI_rate	=	median daily rate of increase in NDVI between calving and peak lactation (rate of green-up)

Caribou distribution in relation to particular components of NDVI varies among herds and among scales of analysis. For the Porcupine Caribou herd, annual calving grounds are located in areas, within the extent of calving, which have higher than expected rate of green-up (NDVI_rate). In contrast, concentrated calving areas are located in areas, within the annual calving grounds, that have higher than expected green biomass (NDVI_calving, NDVI_peak-lactation). High densities of caribou in the concentrated calving areas may require that these areas have high forage biomass to minimize intraspecific competition for forage. Herds whose calving grounds are located in wet coastal habitats (e.g. Central Arctic, Teshekpuk Lake) tend to respond more consistently to rate of green-up (Kelleyhouse 2001, Wolfe et al. 2000) than do herds whose calving grounds include a larger component of upland habitats (e.g. Western Arctic, Porcupine, Bathurst; Kelleyhouse 2001, Griffith et al. 2001). Regardless of the particular component of NDVI that is associated with caribou distribution, all NDVI components reflect some aspect of forage quality and availability.

In addition to being associated with caribou distribution on calving grounds, NDVI_peak-lactation has been associated with calf survival for the Porcupine Caribou herd. Calf survival during June was strongly and positively correlated with median NDVI_peak-lactation within the extent of calving. At the smaller scale of the annual calving ground, calf survival was strongly correlated with NDVI_peak-lactation within the annual calving ground and with the proportion of calves born in low predation risk areas. Because distribution of cows is associated with NDVI (green forage), and because calf survival can be predicted from NDVI, a basis for assessing the implications of climate change and industrial development on calving grounds is established.

Energetic Requirements – Bob White (Institute of Arctic Biology, University of Alaska Fairbanks)

This presentation explored the relationship between milk intake and growth rate in caribou calves.

The quantity of milk a cow produces depends on her condition (i.e., weight; fat and protein levels); cows with more reserves produce more milk. Milk production may or may not increase over the first 3 weeks; there is a lot of variation among animals. Milk intake by calves less than 3 weeks of age is high (1-2 litres per day), and then declines steadily over the next five months. In the first week of life, calves nurse up to 30 times per day. This rate declines to 2 or 3 times per day after a few months. The milk intake per nursing bout increases as the calves grow but it is insufficient to compensate for the lower frequency of nursing. Yet while the total milk intake declines, the amount of energy obtained from nursing remains relatively constant. The milk becomes more concentrated over time, compensating for the decline in intake as the calves age. The low energy value of milk at calving may contribute to cow-calf bonding as the need to nurse up to 30 times a day ensures that a calf stays physically close to its mother.

Calf growth rate is positively correlated with milk intake, more tightly after 3 weeks than before. One possible explanation for this finding is that, until the rumen develops at about 3 weeks of age and calves can start digesting forage, the milk they ingest must be used for maintenance as well as growth. After 3 weeks of age, all milk can be directed into growth. Calf growth rate is also correlated with maternal weight, based on data collected from the Porcupine, Leaf River, and George River herds. Nearly all of the protein required to grow a foetus comes from the cow's own reserves rather than from winter forage. Pregnant cows with few protein reserves tend to give birth to small calves. Additionally, calf weight 3 weeks post-calving is very highly correlated with weight in late fall. This relationship implies that calves cannot compensate later for lost growth early in life.

The presentation concluded with discussion around the question: "When is a calving ground no longer a calving ground?" Or asked another way, "At what point does the calving period end?" From an energetics viewpoint, calving grounds are more than just where calves are dropped. A definition for calving grounds must consider where calves are until they are able to eat and digest green vegetation (generally about 3 to 5 weeks post-calving), because this initial period is critical to their growth, their ultimate size as adults, and the size of their own calves in later years (a generational effect).

Predation – Anne Gunn (Wildlife & Fisheries, Government of the Northwest Territories)

The data presented were from a 1980s data set generated by searches on foot and from helicopters for dead calves on the Beverly and Qamanirjuaq calving grounds. Surveys from 1981 to 1983 did not show high numbers of predators, but this doesn't mean that predation rates were low. The level of predation varied between calving grounds and from year to year.

Wolf predation was the leading cause of death among calves in the Beverly herd, being responsible for 50-70% of calf mortality. In 13% of these deaths, however, calves had health problems (e.g., pneumonia) that would ultimately have led to their deaths anyway. Bears also killed calves, but evidence of these kills was difficult to detect because all that was typically left behind was the hooves. The relationship between predator densities and calf mortality is not clear, but there is some evidence to suggest that there are fewer wolves on the calving grounds than outside it, at least for the Bathurst and Beverly herd although that relationship does not appear to hold for some herds in the northeast.

The second leading cause of calf mortality (15%) was stillbirths (neonatal atelectasis – failure of the lungs to inflate), followed by premature births (foetal atelectasis). Underweight calves (< 4 kg) were more likely to be born dead than chance would dictate. This implies that cows in poor condition (including those stressed by disturbance?) have a higher probability of losing their calves, because there is an established link between cow condition and foetal development.

The method used to survey calf mortality influences the results. For example, if sampling occurs after the peak of calving, many deaths due to natural causes such as stillbirths, complications around premature births (e.g., atelectasis), abandonment of under-developed calves, and starvation could be missed. Including only calves up to 3 days of age in surveys would help address these sampling biases, and necropsies on calf carcasses could identify when such factors as atelectasis have played a role.

Forces of Change

In this section, summaries of presentations about the impacts of global climate change and industrial development on caribou are documented.

Global Climate Change

Baking the Tundra *– Greg Henry (Department of Geography, University of British Columbia)*

The Arctic has experienced a warming trend over the past 30-40 years, particularly in western Alaska and the central Canadian Arctic, including Hudson Bay. Northern Quebec and Labrador appear to have been affected little by climate change as of yet. Researchers predict longer and warmer seasons, a northern migration of permafrost, a deeper active layer, changes in soil moisture, a release of nutrients and labile carbon, and a variety of direct (plant growth) and indirect effects (nutrient cycling). In terms of tundra plants, the seasonal trend will likely be towards earlier leaf-out, possibly delayed senescence, increased net primary production, and greater reproductive success. These trends are likely to be accompanied by a change in species composition and relative abundance.

Feedbacks to surface energy balance, gas exchange, carbon balance, and nutrient cycling may also occur. There will also likely be feedbacks to higher trophic levels through changes in forage quantity and quality; for example, as the size and success of vascular plants increases, there may be a loss of lichen biomass through shading. These changes can take only days to occur (e.g., individual plants) or hundreds of years (e.g., moving treeline).

Field experiments are being conducted to explore the impacts of warming on tundra plants and ecosystems. Many of these experiments are part of the International Tundra Experiment (ITEX), with common protocols followed at a number of sites throughout the circumarctic region. In a meta-analysis of results across the ITEX network, the following general results were found for the first four years of warming (Arft et al. 1999):

- Flowering and leaf-out occurred earlier in all plant groups (deciduous shrubs, evergreen shrubs, forbs, and graminoids) but there was no effect on senescence.
- Reproductive effort increased in high arctic sites, especially in herbaceous plants, but there was no significant effect in low arctic sites.
- Vegetative growth increased more in low arctic than in high arctic sites and mainly in herbaceous species.

After 5 years of experimental warming at a high arctic location, deciduous shrubs, graminoids, and forbs in dry and mesic sites exhibited strong growth and biomass responses. Evergreen shrubs in mesic sites showed increased reproductive effort in response to warming, but no significant growth or biomass response. Increased shrub biomass was accompanied by increased litter and a loss of lichen biomass, a result found in many other arctic warming experiments (Cornelissen et al. 2001). In the wet sedge plots, no strong growth responses to warming have yet been detected; the standing water at these sites may be absorbing the heat, thereby dampening the effect on the plants there. This may partially explain the observed differences in trends of NDVI at calving for the Porcupine Herd and the adjacent Central Arctic Herd. Both herds have experienced significant warming within their calving grounds although only the Porcupine range has shown a strong plant (NDVI) response to this warming trend. The fact that the majority of Central Arctic calving grounds occurs in wet sites may mean that the abundant standing water at calving absorbs most of the increased heat and thus no plant response could be measured using NDVI from satellites.

Additional experiments were conducted to examine the effects of warming and snow manipulation on arctic plants. Warmed plots from which snow was also removed showed large increases in shrub and herbaceous plant abundance, leading to declines in lichen biomass. Warming also increased the ratio of carbon to nitrogen in shrub species but did not affect the ratio in herbaceous species (Tolvanen and Henry 2001). This response may have implications for forage quality where caribou rely on shrubs.

Discussion focused on how the existing program of tundra warming research might be used to explore the impacts of climate change on caribou calving grounds. Some of the existing Canadian Tundra and Taiga Experiment (CANTTEX) monitoring plots are near calving grounds, and others could be added to more effectively cover the areas of interest. There is a need to understand the long-term functional responses of tundra plants to warming and the importance of these responses to herbivores such as caribou.

***An Overview of Climate Trends North America** – Brad Griffith (US Geological Survey, University of Alaska Fairbanks)*

There has been a strong warming in the Arctic, particularly since the late 1970's. The warming has been most pronounced in the winter and less strong in the spring. During this warming, many North American barren-ground caribou herds have increased. However, the warming is heterogeneous across the North American Arctic. Strong warming is expected (documented) in the west; some areas may not have warmed; and cooling may have predominated in the east. The warming trend has been correlated with earlier green-up in the zone north of 40^o using NDVI (Myneni et al. 1997, 1998).

Evidence of warming on the calving grounds of five North American herds, as detected from NDVI trends, has been variable. Of the five herds studied, there have been increasing trends in NDVI_peak-lactation, 1985-1999, in three herds (Porcupine, Western Arctic, Bathurst) and no evidence of warming (earlier green-up) on the calving grounds of two herds that occupy wet coastal areas (Central Arctic, Teshekpuk Lake). The lack of trend in coastal calving grounds may be due to the heat capacity of water masking the signal, or we may have sampled too early (21 June). Across North America, 2000 and 2001 have been outliers and it is not clear if these observations suggest a phase shift in the warming, or if they are simply unusual observations. The increase in NDVI_peak-lactation through time, where it occurs, suggests that forage at peak-lactation is becoming closer to maturity, and this may suggest a decline in forage quality on the calving grounds. This result is predicted on a 15-year record that indicates no increase in *maximum* NDVI. Further research is needed on this topic.

The Arctic Oscillation is a large-scale pattern of atmospheric pressure that is related to several other hemispheric scale climate indicators. There is a positive cool phase and a negative warm phase to the AO. The population size of the PCH tends to track the pattern in the AO over the years, although the data set is too small as yet to be certain about the relationship. The putative association between the AO and PCH population size may be related to winter range conditions. During the decline phase of the population, 1989-2001, there have been more days in both spring and fall with potential icing conditions compared to the increase phase of the population, 1975-1989. Icing may reduce access to forage, facilitate hunting by predators, or reduce caribou survival on winter range. There is also evidence that NDVI_calving is weakly associated with AO from the previous winter (16-month lag). The lagged effect may be related to the one-year delay between cottongrass tiller formation and subsequent appearance of cottongrass flowers, which are a major forage item for PCH caribou. The mechanisms explaining the relationship between large-scale atmospheric conditions and caribou need to be further examined.

Industrial Development Activities

***Mining Development in Slave Geological Province** – David Livingstone (Department of Indian Affairs and Northern Development, Yellowknife)*

There is considerable interest in continuing to develop North America's arctic regions for mining. The timing and rate of that development depends on commodity prices, particularly gold and diamonds, so it is difficult to predict with certainty. Currently, there are two producing mines in the Slave Geological Province (the lowest number since 1940) and two mines are under construction; of the two mines under construction, only the Diavik Diamond Mine is located where it might impact barren-ground caribou. Exploration for both gold and diamonds is significantly lower than the historical average, and the situation will likely remain this way until commodity prices improve. The number of companies and prospectors engaged in advanced exploration in the area, particularly for diamond deposits, has decreased by over 50% since 1994. Recent world events and the deepening recession have softened the demand for diamonds, and will likely result in further declines in exploration expenditures by the mining industry. Currently, there are four exploration projects under way on barren-ground caribou range; two of these are for diamond mines, one is for a cobalt-gold-bismuth mine, and one (on hold pending marketing) is for a rare metals mine. There are unlikely to be any new mines developed for the next five years.

Other developments in the Slave Geological Province likely to impact barren-ground caribou include roads (both winter and all-weather), hydroelectric, and recreational outfitter facilities. Currently, all-weather roads in the Northwest Territories are extremely limited; most over-land access is by way of winter roads. Winter roads provide adequate service for diamond and gold mines, but lead/zinc mines require all-weather surfaces for transportation of goods. A proposal has been made to develop an all-weather road in the Northwest Territories, as a means of attracting more mining companies to the region. Another all-weather road is proposed for Nunavut, as well as a deep-sea port. The Nunavut road proposal received funding in 2001 for a feasibility study, and will be reviewed again when that is complete. The existing network of winter roads includes a stretch between Yellowknife and Lupin and numerous feeder roads. Proposals for alternative winter roads are on hold due to current economic constraints in the mining industry. These include stretches from Rae to Lupin, Izok to Coast, and Lupin to Ulu.

There are two operational hydroelectric facilities in the Slave Geological Province, and two more have been proposed. The proposed station at Indin Lake would provide power to the diamond properties in the region, and would include a transmission line across barren-ground caribou range.

About 20 permanent outfitter camps operate within the Northwest Territories, most of which have satellite facilities remote from the main camp. It is unknown how many additional camps are in the proposal stage. In Nunavut, there is increasing concern among First Nations people about the impact these camps may be having on the Bathurst caribou herd. The harvest is small relative to the size of the herd, but the outfitters are non-aboriginal and there is real concern about the effects of disturbance on the herd.

Discussion focussed on the cumulative effects of development on caribou and how to assess it. The development of a conceptual approach to cumulative effects assessment (CEA) on caribou range is needed, and engaging the mining companies and local communities in a caribou monitoring program would help everyone better understand how the combination of developments in the area is affecting caribou. In Canada, CEA has been put into law. The Northwest Territories is in the process of developing a framework for CEA, including a specific plan for the Slave Geological Province.

The CEA framework under development in the Northwest Territories includes:

- land use planning;
- developing a protected areas strategy (there are currently no protected areas in the Slave Geological Province);
- cumulative effects monitoring;
- research (caribou resilience, thresholds, carrying capacity indicators, linear disturbance models, etc.); and
- monitoring caribou (distribution, community perceptions of physical condition, herd trends, spring and fall calf survival, plant phenology at spring migration).

The focus for monitoring should include both the calving grounds and the post-calving areas.

Monitoring work around the Ekati diamond mine suggests a tendency for caribou to avoid the mine site, but it is difficult to distinguish how much of the avoidance is related to the mine site and how much to the patchiness of vegetation in the area. There is a 21 km stretch of road connecting two pits and a second road under construction. These roads are both perpendicular to the migration route used by the Bathurst caribou herd, and as many as 5,000 caribou can pass through the area over the course of a few days. The effect of the Diavik diamond mine on caribou is not known but caribou will encounter the site during spring and fall migrations and summer movements.

Oil Development in Arctic Alaska *– Steve Murphy (ABR, Inc.)*

Oil development in Alaska has brought roads, buildings, noisy processing facilities, airstrips, freshwater impoundments, drilling sites, oil wells, etc. into the ranges of the Central Arctic and Teshekpuk Lake caribou herds. Currently, oil deposits are being drilled along the coast of the Central Arctic range, and there is still interest in developing a gas deposit and pipeline there. In the past few years, the NPRA began leasing land for exploration, bringing ice roads and oil exploration activities into the area.

In the early years of oil development, the footprint for a development could cover 11,000 hectares and include open reserve pits and other obstructions to caribou movement. Over the years, improving technologies have resulted in sites with smaller footprints, which means that fewer caribou will encounter these sites as they move across the tundra. Additionally, a number of mitigation strategies can be employed to facilitate caribou movement through development sites and/or to minimize contacts between caribou and infrastructure; these include:

- elevating pipelines to a minimum of five feet, with higher elevations (7-8 ft.) in strategic locations;
- separating pipelines from roads by at least 300 ft. (caribou can handle pipelines and roads much better when they are not combined);
- traffic reduction/convoying through sensitive areas (industry has only recently agreed to do this);
- installing ramps at strategic locations;
- designing and placing facilities to minimize or avoid contact with caribou (away from areas known to be used by caribou); and
- consolidation of production and support facility infrastructure into more dense configurations (caribou avoid infrastructure during calving and post-calving).

Survey data from the Alaska Department of Fish and Game showed that the Central Arctic herd declined in the mid-90s, and there was speculation about a link between lower calf production and oil development. In the past 5 years, however, calf production and herd size have increased and there no longer is evidence of population-level effects on these caribou. Some issues for caribou management in the area remain, however, including: constraints to free passage through oil fields; the number of animals available for subsistence harvesting; and displacement of caribou from preferred habitat (for calving and during the insect season).

The Central Arctic herd was cited as an example of displacement from preferred habitat; telemetry data and aerial surveys during calving have established that the area of concentrated calving has shifted in recent years away from the developing network of infrastructure along the coast. This change in distribution during calving was accompanied by an increase in herd size, however, so some degree of range expansion was not unexpected. The range expansion does not appear to fully explain the shift in calving activity, as a comparable change did not occur in a reference area having no development. Further analysis showed that the traditional area of concentrated calving has not been abandoned altogether, and there are comparable numbers of caribou using it now as before the distributional shift. Studies of caribou responses to infrastructure continue in both the northern and southern extents of the annual calving area. In the southern portion of the Kuparik/Prudhoe fields, two oil companies have started intensive exploration in the new concentrated calving area. In response to these activities, intensive surveys are being conducted to establish caribou distribution patterns in the area and to determine if there is active avoidance of the new infrastructure. The results of this work will drive decisions about additional infrastructure there.

For the Teshekpuk Lake herd, the areas on the west and east sides of the lake are known to be important for calving and insect relief (based on 10 years of satellite data). On the strength of this information, the Bureau of Land Management has agreed not to lease any land in these areas for development.

***Development in Northern Quebec and Labrador** – Fred Harrington (Mount St. Vincent University, Nova Scotia)*

The development activity of most concern for the Leaf and George River caribou herds is disturbance caused by low-level flying from the NATO-run military training facility located in the south end of the winter range. Jets pass over the ground at speeds of ~800 km/hr and elevations of only 30 m. The only mitigation strategy currently in place for moderating the impact on caribou is an agreement to suspend flights when the animals are present. This strategy has worked well for both NATO and the caribou because training normally shuts down for the winter months; most flying occurs when caribou are on their calving and summer ranges to the north. Over the past ten years, however, the calving ground of the George River herd has expanded and is beginning to encroach on the northern edge of the fly zone. Research on woodland caribou in the area has linked jet over-flights with reduced calf survival. Cows disturbed by jets tend to move around more, thereby increasing the risk of losing their calves to predators.

Other developments in northern Quebec and Labrador include roads, human settlements, and the Voisey's Bay nickel deposit on the central Labrador coast. None of these developments, however, is likely to impact the calving grounds of the George River caribou herd. Currently, there are no roads in the areas used for calving by the herd because the elevations that characterize the area tend to discourage their construction. Additionally, there are no human settlements near the calving grounds. In the late 1950s, all of the Inuit communities north of Hebron were relocated to points further south by the Canadian federal government as a cost-saving measure. At Voisey's Bay, there has been a lot of exploration and staking activity along the coast in recent years, but none of this has affected the herd because the calving ground is effectively isolated from the coast by its elevation. There is, however, a hydroelectric facility at the southeast corner of the range (near Churchill Falls) and a plan, which is currently on hold, to install power lines that would cross winter and post-calving ranges.

On the whole, there is relatively little development activity now in the area of the George River herd calving grounds. However, Labrador has no protection measures in place that would safeguard the herd's calving grounds in the event of a major resource discovery. At the federal level, though, some measures are being taken that should provide some protection for calving grounds. After a long period on hold, the federal government is moving forward with plans for a national park in the Ungava region of Labrador, and for two protected areas in Quebec (one of which is adjacent to the proposed park in Labrador).

Synthesis

Definition of Caribou Calving Grounds

On the final day of the workshop, the group reached a consensus on a working definition for "calving grounds" that is based on the information presented and discussed during the previous two days. The objective was to develop a definition that was robust enough to allow for different methodologies and applications from herd to herd.

A calving ground is defined as:
- the area occupied by the parturient barren-ground caribou from calf birth through the initiation of foraging by calves

The location of this area may vary annually; long-term estimates of the extent of calving (outer perimeter of all known calving grounds) should specify the probability of use within this area. From an operational perspective, some terms and key events were defined/refined.

Four terms describe calving grounds:
1. Annual Calving Ground = the calving ground for a particular year;
2. Extent of Calving = the outer perimeter of all known annual calving grounds;
3. Annual Concentrated Calving Area = the area of relatively high use within an annual calving ground; and
4. Extent of Concentrated Calving = the outer perimeter of all known annual concentrated calving areas

The date of calving for a herd is:
- when 50% of cows in the herd have calved (i.e., at peak (median) of calving);

Calving has:
- both spatial (location of birth) and temporal (date of birth) properties; and
- both the spatial and temporal components vary annually and from herd to herd.

Calves can be considered foragers:
- at about three weeks of age (based on expert opinion), but this varies by herd; the standard approach of using three weeks after peak of calving was agreed upon.

Indicators of foraging may include the number of nursing bouts per day (from 30 down to 4 or 5 times), good calf locomotion, time spent foraging, and calf body size (herd-specific indicators should be established for each managed herd). Minimizing disturbance of cows and calves during the first three weeks post-birth is important because it is then that calves are most sensitive to factors that influence growth rate (e.g., maternal and environmental conditions) and most vulnerable to predation. If insect harassment compels the caribou to move before three weeks post-calving, the physical delineation of the calving grounds as defined above would be enlarged.

The calving period is defined as:
- the time of year when caribou use the calving grounds;
- anchored by the initiation of calving; and
- should include some time prior to calving.

During the development of the definition, there was discussion about how to include a temporal component in the definition that would extend consideration to at least some pre-calving cows. It was agreed that anchoring the definition at the initiation of calving, which varies annually for each herd and among herds, would satisfy this need because it would automatically incorporate a temporal component. Additional coverage could be achieved by extending the consideration period to include the pre-calving period. In this way, managers would have the flexibility to set the consideration periods best suited to the herds under their management.

Participants agreed that the new definition represents an improvement on the old for several reasons: 1) physiological relationships between cows and their calves are recognized; 2) the wording is based on a common, standardized language acceptable to everyone; and 3) it explicitly and clearly outlines the biological basis. The only shortcoming identified was that the definition failed to expressly account for the concept of traditional use.

The group discussed how the new definition would change the existing delineation of calving grounds for each herd. It was agreed that the most efficient way to approach this topic would be to spatially depict the changes imposed by the new definition on the calving grounds of selected herds. Steve Arthur volunteered to undertake this task for the Porcupine herd, and Brad Griffith and Anne Gunn agreed to do it for the Bathurst herd. For both herds, at least some satellite data are available.

Current Knowledge of the Ecological Value of Calving Grounds to Caribou Herds

The discussion turned to exploring the following questions:
1. What is the ecological value of the calving grounds in the seasonal cycle of the herd(s) with which you work?
2. What information do you need to know this?
3. Where will this information take you?

An Energetics View – Bob White (University of Alaska Fairbanks)
A working hypothesis to consider is that calving grounds are adjacent to where females need to be when they experience their peak nutritional demands of the year. There has been ample evidence that cow condition leads to population-level effects through calf survivorship, and even carry-over effects on productivity into the future. More research needs to be done on newborn calves to better understand early mortality due to malformation and under-development. Food is critical on the calving grounds as well as on the summer range. Even the caribou of the George River herd, which apparently eat standing dead vegetation on the calving grounds, gain weight in summer so the value of the food there must be reasonable. Protection from predators is also important, but proximity to good quality forage is even more so.

Predation and Calving Grounds – Anne Gunn (NWT Government)
Cows are on the calving grounds at a time when they are behaviourally most sensitive to disturbance. At this time, cows are likely to space themselves away from each other and other sources of disturbance such as humans and their activities. Calving grounds have the potential to set females up for the rut, thereby having a direct impact on the next season's reproductive success.

Western Arctic Herd– Jim Dau (Alaska Department of Fish & Game)
For the Western Arctic caribou herd, the calving grounds are extremely important. This area offers protection from predators, reasonably good food, and relief from insect harassment. More information is needed about the timing of arrival and the timing of calving, as well as a better understanding of predator numbers on the calving grounds. The degree to which these caribou could adapt to changes on their range is unknown.

Central Arctic Herd – Steve Murphy (ABR Inc.)
Recruitment is critical to herd growth, and disturbance of caribou on the calving grounds has a direct effect on reproductive success. The rest of the range is important as well, but it is on the calving grounds that caribou are most sensitive to population level impacts. Studies to explore the impacts on productivity of displacement from calving grounds, like the ones being done for the Porcupine herd, are needed. Over the past 20 years, the Central Arctic herd has displayed a surprising degree of habituation and adaptability to changes occurring on their range. When the animals are in good condition, they appear to have the capacity to handle the stressors they encounter. Future research needs to consider this plasticity in its view of these animals.

Central Arctic Herd – Ray Cameron (University of Alaska Fairbanks)
Abundance of grizzly bears in the northern uplands near Prudhoe Bay has increased substantially over the past decade, in part because of the availability of artificial foods associated with oil development. The highest bear densities overlap the southerly Central Arctic herd calving ground, particularly west of the Sagavanirktok River following the inland shift in concentrated calving activity. Predation on newborn calves may therefore be on the rise. More data are needed on the size of the bear population, its distribution relative to caribou calving concentrations, and rates of predation on caribou calves.

Porcupine Caribou Herd – Steve Arthur (Alaska Department of Fish & Game)
All parts of a caribou's range are ecologically important, but it may be that caribou are less flexible about calving ground habitat than any other habitat on the annual range. For the Porcupine herd, and to some extent the Central Arctic herd as well, the calving grounds provide good food, fewer predators, and less disturbance than elsewhere on the range. The experimental displacement of parturient cows from their calving grounds may be the only way to explore the implications of calving somewhere other than the calving grounds.

Cape Bathurst and the Bluenose Herds – John Nagy (NWT Government)
It seems clear that calving grounds are key to reproductive success, probably because they afford protection from predators and other disturbances that lead to reduced calf survival. Conditions on the calving grounds also affect cow condition at calving, which has a direct bearing on calf survival. There are other periods in the season that are equally important to reproductive

success, though. For example, cow condition leading into the insect season and the rut determines productivity in the following year. Management needs to protect caribou range used during the entire snow-free period, from green-up to senescence, in order to ensure good body condition for the fall. Caribou going into winter in poor condition will start spring that way.

Qamanirjuaq and Beverly Herds – Mitch Campbell (Nunavut Government)
The ecological importance of the calving grounds to the Qamanirjuaq and Beverly herds is demonstrated by the consistency of its use year after year. Local Inuit hunters report that there are few wolves and bears on the calving grounds, so protection from predators (both wolves and humans) is one of the benefits of being there for caribou. Topography may also be important to parturient cows en route to the calving grounds. Calving appears to occur amongst boulder outcrops and ridges. There may be thermal effects associated with areas that attract cows, e.g., a windbreak. Other portions of the range are also important. For example, there is a particular spring staging area in which a tremendous amount of feeding occurs just prior to the final push to the calving grounds. Little is known about this area, which is about 5-6 times the size of the calving grounds, and a better understanding of it would be helpful.

George River Caribou Herd – Fred Harrington (Mount St. Vincent University)
The calving ground of the George River herd is not attractive for its food quality (mostly standing dead graminoids). It is likely that the main value of the calving grounds for this herd is predator avoidance. Elsewhere in the range, black bears, wolves and tall alders are abundant; the bears run caribou calves into the alder stands and kill them there.

To date, the research program for the George River herd has relied entirely on satellite telemetry. This method cannot identify cows with calves, or provide any estimates of calf survival, so the success of a cow's behavioural strategy (i.e., her choice of where to calve) cannot be measured this way. Some way to gauge success for cows calving at different times and in different places is needed. As the environment changes, different genetically-based strategies will become either more or less adaptive over time, and could ultimately alter the strategy of the herd as a whole. For example, if calving later than usual leads to improved reproductive success, it could result in a shift in the timing of rut and parturition for the herd as a whole. Also, a measure of the sensitivity of cows to particular areas and at particular times needs to be developed. This understanding would shed some light on when cows start assessing the surrounding landscape for calving potential.

A long-term study (20-30 years) based on systematic observations of caribou cows on the calving grounds is needed to better understand the relationship between cow behaviour and reproductive success. To support such a monitoring program, a long-term strategy for data collection will need to be implemented, and this is something that Labrador has never done before. Another hurdle in the path of such a scheme is the fact that the calving grounds spans the border between Labrador and Quebec, and there is no co-ordinated management of the George River herd. It is unclear where the management responsibilities lie in the event that the population begins to decline and action needs to be taken. This is of particular concern to the Inuit of the area whose lifestyle depends on the caribou.

Comparative Assessment of Caribou Herds

Toward the end of the workshop, a list of standardized criteria was developed to enable the characterization of all herds represented at the meeting, and to form the basis for a preliminary cross-continental herd comparison. Each herd was assessed according to these criteria (Table 1).

TABLE 1 STANDARDIZED CRITERIA USED TO CHARACTERIZE CARIBOU HERDS AND THEIR RANGES ACROSS NORTH AMERICA

- topography (flat, medium, rugged)
- landform (coastal or inland)
- % water cover (<10,10-20, >20)
- major vegetation (lichen, sedge meadow, tussock tundra, shrub, heath)
- minor vegetation (lichen, sedge meadow, tussock tundra, shrub, heath)
- % barren (<20, 20-50, > 50)
- % snow cover (<20, 20-50, > 50)
- diet at peak (lichen, *Eriophorum* shrub/*Betula*, forbs, sedge/*Salix*, standing dead)
- diet at peak + 10 (lichen, *Eriophorum* shrub/*Betula*, forbs, sedge/*Salix*, standing dead)
- diet at peak +20 (lichen, *Eriophorum* shrub/*Betula*, forbs, sedge/*Salix*, standing dead)
- presence of salt licks (yes/no)
- snow depth (cm) on winter range (<20, 20-50, >50)
- proximity of Industrial Development to CG (close, far)
- hardness of snow, icing events
- location relative to annual range (n, s, e, w)
- average latitude (long/lat)
- distance (km) from winter range (<100, 100-300, >300)
- arrival (<20 May, 20-30 May, > 1 June)
- peak calving (<7 June, 7-11 June, > 11 June)
- departure (June, July, after July)
- provides insect relief (yes/no)
- body condition upon arrival (poor, medium, good)
- major predators
- density of aggregation at calving (low, medium, high)
- population trend (up, flat, down)
- historical changes in CG (shift, rotation, bounces, stable)
- hunting (yes/no)

Participants formed three subgroups to examine the draft data for all herds, discuss the merits of the exercise, and make recommendations about how to improve upon it. The information in the assessment will be further developed and refined over the coming weeks with input from participants.

The material reported in this section represents a synthesis of all subgroup findings as well as points of discussion that were relevant to the topic.

Three questions were tabled to help guide subgroup discussions; these were:

1. What are the patterns or trends in the data?
2. What models would be useful to explain the differences observed between herds?
3. What information is needed to determine this?

Participants agreed that the draft data were too preliminary and ad hoc to support a cross-continental comparison of herd characteristics or any conceptual modelling efforts. The variability associated with the criteria needs to be captured in order to improve the quality and integrity of the data. This problem could be addressed by allowing for a range of values to be entered for each criterion. The variability issue was identified as something that should be further discussed. Another shortcoming of the exercise was that the criteria used represented a mixture of drivers and response variables, and co-linearity among some criteria further confused the picture. Few patterns or trends were evident in the data, possibly because much of the information was descriptive and didn't lend itself well to this type of analysis. Looking for west to east trends isn't likely to be meaningful, but might well be useful for organizing and managing information about all herds. On the whole, participants agreed that the concept of characterizing herds was useful, and that cross-herd comparisons might well be meaningful when done with hard quantitative data. A simplified index was also proposed where the calving grounds were ranked based on vegetation type, green-up, predator abundance, and proximity to insect relief.

In the spirit of the exercise, however, participants suspended their disbelief long enough to point out the patterns and trends that could be seen in the data. In terms of diet, there were discernible changes in food types used between the Bluenose East and Bathurst herds, and between the Qamanirjuaq and Leaf River herds. Herds in the western group tend to eat forbs, those in central group are eating lichens, and those in the east are eating shrubs and standing dead vegetation. It was pointed out that the break between the Bluenose East and Bathurst herds corresponds to a change to shield country, and that these changes in food types used may be related to large-scale geological factors. Also, there may be a correlation between body condition and dominant vegetation type, i.e., tundra/sedge herds tend to arrive on the calving grounds in poor condition whereas lichen herds arrive in good condition. There was also an apparent trend to calve later toward the east.

Management Implications for Caribou on Calving Grounds

While it may not be possible to exclude all activities from an area, it may be possible to mitigate some by managing when and where they occur. It is also important to determine what kinds of activities carry acceptable risks. For example, what levels of tourism activity are acceptable during calving? Another approach would be to focus on making recommendations about the kinds of consequences that should be avoided, e.g., displacement from the calving grounds. It was suggested that comparing caribou calving ground measures in the Northwest Territories and Nunavut with the development area mitigation policies of Alaska's Prudhoe Bay Fields may produce helpful insights into the effectiveness of various approaches.

The decision of whether to allow certain activities within a calving ground lies with policy-makers, and several participants felt that policy should not be set by researchers because of the potential for conflict of interest. Discussion focused on the need for researchers to retain their objectivity, as well as their credibility in order to effectively inform decision-makers. It was noted that although researchers should avoid "advocating" policies, they can and should make recommendations based on their knowledge. Biology should feed into the decision-making process by providing compelling and scientifically sound evidence in support of the expert opinions presented.

The discussion concluded with the point that the separation between science and policy is to a great extent artificial. In most agencies, resource managers must do their own research to guide their management decisions. As well, many of today's agency scientists sit as co-management board members with the stated responsibility of recommending, and at times, making policy decisions. How best to transfer the findings of caribou science on calving grounds to the public (policy makers, community hunters, co-management boards) and to inform decision makers is a topic worthy of further discussion. As a follow-up to the workshop, a proposal was make to hold a second workshop of key individuals from North American caribou user groups to report on the calving grounds workshop and generate further discussion.

Action Items

1. Refine the characterization of herds matrix (Don Russell)
   - time frame 1 month
   - details to be added with references and caveats
2. Solicit from all participants a synopsis of their ongoing and proposed caribou research (Don Russell)
3. Set up a listserve to facilitate post-workshop communication among participants (Gary Kofinas)
4. Prepare a draft report of the workshop proceedings (ESSA Technologies Ltd.)
   - include summaries of all presentations
5. Solicit from participants a brief description (~1 paragraph) of the methods used for conducting calving surveys on their herds (Don Russell)
6. Solicit from participants the power point presentations made at the workshop (Gary Kofinas)
7. Answer the question as to whether or not there should be a follow-up meeting in 1 year’s time, and if so what the focus should be, e.g., climate change trends?, the merits of forming a larger caribou network and communications strategy?
8. Spatially depict the changes imposed by the new definition for calving grounds on the calving grounds of the Porcupine herd (Steve Arthur) and the Bathurst herd (Brad Griffith and Anne Gunn)

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