

Science Update for the Boreal Caribou (*Rangifer tarandus caribou*, pop. 14) in British Columbia



Prepared by Ministry of Environment



Ministry of
Environment

September 2010

**Science Update for the Boreal Caribou
(*Rangifer tarandus caribou*, pop. 14)
in British Columbia**

Prepared by the Ministry of Environment

September 2010

Recommended citation

Ministry of Environment. 2010. Science update for the Boreal Caribou (*Rangifer tarandus caribou* pop. 14) in British Columbia. Victoria, BC. 54 pp.

Cover illustration/photograph

Diane Culling

Additional copies

Additional copies can be downloaded from the B.C. Ministry of Environment Recovery Planning webpage at:

<<http://www.env.gov.bc.ca/wld/recoveryplans/rcvry1.htm>>

Publication information

ISBN: 978-0-7726-6352-8

Date: October 13, 2010

British Columbia. Ministry of Environment.

Science update for the Boreal caribou (*Rangifer tarandus caribou*, pop. 14) in British Columbia [electronic resource]

Content (excluding illustrations) may be used without permission, with appropriate credit to the source.

Disclaimer

This document was developed to provide current science information on Boreal Caribou in British Columbia. This science update has been prepared as advice to the responsible jurisdictions and organizations that may be involved in the management or recovery of the species. The British Columbia Ministry of Environment has received this advice as part of fulfilling its commitments under the Accord for the Protection of Species at Risk in Canada, and the Canada - British Columbia Agreement on Species at Risk.

Success in the management of this species depends on the commitment and co-operation of many different constituencies that may be involved in implementing management actions. The Ministry of Environment encourages all British Columbians to participate in the management of Boreal Caribou.

ACKNOWLEDGEMENTS

Diane Culling (Diversified Environmental Services, Fort St. John) and Deborah Cichowski (Caribou Ecological Consulting, Smithers) developed the first draft of this science update. This science update is based on information from the background section of the draft document, *A Strategy for the Recovery of Boreal Caribou in British Columbia – Draft #3*, written by the Boreal Caribou Technical Advisory Committee (2004) and updated with information collected since 2004 (to March 2010). Joelle Scheck and Conrad Thiessen (Ministry of Environment), and Dale Seip (Ministry of Forests and Range) provided information and support for this project. Dave Hervieux, Alberta Sustainable Resource Management, shared telemetry data from the Alberta Chinchaga Range and Nic Larter of the Northwest Territories Government shared satellite/GPS locations of Caribou collared in the Dehcho area of the NWT that spent time in the Calendar Range.

Two industry-initiated projects were instrumental in advancing our understanding of British Columbia's Boreal Caribou populations in the last decade, including Canfor (previously Slocan Forest Products; Snake-Sahtaneh Range), and Nexen Inc. (Calendar Range and Tsea Core Habitat of the Snake-Sahtaneh Range); Kevin Kuhn and Scott Wagner played important roles in ensuring that these projects occurred.

Thanks also to Brad Culling (Diversified Environmental Services, Fort St. John) for sharing his knowledge and perspective on Boreal Caribou issues in B.C. Joelle Scheck, Conrad Thiessen, Gerry Kuzyk, and Chris Pasztor of the Ministry of Environment, and Dale Seip of the Ministry of Forests and Range reviewed the draft document.

EXECUTIVE SUMMARY

All Caribou in British Columbia belong to the woodland subspecies (*Rangifer tarandus caribou*), and are further divided into 3 ecotypes based on differences in habitat use, behaviour, and migration patterns. The boreal ecotype (Boreal Caribou) resides in the large peatland complexes of the northeastern corner of the province, within the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) Boreal National Ecological Area (NEA). In 2008, the total number of Boreal Caribou in Canada was estimated between 31,000 and 39,000, of which about 1300 reside in B.C. The global distribution of Boreal Caribou is limited to the boreal region of Canada.

In May 2000, COSEWIC designated Boreal Caribou (Woodland Caribou - Boreal population), as nationally Threatened; this designation was reconfirmed in 2002 based on an updated status report. Boreal Caribou are currently designated as Threatened in Canada on Schedule 1 of the federal *Species at Risk Act* (SARA). In British Columbia, the Boreal Caribou is ranked S2 (imperilled) by the Conservation Data Centre and is on the provincial Red list. The B.C. Conservation Framework ranks the Boreal Caribou as a priority 1 under goal 3 (maintain the diversity of native species and ecosystems).

Industrial activities impact Boreal Caribou habitat and population dynamics in northeastern British Columbia. Currently, oil and gas exploration and development are the dominant industrial activities, affecting Boreal Caribou indirectly through habitat alteration and by facilitating increased access and search efficiency for predators, particularly Grey Wolves. Predation and habitat alterations in the form of linear corridor development, including seismic lines, pipelines, and roads, are the primary threats to Boreal Caribou populations in British Columbia. Linear corridors are associated with: a higher incidence of predation resulting from increased predator travel rates and hunting efficiency and increased predator access into Boreal Caribou habitat; increased human access and related disturbance; and potential reductions in available forage. Access development through lowland areas may also result in altered hydrology, which could have long-term impacts on peatland vegetation communities.

Fires are also considered a threat even though it has historically been the most significant natural disturbance factor within Boreal Caribou ranges. When fires have occurred in the past, Caribou would shift their use, if necessary, from burned areas to other portions of their range or to alternate ranges where habitat conditions are more suitable. However, as habitat impacts from industrial activity increase, Boreal Caribou will presumably have fewer areas to shift their use under natural disturbance events such as fire. Both fire frequency and area burned are expected to increase with climate change.

Other factors that may affect Boreal Caribou in B.C. are climate change and extremes in weather, human-caused mortality, disease, and parasites. Boreal Caribou are affected by a combination of these threats, which likely have cumulative impacts that may not be predictable by examining the effects of each factor separately.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS	III
EXECUTIVE SUMMARY	IV
1 COSEWIC SPECIES ASSESSMENT INFORMATION	1
2 SPECIES STATUS INFORMATION	1
3 SPECIES INFORMATION	3
3.1 Species Description.....	3
3.2 Populations and Distribution	4
3.2.1 Global and national	4
3.2.2 British Columbia	5
3.3 Needs of Boreal Caribou	15
3.3.1 Species biology	15
3.3.2 Habitat and ecological requirements	17
3.3.3 Ecological role.....	19
3.4 Biological Limitations.....	20
4 THREATS	20
4.1 Threat Assessment	21
4.2 Description of Threats	23
4.3 High and Medium Impact Threats.....	23
4.3.1 Problematic native species (IUCN #8.2) - predation	23
4.3.2 Oil and gas drilling (IUCN #3.1)	25
4.3.3 Logging and wood harvesting (IUCN #5.3)	26
4.3.4 Roads and railroads (IUCN #4.1)	26
4.3.5 Utility and service lines (IUCN #4.2)	27
4.3.6 Cumulative industrial impacts to Boreal Caribou in British Columbia (IUCN #3, 4, and 5).....	28
4.3.7 Temperature extremes (IUCN #11.3)	29
4.3.8 Habitat shifting and alteration (IUCN #11.1)	29
4.3.9 Cumulative climate and severe weather impacts to Boreal Caribou in British Columbia (IUCN #11)	30
4.3.10 Fire and fire suppression (IUCN #7.1)	31
4.4 Low Impact Threats.....	32
4.4.1 Commercial and industrial areas (IUCN #1.2)	32
4.4.2 Annual and perennial non-timber crops (IUCN #2.1)	32
4.4.3 Livestock farming and ranching (IUCN #2.3)	33
4.4.4 Mining and quarrying (IUCN #3.2)	33
4.4.5 Renewable energy (IUCN #3.3).....	33
4.4.6 Hunting and collecting terrestrial animals (IUCN #5.1)	34
4.4.7 Recreational activities (IUCN #6.1).....	34
4.4.8 Work and other activities (IUCN #6.3)	35
4.4.9 Dams and water management/use (IUCN #7.2)	35
4.4.10 Invasive non-native/alien species (IUCN #8.1)	35
4.4.11 Problematic native species (IUCN #8.2)	35
4.4.12 Industrial and military effluents (IUCN #9.2)	36
4.4.13 Air-borne pollutants (IUCN #9.5)	36
4.5 Cumulative Effects of Threats.....	36
5 ACTIONS ALREADY COMPLETED OR UNDERWAY	38
6 EXISTING MANAGEMENT	39
6.1 Land and Resource Management Plans.....	39

6.2	Ungulate Winter Ranges and Wildlife Habitat Areas	39
6.3	Protected Areas.....	40
6.4	Timing Windows	41
6.5	Forest Management	42
7	KNOWLEDGE GAPS	43
8	REFERENCES.....	45

LIST OF TABLES

Table 1.	National species assessment information from COSEWIC.	1
Table 2.	Provincial conservation ranks for Boreal Caribou in Canada.....	2
Table 3.	Species status information for Boreal Caribou.	2
Table 4.	Size of original and revised Ranges and Core Habitats for Boreal Caribou in northeastern British Columbia.....	8
Table 5.	Original population estimates for Boreal Caribou Ranges in northeastern British Columbia (from Culling <i>et al.</i> 2004).....	12
Table 6.	Current population estimate, trend, risk status and density of Boreal Caribou populations in British Columbia.....	13
Table 7.	Calf survival estimates from surveys conducted on Boreal Caribou Ranges in northeastern British Columbia.....	14
Table 8.	Threat classification for Boreal Caribou in British Columbia.	21
Table 9.	Extent of anthropogenic disturbance within B.C.'s Boreal Caribou Ranges and Core Habitats (from Thiessen 2009).	28
Table 10.	Boreal Caribou Wildlife Habitat Areas (WHAs) and Ungulate Winter Ranges (UWRs) established in the Fort Nelson TSA and proposed for the Fort St. John Timber TSA.....	40
Table 11.	Protected Areas (> 100 ha) in and adjacent to 2010 Boreal Caribou Ranges in northeastern British Columbia.....	40
Table 12.	BC Ministry of Environment Peace Region timing windows for Boreal Caribou (March 2009).	41
Table 13.	Oil and Gas Commission timing windows for Boreal Caribou (March 2003).	42

LIST OF FIGURES

Figure 1.	Three ecotypes of Caribou in British Columbia.....	4
Figure 2.	Current distribution of Boreal Caribou in Canada (from Environment Canada 2008).	5
Figure 3.	The 2004 Boreal Caribou Ranges and Core Habitats in northeastern British Columbia (from Culling <i>et al.</i> 2004).....	7
Figure 4.	The 2004 Boreal Caribou Range and Core Habitat map showing radio-telemetry and survey data from northeastern British Columbia, northwestern Alberta, and the southern Northwest Territories, 1983 to March 2010.....	9
Figure 5.	The 2010 Boreal Caribou Ranges and Core Habitats in northeastern British Columbia (from Culling <i>et al.</i> , in prep.).....	10
Figure 6.	Linkages between threats to Boreal Caribou in northeastern B.C.....	37

LIST OF APPENDICES

Appendix 1.	List of 2004 Boreal Caribou Technical Advisory Committee.	53
Appendix 2.	Summary of regional management objectives and strategies from the Fort Nelson and Fort St. John Land and Resource Management Plans appropriate for the protection of Boreal Caribou.....	54

1 COSEWIC SPECIES ASSESSMENT INFORMATION

Table 1. National species assessment information from COSEWIC.

Date of Assessment: May 2002

Common Name (population):* Woodland Caribou (Boreal population)

Scientific Name:* *Rangifer tarandus caribou*

COSEWIC Status: Threatened (May 2002)

Reason for Designation: A widespread population ranging across the boreal forests of northern Canada. Populations have decreased throughout most of the range. Threatened from habitat loss and increased predation, the latter possibly facilitated by human activities.

Canadian Occurrence: BC, AB, SK, MB, ON, QC, NL, NT

COSEWIC Status History: The Boreal population was designated Threatened in May 2000. This newly-defined population is comprised of a portion of the de-activated “Western population” and all of the de-activated “Labrador-Ungava population.” Status re-examined and confirmed in May 2002. The last assessment was based on an updated status report.

* Common and scientific names reported in this document may be different from names reported by COSEWIC.

In May 2000, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) designated Boreal Caribou (Woodland Caribou - Boreal population), as nationally Threatened (Table 1; COSEWIC 2002); this designation was reconfirmed in 2002 based on an updated status report (Thomas and Gray 2002). Boreal Caribou are currently designated as Threatened in Schedule 1 under the federal *Species at Risk Act* (SARA).

2 SPECIES STATUS INFORMATION

The global conservation rank for Boreal Caribou is G5TNR, which indicates that Woodland Caribou in general are considered globally secure (G5), but that the Boreal Caribou population has not yet been assessed (TNR). All provinces and territories with Boreal Caribou except Manitoba, Ontario, and the Northwest Territories, consider Boreal Caribou to be imperilled or vulnerable (Table 2).

In B.C., Boreal Caribou was ranked S3 (vulnerable) by the B.C. Conservation Data Centre (CDC) in 2000 and placed on the provincial Blue list.¹ In 2006, it was ranked S2

¹ The Blue list includes any indigenous species or subspecies considered to be of Special Concern (formerly Vulnerable) in British Columbia.

(imperilled) and upgraded to the Red list.² On May 3, 2004, the Minister of Water, Land and Air Protection established, by Order, a category of species at risk, and a category of ungulates, both of which included all Caribou in B.C., under sections 11(1) and 11(3) of the *Government Action Regulation of the Forest and Range Practices Act*.

Table 2. Provincial conservation ranks for Boreal Caribou in Canada.

Provincial/Subnational (S) conservation rank		Province/Territory	Comments
S2	Imperilled	Alberta	Designated as Threatened under the <i>Wildlife Act</i>
		British Columbia	Red-listed
S2/S3	Imperilled/ Vulnerable	Quebec	
		Newfoundland and Labrador	Labrador population only; Labrador population also designated as Threatened under the <i>Endangered Species Act</i> of Newfoundland and Labrador
S3	Vulnerable	Saskatchewan	
S4	Apparently Secure	Manitoba	
		Ontario	
SNR	Not yet assessed	Northwest Territories	NWT General Status Rank = Sensitive

Table 3. Species status information for Boreal Caribou.

Boreal Caribou^a		
Legal Designation		
<u>Identified Wildlife:</u> ^b Yes (2004) <u>B.C. Wildlife Act:</u> ^c No <u>SARA Schedule:</u> 1 (2003)		
<u>Conservation Status</u>^d		
B.C. List: Red B.C. Rank: S2 (2006) Global Rank: G5TNR		
<u>B.C. Conservation Framework</u>^e		
Goal 1: Contribute to global efforts for species and ecosystem conservation		Priority: ^f 3 (2010)
Goal 2: Prevent species and ecosystems from becoming at risk		Priority: 6 (2010)
Goal 3: Maintain the diversity of native species and ecosystems		Priority: 1 (2010)
<u>Action Groups:</u> Planning; List under <i>Wildlife Act</i> ; Send to COSEWIC; Habitat Protection; Habitat Restoration; Private Land Stewardship; Species and Population Management; Review Resource Use		

^a Data source: B.C. Conservation Data Centre (2010) unless otherwise noted.

^b Identified Wildlife under the *Forest and Range Practices Act*.

^c Listed as Endangered or Threatened under the *Wildlife Act*.

^d S = Subnational; N = National; G = Global; B = Breeding; X = presumed extirpated; H = possibly extirpated; 1 = critically imperilled; 2 = imperilled; 3 = special concern, vulnerable to extirpation or extinction; 4 = apparently secure; 5 = demonstrably widespread, abundant, and secure; NA = not applicable; NR = unranked; U = unrankable.

^e Data source: Ministry of Environment (2010).

^f Six-level scale: Priority 1 (highest priority) through to Priority 6 (lowest priority).

² The Red list includes any indigenous species or subspecies that have—or are candidates for—Extirpated, Endangered, or Threatened status in British Columbia.

3 SPECIES INFORMATION

3.1 Species Description

All Caribou in British Columbia (B.C.) belong to the woodland subspecies (*Rangifer tarandus caribou*). Woodland Caribou are medium-sized members of the deer family standing 1.0–1.2 m high at the shoulder (Thomas and Gray 2002). Their coats are dark brown on the back, sides, legs, and face, and white at the neck. The white neck hair, or mane, becomes more pronounced on mature bulls during the breeding season (rut). Adult bulls can weigh up to 270 kg but generally weigh 160–210 kg. Adult females usually weigh 110–150 kg.

Unlike other members of the deer family in North America, both male and female caribou typically have antlers. Mature bulls grow large antlers, which they use during the rut to defend their group of cows from competing bulls. Mature breeding bulls normally drop their antlers in December, while young bulls typically retain their antlers until late winter. Reproductive status affects the timing of antler drop in females. Pregnant females drop their antlers during or just after calving, in May and early June, with barren cows losing their antlers slightly earlier. Barrette and Vandal (1986) suggest retaining antlers throughout the winter gives reproductive females a competitive advantage over conspecifics in defending feeding sites (craters).

Caribou are well adapted to winter conditions. Russell and Martell (1984) note that the specific adaptations of caribou to cold and snow include “a superb insulating coat, large, supporting hooves, and an uncanny ability to detect lichens under the snow.” Their distinctive, crescent-shaped hooves and large, widely spaced dew claws set back on the foot, reduce sinking depth and act like shovels when digging through the snow for winter forage (Thomas and Gray 2002).

Caribou in B.C. can be further divided into 3 ecotypes based on differences in habitat use, behaviour, and migration patterns (Figure 1; Heard and Vagt 1998). The boreal ecotype (hereafter, Boreal Caribou) lives in the lowlands of northeastern B.C. Boreal Caribou live at low densities and primarily use large peatlands throughout the year. During winter, they crater for terrestrial lichens, although they also feed on arboreal lichens to a lesser extent. In late winter and periods of high snow accumulation, Boreal Caribou also use closed-canopy mature lodgepole pine (*Pinus contorta*) and black spruce (*Picea mariana*) stands, where snow interception allows greater mobility and access to terrestrial lichens, as well as access to the more abundant arboreal lichen loads associated with older forests. The two other ecotypes in the province include the Mountain Caribou,³ which live in southeastern B.C., and the Northern Caribou,⁴ which live in west-central and northern B.C.

³ The provincial standard for the English name of this ecotype as listed in B.C. Species and Ecosystems Explorer is Caribou (southern mountain population).

⁴ The provincial standard for the English name of this ecotype as listed in B.C. Species and Ecosystems Explorer is Caribou (northern mountain population).

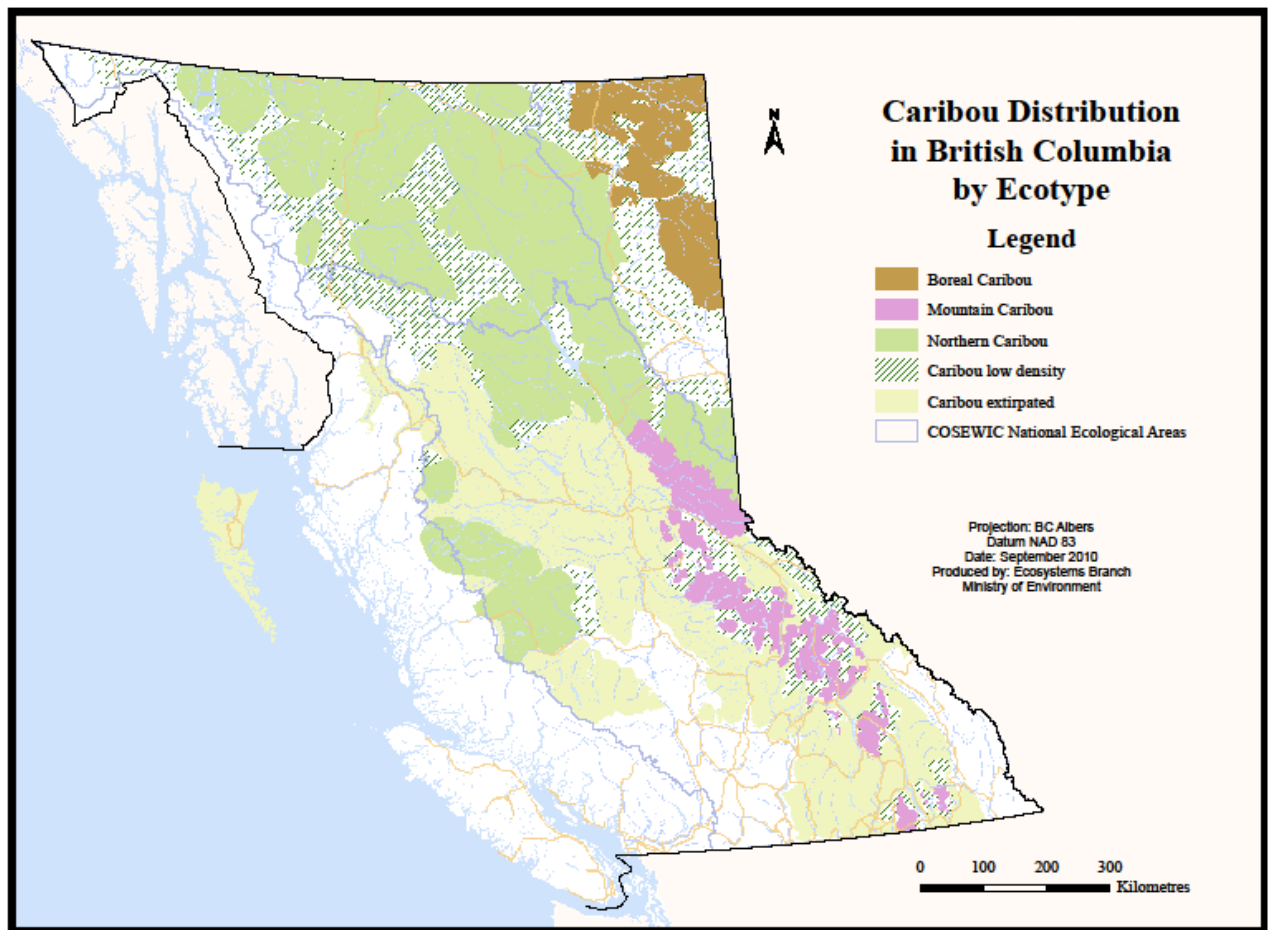


Figure 1. Three ecotypes of Caribou in British Columbia.

3.2 Populations and Distribution

3.2.1 Global and national

All caribou and reindeer in the world are found in arctic, subarctic, boreal, and sub-boreal areas and belong to the same species, *Rangifer tarandus*, with 4 subspecies currently occurring in Canada (Banfield 1974; Thomas and Gray 2002). The global range of the woodland subspecies of caribou (*Rangifer tarandus caribou*) is found primarily in Canada but also extends into Alaska and, to a lesser extent, into the northern United States.

Woodland Caribou occur in all jurisdictions in Canada except Nova Scotia, New Brunswick, Prince Edward Island, and Nunavut (Thomas and Gray 2002). Their range has been reduced from historic areas, with up to a 40% and 20% reduction of their former range in Ontario and B.C., respectively, and with a northern shift of the southern distribution boundary in eastern Canada during the 19th and 20th centuries (Spalding

2000; Thomas and Gray 2002). Woodland Caribou were also more numerous in the northern part of the United States (south of the 49th parallel) but are now mostly absent from that area.

Globally, Boreal Caribou are found only in the boreal region of Canada (Figure 2). In 2008, the total number of Boreal Caribou in Canada was estimated at 31,000–39,000, of which about 1300 reside in northeastern British Columbia (Environment Canada 2008). Based on information provided by individual jurisdictions, Environment Canada (2008) summarized the trend⁵ for 57 identified local populations as: 16 stable, 3 increasing, 17 declining (including suspected or likely declining), and 21 unknown.

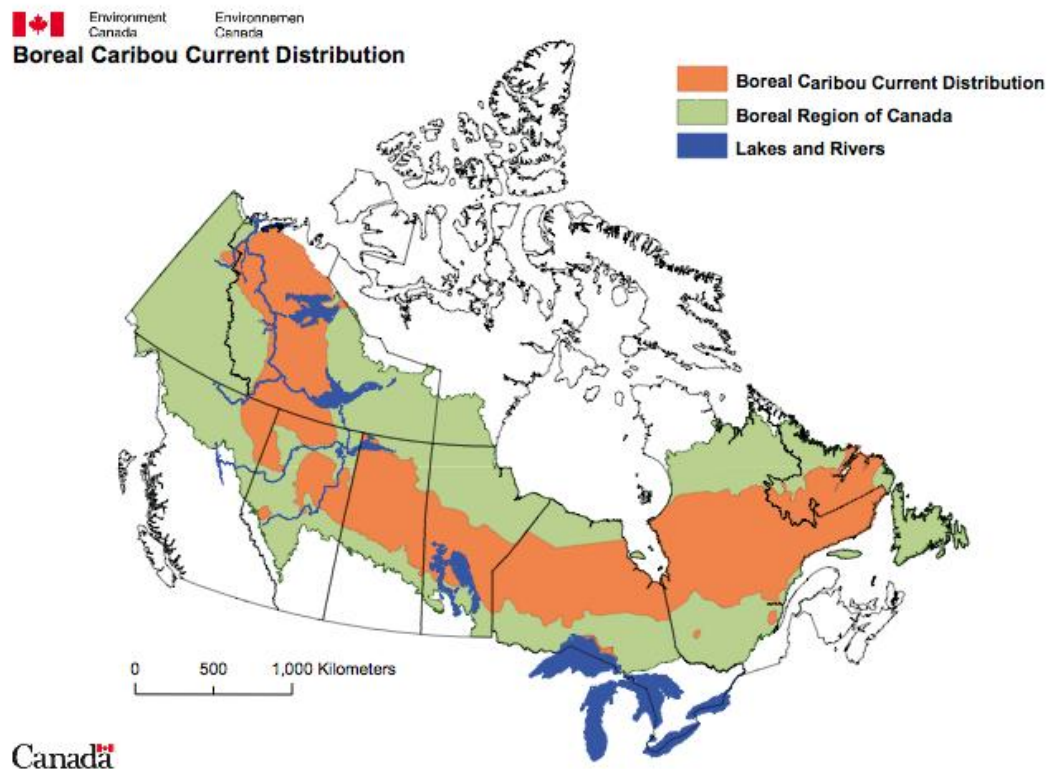


Figure 2. Current distribution of Boreal Caribou in Canada (from Environment Canada 2008).

3.2.2 British Columbia

Of B.C.'s estimated 20,700 Woodland Caribou, approximately 1300 are Boreal Caribou, 1700 Mountain Caribou, and 17,700 Northern Caribou (Ministry of Environment, March 2010, unpubl. data). Boreal Caribou are found in the Boreal Plains and Taiga Plains ecoprovinces in northeastern B.C. and are all within the Boreal COSEWIC National

⁵ Population trend: an indicator of whether a population is self-sustaining over a relatively short measurement period (approximately 3–5 years). Four qualitative states were recognized: stable, increasing, declining, and unknown (Environment Canada 2008).

Ecological Area (Figure 1). The B.C. Boreal Caribou population represents 3–4% of the global/national Boreal Caribou population, and its distribution covers about 5% of the global/national distribution. The Conservation Framework assigned Responsibility Class 7 (low and localized) to Boreal Caribou in B.C. Responsibility Class 7 indicates that the province contains < 10% of the global responsibility for the species, and that its distribution is localized, occurring in < 30% of the province (Ministry of Environment 2010).

In 2004, Culling *et al.* (2004) refined existing B.C. Boreal Caribou distribution mapping and made the first attempt to delineate Boreal Caribou Ranges and Core Habitats (Figure 3). Ranges were defined as broad areas of known historical or current use that supply the resources necessary to support local populations of Boreal Caribou. Core Habitats were defined as areas of high current capability and suitability based on general habitat requirements (treed peatlands, terrestrial and arboreal lichen forage base) and documented occurrence. In 2004, little was known about Boreal Caribou distribution and populations in the province; therefore, Ranges and Core Habitats were defined based on: available habitat mapping, including Earth Cover mapping (Landsat TM7) completed by Ducks Unlimited (Ducks Unlimited 2003); limited aerial survey data, interim radio-telemetry results, and habitat selection modelling from the Snake-Sahtaneh Boreal Caribou study (Culling *et al.* 2006); information from adjacent jurisdictions (Alberta and the Northwest Territories); and incidental sightings and observations.

Culling *et al.* (2004) identified 13 Core Habitats within 4 Boreal Caribou Ranges (Table 4). An additional 2 Core Habitats (Prophet and Parker) were not associated with any range and were somewhat isolated from the general Boreal Caribou distribution; however, they were identified based on historical occupancy and suitable available habitat.

Results of radio-telemetry studies conducted since 2004 confirm the status of all currently defined Ranges and Core Habitats and indicate additional areas of importance to Boreal Caribou. Ranges and Core Habitats were reviewed in February 2010 by compiling all Boreal Caribou radio-telemetry and survey data collected in northeastern British Columbia between 2000 and 2010 (Figure 4; Culling *et al.*, in prep.). Additional radio-telemetry and survey data collected from studies conducted between 1983 and 2009 in northwestern Alberta (D. Hervieux, Alberta Sustainable Resources Management, unpubl. data) and in the Dehcho Region of the Northwest Territories (N. Larter, NWT Environment and Natural Resources, unpubl. data), in which radio-collared Caribou spent time in B.C., were used to augment the B.C. dataset.

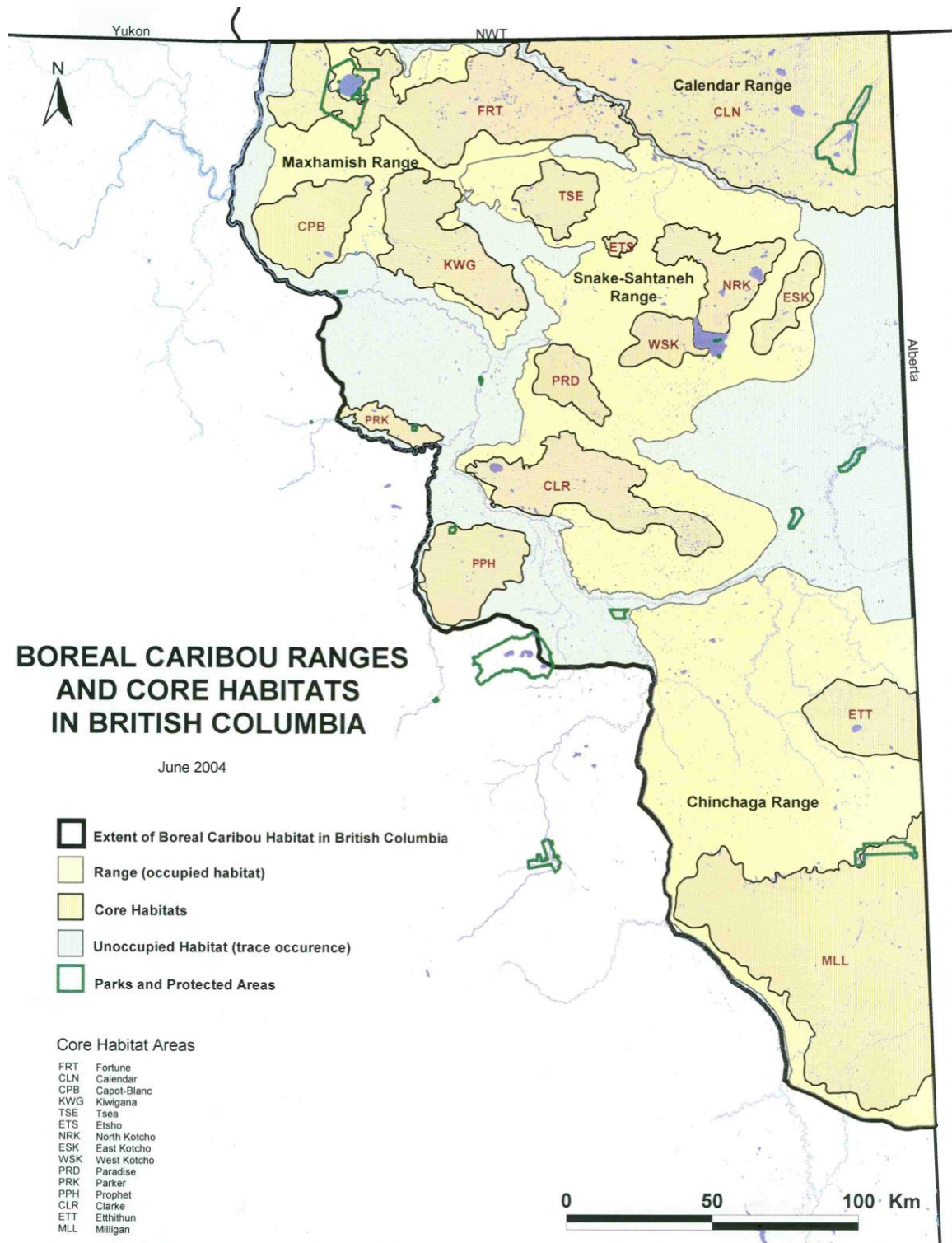


Figure 3. The 2004 Boreal Caribou Ranges and Core Habitats in northeastern British Columbia (from Culling *et al.* 2004).

Table 4. Size of original and revised Ranges and Core Habitats for Boreal Caribou in northeastern British Columbia.

Range	Core Habitat	Area 2004 ^a (km ²)	Area 2010 ^b (km ²)
Chinchaga	Total Range	13,979	13,897
	Milligan	4,929	5,196
	Etthithun	822	780
Snake-Sahtaneh	Total Range	11,980	12,000
	Clarke	1,381	2,224
	Paradise	403	403
	West Kotcho	362	362
	North Kotcho	748	748
	East Kotcho	318	318
	Etsho	60	60
	Tsea	472	689
	Shush Creek	N/A ^c	282
	Total Range	7 095	7,095
Maxhamish	Fortune	2,662	2,662
	Kiwigana	1,301	1,301
	Capot-Blanc	876	876
Calendar	Total Range	4,962	4,973
	Calendar	4,962	4,973
Prophet	Total Range	N/A ^d	1,193
	Prophet	915	1,193
Parker	Total Range	N/A ^d	752
	Parker	224	752
TOTAL RANGES		39,155	39,910
Area of Trace Occurrences		12,016	14,605
Total Extent of Boreal Caribou Distribution in British Columbia		51,171	54,515

^a From Culling *et al.* 2004.^b From Culling *et al.*, in prep.^c Shush Creek Core Habitat was delineated in 2010.^d Prophet and Parker were classified as Core Habitats in 2004; they were upgraded to Range status in 2010.

As radio-telemetry and survey locations shown in Figure 4 indicate, most high quality Boreal Caribou habitat was captured in the 2004 Range and Core Habitat polygons. Areas within identified Core Habitats without radio-telemetry points do not necessarily indicate lack of use by Boreal Caribou, but rather show where radio-telemetry effort is still deficient.⁶

In 2004, it was anticipated that the boundaries of the Parker and Prophet Core Habitats would be adjusted with better supporting data (Culling *et al.* 2004). Results of radio-telemetry studies conducted by the Ministry of Environment (Thiessen 2009) indicated that the boundaries of the Parker Core Habitat should be extended south of the Muskwa River.

⁶ In late March 2010, additional radio-collars were deployed to address remaining data gaps, including 3 GPS collars in the western portion of the Milligan Core Habitat of the Chinchaga Range and 4 GPS and 2 VHF collars in the Fortune Core Habitat of the Maxhamish Range (Figures 3 and 4). During capture activities, a total of 17 caribou in 4 groups and 26 caribou in 2 groups were observed in the western portion of the Milligan and the Fortune core habitats, respectively.

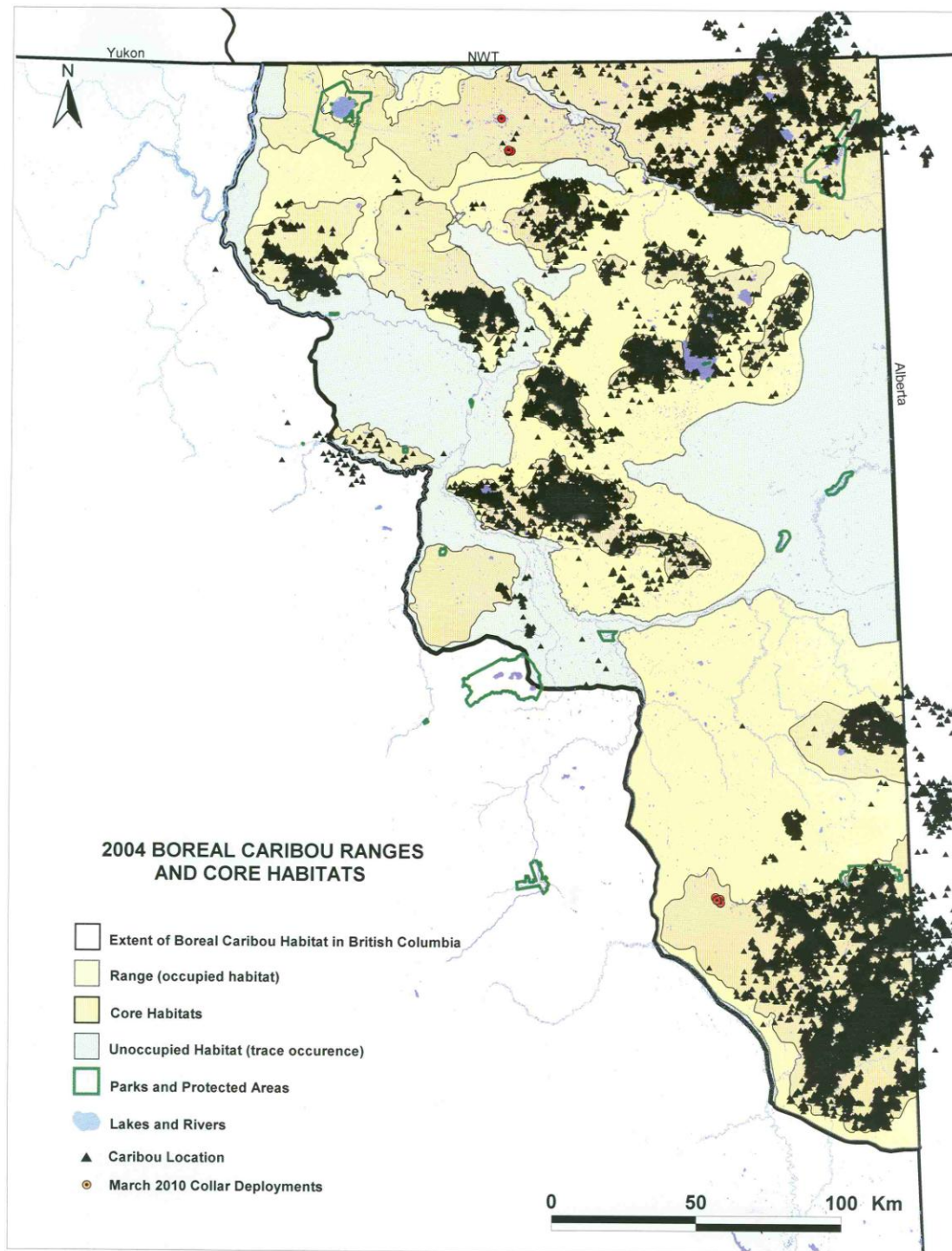


Figure 4. The 2004 Boreal Caribou Range and Core Habitat map showing radio-telemetry and survey data from northeastern British Columbia, northwestern Alberta, and the southern Northwest Territories, 1983 to March 2010.

In 2010, the Parker and Prophet Core Habitats were given Range status and their boundaries, along with those of the other original Ranges and Core Habitats, were adjusted as appropriate. An additional Core Habitat polygon, Shush Creek, was

delineated in the Snake-Sahtaneh Range. The current distribution map identifies 15 Core Habitats within 6 Ranges (Table 4, Figure 5; Culling *et al.*, in prep.).

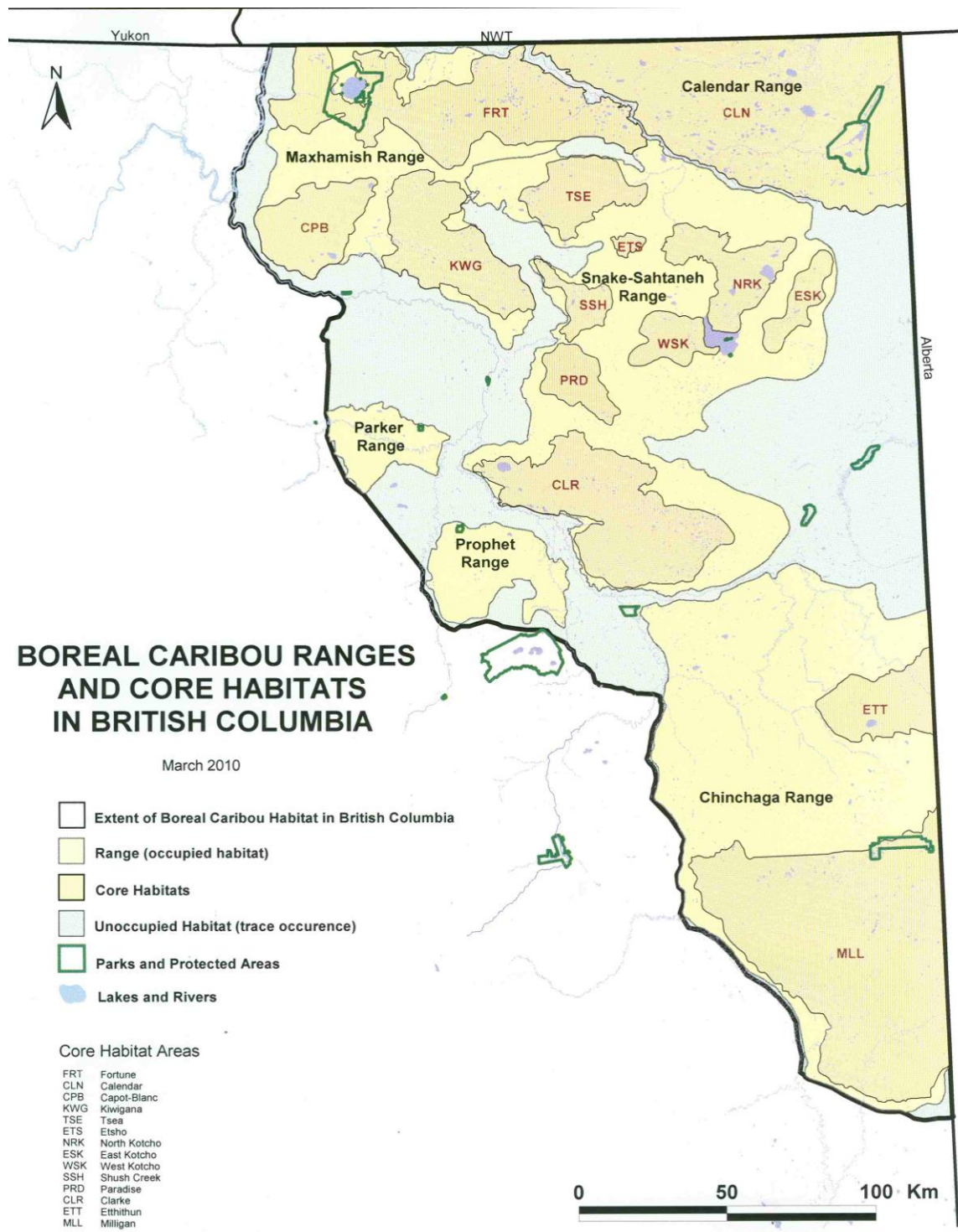


Figure 5. The 2010 Boreal Caribou Ranges and Core Habitats in northeastern British Columbia (from Culling *et al.*, in prep.).

Environment Canada (2008) recommends considering animals as belonging to the same local population if there is any evidence, collaring or otherwise, that indicates Caribou move from one location to another on a seasonal basis, or share a common geography for part of a year. Two of B.C.'s Boreal Caribou Ranges are contiguous with ranges in Alberta (AB) and the Northwest Territories (NT). The Chinchaga Range in B.C. is contiguous with Alberta's Chinchaga Range. Environment Canada (2008) classifies the AB and B.C. Chinchaga Boreal Caribou as one local population (pop. #1, AB/BC Chinchaga). The Calendar Range in B.C. is contiguous with northern Alberta's Bistcho Range and Boreal Caribou habitat in the Dehcho area of the southern Northwest Territories. While recent radio-telemetry results indicate movement between Boreal Caribou in the Calendar Range and the Bistcho and Dehcho Ranges (Culling and Culling, in prep.; N. Larter, pers. comm.; D. Johnson, pers. comm.), Environment Canada (2008) currently lists the Calendar population (pop. #11, BC Calendar) as distinct from the AB/NT Bistcho local population (pop. #2).

Historical numbers and trends

There are no reliable estimates of the number of Boreal Caribou at the time of first European contact. Spalding (2000), in his review of caribou sightings in British Columbia, found only three references to caribou in northeastern B.C. (in 1910, 1915, and 1925) and concluded that recorded historical sightings were insufficient to describe any changes in distribution or abundance.

In the late 1970s, aerial flights were conducted within the area of Boreal Caribou occupancy in B.C. as part of environmental impact assessment surveys for the Alaska gas pipeline. During those flights, few caribou or signs of caribou were seen (B. Webster, pers. comm.); however, Boreal Caribou are highly cryptic and difficult to locate from the air in most areas. In Alberta, Boreal Caribou historically had a geographically dispersed, discontinuous distribution in areas of suitable habitat throughout the northern part of the province; however, populations have been substantially reduced in the past century and continue to decline (Alberta Woodland Caribou Recovery Team 2005).

Current numbers and trends

Boreal Caribou generally exist at low densities throughout Canada (Thomas and Gray 2002). The effectiveness of conventional aerial inventory techniques for Boreal Caribou is hampered by their sparse distribution and typically low sightability in forested habitats (Thomas and Gray 2002; Alberta Woodland Caribou Recovery Team 2005). In 1996, Heard and Vagt (1998) derived an estimate of 725 Boreal Caribou in B.C. and indicated that the population trend was unknown.

During the initial establishment of B.C.'s Boreal Caribou Ranges, Culling *et al.* (2004) used average densities derived from a 2004 Ministry of Environment ungulate survey (Backmeyer 2004) to calculate upper and lower population estimates for each Boreal Caribou Range (Table 5), resulting in a total estimate of 1512 Boreal Caribou for northeastern British Columbia. Although confidence limits were not available, this total

population estimate was assumed to better reflect actual Boreal Caribou numbers than the earlier estimate of 725 animals. In March 2006, the Ministry of Environment conducted a stratified random block count of caribou within the Fortune, Capot-Blanc, and Kiwigana Core Habitats in the Maxhamish Range, and a total count of the Parker Core Habitat (Rowe 2006). The total population estimate (without sightability correction) for the Maxhamish Range was 200 caribou ($\pm 72\%$ at 90% CI⁷). Rowe (2006) suggested the corrected estimate "...could be as high as ~ 340 caribou," which falls within the 2004 estimated range of 220–392 (Culling *et al.* 2004). The total count of the Parker Core Habitat of 20 caribou (Rowe 2006) fell just outside the 2004 estimated at 7–19.

Table 5. Original population estimates for Boreal Caribou Ranges in northeastern British Columbia (from Culling *et al.* 2004).

Range (Herd #) ^a	Estimate 1 ^{b, c}	Estimate 2 ^d	Population estimate ^e
BC Chinchaga (# 1)	433	533	483
BC Maxhamish (# 10)	220	392	306
BC Calendar (# 11)	154	429	291
BC Snake Sahtaneh (# 12)	359	371	365
BC Prophet Core (# 13)	28	79	54
BC Parker Core (# 13)	7	19	13
Total	1201	1823	1512

^a Herd numbers from Environment Canada (2008).

^b Population estimates calculated by Ministry of Water, Land and Air Protection based on 2004 late winter ungulate inventory for Management Units 7-55 and 7-56.

^c Estimate 1 based on an overall density of 0.031 caribou/km² within Boreal Caribou Range areas.

^d Estimate 2 based on stratified densities of Core Habitat areas of 0.086 caribou/km² and Range areas outside of Core Habitat areas of 0.004 caribou/km².

^e Population estimate is the average of Estimate 1 and Estimate 2.

The most recent estimate of B.C.'s Boreal Caribou population is approximately 1300 animals (Table 6; Ministry of Environment, March 2010, unpubl. data). Environment Canada's *Scientific Review for the Identification of Critical Habitat for Woodland Caribou* (*Rangifer tarandus caribou*), *Boreal Population, in Canada* indicates the Snake-Sahtaneh and AB/BC Chinchaga local populations are in decline, with the status of the remaining 4 populations unknown (Environment Canada 2008). Thiessen (2009) evaluated the level of anthropogenic disturbance within B.C.'s Boreal Caribou Ranges and Core Habitats based on the model developed by Sorensen *et al.* (2008), which identified a threshold of < 61% of caribou range within 250 m of industrial development required for population persistence. Thiessen (2009) found that 3 of 4 Ranges (Chinchaga, Snake-Sahtaneh, and Calendar) and 12 of 15 Core Habitats exceeded the 61% disturbance threshold suggesting that most of B.C.'s Boreal Caribou populations are declining. Although levels of anthropogenic disturbance on the Maxhamish Range and the 3 remaining Core Habitats were below the 61% threshold, they all exceeded 50%.

⁷ CI = Confidence interval.

Table 6. Current population estimate, trend, risk status and density of Boreal Caribou populations in British Columbia.

Herd (#)^a	Population estimate^b	Recent trend^c	Population risk status	Range area (km²)
BC Chinchaga (# 1) ^d	250	Decline	Vulnerable	13,979
BC Maxhamish (# 10)	300	Unknown	Vulnerable	7,095
BC Calendar (# 11)	290	Unknown	Vulnerable	4,962
BC Snake-Sahtaneh (# 12)	360	Decline	Vulnerable	11,980
BC Parker Core (# 13)	25 ^e	Unknown	Vulnerable	224
BC Prophet Core (# 14)	54	Unknown	Vulnerable	915
Total	1290– 1340			39,155

^a Herd numbers from Environment Canada (2008).

^b From Ministry of Environment unpublished data (2008) unless otherwise stated.

^c Recent trend defined as trend over last 7 years (1 generation length). Trend based on > 20% change.

^d Environment Canada classifies AB and BC Chinchaga Boreal Caribou as a single population; population estimate and range area refer to B.C. portion of population only (estimate based on Ministry of Environment 2008).

^e From Thiessen (2009).

Rowe (2006) noted that sightability issues limited the effectiveness of conventional stratified inventory within the Maxhamish Range and that trend monitoring is likely a more cost-effective method of assessing population status. Given the difficulties associated with aerial inventories in Boreal Caribou habitat, most effort in the past decade in B.C. has been directed at identifying population trends based on calf recruitment and adult survival, including in the Snake-Sahtaneh Range (Culling *et al.* 2006), Chinchaga Range (Rowe 2007a), Maxhamish Range (Rowe 2006; Thiessen 2009), and the Calendar Range-Tsea Core (Culling and Culling, in prep.).

Caribou populations with late winter calf recruitment (~ 10 months) of less than 15% calves are considered to be decreasing (Bergerud 1996). Noting that the “appropriateness of a 15% target and associated calf to cow ratio depends on the actual survival of adult females in a given population,” Environment Canada (2008) suggests a minimum recruitment rate of 28.9 calves per 100 cows for population stability. As studies of Boreal Caribou to date in British Columbia have been of short duration, with demographic data collected varying between populations and years, results of calf recruitment surveys must be interpreted cautiously. Recruitment varied from 5 to 24 calves per 100 cows in late winter surveys conducted between 2003 and 2009 in B.C.’s Boreal Caribou Ranges (Table 7); all estimates fell below Environment Canada’s recommended threshold of 28.9 calves per 100 cows. In the Snake-Sahtaneh Range, late-winter composition surveys in March 2003 and 2004 indicated calf recruitment of 5 and 9 calves per 100 cows, respectively. While this low recruitment was offset by high adult female survival (0.94) and high pregnancy rates (96%), Culling *et al.* (2006) suggest it is likely unsustainable over the long term as the reproductive female component of the population approached senescence.

Table 7. Calf survival estimates from surveys conducted on Boreal Caribou Ranges in northeastern British Columbia.

Range	Date	Source	Survey type ^a	N (# cows)	Calves/ 100 cows
Late Spring Surveys					
Snake-Sahtaneh Range	June 2002	Culling <i>et al.</i> 2006	Calf survival	20	20
Snake-Sahtaneh Range	June 2003	Culling <i>et al.</i> 2006	Calf survival	15	20
Snake-Sahtaneh Range	June 2004	Culling <i>et al.</i> 2006	Calf survival	24	29
Chinchaga Range	June 2004	Rowe 2007a	Calf survival	15	60
Calendar Range and Tsea Core Habitat (Snake-Sahtaneh Range)	June 2008	Culling and Culling, in prep.	Calf survival	17	24
Calendar Range and Tsea Core Habitat (Snake-Sahtaneh Range)	July 2009	Culling and Culling, in prep.	Calf survival	16	31
Fall/Rut Surveys					
Snake-Sahtaneh Range	Oct 2002	Culling <i>et al.</i> 2006	Minimum count, composition, calf survival	67	12
Snake-Sahtaneh Range	Oct 2003	Culling <i>et al.</i> 2006	Minimum count, composition, calf survival	60	13
Snake-Sahtaneh Range	Oct 2004	Culling <i>et al.</i> 2006	Minimum count, composition, calf survival	72	14
Chinchaga Range	Nov 2004	Rowe 2007a	Calf survival	83	23
Kiwigana and Capot Blanc Core Habitats (Maxhamish Range) and Parker Core Habitat	Oct 2008	Thiessen 2009	Minimum count, composition, calf survival	22	32
Calendar Range and Tsea Core Habitat (Snake-Sahtaneh Range)	Oct 2008	Culling and Culling, in prep.	Minimum count, composition, calf survival	53	15
Late Winter Surveys					
Snake-Sahtaneh Range	Mar 2003	Culling <i>et al.</i> 2006	Minimum count, composition, calf recruitment	74	5
Snake-Sahtaneh Range	Mar 2004	Culling <i>et al.</i> 2006	Minimum count, composition, calf recruitment	123	9

Range	Date	Source	Survey type ^a	N (# cows)	Calves/ 100 cows
Chinchaga Range	Mar 2005	Rowe 2007a	Calf survival	12	17
Maxhamish Range	Mar 2006	Rowe 2006	Stratified random block	31	10
Calendar Range and Tsea Core Habitat (Snake- Sahtaneh Range)	Mar 2008	Culling and Culling, in prep.	Minimum count, composition, calf recruitment	54	24
Calendar Range and Tsea Core Habitat (Snake- Sahtaneh Range)	Mar 2009	Culling and Culling, in prep.	Minimum count, composition, calf recruitment	135	17

^a Seasonal minimum population count and calf survival and recruitment surveys were conducted by relocating all radio-collared adult females; incidental observations of uncollared groups were included.

3.3 Needs of Boreal Caribou

3.3.1 Species biology

The productivity of caribou is low compared to other cervids in North America, with all subspecies of *Rangifer tarandus* typically bearing only 1 young per year and females not breeding until their second year (Bergerud 1974). The mating system of Boreal Caribou is polygynous, with dominant bulls breeding with a number of cows in late September to mid-October. Peak conception for the Snake-Sahtaneh population was estimated at September 30 (Culling *et al.* 2006). Pregnancy rate of females range from 90 to 97% (Seip and Cichowski 1996; Dzus 2001; Culling *et al.* 2006). Gestation is roughly 230 days, and Boreal Caribou calves are born in early May to early June (Bergerud 1974). In the Snake-Sahtaneh study, Culling *et al.* (2006) estimated peak calving at May 15 (n = 66; range May 1 to June 2). Rowe (2007a) found calving occurred between May 5 and May 27 for 7 radio-collared Chinchaga Boreal Caribou (median date = May 14).

Females generally live 10–15 years and males 8–12 years. Annual adult female mortality rates average about 5–15%, but can vary between 0 and 30%. Annual adult mortality of Snake-Sahtaneh females over 58 months (n = 57) was approximately 6% (Culling *et al.* 2006). In the Maxhamish Range, 5 of a total of 20 radio-collared Boreal Caribou died over 2 years (C. Thiessen, pers. comm.).

Calf survival during the first few months of life (especially during the first 6 weeks) is low, often 50% or less (Bergerud 1974). In the Snake-Sahtaneh Range, calf survival to 6 weeks was approximately 20% in 2002 and 2003, and 29% in 2004 (Culling *et al.* 2006). In 2004, weekly survey flights were conducted to track neonatal calf survival. Results confirmed that pregnant Snake-Sahtaneh females were successfully producing offspring,

with about 80% of radio-collared cows confirmed⁸ to have given birth to live calves that accompanied them for a minimum of 5 days; however, survival declined steadily to 29 calves per 100 cows by June 30.

While definitions of fidelity are inconsistent among studies (Rettie and Messier 2001), variable fidelity to calving sites has been reported across the ecotype's range. In Manitoba, Brown *et al.* (2000a) reported calving site fidelity, while Shoesmith and Storey (1977) found fidelity varied by individual. In Saskatchewan, Rettie and Messier (2001) reported no demonstrated fidelity to calving sites. In B.C., fidelity to local areas for calving was observed in the Snake-Sahtaneh Range (Culling *et al.* 2006), the Chinchaga Range (Rowe 2007a), and the Calendar Range (Culling and Culling, in prep.). Culling *et al.* (2006) found fidelity to calving sites varied both among animals and between consecutive years for individuals. One cow returned to within 10 m of her previous year's calving site; however, fidelity typically appeared to be to a general area rather than a specific feature (mean distance between multiple calving sites within the same Core Habitat was 5 km, with a range of 180 m to 15 km; $n = 14$). Snake-Sahtaneh caribou showed strong calving fidelity to individual Core Habitats; radio-collared caribou with multi-year datasets made pre-calving movements of up to 90 km to return to a previous general location within a maternal Core. In over 60% ($n = 66$) of calving events identified, Snake-Sahtaneh cows made significant pre-calving movements in early April to mid-May, travelling a mean distance of 41 km (range 12–119 km). In Labrador, caribou showed a high degree of calving site fidelity, displaying behaviour similar to that observed in the Snake-Sahtaneh Range, with females “traveling relatively long distances through habitat that was apparently suitable for calving and similar to that finally reached” (Brown and Theberge 1985).

Boreal Caribou group size varies throughout the year, but is typically less than 10 adults. The largest groups are found in late fall (during the rut) and winter, with the smallest found during calving and summer (Shoesmith and Storey 1977; Fuller and Keith 1981; Darby and Pruitt 1984; Brown and Theberge 1985; Stuart-Smith *et al.* 1997; Rettie and Messier 2001; Larter and Allaire 2005; Culling *et al.* 2006). Radio-telemetry monitoring indicates B.C.'s Boreal Caribou are typically found in fluid aggregations, with low group fidelity, throughout fall and winter (Culling *et al.* 2006; Culling and Culling, in prep.). Mean group size was 6 caribou for both October (range 1–19) and March (range 1–17) surveys in the Snake-Sahtaneh Range. During the 2008 fall rut count in the Kiwigana and Capot Blanc Core Habitats of the Maxhamish Range and in the Parker Core Habitat, Thiessen (2009) found a total of 36 caribou in 11 groups, with a mean group size of 3 animals (range 1–10). Consistent with the anti-predator strategy of “spacing out” at low densities during the calving season (Bergerud 1996), adult female Boreal Caribou in the Snake-Sahtaneh and Calendar Ranges were typically found either alone or accompanied by their neonate calves during May and June (Culling *et al.* 2006; Culling and Culling, in prep.).

⁸ If parturition success for 3 caribou that lost calves before the first monitoring flight (May 25 survey) followed a similar pattern, parturition and 5-day survival exceeded 90%.

Local populations of Boreal Caribou in B.C. conform to Bergerud's (1996) definition of "sedentary" as they are highly dispersed (spaced out) during calving, as opposed to "migratory" animals that "space away" to aggregate on remote alpine or tundra calving grounds. In northern B.C. and Alberta, Boreal Caribou move or "wander" throughout their range over the year (Hornbeck and Moyles 1995; Stuart-Smith *et al.* 1997; Culling *et al.* 2006; Culling and Culling, in prep.). While Boreal Caribou do not display specific and predictable seasonal movement patterns (Dzus 2001; Culling *et al.* 2006), movements are typically greatest in spring before calving and in fall before the rut (Shoesmith and Storey 1977; Fuller and Keith 1981; Stuart-Smith *et al.* 1997; Rettie and Messier 2001; Culling *et al.* 2006).

Across the range of the ecotype, Boreal Caribou occupy winter and summer ranges that typically overlap, with summer ranges generally smaller than winter ranges (Shoesmith and Storey 1977; Fuller and Keith 1981; Stuart-Smith *et al.* 1997; Brown *et al.* 2000a; Rettie and Messier 2001; Culling *et al.* 2006). Of 6 seasons identified in the Maxhamish Range, Rowe (2007b) found the largest seasonal home ranges in early winter (November and December) and the smallest in late winter (March and April). Adult female caribou without calves tend to have larger summer home ranges than females with calves (Stuart-Smith *et al.* 1997; Rettie and Messier 2001).

3.3.2 Habitat and ecological requirements

In British Columbia, Boreal Caribou are found within the Boreal Plains and Taiga Plains ecoprovinces, on the Alberta Plateau. The area is entirely within the Boreal White and Black Spruce (BWBS) biogeoclimatic zone, which consists of poorly drained, organic peatlands, interspersed with deciduous and mixedwood upland and riparian habitats. Vegetation cover on poorly drained organic soils is dominated by black spruce, with minor components of tamarack (*Larix laricina*). More well-drained mineral soils support white spruce (*Picea glauca*), lodgepole pine, trembling aspen (*Populus tremuloides*), balsam poplar (*Populus balsamifera*), and paper birch (*Betula papyrifera*). Jack pine (*Pinus banksiana*) is found along the eastern edge of the Calendar Range. On lowland sites, Labrador tea (*Ledum groenlandicum*), bog birch (*Betula glandulosa*; also called *B. nana*), and willow (*Salix* spp.) dominate the understory. The climate in the area is continental, and is characterized by long, cold winters and short, cool summers.

At the landscape level, Boreal Caribou require a perpetual supply of large, contiguous areas of suitable summer and winter habitat, with little or no anthropogenic disturbance, to allow them to "space out" at low densities and avoid predators. At the finer scale, caribou select peatland complexes dominated by black spruce bog throughout the year, with mature black spruce and lodgepole pine stands, wetlands (fens), and lakes used seasonally. In northeastern B.C., Boreal Caribou use of commercial forested areas is generally limited to mature lodgepole pine stands that offer late winter snow interception, thermal cover, and access to arboreal lichen.

Boreal Caribou preferentially use treed peatlands throughout the year (Bradshaw *et al.* 1995; Anderson 1999; Brown *et al.* 2000b; Rettie and Messier 2001; Culling *et al.* 2006;

Rowe 2007a). Results of resource selection function modeling indicate that Snake-Sahtaneh caribou showed significant selection for areas of extremely low gradient (0.0–0.60° slope; Culling *et al.* 2006). Subsequent work in the Maxhamish (Rowe 2007b) and Calendar Ranges (Culling and Culling, in prep.) supports the value of slope as a useful predictor of Boreal Caribou habitat in B.C.

The abundant wetlands and waterbodies of the Boreal Plains and Taiga Plains ecoprovinces may provide Boreal Caribou with protection from predators. Boreal Caribou frequently use anti-predator strategies of calving in large muskegs or on islands in lakes, where numbers of predators and alternate prey species are low (Shoesmith and Storey 1977; Cumming and Beange 1978; Fuller and Keith 1981; Edmonds 1988; Racey *et al.* 1991). While large lakes with islands suitable for calving habitat, such as Thinahtea Lake (Calendar Range) and Kotcho Lake (Snake-Sahtaneh Range), are rare within B.C.'s Boreal Caribou Ranges, smaller lakes are abundant. The Snake-Sahtaneh Range contains over 5500 lakes, 74% of which are less than 1 ha. Carruthers *et al.* (1986) suggest clusters of small lakes may provide more predator-detection and escape opportunities for caribou, increase search time for Grey Wolves (*Canis lupus*), and allow efficient exploitation of the abundant feeding sites available along lake margins. Culling *et al.* (2006) found Boreal Caribou showed selection for *clustered lakes* (defined as 2 or more lakes greater than 2 ha each with overlapping 250-m buffers) in all seasons.

The food habits of caribou are unique in the deer family. Although Boreal Caribou eat a wide variety of plant species common to the BWBS biogeoclimatic zone, in winter they forage primarily on terrestrial lichens (*Cladina* spp., *Cladonia* spp.), but also consume arboreal lichens (*Bryoria* spp., *Alectoria* spp., *Usnea* spp.), sedges, and the leaves of ericaceous shrubs (Stardom 1975; Darby and Pruitt 1984; Schaefer and Pruitt 1991; Heggberget *et al.* 2002; Rowe 2007a). While Heggberget *et al.* (2002) note that reindeer and caribou prefer lichens and have higher calf productivity on lichen-rich ranges than on lichen-poor ones, they point out that "...this energy source appears to be neither sufficient as winter diet for reindeer or caribou (at least for pregnant females) nor necessary." In early winter, Boreal Caribou in northeastern B.C. are frequently observed feeding along shorelines of small lakes and wetlands, where they seek out cattails (*Typha latifolia*) and sedges (*Carex* spp.). Klein (1982) attributes use of lake margins and wetlands in fall and early winter to foraging for wintergreen vascular plants that offer high protein and phosphorus and high-digestibility. There is widespread use of wintergreen forage across the range of caribou, including sedges, horsetails (*Equisetum* spp.), and evergreen shrubs, such as bog cranberry (*Vaccinium vitis-idaea*), especially in early and late winter (reviewed by Russell and Martell 1984). Supplementing their energy-rich but nutrient-poor lichen diet with more nutrient-rich wintergreen vascular plants may contribute to improved condition during late winter and pregnancy. Bog birch is of moderate importance as a forage item for caribou in both winter and summer (Tollefson 2007) and evidence of Boreal Caribou browsing on this species in winter in northeastern B.C. is frequently noted (D. Culling, pers. observ.). During the snow-free months, Boreal Caribou are generalists, feeding on a variety of plants, including grasses, sedges, horsetails, forbs, the leaves of numerous shrub species, and lichen (Darby and Pruitt 1984).

While terrestrial lichens are a staple food for Boreal Caribou, arboreal lichens can be an important component of their diet when deep or crusted snow hinders their ability to graze. Lichens are slow growing and poor competitors against vascular plants. They derive their nutrients from airborne particles rather than from the substrate, so are able to exploit habitats where vascular plants are unable to grow. Consequently, terrestrial lichens are most abundant in ecosystems where other forest floor species are less abundant. Terrestrial lichens are also highly susceptible to mechanical damage, especially during the driest months, and can take 30–80 years to become abundant following disturbance. Because lichen regeneration is slow, any type of disturbance has long-term implications for caribou winter habitat. Although Boreal Caribou populations appear to persist at densities below habitat carrying capacity (Seip and Cichowski 1996), there is a limit to how much lichen-producing habitat can be lost and still provide adequate forage for a caribou population within its range.

There is general acceptance that absolute quantity and quality of forage do not limit caribou populations provided there is adequate range available to shift areas of use in response to severe snow conditions or loss of lichen-producing habitats (Schaefer and Pruitt 1991; Seip 1991; Bergerud 1996). Boreal Caribou annual range requirements include:

- calving habitat with low predation risk;
- access to an adequate supply of terrestrial and arboreal lichens;
- snow conditions that allow foraging and movement within the winter range; and
- large tracts of annual range where caribou can exist at low densities as an anti-predator strategy and avoid linear corridors.

3.3.3 Ecological role

Boreal Caribou are one of many ungulate prey species in the multiple predator–prey system in the boreal region of Canada. In boreal ecosystems, Moose (*Alces americanus*) are the primary prey for Grey Wolves, and Boreal Caribou and American Beaver (*Castor canadensis*) are secondary prey species. In areas where other prey is scarce, Boreal Caribou may play a greater role as a food source for predators. Boreal Caribou adults and calves also provide prey for Black Bears (*Ursus americanus*), Coyotes (*Canis latrans*), Wolverine (*Gulo gulo*), and Canada Lynx (*Lynx canadensis*), and support a number of boreal forest scavengers. Grizzly Bears (*Ursus arctos*) and Golden Eagles (*Aquila chrysaetos*) are known to prey on adults and calves of other ecotypes of Caribou (Young and McCabe 1997; Culling *et al.* 2005; Gustine 2005): these species may also occasionally prey on Boreal Caribou along the western edge of Boreal Caribou distribution in B.C.

Because Boreal Caribou feed primarily on terrestrial or arboreal lichens, they do not compete with other wildlife species for winter forage and occupy a unique niche in the boreal ecosystem. The combination of foraging on lichens and residing primarily in peatlands distinguishes them from other boreal ungulates.

Boreal Caribou may also play an important role in lichen dispersal. Most of the terrestrial lichen species favoured by caribou (i.e., *Cladina* spp.) reproduce by thallus fragmentation. These lichens become brittle when dried or frozen and fragments break off when disturbed by trampling and feeding by animals (Goward 2000). The fragments are then scattered nearby where they can start new colonies if they are deposited on suitable substrate.

3.4 Biological Limitations

Boreal Caribou have a low reproductive rate and naturally occur at low densities. Unlike other members of the deer family, caribou have only 1 young per year and females do not generally breed until they are 2 years old. Overall productivity is low, with high pregnancy rates offset by correspondingly high neonate mortality.

4 THREATS

Threats are defined as the proximate (human) activities or processes that have caused, are causing, or may cause the destruction, degradation, and/or impairment of biodiversity and natural processes. Threats can be past (historical), ongoing, and/or likely to occur in the future. Threats do not include intrinsic biological features of the species or population such as inbreeding depression, small population size, and genetic isolation, which are considered limiting factors.

4.1 Threat Assessment

The threat classification below is based on the IUCN-CMP (World Conservation Union-Conservation Measures Partnership) unified threats classification system and is consistent with methods used by the B.C. Conservation Data Centre and the Conservation Framework. For a detailed description of the threat classification system, see the [IUCN-CMP website](#) (IUCN and CMP 2006) and Master *et al.* (2009). Threats for the Boreal Caribou were assessed for the entire province (Table 8).

Table 8. Threat classification for Boreal Caribou in British Columbia.

Threat		Impact ^a	Scope ^b	Severity ^c	Timing ^d
1	Residential & commercial development	Low	Small	Extreme	High
1.2	Commercial & industrial areas	Low	Small	Extreme	High
2	Agriculture & aquaculture	Low	Small	Extreme	High - Moderate
2.1	Annual & perennial non-timber crops	Low	Small	Serious	High - Moderate
2.3	Livestock farming & ranching	Low	Small	Extreme	High - Moderate
3	Energy production & mining	High	Pervasive - Large	Serious	
3.1	Oil & gas drilling	High	Pervasive - Large	Serious	High
3.2	Mining & quarrying	Low	Small	Moderate	High
3.3	Renewable energy	Low	Small	Slight	High - Moderate
4	Transportation & service corridors	High	Large	Serious	High
4.1	Roads & railroads	High	Large	Serious	High
4.2	Utility & service lines	Medium	Large	Moderate	High
5	Biological resource use	Medium	Restricted	Serious	
5.1	Hunting & collecting terrestrial animals	Low	Pervasive - Large	Slight	High
5.3	Logging & wood harvesting	Medium	Restricted	Serious	High
6	Human intrusions & disturbance	Low	Large	Slight	
6.1	Recreational activities	Low	Small	Moderate - Slight	High
6.3	Work & other activities	Low	Large	Slight	High
7	Natural system modifications	High	Large	Serious	High
7.1	Fire & fire suppression	High	Large	Serious	High
7.2	Dams & water management/use	Low	Restricted	Moderate - Slight	High
8	Invasive & other problematic species & genes	High	Pervasive	Serious	
8.1	Invasive non-native/alien species	Unknown	Small	Unknown	High - Moderate

Threat		Impact ^a	Scope ^b	Severity ^c	Timing ^d
8.2	Problematic native species	High	Pervasive	Serious	High
9	Pollution	Low	Restricted	Slight	High
9.2	Industrial & military effluents	Low	Small	Slight	High
9.5	Air-borne pollutants	Low	Restricted	Slight	High
11	Climate change & severe weather	High - Medium	Pervasive	Serious - Moderate	Low
11.1	Habitat shifting & alteration	High - Medium	Pervasive	Serious - Moderate	Low
11.3	Temperature extremes	Unknown	Pervasive	Unknown	Low

^a **Impact** – The degree to which a species is observed, inferred, or suspected to be directly or indirectly threatened in the area of interest. The impact of each stress is based on Severity and Scope rating and considers only present and future threats. Threat impact reflects a reduction of a species population or decline/degradation of the area of an ecosystem. The median rate of population reduction or area decline for each combination of scope and severity corresponds to the following classes of threat impact: very high (75% declines), high (40%), medium (15%), and low (3%).

^b **Scope** – Proportion of the species that can reasonably be expected to be affected by the threat within 10 years. Usually measured as a proportion of the species' population in the area of interest. (Pervasive = 71–100%; Large = 31–70%; Restricted = 11–30%; Small = 1–10%)

^c **Severity** – Within the scope, the level of damage to the species from the threat that can reasonably be expected to be affected by the threat within 10 year or three-generation timeframe. Usually measured as the degree of reduction of the species' population. Extreme = 71–100%; Serious = 31–70%; Moderate = 11–30%; Slight = 1–10%)

^d **Timing** – High = continuing; Moderate = only in the future (could happen in the short term [< 10 years or 3 generations]) or now suspended (could come back in the short term); Low = only in the future (could happen in the long term) or now suspended (could come back in the long term); Insignificant/Negligible = only in the past and unlikely to return, or no direct effect but limiting.

4.2 Description of Threats

There are 4 high, 2 medium or high-medium, and 4 low level 1 threat impacts to Boreal Caribou in British Columbia (Table 8). The overall calculated and assigned threat impact is very high (75% decline).

4.3 High and Medium Impact Threats

Details of high and medium impact threats are discussed below under the IUCN level 2 headings.

4.3.1 Problematic native species (IUCN #8.2) - predation

British Columbia's Boreal Caribou populations exist within a dynamic predator-prey system dominated by Grey Wolves and Moose. While Grey Wolves represent the most significant predator of Boreal Caribou, Caribou are secondary in importance to Moose as a prey species for Grey Wolves. Within the Boreal Plains and Taiga Plains ecoprovinces, American Beaver represent an important alternate prey for Grey Wolves (Culling *et al.* 2006; R. Woods, pers. comm.). Small numbers of white-tailed deer (*Odocoileus virginianus*) are also present, particularly in the Chinchaga Range.

Grey Wolf predation is the major cause of mortality of adult Boreal Caribou (Stuart-Smith *et al.* 1997; Bergerud and Elliott 1998; Rettie and Messier 1998; Schaefer *et al.* 1999; McLoughlin *et al.* 2003; Larter and Allaire 2005; Culling *et al.* 2006). Other causes of adult mortality include bear predation, poaching, accidental deaths (e.g., drowning), and motor vehicle collisions (Rettie and Messier 1998; McLoughlin *et al.* 2003; Culling *et al.* 2006). Of 5 radio-collared caribou mortalities during the Snake-Sahtaneh study, 2 were confirmed Grey Wolf predation, 1 was suspected Black Bear predation, and 2 were due to undetermined causes. Both confirmed cases of Grey Wolf predation occurred on seismic lines (Culling *et al.* 2006).

Grey Wolf predation is a major factor in Boreal Caribou calf mortality, with Black Bears also contributing significant predation pressure on some populations (Bergerud and Elliott 1998; Rettie and Messier 1998; Schaefer *et al.* 1999; Dzus 2001; Mahoney and Virgl 2003; Culling *et al.* 2006). Other predators of Boreal Caribou calves include Canada Lynx, Wolverine, and Coyote (Mahoney *et al.* 1990; Thomas 1995; Rettie and Messier 1998; Spalding 2000; Dzus 2001). Golden Eagles are a confirmed predator of Woodland Caribou calves (Young and McCabe 1997; Gustine 2005). While Golden Eagles typically migrate down the northern Rocky Mountains, to the west of the Snake-Sahtaneh and Maxhamish Ranges, individuals are occasionally seen in the peatlands and may opportunistically prey on Boreal Caribou calves. Culling *et al.* (2006) incidentally observed a Golden Eagle circling a neonate calf in June in the Snake-Sahtaneh Range.

American Beavers are common throughout B.C.'s Boreal Caribou Ranges. The abundant seasonal food source provided by American Beaver during the Grey Wolf denning period contributes to increased pup survival and higher densities of Grey Wolves than would be expected given the low ungulate biomass typically found in peatland habitats. Grey Wolves were closely associated with American Beaver activity within the Snake-Sahtaneh Range from spring through fall and frequently denned in abandoned American Beaver lodges. American Beaver accounted for the majority of items in Grey Wolf scat collected at den sites (Culling *et al.* 2006). The mosaic of riparian and peatland areas within Boreal Caribou Core Habitats allowed Grey Wolves to den in areas that provided ready access to both a source of open water and American Beaver prey, while also permitting hunting forays for Moose calves and Boreal Caribou calves. In addition to American Beaver, Snake-Sahtaneh Grey Wolf scat samples included remains of both Moose calves and Boreal Caribou calves. While pack activities were often centred on active American Beaver ponds during the May-June calving period, individual members were observed traveling and hunting caribou calves in undisturbed black spruce bogs within Boreal Caribou Core Habitats (Culling *et al.* 2006).

Within a multiple predator-prey system, it is possible for predator numbers to remain relatively high even if predation (or human harvest) has drastically reduced one of the prey species. In a multiple predator-prey system, caribou are usually the most vulnerable ungulate prey species and are the first to decline and the last to recover (Seip 1991). Seip (1992) suggested that Grey Wolf predation could eliminate Caribou from areas where the Grey Wolf population is sustained by other prey species because the number of Grey Wolves will not decline as Caribou numbers decline. In this situation, high Grey Wolf densities, maintained by Moose, deer, and American Beaver, could exert continued predation pressure on Caribou, which might ultimately lead to extirpation of local populations.

Boreal Caribou use habitat as an important means of limiting the effects of predation. Boreal Caribou selection of large peatlands results in spatial separation from Moose and Grey Wolves, which tend to select well-drained habitat (James *et al.* 2004; Culling *et al.* 2006). In Alberta, predation pressure and risk were found to be higher in well-drained upland habitat than in fen/bog complexes (James *et al.* 2004; McLoughlin *et al.* 2005). While Moose are present within B.C.'s Boreal Caribou Core Habitats, they are typically associated with riparian and upland sites.

McLoughlin *et al.* (2003) suggest predation should be viewed as a proximate limiting factor for Boreal Caribou in northern Alberta, while disturbances resulting in large-scale changes in habitat structure that affect habitat use and movements of predators and alternate prey may be ultimately responsible for declines of Boreal Caribou populations in that province.

The susceptibility of Caribou to predation may be influenced by habitat alteration. Smith *et al.* (2000) documented that Northern Caribou avoid portions of their winter range that have been altered by logging. Disturbance, whether human-caused or natural, disrupts habitat contiguity and alters the distribution of early seral habitats. Such disturbance can

be detrimental to Boreal Caribou if it results in increased contact with predators and other ungulate prey species, such as Moose, that use early seral habitats. Even if the ungulate prey base does not increase in response to habitat change, any reduction in Boreal Caribou habitat could concentrate Boreal Caribou into remaining undisturbed area. This would effectively increase their density and reduce their ability to space out across the landscape, thus making it easier for predators to locate them (Seip 1991; Vistnes and Nellemann 2001).

4.3.2 Oil and gas drilling (IUCN #3.1)

Similar to northern Alberta, geophysical (seismic) exploration and oil and gas exploration and production are the most significant disturbance factors in Boreal Caribou ranges in northeastern B.C. Although individual conventional oil and gas production facilities (i.e., well sites and dehydration and compression installations) occupy relatively small areas on the landscape, linear disturbances associated with exploration and production (seismic lines, pipelines, and temporary and permanent access roads) affect significant areas. Peatland habitats are slow to recover from disturbance, particularly on sites where agronomic species, such as Alsike clover (*Trifolium hybridum*) and timothy (*Phleum pratense*), have been seeded as a reclamation measure. In assessing the persistence and recovery of historic conventional seismic lines (5–8 m width) developed in northeastern Alberta between the 1960s and 2003, Lee and Boutin (2006) found recovery rates varied greatly by forest type. While recovery rates of aspen and white spruce upland forests to a cover of woody vegetation were relatively slow, D. Culling and D. Cichowski (pers. comm.) found no recovery of lowland black spruce sites 35 years post-disturbance.

The dominant petroleum industry footprint is linear corridor development associated with seismic line clearing, particularly when intensive 3-D seismic programs are being conducted. Once suitable drilling locations have been identified through seismic exploration, additive disturbance results from production activities, including lease site construction and development of additional access (all-season and winter roads) and supporting infrastructure.

New petroleum industry technologies used to extract unconventional gas from shale formations require large volumes of water, which may alter hydrology and peatland vegetation communities. The intensity of activity and infrastructure associated with unconventional gas development may have negative effects within all Boreal Caribou Ranges, especially Core Habitats.

The existing linear corridor footprint in Boreal Caribou habitat in northeastern B.C. is already a concern; current provincial incentive programs that encourage rapid expansion of petroleum industry activities and associated all-season access will result in increased cumulative disturbance within Boreal Caribou Ranges (Sorenson *et al.* 2008; Thiessen 2009).

Disturbance of Boreal Caribou by intense human activity can result in displacement from preferred habitats. In Alberta, simulated petroleum exploration noise was found to

increase energy expenditure by Boreal Caribou (Bradshaw *et al.* 1997). Avoidance of well sites by Boreal Caribou in Alberta was greatest during late winter and calving (Dyer *et al.* 2001). Physical disturbance from petroleum industry exploration, including roads, drilling sites, and seismic lines, can result in avoidance of habitats ≥ 250 m, well beyond the actual development footprint (Cameron *et al.* 1979; Smith and Cameron 1985; Nellemann and Cameron 1998; Dyer *et al.* 2001; Oberg 2001). In Alaska, Nellemann and Cameron (1998) found that the greatest incremental impacts to Barren-ground Caribou (*Rangifer tarandus groenlandicus*) were attributed to initial construction of roads and related facilities and that females and calves were far more sensitive to surface development than adult males and yearlings. Oil and gas facilities also appeared to displace calving caribou to other areas, which may have led to lower fecundity (Nellemann and Cameron 1998).

4.3.3 Logging and wood harvesting (IUCN #5.3)

Throughout the year, B.C.'s Boreal Caribou are found primarily in large peatlands. With the exception of lodgepole pine stands used during periods of deep snow accumulation in late winter, little use is made of commercial forest types (D. Hervieux, pers. comm.; Culling *et al.* 2006). The majority of logging within Boreal Caribou Ranges targets upland white spruce, trembling aspen, and lodgepole pine stands (Goddard 2009), but access development can increase connectivity between peatland complexes and predator-rich upland areas. Increased access from petroleum industry developments often reduces logistical costs associated with forestry, which may result in easier access to timber stands formerly considered uneconomic to harvest.

4.3.4 Roads and railroads (IUCN #4.1)

One of the major threats to Boreal Caribou is increasing linear corridor development and access into their habitat (Sorenson *et al.* 2008). The resulting threat may take several forms including increased predation risk, direct human-caused mortality, and displacement from preferred habitats. The existing density of linear corridors developed during conventional natural gas exploration and production activities over the past several decades in B.C.'s Boreal Caribou ranges is already of concern. Development associated with unconventional gas extraction is expected to increase the industrial footprint. Forestry activities can also result in additional roaded access within Boreal Caribou ranges.

Linear corridors provide easier access for predators to travel into Boreal Caribou habitat and to prey on Boreal Caribou (James and Stuart-Smith 2000). In Alberta, predation risk was higher for Boreal Caribou found close to linear corridors than for Boreal Caribou found farther away (James and Stuart-Smith 2000), and Boreal Caribou avoided linear corridors, both roads and seismic lines (James and Stuart-Smith 2000; Dyer *et al.* 2001). During winter, Grey Wolves travelled farther and faster on packed (snow machine trails or ploughed) linear corridors and unpacked linear corridors than in forests (James 1999). There was no difference in distance travelled on packed or unpacked linear corridors,

suggesting that ease of movement was not the sole influence on Grey Wolf use of linear corridors, but also possibly the longer sight-lines (James 1999). Within Alberta Boreal Caribou ranges, Grey Wolf locations were closer to linear corridors than random points, and Grey Wolves used linear features as travel routes (James 1999; James and Stuart-Smith 2000; Neufeld 2006). In addition, Caribou use of areas adjacent to linear corridors varied with season and type and age of disturbance; avoidance distances ranged from 0.1 to 1.2 km (Smith *et al.* 2000; Dyer *et al.* 2001; Oberg 2001). Avoidance of anthropogenic features that results in increased Boreal Caribou densities in undisturbed areas could make it easier for Grey Wolves to find individual caribou (Smith *et al.* 2000; Dyer *et al.* 2001, 2002; Kuzyk *et al.* 2004).

In northeastern B.C., Boreal Caribou are frequently found on or near linear features, including roads, conventional seismic lines, and pipeline and utility corridors, particularly when artificially seeded right-of-ways and road salt provide attractants, or when ploughed roads allow easier travel during periods of deep snow. While James (1999) reported a general trend of avoidance of anthropogenic features by caribou, he noted considerable variation among individuals. Dyer *et al.* (2001) found avoidance of developments (seismic lines, roads, and well sites) of ≥ 250 m. There are ecological costs regardless of whether caribou use or avoid linear features; avoidance results in a functional loss of habitat that exceeds the physical footprint of the feature, while use can increase vulnerability to predation.

Linear corridors can result in direct human-caused mortality of Boreal Caribou including vehicle collisions, and increased hunting and poaching (see section 4.46 for a discussion on hunting and poaching). Woodland Caribou-vehicle collisions occur throughout western Canada (Johnson 1976; Simpson *et al.* 1994; Brown and Ross 1994). The remote nature of B.C.'s Boreal Caribou ranges may result in the under-reporting of caribou-vehicle collisions. In the Chinchaga Range, Boreal Caribou are subject to vehicle collisions when they move into agricultural areas (B. Webster, pers. comm.).

Intense human activity along linear corridors can result in displacement of caribou from preferred habitats. This may contribute to poorer body condition if caribou have to increase energy expenditure to avoid disturbances, or use lower quality habitats where food quantity and/or quality is lower (Dyer 1999). Poor body condition of adult females may result in reduced reproductive success (Bergerud 1996).

4.3.5 Utility and service lines (IUCN #4.2)

Pipelines associated with industry projects in northeastern B.C. increase the linear corridor footprint within Boreal Caribou ranges (see section 4.3.4). Pipelines may alter Boreal Caribou movements and facilitate predator mobility.

4.3.6 Cumulative industrial impacts to Boreal Caribou in British Columbia (IUCN #3, 4, and 5)

Studies of Boreal Caribou in other provinces indicate survival rates and finite rate of population growth are lower in caribou ranges with more anthropogenic and natural disturbance and/or in close proximity to anthropogenic and natural disturbance (Dunford 2003; Boutin and Arienti 2008; Environment Canada 2008; Sorenson *et al.* 2008). Thiessen (2009) recently assessed the level of anthropogenic disturbance on Boreal Caribou Ranges and Core Habitat in northeastern B.C. All known industrial developments (seismic lines, roads, pipelines, well pads, and cutblocks) were mapped and buffered by 250 m on either side (i.e., 500 m total width on linear features) to mimic effective/functional habitat loss; the area of anthropogenic disturbance was then calculated for each Caribou Range and Core Habitat (Table 9).

Table 9. Extent of anthropogenic disturbance within B.C.'s Boreal Caribou Ranges and Core Habitats (from Thiessen 2009).

Boreal Caribou Range (Herd #) ^a	Boreal Caribou Core Habitat	Area (ha)	Anthropogenic disturbance area (ha)	% Area impacted
BC Chinchaga (# 1)	Range Total	1,397,900	1,101,200	78.8
	Etthithun	82,200	62,000	75.4
	Milligan	492,900	456,000	92.5
Maxhamish (# 10)	Range Total	709,500	402,000	56.7
	Capot-Blanc	87,500	45,300	51.8
	Fortune	266,200	158,900	59.7
	Kiwigana	130,100	67,800	52.1
Calendar (# 11)	Calendar	496,200	353,300	71.2
Snake-Sahtaneh (# 12)	Range Total	1,198,000	1,004,300	83.8
	Tsea	47,200	45,300	96.0
	Etsho	6,200	3,800	61.9
	North Kotcho	74,800	55,400	74.0
	East Kotcho	31,800	27,200	85.4
	West Kotcho	36,200	34,200	94.4
	Paradise	40,300	28,900	71.8
	Clarke	138,100	129,200	93.5
Parker Core (# 13)	Parker Core	22,400	15,200	67.9
Prophet Core (# 14)	Prophet Core	91,500	71,600	78.2

^a Herd numbers from Environment Canada (2008).

Sorensen *et al.* (2008) indicated that a disturbance level of 61% or greater was consistent with decreasing Boreal Caribou populations in Alberta. In B.C., anthropogenic

disturbance on 3 of the 4 original Boreal Caribou Ranges and on 12 of 15 Core Habitats exceeded 61% (Table 9). The Maxhamish Range currently has the lowest level of anthropogenic disturbance and the Snake-Sahtaneh has the highest, with 3 of its Core Habitats exceeding 90% disturbance.

4.3.7 Temperature extremes (IUCN #11.3)

Boreal Caribou are well adapted to harsh winter conditions (Russell and Martell 1984). While inclement weather causing hypothermia of newborn calves has been postulated as a source of mortality, little direct evidence supports this claim (Bergerud 1996). However, deep snow persisting long into spring may play a role in caribou survival and recruitment, through either: reduced nutrition from a relative food shortage during late pregnancy that results in poor condition of cows, delayed calving dates, and reduced neonatal survival (Cameron *et al.* 1993); and/or increased winter and summer mortality rates of adults and calves. There are no records of any long-term population declines of Woodland Caribou in British Columbia resulting from severe winter weather or disease.

For British Columbia, climate change models predict an increase in average annual temperature, an increase in average winter temperatures, little change in precipitation pattern, and a slightly longer summer season extended in both spring and fall (Stocks *et al.* 2000; Cubasch and Meehl 2001; Ministry of Water, Land and Air Protection 2002). Sudden, extreme, and intense weather events are also expected.

In reviewing potential impacts of climate change on reindeer and caribou, Vors and Boyce (2009) suggest a “trophic mismatch” may occur between plant phenology and *Rangifer* reproductive cycles. If onset of vegetation green-up shifts forward, but timing of spring movements and parturition remain constant, caribou may be unable to fully exploit the period of abundant high-quality spring forage important to meeting the physiological demands of late pregnancy and lactation. This may result in lower calf production and higher calf mortality.

Climate change could also affect snow conditions, which may alter the ability of Boreal Caribou to move within peatlands during winter, or could affect the permafrost layer resulting in changes in water levels in peatlands and their associated effects on caribou movement and vegetation composition. Warmer temperatures could result in increased snow accumulation if winter temperatures stay below freezing, or reduced snow accumulations and/or increased ice/crusting conditions if temperatures oscillate above and below freezing. Increased ice crusting could impede caribou foraging attempts for terrestrial lichens.

4.3.8 Habitat shifting and alteration (IUCN #11.1)

Vegetation composition in B.C.’s Boreal Caribou ranges will be affected by changes in local climatic conditions, even without changes in natural disturbance patterns. A recent vegetation-climate model developed by Hamann and Wang (2006) suggests that most of

B.C.'s Boreal Caribou range will shift from the Boreal White and Black Spruce biogeoclimatic zone to the Interior Douglas-Fir and Ponderosa Pine zones in the next 80 years. At the same time, the frequency of Douglas-fir, which is currently absent from Boreal Caribou range, is expected to increase dramatically. The new biogeoclimatic zones reflect warmer and more productive conditions than are currently present. This could lead to increased productivity of forest floor vegetation, resulting in increased competition and subsequent declines in terrestrial lichen abundance. Changes in moisture regimes may also result in shifts in lichen species composition.

4.3.9 Cumulative climate and severe weather impacts to Boreal Caribou in British Columbia (IUCN #11)

Climate change and the resulting alteration of long-term weather patterns may affect Boreal Caribou by affecting snow conditions and icing events (see section 4.3.7) and changing vegetation composition (see section 4.3.8). Climate change may also increase the impact of other threats by altering the frequency and severity of natural disturbances (fire [see section 4.3.10] and forest insect infestations), promoting shifts in species distribution, and increasing the incidence of diseases and parasites (Vors and Boyce 2009).

Mammal species distribution

Climate change is expected to result in shifts in the distribution of northern fauna, as mammal species expand their ranges northward (Vors and Boyce 2009). Changes in vegetation species and snow conditions resulting from climate change could result in more favourable habitat conditions for other ungulate species. Hoefs (2001) reports both mule (*Odocoileus hemionus*) and white-tailed deer have colonized the southern Yukon Territory, with white-tailed deer first observed north of the British Columbia border in 1975. White-tailed deer have been observed with increasing regularity in the Taiga Plains ecoprovince and as far north as Fort Simpson, NWT (N. Larter, pers. comm.). Increased use of Boreal Caribou habitat by other ungulates could lead to increased predation pressure on Boreal Caribou or increased risk from diseases and parasites (Vors and Boyce 2009).

Diseases and parasites

Climate change could also result in more favourable conditions for diseases and parasites that affect Boreal Caribou (Vors and Boyce 2009). Disease has played a major role in caribou declines in eastern North America where altered landscapes and mild winters allowed white-tailed deer carrying the meningeal worm (*Parelaphostrongylus tenuis*) to expand north and infect caribou (Bergerud and Mercer 1989). The northward expansion of Chronic Wasting Disease, and its effect on ungulate populations, is a major concern of wildlife managers in western Canada. Genetic research from Alaska suggests the spread of Chronic Wasting Disease from mid-latitude cervids to high-latitude caribou is possible (Happ *et al.* 2007). While the possibility of Chronic Wasting Disease occurring in B.C.'s Boreal Caribou ranges is currently low (the closest areas of infection are in southeastern

and south-central Alberta), it could potentially become an issue in Boreal Caribou ranges in B.C. in the future. As Chronic Wasting Disease transmission is fostered by high ungulate densities, such as those found in Elk (*Cervus canadensis*) and White-tailed Deer populations in agricultural areas, the spacing out behaviour of Boreal Caribou would seem to put them at lower risk. However, if climate change and industrial development impacts to habitat availability result in Boreal Caribou concentrating at higher densities, they may become more susceptible. The northward range expansion of White-tailed Deer, spurred by climate change, could potential result in threats to Boreal Caribou from both the meningeal worm and Chronic Wasting Disease over time.

Forest insect infestation

With increased average winter temperatures and fewer cold weather extremes predicted, forest insect activity could also increase as winter temperatures become insufficient to maintain populations at endemic levels (Ministry of Water, Land and Air Protection 2002). Historically, forest insects have likely played a minor role in disturbance in B.C.'s Boreal Caribou ranges; however, eastern spruce budworm (*Choristoneura fumiferana*) may be a concern where mature patches of spruce are found. Also see the possible effects of the mountain pine beetle (*Dendroctonus ponderosae*) in section 4.4.11.

Changes in industrial activities and development patterns

Industrial development practices may be adapted in response to anticipated landscape level changes as a result of climate change, resulting in further impacts to Boreal Caribou. Describing potential climate change impacts for woodland caribou populations in Ontario, Racey (2005) suggests reductions in the supply of older forest will result in "...greater demand by the forest industry, leading to more conflict over ecological and economic values. Although forests may experience enhanced productivity, forest management practices will try to adapt harvest, regeneration, silviculture, and fire management practices to both maintain economic benefits and increase the ability of forests to sequester carbon." While the caribou populations Racey is referring to rely on commercial forests, in contrast to the use of non-commercial black spruce peatlands used by B.C.'s Boreal Caribou populations, his description highlights concerns about how attempts to mitigate climate change impacts on industrial interests may have additional consequences for Boreal Caribou.

4.3.10 Fire and fire suppression (IUCN #7.1)

Boreal Caribou inhabit ecosystems that experience, and are adapted to, frequent large-scale, stand-initiating wildfires. While fire has historically been the most significant natural disturbance factor within Boreal Caribou ranges, both fire frequency and area burned are expected to increase with climate change.

Wildfires may have short-term detrimental impacts to caribou lichen forage supply (Joly *et al.* 2003), but periodic burning may play an important role in rejuvenating older forests with declining lichen productivity (Bergerud 1978; Klein 1982). While fire consumes

terrestrial lichens, periodic fires remove competing vegetation, such as mosses, allowing re-establishment of terrestrial lichens to those sites. Without periodic fires, other plant species can out-compete terrestrial lichens in the long term on some sites. On sites where mosses are absent or scarce, periodic fires may not be as required to reduce competition. In northern Alberta, terrestrial lichen abundance in peatlands recovered after 40 years following fire (Dunford *et al.* 2006).

While Boreal Caribou use of burned areas within 60 years of fire is generally low (Schaefer and Pruitt 1991; Dalerum *et al.* 2007), it has been reported in southeastern Manitoba (Darby and Pruitt 1991), northern Alberta (Dunford 2003), the Mackenzie Valley, NWT (Nagy *et al.* 2005), and the Snake-Sahtaneh Range (Culling *et al.* 2006). Use of burned areas may depend on the amount of area burned, with use of post-fire habitat increasing with greater abundance of wildfire (Dunford 2003) or with greater patchiness of the area within the burn perimeter (Culling *et al.* 2006). In northern Alberta, Boreal Caribou did not shift home ranges or change home range size in response to fire, presumably as home ranges were sufficiently large to provide adequate habitat and space even with fire disturbance (Dalerum *et al.* 2007). Barren-ground Caribou were reported to travel up to 25 km through large burns but did not spend much time in them; lack of use was more likely due to a lack of available food rather than to blowdown, thick re-growth, or poor snow conditions (Thomas *et al.* 1998). In the Snake-Sahtaneh Range, Culling *et al.* (2006) found Boreal Caribou showed selection for burned habitats (< 50 years) during the snow-free months, with highest use during fall and early winter (mid-September to mid-December). Snake-Sahtaneh Boreal Caribou were also observed within the perimeter of older fires, both in burned patches and in remnant unburned patches in the late spring and early summer months.

Historically, when natural disturbance events occurred, Caribou were able to shift their use, if necessary, from those areas to other portions of their range or to alternate ranges. However, as impacts from anthropogenic disturbance and climate change increase, Caribou will presumably have fewer options for range rotation. As well, threat factors may interact as insect epidemics kill large stands of trees, which may contribute to the amount of area affected by wildfire.

4.4 Low Impact Threats

Details of low impact threats are discussed below, listed under the IUCN level 2 headings.

4.4.1 Commercial and industrial areas (IUCN #1.2)

Often large camps for industry (e.g., oil and gas) that house up to 5000 persons are built, which directly alienates habitat.

4.4.2 Annual and perennial non-timber crops (IUCN #2.1)

The Chinchaga Range is unique among the identified B.C. Boreal Caribou ranges in that it is adjacent to an established agricultural area. Land conversion for cereal and forage

crop production has occurred primarily on upland mineral soils (previously supporting mixedwood forests) immediately adjacent to peatlands. As such, the direct impacts of agricultural development to habitat supply for the Boreal Caribou in the Chinchaga Range are low; however, forest cover changes that support expansion of white-tailed deer populations would be detrimental due to potential disease transmission. Boreal Caribou may derive some benefit from localized reductions in Grey Wolf densities resulting from formal and informal Grey Wolf control measures taken to protect livestock in the “agricultural zone.”

4.4.3 Livestock farming and ranching (IUCN #2.3)

Agricultural development is found on the south edge of Chinchaga and Prophet, adjacent to Fort Nelson. Threats to caribou include direct habitat loss and fencing that may alter movements.

4.4.4 Mining and quarrying (IUCN #3.2)

Peat mining is a significant commercial activity in Boreal Caribou ranges in eastern Alberta (D. Hervieux, pers. comm.). Although peat mining is not currently a threat to Boreal Caribou in B.C., it could become a future threat. Increases in all-weather access related to the petroleum industry could foster development of peat mining operations in the future and direct extraction of peat could remove important Boreal Caribou habitat.

4.4.5 Renewable energy (IUCN #3.3)

Geothermal energy potential has been identified near the Clark Core Habitat in the Snake-Sahtaneh Range (Ministry of Energy, Mines and Petroleum Resources, n.d.). Potential demand for electricity produced from this source could be from either the local municipality (Fort Nelson) or the petroleum sector. Carbon credit trading ventures within the petroleum industry and provincial initiatives to reduce greenhouse gas emissions could promote development of these geothermal resources. The infrastructure and footprint associated with geothermal energy generation are similar to that of conventional natural gas production; development would be additive to existing natural gas industry activities.

The potential for developing wind energy is being explored in some of the hills in Boreal Caribou Range. There can be direct removal of Boreal Caribou habitat and potential noise from wind turbines that could disturb Boreal Caribou from the area.

Transmission lines associated with renewable electricity generation projects in northeastern B.C. would increase the linear corridor footprint within Boreal Caribou ranges.

4.4.6 Hunting and collecting terrestrial animals (IUCN #5.1)

First Nations have hunted caribou for thousands of years, primarily for food and clothing, but also for other uses (Ministry of Environment, Lands and Parks 1997). Little is known about the extent of historical or current hunting use of Boreal Caribou by First Nations. Similarly, little is known about historical hunting and use of Boreal Caribou by non-Aboriginal people.

Spalding (2000), in summarizing the early history of Woodland Caribou in British Columbia, stated “Although there is no evidence supporting a single, universal factor causing early caribou declines, indications are that hunting with firearms, acting as an additive to the ever-present natural factors, particularly predation, triggered the major caribou losses observed during the first four decades of this century.” Substantial declines in some local populations apparently occurred when liberal hunting regulations were still in effect (Bergerud 1978). Thus, over-hunting may have caused or contributed to these declines. As is frequently the case, increases in hunting pressure and harvest were often the result of new access or transportation methods, such as snowmobiles and all-terrain vehicles.

Because there is little information on historical Boreal Caribou numbers in British Columbia, it is unknown whether liberal hunting regulations had an impact on Boreal Caribou numbers. However, poor access before oil and gas development likely contributed to limited hunting pressure on Boreal Caribou. Boreal Caribou were closed to hunting between 1978/79 and 1987/88, and have been closed to hunting since 2001.

Poaching may also be a mortality factor for Boreal Caribou in British Columbia. In Alberta, although licensed hunting of Boreal Caribou has not been allowed since 1981, hunting may account for at least 15–20% of radio-collared caribou mortality for some Boreal Caribou populations (D. Hervieux, pers. comm.). Improved access into caribou range due to an expanding network of linear corridors could lead to increased illegal hunting of caribou (Dzus 2001).

4.4.7 Recreational activities (IUCN #6.1)

The creation of winter trails may make caribou more vulnerable to predators (James and Stuart-Smith 2000). Compacted trails such as those created by snowmobiling and snowshoeing provide easier travel corridors for Wolves into late winter caribou habitat (Bergerud 1996). Both Boreal Caribou and Grey Wolves take advantage of the easier travel provided by following snowmobile trails (D. Culling, pers. observ.), which puts the caribou at increased risk of Grey Wolf encounters. While recreational snowmobiling is not common in the peatland habitats in B.C.’s Boreal Caribou ranges, snowmobiles are occasionally used around industrial sites. Despite the abundance of linear corridors in B.C.’s Boreal Caribou ranges, recreational use is low as most backcountry recreation users focus their activities in the mountainous areas to the west. However, some recreational use does occur during hunting season (R. Backmeyer, pers. comm.) and one recreational trail is currently being established in the Parker Lake Range under provisions

in the *Forest and Range Practices Act*. The trail follows existing rights-of-way and will be maintained by the Fort Nelson Snowmobile Club (J. Scheck, pers. comm.).

4.4.8 Work and other activities (IUCN #6.3)

Research activities, such as collaring animals and the use of heli-flights, occur in much of the Boreal Caribou range, but are thought to have a low impact to Boreal Caribou. There is a very low probability that animals are injured during capture.

4.4.9 Dams and water management/use (IUCN #7.2)

All-weather road development can result in altered hydrology that affects vegetation communities.

New petroleum industry technologies used to extract unconventional gas from shale formations require large volumes of water, which may result in altered hydrology and changes to peatland vegetation communities. This could affect Boreal Caribou as wetland complexes are important habitats.

4.4.10 Invasive non-native/alien species (IUCN #8.1)

Invasive plants introduced through oil and gas exploration/extraction when re-vegetating linear corridors. This may result in potential competition with other ungulates attracted to forage but impact unknown.

4.4.11 Problematic native species (IUCN #8.2)

Currently, the mountain pine beetle (MPB) has affected significant portions of some Northern Caribou winter ranges in both B.C. and Alberta. In recent years, the MPB epidemic has spread from the interior of the province, to attack lodgepole pine stands in the northeast. MPB currently occurs in the southern Chinchaga Range, with possible advancement north. Mature lodgepole pine stands within the larger peatland complexes in Boreal Caribou ranges offer Boreal Caribou respite from deep snow in late winter, allowing easier access to terrestrial lichens.

Although the effects of MPB on Caribou habitat and winter range use are not known, MPB could result in increased or decreased lichen productivity depending on site conditions. A reduction in the forest canopy and consequently snow interception could have implications for Caribou movement and foraging during winter. Eventual blowdown of beetle-killed trees could also have implications for Caribou movement. Larger MPB outbreaks are often managed through increased forest harvesting; extensive salvage logging also occurs soon after beetle attack. Winter ranges not located in protected areas will likely be subjected to increased forest harvesting and salvage if MPB outbreaks occur, leading to concerns over the additive effects of MPB, forest harvesting for MPB management, and salvage logging of beetle-killed forests on Caribou winter ranges.

4.4.12 Industrial and military effluents (IUCN #9.2)

Pipeline leaks and flare stack leaks creating mineral licks introducing toxics could affect Boreal Caribou health. Direct mortality can result from Boreal Caribou consuming toxins at waste sites.

4.4.13 Air-borne pollutants (IUCN #9.5)

Flare stacks (sour gas poisoning) has the potential to negatively affect the health of Boreal Caribou.

4.5 Cumulative Effects of Threats

Industrial activities impact Boreal Caribou habitat and population dynamics in northeastern British Columbia. Currently, oil and gas exploration and development are the dominant industrial activity, affecting Boreal Caribou indirectly through habitat alteration and by facilitating increased access and search efficiency for predators, particularly Grey Wolves. Predation and linear corridor development, including seismic lines, pipelines, and roads, are the primary threats to Boreal Caribou populations in British Columbia. Linear corridors are associated with: a higher incidence of predation resulting from increased predator travel rates and hunting efficiency and increased predator access into caribou habitat; increased human access and related disturbance and mortality; habitat alteration; and potential reductions in available forage. Access development through lowland areas may also result in altered hydrology, which may have long-term impacts on peatland vegetation communities.

Natural disturbance events such as fires are also considered a threat even though it has historically been the most significant disturbance factor within Boreal Caribou ranges. Boreal Caribou shift their habitat use from burned areas to areas more suitable. Both fire frequency and area burned are expected to increase with climate change.

A number of other threats also affect Boreal Caribou: climate change and extremes in weather; human-caused mortality; and, to a lesser extent, disease and parasites. These threats have cumulative impacts that may not be predictable by examining the effects of each factor separately. Figure 6 shows linkages between threats to Boreal Caribou in northeastern B.C. and their relative contributions to effects on caribou numbers. Because the habitat composition and historic and current anthropogenic footprint vary between B.C.'s Boreal Caribou ranges, the scope and severity of threats to individual Boreal Caribou herds also vary.

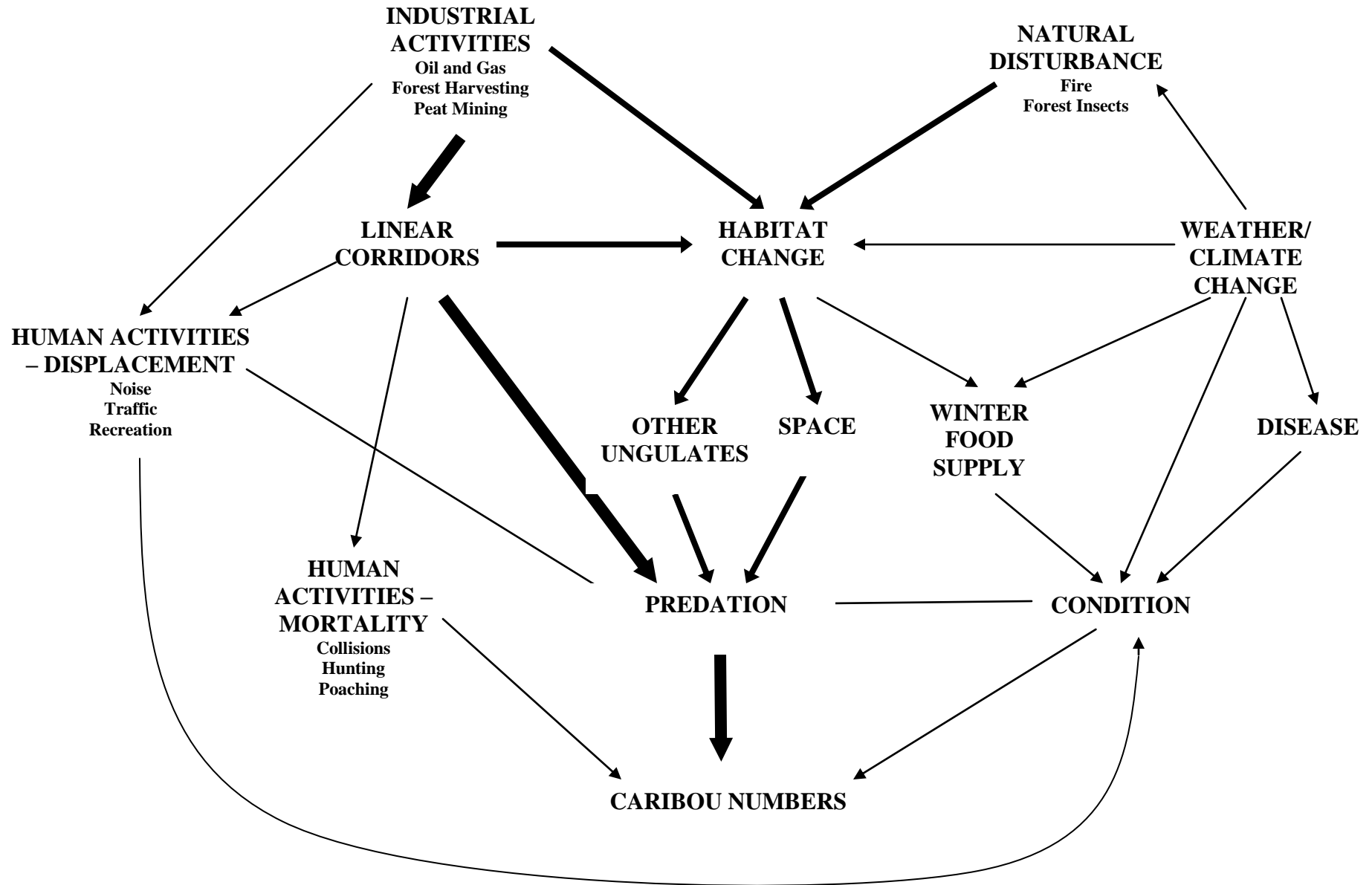


Figure 6. Linkages between threats to Boreal Caribou in northeastern B.C.

5 ACTIONS ALREADY COMPLETED OR UNDERWAY

Recovery planning for Boreal Caribou in British Columbia began in 2004. At that time, information available on provincial Boreal Caribou distribution, habitat needs, and population status was limited to an ongoing radio-telemetry study of Boreal Caribou in the Snake-Sahtaneh Range (Culling *et al.* 2006). Since then, several research projects have been conducted, resulting in a much improved understanding of Boreal Caribou and their needs in British Columbia. Completed and ongoing Boreal Caribou recovery and management actions to date are listed below. Actions have been categorized by the action groups of the Conservation Framework. The status of the action group for this species is given in brackets.

Compile Status Report (complete)

- COSEWIC report completed (COSEWIC 2002).

Send to COSEWIC (complete)

- Boreal Caribou designated Threatened by COSEWIC in 2000 and confirmed in 2002 (COSEWIC 2002).

Planning (in progress)

- BC Science Update completed (this document, 2010).
- BC Implementation plan completed (Ministry of Environment and Ministry of Energy, Mines and Petroleum Resources 2010).

Habitat protection and private land stewardship (in progress)

- GPS/VHF telemetry studies: Snake-Sahtaneh Range (Culling *et al.* 2006), Chinchaga Range (Rowe 2007a), Maxhamish Range (Rowe 2007b; Thiessen 2009; Ministry of Environment, ongoing), Parker Range (Thiessen 2009; Ministry of Environment ongoing), Prophet Range (Thiessen 2009; Ministry of Environment ongoing), and Calendar Range (Culling and Culling, in prep.).
- Late winter (March) inventories: Snake-Sahtaneh Range (Culling *et al.* 2006), Maxhamish Range (Rowe 2006; Ministry of Environment ongoing), Parker Range (Ministry of Environment ongoing), Prophet Range (Ministry of Environment, ongoing), and Calendar Range (Culling and Culling, in prep.).
- Fall rut count/calf survival surveys: Snake-Sahtaneh Range (Culling *et al.* 2006), Chinchaga Range (Rowe 2007a), Maxhamish Range (Thiessen 2009; Ministry of Environment, ongoing), Parker Range (Ministry of Environment, ongoing), Prophet Range (Ministry of Environment, ongoing), and Calendar Range (Culling and Culling, in prep.).
- Spring calf survival surveys: Snake-Sahtaneh Range (Culling *et al.* 2006), Chinchaga Range (Rowe 2007a), and Calendar Range (Culling and Culling, in prep.).
- Moose and Boreal Caribou inventory of Management Units 7-55 and 7-56 (Snake-Sahtaneh, Maxhamish, and Calendar ranges; Backmeyer 2004).
- Identification and mapping of high capability Boreal Caribou habitat, and development of the *Boreal Caribou Range and Core Habitat Map* (Culling *et al.* 2004, in prep.).
- *Interim Oil and Gas Industry Guidelines for Boreal Caribou ranges in northeastern British Columbia* (Culling *et al.* 2004); prepared for the BC Oil and Gas Commission, Fort St. John.

- Evaluation of anthropogenic disturbance levels in B.C. Boreal Caribou Ranges and Core Habitats (Thiessen 2009).
- Fort Nelson and Fort St. John Land and Resource Management Plans (Appendix 2).
- Identification, designation, and establishment of boundaries of Boreal Caribou Wildlife Habitat Areas (WHAs) and Ungulate Winter Range (UWR) under the *Forest and Range Practices Act* were approved by the Ministry of Environment in August 2010 (Table 10). General Wildlife Measures (GWMs) for these areas are in progress.
- Establishment of parks and protected areas that may provide benefit to Boreal Caribou (Table 11).

Species and population management (in progress)

- Ph.D. candidate (University of Alberta) initiating study of Boreal Caribou habitat use and predator–prey dynamics (September 2010).
- Moose inventory in Boreal Caribou Cores in the Horn River Basin and surrounding areas (Thiessen 2010).

Review resource use (complete)

- Boreal Caribou were closed to hunting between 1978/79 and 1987/88, and have been closed to hunting since 2001.
- Report All Poachers and Polluters (RAPP) program (<http://www.env.gov.bc.ca/cos/rapp/rapp.html>).

6 EXISTING MANAGEMENT

This section contains information on some of the existing management actions.

6.1 Land and Resource Management Plans

Boreal Caribou range in British Columbia falls within the Fort Nelson and Peace Forest Districts that include two completed Land and Resource Management Plans (LRMPs): the Fort Nelson LRMP (Fort Nelson LRMP 1997) and the Fort St. John LRMP (Fort St. John LRMP 1997), respectively (Appendix 2). Both LRMPs were completed before the delineation of formal Boreal Caribou Ranges and Core Habitats in 2004 and before the listing of Boreal Caribou as “Threatened” on Schedule 1 of the federal *Species at Risk Act*. There are no LRMP-wide Boreal Caribou management strategies; strategies for Boreal Caribou are primarily contained in individual resource management zone objectives (Appendix 2). The LRMP objectives and strategies should be considered as a starting point for Boreal Caribou management, focusing on the intent of the LRMP to the extent possible, rather than on a literal interpretation of the objectives and strategies.

6.2 Ungulate Winter Ranges and Wildlife Habitat Areas

Ungulate Winter Ranges (UWRs) and Wildlife Habitat Areas (WHAs) are legal designations under the *Forest and Range Practices Act* for managing wildlife and their habitat. The *Oil and Gas Activities Act* will also include the authority to enable the designation of UWRs or WHAs (or a similar mechanism) when it comes into force. UWRs and WHAs for Boreal Caribou have been established under the *Forest and Range Practices Act* in the Fort Nelson Timber Supply

Area (TSA) and have been proposed for the Fort St. John TSA (Table 10). For Boreal Caribou, UWRs contain important wintering areas while WHAs contain important calving areas. All 2004 Boreal Caribou Core Habitats in the Fort Nelson TSA are covered by Type A or Type B UWRs. General Wildlife Measures (GWM) for Type A (Prime Habitat) UWRs call for no new forest harvesting or roads. In Type B (Management Area) UWRs, GWMs focus on minimizing impacts of forest harvesting activities and associated access. In the Fort Nelson TSA, all but 3 small WHAs overlap Type A UWRs. GWMs for WHAs call for no new forest harvesting or roads and a restriction on forest activities during the calving period from May 1 to June 1. Although over 1 million hectares have been proposed for Boreal Caribou WHAs and Type A UWRs where no new forest harvesting or road building for forest harvesting will take place, a portion of these areas has already been disturbed (Goddard 2009).

Table 10. Boreal Caribou Wildlife Habitat Areas (WHAs) and Ungulate Winter Ranges (UWRs) established in the Fort Nelson TSA and proposed for the Fort St. John Timber TSA.

Timber Supply Area	WHA ^a		UWR Type A ^b		UWR Type B ^c	
	Area (ha)	#	Area (ha)	#	Area (ha)	#
Fort St. John TSA	181,316	8	242,472	6	325,141	7
Fort Nelson TSA	276,335	15	701,047	58	800,088	42
TOTAL	457,651	23	943,519	64	1,125,229	49

^a All but 3 small Wildlife Habitat Areas overlap Type A Ungulate Winter Range.

^b Type A Ungulate Winter Ranges consist of Prime Habitat within Core Habitat.

^c Type B Ungulate Winter Ranges consist of Management Areas Within Core Habitat.

6.3 Protected Areas

Protected areas in B.C.'s Boreal Caribou ranges are generally small and therefore do not contribute significantly to protection or management of Boreal Caribou and their habitat. In B.C., parks and protected areas cover 1.4% of Boreal Caribou Ranges, 2.0% of Core Habitats, and 1.2% of all Boreal Caribou habitat (including trace occurrence areas; Table 11). Within the Calendar Range, the Thinahtea Protected Area contains habitat attributes important to Boreal Caribou, including Thinahtea Lake, which has many small islands that may offer predator avoidance habitat. Milligan Hills Provincial Park is a predominantly upland area and has little potential to capture Boreal Caribou calving habitat (Rowe 2007a). Rowe (2007a) suggests any future protected areas where the objectives are Boreal Caribou habitat management should be associated with high value winter or calving habitat. Telemetry data indicate Boreal Caribou make very little use of the area encompassed by Milligan Hills Provincial Park. Portions of the Fortune Core of the Maxhamish Range falling within the Maxhamish Lake Protected Area (i.e., outside the Provincial Park boundary), represent high suitability Boreal Caribou habitat.

Table 11. Protected Areas (> 100 ha) in and adjacent to 2010 Boreal Caribou Ranges in northeastern British Columbia.

Range/Core Habitat		Protected Area			
Range	Core Habitat	Name	Size (ha)	% of range	% of Core Habitat
Maxhamish	Fortune	Maxhamish Lake Provincial Park and Protected Area ^a	27,516	3.9	4.3
Calendar	Calendar	Thinahtea Protected Area	20,379	4.1	4.1

Range/Core Habitat		Protected Area			
Range	Core Habitat	Name	Size (ha)	% of range	% of Core Habitat
Chinchaga	Etthithun	Milligan Hills Provincial Park	7,226	0.5	8.8
		Chinchaga Lakes Protected Area	1,389	0.1	1.7
Prophet	Prophet	Goguka Creek Protected Area	435		0.5
Parker	Parker	Parker Lake Ecological Reserve	259		1.2
Snake-Sahtaneh		None			
Trace Occurrence Area		Hay River Protected Area	2,324		0.2 ²
		Ekwan Lake Protected Area	1,892		0.2 ²
		Sikanni Old Growth Park	1,439		0.1 ²
		Fort Nelson River Ecological Reserve	121		< 0.1 ²

^a Maxhamish Range contains all of the park and protected area; Fortune Core Habitat contains 11,531 ha of the park and protected area.

^b % of trace occurrence area.

6.4 Timing Windows

Fish and wildlife timing windows are best management guidelines to reduce wildlife and habitat impacts from industry activity. In 2009, the Ministry of Environment created timing windows for Boreal Caribou in the Peace Region (Table 12), to avoid/minimize impacts to wildlife (Ministry of Environment 2009).

Table 12. BC Ministry of Environment Peace Region timing windows for Boreal Caribou (March 2009).

Season	Risk category	Timing	Management direction
Late winter and calving/lambing	Critical	March 15 to July 15	Development activities are inappropriate during this timeframe. Aerial activities should adhere to guidelines (BC Ministry of Environment. 2008). If working within a critical window is unavoidable, proponent should contact an appropriate qualified professional (e.g., Registered Professional Biologist with B.C. accreditation) to discuss alternatives, and potential mitigation and monitoring plans.
Rut/winter	Caution	September 15 to March 14	Proponents should minimize development activities during these timeframes.
Summer	Low	July 16 to September 14	Restrictions would not normally apply. Where ground conditions permit, plan development activities within these timeframes.

The Oil and Gas Commission (2003) also has timing windows for Boreal Caribou (Table 13). May 15 to July 15 is considered *critical*, whereas October 15 to November 15 and January 15 to April 15 are considered *cautionary*. Most of the winter drilling and pipelining season is during the late winter cautionary period.

Table 13. Oil and Gas Commission timing windows for Boreal Caribou (March 2003).

Season	Risk category	Timing	Management direction
Calving/lambing	Critical	May 15 to July 15	Helicopter-supported activities are to be avoided; exploration and transmission developments are generally permitted unless site-specific sensitivities dictate otherwise. If working within a critical window is unavoidable, project applications must be accompanied by a rationale for the variance request, as well as mitigation and monitoring plans.
Rut	Caution	October 15 to November 15	Operations may proceed subject to Oil and Gas Commission review although it is recommended that operators avoid intensive activities or overlapping operations; mitigation measures may be required during these periods to ensure species and habitat protection.
Winter	Caution	January 15 to April 15	

As peak conception for the Snake-Sahtaneh Range was estimated at September 30 (Culling *et al.* 2006), the existing October 15 to November 15 cautionary window does not coincide with the peak of the rut. As calving and rutting occurs approximately 2 weeks earlier in the Boreal ecotype than the Northern ecotype, Culling *et al.* (2004) recommended shifting the timing windows as follows:

- Rut: shift the cautionary fall rut period to start September 15 to October 15 within identified Boreal Caribou ranges, and September 15 to October 30 within Core Habitats. Shifting this period forward would provide Boreal Caribou greater protection from disturbance during the rut. An extended cautionary period within Core Habitats will reduce potential impacts to caribou during the second estrous cycle, in late October, while allowing development activities restart outside Core Habitats with relatively little risk.
- Calving: shift the critical calving period to April 15–June 30 to reduce stress on Boreal Caribou during late pregnancy, parturition, and neo-natal period.

The recommended changes to the existing timing windows under the Oil and Gas Commission all fall within those suggested by the Ministry of Environment (2009). Coordination of timing windows between agencies would allow industry to better address Boreal Caribou management objectives.

6.5 Forest Management

The Ministry of Forests and Range conducts Timber Supply Reviews in each Timber Supply Area (TSA) to determine allowable forest harvest levels based on current management practices. Only management practices contained in the Timber Supply Analysis report are considered in setting the allowable annual cut. In the Fort St. John TSA, management practices for Boreal Caribou include management of Caribou habitat in the Chinchaga Range to maintain adjacent forest cover through the application of green-up criteria with a 2-pass harvesting system and 40 years between passes (Ministry of Forests 2002). Although this management practice is applied to 120,890 ha or 10.1% of the timber harvesting land base, it does not impact on the allowable annual cut (Ministry of Forests 2002). In the Fort Nelson TSA, management practices for Caribou include all areas identified as significant Caribou habitat being excluded from harvest

(Ministry of Forests and Range 2005). The area of the timber harvesting land base excluded from harvest (following other reductions) was 20,158 ha for significant Caribou habitat; this area includes both Northern Caribou and Boreal Caribou habitat since ecotypes were not differentiated in the analysis.

Management practices for Boreal Caribou are included in the Fort St. John Pilot Project Sustainable Forest Management Plan (SFMP; Jukes *et al.* 2003) and the Fort Nelson SFMP (Ministry of Forests and Canadian Forest Products Ltd. 2005). The Fort Nelson SFMP focused on developing a management strategy for Boreal Caribou. At the time the SFMP was finalized, the Snake-Sahtaneh study was underway but little other information was available on Boreal Caribou. In the Fort St. John Pilot Project SFMP, the Target Statement for caribou indicated “40% of forests will be greater than the baseline target age by caribou management zone,” but was more applicable to Northern Caribou habitat than Boreal Caribou habitat. Boreal Caribou habitat in the Fort St. John Pilot Project area was contained in the Milligan Caribou management zone (Chinchaga Range). This zone included approximately 511,684 ha of forested land of which 127,684 ha (25%) were considered to contribute to the long-term timber harvesting land base. No target was required for the Milligan Caribou management zone because of the low proportion of timber harvesting land base and because Boreal Caribou likely used stands that did not fall within the timber harvesting land base. The process for revising the Fort St. John Pilot Project SFMP began in 2009 and a draft plan was available on the Fort St. John Pilot Project website in February 2010 (<http://fsjpilotproject.com/project.html>). In the updated draft plan, Boreal Caribou will be managed by following the General Wildlife Measures (GWM) associated with Boreal Caribou Ungulate Winter Ranges and Wildlife Habitat Areas designated under the *Forest and Range Practices Act*.

Forest licensees participating in the Fort St. John Pilot Project SFMP and the Fort Nelson SFMP are certified under the Canadian Standards Association (CSA) Sustainable Forest Management Standard CAN/CSA-Z809-02. Forest management practices for Boreal Caribou are incorporated into the certification under the “Species diversity” and “Protected areas and sites of special geological significance” critical elements.

7 KNOWLEDGE GAPS

Considerable information is available from studies conducted in Alberta on the ecology and effects of disturbance on Boreal Caribou. Because the Boreal Caribou in those studies inhabit similar, often contiguous ecosystems to Boreal Caribou in northeastern B.C., which are subjected to similar anthropogenic disturbances, information from those studies provides important groundwork for informing management of Boreal Caribou in B.C.

Given the current incomplete understanding of Boreal Caribou populations and movements in B.C., range delineation must be considered an adaptive process, with ongoing data collection expected to result in further refinement of Ranges and Core Habitat polygons. Environment Canada (2008) recommends re-examining defined ranges as new information becomes available and at least every 5 years. Since 2000, knowledge of B.C.’s Boreal Caribou population distribution and ecology has been advanced by a series of GPS/VHF radio-telemetry studies throughout various ranges.

Area-specific knowledge gaps include:

- Chinchaga, Maxhamish, Calendar, and Snake-Sahtaneh Ranges:
 - long-term population trends are unknown. A minimum sample of 20 Boreal Caribou in each of these 4 major ranges should be fitted with VHF radio-collars to track annual survival and recruitment; the sample size should be maintained at 20 radio-collared animals over the long term;
- Tsea Core Habitat:
 - this represents a potential movement corridor between the Snake-Sahtaneh, Maxhamish, and Calendar Ranges (Culling and Culling, in prep.); connectivity needs to be identified with additional GPS radio-telemetry studies;
- Fortune Core Habitat:
 - Boreal Caribou habitat use and boundaries need to be refined in the Fortune Core Habitat using GPS radio-telemetry of collared Boreal Caribou;
- Parker Range and Prophet Range:
 - range boundaries need to be refined, potential Wildlife Habitat Areas delineated, and connectivity assessed between these Ranges and adjacent Boreal and Northern Ecotype Caribou Ranges with additional GPS radio-telemetry studies;
 - long-term population trends are unknown. A minimum sample of Boreal Caribou (5–10 in each of these minor Ranges should be fitted with VHF radio-collars to track) annual survival and recruitment, the sample size should be maintained over the long-term; and
- a Traditional Ecological Knowledge (TEK) study should be undertaken to address questions of historical distributions and populations.

8 REFERENCES

- Alberta Woodland Caribou Recovery Team. 2005. Alberta Woodland Caribou recovery plan 2004/05–2013/14. Alberta Sustainable Resource Development, Fish and Wildlife Division, Alberta Species at Risk Recovery Plan No. 4. Edmonton, AB. 48 pp.
- Anderson, R.B. 1999. Peatland habitat use and selection by Woodland Caribou (*Rangifer tarandus caribou*) in northern Alberta. M.Sc. thesis. Univ. Alberta, Edmonton, AB. 49 pp.
- Backmeyer, R.J. 2004. Moose and Boreal Caribou inventory: Management Units 7–55 and 7–56. B.C. Min. Environ., Wildlife Branch, Victoria, BC. Tech. Rep. 6 pp.
- Banfield, A.W.F. 1974. The mammals of Canada. Univ. Toronto Press, Toronto, ON. 438 pp.
- Barrette, C. and D. Vandal. 1986. Social rank, dominance, antler size, and access to food in snow-bound wild Woodland Caribou. *Behaviour* 97(1–2):118–146.
- B.C. Conservation Data Centre. 2010. BC Species and Ecosystems Explorer. B.C. Min. Environ., Victoria, BC. <<http://a100.gov.bc.ca/pub/eswp/>> [Accessed Aug. 23, 2010]
- BC Ministry of Environment. 2008. Peace Region Guidelines for Aircraft Operations/Wildlife Interactions. B.C. Min. Environ., Fort St. John, BC. <ftp://ftpfsj.env.gov.bc.ca/pub/outgoing/Peace_Region_Wildlife_Values/Industrial_Sectors/Best_Management_Practices/> [Accessed July 15, 2009]
- Bergerud, A.T. 1974. The decline of caribou in North America following settlement. *J. Wildl. Manage.* 38:757–770.
- Bergerud, A.T. 1978. The status and management of caribou in British Columbia. BC Fish and Wildlife Branch, Victoria, BC.
- Bergerud, A.T. 1996. Evolving perspectives on caribou population dynamics, have we got it right yet? *Rangifer*, Special Issue No. 9:95–116.
- Bergerud, A.T. and J.P. Elliott. 1998. Wolf predation in a multiple-ungulate system in northern British Columbia. *Can. J. Zool.* 76:1551–1569.
- Bergerud, A.T. and W.E. Mercer. 1989. Caribou introductions into eastern North America. *Wildl. Soc. Bull.* 17:111–120.
- Boreal Caribou Technical Advisory Committee. 2004. A strategy for the recovery of Boreal Caribou in British Columbia – draft #3. B.C. Min. Water, Land and Air Protection, Victoria, BC.
- Boutin, S. and C. Arienti. 2008. BCC equation reanalysis – final report. Unpublished report prepared for the Alberta Caribou Committee, Edmonton, AB. 19 pp.
- Bradshaw, C.A., S. Boutin, and D.M. Hebert. 1997. Effects of petroleum exploration on Woodland Caribou in northeastern Alberta. *J. Wildl. Manage.* 61:1127–1133.
- Bradshaw, C.A., D.M. Hebert, A.B. Rippin and S. Boutin. 1995. Winter peatland habitat selection by Woodland Caribou in northeastern Alberta. *Can. J. Zool.* 73:1567–1574.
- Brown, K.G., C. Elliot, and F. Messier. 2000a. Seasonal distribution and population parameters of Woodland Caribou in central Manitoba: implications for forestry practices. *Rangifer*, Special Issue No. 12:85–94.
- Brown, K., W.J. Rettie, B. Wynes, and K. Morton. 2000b. Wetland habitat selection by Woodland Caribou as characterized using the Alberta Wetland Inventory. *Rangifer*, Special Issue No. 12:153–157.
- Brown, W.K. and I. Ross. 1994. Caribou-vehicle collisions: a review of methods to reduce caribou mortality on Highway 40, west-central Alberta. Prepared by Terrestrial and

- Aquatic Environmental Managers Ltd. for Alberta Environmental Protection, Fish and Wildlife Services and Alberta Transportation and Utilities, Research and Development Branch, Calgary, AB. 123 pp.
- Brown, W.K. and J.B. Theberge. 1985. The calving distribution and calving-area fidelity of a Woodland Caribou herd in central Labrador. Pages 57–67 in *Proceedings of the Second North American Caribou Workshop*. T.C. Meredith and A.M. Martell, eds. McGill Subarctic Res. Pap. No. 40.
- Cameron, R.D., W.T. Smith, S.G. Fancy, K.L. Gerhart, and R.G. White. 1993. Calving success of female caribou in relation to body weight. *Can. J. Zool.* 71:480–486.
- Cameron, R.D., K.R. Whitten, W.T. Smith, and D.D. Roby. 1979. Caribou distribution and group composition associated with construction of the Trans-Alaska Pipeline. *Can. Field-Nat.* 93:155–162.
- Carruthers, D.R., S.H. Ferguson, R.D. Jakimchuk, and L.G. Sopuck. 1986. Distribution and habitat use of the Bluenose Caribou herd in mid-winter. *Rangifer Spec. Issue* 1:57–63.
- COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2002. COSEWIC assessment and update status report on the Woodland Caribou *Rangifer tarandus caribou* in Canada. Ottawa, ON. 98 pp.
- Cubasch, U. and G.A. Meehl. 2001. Projections of future climate change. In J.T. Houghton, Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden, X. Dai, K. Maskell, and C.A. Johnson, eds. *Climate change 2001: the scientific basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge, UK.
- Culling, D.E. and B.A. Culling. In preparation. Boreal Caribou ecology and seasonal habitat use in the Calendar Range and Tsea Core Habitat, northeastern British Columbia – 2008 to 2010. Prepared for Nexen Inc., Calgary, AB.
- Culling, D.E., B.A. Culling, R.J. Backmeyer, and T.M. Antoniuk. 2004. Interim oil and gas industry guidelines for Boreal Caribou ranges in northeastern British Columbia. Prepared for Oil and Gas Commission, Fort St. John, BC. 32 pp.
- Culling, D.E., B.A. Culling, and T. Raabis. 2005. Seasonal habitat use and movements of Graham Caribou, 2001 to 2003. Prepared for Canadian Forest Products Ltd. and B.C. Min. Water, Land and Air Protection, Fort St. John, BC. 88 pp.
- Culling, D.E., B.A. Culling, T.J. Raabis, and A.C. Creagh. 2006. Ecology and seasonal habitat selection of Boreal Caribou in the Snake-Sahtaneh watershed, British Columbia. Prepared for Canadian Forest Products Ltd., Fort Nelson, BC. 80 pp.
- Culling, D.E., B.A. Culling, C. Thiessen, M.R. Rowe, and R.J. Backmeyer. In preparation. Rationale for 2010 revised Boreal Caribou range and core habitat map. Prepared for B.C. Min. Environ., Fort St. John, BC.
- Cumming, H.G. and D.B. Beange. 1987. Dispersion and movements of Woodland Caribou near Lake Nipigon, Ontario. *J. Wildl. Manage.* 51(1):68–79.
- Dalerum, F., S. Boutin, and J.S. Dunford. 2007. Wildfire effects on home range size and fidelity of Boreal Caribou in Alberta, Canada. *Can. J. Zool.* 85:26–32.
- Darby, W.R. and W.O. Pruitt. 1984. Habitat use, movements and grouping behaviour of Woodland Caribou, *Rangifer tarandus caribou*, in southeastern Manitoba. *Can. Field-Nat.* 98(2):184–190.
- Ducks Unlimited Inc. 2003. Fort Nelson, British Columbia earth cover classification user's guide. Prepared for: Ducks Unlimited Canada, Edmonton, AB; Slokan Forest Products

- Ltd., and B.C. Min. Sustainable Resource Management through Forest Renewable British Columbia. Ducks Unlimited Inc., Rancho Cordova, CA. 77 pp. + digital mapping.
- Dunford, J.S. 2003. Woodland Caribou-wildfire relationships in northern Alberta. M.Sc. thesis. Univ. Alberta, Edmonton, AB.
- Dunford, J.S., P.D. McLoughlin, F. Dalerum, and S. Boutin. 2006. Lichen abundance in the peatlands of northern Alberta: implications for Boreal Caribou. *Ecoscience* 13(4):469–474.
- Dyer, S.J. 1999. Movement and distribution of Woodland Caribou (*Rangifer tarandus caribou*) in response to industrial development in northern Alberta. M.Sc. thesis. Univ. Alberta, Edmonton, AB. 84 pp.
- Dyer, S.J., J.P. O'Neill, S.M. Wasel, and S. Boutin. 2001. Avoidance of industrial development by Woodland Caribou. *J. Wildl. Manage.* 65:531–542.
- Dyer, S.J., J.P. O'Neill, S.M. Wasel, and S. Boutin. 2002. Quantifying barrier effects of roads and seismic lines on movements of female Woodland Caribou in northeastern Alberta. *Can. J. Zool.* 80:839–845.
- Dzus, E. 2001. Status of the Woodland Caribou (*Rangifer tarandus caribou*) in Alberta. Alberta Environment, Fisheries and Wildlife Management Division, and Alberta Conservation Association, Edmonton, AB. Wildlife Status Rep. No. 30. 47 pp.
- Edmonds, E.J. 1988. Population status, distribution, and movements of Woodland Caribou in west central Alberta. *Can. J. Zool.* 66:817–826.
- Environment Canada. 2008. Scientific review for the identification of critical habitat for Woodland Caribou (*Rangifer tarandus caribou*), Boreal population, in Canada. August 2008. Ottawa, ON. 72 pp. + 180 pp. Appendix.
- Fort Nelson LRMP. 1997. Fort Nelson Land and Resource Management Plan. Prepared by Fort Nelson LRMP Working Group, Fort Nelson, BC. 178 pp. + map.
- Fort St. John LRMP. 1997. Fort St. John Land and Resource Management Plan – October 1997. Prepared by Fort St. John LRMP Working Group, Fort St. John, BC. 203 pp. + map.
- Fuller, T.K. and L.B. Keith. 1981. Woodland Caribou population dynamics in northeastern Alberta. *J. Wildl. Manage.* 45(1):197–213.
- Goddard, A.D. 2009. Boreal Caribou in northeastern British Columbia: biological rationale, data summary and literature review. B.C. Min. Environ., Fort St. John, BC. Peace Region Technical Report. 21 pp.
- Goward, T. 2000. Fire, terrestrial lichens, and the Itcha-Ilgachuz Caribou. Pages 665–669 in L.M. Darling, ed. Proceedings of a conference on the biology and management of species and habitats at risk, Kamloops, BC, 15–19 Feb., 1999. B.C. Min. Environ., Lands, and Parks, Victoria, BC and University College of the Cariboo, Kamloops, BC.
- Gustine, D.D. 2005. Plasticity in selection strategies of Woodland Caribou (*Rangifer tarandus caribou*) during winter and calving. M.Sc. thesis. Univ. Northern B.C., Prince George, BC. 197 pp.
- Hamann, A. and T. Wang. 2006. Potential effects of climate change on ecosystem and tree species distribution in British Columbia. *Ecology* 87(11):2773–2786.
- Happ, G.M., H.J. Huson, K.B. Beckmen, and L.J. Kennedy. 2007. Prion protein genes in caribou from Alaska. *J. Wildl. Dis.* 43(2):224–228.
- Heard, D.C. and K.L. Vagt. 1998. Caribou in British Columbia: a 1996 status report. *Rangifer*, Special Issue No. 10:117–123.

- Heggberget, T.M., E. Gaare, and J.P. Ball. 2002. Reindeer (*Rangifer tarandus*) and climate change: importance of winter forage. *Rangifer* 22(1):13–31.
- Hervieux, D. *n.d.* Boreal Caribou radio-telemetry and survey data, 1983–2009. Alberta Sustainable Resources Management, Fish and Wildlife Division, Grande Prairie, AB. Unpublished report.
- Hoefs, M. 2001. Mule, *Odocoileus hemionus*, and white-tailed, *O. virginianus*, deer in the Yukon. *Can. Field-Nat.* 115(2):296–300.
- Hornbeck, G.E. and D.L.J. Moyles. 1995. Ecological aspects of Woodland Caribou in the Pedigree area of northwestern Alberta. Members of the Pedigree Caribou Standing Committee, Calgary, AB. 66 pp.
- International Union for Conservation of Nature and Conservation Measures Partnership (IUCN and CMP). 2006. IUCN – CMP unified classification of direct threats, ver. 1.0 – June 2006. Gland, Switzerland. 17 pp.
<<http://www.conservationmeasures.org/initiatives/threats-actions-taxonomies/threats-taxonomy>> [Accessed Aug. 23, 2010]
- James, A.R.C. 1999. Effects of industrial development on the predator-prey relationship between wolves and caribou in northeastern Alberta. Ph.D. thesis. Univ. Alberta, Edmonton, AB. 70 pp.
- James, A.R.C., S. Boutin, D.M. Hebert, and A.B. Rippin. 2004. Spatial separation of caribou from moose and its relation to predation by wolves. *J. Wildl. Manage.* 68:799–809.
- James, A.R.C. and A.K. Stuart Smith. 2000. Distribution of caribou and wolves in relation to linear corridors. *J. Wildl. Manage.* 64:154–159.
- Johnson, D.R. 1976. Mountain Caribou: threats to survival in the Kootenay Pass Region, British Columbia. *Northwest Sci.* 50:97–101.
- Joly, K., B.W. Dale, W.B. Collins, and L.G. Adams. 2003. Winter habitat use by female caribou in relation to wildland fires in interior Alaska. *Can. J. Zool.* 81:1192–1201.
- Jukes, W., D. Menzies, D. Rosen, G. Taylor, R. St. Jean, and J. Beale. 2003. Fort St. John Pilot Project Sustainable Forest Management Plan. Fort St. John Pilot Project Working Group. 271 pp. + appendices. (see <www.fsjpilotproject.com>)
- Klein, D.R. 1982. Fire, lichens, and caribou. *J. Range Manage.* 35(3):390–395.
- Kuzyk, G.W., J. Kneteman, and F.K.A. Schmiegelow. 2004. Winter habitat use by wolves, *Canis lupus*, in relation to forest harvesting in west-central Alberta. *Can. Field-Nat.* 118:368–375.
- Larter, N.C. *n.d.* Government of Northwest Territories, Department of Environment and Natural Resources, unpublished Boreal Caribou radio-telemetry data. Fort Simpson, NT.
- Larter, N.C. and D.G. Allaire. 2005. Trout Lake Boreal Caribou study progress report, February 2005. Dep. Resources, Wildlife & Economic Development – Dehcho Region, Fort Simpson, NT.
- Lee, P. and S. Boutin. 2006. Persistence and developmental transition of wide seismic lines in the western Boreal Plains of Canada. *J. Environ. Manage.* 78:240–250.
- Mahoney, S.P., H. Abbott, L.H. Russell, and B.R. Porter. 1990. Woodland Caribou calf mortality in insular Newfoundland. Pages 592–599 in *Transactions of the 19th Congress of the International Union of Game Biologists*, Trondheim, Norway, 1989. S. Myrberget, ed. Norwegian Institute for Nature Research, Trondheim, Norway.
- Mahoney, S.P. and J.A. Virgl. 2003. Habitat selection and demography of a nonmigratory Woodland Caribou population in Newfoundland. *Can. J. Zool.* 81:321–334.

- Master, L., D. Faber-Langendoen, R. Bittman, G.A. Hammerson, B. Heidel, J. Nichols, L. Ramsay, and A. Tomaino. 2009. NatureServe conservation status assessments: factors for assessing extinction risk. NatureServe, Arlington, VA.
<http://www.natureserve.org/publications/ConsStatusAssess_StatusFactors.pdf>
[Accessed Aug. 23, 2010]
- McLoughlin, P.D., J.S. Dunford, and S. Boutin. 2005. Relating predation mortality to broad-scale habitat selection. *J. Anim. Ecol.* 74:701–707.
- McLoughlin, P.D., E. Dzus, B. Wynes, and S. Boutin. 2003. Declines in populations of Woodland Caribou. *J. Wildl. Manage.* 67(4):755–761.
- Ministry of Energy, Mines and Petroleum Resources. *n.d.* Geothermal resources map.
<<http://www.em.gov.bc.ca/Geothermal/GeothermalResourcesMap.htm>>. [Accessed Feb. 15, 2010]
- Ministry of Environment. 2009. Peace Region least-risk timing windows: biological rationale - October 2009. Ecosystems Section, Fort St. John, BC. Peace Region Technical Report.
- Ministry of Environment. 2010. Conservation framework. Victoria, BC.
<<http://www.env.gov.bc.ca/conservationframework/index.html>> [Accessed Feb. 1, 2010]
- Ministry of Environment and Ministry of Energy, Mines and Petroleum Resources. 2010. Implementation plan for the management of Boreal Caribou (*Rangifer tarandus caribou* pop. 14) in British Columbia. Prepared for B.C. Ministry of Environment, Victoria, BC. 23 pp.
- Ministry of Environment, Lands and Parks. 1997. Toward a Mountain Caribou management strategy for British Columbia - background report. Prepared by MAIA Publishing for the B.C. Wildlife Branch, Victoria, BC. 72 pp.
- Ministry of Forests. 2002. Fort St. John Timber Supply Area analysis report. Victoria, BC. 152 pp.
- Ministry of Forests and Range. 2005. Fort Nelson Timber Supply Area analysis report. Victoria, BC. 188 pp.
- Ministry of Forests and Canadian Forest Products Ltd. 2005. Sustainable forest management plan for Fort Nelson Defined Forest Area. Fort Nelson, BC. 228 pp.
- Ministry of Water, Land and Air Protection. 2002. Indicators of climate change for British Columbia. Victoria, BC. 48 pp.
- Nagy, J.A., D. Auriat, W. Wright, T. Slack, I. Ellsworth, and M. Kienzler. 2005. Ecology of Boreal Woodland Caribou in the Lower Mackenzie Valley, NT: work completed in the Inuvik Region April 2003 to November 2004. Dep. Resources, Wildlife and Economic Development, Inuvik, NT. 54 pp.
- NatureServe. 2009. NatureServe explorer: an online encyclopedia of life [web application]. Version 7.1. Arlington, VA. <<http://www.natureserve.org/explorer>> [Accessed Aug. 23, 2010]
- Nellemann, C. and R.D. Cameron. 1998. Cumulative impacts of an evolving oil-field complex on the distribution of calving caribou. *Can. J. Zool.* 76:1425–1430.
- Neufeld, L.M. 2006. Spatial dynamics of wolves and Woodland Caribou in an industrial forest landscape in west-central Alberta. M.Sc. thesis. Univ. Alberta, Edmonton, AB.
- Oberg, P.R. 2001. Responses of Mountain Caribou to linear features in a west-central Alberta landscape. M.Sc. thesis. Univ. Alberta, Edmonton, AB.
- Oil and Gas Commission. 2003. Fish and wildlife timing windows for oil and gas exploration and development in northeast British Columbia. Fort St. John, BC. 3 pp.

- Racey, G.D. 2005. Climate change and Woodland Caribou in Northwestern Ontario: a risk analysis. *Rangifer*, Special Issue No. 16:123–136.
- Racey, G.D., K. Abraham, W.R. Darby, H.R. Timmermann, and Q. Day. 1991. Can Woodland Caribou and the forestry industry coexist: the Ontario scene. *Rangifer*, Spec. Issue No. 7:108–115.
- Rettie, W.J. and F. Messier. 1998. Dynamics of Woodland Caribou populations at the southern limit of their range in Saskatchewan. *Can. J. Zool.* 76:251–259.
- Rettie, W.J. and F. Messier. 2001. Range use and movement rates of Woodland Caribou in Saskatchewan. *Can. J. Zool.* 79:1933–1940.
- Rowe, M.R. 2006. Summary report: 2006 Maxhamish Range Boreal Caribou inventory, Kiwigana, Fortune, and Capot-Blanc areas. Project No. 2005-7B-2 (Wildlife Inventory Program: 2005–06) Peace Region: 7B. B.C. Min. Environ., Wildlife Branch, Fort St. John, BC. 8 pp.
- Rowe, M.R. 2007a. Boreal Caribou and Wolf management and habitat selection within the Chinchaga Range – 2004 to 2007. B.C. Min. Environ., Wildlife Branch, Fort St. John, BC. 28 pp.
- Rowe, M.R. 2007b. Boreal Caribou movement and habitat selection within the Maxhamish Range. B.C. Min. Environ., Wildlife Branch, Fort St. John, BC. 14 pp.
- Russell, D.E. and A.M. Martell. 1984. Winter range ecology of Caribou (*Rangifer tarandus*). In R. Olson, F. Geddes, and R. Hastings. 1984. Northern ecology and resource management. Univ. Alberta Press, Edmonton, AB. 438 pp.
- Schaefer, J.A. and W.O. Pruitt. 1991. Fire and Woodland Caribou in southeastern Manitoba. *Wildl. Monogr.* 116:1–39.
- Schaefer, J.A., A.M. Veitch, F.H. Harrington, W.K. Brown, J.B. Theberge, and S.N. Luttich. 1999. Demography of decline of the Red Wine Mountain Caribou herd. *J. Wildl. Manage.* 63(2):580–587.
- Seip, D.R. 1991. Predation and caribou populations. *Rangifer*, Special Issue No. 7:46–52.
- Seip, D.R. 1992. Factors limiting Woodland Caribou population and their interrelationships with wolves and moose in southeastern British Columbia. *Can. J. Zool.* 70:1494–1503.
- Seip, D.R. and D.B. Cichowski. 1996. Population ecology of Caribou in British Columbia. *Rangifer*, Special Issue No. 9:73–80.
- Shoesmith, M.W. and D.R. Storey. 1977. Movements and associated behaviour of Woodland Caribou in central Manitoba. *Proc. Int. Congr. Game Biol.* 13:51–64.
- Simpson, K., J.P. Kelsall, and M. Leung. 1994. Integrated management of Mountain Caribou and forestry in southern British Columbia. Report prepared for B.C. Min. Environ., Lands and Parks, Victoria, BC. 106 pp.
- Smith, K.G., E.J. Ficht, D. Hobson, T.C. Sorensen, and D. Hervieux. 2000. Winter distribution of Woodland Caribou in relation to clear-cut logging in west-central Alberta. *Can. J. Zool.* 78:1433–1440.
- Smith, W.T. and R.D. Cameron. 1985. Reactions of large groups of caribou to a pipeline corridor on the Arctic Coastal Plain of Alaska. *Arctic* 38(1):53–57.
- Sorenson, T., P.D. McLoughlin, D. Hervieux, E. Dzus, J. Nolan, B. Wynes, and S. Boutin. 2008. Determining sustainable levels of cumulative effects for Boreal Caribou. *J. Wildl. Manage.* 72:900–905.

- Spalding, D.J. 2000. The early history of Woodland Caribou (*Rangifer tarandus caribou*) in British Columbia. B.C. Min. Environ., Lands and Parks, Wildlife Branch, Victoria, BC. Wildl. Bull. No. B-100. 61 pp.
- Stardom, R. 1975. Woodland Caribou and snow conditions in southeast Manitoba. Pages 324–334 in J.R. Luick, P.C. Lent, D.R. Klein and R.G. White, eds. Proceedings of the First International Reindeer and Caribou Symposium 9–11 Aug. 1972, University of Alaska, Fairbanks, AK. Biological Papers of the University of Alaska, Special Rep. No. 1.
- Stocks, B.J., M.A. Fosberg, B.M. Wotton, T.J. Lynham, and K.C. Ryan. 2000. Climate change and forest fire activity in North American boreal forests. Pages 368–376 in E.S. Kasischke and B.J. Stocks, eds. Fire, climate change and carbon cycling in the boreal forest. Ecological Studies 138. Springer-Verlag, New York.
- Stuart-Smith, A.K., C. Bradshaw, S. Boutin, D. Hebert, and A.B. Rippin. 1997. Woodland Caribou relative to landscape patterns in northeastern Alberta. J. Wildl. Manage. 61(3):622–633.
- Thiessen, C. 2009. Peace Region Boreal Caribou monitoring: annual report 2008–09. B.C. Min. Environ., Fort St. John, BC. Peace Region Technical Report. 36 pp.
- Thiessen, C. 2010. Horn River Basin Moose inventory January/February 2010. B.C. Min. Environ., Wildlife Branch, Fort St. John, BC. 44 pp.
- Thomas, D.C. 1995. A review of wolf-caribou relationships and conservation implications in Canada. Pages 261–273 in L.N. Carbyn, S.H. Fritts, and D.R. Seip. 1995. Ecology and conservation of wolves in a changing world. Canadian Circumpolar Institute, Occasional Publication No. 35. 642 pp.
- Thomas, D.C. and D.R. Gray. 2002. Update COSEWIC status report on the Woodland Caribou *Rangifer tarandus caribou* in Canada. In COSEWIC assessment and update status report on the Woodland Caribou *Rangifer tarandus caribou* in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa, ON. 98 pp.
- Thomas, D.C., H.P.L. Kiliaan, and T.W.P. Trottier. 1998. Fire-caribou relationships: (III) Movement patterns of the Beverly herd in relation to burns and snow. Can. Wildl. Serv., Prairie and Northern Reg., Edmonton, AB. Tech. Rep. Series No. 311. 176 pp.
- Tollefson, J.E. 2007. *Betula glandulosa*. In Fire Effects Information System [online]. U.S. Dep. Agric. For. Serv., Rocky Mountain Res. Sta., Fire Sciences Laboratory. <http://www.fs.fed.us/database/feis/> [Accessed Mar. 15, 2010]
- Vistnes, I. and C. Nellemann. 2001. Avoidance of cabins, roads, and power lines by reindeer during calving. J. Wildl. Manage. 65(4):915–925.
- Vors, L.S. and M.S. Boyce. 2009. Global declines of caribou and reindeer. Global Change Biol. (2009) 15:2626–2633.
- Wittmer, H.U., B. McLellan, R. Serrouya, and C.D. Apps. 2007. Changes in landscape composition influence the decline of a threatened Woodland Caribou population. J. Anim. Ecol. 76:568–579.
- Young, D.D. and T.R. McCabe. 1997. Grizzly bear predation rates on caribou calves in northeastern Alaska. J. Wildl. Manage. 61(4):1056–1066.

Personal Communications

Rod Backmeyer, formerly of BC Ministry of Environment, Wildlife Branch, Fort St. John, BC; currently with BC Integrated Land Management Bureau, Fort St. John, BC.

Debbie Cichowski, Caribou Ecological Consulting, Smithers

Diane Culling, Diversified Environmental Services, Fort St. John

Dave Hervieux, Alberta Sustainable Resource Management, Fish and Wildlife Division, Grande Prairie, AB.

Deborah Johnson, formerly of Northwest Territories Department of Environment and Natural Resources, Fort Smith, NT.

Nic Larter, Northwest Territories Department of Environment and Natural Resources, Fort Simpson, NT.

Joelle Scheck, BC Ministry of Environment, Ecosystems Section, Fort St. John, BC.

Conrad Thiessen, Wildlife Biologist, BC Ministry of Environment, Wildlife Branch, Fort St. John, BC.

Bryan Webster, formerly of BC Ministry of Environment, Wildlife Branch, Fort St. John, BC.

Rob Woods, BC Ministry of Environment, Wildlife Branch, Fort St. John, BC.

Appendix 1. List of 2004 Boreal Caribou Technical Advisory Committee.

Ian Hatter (Chair), BC Ministry of Water, Land and Air Protection, Victoria
Rod Backmeyer, BC Ministry of Water, Land and Air Protection, Fort St. John
Doug Eady, BC Wildlife Federation, Charlie Lake
Kerry Harvey, Oil and Gas Commission, Fort St. John
Elizabeth Hunt/Winn Hays-Byl, BC Ministry of Forests, Dawson Creek
Warren Jukes, Canadian Forest Products Ltd., Chetwynd
Kevin Kuhn, Slocan Forest Products Ltd., Fort Nelson
Craig Langford/Roger Shaneman, Canadian Association of Oil Producers, Calgary, AB
Bob Purden, Oil and Gas Commission, Fort St. John
Don Russell, Canadian Wildlife Service, Edmonton, AB
Wayne Sawchuk, Chetwynd Environmental Society, Chetwynd
Dale Seip, BC Ministry of Forests, Prince George
Treaty 8 Tribal Association, Fort St. John
Mary Viszlai-Beale, BC Ministry of Forests, Fort Nelson
Bryan Webster, Guide Outfitters Association of B.C., Fort St John
Liz Williams, BC Ministry of Sustainable Resource Management, Victoria

Appendix 2. Summary of regional management objectives and strategies from the Fort Nelson and Fort St. John Land and Resource Management Plans appropriate for the protection of Boreal Caribou.

Table A2-1. Summary of regional management objectives and strategies appropriate for the protection of Boreal Caribou from the Fort Nelson and Fort St. John LRMPs.

Level	Fort Nelson LRMP	Fort St. John LRMP
Landscape level	<ul style="list-style-type: none"> manage natural seral stage distribution by landscape unit using knowledge of natural disturbance patterns identify critical ungulate winter habitats for consideration as Wildlife Habitat Areas. 	<ul style="list-style-type: none"> identify and map high capability caribou habitat consider identifying and designating critical caribou habitat areas on a priority basis as Wildlife Habitat Areas (WHAs).
Stand level	<ul style="list-style-type: none"> identify and map important habitat elements plan patch size, access, disturbance to emulate natural disturbance patterns using aggregate cutblocks and clustered harvest patterns, focus on patch sizes at the upper limits identified in the biodiversity guide for this Natural Disturbance Type stand level biodiversity to focus on riparian areas and wildlife tree patches. 	<ul style="list-style-type: none"> incorporate the maintenance of medium and high capability caribou habitat corridors into landscape level plans encourage the use of silvicultural systems that minimize negative impacts on moderate and high caribou habitat.
Movement corridors	<ul style="list-style-type: none"> design connectivity corridors between important habitat areas where ecologically appropriate (e.g., Wildlife Habitat Areas [WHAs], Forest Ecosystem Networks [FENs]). 	<ul style="list-style-type: none"> maintain connectivity (migration/travel) corridors between important seasonal habitats incorporate maintenance of caribou connectivity corridors into landscape level plans.
Access/ Recreation	<ul style="list-style-type: none"> use existing corridors and crossing where practical where significant access concerns exist, conduct an interagency access management planning process provide for new roads to be constructed for industrial, commercial, and recreational use accommodate expansion of existing and development of new transportation, utility corridors, and communication sites and airstrips through operation planning, develop specific prescriptions that recognize the unique recreational features of these areas and integrate recreational uses with the other values present. 	<ul style="list-style-type: none"> limit line of sight on linear access, such as seismic line cutting, in medium and high capability caribou habitat areas to minimize predation establish and maintain a permanent road infrastructure to facilitate long-term integrated resource management encourage shared access plan and develop new access routes to avoid direct disturbance within, or close to, high capability ungulate wintering habitats deactivate all new non-permanent access that is no longer required for resource management incorporate existing recreational activities and assess potential for the development of new recreational opportunities in more detailed plans (additional motorized recreational pursuits, etc.).
Protected Areas	<ul style="list-style-type: none"> Klua Lakes Protected Area, Maxhamish Lake Park and Protected Area, Thinahtea Protected Area, Hay River Protected Area. 	<ul style="list-style-type: none"> Milligan Hills, Chinchaga Lakes Protected Area,^a Ekwan Lake Protected Area, Sikanni-Old Growth.

^a Grandfathered oil and gas tenures cover over 80% of Chinchaga Lakes Protected Area.