

Recovery Strategy for the Woodland Caribou (*Rangifer tarandus caribou*), Boreal population, in Canada

Woodland Caribou, Boreal population



2012

Recommended citation:

Environment Canada. 2012. Recovery Strategy for the Woodland Caribou (*Rangifer tarandus caribou*), Boreal population, in Canada. *Species at Risk Act Recovery Strategy Series*. Environment Canada, Ottawa. xi + 138pp.

For copies of the recovery strategy, or for additional information on species at risk, including the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) Status Reports, residence descriptions, action plans, and other related recovery documents, please visit the Species at Risk Public Registry (www.sararegistry.gc.ca).

Cover photo: © John A. Nagy

Également disponible en français sous le titre
«Programme de rétablissement du caribou des bois (*Rangifer tarandus caribou*), population boréale, au Canada»

© Her Majesty the Queen in Right of Canada, represented by the Minister of the Environment, 2012. All rights reserved.

ISBN: 978-1-100-20769-8

Catalogue no. En3-4/140-2012E-PDF

Content (excluding the cover photo and the illustration on page 87) may be used without permission, with appropriate credit to the source.

Note: The Woodland Caribou, Boreal population is referred to as “boreal caribou” in this document.

PREFACE

The federal, provincial, and territorial government signatories under the *Accord for the Protection of Species at Risk* agreed to establish complementary legislation and programs that provide for effective protection of species at risk throughout Canada. Under the *Species at Risk Act* (SARA), the federal competent ministers are responsible for the preparation of recovery strategies for listed extirpated, endangered, and threatened species and are required to report on progress every five years. The Minister of the Environment is the competent minister for this recovery strategy.

Environment Canada's Canadian Wildlife Service led the development of this recovery strategy. Seven provinces, two territories, one Aboriginal government, four wildlife management boards and the Parks Canada Agency contributed information for this recovery strategy. Additional effort was made by Environment Canada to engage Aboriginal communities that the minister considered directly affected by the recovery strategy. These efforts included two rounds of engagement, one before and the second one after the proposed recovery strategy was posted on the Species at Risk Public Registry, to gather information on boreal caribou and to provide communities with an opportunity to comment on the proposed recovery strategy. In the first round, 271 Aboriginal communities were contacted and 161 engaged, and in the second round, 265 Aboriginal communities were contacted and 87 engaged. In addition, 25 formal submissions were received from Aboriginal communities and organizations.

Following the posting of the proposed recovery strategy on August 26, 2011, the standard 60-day public comment period was extended by 120 days to February 22, 2012 as a result of Environment Canada's desire to consult Aboriginal communities prior to finalizing the recovery strategy. The high level of interest in boreal caribou resulted in the submission of 19,046 comments during and subsequent to the public comment period. The majority of these were received as copies of form letters initiated by environmental group's campaigns. A total of 192 more detailed and/or technical submissions were received from governments, wildlife management boards, Aboriginal communities and organizations, industry stakeholders, environmental organizations and academia.

Landscape level planning will be essential for the recovery of boreal caribou. Provinces and territories have the primary responsibility for management of lands, natural resources and wildlife within boreal caribou ranges, however this responsibility does vary in some parts of the country. In the Northwest Territories, for example, Aboriginal Affairs and Northern Development Canada has the primary role in land and natural resources management, as the manager of federal Crown lands. Success in the recovery of this species depends on the commitment, collaboration and cooperation of many different constituencies that will be involved in implementing the broad strategies and general approaches set out in this recovery strategy and will not be achieved by Environment Canada, or any other jurisdiction, alone. All Canadians are invited to come together to support and implement this strategy for the benefit of boreal caribou and Canadian society as a whole.

This recovery strategy will be followed by range plans and action plans that will provide information on measures that will be taken by provinces and territories, Environment Canada, other federal departments, wildlife management boards, Aboriginal communities, stakeholders,

and other organizations, to achieve the survival and recovery of boreal caribou. Implementation of this strategy is subject to appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations.

ACKNOWLEDGEMENTS

Environment Canada would like to express its gratitude to the Aboriginal people who shared their knowledge about boreal caribou in support of the recovery of this species. Knowledge was shared by Aboriginal Traditional Knowledge holders and Aboriginal communities on boreal caribou life history, habitat use, population status, threats facing the species and conservation measures, and this information has been used in the development of this recovery strategy (see Appendices B and C). Aboriginal people consistently indicated that conservation of boreal caribou is essential, as this species is integral to the culture, identity and survival of their communities. The Aboriginal Traditional Knowledge that was shared may also be used to support the development of range plans and/or action plans for boreal caribou, where consent for such use is granted. Environment Canada appreciates that so many Aboriginal people were willing to share their knowledge and experiences to help in the recovery of this species.

Gratitude is also extended to federal, provincial and territorial jurisdictions, the Tłıchǫ government, and wildlife management boards with management responsibility for boreal caribou, for generously sharing information and providing expertise to develop this recovery strategy. The Boreal Caribou Working Group, comprised of Environment Canada staff from across Canada, contributed extensively by working with Canadians to gather information and support processes to collect Aboriginal Traditional Knowledge used to inform the development of this recovery strategy, and by compiling material and drafting the recovery strategy. Appreciation is extended to Environment Canada's Wildlife and Landscape Science Directorate, the boreal caribou Science Management Committee and boreal caribou science advisors, for their extensive efforts and contribution to the recovery strategy through the provision of the 2008 "Scientific Review for the Identification of Critical Habitat for Woodland Caribou (*Rangifer tarandus caribou*), Boreal Population, in Canada", and the "Scientific Assessment to Inform the Identification of Critical Habitat for Woodland Caribou (*Rangifer tarandus caribou*), Boreal Population, in Canada, 2011 Update". Acknowledgement and thanks are given to all other parties that provided advice and input used in the development of this recovery strategy, including the Species at Risk Advisory Committee (SARAC), various Aboriginal organizations, industry stakeholders, non-government organizations and academia.

EXECUTIVE SUMMARY

This recovery strategy is for the Woodland Caribou (*Rangifer tarandus caribou*), Boreal population herein referred to as “boreal caribou”, assessed in May 2002 as threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Boreal caribou are distributed across Canada, occurring in seven provinces and two territories and extending from the northeast corner of Yukon east to Labrador and south to Lake Superior.

Boreal caribou are distributed broadly throughout the boreal forest. They require large areas comprised of continuous tracts of undisturbed habitat rich in mature to old-growth coniferous forest, lichens, muskegs, peat lands, and upland or hilly areas. Large areas with suitable quality habitat allow boreal caribou to disperse across the landscape when conditions are unfavorable (e.g. natural fire disturbance, anthropogenic disturbance) and to maintain low population densities to reduce their risk of predation.

The geographic area occupied by a group of boreal caribou that are subject to similar factors affecting their demography and used to satisfy their life history processes (e.g. calving, rutting, wintering) over a defined time frame is referred to as a range. There are 51 boreal caribou ranges in Canada. Information available to delineate boreal caribou ranges varies in certainty and therefore ranges are categorized into three types: conservation units, improved conservation units and local population units. In this recovery strategy, the group of boreal caribou occupying any of the three types of ranges is referred to as a “local population” of boreal caribou.

Due to the specific life history characteristics they possess, boreal caribou are limited in their potential to recover from rapid, severe population declines. Habitat alteration (i.e. habitat loss, degradation, and fragmentation) from both anthropogenic and natural sources, and increased predation as a result of habitat alteration have led to local population declines throughout their distribution. Some local populations of boreal caribou are at risk because of other factors, mainly over-harvest. Threats are closely interrelated and act cumulatively to have direct or indirect impacts on boreal caribou and their habitat. Recovery of all boreal caribou local populations across Canada is technically and biologically feasible.

The recovery goal for boreal caribou is to achieve self-sustaining local populations in all boreal caribou ranges throughout their current distribution in Canada, to the extent possible. Achieving the recovery goal would allow for local population levels sufficient to sustain traditional Aboriginal harvesting activities, consistent with existing Aboriginal and treaty rights of Aboriginal peoples of Canada. Ranges that are highly disturbed will take decades to recover from habitat alteration, as boreal caribou occur in mature boreal forest ecosystems that have evolved over centuries. Achieving this recovery goal for all local populations will take a number of decades.

To guide recovery efforts, the population and distribution objectives for boreal caribou across their distribution in Canada are, to the extent possible, to:

- Maintain the current status of the 14 existing self-sustaining local populations; and,
- Stabilize and achieve self-sustaining status for the 37 not self-sustaining local populations.

Performance indicators are identified as a means by which progress towards achieving the population and distribution objectives can be measured.

The critical habitat necessary to achieve the population and distribution objectives for the recovery and survival of boreal caribou is partially identified in this strategy. Critical habitat for boreal caribou is identified as: i) the area within the boundary of each boreal caribou range that provides an overall ecological condition that will allow for an ongoing recruitment and retirement cycle of habitat, which maintains a perpetual state of a minimum of 65% of the area as undisturbed habitat; and ii) biophysical attributes required by boreal caribou to carry out life processes.

Critical habitat for boreal caribou is identified for all boreal caribou ranges, except for northern Saskatchewan's Boreal Shield range (SK1), as additional information described in the schedule of studies is required.

This recovery strategy identifies 65% undisturbed habitat in a range as the disturbance management threshold, which provides a measurable probability (60%) for a local population to be self-sustaining. This threshold is considered a minimum threshold because at 65% undisturbed habitat there remains a significant risk (40%) that local populations will not be self-sustaining.

The recovery of boreal caribou requires actions that will vary according to both the habitat and population conditions within each boreal caribou range. This recovery strategy provides broad strategies and general approaches to achieve the population and distribution objectives, which will assist in the development of subsequent range plans and action plans. The suite of actions needed to maintain or recover the self-sustaining status of a boreal caribou local population will be determined and managed by the responsible jurisdictions in collaboration with Environment Canada, and consistent with this recovery strategy. The recovery actions most appropriate for a specific range will be governed by local opportunities and constraints, and the level of urgency for a given recovery action will be determined by both the population and habitat conditions within the range.

To guide the protection of critical habitat and the recovery of boreal caribou, range plans and/or action plans will be prepared following this recovery strategy. These plans will provide detailed information on recovery measures that will be implemented by provinces and territories, Environment Canada, other federal departments, wildlife management boards, Aboriginal communities, stakeholders, and other organizations involved in the conservation, survival and recovery of boreal caribou. Success in recovering boreal caribou will depend on the commitment, collaboration and cooperation among all interested parties.

RECOVERY FEASIBILITY SUMMARY

Recovery of boreal caribou is considered to be both technically and biologically feasible across the species' distribution in Canada based on the following four criteria outlined in the draft SARA Policies (Government of Canada, 2009).

Current evidence supports the conclusion that the recovery of all local populations is biologically and technically feasible. However, small local populations, and particularly those isolated from the core distribution of the national boreal caribou population, are at greater risk of not becoming self-sustaining. In these situations, a local population may have greater difficulty withstanding stochastic events, and may not experience enough immigration to maintain genetic diversity and therefore will be at greater risk of not persisting in the long-term. There may be other situations where recovery of a particular local population proves to be, over time and through unforeseen circumstances, not biologically or technically feasible and, as such, may affect the likelihood of achieving the population and distribution objectives.

1. Individuals of the wildlife species that are capable of reproduction are available now or in the foreseeable future to sustain the population or improve its abundance.

Yes. According to current best estimates, there are approximately 34,000 (see Section 3.2.2) boreal caribou across nine provinces and territories in Canada capable of successful reproduction and available to improve local population growth rates and abundance to achieve self-sustainability (Environment Canada, 2011b).

2. Sufficient suitable habitat is available to support the species or could be made available through habitat management or restoration.

Yes. Some boreal caribou local populations have sufficient suitable habitat within their ranges. For other boreal caribou local populations where sufficient suitable habitat is currently unavailable to support local populations at a self-sustaining level, sufficient habitat could be made available through habitat management or restoration.

3. The primary threats to the species or its habitat (including threats outside Canada) can be avoided or mitigated.

Yes. The primary threat to most boreal caribou local populations is unnaturally high predation rates as a result of human-caused and natural habitat loss, degradation, and fragmentation. These habitat alterations support conditions that favour higher alternate prey densities (e.g. moose (*Alces alces*), deer (*Odocoileus* spp.)), resulting in increased predator populations (e.g. wolf (*Canis lupus*), bear (*Ursus* spp.)) that in turn increase the risk of predation to boreal caribou. This threat can be mitigated through coordinated land and/or resource planning, and habitat restoration and management, in conjunction with predator and alternate prey management where local population conditions warrant such action. In some ranges, over-exploitation through hunting can also be an issue. This threat can be avoided or mitigated through regulations and stewardship.

4. Recovery techniques exist to achieve the population and distribution objectives or can be expected to be developed within a reasonable timeframe.

Yes. Recovery techniques (e.g. protection and management of boreal forest habitat, habitat restoration, predator and alternate prey management, hunting regulations, stewardship initiatives)

are available to achieve the population and distribution objectives for boreal caribou, although there is uncertainty with regard to the effectiveness of some of these techniques, as they have not yet undergone a sufficiently long trial period.

TABLE OF CONTENTS

PREFACE	III
ACKNOWLEDGEMENTS	V
EXECUTIVE SUMMARY	VI
RECOVERY FEASIBILITY SUMMARY	VIII
TABLE OF CONTENTS.....	X
1 COSEWIC SPECIES ASSESSMENT INFORMATION	1
2 SPECIES STATUS INFORMATION.....	1
3 SPECIES INFORMATION.....	2
3.1 SPECIES DESCRIPTION.....	2
3.2 POPULATION AND DISTRIBUTION	2
3.2.1 Boreal Caribou Ranges.....	4
3.2.2 Local Populations.....	9
3.3 NEEDS OF THE BOREAL CARIBOU	9
3.3.1 Habitat and Biological Needs.....	9
3.3.2 Connectivity	10
3.3.3 Limiting Factors.....	10
4 THREATS	12
4.1 THREAT ASSESSMENT	12
4.2 DESCRIPTION OF THREATS.....	13
4.2.1 Habitat Alteration (Disturbance)	13
4.2.2 Natural Processes	15
4.2.3 Biological Resource Use	16
4.2.4 Climate and Natural Disasters	17
4.2.5 Other Threats.....	17
5 POPULATION AND DISTRIBUTION OBJECTIVES	18
5.1 RECOVERY OF BOREAL CARIBOU	18
5.1.1 Varying Ecological Conditions.....	18
5.1.2 Connectivity Between and Within Boreal Caribou Ranges	19
5.2 OBJECTIVES	19
5.2.1 Recovery Goal	19
5.2.2 Population and Distribution Objectives	20
5.3 TIMELINES TO RECOVERY	20
5.4 PRIORITIZING RECOVERY ACTIONS AND MANAGING RISK	22
5.5 ACHIEVING RECOVERY FOR SELF-SUSTAINING LOCAL POPULATIONS	22
5.6 ACHIEVING RECOVERY FOR NOT SELF-SUSTAINING LOCAL POPULATIONS	22
6 BROAD STRATEGIES AND GENERAL APPROACHES TO MEET OBJECTIVES.....	24
6.1 ACTIONS ALREADY COMPLETED OR CURRENTLY UNDERWAY	24
6.2 STRATEGIC DIRECTION FOR RECOVERY	26
6.3 NARRATIVE TO SUPPORT THE RECOVERY PLANNING TABLE	28
6.3.1 Landscape Level Planning	28
6.3.2 Habitat Management	29
6.3.3 Mortality and Population Management.....	30
6.3.4 Population Monitoring.....	30

7	CRITICAL HABITAT.....	32
7.1	IDENTIFICATION OF CRITICAL HABITAT FOR BOREAL CARIBOU.....	32
7.1.1	<i>Components of Critical Habitat.....</i>	34
7.2	SCHEDULE OF STUDIES.....	35
7.3	ACTIVITIES LIKELY TO RESULT IN THE DESTRUCTION OF CRITICAL HABITAT.....	36
7.4	RANGE PLANS.....	38
8	MEASURING PROGRESS.....	41
8.1	ADAPTIVE MANAGEMENT.....	41
8.2	PERFORMANCE INDICATORS.....	41
9	STATEMENT ON ACTION PLANS.....	43
9.1	COORDINATED APPROACH.....	43
9.1.1	<i>Provincial and Territorial Jurisdictional Leadership.....</i>	43
9.1.2	<i>Aboriginal Involvement.....</i>	44
9.1.3	<i>Stakeholder Engagement.....</i>	44
9.2	RANGE SPECIFIC ACTIONS.....	44
9.2.1	<i>Habitat and Population Management.....</i>	44
10	GLOSSARY.....	46
11	REFERENCES.....	48
	APPENDIX A: EFFECTS ON THE ENVIRONMENT AND OTHER SPECIES.....	57
	APPENDIX B: ENGAGEMENT WITH ABORIGINAL PEOPLE IN THE DEVELOPMENT OF THE RECOVERY STRATEGY FOR BOREAL CARIBOU.....	58
	APPENDIX C: ABORIGINAL TRADITIONAL KNOWLEDGE SUMMARY REPORTS ON BOREAL CARIBOU.....	60
	APPENDIX D: SCIENTIFIC ASSESSMENTS OF CRITICAL HABITAT FOR BOREAL CARIBOU.....	61
	APPENDIX E: IDENTIFYING DISTURBANCE MANAGEMENT THRESHOLDS.....	64
	APPENDIX F: SUMMARY OF BOREAL CARIBOU LOCAL POPULATION CONDITION AND HABITAT CONDITION.....	67
	APPENDIX G: DETAILS ON THE IDENTIFICATION OF CRITICAL HABITAT FOR BOREAL CARIBOU.....	72
	APPENDIX H: BIOPHYSICAL ATTRIBUTES FOR BOREAL CARIBOU CRITICAL HABITAT.....	76
	APPENDIX I: MITIGATION TECHNIQUES TO AVOID DESTRUCTION OF CRITICAL HABITAT.....	86
	APPENDIX J: CRITICAL HABITAT FACTSHEETS.....	87
	CRITICAL HABITAT FACTSHEETS: NORTHWEST TERRITORIES.....	88
	CRITICAL HABITAT FACTSHEETS: BRITISH COLUMBIA.....	89
	CRITICAL HABITAT FACTSHEETS: ALBERTA.....	94
	CRITICAL HABITAT FACTSHEETS: SASKATCHEWAN.....	106
	CRITICAL HABITAT FACTSHEETS: MANITOBA.....	108
	CRITICAL HABITAT FACTSHEETS: ONTARIO.....	121
	CRITICAL HABITAT FACTSHEETS: QUEBEC.....	130
	CRITICAL HABITAT FACTSHEETS: NEWFOUNDLAND AND LABRADOR.....	136

1 COSEWIC SPECIES ASSESSMENT INFORMATION¹

Date of Assessment: May 2002

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

Scientific Name: *Rangifer tarandus caribou*

COSEWIC Status: Threatened

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: Northwest Territories (extending into Yukon), British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, Newfoundland and Labrador.

COSEWIC Status History: The Boreal population was designated threatened in May 2000. Status re-examined and confirmed in May 2002.

2 SPECIES STATUS INFORMATION

This recovery strategy is for the Woodland Caribou (*Rangifer tarandus caribou*), Boreal population, herein referred to as “boreal caribou”. Boreal caribou are listed as threatened under Canada’s *Species at Risk Act* (SARA), based on an observed, estimated, inferred or suspected reduction in population size of > 30% over three caribou generations (approximately 20 years). Boreal caribou have been provincially/territorially ranked in some jurisdictions (see Table 1). Boreal caribou have not been ranked globally by NatureServe.

Table 1. Canadian status and provincial/territorial designations for boreal caribou.

Canadian Status	Provincial/Territorial Designation
SARA – Schedule 1 (Threatened)	NT – Not Listed YT – Not Listed BC – Red Listed (Threatened – Endangered) AB – Threatened SK – Not Listed MB – Threatened ON – Threatened QC – Vulnerable (Special Concern – Threatened) NL – Threatened

¹ At the November 2011 Wildlife Species Assessment Meeting, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) voted to adopt 12 designatable units (DUs) for Caribou (*Rangifer tarandus*) in Canada. The report *Designatable Units for Caribou (Rangifer tarandus) in Canada* is available by contacting the COSEWIC Secretariat (cosewic/cosepac@ec.gc.ca). COSEWIC will begin the process of assessing all DUs in 2012.

3 SPECIES INFORMATION

There are four existing subspecies of caribou in Canada including the Peary Caribou (*Rangifer tarandus pearyi*), Barren-ground Caribou (*R. t. groenlandicus*), Grant's Caribou (*R. t. granti*), and Woodland Caribou (*R. t. caribou*) (Banfield, 1974). A fifth subspecies, the Dawson's Caribou (*R. t. dawsoni*), which occurred in Haida Gwaii (i.e. Queen Charlotte Islands, BC) is extinct. Each subspecies displays differences in morphology, behaviour, and areas of geographic occurrence. Based on the classification system used by COSEWIC in its 2002 assessment, there are six geographically distinct populations of the forest-dwelling Woodland Caribou: Northern Mountain population (special concern), Southern Mountain population (threatened), Boreal population (threatened), Forest-tundra population (not assessed), Atlantic-Gaspésie population (endangered), and the insular Newfoundland population (not at risk).

Boreal caribou are endemic to Canada, and are distributed across nine provinces and territories, including British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, Newfoundland and Labrador, Northwest Territories, and Yukon (see Figure 1).

3.1 Species Description

Like all Woodland Caribou, boreal caribou are a medium-sized (1.0-1.2 m shoulder height and weighing 110-210 kg) member of the deer family (*Cervidae*) (Thomas and Gray, 2002). Adults have a dark brown coat with a creamy white neck, mane, shoulder stripe, underbelly, underside of the tail, and patch above each hoof (Banfield, 1974; Boreal Caribou ATK Reports, 2010-2011). A distinctive characteristic of all caribou is large crescent-shaped hooves that provide flotation in snow and soft ground (e.g. peat lands), and assist in digging through snow to forage on lichens and other ground vegetation (Thomas and Gray, 2002). Antlers of boreal caribou are flattened, compact, and relatively dense. As a unique feature among the deer family, both male and female boreal caribou have antlers during part of the year, although some females may have only one antler or no antlers at all (Thomas and Gray, 2002; Boreal Caribou ATK Reports, 2010-2011). In comparison to Barren-ground Caribou, boreal caribou antlers are thicker and broader, and their legs and heads are longer.

3.2 Population and Distribution

Boreal caribou are forest-dwelling, sedentary caribou that occur only in Canada and are distributed broadly across the boreal forest (Thomas and Gray, 2002; Festa-Bianchet, 2011). The Canadian distribution of boreal caribou stretches from the northeast corner of Yukon east to Labrador, and extends as far south as Lake Superior (see Figure 1) (Environment Canada, 2008; Environment Canada, 2011b). Across Canada, the southern limit of boreal caribou distribution has progressively receded northward since the early 1900s (see Figure 1), a trend that continues today (Thomas and Gray, 2002; Schaefer, 2003; Festa-Bianchet et al., 2011). Aboriginal Traditional Knowledge indicates that boreal caribou have moved northward as a result of habitat loss in the south (Boreal Caribou ATK Reports, 2010-2011).



Figure 1. Distribution (i.e. extent of occurrence) of boreal caribou in Canada. The current distribution of boreal caribou is shown in brown. The estimated southern extent of historical Woodland Caribou distribution is indicated by the dashed line.

3.2.1 Boreal Caribou Ranges

The geographic area occupied by a group of boreal caribou that are subject to similar factors affecting their demography and used to satisfy their life history processes (e.g. calving, rutting, wintering) over a defined time frame is referred to as a range (Environment Canada, 2011b). Boreal caribou are distributed across 51 ranges (see Figure 2 and Table 2) based on the best available information provided by the provincial and territorial jurisdictions, including observational and telemetry data, and biophysical analyses (Environment Canada, 2011b).

In this recovery strategy, “local population” refers to a group of boreal caribou occupying any of the three types of boreal caribou ranges (conservation unit, improved conservation unit, local population unit).

Environment Canada (2011b) identified three types of boreal caribou ranges, categorized based on the degree of certainty in the delineated boundaries. Eight ranges have been identified as “conservation units” (low certainty), 20 ranges as “improved conservation units” (medium certainty), and 23 ranges as “local population units” (high certainty) (see Appendix F). It is anticipated there will be changes to conservation units

and improved conservation units as more information becomes available. In this recovery strategy, “local population” refers to a group of boreal caribou occupying any of the three types of boreal caribou ranges (conservation unit, improved conservation unit, local population unit).

As a result of limited information on many of the ranges in Canada, only three transboundary ranges (a range that extends across a provincial or territorial boundary) have been defined: Northwest Territories range (NT1), Chinchaga range (AB1), and Lac Joseph range (NL1). As new and more refined information is continually being collected by jurisdictions, range delineation and population demographic information will be updated and may result in revisions to range boundaries and possibly more transboundary ranges.

Ranges can and do vary greatly in size; some cover very large areas (e.g. Northwest Territories range (NT1): 44,166,546 ha), whereas others are much smaller (e.g. Charlevoix range (QC2): 312,803 ha). Whether a range can support a self-sustaining local population is a function of both the amount and quality of habitat available for boreal caribou.

Of the 51 boreal caribou local populations, 14 are “self-sustaining”, 26 are “not self-sustaining”, 10 are “as likely as not self-sustaining”, and one is “unknown”, based on Environment Canada’s (2011b) methodology and updated data from provincial and territorial jurisdictions (see Figure 3 and Appendix F). In the population and distribution objectives, “not self-sustaining” local populations refers to both the local populations assessed as “as likely as not self-sustaining” and those assessed as “not self-sustaining”. The high fire in combination with very low anthropogenic disturbance estimates for northern Saskatchewan’s Boreal Shield range (SK1) represent a unique situation that falls outside the range of variability observed in the data that informed the disturbance model used by Environment Canada (2011b) as a component of the integrated risk assessment framework. The probability of self-sustainability is reported as “unknown” due to the uniqueness of the disturbance regime and the uncertainty about the status of the population. Nevertheless, the high fire (55%) observed for northern Saskatchewan’s Boreal Shield range (SK1) warrants caution with respect to additional anthropogenic disturbance. See detailed explanation in Appendix F.

The assessment of the likelihood of self-sustainability may change when ranges that cross jurisdictional boundaries are combined. Range boundaries and integrated risk assessments will be updated annually based on new or more refined evidence provided by the provincial and territorial jurisdictions.

In some cases, there are discrepancies between the range boundaries as presented in Figure 2, which were based on information provided by provincial and territorial jurisdictions, and the information that was provided by Aboriginal Traditional Knowledge holders. These will be addressed in range plans and/or action plans (see Sections 7.4 and 9) where provinces and territories, Aboriginal communities, and other people with knowledge of a particular boreal caribou range can work together to ensure range boundaries are based on the best available information.

Boreal caribou use of a range may change over time as a result of variation in ecological conditions (e.g. vegetation change as a result of natural disturbances, predator/prey dynamics) and patterns of human disturbance (e.g. industrial development) affecting the landscape. Variation in habitat conditions, resource availability, and the amount and arrangement of disturbance on the landscape, influences patterns of boreal caribou range use that result in either: a) a discrete range, where boreal caribou occupy a clearly defined area with little exchange with other ranges (e.g. Coastal range (ON6), Charlevoix range (QC2)); or b) a continuous range where boreal caribou are dispersed over a large area and may move more freely and over greater distances within the area characterized by common biophysical attributes (e.g. Northwest Territories range (NT1)).

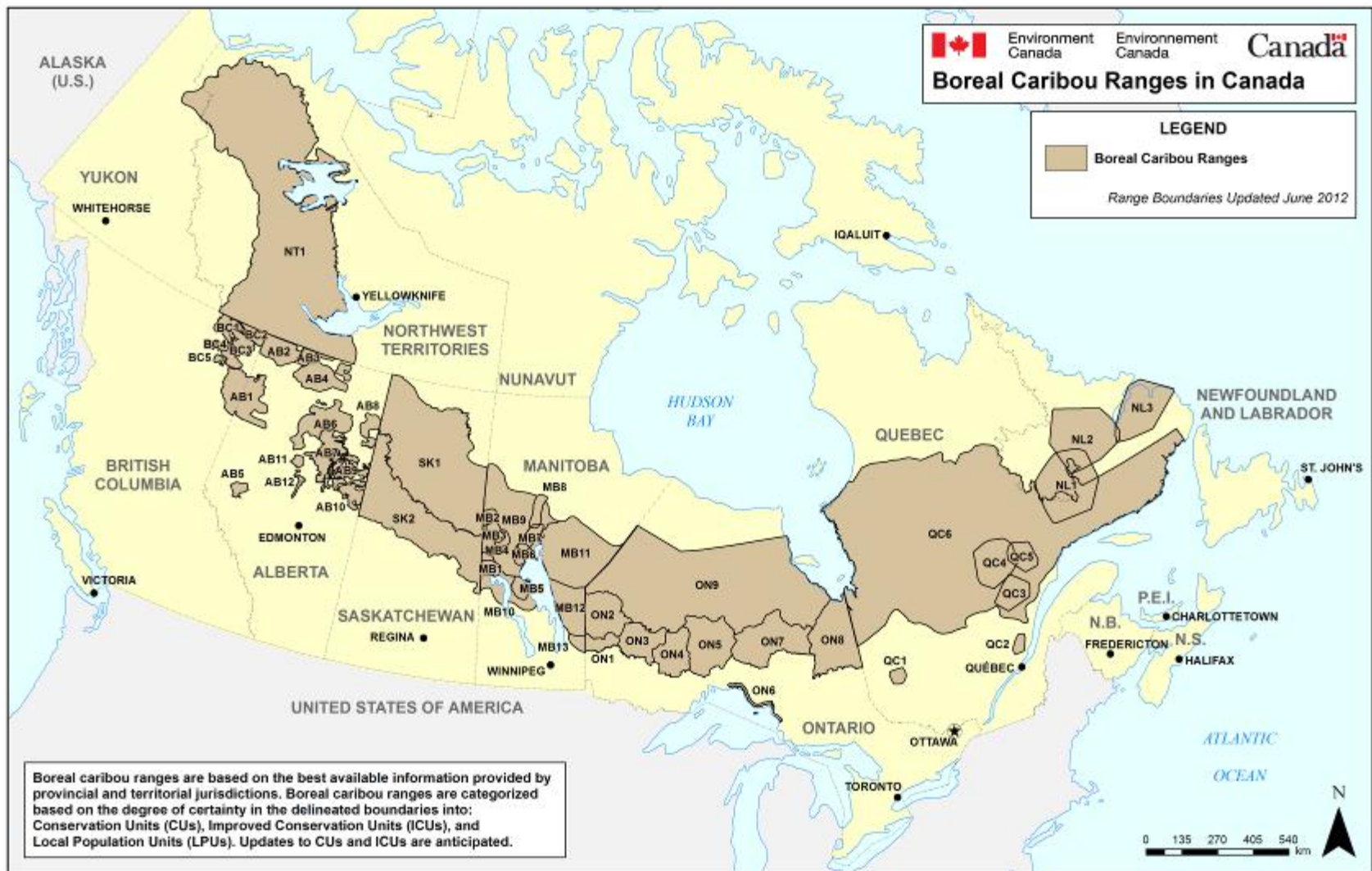


Figure 2. Geographic distribution of the 51 known ranges of boreal caribou in Canada.

Table 2. Range identification and range names for the 51 known ranges of boreal caribou in Canada.

Range ID	Range Name
NT1	Northwest Territories
BC1	Maxhamish
BC2	Calendar
BC3	Snake-Sahtahneh
BC4	Parker
BC5	Prophet
AB1	Chinchaga (incl. BC portion)
AB2	Bistcho
AB3	Yates
AB4	Caribou Mountains
AB5	Little Smoky
AB6	Red Earth
AB7	West Side Athabasca River
AB8	Richardson
AB9	East Side Athabasca River
AB10	Cold Lake
AB11	Nipisi

Range ID	Range Name
AB12	Slave Lake
SK1	Boreal Shield
SK2	Boreal Plain
MB1	The Bog
MB2	Kississing
MB3	Naosap
MB4	Reed
MB5	North Interlake
MB6	William Lake
MB7	Wabowden
MB8	Wapisu
MB9	Manitoba North
MB10	Manitoba South
MB11	Manitoba East
MB12	Atikaki-Berens
MB13	Owl-Flinstone
ON1	Sydney

Range ID	Range Name
ON2	Berens
ON3	Churchill
ON4	Brightsand
ON5	Nipigon
ON6	Coastal
ON7	Pagwachuan
ON8	Kesagami
ON9	Far North
QC1	Val d'Or
QC2	Charlevoix
QC3	Pipmuacan
QC4	Manouane
QC5	Manicouagan
QC6	Quebec
NL1	Lac Joseph
NL2	Red Wine Mountain
NL3	Mealy Mountain

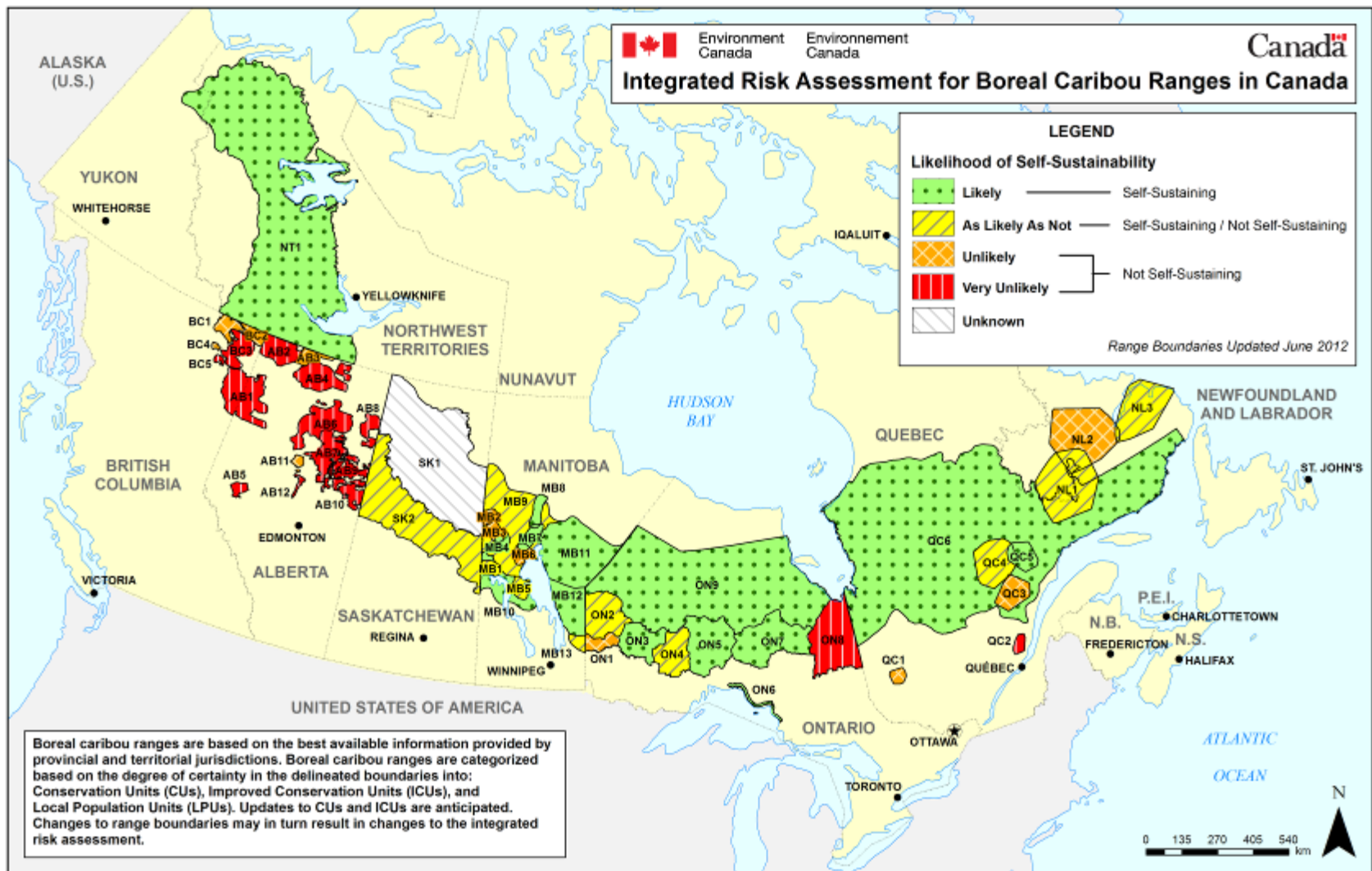


Figure 3. Integrated risk assessment for boreal caribou ranges in Canada, reflecting the capacity of each range to maintain a self-sustaining local population of boreal caribou.

3.2.2 Local Populations

Precise enumeration of the size of a boreal caribou local population is a challenge due to the large areas that boreal caribou occupy (often over thousands of square kilometres), the low densities at which they occur (making survey from aircraft challenging), and their relatively solitary habits (Environment Canada, 2008; Callaghan et al., 2010). Across Canada, densities average two to three animals per 100 km², but densities vary regionally and can be higher in areas with high quality habitat (Environment Canada, 2011b). The literature also reports that more than 300 boreal caribou are needed for self-sustaining local populations, thereby requiring ranges of at least 10,000 to 15,000 km² in size subject to type and quality of habitat (Environment Canada, 2011b).

Within ranges, boreal caribou are often found in small groups of fewer than 15 individuals. This will vary seasonally in accordance with life processes (e.g. calving, rutting, wintering) and based on local conditions within the range (Boreal Caribou ATK Reports, 2010-11). Boreal caribou typically form relatively mixed-sex groups; however, during calving periods females are generally solitary (Boreal Caribou ATK Reports, 2010-2011; Nagy et al., 2011).

Based on the best available information, the current overall number of boreal caribou in Canada is estimated to be approximately 34,000 individuals (Environment Canada, 2011b). This number is based on mean local population size estimates as provided by the provincial and territorial jurisdictions. Appendix F outlines the current population size and trend information for each of the 51 ranges, as provided by provincial and territorial jurisdictions (Environment Canada, 2011b).

3.3 Needs of the Boreal Caribou

3.3.1 Habitat and Biological Needs

Boreal caribou require large range areas comprised of continuous tracts of undisturbed habitat. In general, boreal caribou prefer habitat consisting of mature to old-growth coniferous forest (e.g. jack pine (*Pinus banksiana*), black spruce (*Picea mariana*)) with abundant lichens, or muskegs and peat lands intermixed with upland or hilly areas (Stuart-Smith et al., 1997; Rettie and Messier, 2000; Courtois, 2003; Brown et al., 2007; Boreal Caribou ATK Reports, 2010-2011). Large range areas reduce the risk of predation by allowing boreal caribou to maintain low population densities throughout the range and by allowing them to avoid areas of high predation risk, such as areas with high densities of alternate prey species (e.g. moose and deer) and predators (e.g. wolf and bear) (Rettie and Messier, 2001; Brown et al., 2003; Whittington et al., 2011) (see Section 4.2). Boreal caribou use a variety of habitats to avoid predators, including muskegs and bodies of water, as well as mature and old-growth forests (Boreal Caribou ATK Reports, 2010-2011).

Boreal caribou select habitat that provides food, particularly terrestrial and arboreal lichens, during late winter and early spring, and avoid early stage, successional forests and recently disturbed areas (Schaefer and Pruitt, 1991; Stuart-Smith et al., 1997; Rettie and Messier, 2000; Dunford et al., 2006; Boreal Caribou ATK Reports, 2010-2011), which have poor feeding options, impede movement, and attract other ungulates (Whitefeather Forest, 2006). In order to

access forage during winters with deep or crusted snow, boreal caribou require habitat that has arboreal lichens and shallower snow (such as mature coniferous stands with closed canopies and upland or hilly areas exposed to wind), where it is easier to dig for ground lichens (Vandal and Barrette, 1985; Thomas and Armbruster, 1996; Courbin et al., 2009; Boreal Caribou ATK Reports, 2010-2011; Moreau et al., 2012).

Boreal caribou have specific habitat requirements during calving and post-calving periods. To calve, pregnant cows travel to isolated, relatively predator-free areas where nutritious forage is available, such as islands in lakes, peat lands or muskegs, lakeshores and forests (Boreal Caribou ATK Reports, 2010-2011). Unavailable, inadequate or degraded habitat affects the reproductive success of females as well as the survival of calves, and can result in population decline (Thomas and Gray, 2002; McCarthy et al., 2011; Pinard et al., 2012).

Boreal caribou shift their use of habitat and their distribution within the range in response to various natural processes (e.g. forest fire, food availability, weather conditions) and human activities (e.g. development, logging, recreation) (Boreal Caribou ATK Reports, 2010-2011; Environment Canada, 2011b). For example, any mature and old-growth forest stands lost to fire or tree removal practices will result in the degradation of suitable habitat in the short-term. In response to such changing environmental conditions, boreal caribou will shift within their range. Over time, a disturbed area may recover and become suitable for use by boreal caribou.

3.3.2 Connectivity

Connectivity of habitat both within a range and between ranges is essential for boreal caribou persistence on the landscape. Within a range, habitat connectivity allows for seasonal movement among habitats with the different resources needed by boreal caribou to satisfy their life history requirements (see Appendix H for examples of biophysical attributes), and for boreal caribou to use different areas as they respond to disturbance or as disturbed habitat recovers (Saher and Schmiegelow, 2005).

Connectivity between boreal caribou ranges allows for immigration and emigration between local populations, which increases gene flow, thereby helping to maintain genetic diversity and the species' subsequent resilience to environmental stressors (e.g. disease, severe weather). Studies have demonstrated that isolation of local populations as a result of disturbance to the landscape (i.e. any form of anthropogenic or natural habitat alteration), can result in a significant reduction in genetic diversity (Courtois et al., 2003; Weckworth et al., 2012). Connectivity between ranges also maintains recovery or rescue effects between boreal caribou ranges. Finally, connectivity within and between boreal caribou ranges will allow for movement in response to changing environmental conditions (e.g. climate change) (Racey and Armstrong, 2000; Courtois et al., 2003; McLoughlin et al., 2004; Pither et al., 2006; Boreal Caribou ATK Reports, 2010-2011).

3.3.3 Limiting Factors

Boreal caribou possess certain life history characteristics that limit their potential to recover from rapid, severe population declines. As a primary anti-predator survival strategy, boreal caribou spatially separate themselves from predators and alternate prey, maintaining low population

densities across their range (Bergerud, 1988; Bergerud, 1996; Johnson et al., 2001; Environment Canada, 2008). Accordingly, continuous tracts of undisturbed habitat of suitable quality (i.e. with the required biophysical attributes) are needed to ensure self-sustaining local populations.

Boreal caribou have a low reproductive output relative to other ungulates and therefore are vulnerable to higher rates of mortality whether caused by predation or over-harvesting. Females typically do not produce young until three years of age and then have only one calf per year (Bergerud, 2000). In addition, while all age classes of boreal caribou are vulnerable to predation, calf mortality can be especially high, particularly within the first thirty days after birth (Bergerud and Elliot, 1986; Gustine et al., 2006). Calves disperse themselves over the landscape as an anti-predator tactic. In most cases predation is the main proximate factor limiting boreal caribou population growth, since the survival of calves to one year of age is usually low and is often insufficient to compensate for annual adult mortality in declining populations (Bergerud, 1974; Stuart-Smith et al., 1997; DeMars et al., 2011).

Small local populations with few adult females (and hence few births) and low calf survival have a low potential for population growth (Bergerud, 1980; Bergerud, 2000; McCarthy et al., 2011). In addition to being affected by reproductive and mortality rates related to their age distribution, small local populations can be disproportionately affected by stochastic events (e.g. environmental events such as winter icing or heavy snowfalls, fire, disease). Consequently, population growth is likely to be highly variable in small local populations, with an increased probability of extirpation (Caughley, 1994; Courtois et al., 2007).

4 THREATS

4.1 Threat Assessment

There are a variety of threats that directly and/or indirectly affect boreal caribou and their habitat across Canada. A summary of these threats and their national level of concern are provided below (see Table 3). The level of concern was determined using best available information, including Aboriginal Traditional Knowledge and comments received through engagement with Aboriginal communities. Threats and their level of concern differ between regions and local populations. For example, the level of concern for the effect of hunting on local populations is high in Labrador, while it remains medium nationally. Actions to mitigate threats will be addressed in subsequent range plans and/or action plans (see Sections 7.4 and 9).

Many of the threats to boreal caribou and their habitat are related and may interact, in which case they can have cumulative impacts that may not be evident when threats are examined individually (Weclaw and Hudson, 2004; Boreal Caribou ATK Reports, 2010-2011; Badiou et al., 2011). Additionally, the impacts of threats on the size and distribution of boreal caribou local populations have a lag effect, which can take years to manifest (Vors et al., 2007).

Table 3. Threat assessment table for boreal caribou.

Threat	Level of Concern ¹	Extent	Occurrence	Frequency	Severity ²	Causal Certainty ³
Habitat Alteration (Disturbance)						
Habitat alteration (loss, degradation or fragmentation) as a result of human land-use activities	High	Widespread across Canada	Current	Continuous	High	High
Habitat alteration (loss, degradation or fragmentation) as a result of forest fire	Medium	Widespread across Canada	Current	Recurrent	Moderate	High
Natural Processes						
Predation	High	Widespread across Canada	Current	Continuous	High	High
Parasites and disease	Low	Localized across Canada	Anticipated	Unknown	Unknown	Low

Threat	Level of Concern ¹	Extent	Occurrence	Frequency	Severity ²	Causal Certainty ³
Biological Resource Use						
Hunting	Medium	Localized across Canada	Current	Seasonal	Moderate	Medium
Climate and Natural Disasters						
Climate change and severe weather	Medium	Widespread across Canada	Current	Unknown	Unknown	Low-Med
Other Threats						
Noise and light disturbance	Low-Med	Localized across Canada	Current	Recurrent	Unknown	Low
Vehicle collisions	Low	Localized across Canada	Current	Recurrent	Low	Low
Pollution	Low	Localized across Canada	Unknown	Unknown	Unknown	Low

1 Level of concern: qualifies the level of concern for managing the threat for the recovery of the species, consistent with the population and distribution objectives. This criterion considers all other criteria in the table.

2 Severity: reflects the population-level effect (i.e. high means a very large population-level effect; low means a limited population-level effect).

3 Causal certainty: reflects the degree of evidence that is known for the threat (i.e. high: available evidence strongly links the threat to stresses on population viability; medium: there is a correlation between the threat and population viability according to best available information; low: the threat is assumed or plausible).

4.2 Description of Threats

The threats to boreal caribou and their habitat identified in Table 3 are described below.

4.2.1 Habitat Alteration (Disturbance)

Habitat alteration occurs when changes are made on the landscape that adversely impact the ecosystem, either temporarily or permanently, reducing the overall function of habitat within the range for boreal caribou. Habitat loss is a change to a landscape that results in areas with no immediate or long-term future value to boreal caribou (e.g. conversion to agriculture, development of industrial facilities) whereas habitat degradation refers to a reduced but not total loss of habitat value for boreal caribou (e.g. reduction in the availability or quality of habitat following timber harvesting or seismic line development). Habitat fragmentation is the dissection of habitat by human-made linear features (e.g. roads, seismic lines, pipelines, hydroelectric

corridors) and polygonal features (e.g. forestry cut blocks) that may affect how boreal caribou use habitat or may result in a negative impact on the overall condition of a local population.

Environment Canada mapped total disturbance levels on boreal caribou ranges across their distribution in Canada as a predictor of self-sustainability for boreal caribou local populations. The total disturbance footprint was measured as the combined effects of fire that has occurred in the past 40 years and buffered (500 m) anthropogenic disturbance defined as any human-caused disturbance to the landscape that could be visually identified from Landsat imagery at a scale of 1:50,000. Although the effect of anthropogenic disturbance varies for individual ranges (i.e. in some ranges extending up to 14 km), Environment Canada (2011b) demonstrated that the application of a 500 m buffer to mapped anthropogenic features best represents the combined effects of increased predation and avoidance on caribou population trends at the national scale (Environment Canada, 2011b).

Data and approaches used to measure disturbance in Environment Canada's meta-analysis (2011b) were consistently applied across all provinces and territories. Disturbance data has been used for the purposes of this recovery strategy. Provinces and territories may have updated information and tools (e.g. Lidar remote sensing, detailed field sampling, other inventory techniques) to measure disturbance that were not considered in the national-level integrated risk assessment. Strong evidence validated by Environment Canada may be used to update disturbance measures and the integrated risk assessment.

Environment Canada (2011b) developed a methodology for consideration of disturbance management thresholds, which is described in more detail in Appendix E. This recovery strategy identifies 65% undisturbed habitat in a range as the disturbance management threshold, which provides a measurable probability (60%) for a local population to be self-sustaining. This threshold is considered a minimum threshold because at 65% undisturbed habitat there remains a significant risk (40%) that a local population will not be self-sustaining.

In any given range, habitat disturbance reduces the suitability of adjacent habitat, increase rates of predation, increase access to the land for hunting opportunities, and can act as barriers to boreal caribou movement (Chubbs et al., 1993; Smith et al., 2000; Dyer et al., 2001; Lander, 2006; Boreal Caribou ATK Reports, 2010-2011; Environment Canada, 2011b). In some cases boreal caribou may use areas of inadequate or degraded habitat (e.g. remnant habitat following certain types of forest fires, buffer habitat surrounding certain types of development), particularly in highly disturbed ranges where opportunities for movement to suitable undisturbed habitat are limited or unavailable. In these situations boreal caribou are at a higher mortality risk. In addition, large-scale disturbances to the landscape (e.g. intense forest fire, widespread forest harvest) can cause boreal caribou to cease their use of portions of the range.

4.2.1.1 Habitat Alteration (Loss, Degradation or Fragmentation) as a Result of Human Land-use Activities

Aboriginal Traditional Knowledge and science identify disturbance primarily associated with the following human land-use activities as having a negative effect on boreal caribou local populations across Canada: forestry; oil and gas exploration and development; mining and mineral exploration and development; hydro-electric development; and tourism. These activities

affect boreal caribou through a combination of direct and functional habitat loss, decreased habitat quality (i.e. habitat degradation), and development of linear features such as roads and seismic lines (i.e. habitat fragmentation) (Thomas and Gray, 2002; Vors et al., 2007; Boreal Caribou ATK Reports, 2010-2011).

The effects of habitat alteration may reduce the viability of a boreal caribou local population through the reduction of habitat quality and quantity, possibly leading to a reduction in the size of the range, and potentially resulting in the extirpation of a local population.

4.2.1.2 Habitat Alteration (Loss, Degradation or Fragmentation) as a Result of Forest Fire

Forest fires are required for boreal forest regeneration and have historically played a significant role in the local population size and distribution of boreal caribou within their range and across their Canadian distribution (Thomas and Gray, 2002; Dzus et al., 2010). Natural processes such as forest fires can directly alter habitat, making it unsuitable for boreal caribou (e.g. loss of mature conifer stands, loss of lichens and other forage plants, barriers to movement) (Environment Canada, 2011b). Boreal caribou generally do not return to burned areas for several decades until the forest is old enough to support lichens and other food sources, although they may make limited use of burned areas to feed on new growth (Boreal Caribou ATK Reports, 2010-2011).

Historically, when a forest fire occurred, boreal caribou would shift their use of habitat from the burned areas to areas that are more suitable. However, with the increase of industrial exploration and development, in a number of ranges there are fewer available suitable areas into which boreal caribou can move. When combined with human-caused disturbance, forest fires can threaten boreal caribou recovery even though they are a natural component of the boreal forest ecosystem. In some areas, forest fires have been reported as occurring more frequently than in the past (Whitefeather Forest, 2006; Boreal Caribou ATK Reports, 2010-2011).

4.2.2 Natural Processes

4.2.2.1 Predation

Across most of the distribution of boreal caribou, human-induced habitat alterations have caused an imbalance in predator-prey relationships resulting in unnaturally high predation rates. This is the major factor affecting the viability of most boreal caribou local populations (Bergerud, 1988; Stuart-Smith et al., 1997; Rettie and Messier, 1998; Schaefer et al., 1999; James and Stuart-Smith, 2000; Wittmer et al., 2005; Chabot, 2011). Based on the weight of evidence coming from science and Aboriginal Traditional Knowledge, increased wolf and/or bear predation is the main proximate cause of boreal caribou decline across Canada (Bergerud, 1988; Edmonds, 1988; Seip, 1992; Boertje et al., 1996; Boreal Caribou ATK Reports, 2010-2011; Pinard et al., 2012). However, in some parts of Canada, cougar (*Puma concolor*), coyotes (*Canis latrans*), lynx (*Lynx canadensis*), and eagles (*Haliaeetus leucocephalus* and *Aquila chrysaetos*) have also been identified as predators of boreal caribou, particularly calves (Thomas and Gray, 2002; Boreal Caribou ATK Reports, 2010-2011; McCarthy et al., 2011).

Human-caused habitat alterations have been shown to facilitate movement of predators within the boreal forest and hence can increase the abundance, distribution and hunting efficiency of species that prey on boreal caribou (James and Stuart-Smith, 2000; Neufeld, 2006; Boreal Caribou ATK Reports, 2010-2011). Additionally, although boreal caribou may not be the target prey species, they are taken opportunistically when encountered. In boreal caribou ranges with habitat alterations that provide favorable conditions for prey species such as deer and moose, predators such as wolves can increase in number, which can significantly reduce or even eliminate boreal caribou local populations (Seip, 1991; Seip, 1992; Wittmer et al., 2005; Courtois and Ouellet, 2007; Courbin et al., 2008; Boreal Caribou ATK Reports, 2010-2011). In addition to deer and moose, elk (*Cervus canadensis*), bison (*Bison bison*), and beaver (*Castor canadensis*) are other species that predators of boreal caribou commonly hunt and that have increased in number within the distribution of boreal caribou (Boreal Caribou ATK Reports, 2010-2011).

4.2.2.2 Parasites and Diseases

Viral, parasitic, and bacterial diseases can affect individual boreal caribou and may have effects at the local population level in certain parts of the country, although it is not thought to be one of the major threats affecting boreal caribou at the national level.

Other natural processes such as forest insects and disease can leave large areas of forest defoliated, and eventually dead, and may have an effect on boreal caribou habitat. In particular the mountain pine beetle (*Dendroctonus ponderosae*), which covers large areas of northeastern British Columbia and northern Alberta and threatens to move into Saskatchewan, could indirectly affect boreal caribou (Richie, 2008; Environment Canada, 2011a).

4.2.3 Biological Resource Use

4.2.3.1 Hunting

Hunting has and continues to contribute to the decline of boreal caribou (Bergerud, 1967; Kelsall, 1968; Bergerud, 1974; Bergerud, 1978; Courtois et al., 2007; Boreal Caribou ATK Reports, 2010-2011). Both targeted hunting and incidental harvest (when boreal caribou intermingle seasonally with legally hunted migratory caribou ecotypes) of boreal caribou are of concern in several areas, and may be contributing to local population declines and/or preventing recovery (Environment Canada, 2011a).

Although the extent of hunting is poorly understood in most areas, analyses of historical population trends, data from radio-collared animals, and current demographic information suggest that hunting remains a significant component of adult female boreal caribou mortality and hence is a primary threat in some ranges (Dzus, 2001; Schmelzer et al., 2004; Courtois et al., 2007). Hunting of boreal caribou is facilitated by the construction of roads and other linear features and by the use of off-road vehicles that enable access to previously inaccessible areas (Boreal Caribou ATK Reports, 2010-2011). Moreover, Aboriginal Traditional Knowledge indicates that technological advances in hunting tools (e.g. high-powered rifles and scopes) and in methods used to locate and access hunting sites (e.g. GPS, satellite tracking, aircraft,

snowmobiles, trucks) have facilitated the chase of boreal caribou, resulting in a greater number of caribou being taken (Boreal Caribou ATK Reports, 2010-2011; Environment Canada, 2011a).

4.2.4 Climate and Natural Disasters

4.2.4.1 Climate Change and Severe Weather

Climate change has been identified by Aboriginal Traditional Knowledge holders and scientists as a threat to boreal caribou and their habitat. Both groups indicate that there are many uncertainties surrounding the impacts of climate change and how climate change may interact with other threats. The long-term effects of climate change and the implications on boreal caribou habitat are unknown.

Greater weather variability and severe weather events, which are expected to increase with climate change, are likely to increase the frequency and severity of wildfires and cause more freeze-thaw cycles, freezing rain, deep snow, hot summer temperatures, and changes in the forest composition and food supply (Thomas and Gray, 2002; Vors and Boyce, 2009; Boreal Caribou ATK Reports, 2010-2011). In some areas, a shift in the timing and length of seasons, with earlier spring thaws and later freeze-ups, has been observed by many Aboriginal Traditional Knowledge holders (Boreal Caribou ATK Reports, 2010-2011). Climate change will likely also lead to changes in habitat which, in the Northwest Territories, can increase permafrost melting.

Climate related changes in habitat favour deer and other prey species, which expand into boreal caribou range, increasing predator populations and predation of boreal caribou, and facilitating the spread of disease. Climate change may result in habitat change for boreal caribou, as it drives boreal forest composition to shift northwards, and results in other factors including the spread of forest insects that cause tree mortality (e.g. mountain pine beetle) (Johnston, 2009; Johnston, 2010).

4.2.5 Other Threats

Other threats that have a lower level of concern at the national scale (although they may be of greater concern for individual ranges) include:

Noise and Light Disturbance: Noise and light disturbance result in short-term behavioural and physiological responses of individual boreal caribou, including a startle response, elevated heart rate, and production of glucocorticoids. Sustained or repeated disturbance can result in avoidance of areas and the reduction in use of suitable habitat (Sapolsky, 1992; Creel et al., 2002).

Vehicle Collisions: In some areas, boreal caribou are vulnerable to mortality from vehicle or rail collisions (Brown and Hobson, 1998); however, on a national scale, vehicle collisions are not thought to pose a major threat to boreal caribou (Boreal Caribou ATK Reports, 2010-2011).

Pollution: The threat of pollution (e.g. from oil and gas, chemical spraying for forestry, pesticides, hydro, salt, dust and litter coming from the creation of roads) was identified as a concern through meetings held with Aboriginal communities (Environment Canada, 2011a) and by Aboriginal Traditional Knowledge holders (Boreal Caribou ATK Reports, 2010-2011). Very little is known about the severity of this threat to boreal caribou local populations.

5 POPULATION AND DISTRIBUTION OBJECTIVES

The national population of boreal caribou is currently made up of local populations distributed across 51 ranges in Canada (see Figure 2 and Table 2). Boreal caribou ranges are the fundamental units of conservation and management for boreal caribou recovery planning and actions (Thomas and Gray, 2002). The range is the appropriate unit of analysis for identifying critical habitat and other requirements for self-sustaining local populations of boreal caribou. The range represents the geographic area occupied by a group of individuals that are subject to similar factors affecting their demography and is used to satisfy their life history processes (e.g. calving, rutting, wintering) over a defined time frame.

5.1 Recovery of Boreal Caribou

5.1.1 Varying Ecological Conditions

Aboriginal Traditional Knowledge and comments received through engagement with Aboriginal communities identifies the need for continued presence of self-sustaining local populations in all boreal caribou ranges across Canada (Environment Canada, 2011a; Boreal Caribou ATK Reports, 2010-2011). This is reflected in the knowledge that all animals are connected to each other and that boreal caribou are essential to the balance of nature and for their role in the boreal ecosystem.

Boreal caribou encounter a wide variety of ecological conditions across their distribution. Taken together, all boreal caribou ranges contribute to ensuring that the full ecological gradient is represented and captures local adaptations to change. This allows for maintenance of the evolutionary potential of the species and accounts for the full spectrum of ecological interactions boreal caribou can have within the full array of ecological settings (Redford et al., 2011).

Science supports that conservation of a species such as boreal caribou is achieved by maintaining multiple local population units across a species' geographical range, in representative ecological settings, with replicate local populations in each setting that are self-sustaining, genetically robust, ecologically functional, and resilient to climate and other changes (Environment Canada, 2011b). Without connectivity, redundancy and representivity across several ecological scenarios there is an increased risk to the survival and recovery of boreal caribou.

Small local populations, particularly those isolated from the core distribution of the national population of boreal caribou, are at greater risk of not becoming self-sustaining or maintaining self-sustaining status. In these situations, a local population may have greater difficulty withstanding stochastic events, and may not experience enough immigration to maintain genetic diversity or adequate population size, and therefore will be at greater risk of not persisting in the long-term. Accordingly, different recovery actions (e.g. translocation, captive breeding) may be necessary to maintain and recover small local populations, and particularly those that are declining. There may be considerable uncertainty regarding the effectiveness of such recovery tools. It will be important to assess feasibility and conduct a risk assessment prior to undertaking any such activities.

There are several small local populations including Parker (BC4) and Prophet (BC5) in British Columbia, Nipisi (AB11) and Slave Lake (AB12) in Alberta, The Bog (MB1), Kississing (MB2), North Interlake (MB5), William Lake (MB6) and Owl-Flinstone (MB13) in Manitoba, and Red Wine Mountain (NL2) in Newfoundland and Labrador. Small isolated local populations include Little Smoky (AB5) in Alberta, Coastal (ON6) in Ontario, and Val D'Or (QC1) and Charlevoix (QC2) in Quebec (see Figure 2).

5.1.2 Connectivity Between and Within Boreal Caribou Ranges

Maintaining a long-term self-sustaining status for boreal caribou ranges depends on connectivity within and between ranges. Connectivity between ranges enables immigration and emigration between neighbouring boreal caribou local populations, which allows for the maintenance of local population size and genetic diversity. Maintaining genetic diversity is needed to maintain the resilience of a local population as described in Section 3.3.2.

Connectivity also allows wide ranging mammals like boreal caribou to adapt to changes in their natural environment (e.g. climate change, disturbance), recognizing that a contiguous population does not mean that each range must be physically connected to other ranges or that areas of habitat within a range must be physically connected to other areas. However, it does mean that the distance between ranges and between core habitat areas within a range should not be so large that no movement of boreal caribou could occur, though it may not be their preferred habitat type. Connectivity between ranges benefits gene flow and helps to maintain or increase population size. Connectivity within a range is important for seasonal movement and the use of habitat as boreal caribou respond to disturbance or as disturbed habitat recovers (Saher and Schmiegelow, 2005).

5.2 Objectives

5.2.1 Recovery Goal

The recovery goal for boreal caribou is to achieve self-sustaining local populations in all boreal caribou ranges throughout their current distribution in Canada, to the extent possible.

The recovery goal reflects the best available information, including scientific knowledge, Aboriginal Traditional Knowledge and comments received through engagement with Aboriginal communities. The goal is informed by the scientific principles of conservation and reflects the intent to recover all local populations. Achieving the recovery goal would allow for local population levels sufficient to sustain traditional Aboriginal harvesting activities, consistent with existing Aboriginal and treaty rights of Aboriginal peoples of Canada. Feedback received from Aboriginal communities indicated a strong support for this recovery goal.

Recovery for boreal caribou is the achievement of self-sustaining local populations, which are demographically and genetically viable connected local populations across the species' distribution. Current evidence supports the conclusion that the recovery of all local populations is biologically and technically feasible. As noted in Sections 3.3.3 and 5.1.1, small and isolated local populations are at greater risk of not becoming self-sustaining or maintaining self-sustaining status. There may be situations where recovery of a particular local population proves

to be, over time and through unforeseen circumstances, not biologically or technically feasible. Each boreal caribou local population contributes to the biodiversity, ecological functionality, and resilience of the species to environmental change, reducing the risk of species' extinction (Ray, 2011).

5.2.2 Population and Distribution Objectives

To guide recovery efforts, the population and distribution objectives (see Figure 4) are, to the extent possible, to:

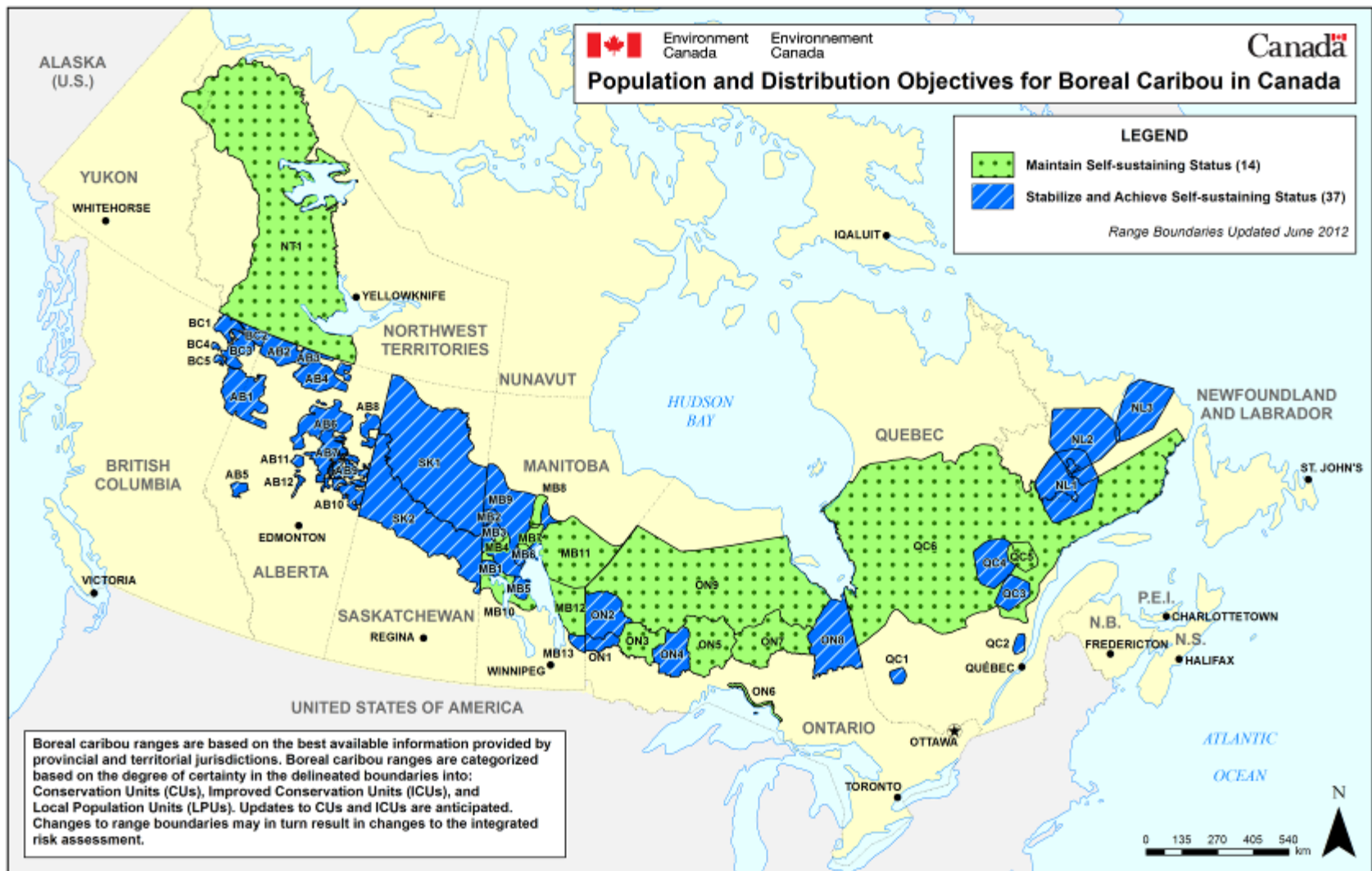
- Maintain the current status of the 14 existing self-sustaining local populations (green dotted ranges); and
- Stabilize and achieve self-sustaining status for the 37 not self-sustaining local populations (blue hatched ranges).

“Not self-sustaining” local populations refers to the local populations assessed as “as likely as not self-sustaining”, those assessed as “not self-sustaining”, and that assessed as “unknown”. Given the uncertainty about the status of the Boreal Shield (SK1) local population, the population and distribution objective is to manage for self-sustaining status. Implementation of the schedule of studies for SK1 included in this recovery strategy (see Section 7.2) will provide the data required to complete the integrated risk assessment for this range to determine its current status as self-sustaining or not self-sustaining.

5.3 Timelines to Recovery

Boreal caribou exist in mature boreal forest ecosystems that evolved over centuries, and in turn take decades to recover from disturbance. Reversing ecological processes detrimental to boreal caribou (e.g. habitat degradation and loss, the increase in predator and alternate prey populations), and instituting changes to management frameworks and ongoing land use arrangements, will often require time frames in excess of 50 to 100 years. Given these realities, while it is currently biologically and technically feasible to recover all local populations, under the best efforts of all parties, some local populations will not return to a self-sustaining status for a number of decades.

For several boreal caribou local populations, immediate actions to avoid extirpation are needed such that recovery can be achieved over time. Recovery will be monitored continuously and reported every five years (see Section 8).



5.4 Prioritizing Recovery Actions and Managing Risk

All local populations are included in the goal for the recovery of boreal caribou based on their contributions to connectivity, representivity and redundancy. Each local population also faces different challenges to maintain or achieve self-sustaining status. Successful recovery of boreal caribou will require practical considerations and implementation of recovery actions tailored for each range. Prioritization of recovery actions is best addressed at the range and/or action planning stage where the allocation of effort and the rate of risk reduction for individual ranges can best be determined.

Range and/or action planning will consider a multitude of information and factors, such as regional ecological conditions, local population size and trend, boreal caribou movement between ranges, habitat condition between ranges, distribution of resources for restoration efforts, and others. In prioritizing recovery actions, consideration should be given to the current risk of extirpation of a local population, the length of time to achieve a self-sustaining status, ecological needs of connectivity, representivity and redundancy, as well as population and habitat conditions.

5.5 Achieving Recovery for Self-Sustaining Local Populations

Recovery is achieved for the 14 self-sustaining local populations by maintaining population and range conditions that support their self-sustaining status.

5.6 Achieving Recovery for Not Self-Sustaining Local Populations

Recovery is achieved for the 37 not self-sustaining local populations through a combination of coordinated habitat restoration and population management actions applied over time to return a local population to a self-sustaining status. For each not self-sustaining local population, the timeframe for achieving recovery will vary depending on whether the habitat condition and/or the population condition is/are a limiting factor.

For boreal caribou ranges where local populations are declining, stabilizing the local population by halting its decline will require immediate action. For all ranges wherein the local population size is small, achieving a stable population trend and recovering the population to a minimum of 100 animals² will be necessary to mitigate risk of quasi-extinction. Although certain local populations with fewer than 100 animals may be stable and persist over the short-term where adequate suitable habitat supply is available, the long-term persistence of those populations is less certain. In some instances, continued human intervention may be required to achieve the minimum population size target.

In addition to managing local population size, habitat management will also be necessary. This recovery strategy identifies 65% undisturbed habitat in a range as the disturbance management

² 100 animals provides a 0.7 probability of not reaching a quasi-extinction threshold of less than 10 reproductively active females under stable conditions (Environment Canada, 2011b).

threshold, which provides a measurable probability (60%) for a local population to be self-sustaining (see Appendix E).

For boreal caribou ranges with less than 65% undisturbed habitat:

- restoration of disturbed habitat to a minimum of 65% undisturbed habitat will be necessary.

For boreal caribou ranges with greater than or equal to 65% undisturbed habitat:

- maintenance of a minimum of 65% undisturbed habitat will be necessary.

There are 31 ranges where total disturbance exceeds 35% and which thereby do not meet the disturbance management threshold of 65% undisturbed habitat (see Section 7.1.1). Of these ranges, local population trends are declining (11 local populations), stable (eight local populations) or unknown (12 local populations).

In six ranges the habitat condition is good (i.e. undisturbed habitat exceeds 65%), and the local population trend is either declining (three local populations) or stable (three local populations). Note that for the three ranges that report stable population trend with good habitat condition, the quality of trend data and/or the small estimated population size resulted in those local populations being assessed as not self-sustaining.

6 BROAD STRATEGIES AND GENERAL APPROACHES TO MEET OBJECTIVES

6.1 Actions Already Completed or Currently Underway

Federal, provincial and territorial governments, wildlife management boards, Aboriginal people, non-government organizations, and affected industries across Canada have taken a range of actions to manage and protect boreal caribou and their habitat. Examples of actions already completed or currently underway vary across Canada, and include:

- identification and delineation of boreal caribou ranges and habitats within ranges;
- assessment of the population size and/or trend and/or distribution of local populations of boreal caribou across Canada;
- consideration of boreal caribou habitat requirements when planning and implementing forest harvesting and other industrial activities;
- development and implementation of operating guidelines for industrial development within boreal caribou ranges;
- land-use planning to identify areas within boreal caribou ranges where boreal caribou conservation is prioritized;
- closed, restricted, and/or managed hunting by Aboriginal and non-Aboriginal people, on a voluntary basis or through regulations;
- predator and alternate prey management in some ranges where local populations of boreal caribou are rapidly declining;
- development of cooperative stewardship agreements and activities to support the engagement of Aboriginal organizations and stakeholders in the monitoring, management, and conservation of boreal caribou;
- preparation of outreach materials on boreal caribou and dissemination to interest groups and the general public; and
- research on boreal caribou ranges, habitat, ecology and limiting factors.

Collectively, these actions, and the level of commitment associated with these actions, are an encouraging foundation upon which to build. Table 4 outlines the status of provincial and territorial recovery planning for boreal caribou.

Table 4. Status of boreal caribou recovery planning in provincial and territorial jurisdictions where boreal caribou occur.

Provincial/ Territorial Jurisdiction	Recovery Document	Recovery Objective
Northwest Territories	<ul style="list-style-type: none"> • Action Plan for Boreal Woodland Caribou Conservation in the Northwest Territories, 2010-2015 • Implementation Plan for the Action Plan for Boreal Woodland Caribou in the Northwest Territories: 2010-2015 	<ul style="list-style-type: none"> • Conserve boreal caribou in all areas of the Northwest Territories to prevent from becoming a species at risk in the Northwest Territories • Maintain current contiguous distribution
British Columbia	<ul style="list-style-type: none"> • Implementation Plan for the Ongoing Management of Boreal caribou in British Columbia, 2011 	<ul style="list-style-type: none"> • Decrease rate of decline • Reduce risk of extirpation for four populations within 50 years
Alberta	<ul style="list-style-type: none"> • A Woodland Caribou Policy for Alberta, June 2011 • Alberta Woodland Caribou Recovery Plan, 2004/5 – 2013/14 	<ul style="list-style-type: none"> • Self-sustaining populations and maintain distribution • Ensure long-term habitat requirements within ranges
Saskatchewan	<ul style="list-style-type: none"> • Draft Recovery Strategy for Boreal Woodland Caribou in Saskatchewan, 2007 	<ul style="list-style-type: none"> • Promote, sustain, and enhance populations • Maintain distribution of caribou and necessary ecosystems across range
Manitoba	<ul style="list-style-type: none"> • Manitoba's Conservation and Recovery Strategy for Boreal Woodland Caribou, 2005 • Draft Action Plans for Boreal Woodland Caribou Ranges in Manitoba – Owl-Flintstone and Atikaki-Berens Ranges 	<ul style="list-style-type: none"> • Self-sustaining populations on all existing ranges • Maintain and/or increase habitat to support self-sustaining local populations • Manage habitat on all ranges
Ontario	<ul style="list-style-type: none"> • Ontario Recovery Strategy, Woodland Caribou, 2008 • Ontario Woodland Caribou Conservation Plan, 2009 	<ul style="list-style-type: none"> • Maintain self-sustaining, genetically-connected local populations of Woodland Caribou (forest-dwelling boreal population) where they currently exist, improve security and connections among isolated mainland local populations, and facilitate the return of caribou to strategic areas near their current extent of occurrence
Quebec	<ul style="list-style-type: none"> • Quebec Recovery Strategy for Woodland Caribou, 2005-2012 • Updated Recovery Strategy (2012-2022) is completed and will be published shortly 	<ul style="list-style-type: none"> • Maintain current distribution • Achieve and maintain uniform distribution (> 12,000 caribou) • Maintain and consolidate the isolated Val-d'Or and Charlevoix herds
Newfoundland and Labrador	<ul style="list-style-type: none"> • Recovery Strategy for Three Woodland Caribou Herds in Labrador, 2004 • Updated Recovery Strategy is currently being drafted 	<ul style="list-style-type: none"> • Prevent extinction and improve status of all populations • Achieve self-sustaining populations across current and historical ranges

6.2 Strategic Direction for Recovery

The following table (see Table 5) and narrative describe, at a national level, the broad strategies and general approaches to be taken and the research and management activities needed to address the threats to boreal caribou and achieve the population and distribution objectives for each range. Many strategies and approaches are interrelated and details on their implementation and their level of priority will differ across the country and by local population and habitat conditions. Sequencing and timing of specific recovery actions and their level of priority will be outlined and addressed in subsequent range plans and/or action plans (see Sections 7.4 and 9).

Table 5. Recovery planning table for boreal caribou

Threat or Limitation	Priority ¹	Broad Strategy to Recovery	General Description of Research and Management Approaches
Landscape Level Planning			
Habitat alteration as a result of human land-use activities Habitat alteration as a result of natural processes	Urgent	Undertake landscape level planning that considers current and future boreal caribou habitat requirements	<ul style="list-style-type: none"> • Develop range plans (see Section 7.4) that outline range-specific population and habitat management activities with measurable targets to achieve recovery goal. • Undertake coordinated land and/or resource planning to ensure that development activities are planned (type, amount, and distribution) and implemented at appropriate spatial and temporal scales (e.g. consider sensitive periods/areas such as calving). • Plan to maintain habitat within and between boreal caribou ranges, to maintain connectivity where required. • Undertake coordinated planning among provincial and territorial jurisdictions that jointly manage ranges (i.e. transboundary ranges) to reach agreement on the overall strategic direction for local population recovery. • Develop range-appropriate cumulative effects assessment approaches. Very large ranges (Northwest Territories (NT1), Far North (ON9), and Quebec (QC6)) will require different approaches. • Communicate among governments, wildlife management boards, Aboriginal communities and organizations, non-governmental organizations, and other organizations responsible for land and/or resource management and/or conservation within the boreal forest to ensure coordination of planning and management and, where applicable, facilitate cross-jurisdictional cooperation and implementation.
Habitat Management			
Habitat alteration as a result of human land-use activities Habitat alteration as a result of natural processes	Urgent	Manage habitat to meet current and future habitat requirements of boreal caribou	<ul style="list-style-type: none"> • Protect key areas for boreal caribou through appropriate habitat management and protection mechanisms (e.g. legislated protected areas, no development zones, mixed use zones, and conservation agreements). • Undertake coordinated actions to reclaim boreal caribou habitat through restoration efforts (e.g. restore industrial landscape features such as roads, old seismic lines, pipelines, cut-lines, temporary roads, cleared areas; reconnect fragmented ranges).

Threat or Limitation	Priority ¹	Broad Strategy to Recovery	General Description of Research and Management Approaches
			<ul style="list-style-type: none"> • Measure and monitor disturbance on the landscape (see Section 4.2.1). Update range plans to reflect changes in habitat condition. • Where ranges are highly disturbed, identify areas that will be prioritized for boreal caribou recovery and targeted for early habitat reclamation. Incorporate management guidelines and actions into permitting conditions for activities identified as affecting boreal caribou or their habitat. • For ranges that are jointly managed (i.e. transboundary), undertake collaborative habitat management among responsible provincial and territorial jurisdictions to ensure equitable efforts are underway. • Encourage stewardship of boreal caribou habitat among industries, interest groups, and Aboriginal communities and organizations. • Assess the impact of natural disturbance (e.g. forest fire) on the long-term habitat management of boreal caribou ranges. Where necessary, incorporate short- and long-term boreal caribou habitat considerations, along with other considerations, into forest fire management. • Monitor habitat and use adaptive management to assess progress and adjust management activities as appropriate.
Mortality and Population Management			
Predation	High	Manage predators and alternate prey	<ul style="list-style-type: none"> • Where necessary, apply predator management as an interim management tool, in conjunction with other management approaches (e.g. habitat restoration and management), to achieve boreal caribou local population growth. Alternate prey management may also be applied in conjunction with predator management. • Where applicable, consider effective indirect predator management techniques as an alternative to direct predator management (e.g. limiting predator access, penning of boreal caribou). • Where mortality and/or population management are implemented, monitor boreal caribou local populations and consider monitoring the effects on other impacted species.
Hunting	Medium	Manage direct human-caused mortality of boreal caribou	<ul style="list-style-type: none"> • Determine the extent of current hunting, and the effects of hunting on boreal caribou local populations. • In consultation with Aboriginal people, develop and implement harvest strategies, where required to achieve boreal caribou recovery. • Assess and address impacts of hunting regulations for all boreal caribou ranges that overlap with other legally hunted Woodland Caribou ecotypes. • Reduce illegal hunting through stewardship, education and enforcement.

Threat or Limitation	Priority ¹	Broad Strategy to Recovery	General Description of Research and Management Approaches
Population Monitoring			
Knowledge gaps: Population dynamics (trends, size, structure, and distribution)	High	Conduct population studies to better understand population structure, trends and distribution	<ul style="list-style-type: none"> Where necessary, refine understanding of the structure and functioning of boreal caribou local populations. Monitor population size and/or trend, as well as changes in boreal caribou distribution over time and in relation to habitat condition and disturbance. Coordinate data collection, data-sharing, and planning between or among neighbouring provincial and territorial jurisdictions to establish transboundary ranges where appropriate. Revise boreal caribou range delineations based on updated population information from science and Aboriginal Traditional Knowledge.
Knowledge gaps: boreal caribou health and condition	Low - Medium	Monitor boreal caribou health and condition	<ul style="list-style-type: none"> Gather information, monitor and manage the health and body condition of individual boreal caribou.
Knowledge gaps: boreal caribou sensory disturbance	Low - Medium	Monitor and manage sensory disturbance of boreal caribou	<ul style="list-style-type: none"> Assess the extent, distribution, and possible consequences of sensory disturbance (e.g. aircraft traffic, snowmobiles, all-terrain vehicles, tourism, research, and equipment associated with oil and gas or forestry) on boreal caribou, and where required reduce its effects, particularly during sensitive periods (e.g. calving). Minimize disturbance to boreal caribou during monitoring and research programs, and select monitoring and research techniques that are the least intrusive.

¹ Priority: reflects the level of priority of the broad strategy on a national level. This priority for each local population may differ.

6.3 Narrative to Support the Recovery Planning Table

Recovery of boreal caribou will require the commitment, collaboration and cooperation among federal, provincial and territorial jurisdictions, wildlife management boards, Aboriginal people, local communities, landowners, industry and other interested parties. It will be important to monitor habitat conditions, size and/or trend, and the distribution of boreal caribou local populations so that the effectiveness of individual range management regimes can be evaluated, and adjusted as necessary. It should also be recognized that it takes time for the impact of human developments and natural disturbances on boreal caribou to become evident. Therefore, range plans and/or action plans must take into account the likelihood of a delayed boreal caribou population and distribution response to anthropogenic or natural habitat alterations.

6.3.1 Landscape Level Planning

As the range has been identified as the most relevant scale at which to plan for the conservation of boreal caribou, undertaking landscape level land and/or natural resource planning is appropriate for effective management of cumulative effects of habitat disturbance within boreal

caribou ranges and for managing disturbance over time to ensure sufficient habitat is available for boreal caribou, both of which are more difficult in the context of individual project approvals. Range-level planning for boreal caribou should consider current and future human developments and determine detailed management activities that are tailored to the conditions of the range and the local population in question. Range plans and/or action plans should take into account natural disturbances and cumulative effects of development within and between boreal caribou ranges.

It will be important to undertake coordinated land and/or resource planning to ensure that development activities are planned and approved, taking into consideration the cumulative impacts of all current and future developments within a range. Assessing cumulative effects will require a different approach for large continuous ranges than for smaller discrete ranges. The impact of disturbance that may be concentrated in part of a large continuous range may be masked given the size of the range. Dividing the large areas into smaller management units may allow land managers to better understand where the disturbance is occurring and plan accordingly, in order to avoid irreversible range retraction and permanent breaks in range connectivity.

In light of the impacts that actions taken in neighbouring ranges have on boreal caribou, it will be important that provinces and territories take a collaborative approach to land and/or resource planning, particularly in ranges that are jointly managed (i.e. transboundary), to ensure an agreed upon direction to boreal caribou recovery is attained.

6.3.2 Habitat Management

Boreal caribou ranges will need to be managed to ensure their current and future ability to support self-sustaining local populations. The effectiveness of various management activities may vary between and within ranges due to differences in population condition and specific local conditions.

Management of the amount, type and distribution of human developments will be necessary. Both anthropogenic and natural disturbances will need to be monitored and measured. Methods may vary in accordance with the information and tools available to the provinces and territories. Anthropogenic disturbance (i.e. industrial and other human activities) will need to be managed in a manner consistent with land and/or resource planning that has taken into account the current and future habitat requirements of boreal caribou. Disturbed areas may need to be improved or restored to support population and distribution objectives within each boreal caribou range. Maintaining connectivity within and between habitat patches and ranges will be particularly important for boreal caribou. In certain cases, it may be necessary to identify and designate protected areas with biophysical attributes for boreal caribou. For ranges that are jointly managed by provinces and territories (i.e. transboundary), collaborative habitat management approaches will be necessary to ensure that equitable recovery efforts are underway. Though ranges may cross provincial and territorial boundaries, each jurisdiction remains accountable for activities carried out in their own range.

6.3.3 Mortality and Population Management

6.3.3.1 Manage Predators and Alternate Prey

Human-induced habitat alterations have upset the natural balance between boreal caribou and their predators, resulting in unnaturally high predation rates in some boreal caribou ranges. As a result, in some ranges, a population management approach involving management of other wildlife species (i.e. predators and alternate prey) may be required to stop boreal caribou declines and stabilize the local population in order to prevent their extirpation in the short-term. Where the condition of the local population warrants such measures, predator and in some cases alternate prey management may be applied as interim management tools, recognizing that a punctuated approach to mortality management may be necessary over a period of time while habitat conditions in the range recover. Where mortality management is applied, concurrent application of other management tools will be needed to achieve boreal caribou recovery. In particular, habitat restoration and management will be necessary to recover the range conditions to provide an adequate habitat supply system to support boreal caribou local populations. Predator and alternate prey management should be considered simultaneously. Alternate prey management applied in the absence of concurrent predator management has the potential to be harmful to boreal caribou conservation.

6.3.3.2 Manage Direct Human-Caused Mortality of Boreal Caribou

The extent of hunting and its effect on boreal caribou local populations is largely unknown across most of the distribution of boreal caribou. Therefore, it is important to first determine the level of hunting within a range in order to understand the potential impact of hunting on the viability of a local population. Attention should also be given to areas where boreal caribou ranges overlap with legally hunted caribou ecotypes, and hunting regulations for the legally hunted caribou ecotypes should be modified as appropriate. In areas where hunting is shown to have a negative effect on local population viability, harvest strategies should be developed, in consultation with Aboriginal people, to achieve boreal caribou recovery.

6.3.4 Population Monitoring

6.3.4.1 Conduct Population Studies to Better Understand Boreal Caribou Population Structure, Trends and Distribution

There is considerable variation in the level of understanding of boreal caribou local population structure and trends across their distribution. While accurate population size and trend estimates are available for some local populations, for others, size and trend estimates are based primarily on professional judgement and limited data. For local populations where little is known, baseline population ecology studies such as boreal caribou collaring, aerial observations/counting, and on the ground monitoring activities are required to establish a baseline from which to plan and measure recovery progress. For all local populations, size and/or trend, and distribution should be monitored over time to test the efficacy of management actions and adapt those management actions as appropriate.

6.3.4.2 Monitor Boreal Caribou Health and Condition

Parasites and disease can affect individual boreal caribou and may have effects at the local population level in certain parts of the country. Pollution from oil and gas contaminated sites has also been shown to negatively affect the health of boreal caribou and may result in mortality if individuals consume toxins at waste sites. However, little is known about the severity of parasites, disease and pollution to individual boreal caribou or to boreal caribou local populations. Therefore, information on the health and body condition of boreal caribou should be monitored to better understand the relationship between these threats and the viability of local populations, and whether there is a need for additional recovery actions.

6.3.4.3 Monitor and Manage Sensory Disturbance of Boreal Caribou

The extent, distribution and effects of various sources of sensory disturbance (e.g. low-flying aircraft, snowmobiles, equipment associated with various industries) on individual boreal caribou and boreal caribou local populations should be assessed. Where required, management actions to reduce the effects of sensory disturbance on boreal caribou should be implemented and the effectiveness of the management actions should be monitored over time and adapted as necessary.

7 CRITICAL HABITAT

Under SARA, critical habitat is defined as “the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species’ critical habitat in the recovery strategy or in an action plan for the species”. For boreal caribou, critical habitat identification describes the habitat that is necessary to maintain or recover self-sustaining local populations throughout their distribution. In some of the areas identified as critical habitat, the quality of habitat will need to be improved for recovery to be achieved.

Boreal caribou shift in their use of range over space and time, in accordance with changes in the location of biophysical attributes within the range as areas of disturbed and undisturbed habitat cycle on the landscape. For a local population to be self-sustaining over time, this habitat supply system (i.e. critical habitat) must function perpetually.

7.1 Identification of Critical Habitat for Boreal Caribou

Based on the foregoing, critical habitat for boreal caribou is identified for all boreal caribou ranges, except for northern Saskatchewan’s Boreal Shield range (SK1), (see Figure 5) as:

- the area within the boundary of each boreal caribou range that provides an overall ecological condition that will allow for an ongoing recruitment and retirement cycle of habitat, which maintains a perpetual state of a minimum of 65% of the area as undisturbed habitat; and
- biophysical attributes required by boreal caribou to carry out life processes (see Appendix H).

Based on methodology developed by Environment Canada (2011b), a disturbance management threshold of 65% has been identified, which provides a measurable probability (60%) for a local population to be self-sustaining (see Appendix E). The precise location of the 65% undisturbed habitat within the range will vary over time. The habitat within a range should exist in an appropriate spatial configuration such that boreal caribou can move throughout the range and access required habitat when needed. The key to this identification is achieving and maintaining an overall, ongoing range condition that allows for the dynamic habitat supply system, with the biophysical attributes upon which boreal caribou depend, to operate. It is this dynamic habitat supply system within the range boundaries, containing the biophysical attributes, that is the habitat condition necessary for the recovery of boreal caribou.

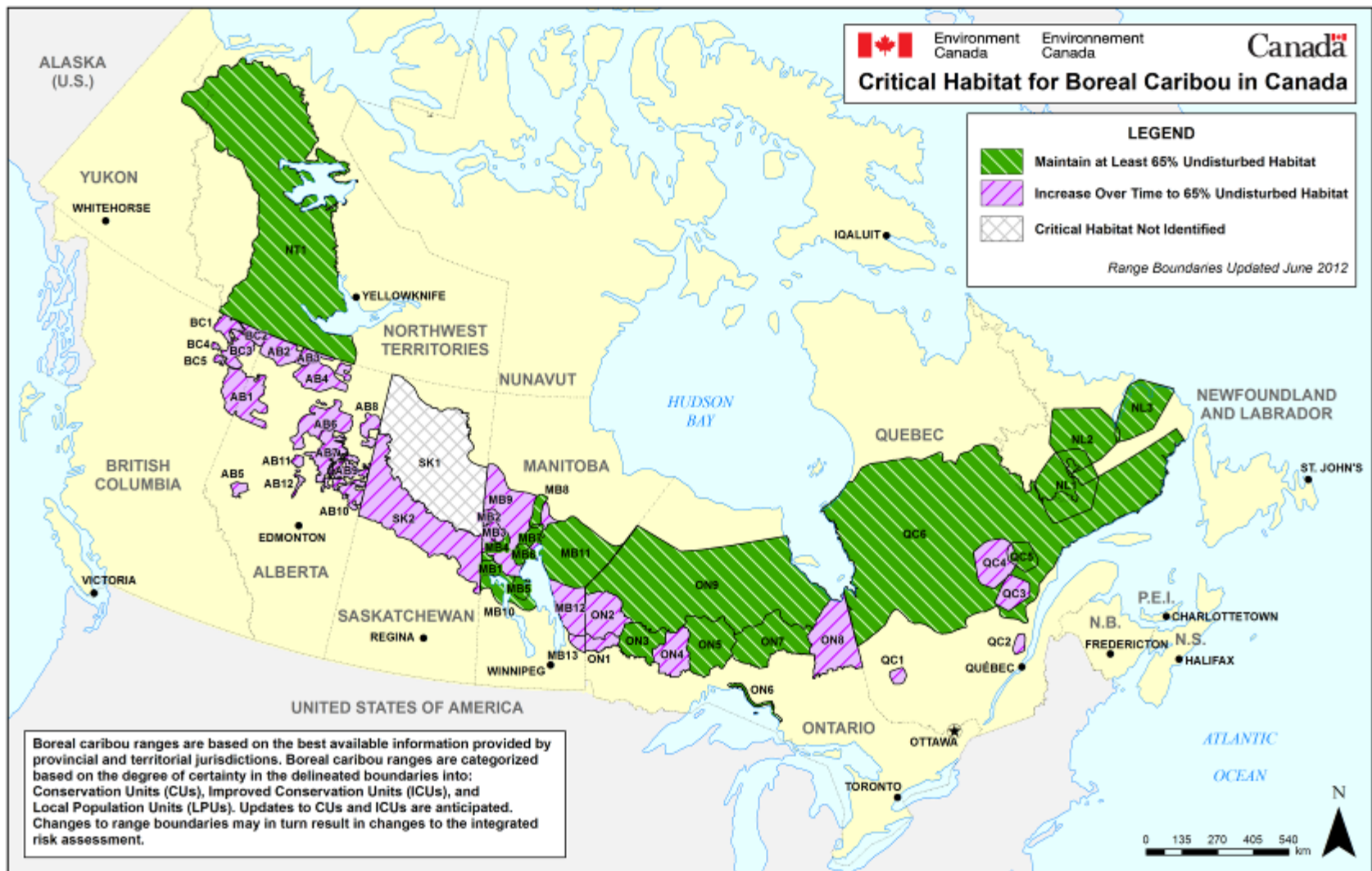


Figure 5. Critical habitat for boreal caribou in Canada.

Critical habitat is not identified in northern Saskatchewan's Boreal Shield range (SK1). The high fire, very low anthropogenic disturbance estimates for northern Saskatchewan represent a unique situation that falls outside the range of variability observed in the data that informed the disturbance model used by Environment Canada (2011b) (see Appendix F). Therefore, the disturbance model that informed the identification of critical habitat has not been applied for this range. More information is needed to confirm if the effect of total disturbance also applies in ranges where there is high fire and very low anthropogenic disturbance. A schedule of studies (see Section 7.2) is required to complete the critical habitat identification for the Boreal Shield range (SK1) in northern Saskatchewan.

7.1.1 Components of Critical Habitat

The identification of critical habitat for boreal caribou is comprised of three components for each range: i) Location of habitat; ii) Amount of habitat; and iii) Type of habitat. Appendix J provides critical habitat component information for each boreal caribou range with the exception of Saskatchewan's Boreal Shield range (SKI) where critical habitat has not been identified.

Location

Location describes where critical habitat is found. For boreal caribou the relevant scale to identify critical habitat is the range, which delineates the area within which critical habitat is located. There are 51 ranges within the current distribution of the boreal caribou (see Figure 2 and Table 2).

Amount

Amount describes the quantity of critical habitat.

A strong relationship exists between habitat disturbance and whether a local population is stable, increasing or decreasing. As the quantity and/or severity of disturbance increases, there is increasing risk that a local population will be in decline (Environment Canada, 2011b), as further described in Appendix E.

This recovery strategy identifies a minimum of 65% undisturbed habitat in a range as the disturbance management threshold, which provides a measurable probability (60%) for a local population to be self-sustaining. This threshold is considered a minimum threshold because at 65% undisturbed habitat there remains a significant risk (40%) that local populations will not be self-sustaining.

Habitat disturbance within a range needs to be managed by the responsible jurisdiction at a level that will allow for a local population to be self-sustaining. As there is variation in habitat and population conditions between boreal caribou local populations across their distribution, for some ranges it may be necessary to manage the range above the 65% undisturbed habitat threshold, while for others it may be possible to manage the range below the 65% undisturbed habitat threshold. However, there must be strong evidence, validated by Environment Canada, from population data collected over an extended period of time to support the management decision to establish a lower range-specific threshold (i.e. the lag effects of disturbance on a local population have been considered and accounted for).

In the absence of strong evidence to support lowering the undisturbed habitat threshold below 65%, the amount of critical habitat for all ranges is at least 65% undisturbed habitat. For management purposes, the amount of critical habitat may need to be maintained or restored, depending on the level of disturbance in a range.

- In ranges with less than 65% undisturbed habitat, initially, critical habitat is the existing habitat that over time would contribute to the attainment of 65% undisturbed habitat.
- In ranges with 65% or more undisturbed habitat, critical habitat is at least 65% undisturbed habitat in a range.
- The habitat that is included in the 65% undisturbed habitat will change over time given the dynamic nature of the boreal forest.

Section 4.2.1 describes the methodology used to measure disturbance for each range.

Type

Type describes the biophysical attributes of critical habitat.

Biophysical attributes are the habitat characteristics required by boreal caribou to carry out life processes necessary for survival and recovery. Biophysical attributes within and adjacent to core habitat areas of boreal caribou use will be more important to a local population than those that are isolated and less accessible to boreal caribou (i.e. spatially separated by a disturbance). The biophysical attributes for boreal caribou will vary over space and time with the dynamic nature of the boreal forest. In addition, particular biophysical attributes will be of greater importance to boreal caribou at different points in time. Certain biophysical attributes are required more by a local population during different life processes, seasons or at various times over the years.

Information from Aboriginal Traditional Knowledge (Boreal Caribou ATK Reports, 2010-2011), habitat selection analyses, and scientific published reports (Environment Canada, 2011b) were used to summarize the biophysical attributes necessary for boreal caribou. Results are categorized by the habitat type (e.g. calving habitat, winter habitat) and are provided by ecozone in order to capture the ecological variation across the current distribution of boreal caribou (see Appendix H). In addition to variation across ecozones, the biophysical attributes necessary for boreal caribou will vary both between and within ranges. For certain ranges, more specific information was made available to describe biophysical attributes and this has been included in Appendix H.

7.2 Schedule of Studies

A schedule of studies is required under SARA where available information is inadequate to identify critical habitat. The schedule of studies outlines the essential studies required to identify the critical habitat necessary to meet the population and distribution objectives for boreal caribou set in this recovery strategy.

There is evidence suggesting that fire does cause stress on boreal caribou local populations when the proportion of the range disturbed by fire is high. Precaution around the additional effects of

anthropogenic disturbance in boreal caribou ranges that experience high levels of fire is necessary. Additional population trend data is required to understand the relationship between disturbance and boreal caribou survival in ranges with high fire and very low anthropogenic disturbance. This disturbance relationship occurs in northern Saskatchewan's Boreal Shield range (SK1).

The following schedule of studies is required to complete the identification of critical habitat in the Boreal Shield range in northern Saskatchewan (SK1).

Table 6. Schedule of studies required to complete the identification of critical habitat in the Boreal Shield range (SK1) in northern Saskatchewan.

Description of Activity	Rationale	Timeline
Collect population information (size, trend, etc.) for a minimum of 2 years in SK1 where population condition is unknown.	The effect of a high fire and very low anthropogenic disturbance habitat condition on the SK1 local population is unknown. These activities will provide the necessary information to identify critical habitat.	Population data collected and critical habitat identified for SK1 by end of 2016.
Update disturbance model in Environment Canada's Scientific Assessment (2011b) by including population information for SK1 to incorporate situations of high fire and very low anthropogenic disturbance.		
Identification of critical habitat in SK1.		

7.3 Activities Likely to Result in the Destruction of Critical Habitat

SARA requires that a recovery strategy identify examples of activities likely to destroy critical habitat. Destruction is determined on a case by case basis. Destruction would result if part of the critical habitat were degraded, either permanently or temporarily, such that it would not serve its function when needed by boreal caribou. Destruction may result from a single activity, multiple activities at one point in time, or from the cumulative effects of one or more activities over time (Government of Canada, 2009).

Activities that are likely to result in the destruction of critical habitat, include, but are not limited to, the following:

- Any activity resulting in the direct loss of boreal caribou critical habitat. Examples of such activities include: conversion of habitat to agriculture, forestry cut blocks, mines, and industrial and infrastructure development.
- Any activity resulting in the degradation of critical habitat leading to a reduced, but not total loss of both habitat quality and availability for boreal caribou. Examples of such activities include: pollution, drainage of an area, and flooding.

- Any activity resulting in the fragmentation of habitat by human-made linear features. Examples of such activities include: road development, seismic lines, pipelines, and hydroelectric corridors.

The likelihood that critical habitat will be destroyed is increased if any one of these activities, or combination thereof, were to occur in such a manner, place and time, that after appropriate mitigation techniques (see Appendix I) any one of the following were to occur:

- compromise the ability of a range to be maintained at 65% undisturbed habitat;
- compromise the ability of a range to be restored to 65% undisturbed habitat;
- reduce connectivity within a range;
- increase predator and/or alternate prey access to undisturbed areas; or
- remove or alter biophysical attributes necessary for boreal caribou.

A single project/activity may or may not result in the destruction of critical habitat; however, when considered in the context of all current and future development activities within and among ranges, the cumulative impacts may result in the destruction of critical habitat.

Mitigation of adverse effects from individual projects/activities will require a coordinated approach and management of cumulative effects within and among ranges. A cumulative effects assessment is essential to position the proposed project/activity in the context of all current and future development activities. The cumulative effects assessment will:

- assess the impact of all disturbances (anthropogenic and natural) at the range-scale;
- monitor habitat conditions, including the amount of current disturbed and undisturbed habitat (see Section 4.2.1), and amount of habitat being restored;
- account for planned disturbances; and
- assess the distribution of disturbance in large ranges for risk of range retraction in parts of the range.

For large continuous ranges, a different approach for assessing cumulative effects will be required than for smaller discrete ranges. Dividing the large areas into smaller management units will allow land managers to understand where the disturbance is occurring and avoid irreversible range retraction and a permanent break in range connectivity.

Determination of whether an activity is likely to result in the destruction of critical habitat will be facilitated by a range plan. For example, a range plan would identify activities that are likely to result in direct loss, degradation, and/or fragmentation of habitat, relevant to specific local circumstances. Any development that does not align with the range plan would be considered an activity likely to destroy critical habitat.

7.4 Range Plans

Given the dynamic nature of boreal caribou habitat requirements, the landscape scale at which those requirements operate, and the highly variable present-day land management and ecological conditions that exist among all boreal caribou ranges, range-specific approaches to protecting critical habitat, and in many cases improving the condition of critical habitat for this species, are needed.

In light of jurisdictional responsibilities for land and natural resource management, it is expected that they will develop range plans. In areas where the responsibility for land and natural resource management varies, range plans will be developed collaboratively between all responsible authorities. Range plans may be stand-alone documents, or part of other planning documents including action plans.

Range plans will outline how the given range will be managed to maintain or attain a minimum of 65% undisturbed habitat over time. Specifically each range plan should reflect disturbance patterns on the landscape, as measured and updated by the provinces and territories, and outline measures and steps that will be taken to manage the interaction between human disturbance and natural disturbance.

Difference between a range plan and an action plan

Action plans, which are required under SARA, provide the public and stakeholders with details on how the recovery strategy will be implemented. Action plans include a broad spectrum of subjects, such as: measures to address threats and to achieve population and distribution objectives; an evaluation of socio-economic costs and benefits to be derived from its implementation; and an approach for monitoring and reporting, etc. An action plan is not necessarily range-specific; it could cover multiple ranges or even specific recovery measures within a range. Range plans are documents that outline how a given range will be managed to ensure that critical habitat is protected from destruction.

Purpose of a range plan

The main purpose of a range plan is to outline how range-specific land and/or resource activities will be managed over space and time to ensure that critical habitat is protected from destruction. As such, each range plan should reflect disturbance patterns on the landscape, as measured and updated by the provinces and territories, and outline the measures and steps that will be taken to manage the interaction between human disturbance, natural disturbance, and the need to maintain or establish an ongoing, dynamic state of a minimum of 65% of the range as undisturbed habitat at any point in time to achieve or maintain a self-sustaining local population. While the general ecological principles and critical habitat dynamics described in the recovery strategy apply to all ranges, individual ranges also possess a unique mix of ecological and land use conditions (e.g. population condition, habitat condition and configuration, social and legal arrangements) that must be factored into decision making.

The range plans, consistent with this recovery strategy, will be one factor considered by the Minister of the Environment in forming an opinion on whether the laws of the province or

territory effectively protect critical habitat within each boreal caribou range. As such, range plans should contain the background information necessary for the Minister of the Environment to make an informed assessment of whether critical habitat protection is in place or is being realistically pursued throughout the range. Specifically, range plans should indicate what laws of the province or territory, legislative and/or regulatory provisions, licences or other instruments issued under an Act or regulation, or contractually binding agreements the jurisdiction intends to use to protect critical habitat. In the absence of range plans, the minister will use the best available information and consult with the jurisdiction to determine whether critical habitat is effectively protected. If the minister is of the opinion that there are no provisions in or measures under SARA or another Act of Parliament that protect the critical habitat (including a section 11 agreement) and the laws of the provinces and territories do not effectively protect their critical habitat, the Minister of the Environment is required to recommend that a protection order be made to the to the Governor in Council.

Range plans may form part of an action plan under SARA. However, in order to be adopted in whole or in part as an action plan by the Minister of the Environment, the range plan and the process used to develop it will need to meet the requirements of section 48 (cooperation) and section 49 (content) of SARA. In addition, range plans will be used to inform reporting that is required under SARA on implementation and progress toward meeting the population and distribution objectives of this recovery strategy. Finally, range plans may be used to inform decisions related to environmental assessments, issuance of permits (either under SARA or other applicable legislation), and other similar approval processes.

Process for developing a range plan

The development of each range plan will be led by the responsible provincial or territorial jurisdiction. In areas where the management responsibility for land and natural resource management varies, range plans will likely be multi-jurisdictional led between all responsible authorities. Range plans should be developed in a collaborative manner with directly affected stakeholders. Jurisdictions should also apply the appropriate level of cooperation with Aboriginal people as they would in any other resource management planning process that is undertaken within their province or territory. The exact process of collaboration that is used is the responsibility of each jurisdiction and may vary between jurisdictions.

Range plans may be updated by the jurisdictions over time to reflect changes in habitat and population conditions for any given range. In particular, range plans should be updated following any significant natural disturbance event (e.g. forest fires).

Timelines for the development of a range plan

Given the variation in management contexts, population and habitat information, and levels of risk across the geographic distribution of boreal caribou, range plans should be completed by the responsible jurisdiction(s) within 3-5 years of the posting of this recovery strategy.

What should be included in a range plan?

There is no single prescriptive approach to developing a range plan, and jurisdictions may select those approaches they consider most appropriate. Range plans should include such things as:

- Demonstration of how at least 65% undisturbed habitat in the range will be achieved and/or maintained over time;
- List of the laws of the province or territory (including any corresponding regulations, permits, licenses, etc.) and conservation measures (such as agreements, programs, compliance incentives, conservation leases, etc.) that will be used to prevent activities likely to destroy critical habitat;
 - Include land tenure assessment for all areas of critical habitat within each range
 - Where protection measures do not exist, the range plan should indicate the steps being taken to put them in place and the expected timeline for implementation
- Information on range-specific activities likely to destroy critical habitat within each range. This will involve identifying and assessing current projects/activities as well as any foreseeable future projects/activities, and should include a cumulative effects analysis;
- An approach for measuring disturbance to the landscape and monitoring critical habitat to ensure that protection mechanisms are in place and are working to prevent the destruction of boreal caribou critical habitat;
- An approach for monitoring population trends to ensure that local populations are responding positively to management techniques;
- An approach for monitoring natural disturbances, and habitat quality and quantity; and
- Identification of information needs and plans for addressing information gaps.

8 MEASURING PROGRESS

Under SARA, the competent minister must report on the implementation of a recovery strategy and the progress towards meeting its objectives every five years. Population and habitat conditions for boreal caribou will change over time given the changes to population demographics, the dynamic nature of the boreal ecosystem and the manner in which the species shifts in its use of the landscape over time. Accordingly, the five-year time frame for reporting on implementation allows for these changes to be included in an updated recovery strategy, and for subsequent range plans and action plans to be updated under an adaptive management framework.

Monitoring of boreal caribou local populations based on performance indicators will be essential to have the information necessary to evaluate the effectiveness of management actions and to make necessary adjustments through an adaptive management process over time.

8.1 Adaptive Management

The process of adaptive management planning and implementation acknowledges and supports the adjustment of management actions in light of new or more refined knowledge. Through adaptive management, knowledge gaps and uncertainties are identified, evaluated, and reported as information needs, addressed through monitoring and research, and then implemented through revised and improved management actions.

The challenge of achieving the recovery goal of self-sustaining local populations of boreal caribou will vary by boreal caribou range given the habitat and population conditions and management context associated with each range. In order to ensure adaptive management is applied to boreal caribou recovery, cooperation with federal, provincial and territorial jurisdictions, wildlife management boards, Aboriginal people, and others involved in the conservation, survival and recovery of boreal caribou is required.

8.2 Performance Indicators

The performance indicators presented below provide a way to define and measure progress toward achieving the population and distribution objectives.

The ultimate performance indicator of boreal caribou recovery is self-sustaining local populations throughout the entirety of their distribution in Canada. Performance indicators for this recovery strategy are that the population and distribution objective is met for each boreal caribou range, and that boreal caribou become less at risk. Recovery of all boreal caribou local populations is technically and biologically feasible; however given the challenges of recovery for boreal caribou, some local populations that are currently not self-sustaining will likely require a number of decades to return to a recovered state.

The performance indicators described below are provided as national guidelines to gauge the successful implementation of the recovery strategy. More detailed performance indicators that

reflect the specific local conditions (e.g. population condition, habitat condition, alternate prey/predator dynamics, mortality rates) of each boreal caribou range will need to be developed at the range plan and/or action plan stage.

General:

- a) Complete range plans for each range within 3-5 years of the posting of this recovery strategy (see Section 7.4).

Population Condition (population trend and size):

- a) Maintain current distribution of boreal caribou across Canada.
- b) Achieve and/or maintain a stable to increasing population trend as measured over five years (i.e. $\lambda \geq \text{stable}$) or other empirical data that indicates population trend is stable or increasing.
- c) Achieve a minimum of 100 animals for boreal caribou ranges with population estimates of less than 100 animals, or show progress towards this goal every five years.

Habitat Condition (amount and type of undisturbed habitat):

- a) For ranges with 65% or more undisturbed habitat, maintain the undisturbed habitat that includes the biophysical attributes needed for boreal caribou to carry out life processes at a minimum of 65% of the total range.
- b) For ranges with less than 65% undisturbed habitat, identify in a range and/or action plan specific areas of existing undisturbed habitat, as well as those areas where future habitat is to be restored to an undisturbed condition over reasonable, gradual increments every five years.
- c) Provide measurements of disturbance for each range that reflect the best available information, as provided by the provinces and territories, to update the recovery strategy accordingly every five years.

9 STATEMENT ON ACTION PLANS

As required by SARA, the Minister of the Environment will complete one or more action plans under this recovery strategy by December 31, 2015. These action plans will provide information on recovery measures that should be taken by Environment Canada and other federal government departments and agencies including Parks Canada Agency, Aboriginal Affairs and Northern Development Canada, Department of National Defence and the Canadian Forces among others, provincial and territorial jurisdictions, wildlife management boards, Aboriginal people, stakeholders and other organizations involved in the conservation, survival and recovery of boreal caribou. Action plans provide the public and stakeholders with details on how the recovery strategy will be implemented. Action plans include a broad spectrum of subjects, such as: measures to address threats and to achieve population and distribution objectives; an evaluation of socio-economic costs and benefits to be derived from its implementation; and an approach for monitoring and reporting. An action plan is not necessarily range-specific; instead it could cover multiple ranges.

Range plans are documents that outline how the habitat condition within a given range will be managed over time and space to ensure that critical habitat for boreal caribou is protected from destruction and therein, that each local population will either continue to be self-sustaining or become self-sustaining over time.

The Minister of the Environment may adopt or incorporate parts of a range plan, an existing provincial or territorial plan, or other relevant planning documents that meet the requirements of SARA as an action plan. Where the Minister of the Environment proposes to adopt an existing plan or a portion of it as a SARA action plan, it will be posted on the Species at Risk Public Registry for the prescribed 60-day comment period. Within 30 days after the expiry of the comment period, and considering the comments received, the minister will publish a final action plan.

9.1 Coordinated Approach

9.1.1 Provincial and Territorial Jurisdictional Leadership

Provinces and territories have the primary responsibility for management of lands and wildlife within boreal caribou distribution, however this responsibility does vary in some parts of the country. In the Northwest Territories, for example, Aboriginal Affairs and Northern Development Canada also has a significant role to play, as does the Parks Canada Agency where boreal caribou exist within national parks and historic sites.

Range plans and/or action plans will inform broader land-use planning and decision making, and will require substantial inter-agency communication and cooperation. Coordination will be particularly important for range and/or action plans that address boreal caribou recovery in transboundary ranges, and for ensuring connectivity within ranges and across the species current distribution is maintained.

9.1.2 Aboriginal Involvement

The Minister of the Environment must cooperate with affected Aboriginal organizations for recovery strategies and action plans. Across Canada, cooperation with Aboriginal people is key to the success in developing and implementing action plans.

In acknowledgement of the existing Aboriginal and treaty rights of Aboriginal peoples of Canada, and to the extent possible, details of harvesting plans for local populations, consistent with the principles of conservation, will be addressed in range and/or action plans subsequent to this recovery strategy. When applicable, harvesting plans will follow the required process under Land Claim Agreements or provincial/territorial laws. Aboriginal involvement will be required to determine population targets that ensure stable boreal caribou local populations are maintained and recovery of local populations that are not self-sustaining is achieved, while providing for traditional harvesting practices consistent with conservation and existing Aboriginal and treaty rights of Aboriginal peoples of Canada.

9.1.3 Stakeholder Engagement

Success in the recovery of this species depends on the commitment, collaboration, and cooperation of many different constituencies that will be involved in implementing the broad strategies and general approaches set out in this recovery strategy and will not be achieved by Environment Canada, or any other jurisdiction, alone. All stakeholders, including the industry sector, environmental organizations, and private landowners should be engaged where appropriate in developing and implementing action plans.

9.2 Range Specific Actions

The recovery of boreal caribou requires actions that will vary by individual boreal caribou range based on the population and habitat conditions. Each range will require a range-specific path forward for the recovery of boreal caribou. As described under Section 7.4, range plans and/or action plans are needed to guide protection and management of critical habitat, and overall recovery actions, in each boreal caribou range.

Range plans describe how critical habitat will be protected. These jurisdictionally-led range plans will be produced for each range within 3-5 years of the posting of this recovery strategy. In the absence of a range plan, the Minister of the Environment will use the best available information and consult with the jurisdiction to make a determination on the state of protection of critical habitat for boreal caribou.

9.2.1 Habitat and Population Management

The broad strategies and general approaches to meet the population and distribution objectives (see Section 6), as set out in this recovery strategy, will inform the development of subsequent range plans and action plans, where detailed local-level planning will occur to guide the implementation of recovery actions.

The broad strategies and general approaches are designed to guide range and action planning based on the state of each boreal caribou range. Many approaches and strategic directions are inter-related and should be implemented as described in the range plans and action plans. Generally, for self-sustaining local populations, minimal management actions may be necessary, and strategically planned development could take place without threatening boreal caribou and the status of the local population. Where local populations are not self-sustaining, specific management action is needed, in some cases for many decades, until sufficient habitat is restored and the population condition is improved. Mortality management, including predator and alternate prey management, may be needed to help prevent extirpation of a boreal caribou local population in the interim while habitat management efforts are underway to restore the ecological conditions of the range necessary to support a self-sustaining local population.

Jurisdictions are accountable for the long-term planning and management of boreal caribou ranges with the implementation of different habitat and population management tools available at their discretion, depending on the specific local conditions. The implementation of habitat management practices, such as fire suppression, and mortality management practices, such as predator control, are at the discretion of jurisdictions, and the application of these tools will vary in accordance with jurisdictional policies and procedures.

10 GLOSSARY

Note: The following terms are defined in accordance with their use in this document.

Aboriginal Traditional Knowledge (ATK): ATK includes, but is not limited to, the knowledge Aboriginal peoples have accumulated about wildlife species and their environment. Much of this knowledge has accumulated over many generations.

Anthropogenic: caused by human activity.

Biological feasibility: recovery is determined to be biologically feasible under the following circumstances: individuals of the wildlife species that are capable of reproduction are available now or in the foreseeable future to sustain the population or improve its abundance; sufficient suitable habitat is available to support the species or could be made available through habitat management or restoration; and primary threats to the species or its habitat can be avoided or mitigated.

Biophysical attributes: habitat characteristics required by boreal caribou to carry out life processes necessary for survival and recovery (see Appendix H).

Current distribution (extent of occurrence): the area that encompasses the geographic distribution of all known boreal caribou ranges, based on provincial and territorial distribution maps developed from observation and telemetry data, local knowledge (including in some cases Aboriginal Traditional Knowledge), and biophysical analyses.

Disturbance management threshold: at the scale of boreal caribou range, the habitat disturbance point below which conditions are such that the recovery goal will likely be met (i.e. acceptable level of risk), and above which the outcome is either highly uncertain or unacceptable.

Disturbed habitat: habitat showing: i) anthropogenic disturbance visible on Landsat at a scale of 1:50,000, including habitat within a 500 m buffer of the anthropogenic disturbance; and/or ii) fire disturbance in the last 40 years, as identified in data from each provincial and territorial jurisdiction (without buffer).

Existing habitat: the entire boreal caribou range area minus permanent alterations. See also *permanent alterations*.

Local population: a group of boreal caribou occupying a defined area distinguished spatially from areas occupied by other groups of boreal caribou. Local population dynamics are driven primarily by local factors affecting birth and death rates, rather than immigration or emigration among groups.

In this recovery strategy, “local population” refers to a group of boreal caribou occupying any of the three types of boreal caribou ranges (i.e. conservation unit, improved conservation unit, local population unit). See also *range*.

Not self-sustaining local population: in the population and distribution objectives “not self-sustaining local population” includes both the local populations assessed as “as likely as not self-sustaining” and those assessed as “not self-sustaining”.

Permanent alterations: existing features found within a range, such as industrial and urban developments, permanent infrastructure, and graded or paved roads that do not currently possess or have the potential to possess the biophysical attributes of critical habitat for boreal caribou.

Quasi-extinction: a population with less than 10 reproductively active females.

Range: the geographic area occupied by a group of individuals that are subject to similar factors affecting their demography and used to satisfy their life history processes (e.g. calving, rutting, wintering) over a defined time frame. Environment Canada (2011b) identified three types of boreal caribou ranges categorized based on the degree of certainty in the delineated range boundaries (i.e. conservation unit, improved conservation unit, local population unit).

Range plan: a document that demonstrates how the habitat condition within a given range will be managed over time and space to ensure that critical habitat for boreal caribou is protected from destruction and therein, that each local population will either continue to be self-sustaining or become self-sustaining over time.

Self-sustaining local population: a local population of boreal caribou that on average demonstrates stable or positive population growth over the short-term (≤ 20 years), and is large enough to withstand stochastic events and persist over the long-term (≥ 50 years), without the need for ongoing active management intervention.

Technical feasibility: recovery is determined to be technically feasible when recovery techniques exist to achieve the population and distribution objectives or can be expected to be developed within a reasonable timeframe.

To the extent possible: current evidence supports the conclusion that the recovery of all local populations is technically and biologically feasible. There may be situations where recovery of a particular local population proves to be, over time and through unforeseen circumstances, not biologically or technically feasible and as such may affect the likelihood of achieving the population and distribution objectives for some local populations.

Undisturbed habitat: habitat not showing any: i) anthropogenic disturbance visible on Landsat at a scale of 1:50,000, including habitat within a 500 m buffer of the anthropogenic disturbance; and/or ii) fire disturbance in the last 40 years, as identified in data from each provincial and territorial jurisdiction (without buffer). Disturbance within the 500 m buffer would result in a reduction of the undisturbed habitat.

11 REFERENCES

- Adams, L.G., B.W. Dale, and L.D. Mech. 1995. Wolf predation on caribou calves in Denali National Park, Alaska. *In* Carbyn, L.N., S.H. Fritts and D.R. Seip (editors). *Ecology and Conservation of Wolves in a Changing World*. Canadian Circumpolar Institute, Occasional Publication no. 35, Edmonton, Alberta.
- Badiou, P., S. Boutin, M. Carlson, M. Darveau, P. Drapeau, J. Jacobs, C. Johnson, J. Kerr, M. Manseau, P. McLoughlin, G. Orians, S. Pimm, P. Raven, D. Roberts, T. Root, N. Roulet, J. Schaefer, D. Schindler, M. St-Laurent, J. Strittholt, N. Turner, A. Weaver, and J. Wells. 2011. Keeping woodland caribou in the boreal forest: Big challenge, immense opportunity. International Boreal Conservation Science Panel. 12 pp.
- Banfield, A.W.F. 1974. *Mammals of Canada*. University of Toronto Press. Toronto, Ontario. 438 pp.
- Bergerud, A.T. 1967. Management of Labrador caribou. *Journal of Wildlife Management* 31: 626-642.
- Bergerud, A.T. 1974. Decline of caribou in North America following settlement. *Journal of Wildlife Management* 38:757-770.
- Bergerud, A.T. 1978. The status and management of Woodland Caribou in British Columbia. Report to Fish and Wildlife Branch, Government of British Columbia. Victoria, British Columbia. 138 pp.
- Bergerud, A.T. 1980. A review of the population dynamics of caribou and wild reindeer in North America. *In* D. Reimers, E. Gaare, and S. Skenneberg (editors). *Proceedings of the 2nd International Reindeer/Caribou Symposium*, Roros, Norway.
- Bergerud, A.T. 1988. Caribou, wolves and man. *Trends in Ecology & Evolution* 3:68-72.
- Bergerud, A.T. 1996. Evolving perspectives on caribou population dynamics: have we got it right yet? *Rangifer Special Issue* No. 9. pp. 95-115.
- Bergerud, A.T. 2000. Caribou. *In* S. Demarais and P.R. Krausman (Editors). *Ecology and Management of Large Mammals in North America*. Prentice Hall, Upper Saddle River, New Jersey.
- Bergerud, A.T., R.D. Jakimchuk, and D.R. Carruthers. 1984. The buffalo of the north: caribou (*Rangifer tarandus*) and human developments. *Arctic* 37: 7-22.
- Bergerud, A.T., and J.P. Elliot. 1986. Dynamics of caribou and wolves in northern British Columbia. *Canadian Journal of Zoology* 64: 1515-1529.
- Bergerud, A.T., and R.E. Page. 1987. Displacement and dispersal of parturient caribou at calving as antipredator tactics. *Canadian Journal of Zoology* 62: 1566-1575.

- Bergerud, A.T., R.S. Ferguson, and H.E. Butler. 1990. Spring migration and dispersion of Woodland Caribou at calving. *Animal Behaviour* 39: 360-368.
- Boertje, R.D., P. Valkenburg, and M.E. McNay. 1996. Increases in moose, caribou, and wolves following wolf control in Alaska. *Journal of Wildlife Management* 60: 474-489.
- Boreal Caribou Aboriginal Traditional Knowledge (ATK) Reports. 2010-2011. Compiled June 2011. Ottawa: Environment Canada.
- Bradshaw, C.J.A., D. M. Hebert, A.B. Rippin, and S. Boutin. 1995. Winter peat land habitat selection by Woodland Caribou in northeastern Alberta. *Canadian Journal of Zoology* 73: 1567-1574.
- Bradshaw, C.J.A., S. Boutin, and D.M. Hebert. 1998. Energetic implications of disturbance caused by petroleum exploration to Woodland Caribou 76: 1319-1324.
- Brown, G.S., F.F. Mallory, and W.J. Rettie. 2003. Range size and seasonal movement for female Woodland Caribou in the boreal forest of northeastern Ontario. *Rangifer Special Issue* No. 14: 227-233.
- Brown, G.S., W.J. Rettie, R.J. Brooks, and F.F. Mallory. 2007. Predicting the impacts of forest management on woodland caribou habitat suitability in black spruce boreal forest. *Forest Ecology and Management* 245: 137-147.
- Brown, W.K., J. Huot, P. Lamothe, S.N. Luttich, M. Pare, G. St.Martin, and J.B. Theberge. 1986. The distribution and movement patterns of four Woodland Caribou herds in Québec and Labrador. *Rangifer Special Issue* No. 1: 43-49.
- Brown, W.K., and J.B. Théberge. 1990. The effect of extreme snow cover on feeding-site selection by Woodland Caribou. *Journal of Wildlife Management* 54: 161-168.
- Brown, W.K., and D.P. Hobson. 1998. Caribou in west-central Alberta - information review and synthesis. Terrestrial & Aquatic Environmental Managers, Calgary, Alberta.
- Callaghan, C., S. Virc, and J. Duffe. 2010. Woodland Caribou, boreal population, trends in Canada. Technical Thematic Report No. 11. In *Canadian Biodiversity: Ecosystem Status and Trends 2010*.
- Caughley, G. 1994. Directions in conservation biology. *Journal of Animal Ecology* 63: 15-244.
- Caughley, G., and A. Gunn. 1996. Conservation Biology in Theory and Practice. Blackwell Science, Cambridge, Massachusetts, USA. 459 pp.
- Chabot, A. 2011. Suivi télémétrique et stratégie générale d'aménagement de l'habitat des caribous forestiers du Nitassinan de la Première Nation innue d'Essipit. Rapport du Groupe-Conseil AGIR inc., présenté au Conseil de la Première Nation innue d'Essipit. 43 p. et 1 annexe.

- Chubbs, T.E., L.B. Keith, S.P. Mahoney, and M.J. McGrath. 1993. Response of Woodland Caribou (*Rangifer tarandus*) to clear-cutting in east-central Newfoundland. *Canadian Journal of Zoology* 71: 487-493.
- Courbin, N., D. Fortin, C. Dussault, and R. Courtois. 2009. Landscape management for Woodland Caribou: the protection of forest blocks influences wolf-caribou co-occurrence. *Landscape Ecology* 24: 1375-1388.
- Courtois, R. 2003. La conservation du caribou forestier dans un contexte de perte d'habitat et de fragmentation du milieu. Ph.D. thesis, Université du Québec à Rimouski. 350 pp.
- Courtois, R., L. Bernatchez, J.-P. Ouellet, and L. Breton. 2003. Significance of caribou (*Rangifer tarandus*) ecotypes from a molecular genetics viewpoint. *Conservation Genetics* 4: 393-364.
- Courtois, R., and J.-P. Ouellet. 2007. Modeling the impact of moose and wolf management on persistence of Woodland Caribou. *Alces* 43: 13-27.
- Courtois, R., J.P. Ouellet, L. Breton, A. Gingras, and C. Dussault. 2007. Effects of forest disturbance on density, space use, and mortality of woodland caribou. *Écoscience*, 14: 491-498.
- Creel, S., J.E. Fox, A. Hardy, J. Sands, B. Garrott, and R.O. Peterson. 2002. Snowmobile activity and glucocorticoid stress responses in wolves and elk. *Conservation Biology* 16(3): 809-814.
- Cumming, H.G. 1992. Woodland Caribou: facts for forest managers. *Forestry Chronicles* 68: 481-491.
- Cumming, H.G., and B.T. Hyer. 1998. Experimental log hauling through a traditional caribou wintering area. *Rangifer Special Issue* No. 10: 241-258.
- Dale, B. W., L.G. Adams, and R.T. Bowyer. 1994. Functional response of wolves preying on barren-ground caribou in a multiple-prey ecosystem. *Journal of Animal Ecology* 63(3): 644-652.
- Darby, W.R., and W.O. Pruitt, Jr. 1984. Habitat use, movements and grouping behaviour of Woodland Caribou, *Rangifer tarandus caribou*, in southeastern Manitoba. *Canadian Field Naturalist* 98: 184-190.
- DeMars, C., C. Thiessen, and S. Boutin. 2011. Assessing Spatial Factors Affecting Predation Risk to Boreal Caribou Calves: Implications for Management. University of Alberta and BC Ministry of Natural Resource Operations 1-35.
- 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* 13:469-474.

- Dyer, S.J., J.P. O'Neill, S.M. Wasel, and S. Boutin. 2001. Avoidance of industrial development by Woodland Caribou. *Journal of Wildlife Management* 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. *Canadian Journal of Zoology* 80: 839-845.
- Dzus, E. 2001. Status of the Woodland Caribou (*Rangifer tarandus caribou*) in Alberta. Alberta Environment, Fisheries and Wildlife Division, and Alberta Conservation Association. Wildlife Status Report no. 30. Edmonton, Alberta. 47 pp.
- Dzus, E., J. Ray, I. Thompson, and C. Wedeles, C. 2010. Caribou and the National Boreal Standard: Report of the FSC Canada Science Panel. Toronto, ON, Forest Stewardship Council of Canada.
- Edmonds, E.J. 1988. Population status, distribution, and movements of Woodland Caribou in west central Alberta. *Canadian Journal of Zoology* 66: 815-826.
- Environment Canada. 2008. Scientific Review for the Identification of Critical Habitat for Woodland Caribou (*Rangifer tarandus caribou*), Boreal Population, in Canada. August 2008. Ottawa: Environment Canada. 72pp. plus 80 pp Appendices.
- Environment Canada. 2010. Planning for a Sustainable Future: a Federal Sustainable Development Strategy for Canada. Ottawa: Environment Canada. 75pp.
- Environment Canada. 2011a. Round 1: Report on the Engagement Process with Aboriginal Communities and Stakeholders in the Development of the Proposed Recovery Strategy for Boreal Caribou. Unpublished. Ottawa: Environment Canada. 62pp.
- Environment Canada. 2011b. Scientific Assessment to Support the Identification of Critical Habitat for Woodland Caribou (*Rangifer tarandus caribou*), Boreal Population, in Canada. Ottawa, ON. 115pp. plus Appendices.
- Environment Canada. 2012. What People Have Said on the Proposed Recovery Strategy for Boreal Caribou: A summary of the engagement process, comments received and changes made. Ottawa: Environment Canada. 5pp.
- Festa-Bianchet, M., J.C. Ray, S. Boutin, S.D. Côté, and A. Gunn. 2011. Caribou conservation in Canada: an uncertain future. *Journal of Canadian Zoology* 89: 419-434.
- Gillett, N.P., A.J. Weaver, F.W. Zwiers, and M.D. Flannigan. 2004. Detecting the effect of climate change on Canadian forest fires. *Geophysical Research Letters* 31 (18).
- Government of Canada. 2009. *Species at Risk Act* Policies, Overarching Policy Framework [Draft]. *Species at Risk Act* Policy and Guidelines Series. Environment Canada, Ottawa. 38 pp.

- Gustine, D.D., K.L. Parker, R.J. Lay, N.P. Gillingham, and D. Heard. 2006. Calf survival of woodland caribou in a multipredator ecosystem. *Wildlife Monographs* 165:1–32
- Harrington, F.H., and A.M. Veitch. 1991. Short-term impacts of low-level jet fighter training on caribou in Labrador. *Arctic* 44: 318-327.
- James, A.R.C., and A.K. Stuart-Smith. 2000. Distribution of caribou and wolves in relation to linear features. *Journal of Wildlife Management* 64: 154-159.
- Johnson, C.J., K. L. Parker, and D.C. Heard. 2001. Foraging across a variable landscape: behavioural decisions made by Woodland Caribou at multiple spatial scales. *Oecologia* 127(4): 590 – 602.
- Johnston, M. 2009. Vulnerability of Canada's Tree Species to Climate Change and Management Options for Adaptation: An Overview for Policy Makers and Practitioners. Canadian Council of Forest Ministers. 44 pp.
- Johnston, M. 2010. Tree Species Vulnerability and Adaptation to Climate Change: Final Technical Report. Saskatchewan Research Council, June 2010.
- Kelsall, J.P. 1968. The migratory barren-ground caribou of Canada. Monograph no.3, Canadian Wildlife Service, Indian Affairs and Northern Development. Queen's Printer, Ottawa, Ontario. 339 pp.
- Lander, C.A. 2006. Distribution and movement of Woodland Caribou on disturbed landscapes in Manitoba. M.Sc. Thesis, Natural Resources Institute, University of Manitoba, Winnipeg, Manitoba.
- Mahoney, S.P., and J.A. Schaefer. 2001. Hydroelectric development and the disruption of migration in caribou. Abstract, 9th North American Caribou Workshop. Kuujuaq, Quebec, April 23-27, 2001.
- McCarthy, S.C., R.B. Weladji, C. Doucet, and P. Saunders. 2011. Woodland caribou calf recruitment in relation to calving/post-calving landscape composition. *Rangifer Special Issue* 31: 35-47.
- McLoughlin, P.D., D. Paetkau, M. Duda, and S. Boutin. 2004. Genetic diversity and relatedness of boreal caribou populations in western Canada. *Biological Conservation* 118: 593-598.
- Moreau, G., D. Fortin, S. Couturier, and T. Duchesne. 2012. Multi-level functional responses for wildlife conservation: the case of threatened caribou in managed boreal forests. *Journal of Applied Ecology* 49: 611-620.
- Nagy, J.A., D.L. Johnson, N.C. Larter, M.W. Campbell, A.E. Derocher, A. Kelly, M. Dumond, D. Allaire, and B. Croft. 2011. Subpopulation structure of caribou (*Rangifer tarandus* L.) in arctic and subarctic Canada. *Ecological Applications* 21:2334–2348.

- Neufeld, L.M. 2006. Spatial dynamics of wolves and Woodland Caribou in an industrial forest landscape in west-central Alberta. M.Sc. Thesis. University of Alberta, Edmonton, Alberta.
- Ontario Woodland Caribou Recovery Team. 2008. Woodland Caribou (*Rangifer tarandus caribou*) (Forest-dwelling, Boreal Population) in Ontario. Prepared for the Ontario Ministry of Natural Resources, Peterborough, Ontario. 93pp.
- Pinard, V., C. Dussault, J. Ouellet, D. Fortin, and R. Courtois. 2012. Calving rate, calf survival rate, and habitat selection of forest-dwelling caribou in a highly managed landscape. *The Journal of Wildlife Management* 76: 189-199.
- Pither, R., M. Manseau, J. Clark, M. Ball, P. Wilson, and A. Arsenault. 2006. Relating the population genetic structure of Woodland Caribou to landscape connectivity. 11th North American Caribou Workshop. Jasper, Alberta, Canada. April 23-27, 2006.
- Pitt, W.C., and R.A. Jordan. 1994. A survey of the nematode parasite *Parelaphostrongylus tenuis* in the white-tailed deer, *Odocoileus virginianus*, in a region proposed for caribou, *Rangifer tarandus caribou*, re-introduction in Minnesota. *Canadian Field-Naturalist* 108: 341-346.
- Podur, J., D. L. Martell, and K. Knight. 2002. Statistical quality control analysis of forest fire activity in Canada. *Canadian Journal of Forest Research* 32: 195- 205.
- 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., and T. Armstrong. 2000. Woodland Caribou range occupancy in northwestern Ontario: past and present. *Rangifer Special Issue* No. 12:153-184.
- Ray, J. 2011. Biological Considerations for Recovery Objectives for Boreal caribou in Canada. Wildlife Conservation Society Canada, Toronto, Ontario.
- Redford, K.H., G. Amato, J. Baillie, P. Beldomenico, E.L. Bennett, N. Clum, R. Cook, G. Fonseca, S. Hedges, F. Launay, S. Lieberman, G.M. Mace, A. Murayama, A. Putnam, J.G. Robinson, H. Rosenbaum, E.W. Sanderson, S.N. Stuart, P. Thomas, and J. Thorbjarnarson. 2011. What does it mean to successfully conserve a (vertebrate) species? *BioScience* 61(1): 39-48.
- Rettie, W.J., and F. Messier. 1998. Dynamics of Woodland Caribou populations at the southern limit of their range in Saskatchewan. *Canadian Journal of Zoology* 76:257-259.
- Rettie, W.J., and F. Messier. 2000. Hierarchical habitat selection by Woodland Caribou: its relationship to limiting factors. *Ecography* 23: 466-478.
- Rettie, W.J., and F. Messier. 2001. Range use and movement rates of Woodland Caribou in Saskatchewan. *Canadian Journal of Zoology* 79:1933-1936.
- Richie, C. 2008. Management and challenges of the mountain pine beetle infestation in British Columbia. *Alces* 44: 127-135.

- Safer, D.J., and F.K.A. Schmiegelow. 2005. Movement pathways and habitat selection by woodland caribou during spring migration. *Rangifer Special Issue* No.16: 143-154.
- Sapolsky, R. 1992. Neuroendocrinology of the stress response. Pages 287-324 in J.B. Becker, S. M. Breedlove and D. Crews (Editors). *Behavioural Endocrinology*. MIT Press, Cambridge, Massachusetts.
- Schaefer, J.A. 2003. Long-term range recession and the persistence of caribou on the taiga. *Conservation Biology* 15: 1435-1439.
- Schaefer, J.A., and W.O. Pruitt, Jr. 1991. Fire and Woodland Caribou in southwestern Manitoba. *Wildlife Monographs* 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. *Journal of Wildlife Management* 63(2): 580-587.
- Schmelzer, I., J. Brazil, T. Chubbs, S. French, B. Hearn, R. Jeffery, L. LeDrew, H. Martin, A. McNeill, R. Nuna, R. Otto, F. Phillips, G. Mitchell, G. Pittman, N. Simon, and G. Yetman. 2004. Recovery Strategy for Three Woodland Caribou Herds (*Rangifer tarandus caribou*; Boreal Population) in Labrador. Newfoundland and Labrador Department of Environment and Conservation, Corner Brook, Newfoundland and Labrador.
- Schwartz C.C., and A.W. Franzmann. 1989. Bears, wolves, moose, and forest succession, some management considerations on the Kenai Peninsula, Alaska. *Alces* 25: 1-10.
- Seip, D.R. 1991. Predation and caribou populations. *Rangifer Special Issue* No.11: 46-52.
- Seip, D.R. 1992. Factors limiting Woodland Caribou populations and their interrelationships with wolves and moose in southeastern British Columbia. *Canadian Journal of Zoology* 70: 1494-1503.
- Skinner, W. R., B. J. Stocks, D. L. Martell, and A. Shabbar. 1999. The association between circulation anomalies in the mid-troposphere and area burned by wildland fire in Canada, *Theoretical and Applied Climatology* 63: 89-105.
- Skinner, W. R., M. D. Flannigan, B. J. Stocks, D.L. Martell, B.M. Wotton, J.B. Todd, J.A. Mason, K.A. Logan, and E.M. Bosch. 2002. A 500 hPa synoptic wildland fire climatology for large Canadian forest fires, 1959– 1996. *Theoretical and Applied Climatology* 71: 157-169.
- 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. *Canadian Journal of Zoology* 78: 1433-1436.
- Stocks, B.J., J. A. Mason, J. B. Todd, E. M. Bosch, B. M. Wotton, B. D. Amiro, M. D. Flannigan, K. G. Hirsch, K. A. Logan, D. L. Martell, and W. R. Skinner. 2003. *Journal of Geophysical Research* 108 (D1), 8149, doi:10.1029/ 2001JD000484.

- Stuart-Smith, A.K., C.J.A. Bradshaw, S. Boutin, D.M. Hebert, and A.B. Rippin. 1997. Woodland Caribou relative to landscape pattern in northeastern Alberta. *Journal of Wildlife Management* 61: 622-633.
- Telfer, E.S. 1978. Cervid distribution, browse and snow cover in Alberta. *Journal of Wildlife Management* 42: 352-361.
- Thomas, D.C., and H.J. Armbruster. 1996. Woodland Caribou Habitat Studies in Saskatchewan: Second Annual Report Including Some Preliminary Recommendations. Environment Canada, Canadian Wildlife Service, Edmonton, Alberta.
- 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. 1-98 pp.
- Toupin, B., J. Huot, and M. Manseau. 1995. Effect of insect harassment on the behaviour of the Rivière George caribou. *Arctic* 49(4): 375-382.
- Tyler, N.C. 1991. Short-term behavioural responses of Svalbard reindeer (*Rangifer tarandus*) to direct provocation by a snowmobile. *Biological Conservation* 56: 159-194.
- Vandal, D., and C. Barrette. 1985. Snow depth and feeding interaction at snow craters in Woodland Caribou. Pages 199–212 in T.C. Meredith and A.M. Martell (editors). Proceedings of the Second North American Caribou Workshop, Val Morin, Quebec, 15–20 October 1984. McGill Subarctic Research Papers no. 36, Centre for Northern Studies and Research, McGill University, Montreal, Quebec.
- Van Wagner, C. E. 1988. The historical pattern of annual burned area in Canada. *Forestry Chronicle* 64: 182-185.
- Vors, L.S., J.A. Schaefer, B.A. Pond, A.R. Rogers, and B.R. Patterson. 2007. Woodland Caribou extirpation and anthropogenic landscape disturbance in Ontario. *Journal of Wildlife Management* 71:1249-1256.
- Vors, L.S., and M.S. Boyce. 2009. Global declines of caribou and reindeer. *Global Change Biology* 15: 2626-2633.
- Weckworth, B.V., M. Musiani, A. McDevitt, M. Hebblewhite, and S. Mariani. 2012. Reconstruction of caribou evolutionary history in western North America and its implications for conservation. *Molecular Ecology*, In press.
- Weclaw, P., and R.J. Hudson. 2004. Simulation of conservation and management of Woodland Caribou. *Ecological Modelling* 157: 75-94.
- Whitefeather Forest. 2006. Keeping Woodland Caribou on the land: Cross-cultural research in the Whitefeather forest. Whitefeather Forest Management Corporation. Draft Report: June 16, 2006. pp.43.

- Whittington, J., M. Hebblewhite, N.J. DeCesare, L. Neufeld, M. Bradley, J. Wilmshurst, and M. Musiani. 2011. Caribou encounters with wolves increase near roads and trails: a time-to-event approach. *Journal of Applied Ecology* 48: 1535–1542.
- Wittmer, H.U., B.N. McLellan, D.R. Seip, J.A. Young, T.A. Kinley, G.S. Watts, and D. Hamilton. 2005. Population dynamics of the endangered mountain ecotype of Woodland Caribou (*Rangifer tarandus caribou*) in British Columbia, Canada. *Canadian Journal of Zoology* 83: 367-418.