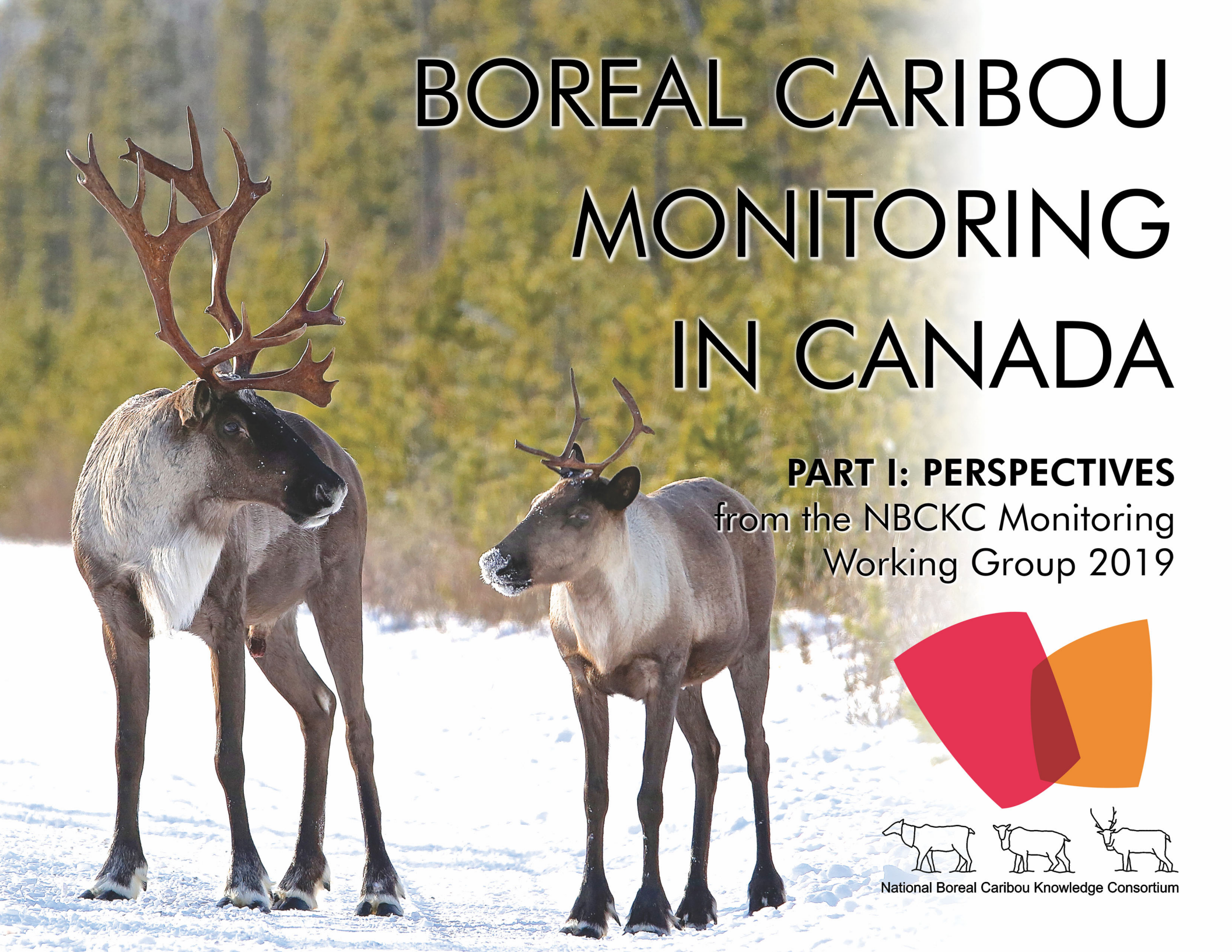


BOREAL CARIBOU MONITORING IN CANADA

PART I: PERSPECTIVES
from the NBCKC Monitoring Working Group 2019

National Boreal Caribou Knowledge Consortium

EXECUTIVE SUMMARY

Monitoring of the Threatened woodland caribou (*Rangifer tarandus caribou*) boreal population (hereafter boreal caribou) presents many challenges, as boreal caribou are broadly distributed in densely-vegetated areas, at low density. Several bodies including Indigenous, federal, provincial and territorial governments are responsible for their conservation and management. Boreal caribou are also a cultural keystone species for many Indigenous Peoples across Canada who are seeking meaningful involvement in decision-making concerning this species.

The National Boreal Caribou Knowledge Consortium (NBCKC) brings together experts and knowledge holders to collaboratively generate and share knowledge, pool capacity, and address knowledge gaps to inform boreal caribou conservation and recovery. The Monitoring Working Group of the NBCKC was formed in 2018 to investigate monitoring priorities, methods and constraints.

This Monitoring Perspectives (Part I) report summarizes the findings from 37 interviews that were conducted with 48 caribou monitoring experts and knowledge holders representing 33 different governmental and non-governmental organizations across 8 provinces and territories. This report is the first in a series designed to guide boreal caribou monitoring programs across Canada, and contains perspectives compiled from experts and knowledge holders pertaining to techniques, data/knowledge sharing, capacity and budget, and roles of jurisdictions.

The majority of boreal caribou monitoring is conducted at the range level by the provincial and territorial governments, but numerous other groups carry out monitoring at smaller scales. Key metrics currently monitored in most ranges include 'disturbance/occupancy', 'population trend' and 'total population size', metrics that were highlighted in the 2012 federal boreal caribou Recovery Strategy as a means to track progress toward recovery goals, though many additional metrics are also monitored.

Aerial-based survey and telemetry methods are currently the most common approaches to estimating population trend and size of boreal caribou; however, many populations are also monitored through genetic methods, camera-trapping and land-based ways of knowing. The ideal approach likely varies with spatial scale, timeframe and budget.

Some key messages from interviews included:

- Financial resource-limitations are a major challenge to monitoring (>90% of respondents).
- Willingness to share monitoring information is conditional (69%), where conservation risks of public data sharing and sensitivity to Indigenous views on knowledge must be balanced with benefits of transparency in data on threats and recovery efforts.
- Extirpation ("running out of boreal caribou to monitor"; 33%) and funding (33%) are the primary concerns for future monitoring, as well as data quality (11%) and partnerships (8%).
- Outstanding knowledge gaps include general trend information (30%), disturbance-habitat relationships (24%), climate change (9%), health (9%), predator-prey dynamics (9%) and management actions (9%).
- Critical actions to improve boreal caribou monitoring programs include improved collaboration and knowledge sharing (31%), additional resources (25%), increased Indigenous/community involvement (13%), and having defined goals for monitoring programs (13%).

The perspectives compiled through this study established the need for a comprehensive evaluation of monitoring methods for boreal caribou, including consideration of Indigenous Knowledge systems and of monitoring costs and logistical constraints. These topics will be addressed in future NBCKC documents, including the Monitoring Working Group's next report (Part II: Monitoring Practices) which will build on the information contained in this report and will outline tools and guidance for monitoring boreal caribou across a variety of potential ecological and economic conditions.

Photo: Rachel Cook

BOREAL CARIBOU MONITORING IN CANADA

PART I: PERSPECTIVES FROM THE NBCKC MONITORING WORKING GROUP

FOREWORD

BOREAL CARIBOU IN CANADA

Woodland caribou, *Rangifer tarandus caribou*, boreal population (hereafter boreal caribou) were assessed as 'Threatened' by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 2002, based on population declines over much of their range, as well as threats associated with habitat loss and increased predation (**COSEWIC 2002**). They were listed as Threatened under the *Species at Risk Act* (SARA) in 2003, and a federal boreal caribou Recovery Strategy was released in 2012 (**EC 2012**). The federal boreal caribou Action Plan was released in early 2018, providing details on the federal government's contribution to recovery efforts (**ECCC 2018**).

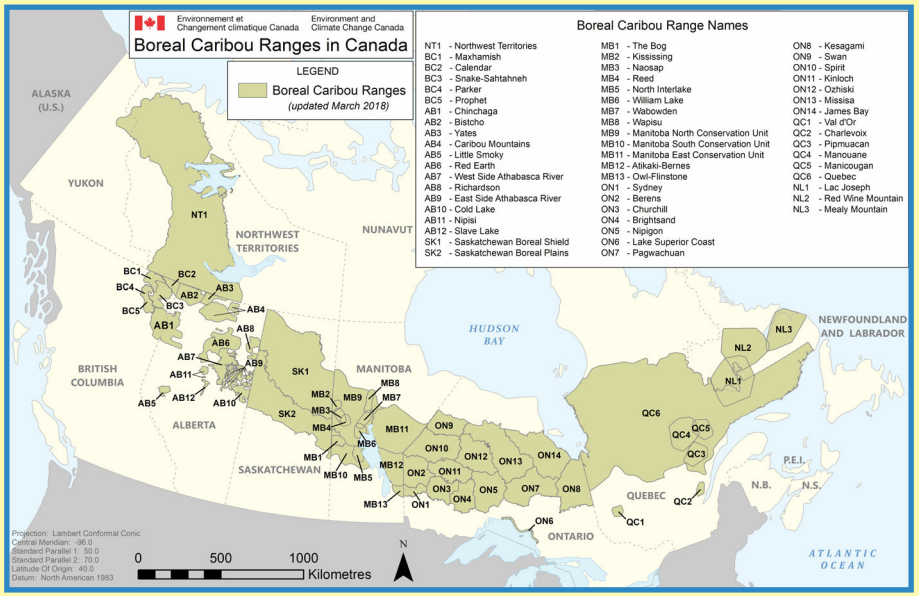


Figure 1. Geographic distribution of current boreal caribou ranges across Canada. (Courtesy of ECCC Science and Technology Branch)

WHY DOES THE MONITORING OF BOREAL CARIBOU PRESENT A CHALLENGE?

Boreal caribou exemplify many of the characteristics of species that are challenging to monitor. Their distribution spans the vast Canadian boreal forest, often in remote areas which are difficult to access (Festa-Bianchet et al. 2011; EC 2012; COSEWIC 2014). Individuals tend to aggregate in small groups, dispersed throughout home ranges which can cover hundreds of square kilometres (Festa-Bianchet et al. 2011). Low densities of individuals as well as thick vegetation can impede the effectiveness of observation via standard aerial survey methods commonly used for large ungulates (Carr et al. 2012; DeMars et al. 2015). Monitoring of boreal caribou also involves nine provincial/territorial governments (legally responsible for wildlife management in their jurisdictions), numerous Indigenous governments, and the federal government (responsible for protecting boreal caribou as a Species at Risk). Various industries are involved in development and resource extraction in boreal caribou habitat, and often have requirements to monitor boreal caribou as a result.

Across their range, boreal caribou have been a cultural keystone species for many Indigenous Peoples in Canada, and continue to be central to many Indigenous communities, economies, landscapes and lifeways. Where boreal caribou numbers remain strong, harvest continues to play an important role in passing knowledge on to younger generations. Due to their long stewardship history and relationship with boreal caribou, many Indigenous communities have a desire for greater involvement in the monitoring and management of boreal caribou today (e.g. ICE 2018). The result is a mosaic of parties implicated in the monitoring and management of boreal caribou, with variable objectives, resources and budgets.

Photo: Susan C. Morse

The National Boreal Caribou Knowledge Consortium (NBCKC) is a forum for collaborative knowledge generation and sharing to support conservation and recovery of boreal caribou in Canada.

It aims to bring together the expertise and experience of its members to:

- Consider knowledge generated through both scientific and Indigenous ways of knowing
- Track the state of knowledge and identify knowledge gaps as well as priority areas for collaboration
- Collaborate and share lessons learned to address key knowledge gaps
- Provide knowledge to inform decision making

NATIONAL BOREAL CARIBOU KNOWLEDGE CONSORTIUM

The federal Action Plan called for the creation of the National Boreal Caribou Knowledge Consortium (NBCKC). The NBCKC was launched in June 2018, hosted by Environment and Climate Change Canada's Science and Technology Branch. Recognizing that provinces and territories have already invested time and effort into monitoring programs to address the needs outlined in the Recovery Strategy, the Action Plan states that "The role for the federal government in population monitoring will be to continue to develop standardized monitoring protocols in collaboration with provincial and territorial governments, Wildlife Management Boards, Indigenous Peoples, and stakeholders" (ECCC 2018). In this context, and recognizing the diverse objectives of the mosaic of parties involved in monitoring and management, the development of monitoring tools and guidelines (instead of fixed standards) became the mandate of the NBCKC Monitoring Working Group.

Photo: Cole Burton

NBCKC – Monitoring Working Group

The Monitoring Working Group was formed under the NBCKC to investigate both (i) the diversity of monitoring priorities and constraints across the boreal range, and (ii) the variability in

Photo: Al Arsenault

methods used to monitor boreal caribou across Canada. These were laid out as steps toward developing scientifically rigorous monitoring approaches that address regional differences in boreal caribou population condition and monitoring needs, resource availability, and variability in ecosystem type or level of disturbance. Discussions within the Monitoring Working Group (herein referred to as Working Group) focused first on "Perspectives", i.e. understanding the current state of monitoring across the country and related concerns expressed by

Photo: Craig DeMars

individuals and organizations (summarized in this document). The second phase of discussions focuses on "Practices", i.e. evaluating available monitoring approaches and their suitability for addressing specific recovery objectives (summarized in the second report, Part II: Monitoring Practices).

Working Group members include representation from Indigenous knowledge holders, Indigenous organizations, wildlife co-management boards, academia, consultancy firms, environmental non-governmental organizations (ENGOs), federal and provincial/territorial governments, and industry. Previous reviews commissioned by the Government of the Northwest Territories (Demars et al. 2015) and the National Boreal Caribou Technical Committee (NBCTC; Rettie 2017) have discussed some of the challenges faced by boreal caribou monitoring and provide a valuable foundation for the Working Group to build on.

MONITORING WORKING GROUP INTERVIEWS

To gain a better understanding of the current practices and concerns surrounding boreal caribou monitoring in Canada, the Working Group conducted a series of interviews with its members and other boreal caribou monitoring experts. A questionnaire (available upon request from cnscb-nbckc@canada.ca) was developed where respondents were asked to answer 31 questions, including both closed (e.g. multiple choice/selection) and open-ended formats (which are identified as such in the results presented here). Questions addressed monitoring goals and objectives, methods of knowledge collection and sharing, challenges faced in monitoring, remaining knowledge gaps, and how efforts are expected to move forward in the future.

It is important to note that while these interviews were intended to be inclusive of diverse approaches to boreal caribou monitoring, the manner in which they were conducted – and in fact the term 'monitoring' itself – likely induced a bias toward a science perspective rather than an Indigenous one (e.g. Benson & Winbourne 2015). For instance, the scientific approach to population monitoring focuses largely on standardized

Photo: Chuck Grandy

collection of repeated measures over time, while Indigenous Knowledge is based on cross-generational connections between the land and people (Ban et al. 2018). As a result, and despite the intentions of the NBCKC Monitoring Working Group Secretariat, some responses may emphasize scientific knowledge more than Indigenous ways of knowing. Note also that while the term "Traditional Ecological Knowledge" (TEK) was used often in interview questions and responses, in many cases the discussions pertain equally to broader Indigenous Knowledge (IK) and not just longer/cross-generational traditional insights specific to TEK.

For the purposes of this report, and unless otherwise specified (e.g. Appendix A) we use the term Indigenous Knowledge (IK) as it encompasses both historical and contemporary types of knowledge. Quotes from Working Group interviews however, are presented in the interviewee's own words.

Interviews were conducted via WebEx teleconference, or in person, between November 5th and December 6th 2018, by two Environment and Climate Change Canada (ECCC) employees responsible for delivering the scope of work defined by the Working Group. One researcher asked the questions and both took notes of the responses; audio recordings were also made. Interviews were semi-structured in that respondents could ask for clarification on the meaning of questions, and were free to add additional points throughout the interview. Interviews lasted anywhere from 30 minutes to two hours. A snowball sampling technique was used, where interviews with core Working Group members led to referral of additional knowledge holders outside of the Working Group, with the goal of achieving adequate representation among regions and organization types.

Photo: Rachel Cook

A total of 37 interviews were conducted with 48 individuals from 33 different organizations across 8 provinces and territories. What follows is an aggregation of the responses heard during the interviews (statistics on interviewees and additional responses are available from cnscb-nbckc@canada.ca). With the consent of interviewees, quotes have been taken directly from their responses, and appear as anonymous unless personal identification was explicitly requested. Note that these are individual responses and opinions, and not necessarily a representation of the views of ECCC or other participating organizations. Note also that this report on Monitoring Perspectives represents the first of two key documents being produced by this Working Group; Part II: Monitoring Practices will provide an in-depth critical assessment of individual monitoring methods and their relevance to key objectives for boreal caribou recovery.

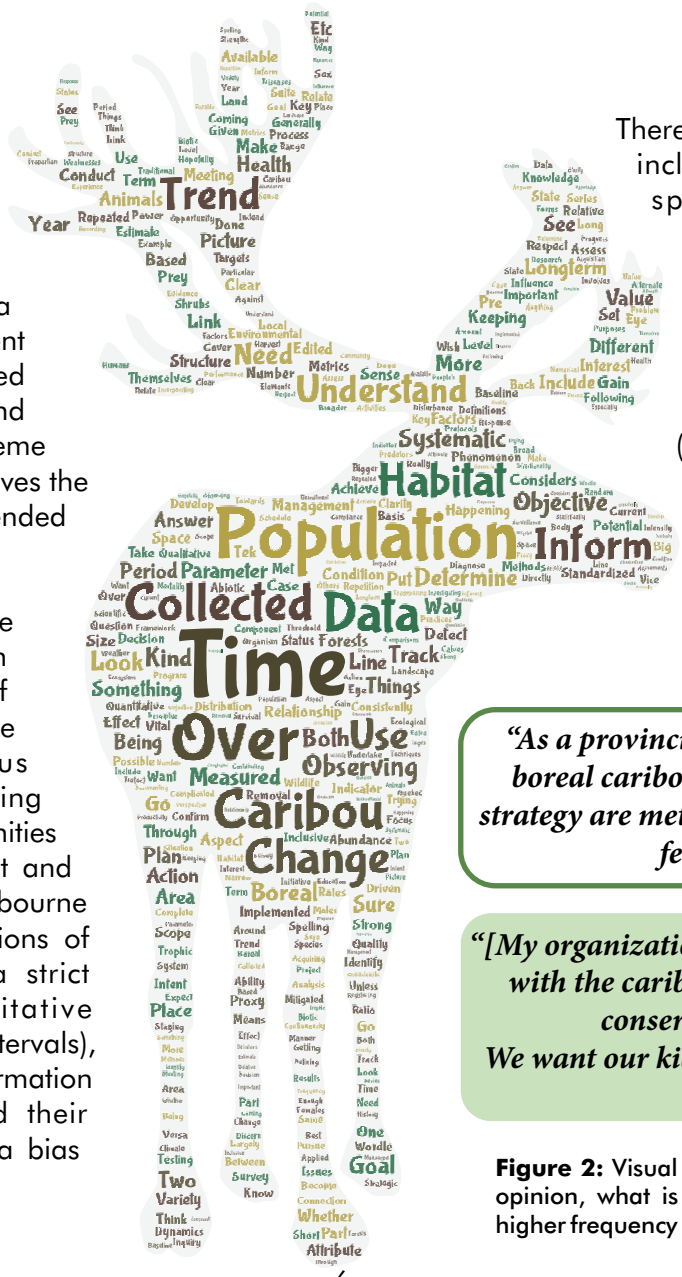
BOREAL CARIBOU IN CANADA

PERSPECTIVES ON MONITORING

WHAT IS MONITORING?

The term 'monitoring' has been used to describe a range of activities across diverse disciplines, including toxicology, medicine, computing, and environmental science. In the context of threatened species, monitoring is often used as a tool to gather information about a species' conservation status to inform management actions aimed at recovery. Respondents were asked to provide their own definition of monitoring and gave a diversity of responses, but one common theme was longevity, i.e. that monitoring primarily involves the collection of data or knowledge over an extended period of time.

We note that monitoring is a concept that cannot be directly translated into Indigenous culture, which often focuses on the understanding of relationships and the ecosystem as a whole (Benson & Winbourne 2015). Indigenous Knowledge based on long-term and on-going interactions with the land is shared within communities and may be used to inform decisions on what and where to harvest in the next year (Benson & Winbourne 2015). For this report, all broad-sense definitions of 'monitoring' were considered rather than a strict interpretation (e.g. standardized quantitative observations of the same metric at regular time intervals), in an effort to include diverse forms of information relevant to boreal caribou populations and their recovery, but there likely remains nonetheless a bias towards scientific methods.



WHY ARE BOREAL CARIBOU BEING MONITORED?

There are many motivations for ecological monitoring, including gathering general information about species or ecosystems, complying with a government mandate, or testing specific predictions (Lindenmayer & Likens 2010). Monitoring of threatened species is often required to provide information on the status, trend or cause of decline, as the state of the system will determine management actions (Yoccoz et al. 2001).

Interview respondents indicated that they monitored boreal caribou for a number of reasons, ranging from legal obligations to desires to safeguard spiritual relationships with caribou.

> ***"As a provincial government we have a mandate to monitor boreal caribou to ensure the requirements of our recovery strategy are met, to complete range plans and to work with the federal government requirements"***

> ***"[My organization] has always had an important relationship with the caribou. One of our priorities is protection and conservation of caribou for our members. We want our kids to see the caribou, and potentially harvest them as we have in the past."***

Figure 2: Visual representation of the responses to Question 1: "In your opinion, what is monitoring?" (open-ended). Larger words represent a higher frequency in responses.

Table 1: Reasons for monitoring boreal caribou, in response to Question 2 (open-ended): "Is your organization currently monitoring boreal caribou, or have you monitored caribou in the past? Why or why not?". Note that individuals identifying as 'not monitoring' were excluded from subsequent questions pertaining to specific details of monitoring programs and approaches.

Reason	Percentage
We do not directly monitor/Not within our mandate/jurisdiction	28%
Is within our mandate/to meet ECCC requirements	16%
Measuring the response to treatments/management actions	13%
To support recovery/conservation of boreal caribou	13%
Identify status/trend	9%
To facilitate community involvement/inform the community	6%
To satisfy the conditions of environmental impact assessment (EIS)	3%
Other	13%

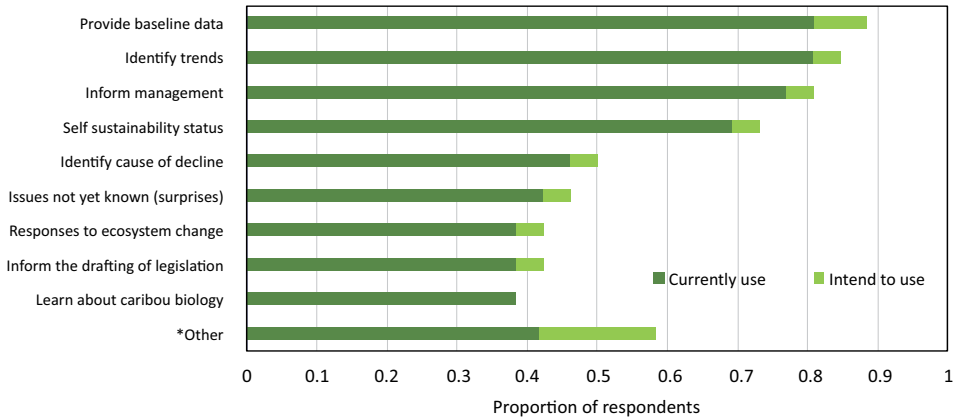


Figure 3: Goals of monitoring programs, in response to Question 3: "Does your monitoring program have defined goals? If yes, what are they? [Select all that apply]". *Other goals identified included: tracking range recession, identifying survivorship and causes of mortality, measuring effectiveness of mitigation measures, making decisions at the range scale, community involvement on the land, creating a link for elders/trappers with youth, ensuring that Indigenous Knowledge is included in management plans, and ensuring the health of boreal caribou.

In the questionnaire, goals were defined as "broad statements of what you hope to achieve as a result of a monitoring program", and objectives as "qualitative statements which specify how goals will be achieved; they commonly include what, where and when information will be collected".

Twenty-three respondents said their monitoring program has specific monitoring goals and twenty also said they also have specific objectives. Providing baseline data was a goal of almost all monitoring programs. If using monitoring to inform management, identifying the cause of decline may be an important step in determining the effectiveness of conservation actions (Lindenmayer et al. 2013), yet fewer than 50% of respondents indicated that identifying the cause of decline was a goal. Some respondents quickly identified a series of specific points pertaining to how their goals would be achieved, and others provided much more general responses.

"…enhancing the body of knowledge in the area around mine sites, to help with planning."

"To use TEK [Traditional Ecological Knowledge] to inform where the cameras will be located, and do it in a way that informs the community of monitoring."

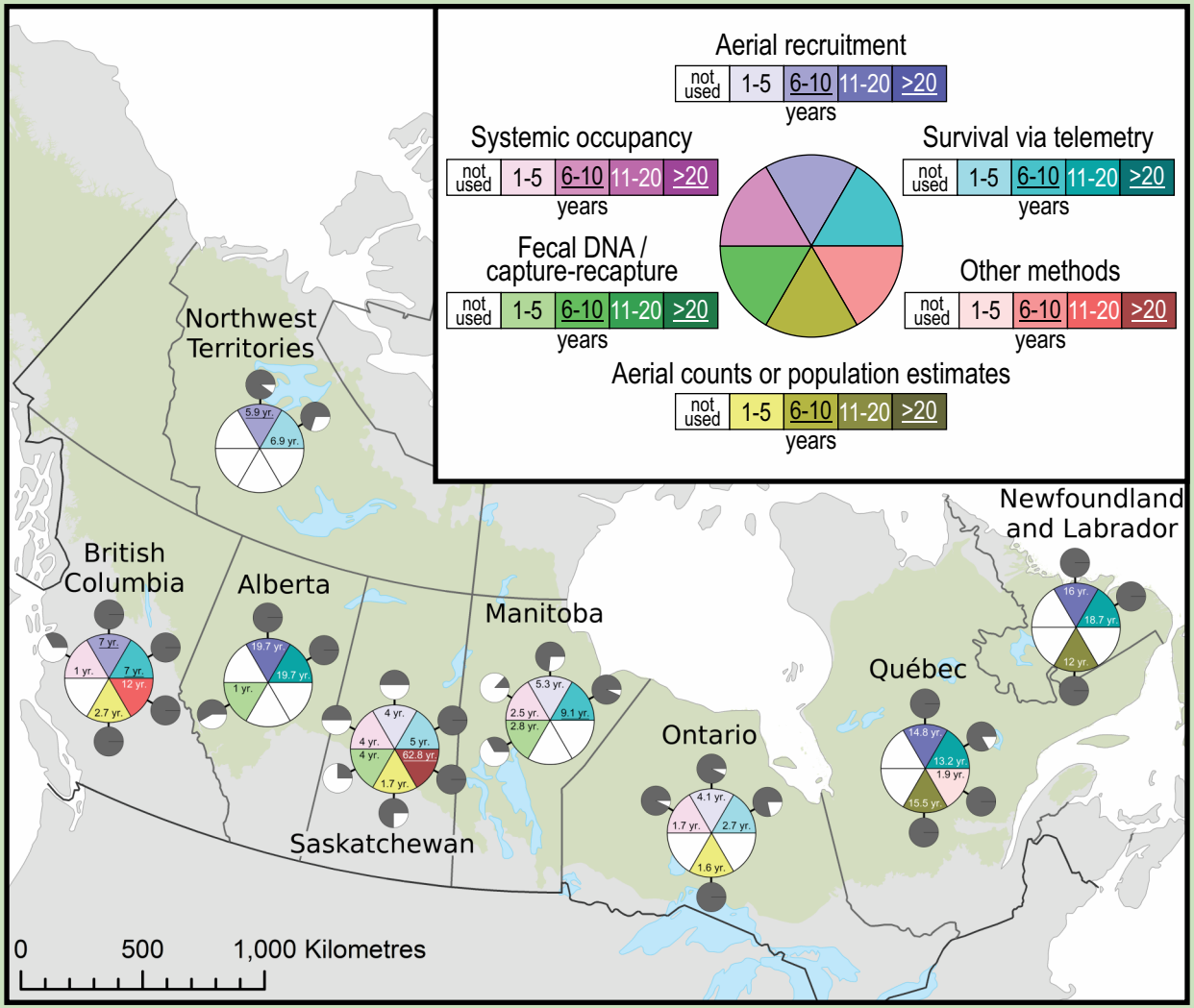
"1) To monitor caribou population trend in treatment versus control areas;
2) To monitor changes in moose density and wolf density to look at how management levers affect population growth rate…"

"1) Undertake periodic winter calf recruitment surveys across high conservation concern management units; 2) Track human disturbance footprint for individual management units; and 3) Track habitat quality and amount for individual management units…"

WHAT IS BEING MONITORED WHERE?

Monitoring recommended in the Recovery Strategy

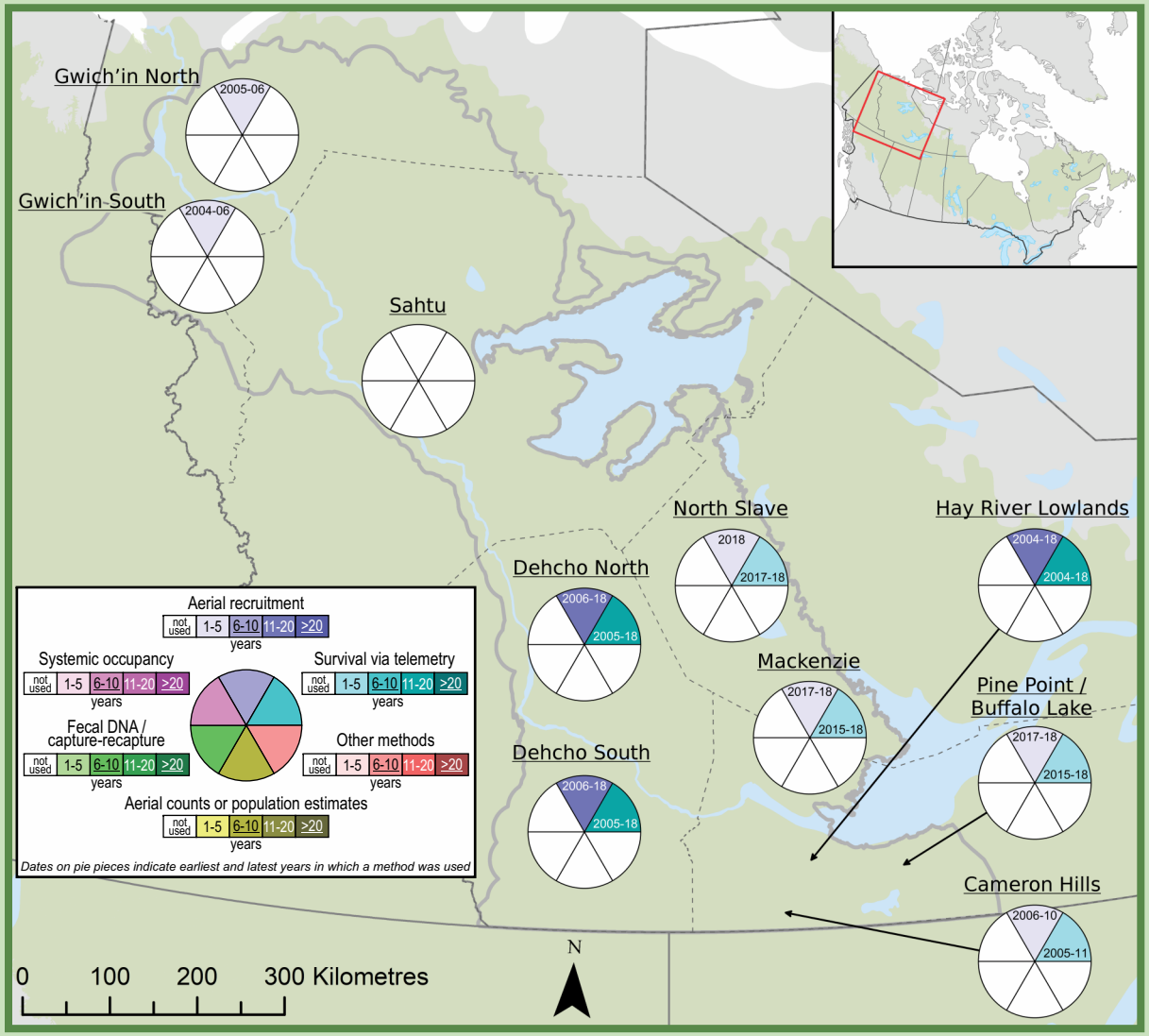
According to the Recovery Strategy for boreal caribou (EC 2012), recovery goals for population trend and size are to: i) Maintain the current distribution of boreal caribou across Canada; ii) Achieve and/or maintain a stable to increasing population trend (expressed as the rate of increase λ measured over five years, i.e. λ ≥ stable, or other empirical data that indicate population trend is stable or increasing); and iii) Achieve a minimum of 100 animals for local populations of fewer than 100 animals, or show progress towards this goal every five years. Thus distribution/occupancy, population trend (λ) and total population size should be monitored to track progress towards national level recovery goals. Nonetheless, it is important to note that many other metrics are monitored besides the key parameters identified in the Recovery Strategy, and that while the majority of monitoring has been conducted by the provincial and territorial governments, many other groups have also been involved in the monitoring of boreal caribou.



Summary of the types of monitoring methods used by provincial/territorial governments across Canada, grouped into six general categories. Colour intensity and labels in each of the slices represents the mean, across all ranges or study areas within a given province or territory, of the number of total years of data for a given monitoring method category. Ranges or study areas that did not use a given method (zero total years) are not included in this mean. Sub-pie plots (smaller pies) represent the proportion of ranges or study areas, within that province or territory, that are using a given type of method. Absence of a sub-pie plot indicates that the method was not used by any of the ranges or study areas within that province or territory. Note that for this and all subsequent maps, methods are grouped together into six general categories that represent the diversity of related approaches; e.g. 'Aerial population estimates' includes aerial-based minimum-counts as well as other population-estimation approaches. See page 18 for additional definitions of monitoring terms. Full details of all provincial/territorial monitoring data are summarized in a supplementary table, available upon request from cnscb-nbckc@canada.ca.

PROVINCIAL AND TERRITORIAL GOVERNMENT MONITORING PROGRAMS

- NORTHWEST TERRITORIES -

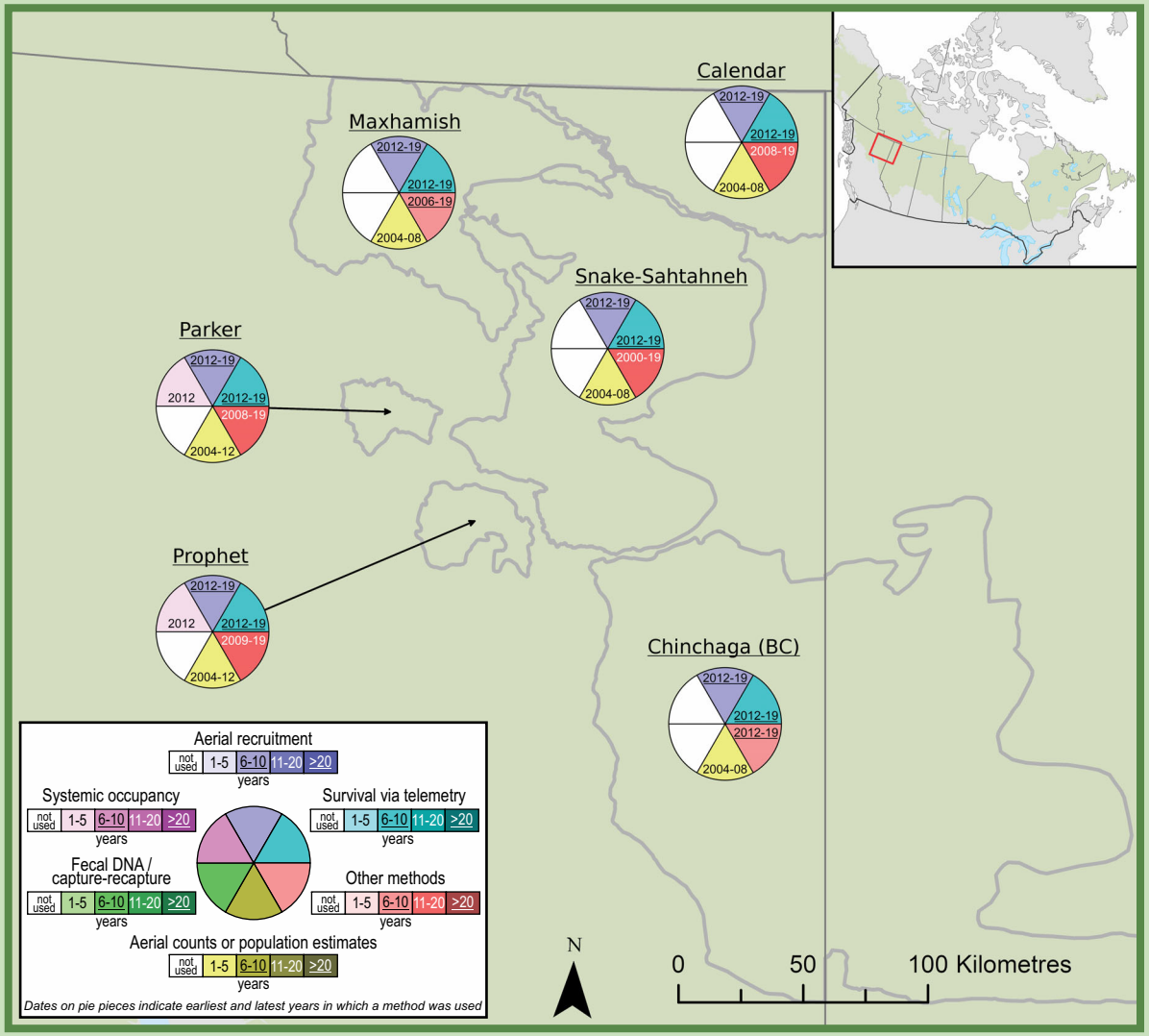


All boreal caribou in the Northwest Territories (NWT) are considered part of one expansive local population (NT1), but they have been monitored by the territorial government as about ten smaller study areas since the early 2000s. In the Dehcho and Hay River Lowlands study areas, monitoring has been conducted almost every year since 2004/05 to estimate both adult survival (via telemetry of radio-collared females) and calf recruitment (via aerial surveys). Similar monitoring has been conducted in several other study areas since 2015. Previous monitoring programs took place in the Gwich'in and Sahtu settlement regions, but both ended in 2011. Data were too sparse to derive estimates of population trend in the Sahtu region. Note that the NT1 population extends across the territorial border into the Yukon, and therefore its monitoring data includes animals from both territories (i.e. no separate surveying is conducted for the Yukon). Collared caribou in the southern NWT, and in adjacent ranges in northern Alberta and British Columbia, also regularly cross the border between these jurisdictions.

PROVINCIAL AND TERRITORIAL GOVERNMENT MONITORING PROGRAMS

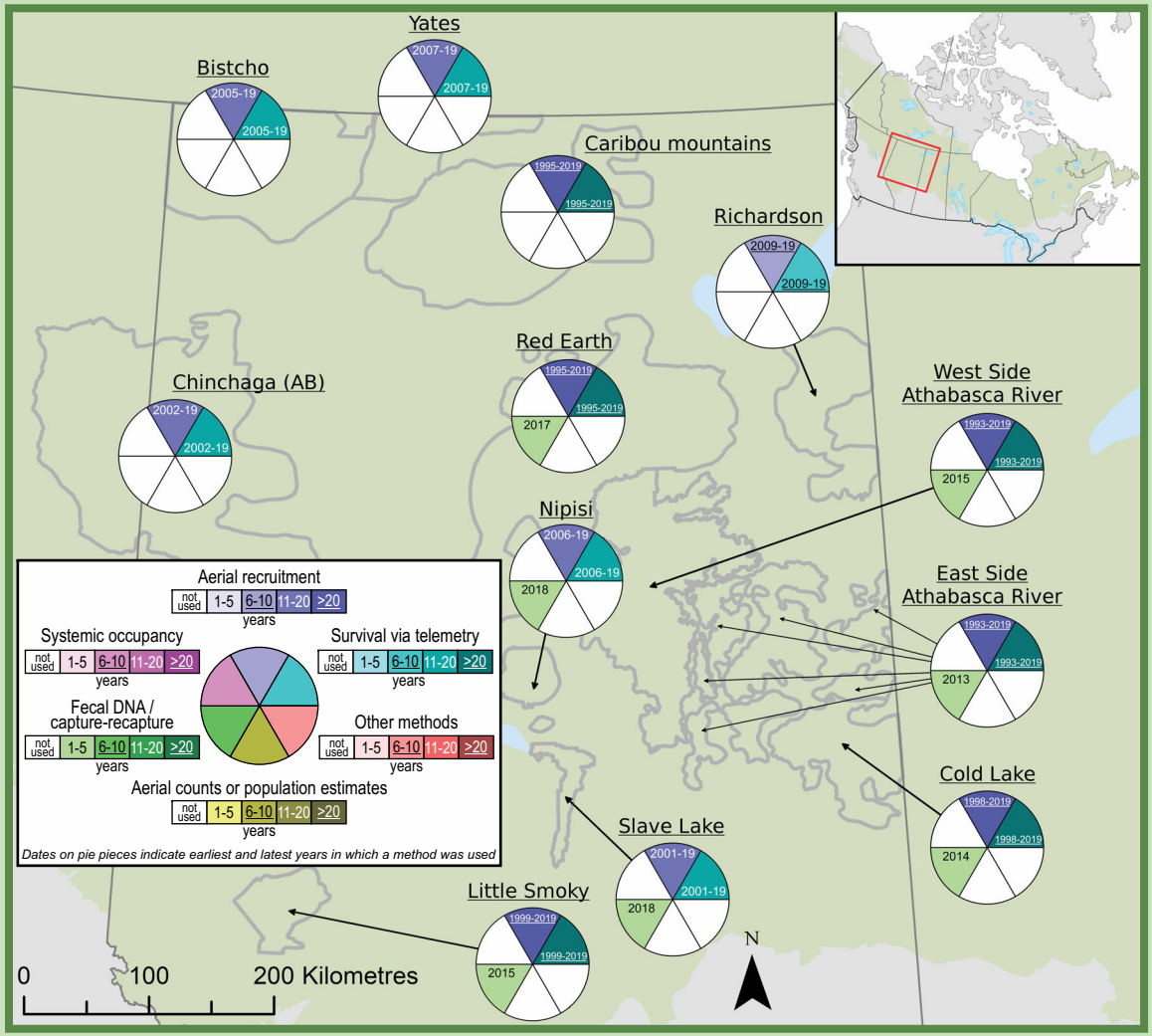
- BRITISH COLUMBIA -

All six of the local boreal caribou populations in British Columbia (BC) have been monitored annually in recent years by the provincial government. Since 2012, every range has been monitored via telemetry of radio-collared females to estimate adult survival and via aerial surveys to estimate calf recruitment. Systematic occupancy surveys were also conducted in two ranges (Parker and Prophet) in 2012. Minimum count population estimates were conducted in all ranges starting in 2004, providing between 2-4 estimates per population between 2004-12. The BC Wildlife Health Program, in partnership with a collaborative and funded by external sources, specifically focused on boreal caribou health following some unusual mortalities. Opportunistically collected biological samples were used to build a model for caribou health assessment to be applicable for general wild ungulate health. The existing BC caribou sample archive (from boreal and mountain caribou) and samples collected using standardized protocols from regional radio-collaring and marking studies are now being applied to a provincial and subspecies/ecotype-wide health assessment of caribou herds and populations. The health determinants measured from these samples (mapped as "Other methods") will be associated in a spatial/temporal analysis of the quality of caribou herds and their habitat as well as comparing results between recovery and management actions.



PROVINCIAL AND TERRITORIAL GOVERNMENT MONITORING PROGRAMS

- ALBERTA -



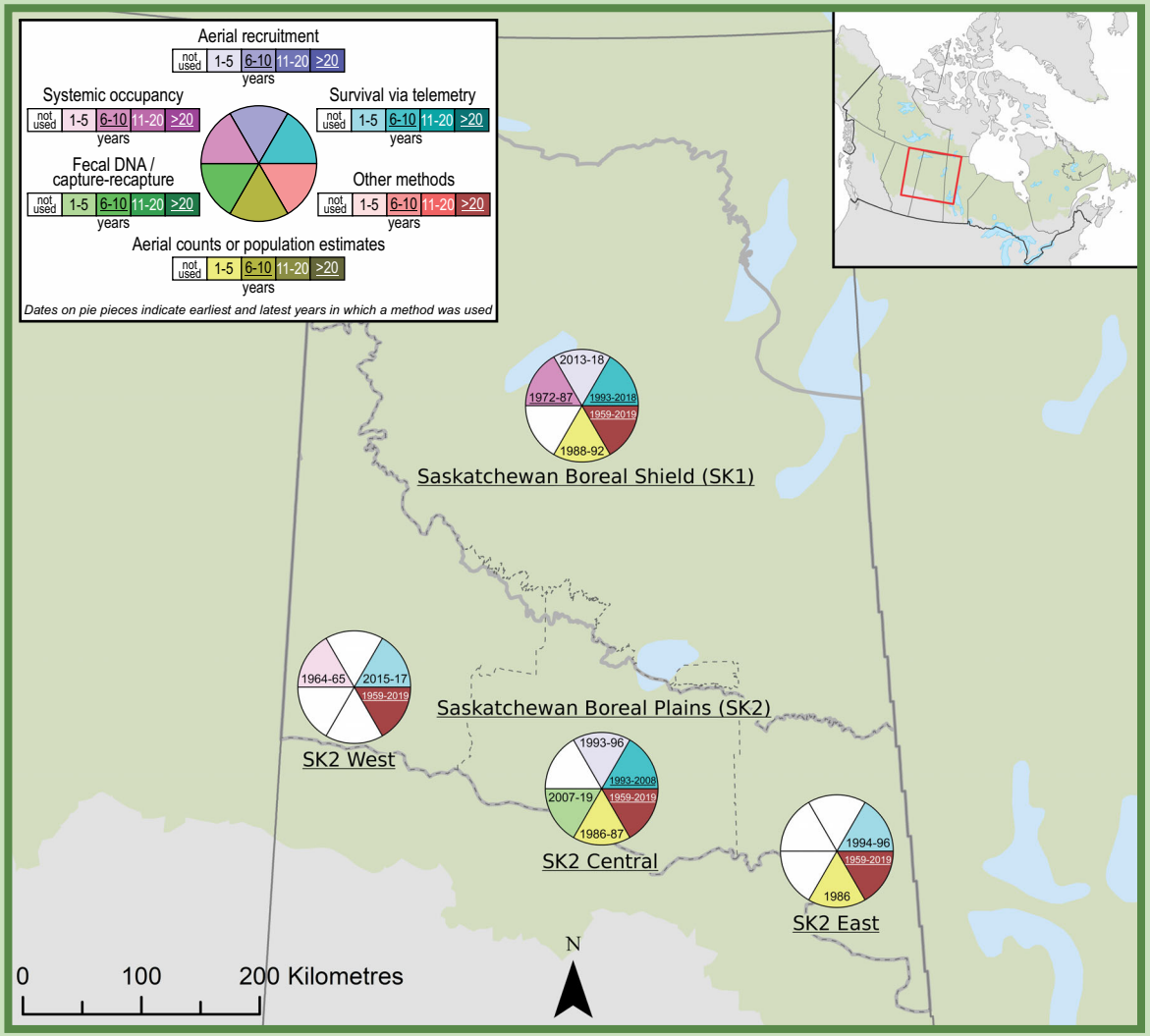
**Note that in Alberta, minimum-counts have been conducted for all ranges in all years where survival and recruitment have been estimated, but that these counts should not be considered estimates of population size.*

Since 1980, Alberta has developed a detailed and extensive woodland caribou population monitoring program. Based on a telemetry sample of adult female caribou (target of at least 30 radio-collared animals per local population), all 12 of the remaining boreal woodland caribou local population ranges in Alberta are annually monitored for: adult female caribou mortality, calf survival to 9 or 10 months of age, late winter population composition, minimum-count population size (based on the radio-collared sample and other animals found through reconnaissance flying), annual population growth, individual animal locations/movements/and home ranges, and the overall distribution (range occupancy). In addition, in two boreal caribou ranges, portions of the local population, which may be partially or completely distinct demographic units, are monitored separately. Alberta has completed mortality investigations of radio-collared caribou mortalities; these investigations were reinstated at a provincial-scale in 2018. To date, Alberta has also delivered a fecal DNA capture-mark-recapture program in 7 boreal caribou populations, in an attempt to enumerate (at a point in time) each caribou population in the province; fecal DNA sampling has also been completed for one additional population to investigate genetic relationships with adjacent caribou populations. Alberta continues to develop information on habitat disturbance, change and loss within each caribou range, including assessments of current habitat quality within each range.

PROVINCIAL AND TERRITORIAL GOVERNMENT MONITORING PROGRAMS

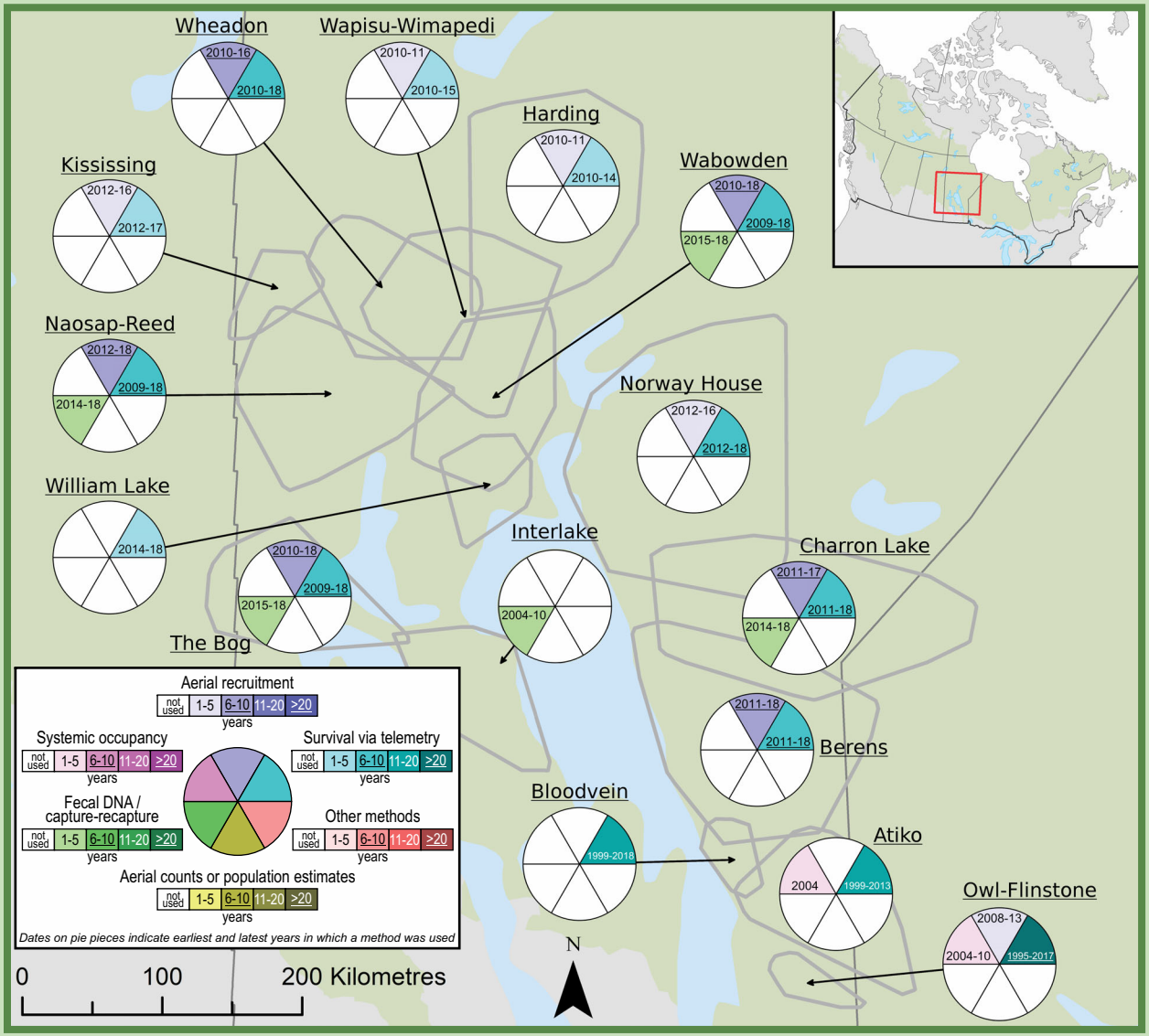
- SASKATCHEWAN -

Occupancy of boreal caribou populations in Saskatchewan has been monitored annually across the boreal caribou range by the provincial government since 1959, through interview surveys and volunteer sighting reports. Occupancy was also monitored through systematic surveys in SK1 and SK2-West in the 1960s/1970s, and more recently in all four populations through a combination of systematic surveys and fecal DNA (pellet) collection (1-5 years of data/population since 2005; mapped as "Other methods"). Fecal DNA collections provided valuable insight into the relatedness of caribou across the range (genetic connectivity) and how well their habitats are connected across the range (landscape connectivity). This approach also provided a source of historic and current occupancy. In parts of each range, adult female survival has been monitored through telemetry (2-6 years/population between 1993-2018) and calf recruitment has been monitored through aerial surveys (1993-96 in SK2-Central, 2013-18 in SK1); aerial estimates of minimum population count were conducted briefly in the late 1980s. Fecal DNA-based estimates of population size and trend through capture-mark-recapture methods have been conducted in parts of the SK2-Central range since 2007 (4 years). Additional industry-led surveys of habitat, distribution and population parameters have been conducted in northern Saskatchewan sporadically since the 1980s and regularly since 2008.



PROVINCIAL AND TERRITORIAL GOVERNMENT MONITORING PROGRAMS

- MANITOBA -

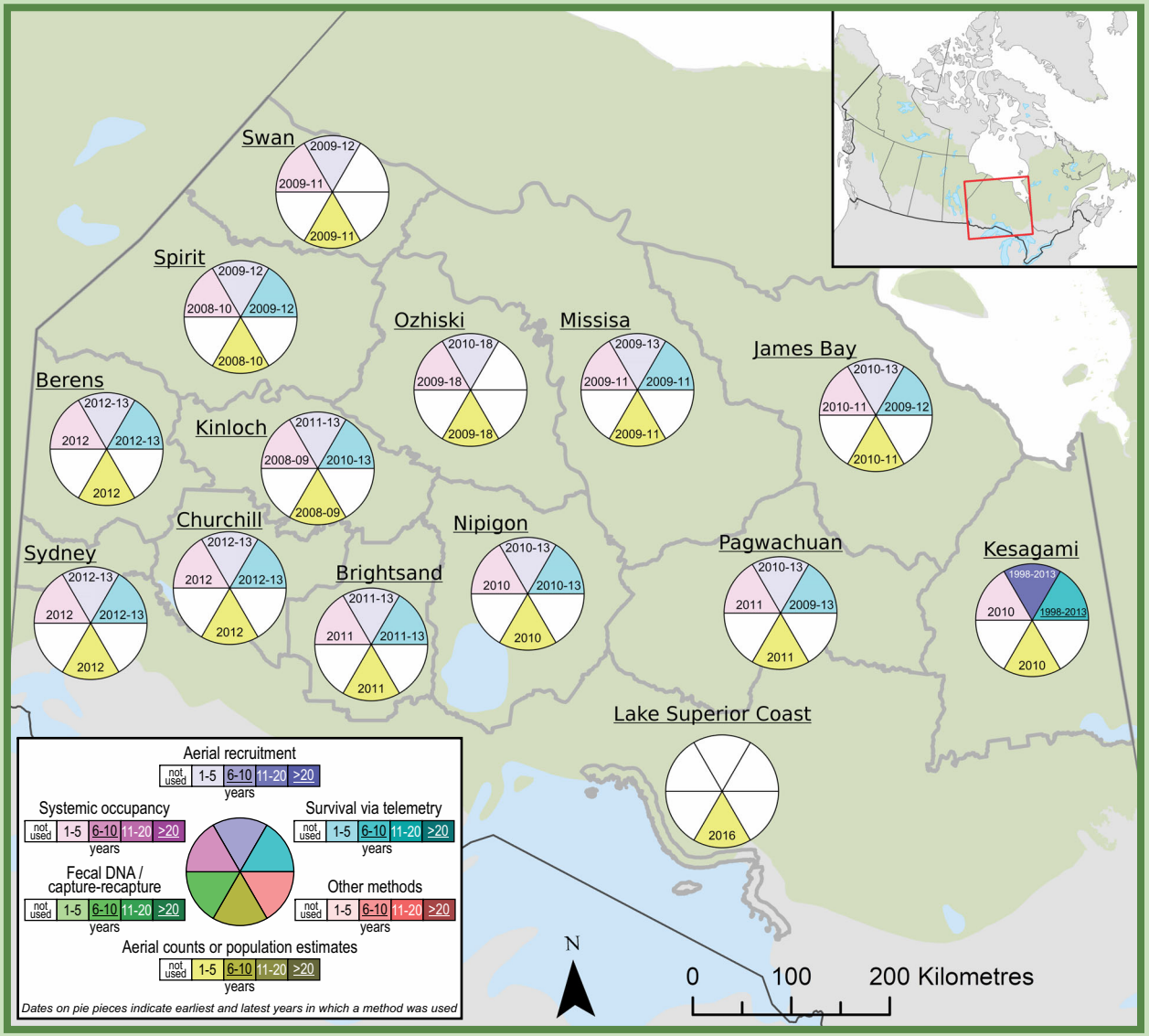


Monitoring of adult female survival via telemetry dates back to the late 1990s for three of Manitoba's 15 populations (Atiko [14 years of estimates], Bloodvein [19], Owl-Flintstone [22]), and was initiated between 2009-14 for all other ranges except Interlake (giving 4-9 years' estimates per range). The provincial government also used aerial surveys to estimate calf recruitment for most local populations over 2-7 years between 2010-18, while two populations (Atiko and Owl-Flintstone) have been sporadically monitored for occupancy through systematic surveys since 2004. Fecal DNA-based estimates of population size and trend through capture-mark-recapture methods were conducted in the Interlake range between 2004-10, as well as in Charron Lake and part of the Bog, Naosap-Reed and Wabowden populations between 2014-18; further collections and genotyping in these latter regions were continued in 2019.

PROVINCIAL AND TERRITORIAL GOVERNMENT MONITORING PROGRAMS

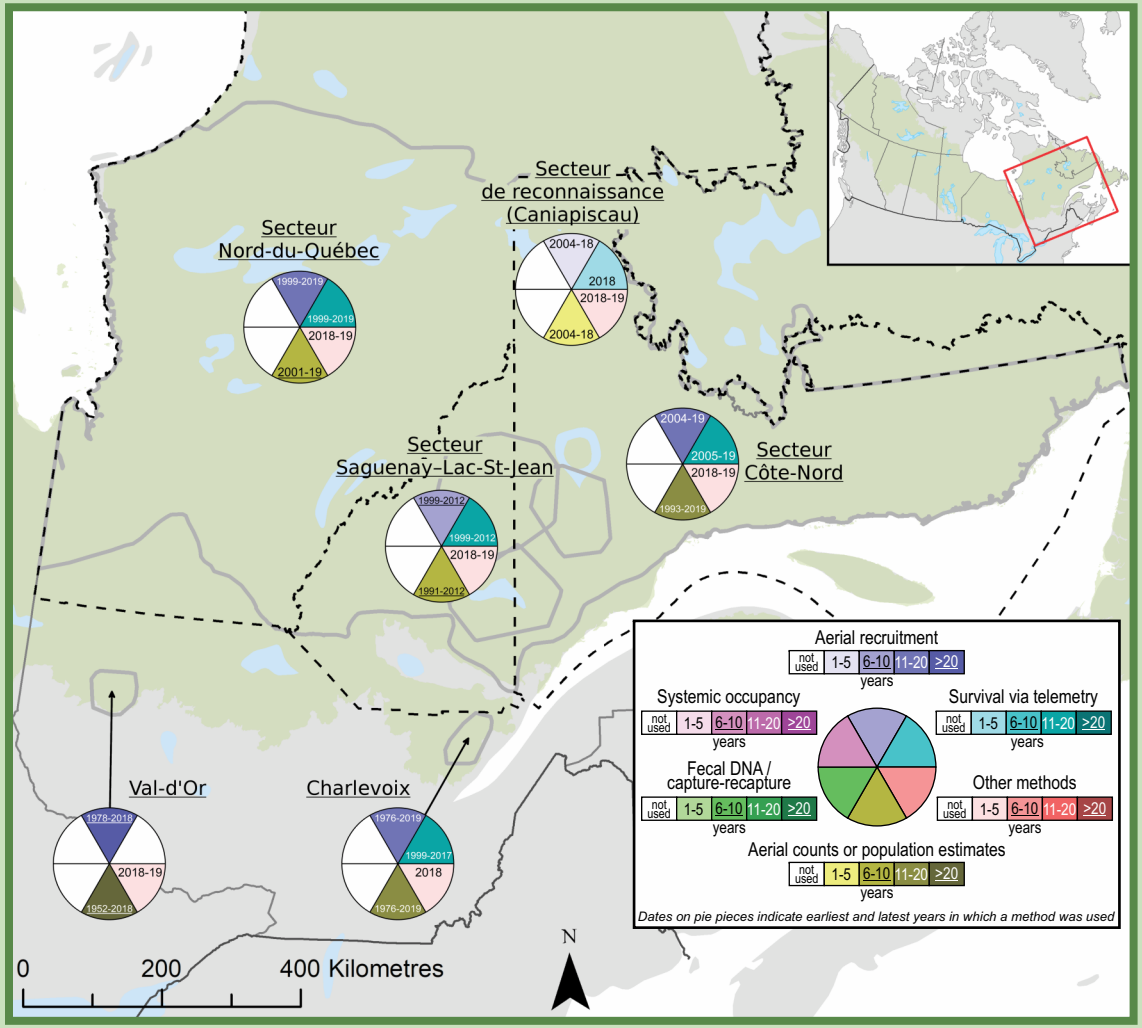
- ONTARIO -

For most of the 14 boreal caribou populations in Ontario, consistent monitoring occurred only for a few years between 2008-2013; exceptions are the Kesagami population that was first surveyed in 1998, the Ozhiski population surveyed through 2018, and a single population estimate made for the Lake Superior Coast population in 2016. For most populations, the provincial government monitored survival through telemetry of radio-collared adult female caribou (collecting between 1-6 years of data per population), and conducted aerial surveys for calf recruitment estimates (2-12 years) as well as minimum population counts (1-3 years). Occupancy was also estimated via systematic surveys (1-3 years) for all populations except Lake Superior Coast.



PROVINCIAL AND TERRITORIAL GOVERNMENT MONITORING PROGRAMS

- QUÉBEC -



Boreal caribou monitoring in Québec has included both small-scale studies in the isolated Charlevoix and Val-d'Or populations, and broader efforts across three large administrative regions (Nord-du-Québec, Saguenay/Lac-St-Jean and Côte-Nord). The government of Québec has monitored survival of radio-collared adult females via telemetry since 1999 in both the Saguenay/Lac-St-Jean (until 2012) and Nord-du-Québec (ongoing through 2019) regions, as well as in the isolated Charlevoix population (until 2017). Telemetry-based survival monitoring has occurred more recently in the Côte-Nord region (since 2005) and as a pilot study at the northern limits of the Côte-Nord region in 2018 (secteur de reconnaissance Caniapiscau), though note that all regions had low sample sizes in some years. Aerial surveys have been used in all populations/regions at varying frequencies, to estimate both abundance and calf recruitment. These surveys date back as far as 1976 in the Charlevoix herd, the 1950s for Val-d'Or, the early 1990s for Saguenay/Lac-St-Jean and Côte-Nord regions and 2001 for Nord-du-Québec region, providing between 9 years (Nord-du-Québec and Saguenay/Lac-St-Jean regions) and about 35 years (Val-d'Or) of estimates of these parameters per population/region. In 2018-19, all populations/regions were monitored by the provincial government through three additional methods (mapped as "Other methods"): fecal pellet analysis to examine gestation rate and pathogen prevalence; a new genetic study comparing DNA of all the caribou ecotypes in Québec; and collection of samples for health and body condition assessments. Note that these methods were applied in Charlevoix in 2018 only, and that they have not yet been applied to all the sub-populations within the different regions. Additional collaborative research projects have been conducted in various regions of Québec but are not listed here.

PROVINCIAL AND TERRITORIAL GOVERNMENT MONITORING PROGRAMS

- NEWFOUNDLAND/LABRADOR -

Three local populations of boreal caribou are recognized in Labrador, all of which have been aerially monitored since the late 1950s. The provincial government has conducted aerial calf recruitment surveys for the Mealy Mountain and Red Wine Mountain populations since 1958 (23 and 11 years, respectively) and for Lac Joseph since 1967 (14 years). Aerial population estimates (minimum counts) have also been conducted sporadically for all three populations (13 years for Mealy Mountain, 9 years for Red Wine Mountain, 14 years for Lac Joseph). Since the 1980s, adult female survival has also been estimated via telemetry through the radio-collaring of female caribou for Mealy Mountain (in 15 years), some parts of the Red Wine Mountain (22 years), and Lac Joseph (19 years). Note that Newfoundland caribou are considered a distinct designatable unit from boreal caribou, and are therefore not considered in this review.

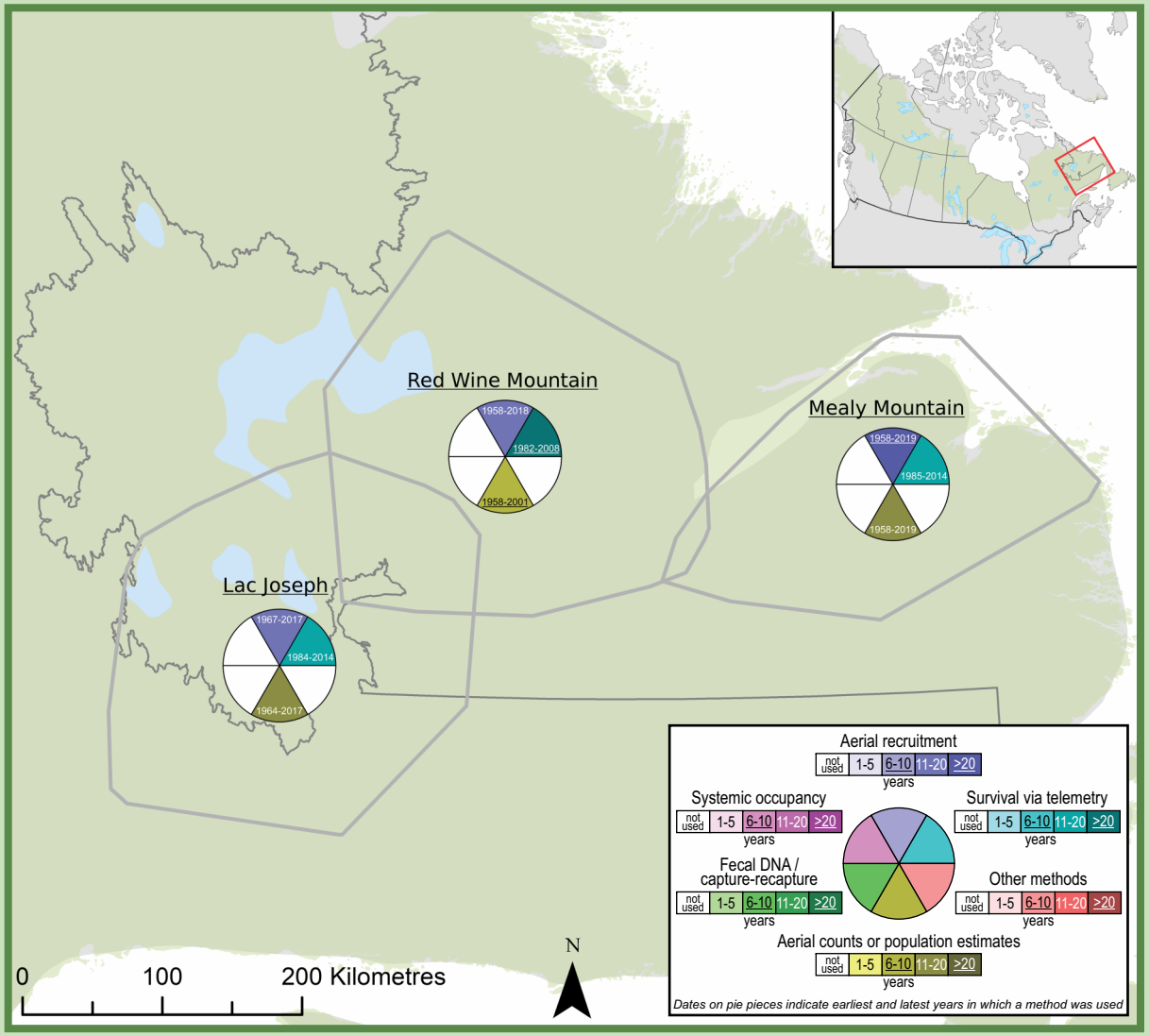


Photo: Sarah Schmid

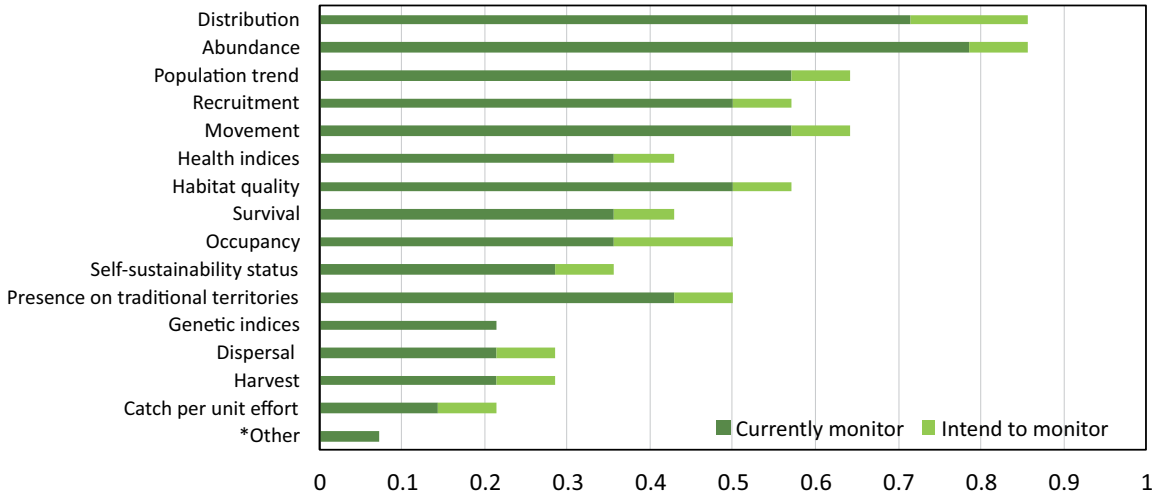


Figure 4: Metrics that non-provincial/territorial government respondents currently monitor or intend to monitor in the future, in response to Question 10: "What metrics do/would you intend to monitor? [Select all that apply]". Other responses included historical information and mortality risk.

Photo: Susan C. Morse

BOREAL CARIBOU IN CANADA

HOW IS MONITORING CONDUCTED?

NUMEROUS METHODS ARE CURRENTLY BEING USED

Many methods for monitoring boreal caribou were identified, including telemetry based methods, genetic methods, and land-based ways of knowing.

Table 2: Common terms used in monitoring methodology.

Term	Definition
Telemetry	Use of global positioning system (GPS) or very high frequency (VHF) radio collars, usually deployed on female caribou.
Systematic surveys	Non-aerial surveys conducted following a structured sampling design to detect signs of caribou.
Capture-Mark-Recapture (CMR)	A method in which individuals of a population are captured, marked with an individual identifier and then released back into the population. The proportion of marked individuals captured or resighted in subsequent samples can be used to estimate population size and other parameters.
Spatially explicit Capture-Mark-Recapture (SECR)	A CMR based method which takes into account location of captures, which is used to model detection probability based on trap locations and an individual's home range centre.

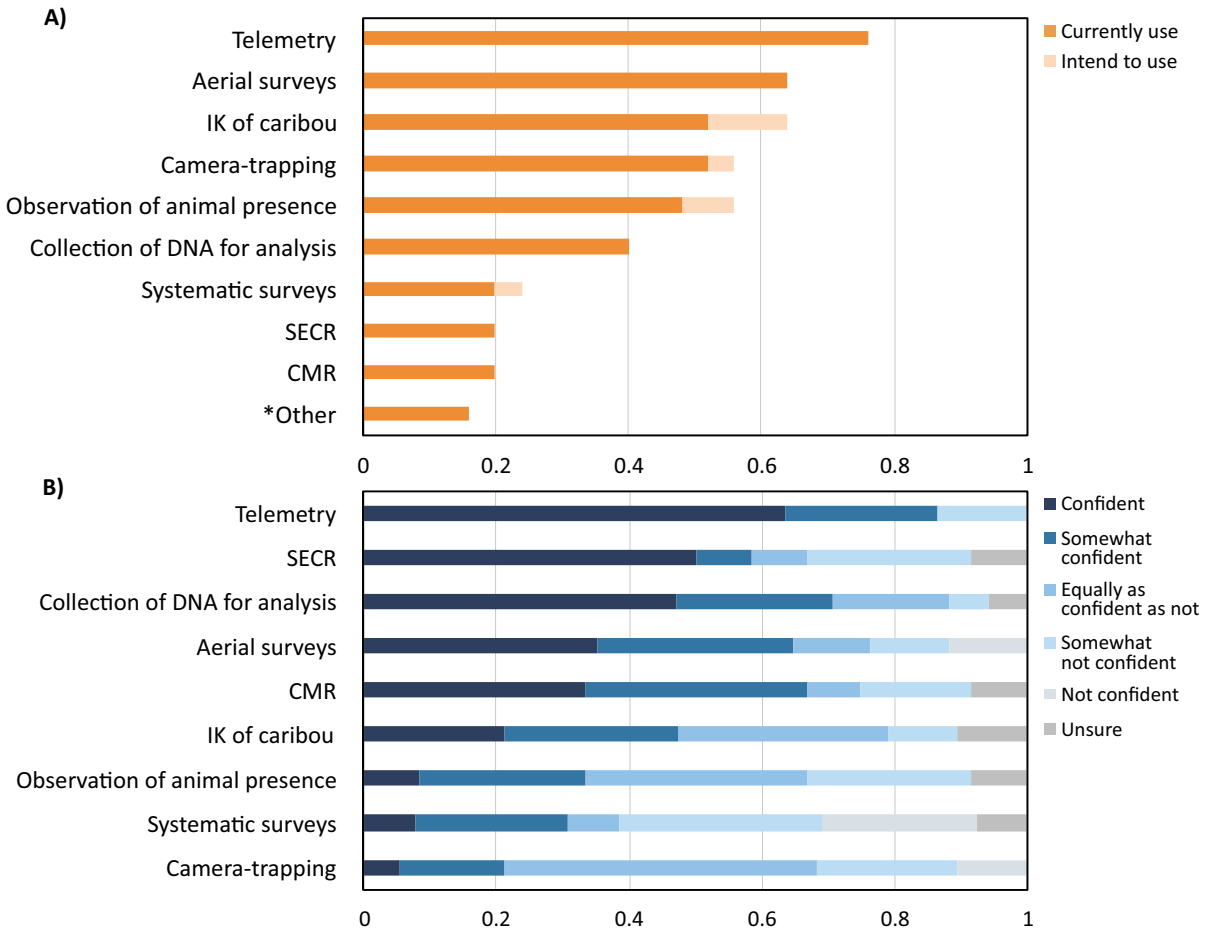


Figure 5: A) Monitoring methods currently in use or intended to be used in future programs, identified in response to Question 16: "What methods does or would your organization use to collect and analyse boreal caribou monitoring information?" B) Perceived confidence in monitoring methods, in response to Question 17: "Thinking of the methods identified above, please rate your level of confidence in the parameter estimates provided by each method under ideal circumstances". Note that these are the respondents' perceptions and do not represent any direct measures of accuracy or precision. See Table 2 inset for additional descriptions of methods.

Confidence in methods is variable

According to interview respondents, telemetry, the technique most commonly used, was also the method thought to be the most reliable (86% confident or somewhat confident, though note that a few respondents were strongly opposed to its use). In many other cases, however, there was a disconnect between the methods being used and the level of expressed confidence in these approaches. For example, spatially explicit capture-mark-recapture was rated with high levels of confidence, yet only 20% of respondents indicated that they are currently using the technique. On the other hand, camera trapping was named as the fourth most common method used, yet received the lowest level of confidence in estimates. Note that these answers do not consider the different scales at which monitoring is taking place, as methods vary in their applicability based on scale. For instance, camera trapping is usually applied at smaller scales, and so is a more practical option for small groups and local community based monitoring programs. Note also that specific levels of confidence in the diverse applications of a given method were not examined in detail (e.g. for telemetry with radio collars, which have numerous applications, confidence in measures of distribution, survival, habitat selection were not individually examined). Spatial scale and other considerations dictating the most appropriate methods to use for a given objective are discussed in more detail in the Part II: Monitoring Practices report.

Sixty-four percent of respondents said they use, or intend to use Indigenous Knowledge of caribou as a method for monitoring boreal caribou. The level of confidence associated with Indigenous Knowledge varied depending on the type of information. Respondents indicated that Indigenous Knowledge can be highly accurate at determining distributions and large scale changes over time, but may be considered less accurate when it comes to measures such as density or when referring to broad areas of distribution. However, Indigenous Knowledge was also highlighted as an important component of combined approaches to monitoring, such as the value of using community member knowledge to inform placement of camera traps. See Appendix A (Lessons Learned: Bringing Together Science, Traditional and Local Ecological Knowledge) for a more detailed discussion of how science and Indigenous Knowledge can be combined into a comprehensive perspective on monitoring.

Note that these are approximate measures of confidence based on experts' perceptions, and thus must be interpreted with caution. Perceptions are influenced by experiences and personal motivation (Bennett 2016), meaning they draw on the wealth of knowledge held by respondents but are largely subjective. However, perceptions can be a useful tool in conservation planning and management (Bennett 2016), and are especially valuable when there is a lack of quantitative information.

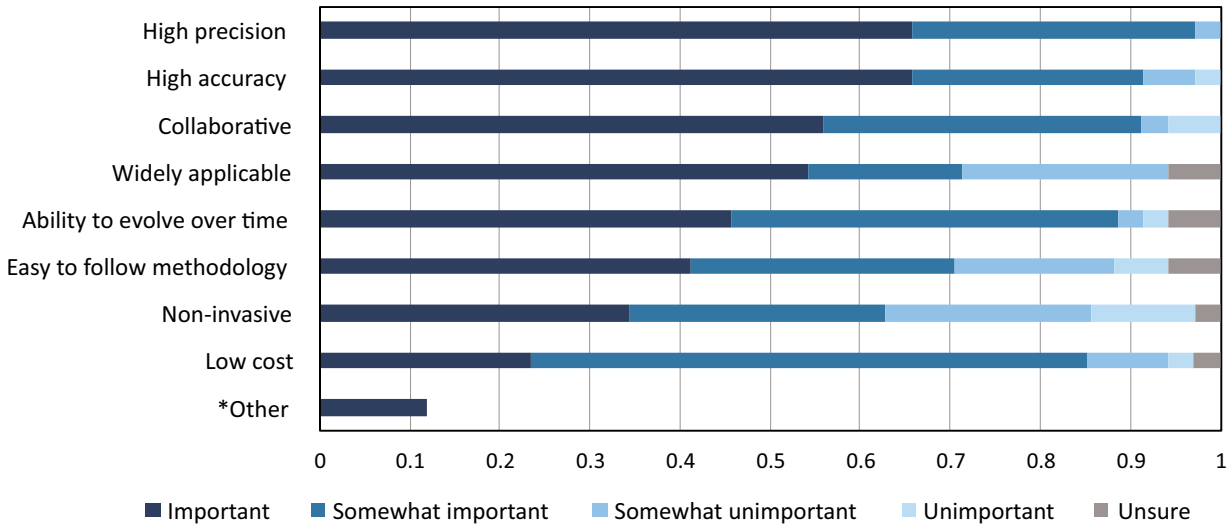


Figure 6: Key elements of monitoring programs, in response to Question 24: "Is the following characteristic important, somewhat important, somewhat unimportant or unimportant for a monitoring program/approach to have?"

Precision and accuracy identified as important

High accuracy and precision were consistently identified as important characteristics in monitoring programs, although little statistical information was provided by respondents on the accuracy and precision of the methods they are currently using.

"…I don't think collaring really is invasive."

No consensus on invasiveness of methods

Opinions on non-invasiveness were varied, and not everyone agreed about which methods might cause stress or harm to boreal caribou. Some felt strongly that it is never okay to put collars on boreal caribou, while others felt there are no issues in doing so. Many fell somewhere on the gradient between, or stated that while they would prefer not to collar boreal caribou, they recognized the value of telemetry data.

"I think we need to get away from continual collaring. We don't really know the effect collaring is having, but even killing 1/100 animals because of collaring would be very bad... We shouldn't be using collars to refine range boundaries."

"We don't want to see collars on animals…Collars should not be used without the express consent of the First Nations."

"We want to be as non-invasive as possible, but estimating body condition of caribou with good accuracy requires that the animal is captured so that reliable measurements can be taken"

"Some people don't like the collars - but understand that it can be the best way to do it"

Cost is relevant but not the most important factor

Low cost was generally seen as somewhat important. Respondents felt it was important to consider, but for the most part were willing to invest larger amounts to obtain more reliable data. The key here is the presumption that spending more will provide more reliable data. This could refer to sampling intensity, or different methodologies. However, there has not been a comparative review of the costs associated with all of the various methods (see the Part II: Monitoring Practices document for cost details).

Photo: Roy V. Rea

Photo: Ducks Unlimited Canada

Resource constraints

Not having the financial resources to carry out monitoring operations was a concern expressed by nearly all participants (>90%). Tied to this was concern about the vast size of the ranges needing to be covered.

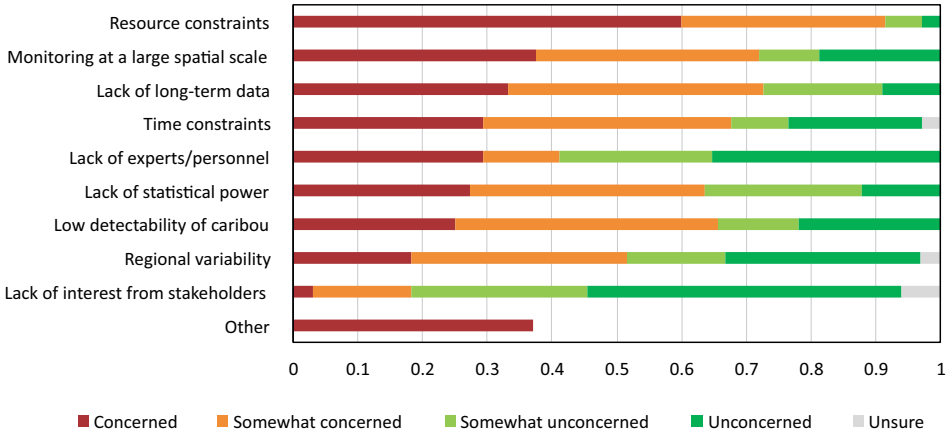


Figure 7: Monitoring challenges identified in response to Question 23: "There are many challenges associated with monitoring boreal caribou. Are you concerned, somewhat concerned, somewhat unconcerned, or unconcerned about the impact each of the following has on your ability to monitor boreal caribou?"

Other concerns expressed by respondents

- Respectfully incorporating local communities in monitoring
- Inability to monitor
- Lack of action
- Social acceptability
- Having Indigenous voices heard
- Lack of understanding of what constitutes appropriate monitoring
- Political turmoil
- Focus on restoration rather than protection
- Participation in harvest surveys
- Consistency in staff to minimize observer bias
- Provincial priorities

[Biggest concern for monitoring in the future] "Having the funding and capacity to do the monitoring and ensuring there is a collaborative approach"

"Lack of resources and personnel to do the work and finances to do it"

Uncertainty that may hinder action

Respondents noted that although statistical power is important to consider, more focus should be geared towards action. In many cases where there are existing data, small improvements in accuracy or precision of parameter estimates might not affect management decisions. This is an important point: although monitoring plays a vital part in threatened species recovery, it alone cannot facilitate recovery (Lindenmayer et al. 2013), and in many cases management may be required. Monitoring for guiding action is most valuable when the outcome of the monitoring is used to modify management actions. Uncertainty in ecological systems can never be eliminated, but following an adaptive management strategy allows for this uncertainty to be systematically reduced over time (e.g. Keith et al. 2011).

Data sharing

Monitoring data are not always widely accessible. Sensitivity and concern over intellectual property rights often result in limited sharing between parties. When respondents were asked whether they would be open to sharing data with other stakeholders, 69% said they would be under certain conditions, 14% said yes unconditionally, 3% said maybe, and another 3% were unsure. None said they would not share. Responses generally fell into one of two categories: i) concern about sharing sensitive information, and ii) the need for transparency in data collection.

For a deeper discussion of issues surrounding data and knowledge sharing, see Appendix B (Lessons Learned: Data and Knowledge Sharing for Boreal Caribou Monitoring).

Concern

"There is some sensitive information from Traditional Knowledge - and concerns over that, but generally we are open to working together for the sake of the caribou."

"If you are monitoring from a research perspective, you want to make sure you are going to be able to do your research first."

Need for transparency

"There may be reasons to need a time lag between collection and release, but open science and open data should be the overarching theme. Data is publicly funded, so we have a duty to share in the not too distant future."

"We don't have concerns about sharing Traditional Knowledge - we would like to share it because we want the people to know what our culture is and our traditional lifestyles. We do like to share our Traditional Knowledge."

"We don't feel that there is anything confidential. Given the way they move around, releasing a telemetry point from two years ago isn't a concern. We don't have concern about harm coming to the caribou - there is a bit of a concern about misinterpretation of the data, but if that happens we would challenge the scientific integrity of the work."

Not being allowed to monitor

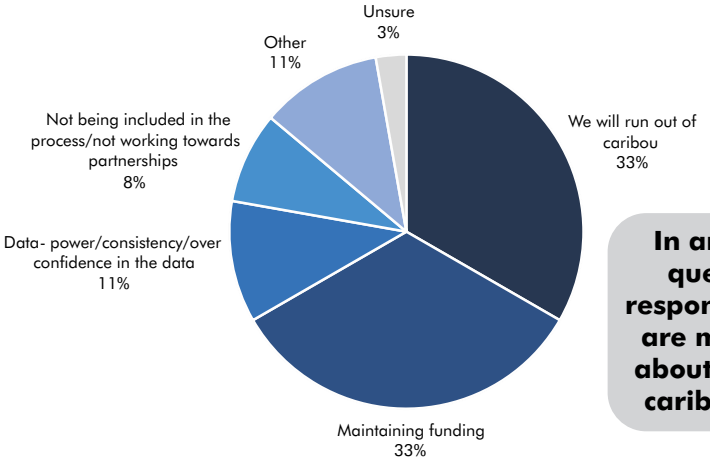
In some areas, provincial/territorial governments are the only ones with the authority to monitor boreal caribou (note that some passive monitoring, e.g. via cameras, does not require permits, though must still be conducted in accordance with privacy and land-access regulations). Several respondents expressed concern about not being involved in the monitoring process. Some organizations indicated that they are keen to share their data for use in provincial recovery planning, yet have been met with resistance due to concerns over the validity of methods used for information collection. There was a desire expressed for all types of data to be used in provincial/territorial planning (and some provinces are now explicitly requiring such data sharing, e.g. Government of Alberta 2018), though some respondents were concerned about the usefulness of certain boreal caribou data that are collected. Providing guidance for monitoring could help resolve this issue; this is discussed further in the Part II: Monitoring Practices document.

"We [the mining industry] have collected a lot of data on woodland caribou that oftentimes sits in a report, and is not incorporated into recovery planning documents. There is a larger body of information than it first appears so we want our information to be able to help inform recovery planning"

"There sometimes can be an element of exclusion or territoriality with respect to certain provinces/territories sharing data, as well as reluctance to integrate high quality data systematically collected by consultants. "

"…any proponent who is doing work in caribou country will have some data - almost none of it sees the light of day … The impact assessment agencies are very passive - and often don't have a lot of caribou knowledge - the standards aren't good - and most of the information is useless – I know this from direct experience - I have evaluated many of them - but the question is how do they become useful and how do they add to the big picture?"

CONCERNS FOR MONITORING IN THE FUTURE



In an open ended question, 1/3 of respondents said they are most concerned about running out of caribou to monitor!

Figure 8: Future concerns for boreal caribou monitoring identified in response to Question 28 (open-ended): "What are your biggest concerns about boreal caribou monitoring in the future?"

Action

"That there won't be any caribou left to monitor. We need to get on this, we have known about this decline for 20-25 years, and we are still talking about monitoring."

"That the federal Recovery Strategy is to over monitor - the system is more complicated than monitoring to a certain undisturbed threshold. There are a lot of other things that we need to be doing about understanding the mechanisms around that disturbance number. While we are doing this monitoring, we need to do better at understanding if we are accomplishing our objective."

"It is the time for action, monitoring will not change the fact that half of the local populations are in decline, we need to just do something."

Cost

"Inefficient spending of money - without careful thought into what you are trying to achieve, you are spending money poorly."

"How we are going to fund and maintain these programs into the future…The scale is so large, that is the biggest challenge, that and having the people available."

Photo: Roy V. Rea

KNOWLEDGE GAPS

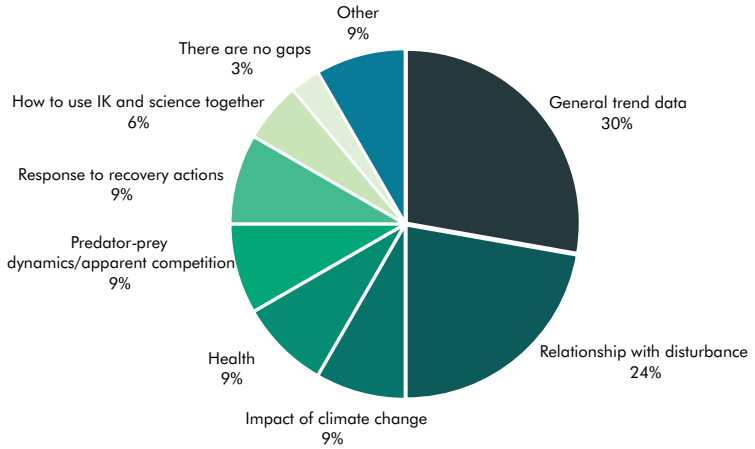


Figure 9: Knowledge gaps identified in response to Question 25 (open-ended): "What do you think are the most important knowledge gaps to fill about boreal caribou populations?"

Population and trend data are still a concern

Approximately one third (30%) of individuals said that the most important gap to fill is general information on trends in boreal caribou abundance, indicating that there are areas where very basic information is still not available, or where existing data are not communicated or accessible.

Desire for a better understanding of disturbance impacts

One quarter (24%) of respondents identified the relationship between disturbance and habitat as a key knowledge gap. Specifically, there is a desire to better understand the conditions of this relationship, such as whether the relationship changes with type of disturbance (natural vs. anthropogenic). Three percent said there are no knowledge gaps.

"… we know enough to manage them, we are just not doing enough of the management. We need experiments (pilots) on the landscape with actual management. DO something! See how it works out! Monitoring is absolutely key - it is more important than modeling/meta-analysis/understanding of ecology; monitoring is the most important right now."

Photo: Al Arsenault

Climate change, health, predator/prey dynamics, and management actions also of interest

"Health is also a piece that is missing… the threat of chronic wasting disease is real"

"Animal health such as it relates to climate change effects: disease, parasites, food availability"

"Regarding dynamics of ungulate populations - there are two sides to the equation - factors that contribute to the productivity of ungulates and factors that directly account for their deaths... Large ungulate biologists, particularly since the advent of radio-telemetry a half century ago, focused on what kills animals to a greater extent than what makes animals healthy and productive. Thus, the cumulative and multifaceted influences of health and productivity on population dynamics are less understood and quantified than are the effects of direct mortality factors such as predation"

"Understanding predator/prey dynamics, and the nuances of apparent competition"

"One thing I have heard concerns about is muskox imposing on boreal caribou habitat"

WHAT CAN BE DONE TO IMPROVE MONITORING?

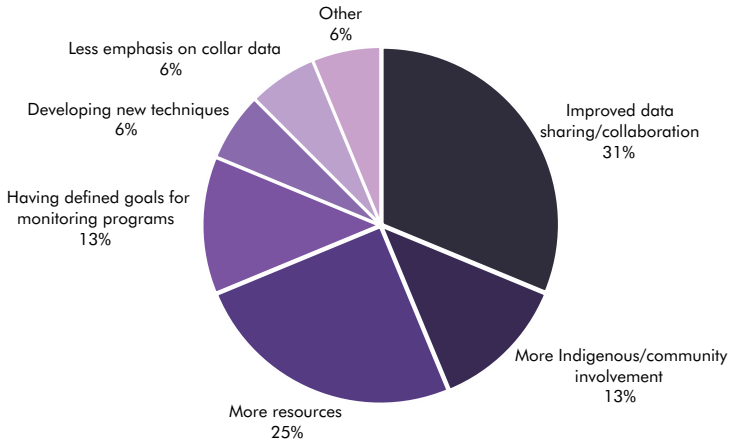


Figure 10: Suggestions for improving monitoring of boreal caribou, in response to Question 27 (open ended): "What actions would you suggest be taken to help to improve boreal caribou monitoring?"

Photo: Gerry Racey

Working better together – with more resources

Approximately one third (31%) of respondents felt that working together would improve boreal caribou monitoring. If data can be collected in a more collaborative way, and if data collected are complementary, it would help to address both of these concerns. Additionally, data collected in collaboration with multiple parties are often more likely to be accepted by all members, compared to situations where one party is completing surveys (Cundill & Fabricius 2009). Specifically, the need for more direct involvement of Indigenous and local communities was mentioned by 13% of respondents.

"Improve the way that local and Indigenous communities are engaged in the process. It is very important, and is not really happening in Canada."

"Sharing information - particularly across jurisdictions. At a larger scale - having scientific or statistical expertise at the design stage is useful."

"Collaborative methods: across industries and with government, open data sharing"

"For us it is making the funding accessible at a local level, and making sure that monitoring is participatory"

Photo: Government of Ontario

Figure 11: Key words used to describe the role that various groups play in monitoring for boreal caribou, in response to Question 29 (open-ended): "What roles do you see for government/Indigenous Peoples/academics/industry/ENGOs in monitoring?" Larger words represent a higher frequency in responses.

Collectively, interviewees saw a slightly different role for each group and organization involved in boreal caribou monitoring. Roles can be complementary to one another, but a conscious effort is needed to make monitoring as efficient and effective as possible. This includes fostering communication of work being done so that efforts are not duplicated, as well as working collaboratively on projects.

Next steps

Monitoring of boreal caribou is taking place all across Canada, using many different approaches to knowledge collection, and thus there is a need for a comprehensive evaluation of methods. Previous comparisons provide valuable perspectives (e.g. Demars et al. 2015; Rettie 2017), but this assessment would benefit from additional consideration of Indigenous Knowledge systems, and of associated costs and logistical feasibility. With many organizations in the infancy of developing monitoring programs, providing a detailed account of the methods which can be used to measure various characteristics across a range of spatial scales would be beneficial. These concerns are addressed in the Part II: Monitoring Practices document.

Photo: Gerry Racey

APPENDIX A

LESSONS LEARNED: BRINGING TOGETHER SCIENCE, TRADITIONAL AND LOCAL ECOLOGICAL KNOWLEDGE

Traditional Ecological Knowledge and Local Ecological Knowledge (TEK and LEK respectively) are immense sources of information with the potential to greatly improve threatened species research and management (Huntington 2000; Anadon et al. 2009). Land-users who spend vast amounts of time on a landscape develop an intimate understanding of the plants, animals and environmental conditions they encounter, and are thus often the first people able to detect changes in the environment (Gadgil et al. 1993; Berkes et al. 2000; Ban et al. 2018). TEK/LEK provides insights that may be missed by conventional science, in which surveys are more focused and cover shorter time periods (Gagnon & Berteaux 2009). Whereas LEK is said to be knowledge collected over the span of one's lifetime, TEK is passed on from generation to generation (Anadon et al. 2009). Thus, TEK usually provides a longer time scale of information compared to scientific approaches, but on a regional scale (Gagnon & Berteaux 2009). Studies which use a combination of science and TEK/LEK together are therefore able to examine patterns over much larger spatial and temporal scales than each method could address alone (Gagnon & Berteaux 2009). Determining methods to effectively include these sources of knowledge when managing threatened species is a topic of increasing discussion (Polfus et al. 2014).

Boreal caribou play an important role in the lives and culture of many Indigenous Peoples. Under the *Species at Risk Act*, the federal government has a legal obligation to consult Indigenous Peoples likely to be affected by recovery efforts to the extent possible. Although there have been some efforts to explicitly recognize the TEK perspective in boreal caribou recovery planning (e.g. bridging science and TEK information within the Recovery Strategies in some provincial range plans; WSP 2014), there is much untapped potential for both TEK and LEK of boreal caribou to play a greater role in monitoring and recovery. There is already significant work underway in this field (Moller et al. 2004), and attempting to offer a full solution to this issue is outside the realm of this report. However, to contribute toward the advancement of co-applying TEK/LEK with scientific methods of boreal caribou monitoring, listed here are some valuable perspectives and themes that emerged through the series of interviews held with members of the National Boreal Caribou Knowledge Consortium Monitoring Working Group (see Monitoring Perspectives: Foreword for additional details).

Photo: Sarah Schmid

I. Build lasting relationships

Monitoring Working Group members stressed that the best co-application of TEK/LEK and science comes though the formation of meaningful partnerships. This point has been acknowledged by previous work such as Benson and Winbourne (2015), who suggested that Indigenous involvement in monitoring projects is best viewed as a long-term partnership.

Starting early

Relationships can take a long time to develop, and should not be expected to form overnight. Efforts to collaborate between Indigenous or local communities and other parties monitoring boreal caribou should be made well in advance of any proposed project. Spending extended periods of time in or living in communities can be a great way to help build relationships. However, as this is not an option for everyone, advanced planning and being mindful of timing in regard to others' schedules have been suggested as key elements for success in previous collaborations (e.g. Huntington et al. 2011). Building meaningful working relationships is a long road, requiring substantial time and financial commitments which need to be considered and anticipated from the outset (Polfus et al. 2014).

> ***"The most important thing is having a relationship, and collaborating"***

Face-to-face communications

Numerous respondents stated that making an effort to communicate face-to-face was important. Although travelling to remote areas can be expensive, having these face-to-face discussions can go a long way toward building partnerships and should be the method of communication whenever possible.

> ***"Come to the north - visit the communities!"***

Bringing results back to the community

Communications should not stop once fieldwork is complete. Results of studies need to be brought back to the community, and communicated in a way that is easily distributable and understood by community members (e.g. in their language, in the context of issues that concern them). This is a vital step towards building meaningful partnerships. It was suggested that (i) these costs be included in project budgets and as deliverables to ensure that this takes place, and (ii) presentations in the community could be an effective method of sharing results.

> ***"It is important to provide feedback, both written and verbally using plain language summaries. Education and awareness on the different types of caribou and why management is important."***

> ***"[Re: best method for sharing knowledge] Share in the community...to those people that are harvesters, and have depended on [caribou] for food. Too often the information shared with the general public ends up in the hands of people that may not use it for that purpose." Walter Bezha*** – *Délı̨nę Got'ı̨nę (Délı̨nę Dene)*

Photo: Gerry Racey

II. Collaboratively discuss the level of local involvement

Interview responses from both Indigenous organizations themselves as well as non-Indigenous organizations revealed a desire for greater Indigenous involvement in multiple aspects of boreal caribou monitoring.

Planning

Even when efforts are made to include Indigenous Peoples or TEK in monitoring, a recurring theme was the desire for communities to play a large role both in the development of monitoring programs (e.g. shaping research questions, characterizing research protocols) and in management decisions being made with the resulting data.

> ***"We have expressed concerns about not having a systematic way to do these surveys in a collaborative way… Often we are just asked to sit on an airplane - but we need to define monitoring programs in collaboration with the government"***

> ***"[Re: role of Indigenous Peoples in monitoring] Being involved - species are very important traditionally and culturally, and their protection is something that we want to be involved with as much as possible, including making recommendations on legislation and decisions made by the government"***

Involving Indigenous and local people in monitoring programs is not a 'one size fits all approach'. As suggested by Danielsen et al. (2009), varying levels of involvement have different associated costs and benefits for both local people and researchers, and thus should be chosen based on the needs of the project. However, greater involvement in planning and execution of projects fosters a greater sense of ownership (Huntington et al. 2011), and increases the probability of the data being considered valid by all concerned (Moller et al. 2004; Cundill & Fabricus 2009). Collaborative discussions regarding the questions being asked can lead to increased chances of gathered information being valued by Indigenous governments (Ban et al. 2018) and disseminated through the community (Gagnon & Berteaux 2009) than when such collaborative research discussions do not occur.

Involving communities in planning can be important for more than just relationship building. Drawing on local experts' existing knowledge of the region can be especially useful in developing protocols, for example for focusing field efforts (Anadon et al. 2009; Huntington et al. 2011) or identifying sites potentially occupied by rare species which were previously unknown (Ramstad et al. 2007; Gagnon & Berteaux 2009). This notion was echoed in the responses from participants:

> ***"Having Indigenous Peoples with Traditional Knowledge sitting at the table and helping with the sampling design would be very useful."***

> ***"Indigenous nations should be partners in developing and conducting monitoring programs, including ensuring that Indigenous Local and Traditional Knowledge is integrated in an adequate and meaningful manner."***

Making efforts to build on pre-existing relationships provides an opportunity to add value to the information already being collected.

Photo: Sara McCarthy

Capacity building

Training local and Indigenous Peoples as researchers to conduct field work can be advantageous for all parties. Interviewees suggested using community members as project leads could be very effective for monitoring boreal caribou.

> *"[Indigenous groups] need to be taking the lead role in the field component and data collection. I think that it could be done much cheaper, and more effectively this way. We can do things cheaply, the incentive cost for people to do the work is very low. Governments are spending large amounts of money to send staff into these remote areas where communities already are on the ground and want to be engaged. If we have a collaborative approach, we can play into each others' strengths."*

Inclusion of local residents in fieldwork allows for the development of shared experiences (Huntington et al. 2011) and can offer opportunities for informal exchanges of information. Including local people in field work may also serve as a jumping off point for collaborative projects in the future (Huntington et al. 2011). In some situations, locally run programs may be more cost effective than those run from a remote location, while empowering communities to continue research once they have gained adequate experience (Moller et al. 2004; Huntington et al. 2011). Moreover, increased local capacity and stronger ties between local communities and regulatory agencies can lead to more agile management actions (Danielsen et al. 2009). Numerous Indigenous communities are already leading their own caribou recovery efforts and note the desire for capacity building within their communities (Benson & Winbourne 2015; CIER 2015; Cold Lake First Nations 2018; Inuit Tapiriit Kanatami 2018).

> *"A lot of the time – they [Indigenous groups] should be the leads in the monitoring programs. They can also help with the communication part as well, talking within their communities and to others in the area."*

> *"We [Indigenous groups] need to be leaders and drivers of the research and monitoring. We can do this through TEK groups and having our boots on the ground."*

> *"[Indigenous groups] need to be the lead on the ground in local areas."*

Photo: Ducks Unlimited Canada

III. Remember that Indigenous nations are unique

Desire to share TEK/LEK

When asked about willingness of Indigenous communities to share their TEK, the response was varied.

> *"Knowledge could be used in negative ways, if Traditional Knowledge is collected would have to check with communities prior to sharing of that knowledge."*

> *"There is some sensitive information from Traditional Knowledge - and concerns over that, but generally we are open to working together for the sake of the caribou."*

> *"It is up to each harvester, I have no issues myself, except the fact that information must be used for the benefit of caribou."*
> *Walter Bezha – Dél̨ı̨nę Got'ı̨nę (Dél̨ı̨nę Dene)*

Each community/nation will be different in their preferences for collaboration. Unique relationships with boreal caribou, cultures, knowledge, values, and experiences can all influence attitudes towards collaborative work. Some interview respondents from Indigenous communities felt that it was important to share their knowledge so there was a broader understanding of their culture and relationship with boreal caribou, while others were hesitant to share knowledge outside of their community for fear it will be used inappropriately. Many mentioned mistrust due to past relationships with either industry or government, and said they would be hesitant to share information because of this history. The impacts of unjust land seizures, and violations of Indigenous rights are still felt in many Indigenous communities (ICE 2018), and will require a long-term commitment to reconciliation to rebuild relationships.

Formal recognition is essential

There was a fear expressed that LEK will not be properly credited to the people who collected it.

> *"It is our information - we want to be credited, and make sure that the local communities are credited."*

Concern over use and ownership of knowledge has been cited as a barrier to sharing information (Huntington 2000). Like any other form of data or knowledge, it is essential to formally credit the source from which information was obtained. To help prevent these issues, research agreements should clearly specify data ownership and sharing restrictions prior to data collection (Ban et al. 2018). See Appendix B (Lessons Learned: Data and Knowledge Sharing for Boreal Caribou Monitoring) for further discussion of data/knowledge sharing challenges and approaches.

Knowledge sharing is a two-way street

> *"I would rather be supportive of people who share their knowledge with us" Walter Bezha – Dél̨ı̨nę Got'ı̨nę (Dél̨ı̨nę Dene)*

Sharing needs to be a mutually beneficial situation: if expecting to receive knowledge, one also needs to be willing to share knowledge. This notion of reciprocity is central in research involving Indigenous Peoples. From a scientific perspective, often the focus can be on collecting TEK/LEK, but communicating scientific knowledge to communities is just as important. This again comes back to the concept of building strong partnerships, where the sharing and receiving of knowledge should go hand-in-hand.

IV. Improving boreal caribou monitoring through TEK/LEK

When asked what could be done to improve boreal caribou monitoring in Canada, collaboration among stakeholders and Indigenous rights holders was a popular theme, and many cited the important role of TEK and community based programs.

"The two knowledge systems are complementary. Large scale is better, but TEK can provide a lot of information about smaller areas for long time periods."

"Improve the way that local and Indigenous communities are engaged in the process. It is very important, and is not really happening in Canada."

"Defining a protocol to include more elements that can come from hunters and Traditional Knowledge..."

"There is a big body of knowledge available. TEK really helps in program design, determining goals and objectives and helping to fill data gaps."

Understanding TEK/LEK

Some interview respondents explained that there may be reluctance by Indigenous Knowledge Holders to share some knowledge with ecologists, for fear that the information would be overly scrutinized, misinterpreted or misunderstood and end up reflecting poorly on the community (e.g. if community members made recommendations about where to look for boreal caribou, and then they didn't find any caribou at that location). TEK and LEK, similar to any knowledge system, have their own limitations which should be recognized, respected and acknowledged. Expectations for predictions made through TEK/LEK should be afforded the same understanding about precision and accuracy as scientific methods of data collection.

It has been suggested than an 'ethical space', which respects all knowledge systems, is essential before TEK and science can be applied collaboratively (ICE 2018). An ethical space is one in which all parties can contribute towards the direction, all knowledge systems are treated as equal and are afforded mutual respect.

Acknowledge applicability

Although TEK can be an extremely valuable source of information, there is a need to understand its limitations. Not every study or project is suited to the inclusion of TEK (Huntington 2000). Indeed there was concern raised by some interviewees about having TEK as a mandatory component of all monitoring programs. It has been suggested that mandating inclusion of TEK in every study may actually diminish chances of meaningful inclusion, and that TEK should be included only when appropriate for the study at hand (Huntington 2000). For example, the effort to gather TEK may not be justified when asking questions at very large scales without coordinated efforts among the local communities.

Photo: Susan C. Morse

V. There are barriers to co-application

"We want to – but don't know how"

Many conservation practitioners are unfamiliar with traditional ways of knowing, and have thus not made an effort to integrate this type of knowledge (Huntington 2000). As conservation practitioners are often over-extended, finding time to develop these skills may be difficult, and although many interviewees expressed the value and need to integrate TEK in multiple levels of monitoring programs, few indicated that they are currently working collaboratively with Indigenous knowledge holders.

> ***"We believe that Indigenous Peoples (elders and Indigenous harvesters) could provide valuable knowledge through Local Ecological Knowledge. However, we currently have no expertise and no means to collect and analyze this kind of data"***

This situation may be a result of unfamiliarity with social science methods, or resistance to altering current methodologies (Huntington 2000). However, requiring ecologists to become social scientists, or conversely requiring Knowledge Holders to become ecologists, might not be helpful. Consulting an expert to strengthen conservation practitioners' understanding of Indigenous Knowledge systems, and provide guidance on how to facilitate meaningful partnerships with Indigenous and local communities may be beneficial.

Additionally, there are many avenues for inclusion of TEK and local communities that do not require complete knowledge of social science techniques (Danielsen et al. 2009). Indigenous and local communities often have the expertise necessary to collect TEK/LEK, but lack the resources required to complete these studies. Thus providing funding to ensure that communities are able to collect their own knowledge, in addition to offering training opportunities for conservation practitioners who wish to develop a greater understanding of TEK/LEK methods and strengthening avenues for sharing knowledge, may be a more effective way to facilitate co-application.

Providing clear guidelines for the inclusion of TEK in recovery planning has also been suggested as an avenue to improve Indigenous involvement in threatened species recovery (Hill et al. 2019).

Moving towards co-application

In addition to the points presented here, the literature has shown that science and TEK/LEK can be very effective when used as complementary approaches. For instance, Anadon et al. (2009) used LEK to determine presence and relative abundance of tortoises, followed by transect sampling to obtain absolute abundance relative to the abundances obtained from LEK. This methodology, similar to a double sampling technique (Anadon et al. 2009) may be applicable to boreal caribou populations. Gibbs et al. (1999) discussed how opportunistic sampling carried out by individuals on the land was able to complement systematic monitoring, providing valuable information regarding breeding phenology and distribution. The aspect of complementarity is arguably one of the biggest advantages of the co-application of TEK/LEK and science. Each way of knowing offers unique and valuable contributions to the overall state of knowledge (Moller et al. 2004).

It is clear that the use of Traditional and Local Ecological Knowledge is valuable for boreal caribou conservation. Although it has been suggested that TEK may not be essential in every project, inclusion of local communities in planning has potential to foster a sense of joint ownership of actions, build relationships for the future, and lead to more effective conservation of boreal caribou.

There is a broadly-held desire to have better inclusion of TEK/LEK and local communities in boreal caribou monitoring. Some Indigenous communities are hesitant to share their TEK, and how co-application will best be achieved will be different in each situation. Efforts focused on building reciprocal relationships between Indigenous and non-Indigenous organizations, and clear communication, will be essential moving forward. Directly addressing communities to ask them what they are concerned about, and how they want to be involved, can open the door to a range of possible methods of collaboration and meaningful application of TEK/LEK. Support in terms of training and resources should be made available to communities who want to play a greater part in scientific monitoring of wildlife on their land, as well as to conservation practitioners who want to better understand how to work with Indigenous and local communities. Avenues for Indigenous and local communities to initiate greater involvement should also be strengthened. The participants of these interviews are motivated to work together to conserve boreal caribou – and are open to exploring methods to ensure this is done in the best way possible.

APPENDIX B

LESSONS LEARNED: DATA AND KNOWLEDGE SHARING FOR BOREAL CARIBOU MONITORING

Addressing concerns about the sharing of data and knowledge represents an important challenge for the monitoring of a species as wide-reaching as boreal caribou in Canada. During the interviews conducted by the National Boreal Caribou Knowledge Consortium (NBCKC) Monitoring Working Group (see Monitoring Perspectives: Foreword), respondents were asked "What actions would you suggest be taken to help to improve boreal caribou monitoring?" Although this was an open-ended question, 31% of respondents indicated that their biggest priority relates to improving data sharing and collaboration; no other action received as much support among interviewees.

More broadly, the 2018 federal Action Plan for boreal caribou identified the need to "Develop national standards for population monitoring" (ECCC 2018), highlighting the importance of communicating monitoring information across the vast expanse of Canadian forest that is home to boreal caribou. Establishment of the NBCKC is a direct result of this need for cross-Canada collaboration. Highlighted here are some key messages derived by the Monitoring Working Group regarding data and knowledge sharing (including direct quotes from interviews) in the context of other available resources on this topic.

"Working on protocols to share knowledge and data, and having avenues to share knowledge, as well as funding for systems where there are less resources"

KEY MESSAGES

Jurisdictional responsibilities and involvement of diverse knowledge holders creates complicated dynamics. Potential disagreements among partners may be a key complicating factor in conservation data-sharing (Minderman et al. 2019). Because the legal responsibility to manage most Canadian wildlife belongs to the provincial, territorial and Indigenous governments, monitoring of a widespread species like boreal caribou is by necessity subject to region-specific priorities, policies and approaches. However, there are additional rights holders for which boreal caribou are traditionally and culturally important, industries involved with development and resource extraction in caribou habitat, and the federal government responsible for protecting Species at Risk. Few other organisms in Canada are spread across so many jurisdictions and of interest to so many different parties as caribou, and thus the explicit sharing of knowledge among these groups is both more difficult and more critical than for many other species.

"Often the picture of a particular population is built out of pieces because few can look at the whole picture at once."

"Truncation of data based on administrative boundaries can result in divergent management approaches or monitoring effort between jurisdictions for a particular population"

"Data holders have to buy into the idea that sharing data from across jurisdictions will lead to a better understanding, and that there is a greater sum of the parts: there has to be buy-in from a big picture perspective."

Willingness to share boreal caribou monitoring knowledge and data is often conditional. When asked whether they would be open to sharing data with others, the majority of interview respondents (69%) said that they would be willing to share only under certain conditions, ranging from basic communication of data usage to strict limitations on application and analysis. Just 14% replied yes unconditionally; none refused outright to share. This hesitation is not limited to boreal caribou, as recent reviews have suggested that scientists in ecology lack a 'culture' of data sharing, which would demand a significant shift in mind-set if ecological science research were to adopt a more open-science framework (Hampton et al. 2013, 2015). (Note that while all questions were posed to every interviewee and intended to be general in scope, this question in particular reflected a 'science-knowledge' bias, as the Indigenous view considers knowledge as proprietary, with ownership belonging to individuals and families.)

"I would be able to share all data - but under certain conditions. If you are monitoring from a research perspective, you want to make sure you are going to be able to do your research first. So I would need to be sure that the stakeholders share their specific objectives, and if they don't overlap with what I am doing I would share. If they do overlap, I would need to have a discussion with them to make things align better and we aren't trying to do the same thing. As well as an acknowledgement of the people who were involved in the work."

"All the data we collect is made publicly available; the only constraint we have is if we have a specific agreement with academic researchers to protect data until they have had an opportunity to publish, then it is made public. There is a degree of private sector competitiveness, industry people don't always want the data shared and Indigenous partners can decide what of their knowledge is shared."

Challenges with data sharing and management are not unique to boreal caribou. For instance, Tulloch et al. (2018) discuss the broad range of concerns related to publication of any biodiversity data, and propose a decision-tree approach recognizing that the best practice will vary with the relative risks and benefits specific to each population. Another recent assessment of monitoring for threatened species highlights the importance of clear communication among researchers and conservation managers at all stages of a monitoring program, to maintain data integrity and identify trends early (Robinson et al. 2018). It identifies key principles that would enhance monitoring programs for Species at Risk, including: "(i) integrate monitoring with management; (ii) design fit-for-purpose monitoring programs; (iii) engage people and organizations; (iv) ensure good data management; and (v) communicate the value of monitoring" (Robinson et al. 2018). Part of ensuring good data management includes discussing how the data will be stored, processed and shared before they are collected (Robinson et al. 2018). Careful attention to data management is an important part of evaluating population trends (e.g. Gibbs et al. 1999: "Monitoring information is wasted if it is not analyzed correctly, analyzed well, reported timely or communicated appropriately to policy makers").

"Caribou aren't isolated in this problem - there are strict protocols on At-Risk species, which makes sense in populated areas - having the data out there would put the species at further risk. In our case - we would still be restricted by our data sharing agreements; protocols would be up to the data holders."

"Approach and protocol needs to be such that it can be compared through space and time."

Transparency of data and knowledge is gaining support and logistical constraints are declining. Poor transparency in ecological data has been identified as an impediment to scientific progress (Parker et al. 2016), and there is a growing push for open data in ecology (e.g. Parr & Cummings 2005; Reichman et al. 2011; Hampton et al. 2013). Arguments include the public funding of most government-collected data, and the moral difficulty in justifying private protection of data that could serve to address global environmental and conservation challenges (Parr & Cummings 2005). The potential costs to not sharing data have also been raised, as the sensitive information might be highly valuable for mitigating threats and augmenting research efficiency (e.g. Tulloch et al. 2018). Moreover, new and developing data management technologies and storage options are now eliminating previous logistical challenges with implementation of data-sharing and publication of large data banks (e.g. Reichman et al. 2011; Michener & Jones 2012; Hampton et al. 2015; Lowndes et al. 2017).

"It is absolutely essential to have information transparent and out there for everyone."

"[Caribou] information has value that needs to be transparently shared within the limits of confidentiality and respectful stewarding of Traditional Knowledge, because that has its own protocols to adhere to."

Reservations about sharing caribou data centre on sensitivity of information and misuse of data. Several interview respondents expressed concern over releasing information on a Species at Risk that might put it at greater risk (e.g. if location data were used by poachers to target individual animals). Beyond safety concerns, other interviewees suggested that researchers must be able to publish papers before data are released, and that openly shared data might be misinterpreted or mis-represented. Similar reservations have been raised more broadly about the sharing of ecological data (e.g. Cooke et al. 2017; Nguyen et al. 2017; Tulloch et al. 2018). Concern about being 'scooped' by other researchers is common in the field of ecology, where the risks of open data may be viewed to be higher than the rewards (Reichman et al 2011; Tulloch et al. 2018).

"There are always hesitations in provincial government to share such information, due to a concern for the use of the data, but I think the data itself should be available. Conditions might apply and time period specified but as the public pays for the data, ultimately it should be available; maybe a two year release lag?"

"You need data use agreements, and need to ensure regular updates on how the data is being used, as data can be misinterpreted or used inappropriately."

Concerns and methods for sharing may differ for Indigenous Knowledge. Hesitation to share Indigenous Knowledge may stem from somewhat different motivations than concerns over science data sharing. For instance, some Indigenous representatives cited fears that sharing of information could cause degradation of resources (e.g. species locations leading to increased harvest), and mentioned that knowledge-sharing hesitancy often derives from a general mistrust of the intentions of governments, and a belief that traditional information is undervalued. The synthesis of Indigenous Knowledge with science-based data for boreal caribou monitoring is addressed in detail in Appendix A of this report (Lessons Learned: Bringing Together Science, Traditional and Local Ecological Knowledge); moreover, the NBCKC is also addressing these concerns directly through initiatives led by the NBCKC Indigenous Knowledge Circle (for more information or interest in participating, contact cnscb-nbckc@canada.ca).

Cross-cultural differences between science knowledge and Indigenous perspectives can also lead to misunderstandings about motivations for not sharing knowledge. While scientists may value Indigenous Knowledge, they may not fully understand the socio-cultural context of knowledge and rules around sharing and use.

"Indigenous Knowledge includes questions of confidentiality - people are not always comfortable sharing their traditional information; traditional hunters don't want to share that information - but it depends on the hunter - our main traditional hunters don't really feel comfortable sharing information like that. They consider it a cultural value, counting animals - they are not comfortable culturally to share that information because people and caribou have an intimate relationship: advertising your hunt can be considered boasting and disrespectful to the animals."

"The decision to share or not should be made by the knowledge holders, especially with Indigenous Knowledge which may require some sort of extra protections"

"We have a lot to learn from Indigenous groups, and incorporating their Indigenous Knowledge. Often that Indigenous Knowledge is held close to them, but it would help if it was shared."

Monitoring meta-data should also be made available. If data are considered too sensitive to be openly shared, then communication of the type/quantity of data available would still be beneficial to the planning of monitoring programs. For instance, several interviewees expressed frustration at not even knowing what monitoring information might be available, and some suggested the need for a database outlining the type of information that is available (even if the details are not publicly shared). Additionally, very few interview respondents provided monitoring cost insights, citing a lack of such knowledge, concerns over authority to share it, or limitations on their time to collate the necessary numbers. Yet the sharing of information about the costs and logistics of existing programs, and not just the results of these, would be very helpful for the planning of new or modified monitoring initiatives.

"The first thing we need is information about methodology and results to be housed in one place, so that anyone interested can then go to the data owners as needed."

Photo: Helen Schwantje

Improvement and coordination of data-sharing protocols/agreements for boreal caribou are desired. Many interview respondents expressed concern about the lack of transparency and the complexity of current data-sharing agreements for boreal caribou. Some of these issues could potentially be alleviated by developing best practices for sharing, or baseline data-sharing agreements. With the engagement of all the various knowledge holders, such agreements could be adapted to suit the varying needs of the parties involved and could serve to coordinate data-sharing processes into a consistent and streamlined approach.

"People use very complex forms for sharing agreements, which basically means they don't share. It would be good if the Consortium came up with some guidelines for sharing agreements. There will always be local things to consider, but explaining the rationale behind the questions and how to proceed if there is overlap."

"Best practice is through data sharing agreements, on a case by case basis. We want to be acknowledged, and followed up with about any results coming from the data."

"I think the federal government needs to play a role - without data sharing agreements from provinces… Boreal caribou are national - we need a federal/national clearing house for the data. The clearing house can be high level - but transparency about what types of data, the methods and results need to be updated and kept."

"We are entered into strict data sharing agreements. We are obligated to share the results of research/science, but we have to be careful not to reveal any of the raw data in the results."

"We set up a data sharing agreement - usually with the university, or a specific faculty member that outlines what the data will be used for, and specifies terms of the agreement. Usually these agreements are for five year periods, and at the end of the agreement the data is to be removed from any digital media."

MOVING FORWARD WITH DATA AND KNOWLEDGE SHARING

The NBCKC can help with improving communication and sharing of data and knowledge. The NBCKC is currently developing an online Knowledge Sharing Portal, which will serve as a centralized and dynamic repository for boreal caribou knowledge. It will include an interactive map highlighting boreal caribou work across the country, meta-data and contact information on current projects and participants, and access to resources relevant to boreal caribou monitoring and conservation. Beyond this, the NBCKC could also work with its partners to develop a boreal caribou meta-database comprising a complete and up-to-date record of the types of monitoring data and knowledge available and the contact information for requesting access to it (e.g. a detailed expansion of the summary meta-data provided in the Monitoring Perspectives main document). This could help to prevent duplication of existing data and facilitate communication and collaboration.

Understandably, there are concerns that sharing data would disclose sensitive boreal caribou locations, risk data ownership and attribution, or open the door to misinterpretation or misuse. However, there are likely data and knowledge types that can be shared with lower risk, and formal protocols could be developed to minimize the risks of broader information sharing. The NBCKC could work with its partners to develop a suite of knowledge/data sharing protocols or agreements to directly address these concerns.

Existing agreements and procedures could serve as models for national-scale boreal caribou information sharing. Informal data-sharing protocols are a valuable starting point: for instance, the Western Arctic Caribou Herd Working Group has established a consistent practice of sharing results and insights among biologists, researchers, hunters and local knowledge holders (Alaska Department of Fish & Game 2019), and the Regional Industry Caribou Collaboration of northeast Alberta emphasizes both internal and external data planning, collaboration and communication (RICC 2018). Similarly, in their "Consensus Agreement Respecting Implementation of the Recovery Strategy for Boreal Caribou" (CMA 2017), the Government of the Northwest Territories highlights priorities to work with other jurisdictions as well as with co-management partners, Indigenous governments, local communities, NGOs and industry to "share information and collaborate on management actions". More formal arrangements also exist. For example, the BC Oil and Gas Research and Innovation Society engaged a consultancy to manage their boreal caribou data, and provide recommendations for improving data management and communication (Calsys Consulting 2018). The Government of Alberta has also recently established a requirement that all wildlife data be reported via the Fish and Wildlife Information Management System, and recommends outcomes and best practices for operations in caribou ranges (Government of Alberta 2018).

There are a number of existing academic or government-based data-sharing practices and protocols upon which a national boreal caribou data-sharing process could be based. Some examples [see page 40 for full link addresses] include: US Geological Survey Data Sharing Agreements; Best Practices for Information Sharing Agreements outlined by the Saskatchewan Information and Privacy Commissioner; and Guidance on Preparing Information Sharing Agreements Involving Personal Information from the Treasury Board of Canada. A template for data sharing agreements is illustrated in Contract Standards, and suggested elements of data sharing protocols are also provided by research ethics guidelines from the University of Waterloo. While the type of information and its applications affect the specific design and requirements of each protocol, key features common to many of these agreements include: protection against misuse of data, permitted disclosure, intellectual property guidelines, risk assessment, metadata, storage and security.

There are also established guidelines and protocols specific to Indigenous engagement and Indigenous Knowledge research that could serve as further examples for knowledge sharing processes. These include the Tri-Council Policy on Research Involving the First Nations, Inuit and Métis Peoples of Canada, COSEWIC's Aboriginal traditional knowledge: process and protocol guidelines, the National Inuit Strategy on Research, and guidance documents from the Aurora Research Institute, Northern Contaminants Program and Assembly of First Nations.

Photo: Laura Finnegan

LINKS TO EXISTING DATA/KNOWLEDGE SHARING AGREEMENTS AND EXAMPLES

US Geological Survey – Data Sharing Agreements
https://www.usgs.gov/products/data-and-tools/data-management/data-sharing-agreements

Best Practices for Information Sharing Agreements outlined by the Saskatchewan Information and Privacy Commissioner
https://oipc.sk.ca/assets/best-practices-for-information-sharing-agreements.pdf

Guidance on Preparing Information Sharing Agreements Involving Personal Information from the Treasury Board of Canada
https://www.canada.ca/en/treasury-board-secretariat/services/access-information-privacy/privacy/guidance-preparing-information-sharing-agreements-involving-personal-information.html

Contract Standards – Data Sharing Agreement template
https://www.contractstandards.com/public/contracts/data-sharing-agreement

University of Waterloo – Research ethics – Elements of a data sharing agreement
https://uwaterloo.ca/research/office-research-ethics/research-human-participants/pre-submission-and-training/human-research-guidelines-and-policies-alphabetical-list/data-sharing-or-transfer-agreements-what-are-they-and-when/elements-data-sharing-agreement-example

Tri-Council Policy on Research Involving the First Nations, Inuit and Métis Peoples of Canada
http://www.pre.ethics.gc.ca/eng/policy-politique/initiatives/tcps2-eptc2/chapter9-chapitre9/

COSEWIC Aboriginal traditional knowledge – Process and protocol guidelines
https://www.canada.ca/en/environment-climate-change/services/committee-status-endangered-wildlife/aboriginal-traditional-knowledge.html

National Inuit Strategy on Research
https://www.itk.ca/national-strategy-on-research/

Aurora Research Institute – Doing Research in the Northwest Territories
https://nwtresearch.com/sites/default/files/doing-research-in-the-northwest-territories.pdf

Northern Contaminants Program – Guidelines for Responsible Research
http://www.science.gc.ca/eic/site/063.nsf/eng/h_C2EEA952.html

Assembly of First Nations – Ethics Guide on Research and Aboriginal Traditional Knowledge
http://www.afn.ca/uploads/files/fn_ethics_guide_on_research_and_atk.pdf

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MAP SOURCE LAYERS

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