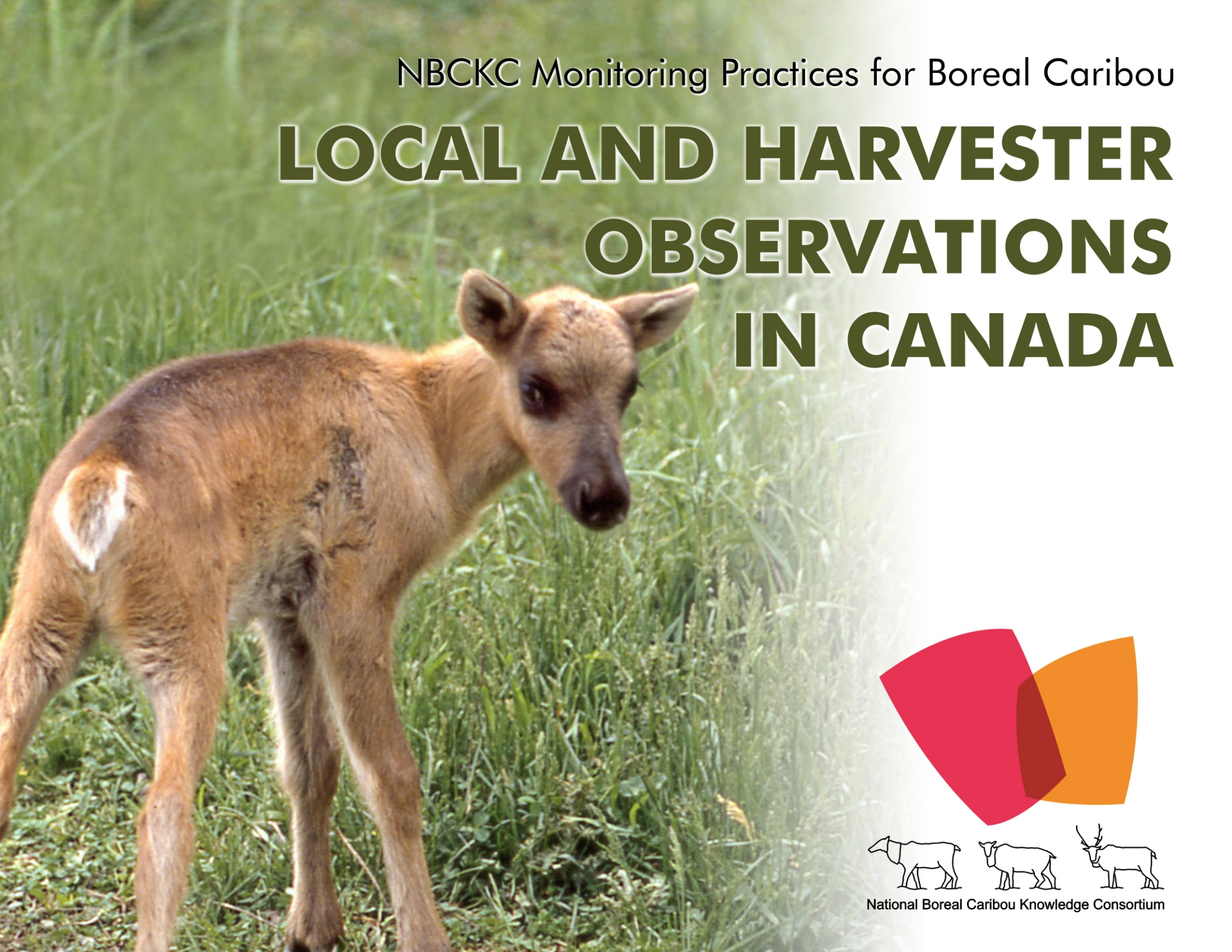
NBCKC Monitoring Practices for Boreal Caribou

LOCAL AND HARVESTER OBSERVATIONS IN CANADA



National Boreal Caribou Knowledge Consortium

Front Cover Photo Credit: OMNRF

Local and Harvester Observations

Contents

LOCAL AND HARVESTER OBSERVATIONS

Photo Credit: Craig DeMars

Introduction to Local and Harvester Observations

Local community members, and Indigenous Peoples in particular, have in-depth knowledge of the land and wildlife from direct observations that are valuable to the monitoring of caribou populations. In cases where caribou are part of the community or Indigenous culture, local and harvester-based perspectives offer ecological insights that may not be available through conventional scientific means (e.g. Gamble 1978, Kutz and Tomaselli 2019, Peacock *et al*. 2020). For instance, local and traditional knowledge can span longer time periods and larger spatial scales than many scientific research studies (Gagnon & Berteaux 2009), yet also can provide more detailed information for specific locations (Johnson *et al*. 2015). Even in areas where caribou no longer exist, historical knowledge and perspectives are extremely valuable for understanding cumulative effects from human actions and longer-term impacts. For many northern species, local knowledge has proven valuable to wildlife conservation, including for braiding traditional and evolutionary perspectives (e.g. Fraser *et al*. 2006), or for broadening coverage of disease surveillance (e.g. Iverson *et al*. 2016, Tomaselli *et al*. 2018). As a result, community-based monitoring is growing in many regions (e.g. Benson & Winbourne 2015, Johnson *et al*. 2015, Carlsson *et al*. 2016, ABEKS 2020, Peacock *et al*. 2020, Thompson *et al*. 2020) and localized studies are informing one another through the establishment of collaborative networks (e.g. the CircumArctic Rangifer Monitoring and Assessment network, Kutz *et al*. 2013). There are many Indigenous-led initiatives for boreal caribou protection that have been formally established over the last several decades and continue today (CIER 2015), and the need for Indigenous-led conservation and monitoring initiatives was emphasized at the 2018 North American Caribou Workshop.

Collaborative monitoring and knowledge co-generation between western scientists and local community members not only provides broader ecological perspectives, but also facilitates stronger relationships and continued flow of information (e.g. the "One Health" approach to public and environmental health and disease; Buttke *et al*. 2015, Cunningham *et al*. 2017, Kutz and Tomaselli 2019, Thompson *et al*. 2020). Engagement of local communities throughout all phases of wildlife research can include collaborative research planning, interviews with hunters and Elders, direct sampling of tissues from harvested animals, school visits, and shared communication of research findings back to the community (see examples in Moller *et al*. 2004, Brook *et al*. 2009, Kutz *et al*. 2013, Carlsson *et al*. 2016). A review by Tondu *et al*. (2014) emphasizes social and engagement themes such as "being present", listening, respecting and communicating as key factors in effective relationships, and Benson & Winbourne (2015) similarly outline recommendations for establishing collaborations between people, local communities and scientific researchers. Most recently, Peacock *et al*. (2020) outline a framework for bringing together knowledge types to inform wildlife co-monitoring and co-management, while Snook *et al*. (2020) use interview findings to highlight challenges and frustrations with caribou co-management.

The sections below outline two complementary approaches to the involvement of community members, Indigenous Knolwedge holders,

LOCAL AND HARVESTER OBSERVATIONS

and other local land users in caribou monitoring. The first focuses on discussions and interviews, either in individual or group formats, which provide insight into diverse metrics such as body size, body condition scores, signs of disease or parasites, and general observations on distribution and movements of caribou (e.g. Kofinas *et al*. 2003, Kendrick *et al*. 2005, Kutz *et al*. 2013, Tomaselli *et al*. 2018). While the information derived from these interviews is largely qualitative in nature, it often provides novel, complementary information and essential context to scientific data (Gagnon & Berteaux 2009, Gagnon *et al*. 2020, Thompson *et al*. 2020). If the community or organization feels comfortable with the practice (as determined prior to the start of the program), and if the information collected is standardized and repeated, information could be used to generate quantitative data with power to detect population change (e.g., Jones et al. 2008, Tomaselli et al. 2018). Note, however, that some communities and organizations may not support that method of interpretation. Further, the richness of information shared is not always conducive to this form of analysis.

The subsequent section explores the ways in which harvesters can be directly involved in recording observations and collecting samples (e.g. feces, tissues, hair, blood, etc.) from animals they are already planning to harvest. Samples are subsequently analysed to derive indices relevant to population health monitoring. Such sampling can be conducted for a specific purpose, such as screening for a targeted disease, or may be a broader, ongoing health surveillance program used to monitor and detect changes over time. It typically requires a local champion to administer the program (e.g., hunters and trappers organizations, government wildlife department, researcher) and may require specific training of local participants for sample collection (e.g. Kutz *et al*. 2013). Harvesters involved in this sampling could include Indigenous hunters, resident hunters, as well as Indigenous and non-Indigenous guide-outfitters.

Finally, while the focus of this chapter (and this monitoring report in general) is on the boreal ecotype of caribou, boreal caribou are not often hunted in most of their range. Thus many of the references and examples cited in this chapter are derived from monitoring of other caribou ecotypes or other ungulates, but are nonetheless relevant anywhere that boreal caribou are harvested. Monitoring through local observations and interviews is directly applicable to all boreal caribou populations.

Photo Credit: Lukas Mundy

LOCAL AND HARVESTER OBSERVATIONS

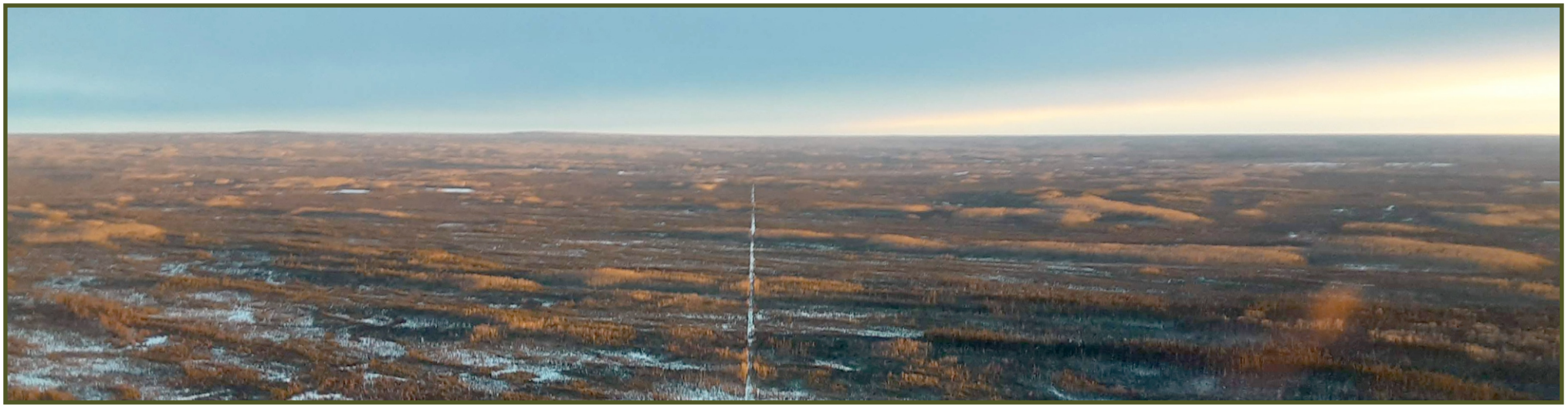


Photo Credit: Agnes Pelletier

Indigenous Knowledge in Monitoring Programs

This chapter serves to highlight the ways in which local and harvester knowledge, observations and sampling can contribute to the monitoring of boreal caribou populations. A fulsome review of Indigenous ways of knowing boreal caribou is provided by Benson & Winbourne (2015), and an updated review of recent approaches to community-based boreal caribou monitoring is underway in collaboration with the NBCKC-Indigenous Knowledge Circle (Benson & Winbourne, *in prep*). The contents of this chapter are not intended to duplicate the material covered in those documents (to which the reader is referred for more detail). In addition, the Practical Aspects to Reconciling Indigenous and non-Indigenous Ways of Knowing toolkit (*in prep*) will highlight practical guidance for using multiple ways of knowing caribou and will help readers understand the characteristics of meaningful collaboration with Indigenous communities. For example, such characteristics include (but are not limited to): Indigenous people co-coordinating the program from the onset of planning; equitable sharing of decision-making as it pertains to the monitoring program; frequent communication throughout all phases of a program; dedication to relationship-building and mutual learning; agreement on ethical principles surrounding project design and implementation; transparency in collection, use, and storage of data (e.g. OCAP principles); adherence to protocols established by local governance and co-management boards, and making space (dedicating time, energy, and resources) to include both capacity building, and compensation for time, in the monitoring program.

We note that although we use the term 'monitoring' in this and other chapters of the toolkit, the term itself likely induces a bias toward a science perspective rather than an Indigenous one (e.g. Benson & Winbourne 2015). Whereas the scientific approach to population monitoring focuses on the standardized collection of repeated measures over time, Indigenous Knowledge is based on cross-generation connections between the land and people (Ban *et al*. 2018). Throughout this report we use the term 'monitoring' to refer to all forms of knowledge that inform the status, health or characteristics of caribou populations, but acknowledge that this word is by definition not fully inclusive.

8. Local and Harvester Interviews

8.1 AT A GLANCE

Discussions and interviews with local community members, Indigenous Elders and hunters are increasingly recognized as a valuable source of knowledge on the health and status of caribou populations (Benson & Winbourne 2015, Peacock *et al*. 2020). For instance, interviews with Dene Elders have revealed novel insights into barren-ground caribou migration and movement (Kendrick *et al*. 2005) as well as signs of disease (Parlee *et al*. 2014). Similarly, the benefits of community-based wildlife health monitoring with the Sahtu peoples of the Northwest Territories are discussed in Brook *et al*. (2009) and Carlsson *et al*. (2016), and detailed studies of body condition and population growth have recently been conducted in collaboration with Indigenous hunters in Alaska (Kofinas *et al*. 2003, Gagnon *et al*. 2020). Sharing and recording of this knowledge can take many forms, some of which are described here.

Photo Credit: Naima Jutha/Tahltan Guide and Outfitters Association

Participatory epidemiology

Epidemiology is a study of incidence, distribution, and possible control of diseases and other factors relating to health. Participatory epidemiology is a "growing branch of epidemiology which uses a combination of practitioner communication skills and participatory methods to improve the involvement of animal keepers in the analysis of animal disease problems, and the design, implementation and evaluation of disease control programmes and policies" (Catley *et al*. 2012). In the context of local and harvest interviews, individual or group discussions that take place during participatory epidemiology sessions can be used to document hunter and Elder knowledge, such as observed changes in body condition, population structure, herd composition (e.g. age/sex ratios), and signs of disease, in a semi-quantitative and repeatable manner (e.g. Brook *et al*. 2009, Tomaselli *et al*. 2018, Jutha *et al*. (unpublished data)). For example, a novel study by Tomaselli *et al*. (2018) on the Dolphin and Union caribou herd and muskoxen demonstrated the value of participatory epidemiology methodologies for providing critical narratives on the species' ecology, as well as a semi-quantitative understanding of historic and current population health and trends for these species.

Formal baseline interviews (individual or group)

Formal interviews are usually conducted with a goal of collecting historic and current status and trends. These interviews happen just once to establish the historic baseline for the community (see Peacock *et al*. 2020). For example, harvest interviews often ask whether hunters observe fewer, the same, or more caribou than in previous years, providing an index of population trend over time (e.g. Benson & Winbourne 2015, Tomaselli *et al*. 2018). Observations and recollections of consumption of harvested caribou can also expand this perspective (e.g. Parlee *et al*. 2014). These

8. Local and Harvester Interviews

interviews may be conducted with knowledge holders who are Indigenous, or may be conducted with knowledge holders who are not Indigenous such as local pilots, long-term residents, outfitters or guides (Tomaselli *et al*. 2018, Peacock *et al*. 2020, Jutha *et al*. (unpublished data)).

Repeated interviews (individual or group)

Regular or repeated interviews and discussions with harvesters and local land-users can offer insights into a wide diversity of metrics relevant to all caribou (Benson & Winbourne 2015). These interviews are conducted annually or semi-annually (as appropriate) to document observations in a manner that is comparable year after year in order to track trends and detect changes in a timely fashion (see Peacock *et al*. 2020). For instance, knowledge of the locations where animals are harvested can provide valuable information on habitat use, distribution or movement patterns (e.g. Polfus *et al*. 2014, Kendrick *et al*. 2005), though the degree of spatial coverage will be driven by the distribution of harvest effort (Benson & Winbourne 2015). In addition, harvesters can offer critical insight into wildlife health, including observations of any abnormalities that could indicate known or novel or emerging diseases or parasite infections (Kofinas *et al*. 2003, Brook *et al*. 2009, Kutz *et al*. 2013, Parlee *et al*. 2014, Carlsson *et al*. 2016, Tomaselli *et al*. 2018, Gagnon *et al*. 2020). Local and community-based information can be collected systematically and on an ongoing basis, providing early warning indicators (Tomaselli *et al*. 2018) and allowing a broader spatial and temporal perspective than many science-based studies (Polfus *et al*. 2014, Gagnon & Berteaux 2009, Kutz and Tomaselli 2019).

Anecdotal reports

Although perhaps less detailed than structured interviews with hunters, additional informal or opportunistic observations by local community members or people on the land can be used as early indicators, signaling any need for formalized monitoring methods to identify problems or highlight novel changes in caribou populations. Opportunistic or informal reports and observations should be properly documented as received, and following up with individuals on these should be a priority to encourage continued awareness/observations/reporting.

Photo Credit: Ryan Abel

8. Local and Harvester Interviews

Surveys

The structure and consistency of survey forms affects participation rate and the value of information gathered. Particular attention must be paid to the wording and formatting of questions, to ensure high response rates (e.g. Carriere 2012). For example, questionnaires and forms should be co-produced by the community to be interviewed. This practice helps to build trust, and encourages active participation from the onset of the program.

Question styles and interview techniques

There are different approaches to establishing a common ground between the rich qualitative knowledge provided by interviewees and the repeatable, robust data that interviewers seek. For example, these could include:

- Semi-quantification of qualitative observations, facilitated through specific interview techniques such as 'proportional piling', where interviewees use small objects such as beans to illustrate quantities or distributions (e.g. Mariner & Paskin 2000, Tomaselli *et al*. 2018).
- Qualitative ranking of body condition of harvested animals, include language such as “Poor/ fair/ good/ excellent”. (Kofinas *et al*. 2003, Brook *et al*. 2009, Kutz *et al*. 2013, Parlee *et al*. 2014, Carlsson *et al*. 2016, Tomaselli *et al*. 2018, Gagnon *et al*. 2020).
- Participatory mapping to gather spatial and temporal data on populations and movement patterns. For instance, a hunter can use a map to identify where caribou were seen in the past relative to where they're seen now (e.g. Mamun & Brook 2017).
- Use-and-occupancy map surveys to provide comprehensive and systematic spatial records of caribou distributions relative to landscape characteristics and change (Tobias 2009).

See Benson & Winbourne 2015, Tomaselli *et al*. 2018, Gagnon *et al*. 2020, Peacock *et al*. 2020, and references therein for additional discussion and details on interview approaches.

Photo Credit: Cole Burton

8. Local and Harvester Interviews

8.2 SUITABILITY FOR MONITORING

8.2.1 CARIBOU POPULATION PARAMETERS THAT CAN BE MONITORED

From Suitability Table 1: Selecting a monitoring method that suits your objectives

		Distribution			Abundance				Demography			Health			
		Distribution/ Occupancy	Dispersal/ Movement	Habitat use	Population density	Population size	Effective population size	Minimum counts	Population growth trend	Survival/ Mortality	Recruitment/ Reproduction	Body condition	Disease	Other health indices	Foraging/ Nutrition
Local/ harvester observations	Harvester interviews	✓✓	✓✓	✓✓	✓✓	✓	x	✓	✓✓	✓✓✓	✓✓	✓✓	✓✓	✓✓	✓✓

x Method is not appropriate for estimating this parameter

✓ Method provides some information or can be combined with other methods for inference

✓✓ Method provides considerable information and is appropriate for estimation

✓✓✓ Method is most appropriate and/or intended specifically for estimation of this parameter

Note: table is meant to be used in combination with the other tools in the toolkit and may not reflect regional subtleties when used alone

***Note that the only parameters listed here are the primary population metrics that are explored in detail in Comparative Table 1 to allow for standardized comparison among monitoring approaches; all other information that can be obtained from this method is detailed in following "Additional parameters and information" section.*

8.2.2 ADDITIONAL PARAMETERS AND INFORMATION THAT CAN BE MONITORED (BEYOND THOSE LISTED IN TABLE 1)

- Sudden or undetected mortality events.
- Changes in caribou movements from year to year (Kendrick *et al*. 2005 for migratory populations; Mamun & Brook 2017).
- Caribou response to disturbance, including wildfire and mining developments (Kendrick *et al*. 2005).
- Characterization of "expected" versus "unusual" or "unprecedented" variation in caribou behaviour, movements or distribution (Kendrick *et al*. 2005; Benson & Winbourne 2015).
- Distinction of different caribou types based on variation in behaviour, habitat use and morphology (Polfus *et al*. 2016).
- Mechanisms of population decline (e.g. poor recruitment, changes in body condition, disease) can be inferred from local observations and interviews (Tomaselli *et al*. 2018).

8. Local and Harvester Interviews

- Habitat and environmental change: harvesters may note changes to the landscape or weather, including snow and ice conditions, changes to insect populations or vegetation growth, disturbance, and long-term climatic changes (e.g. Kofinas *et al*. 2003, Gagnon *et al*. 2020).
- Impacts of industrial development or disturbance Jutha *et al*. (unpublished data).
- Other species: interviews and surveys typically collect information about a variety of species, providing a good source of information on competitors, alternate prey and predators.
- A critical strength of this approach is that it is conducive to collecting new, relevant information which may not have been the original goal of monitoring or not otherwise have been recognized as important.

Photo Credit: Ryan Abel

8.2.3 IMPLEMENTATION

- Traditional knowledge, documented in a consistent and robust manner that includes participatory epidemiology methods, can provide substantial information on historic and current spatial and temporal (annual and seasonal) population trends, habitat use, health, population structure and ecology.
- Ongoing standardized documentation of local observations on caribou health and populations can be a cost-effective method for long-term monitoring, such as in tracking conservation strategies over many years, and may be more sensitive (e.g. able to detect short-term changes) than classical aerial-based population monitoring techniques if those are only conducted at widely-spaced intervals.
- Interviewees can provide information on body condition (e.g. qualitative index of body fat, "skinny, not so bad, fat or really fat" for migratory caribou in Alaska, Kofinas *et al*. 2003) as well as other health/disease indicators (e.g. Brook *et al*. 2009, Kutz *et al*. 2013, Parlee *et al*. 2014, Tomaselli *et al*. 2018).
- Distribution and habitat use by caribou based on local knowledge can be similar to that produced by resource selection model approaches (Polfus *et al*. 2014).
- Informal local observations are also valuable as a corroborative tool to other monitoring approaches, to provide background information, to instigate further investigation, or even to support other sources of information.
- Monitoring of 'Dispersal' would require marked individuals
- Geographic extent of observations may be limited and may not represent the entire population for herds that occupy large geographic ranges. Observations may also be seasonally biased to times when individuals are on the land.

8. Local and Harvester Interviews

- Harvest-specific interviews will serve as a less significant source of information for any populations where harvesting is minimal. However, observations and interviews with Elders and local people out on the land are still highly valuable, though may not offer the types of knowledge (e.g. body condition) that are specific to harvester insights.
- Caution must be taken in the interpretation and use of this information given the sensitivity of traditional knowledge and community data, and the potential harm of its inappropriate application. Consultation and engagement is always necessary before, during, and after collection, analysis/interpretation, and distribution of data. Interviews can be conducted only if the participants are comfortable. All reports and dissemination of information need to explicitly address the contributions of interviewees/Knowledge holders.

Photo Credit: Shana Dennis/Tahltan Guide and Outfitters Association

8.2.4 ADVANTAGES

- Provides a holistic broader knowledge about ecology and ecosystem processes, including important observations on factors that may be of importance, yet of which the scientific community may not be aware. Local experts can provide insights at broader spatial or temporal scales than other monitoring approaches (Gagnon *et al*. 2020).
- Offers a better opportunity to cooperatively engage with local communities and land-users than classical monitoring methods that are based on aerial surveys and marked or collared animals (e.g. Brook *et al*. 2009, Kutz *et al*. 2013, Kutz and Tomaselli 2019).
- Especially beneficial in remote areas where access and infrastructure are limited, i.e. where scientific monitoring is logistically or financially challenging (Johnson *et al*. 2015, Tomaselli *et al*. 2018).
- In the case of harvest, provides information about a direct source of mortality that may influence population trend.
- Offers insight into habitat use that can be valuable to critical habitat identification (Polfus *et al*. 2014).
- Offers a broader diversity of knowledge than often available through scientific methods (Thompson *et al*. 2020). For example, distinctions can be made between 'expected', 'unusual' and 'unprecedented' caribou movements, or projected distribution patterns in subsequent seasons based on migration movement observations (Kendrick *et al*. 2005).
- Interviewing protocols should be improved based on feedback from local/community participants (e.g., Brook *et al*. 2009).

8. Local and Harvester Interviews

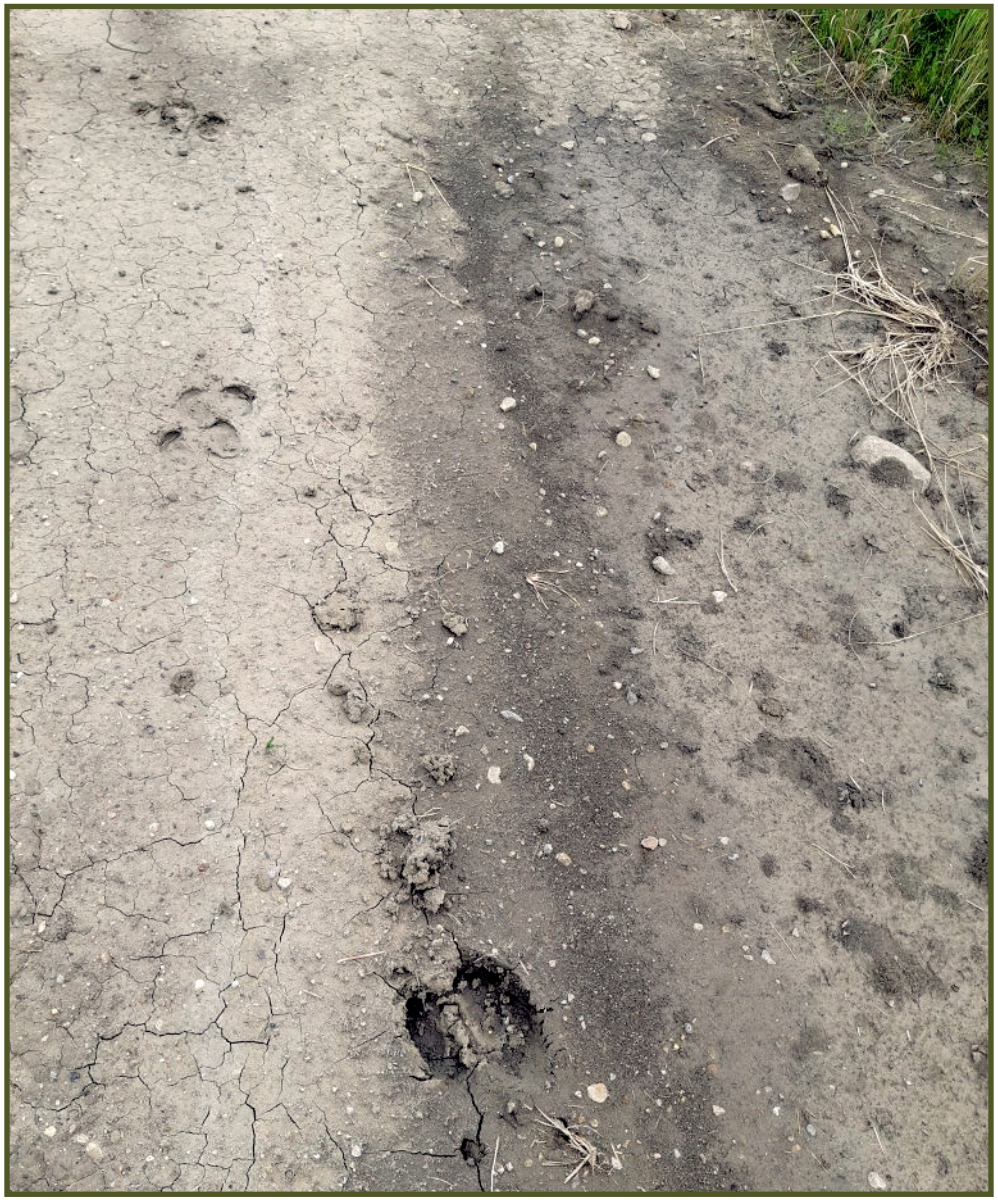


Photo Credit: Walter Andreef

8.2.5 DISADVANTAGES

- Harvesters may be hesitant to report on their harvest, especially in early phases of a monitoring program, and protocols may need to be modified accordingly (e.g. Kofinas *et al*. 2003)
- Study design must be robust (e.g., 'experts' are interviewed, using appropriate social science methodologies such as thematic saturation, snowball technique, etc.) to ensure that data documented are representative. Please see the chapter introduction above for additional information.
- There may be a bias in interviewees' animal observations with respect to the type of animals they see (age, sex, condition). However, all monitoring methods have biases (e.g., captures for radio-telemetry include adult females only), emphasizing the importance of standardized approaches over time.
- Interpretations will reflect the reported experiences of the observer. For example, if average caribou body condition has been deteriorating over time, a caribou that would have once been classified as being in poor condition might later be considered to be in good condition (Tomaselli *et al*. 2018). Interview design should take this into consideration (e.g., rather than asking what the body condition is in a given year, ask for a comparison from year to year), and methods to triangulate the data should be explored.
- Observations need to be considered independently of the interpretations of these observations (e.g. different observers might differently interpret cause of mortality, such as whether a caribou died from disease and was scavenged, or was killed by a predator; Tomaselli *et al*. 2018).

8. Local and Harvester Interviews

8.3 CONSIDERATIONS AND REQUIREMENTS

From Suitability Table 2: Comparing suitability and requirements of monitoring methods

Spatial Scale

- ✓ Method provides some information at this spatial scale
- ✓✓ Method is appropriate for application at this spatial scale
- ✓✓✓ Method is most appropriate for application at this spatial scale

Co-application of Indigenous Knowledge:
P – Planning D – Data collection
A – Analysis R – Reporting

***Note:** Table is meant to be used in combination with the other tools in the toolkit and may not reflect regional subtleties when used alone*

		Spatial Scale		Data Needs **		Community Involvement		Resources			Ethical Considerations		
		Local/study area	Regional/range	Minimum sampling requirements	Ability to assess data confidence	Local opportunity	Co-application of IK	Equipment costs	Personnel costs	Skills required	Capture/ handling	Potential stress from monitoring	Carbon footprint
Local/Harvester Observations	Harvester interviews	✓✓✓	✓	≥1 yr baseline, then annual changes	High	High	P, D, A, R	Low	Med	Med/ High	No	Low	Low

** Two spatial scale scores for Aerial imagery represent Manned and Unmanned aircraft, respectively // ** These are general guidelines only; refer to text for details of sampling requirements*

8.3.1 SPATIAL SCALE

- Spatial scale will depend on the traditional territory of the participating community and/or the area of observation of the participants. Participants can be asked to circle or identify an area on a map that they are knowledgeable of and familiar with, to identify appropriate spatial scale.
- Information from multiple participating communities could be combined to provide data at a broader geographic scale (e.g. the "observation networks" described in Benson & Winbourne 2015). For instance, there were both similarities and differences in findings from interviews conducted with two different communities harvesting the same caribou population (S. Kutz & A. Hanke, unpublished data).
- Spatial and temporal scales of ecological information may be contrasting and potentially complementary between traditional/local knowledge and science, and local knowledge may provide information or inform novel research questions on complex ecological changes at broader temporal and spatial scales that are not monitored through short-term science studies (Polfus *et al*. 2014, Gagnon & Berteaux 2009, Gagnon *et al*. 2020, Thompson *et al*. 2020).

8. Local and Harvester Interviews

8.3.2 DATA NEEDS AND CONFIDENCE

- Initial interviews can document past and present status and trends, establish a baseline, and identify important themes and concerns (Tomaselli *et al*. 2018)
- Annual interviews will provide almost real time tracking of status and trends.

Photo Credit: Foothills Landscape Management Forum

- A single year of local/harvester observation data could provide a general baseline, and identify concerns that will focus future work.
- A study of community based monitoring of migratory caribou in Alaska showed that hunters' assessments of body condition at the moment of harvest were very similar to those recalled at the time of interviews at the end of the season, supporting the accuracy of interview-based knowledge collection (Kofinas *et al*. 2003)
- Semi-quantitative information can be derived from qualitative observations through techniques adapted from the field of participatory epidemiology, such as 'proportional piling', map drawing (e.g. Mariner & Paskin 2000, Tomaselli *et al*. 2018)
- Measures of error and variance could be derived from long-term harvest survey information (e.g. mean number of caribou harvested per year over a given time period), and from comparisons of observations among different participants.
- Data validation can occur through multiple steps. Individual interviews can provide themes to be discussed in appropriately structured group interviews (stratified by age and/or sex as culturally appropriate) to arrive at a consensus. Variability among interviewee or group responses can be assessed. Research teams can validate interview transcription through participant transcript review/validation and can strengthen coding or thematic analysis strategies through inter-researcher reliability indices. Final researcher interpretation of interviews must be presented back to communities for validation to ensure accuracy of researchers' interpretations and presentation of results.
- Confidence in the value and rigour of findings can be strengthened through the use of standardized and repeatable methodologies (Tomaselli *et al*. 2018)

8. Local and Harvester Interviews

8.3.3 COMMUNITY INVOLVEMENT

Note that any application of Indigenous Knowledge must be conducted in a manner which is agreed upon by all parties, is transparent, serves the local communities where the information originated from, and adheres to local Indigenous data governance and sovereignty.

- The success of local and harvest interviews evidently relies entirely on community member participation. Beyond the valuable ecological information it offers, it provides employment opportunities and financial support for traditional harvesters, knowledge holders, and members of hunting and trapping organizations in the community.
- Local communities and peoples should be engaged at all stages of the project, including initial engagement during project development and interview planning, direct participation in research and monitoring, validation of initial results, interpretation of findings, approving dissemination of results (and in what format), and communication of findings back to the community (e.g. Brook *et al*. 2009, Parlee *et al*. 2014, Tondu *et al*. 2014, ABEKS 2020, Gagnon *et al*. 2020, Thompson *et al*. 2020).
- Indigenous Knowledge is highly valuable to this monitoring approach. Knowledge holders are asked to participate in interviews designed based on Indigenous Knowledge principles, on relative abundance of species harvested relative to previous years, condition of the animals harvested, observations about changes to the land and weather. See Thompson *et al*. (2020) and the references cited in the Introduction above for additional resources.
- Caution should be taken to avoid fatigue and lowered participation by community members and local knowledge holders that may be consulted on multiple occasions or by numerous researchers.

Photo Credit: Lukas Mundy

8. Local and Harvester Interviews

Cost: $-$$

8.3.4 RESOURCES

Equipment costs

- If desired, design and licencing or purchase of downloadable phone-applications for data collection (though data sheets and sampling kits may suffice) and/or qualitative data analysis software.
- Equipment may include: maps or electronic devices for participatory mapping, GIS software, transcription software, and audio/video recorders.
- Communication costs for remote communities (e.g. satellite phone bills where cell coverage is unavailable).

Photo Credit: Ryan Abel

Personnel costs

- Requires expert involvement in the design of interviews and surveys (e.g. phrasing of questions, identification of knowledge holders, interview timing) including travel by these experts to local communities. Tomaselli *et al*., (2018) provide an excellent framework for an initial set of baseline interviews that have been adapted for other communities in NWT, Nunavut and northern BC. Standardized approaches for annual interviews are being developed (F. Mavrot *et al*., unpublished). For additional examples, see protocols developed by the CARMA [CircumArctic Rangifer Monitoring and Assessment] for circumpolar monitoring (Kutz *et al*. 2013, Russell *et al*. 2015, https://carma.caff.is/index.php/resources/field-protocols).
- Staff time, including local community coordinators (e.g. Kofinas *et al*. 2003, Tondu *et al*. 2014), is required to conduct interviews, mail out questionnaires, collate data, analyze data and report results, including in-person presentations requiring travel to the communities. Further, accommodation, honorarium, and venue costs associated with collecting Indigenous Knowledge are possible.
- Interview transcription and/or professional translator costs may be necessary.
- Participation should be compensated, as participants are the experts with valuable knowledge. For example, in some jurisdictions, a full day interview would cost anywhere from $250- $500 or more per day per participant. In particular, it should be noted that if participants are Elders, then knowledge shared is based on lifelong experiences. Thus, compensation for their time should be reflective of this knowledge base. Readers should discuss the meaning of fulsome collaboration and appropriate compensation with the communities they are working with. It should also be clarified that honoraria paid for an Elder / interviewee's time is not a purchase of information. Information sharing agreements must also be in place and agreed upon before the interviews begin.

8. Local and Harvester Interviews

Logistical Complexity: MODERATE

Skills required

- Inclusion of experts, training and standardised protocols for data collection (e.g. Kutz *et al*. 2013) may make the collection of local information more scientifically defensible and reduce misinterpretation (Tomaselli *et al*. 2018).
- Might require facilitators that are fluent in both English/French and local language (Benson & Winbourne 2015)
- Local community members can be trained to conduct interviews and can identify key knowledge holders within the community; additional benefits include improvements to data collected and knowledge shared, local employment opportunities, and stronger relationships between researchers and communities (Kofinas *et al*. 2003, Tondu *et al*. 2014, Gagnon *et al*. 2020)

Photo Credit: Foothills Landscape Management Forum

- Information on species sightings can be collected by assigned citizen scientists (in the case of an organized citizen scientist monitoring approach) as well as from the general public (e.g. sourcing information by the general public through websites and phone apps such as iNaturalist, https://www.inaturalist.org/).

Capture/Handling: NO

8.3.5 ETHICAL CONCERNS

Capture/handling

- None.

Potential Stress from monitoring

- None.

Carbon/environmental footprint

- Travel to communities to conduct interviews and later to report back on findings

Human ethics

Unlike other monitoring methods evaluated in the Boreal Caribou Monitoring Toolkit, Local/Harvester Interviews require human ethics considerations. These include:

- Respondents' answers are usually kept confidential, but some harvesters may not want to share information about where they harvest animals, for fear that others will go to that area.
- People may be concerned that the information will be used against them to impose harvest restrictions (e.g. Kofinas *et al*. 2003).

8. Local and Harvester Interviews

- Any community-based sampling program should engage the hunting and trapping organization as well as public health workers in the community early on, in order to get feedback on what is required and whether financial compensation is appropriate.
- Data gathered cannot be used beyond the initial stated purpose without passing new ethical approval and interviewee consent for the new research and monitoring purpose (OCAP principles).
- Power imbalances between Indigenous knowledge systems and science may be limiting the effectiveness of collaborative monitoring (Thompson *et al*. 2020).
- Community members and Elders may experience interview fatigue if consulted repeatedly by researchers. In addition to compensating respondents, efforts should also be made to maintain collaboration among organizations doing research, so that interviews can be conducted alongside other caribou work or interview-style research.

Additional suggestions for building community-collaborative relationships while keeping in mind ethical concerns are explored in Tondu *et al*. (2014) and Benson & Winbourne (2015) and references therein.

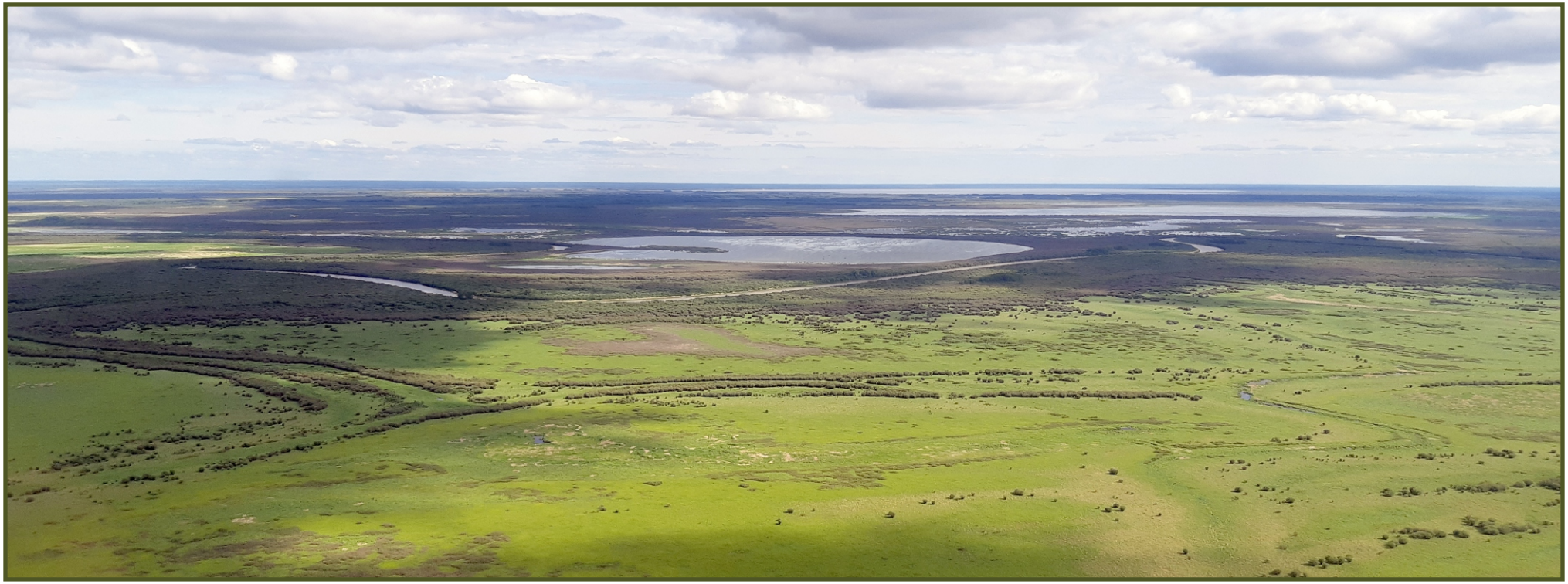


Photo Credit: Lukas Mundy

8. Local and Harvester Interviews

8.4 EXAMPLES

BRITISH COLUMBIA As part of an ongoing, community-based wildlife health monitoring program in northwestern British Columbia, local ecological knowledge of guides and outfitters of the Tahltan Guide and Outfitters Association (TGOA) was systematically collected towards assessing the health, population status, and trends of Northern Mountain woodland caribou. 'Caribou experts' were identified by TGOA leadership and the research team. They participated in semi-structured interviews which, using a standard interview guide, focused on caribou health and disease, nutrition, demography, distribution, behaviour, habitat, and disturbance factors. Participatory activities such as mapping and proportional piling were used to document semi-quantitative data in addition to the in-depth narratives provided by participants. Data were transcribed, coded, and analyzed by thematic analysis. Results of initial analyses were presented back to participants, and additional experts they identified, in focus groups aimed at corroborating, enhancing, and validating outcomes. With permissions by participants, final results of thematic analysis following focus group validation sessions were presented back to participants, the wider local community, and wildlife managers. Local Tahltan research assistants and members of the Tahltan Central Government were involved in the design, implementation, and analysis/validation of interview data, building local capacity and encouraging long-term sustainability of this monitoring program.

NORTHWEST TERRITORIES There are two ongoing community-based harvest monitoring programs for boreal caribou in the NWT (though note that these programs target barren-ground and not boreal caribou populations). One is implemented by the Gwich'in Renewable Resources Board (GRRB) and the other is being carried out by Katlodeeche First Nation (KFN) in the southern NWT. Both programs use harvester surveys, either through directed interviews or through forms filled out and submitted by the harvesters themselves. The Gwich'in program is based on the Porcupine Caribou harvest monitoring program (Porcupine Caribou Management Board 2016). KFN has also developed a mobile data collection app for the survey forms. Both programs collect information about more than just barren-ground caribou, including alternate prey and predators (e.g. GRRB surveys collect information about 5 species, KFN collects information about 7 species). In addition to the number and location (by grid cell) of animals harvested, information about sex, age and the health/condition of harvested animals is collected. General observations about environmental change (e.g. permafrost slumps) are also recorded. In addition to these community-based programs, the Government of the NWT (Environment and Natural Resources) conducts an annual resident hunter survey for residents that purchased a resident big or small game hunting licence. Survey forms are mailed out and ask hunters to provide information about hunting effort (where/when/how long) and harvest success. Respondents can indicate the location of their harvest by coordinates or name of a nearby landmark. Participation is voluntary and response rates are about 50%. While there is some overlap between boreal and barren-ground caribou in these areas, boreal caribou harvest is largely incidental and was not the focus of these surveys.

8. Local and Harvester Interviews

8.4 EXAMPLES

NORTHWEST TERRITORIES & NUNAVUT The Dolphin and Union (DU) barren-ground caribou health surveillance program began in 2015 with interviews, hunter-based sampling (subsistence and guided-outfitted hunts) and samples from captured-collared animals. The goal was to establish health baselines and understand and monitor population and disease dynamics in this declining herd. The program is a community-government-industry-academic partnership, is based in Ekaluktutiak and Kugluktuk (Nunavut), and Ulukhaktok (NWT), and is informed by local, Indigenous, and Western knowledge. First, a set of interviews from 2003 was analyzed, providing a historical baseline of the herd health status, behaviour, and population health and trends. Contemporary individual and group interviews using a mixture of open-ended questions, participatory epidemiology activities, and validation sessions provided updated information on population health indicators and new insights on caribou ecology. Annual interviews with local hunters, co-developed with the community of Ulukhaktok, the co-management board, government and researchers are being implemented to track population status, movements, and health indicators on an annual basis. Together, this historical and contemporary information has mobilized the Indigenous understanding of Dolphin and Union caribou health, abundance and distribution trends for co-management action for this herd whose history remains largely undocumented.

Complementary to the interviews, the collaborative hunter-based sampling program, administered by the communities in partnership with government and academic researchers, documents health indicators such as body condition or pregnancy rates, infectious diseases, stress and mineral elements that may be influencing population dynamics. A similar live animal sampling protocol for biologist-captured caribou supplements the sampling part of the program. All results from the interviews and hunter/biologist based sampling are brought back to the communities regularly for discussion and interpretation. This multifaceted research approach with local community involvement has led the way for a cost-effective opportunistic sample collection in hard-to-access locations, synergistic interactions between Indigenous and Western ways of knowing, and an early-warning system that allows timely detection and response to population changes, including possible disease threats to both wildlife and people. The program also generates opportunities for capacity and expertise building in the partnering communities which promotes the long-term maintenance of locally managed health surveillance programs and, ultimately contributes to the Dolphin and Union caribou co-management decision-making process.

9. Harvester Based Sampling

9.1 AT A GLANCE

In addition to the knowledge that can be gained through interviews and consultations with local community members and hunters (see chapter 8), hunters can also be directly involved with collecting a diversity of data and samples from harvested caribou. Although boreal caribou do not represent a significant hunting target across most of their range, sampling by harvesters can nevertheless represent a valuable source of information on several population metrics in areas where some level of harvesting occurs.

Photo Credit: Naima Jutha

Samples collected from harvested animals can include feces, blood, urine, tissues, parts of the body and milk; sample collectors also record date, location and information on the harvested animal (Kutz *et al*. 2013). Harvest-based sampling is highly suitable to monitoring of body condition, including nutritional indices (e.g. bone marrow fat analysis, kidney fat index, back fat depth) as well as qualitative ranking of the condition of harvested animals (poor/fair/good/ excellent) (e.g. Kofinas *et al*. 2003, Kutz *et al*. 2013, Gagnon *et al*. 2020). Sampling can target specific pathogens (e.g. Obex and lymph nodes for Chronic Wasting Disease), and may identify signs of disease or parasites in caribou populations, including any potential impacts on reproductive success (e.g. Kutz *et al*. 2013, Tomaselli *et al*. 2018). Specific to disease monitoring, such 'participatory epidemiology/participatory disease surveillance' methods allow direct incorporation of local knowledge in wildlife management (see Tomaselli *et al*. 2018 and references therein). Harvest samples can provide insights into pregnancy rates and diet, and in some cases incidental information on other parameters such as distribution or movement, habitat use, and population growth trend. Sampling by hunters may also add value to additional One Health measures such as contaminant levels and zoonotic disease prevalence and specific research projects (e.g. Buttke *et al*. 2015, Cunningham *et al*. 2017). For instance, local Dene and Metis hunters collected fecal samples for use in genetic analysis useful for conservation management (Polfus *et al*. 2016).

While harvest interviews and local observations may in some cases be conducted informally, sample collection is typically a formalized process involving information sessions, training of local hunters or wildlife guardians in sampling protocols, and subsequent follow-up with communities to communicate research findings (e.g. Brook *et al*. 2009, Polfus *et al*. 2016). The procedure developed by CARMA (CircumArctic Rangifer Monitoring and Assessment) for circumpolar monitoring of caribou and reindeer serves as a good example of careful design and implementation of local/harvester-based sampling (Russell *et al*. 2015, https://carma.caff.is/index.php/resources/field-protocols) but other sampling designs are used across caribou ranges.

9. Harvester Based Sampling

9.2 SUITABILITY FOR MONITORING

9.2.1 CARIBOU POPULATION PARAMETERS THAT CAN BE MONITORED

From Suitability Table 1: Selecting a monitoring method that suits your objectives

		Distribution			Abundance				Demography			Health			
x Method is not appropriate for estimating this parameter ✓ Method provides some information or can be combined with other methods for inference ✓✓ Method provides considerable information and is appropriate for estimation ✓✓✓ Method is most appropriate and/or intended specifically for estimation of this parameter *Note: table is meant to be used in combination with the other tools in the toolkit and may not reflect regional subtleties when used alone*		Distribution/ Occupancy	Dispersal/ Movement	Habitat use	Population density	Population size	Effective population size	Minimum counts	Population growth trend	Survival/ Mortality	Recruitment/ Reproduction	Body condition	Disease	Other health indices	Foraging/ Nutrition
Local/ harvester observations	Harvester based sampling	✓✓	✓	✓✓	✓	x	x	✓	✓	x	✓	✓✓✓	✓✓✓	✓✓✓	✓✓

***Note that the only parameters listed here are the primary population metrics that are explored in detail in Comparative Table 1 to allow for standardized comparison among monitoring approaches; all other information that can be obtained from this method is detailed in following "Additional parameters and information" section.*

9.2.2 ADDITIONAL PARAMETERS AND INFORMATION THAT CAN BE MONITORED (I.E. BEYOND THOSE LISTED IN TABLE 1)

- Habitat and environmental change: Harvesters may note changes to the landscape or to weather conditions, which would influence habitat quality or harvest success.
- Other species: Harvester surveys typically collect information about a variety of species, providing a good source of information on alternate prey and predators.
- Population structure/genetic information: for instance, Polfus *et al*. (2016) undertook collaborative work with Dene and Metis community members. In this work, fecal samples collected during community members' activities on the land were donated /provided/ shared for genetic studies.
- Health and disease information for other species and associated risks to caribou (e.g. Parlee *et al*. 2014)

9. Harvester Based Sampling

- Monitoring of contaminants, trace minerals, contaminants (e.g. Elkin & Bethke 1995, Robillard *et al*. 2002)
- Information can be used to evaluate whether regional or territorial levels of harvest are sustainable and to inform any future changes to harvest seasons, bag limits (including sex specific harvest), open/closed areas, etc.
- Teeth can be used for ageing, and bone marrow from jawbones can be tested for pathogens.

9.2.3 IMPLEMENTATION

- Hunter-based sampling is appropriate wherever the species is harvested. Monitoring of Indigenous harvest should be led by the communities or Indigenous government/organization, with support from the provincial or territorial government.
- Suitable for addressing research or management questions such as health and disease screening (Kutz *et al*. 2013), and can serve as an early warning system for new or emerging health issues.
- Suitable for establishing the age and sex distribution of harvested animals, and can serve as an indicator of changes in population recruitment or survival.
- Suitable for collecting longitudinal data across seasons and years where caribou are hunted regularly for subsistence.
- Checks and balances should be in place to ensure that proper data and samples are collected and that unethical procedures are not financially compensated.
- Field conditions may limit the feasibility of sample collection in some circumstances.

Photo Credit: Government of Newfoundland and Labrador, Department of Fisheries, Forest, and Agriculture

9.2.4 ADVANTAGES

- Directly involves community members, and can improve interactions between hunters and researchers (e.g. Brook *et al*. 2009)
- Provides information about animal health and condition, and quantitative measures of parasite or disease exposure/infection, including infection density (e.g. Kutz *et al*. 2013).
- Allows the opportunistic collection of samples from traditional activities on the land (e.g. fecal sample collection for genetic analyses, Polfus *et al*. 2016).
- Can provide samples that can be further analyzed for indicators of health, sex-specific age distribution of the harvested population, select pathogens, and contaminants.

9. Harvester Based Sampling

9.2.5 DISADVANTAGES

- Participation is typically voluntary (unless mandated as a condition of obtaining a license), so samples will be representative only of animals taken by participating hunters.
- Hunters may bias kills towards specific sex/age class and animals in better condition so may not provide information about the general population (i.e. non-random sampling).
- Appropriate storage options (i.e. freezing tissue samples, centrifugation of blood samples, etc.) may not be readily available in sufficient time from collection of sample to maintain sample quality and integrity for successful analysis.
- Minimum sample sizes required for meaningful interpretation may sometimes be challenging to achieve (e.g. if samples derive from edible parts of the animal that hunters wish to keep)
- Because boreal caribou are not often specifically targeted by hunters, harvest-based data may not always provide a complete picture of changes in abundance or distribution (DeMars *et al*. 2015).

9.3 CONSIDERATIONS AND REQUIREMENTS

From Suitability Table 2: Comparing suitability and requirements of monitoring methods

Spatial Scale

- ✓ Method provides some information at this spatial scale
- ✓✓ Method is appropriate for application at this spatial scale
- ✓✓✓ Method is most appropriate for application at this spatial scale

Co-application of Indigenous Knowledge:
P – Planning D – Data collection
A – Analysis R – Reporting

***Note:** Table is meant to be used in combination with the other tools in the toolkit and may not reflect regional subtleties when used alone*

		Spatial Scale		Data Needs **		Community Involvement		Resources			Ethical Considerations		
		Local/study area	Regional/range	Minimum sampling requirements	Ability to assess data confidence	Local opportunity	Co-application of IK	Equipment costs	Personnel costs	Skills required	Capture/ handling	Potential stress from monitoring	Carbon footprint
Local/Harvester Observations	Harvester based sampling	✓	✓✓	≥3 yrs health, variable other goals (see text)	Med	High	P, D, A, R	Med	Low/ Med	Med	No	NA	Low/ Med

** Two spatial scale scores for Aerial imagery represent Manned and Unmanned aircraft, respectively // ** These are general guidelines only; refer to text for details of sampling requirements*

9. Harvester Based Sampling

9.3.1 SPATIAL SCALE

- Generally applies at broad spatial scales (whole range or sub-range) and to the population as a whole
- Spatial scale will depend on the traditional territory of the participating community; information from multiple participating communities could be combined to estimate total harvest at a broader scale.
- Spatial and temporal scales of ecological information may be contrasting and potentially complementary between traditional/local knowledge vs. science, and local knowledge may provide reliable data at temporal and spatial scales that are not otherwise easily monitored (Gagnon & Berteaux 2009, Gagnon *et al*. 2020)
- Local knowledge can also provide perspectives at much broader scales if conducted in a standardized way across communities, such as the circumpolar standardized monitoring of *Rangifer* populations conducted for the International Polar Year (see Kutz *et al*. 2013)

Photo Credit: Dennis Brannen

9.3.2 DATA NEEDS AND CONFIDENCE

- A minimum of 3 years of data are recommended for informing health indices (S. Kutz, *pers. comm*).
- Standardization of harvest location (e.g. blocks or coordinates) is often required, and should be explained as part of sampling protocols prior to the harvest season.
- Community-based monitoring may involve significant regional variation in protocols (e.g. Johnson *et al*. 2015)
- Sampling error could derive from a number of sources, including damage to samples during extraction, contamination or improper storage of tissues (see details in Kutz *et al*. 2013)

9.3.3 COMMUNITY INVOLVEMENT

Note that any application of Indigenous Knowledge must be conducted in a manner which is agreed upon by all parties, is transparent, serves the local communities where the information originated from, and adheres to local Indigenous data governance and sovereignty.

- This method relies entirely on community member participation, and provides employment opportunities and financial support for traditional harvesters, knowledge holders, and members of hunting and trapping organizations in the community.
- Hosting workshops to present results back to the community is critical and provides general support for local community economies.
- In addition to participation by hunters in the sampling, local community members can also be trained to coordinate and lead the sampling collection in collaboration with program staff (e.g. researchers, biologists and veterinarians (e.g. Brook *et al*. 2009, Kutz *et al*. 2013), and can be hired to work in a laboratory setting to analyze samples (e.g. Tondu *et al*. 2014).

9. Harvester Based Sampling

- Hunter-based sampling programs can empower community hunting organizations to be involved and in charge of health monitoring programs in their community and to set priorities for sample collection and analysis.
- Sampling protocols and plans ideally should be based on TEK/LEK principles in order to best capture accurate information on abundance of species harvested relative to previous years, condition of the animals harvested, and changes to the land and weather.

Cost: $

9.3.4 RESOURCES

Equipment Costs

- Freezer space (and stable electrical supply) to store samples.
- Note that costs of sample collection equipment and supplies (i.e. sampling kits) are relatively low, but storage, shipping and processing tissues/blood and laboratory analyses entail significant costs (H. Schwantje, Govt. of BC, personal communication).
- Composition of sampling kits will depend on monitoring objectives as well as the acceptance by the harvesters to provide samples, as some of these may be edible parts or may be technically complicated and time-consuming to obtain.
- If desired, design and licencing or purchase of downloadable phone-applications for data collection (though data sheets and sampling kits may suffice).

Personnel Costs

- Staff time and travel expenses to provide training on sample collection and monitoring harvest kits.
- Staff time to collate data, process samples and send to laboratories, analyze data and report results back in lay person summaries and in person presentations (will likley require travel to local communities).
- Participation in these programs is typically voluntary, but some jurisdictions have mandatory sampling and harvest reporting in response to wildlife management challenges associated with select diseases (e.g. Chronic Wasting Disease). Participation can be encouraged by providing financial incentives.

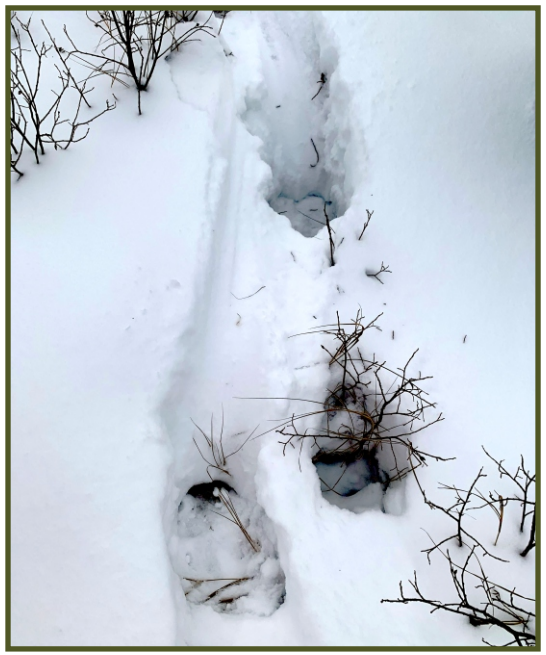


Photo Credit: Walter Andreef

9. Harvester Based Sampling

Logistical Complexity: MODERATE

Skills Required

- May require expert involvement in the design of harvest surveys.
- May require facilitators that are fluent in both English/French and local language.
- Will require expert involvement to train harvesters in collecting information and collecting samples.
- Analyses of samples for select pathogens and contaminants can be quite costly and larger sample sizes are required in order to gather statistically meaningful information (e.g. contaminants).

Photo Credit: Cole Burton

Ensuring that appropriate samples are taken, data are accurately recorded, and samples are stored, preserved properly (e.g. frozen) and submitted to appropriate laboratories is essential to ensure meaningful information is gathered.

Capture/Handling: NO

9.3.5 ETHICAL CONCERNS

Capture/handling

- None.

Potential Stress From Monitoring

- Samples are collected from caribou that were already going to be harvested. Thus, no additional stress is imposed on the caribou as a direct result of the monitoring method.

Carbon/environmental Footprint

- Travel by hunters to remote locations may entail a moderate carbon cost; costs of travel to remote communities in order to establish sampling program and collect information should also be considered.

Human ethics

Unlike other monitoring methods evaluated in the Boreal Caribou Monitoring Toolkit, Harvester-Based Sampling requires human ethics considerations, in addition to any animal ethics concerns. These include:

- Harvesters may need to discuss how information provided by local community members will be kept confidential, prior to sharing any information. For example, harvesters may feel hesitation to share information about where animals are harvested for fear that others will go to that area.

9. Harvester Based Sampling

- Harvesters may need to discuss how information provided by local community members will interpreted and and used, prior to sharing any information. For example, harvesters may have concerns that information will be used against them to impose harvest restrictions (e.g. Kofinas *et al*. 2003).
- Any community-based sampling program should take care that incentives for sampling do not encourage or promote unethical hunting practices (e.g. harvesting an endangered population beyond subsistence needs).
- Any community-based sampling program should engage the hunting and trapping organization in the community from the onset, in order to determine what samples are reasonable for a hunter to give up, and what amount of financial compensation is appropriate.
- Organizers of any community-based sampling program should be aware that power imbalances between Indigenous Knowledge systems and science may be limiting the effectiveness of collaborative monitoring (Thompson *et al*. 2020). Suggestions for building community-collaborative relationships while keeping in mind ethical concerns are explored in Benson & Winbourne (2015) and Tondu *et al*. (2014) and references therein.

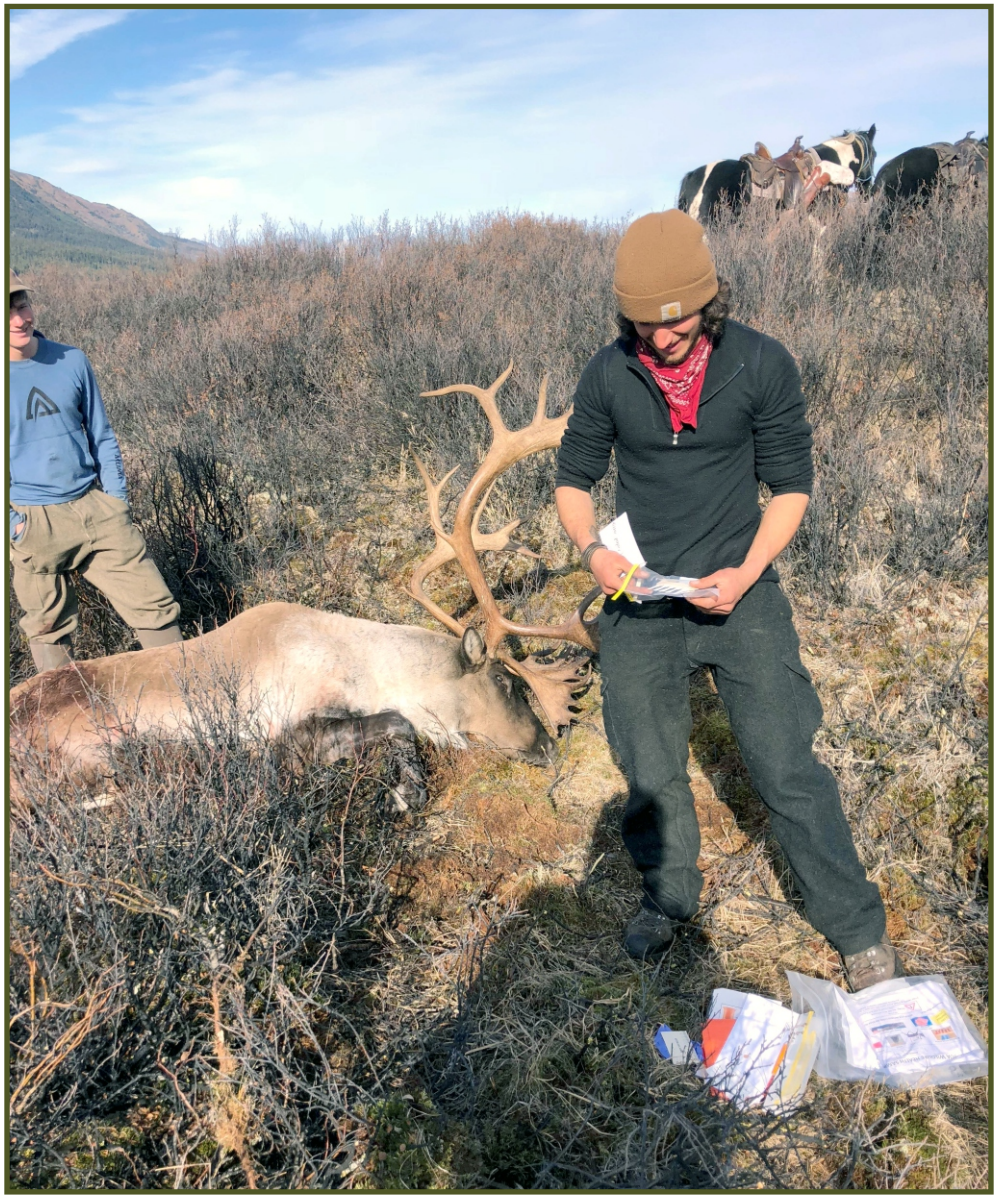


Photo Credit: Naima Jutha

9. Harvester Based Sampling

9.4 EXAMPLE

BRITISH COLUMBIA A community-based wildlife health monitoring program in northwestern British Columbia incorporates the harvest-based sampling of Northern Mountain woodland caribou (among other species) by guides and outfitters of the Tahltan Guide and Outfitters Association. Comprehensive sample kits were designed to allow sampling of blood, feces, hair, hide, liver, kidneys, muscle, metatarsals, mandibles, and abnormalities, and included datasheets for recording dates and locations of kill, sex, estimated age, subjective body condition, and a description of any abnormalities. Analyses of samples targeted a variety of health indicators and metrics to inform individual- and population-level health status of hunted male mountain caribou in this region. Baseline data on and trends for circulating pathogens, body condition, acute and chronic stress, and trace mineral status were some of the important outcomes determined from this program. Sample collection began in the fall 2016 hunting season with excellent sampling return and is ongoing (Jutha *et al*. (unpublished data).

NORTHWEST TERRITORIES Community members, researchers, collaborators, and industry monitors have been involved in collaborative work for non-invasive genetic analysis of barren-ground, boreal and mountain caribou in the Sahtú region of the Northwest Territories, by collecting frozen pellet piles found on the snow in winter. In general, hunters and trappers collected samples while traveling on skidoo trails, winter roads, seismic lines, and traditional trails during normal on-the-land activities. Community members were encouraged to help with sample collection during outreach at public meetings, through promotional posters, regional newspaper stories, on local radio, and in Facebook posts. Community members received a $25 gift card for gas at a local gas station for each caribou fecal pellet sample they provided. Staff from the local Renewable Resource Councils (RRCs) and Norman Wells Government of the Northwest Territories, Environment and Natural Resources, oversaw sample collection, data entry, and gift card distribution. An additional three days were spent flying by helicopter with community participants selected in collaboration with the RRCs of Fort Good Hope, Tuĺıt'a and Délı̨nę to collect scat samples and fill sampling gaps. See Polfus *et al*. 2016 for additional study details. Participants were also involved in collecting muscle tissue samples and blood strip samples from hunted animals in collaboration with a caribou health monitoring study (run by Susan Kutz, University of Calgary).

REFERENCES

Arctic Borderlands Ecological Knowledge Society [ABEKS] (2020) https://www.arcticborderlands.org/

Ban, N. C., Frid, A., Reid, M., Edgar, B., Shaw, D., & Siwallace, P. (2018). Incorporate Indigenous perspectives for impactful research and effective management. Nature Ecology & Evolution 2, 1680-1683.

Benson, K. & Winbourne, J. (2015). Literature Review and Interviews: Indigenous Ways of Knowing Boreal Caribou Populations. Consultants' report prepared for ʔehdzo Got'ı̨nę Gots'ę́ Nákedı (Sahtú Renewable Resources Board), Tulít'a, NT and Environment and Natural Resources (GNWT). Yellowknife, NT.

Brook, R. K., Kutz, S.J., Veitch, A.M., Popko, A.M., Elkin, B.T., & Guthrie, G. (2009). Fostering community-based wildlife health monitoring and research in the Canadian North. EcoHealth 6, 266-278.

Buttke, D. E., Decker, D. J., & Wild, M. A. (2015). The role of one health in wildlife conservation: a challenge and opportunity. Journal of Wildlife Diseases 51, 1-8.

Carlsson, A. M., Veitch, A., Popko, R., Behrens, S., & Kutz, S. (2016). Monitoring wildlife health for conservation and food security in the Canadian Arctic-a case study from the Sahtu settlment area in the Northwest Territories. One Health Case Studies: Addressing complex problems in a changing world. Sheffield, UK: 5m Publishing.

Carrière, S. (2012) Resident Hunter Surveys 1997-2009 Update and review. Department of Environment and Natural Resources Government of the Northwest Territories Yellowknife, NT. Manuscript Report No. 218. https://www.enr.gov.nt.ca/sites/enr/files/218_manuscript.pdf

Catley, A., Alders, R. G., & Wood, J. L. (2012). Participatory epidemiology: approaches, methods, experiences. The Veterinary Journal 191, 151-160.

Centre for Indigenous Environmental Resources (CIER) (2015). Indigenous Communities Leading the Way for Woodland Caribou Recovery in Canada: A 2015 Review of Indigenous-led Action Plans, Final Report. Submitted to the Boreal Leadership Council, June 2015.

Cunningham, A. A., Daszak, P., & Wood, J. L. (2017). One Health, emerging infectious diseases and wildlife: two decades of progress?. Philosophical Transactions of the Royal Society B: Biological Sciences 372, 20160167.

DeMars, C., Boulanger, J., & Serrouya, R. (2015). A literature review for monitoring rare and elusive species, and recommendations on survey design for monitoring boreal caribou. Report submitted to the Government of the Northwest Territories.

Elkin, B. T., & Bethke, R. W. (1995). Environmental contaminants in caribou in the Northwest Territories, Canada. Science of the Total Environment 160, 307-321.

Fraser, D. J., T. Coon, M. R. Prince, R. Dion, and L. Bernatchez. (2006). Integrating traditional and evolutionary knowledge in biodiversity conservation: a population level case study. Ecology and Society 11(2):4.

Gagnon, C. A., Hamel, S., Russell, D. E., Powell, T., Andre, J., Svoboda, M. Y., & Berteaux, D. (2020). Merging indigenous and scientific knowledge links climate with the growth of a large migratory caribou population. Journal of Applied Ecology 57, 1644-1655.

Gagnon, C.A., Berteaux, D. (2009). Integrating Traditional Ecological Knowledge and ecological science: a question of scale. Ecology and Society Soc 14(2): 19.

Gamble, D.J. (1978). The Berger Inquiry: an impact assessment process. Science 199, 946-951

Iverson, S. A., Forbes, M. R., Simard, M, Soos, C., & Gilchrist, H. G. (2016). Avian Cholera emergence in Arctic-nesting northern Common Eiders: using community-based, participatory surveillance to delineate disease outbreak patterns and predict transmission risk. Ecology and Society 21, 12. http://dx.doi.org/10.5751/ES-08873-210412

Johnson, N., Alessa, L., Bebe, C., Danielsen, F., Gearheard, S., Gofman-Wallingford, V., Kliskey, A., Krummel, E.-M., Lynch, A., Mustonen, T., Pulsifer, P., & Svoboda, M. (2015). The contributions of community-based monitoring and Traditional Knowledge to Arctic observing networks: Reflections on the state of the field. Arctic 68, 28-40.

Jones, J. P., Andriamarovololona, M. M., Hockley, N., Gibbons, J. M., & Milner-Gulland, E. J. (2008). Testing the use of interviews as a tool for monitoring trends in the harvesting of wild species. Journal of Applied Ecology 45, 1205-1212.

Kendrick, A., Lyver, P. O. B., Lutsel K'é Dene First Nation. (2005). Denésôliné (Chipewyan) Knowledge of Barren-Ground Caribou (*Rangifer tarandus groenlandicus*) Movements. Arctic 58, 175-191.

Kofinas, G., Lyver, P., Russell, D., White, R., Nelson, A., & Flanders, N. (2003). Towards a protocol for community monitoring of caribou body condition. *Rangifer*, 43-52.

Kutz, S., & Tomaselli, M. (2019). "Two-eyed seeing" supports wildlife health. Science 364, 1135-1137.

Kutz, S., Ducrocq, J., Cuyler, C., Elkin, B., Gunn, A., Kolpashikov, L., Russell, D., & White, R. G. (2013). Standardized monitoring of *Rangifer* health during International Polar Year. *Rangifer* 33, 91-114.

REFERENCES

Mamun, A.A. & Brook, R. (2017). Characterizing, Mapping and Modelling Aboriginal Traditional Knowledge about Woodland Caribou in Saskatchewan in Support of Range Planning. Final Report to the Saskatchewan Ministry of Environment. 119 pages.

Mariner, J. C., & Paskin, R. (2000). Manual on Participatory Epidemiology-methods for the Collection of Action-oriented Epidemiological Intelligence. FAO Animal Health Manual, Rome.

Moller, H., Berkes, F., Lyver, P.O. & Kislalioglu, M. (2004). Combining science and traditional ecological knowledge: monitoring populations for co-management. Ecology and Society 9, 2.

Parlee, B. L., Goddard, E., Lutsel K'é Dene First Nation, & Smith, M. (2014). Tracking change: Traditional Knowledge and monitoring of wildlife health in Canada. Human Dimensions of Wildlife 19, 47-61.

Peacock, S. J., Mavrot, F., Tomaselli, M., Hanke, A., Fenton, H., Nathoo, R., ... & Kafle, P. (2020). Linking co-monitoring to co-management: bringing together local, traditional, and scientific knowledge in a wildlife status assessment framework. Arctic Science 6, 247-266.

Polfus, J. L., Heinemeyer, K., Hebblewhite, M. & Taku River Tlingit First Nation. (2014). Comparing traditional ecological knowledge and western science woodland caribou habitat models: TEK Caribou Habitat Models. The Journal of Wildlife Management 78, 112–121.

Polfus, J. L., Manseau, M., Simmons, D., Neyelle, M., Bayha, W., Andrew, F., ... & Wilson, P. (2016). Łeghaǵots' enetę (learning together): the importance of indigenous perspectives in the identification of biological variation. Ecology and Society 21, 18.

Porcupine Caribou Management Board. (2016). Implementation Plan - A companion document to the Harvest Management Plan for the Porcupine Caribou Herd in Canada. Available at: https://pcmb.ca/wp-content/uploads/2020/06/Implementation-Plan-2016.pdf

Robillard, S., Beauchamp, G., Paillard, G., & Bélanger, D. (2002). Levels of Cadmium, Lead, Mercury and ^{137}Caesium in Caribou (*Rangifer tarandus*) Tissues from Northern Québec. Arctic, 1-9.

Russell, D. E., Gunn, A., & White, R. G. (2015). CircumArctic collaboration to monitor caribou and wild reindeer. Arctic, 6-10.

Snook, J., Cunsolo, A., Borish, D., Furgal, C., Ford, J. D., Shiwak, I., ... & Harper, S. L. (2020). "We're Made Criminals Just to Eat off the Land": Colonial Wildlife Management and Repercussions on Inuit Well-Being. Sustainability 12, 8177.

Thompson, K.-L., Lantz, T., & Ban, N.C. (2020). A review of Indigenous knowledge and participation in environmental monitoring. Ecology and Society 25, 10.

Tobias, T. N. (2009). Living proof: the essential data-collection guide for indigenous use-and-occupancy map surveys. Ecotrust Canada & Union of British Columbia Indian Chiefs, Vancouver BC.

Tomaselli, M., Kutz, S., Gerlach, C., & Checkley, S. (2018). Local knowledge to enhance wildlife population health surveillance: Conserving muskoxen and caribou in the Canadian Arctic. Biological Conservation 217, 337-348.

Tondu, J. M. E., Balasubramaniam, A. M., Chavarie, L., Gantner, N., Knopp, J. A., Provencher, J. F., ... & Simmons, D. (2014). Working with northern communities to build collaborative research partnerships: perspectives from early career researchers. Arctic 67, 419-429.

Back Cover Photo Credit: OMNRF