Considerations and Recommendations for Initiating Indigenous-led Moose Monitoring and Research

Summary Report

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1. Introduction

In recent years, many Indigenous communities have raised concerns over declining moose populations and the limitations of current Crown government monitoring practices. Many communities have expressed a need for more intense monitoring in their territories, and a desire to collect data themselves.

This report aims to provide recommendations on moose monitoring and data collection methods to support Indigenous-led monitoring programs. The intention is to inform and support Indigenous decision-making and engagement both within their communities and with outside audiences (e.g. provincial government, industry). This report contains an introduction to moose biology and population threats, a summary of potential methods for monitoring moose, data collection and project design considerations, and a handful of examples of Indigenous community-led monitoring initiatives from across Canada.

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Credit: Joel Sartore

2. Moose Biology 101

Moose (latin name: Alces alces; Cree name: Moswa) is the largest member of the deer family (Cervidae) in North America, occupying all of the provinces and territories, except for Prince Edward Island.

Diet: Moose are herbivores and only eat plants. They commonly feed on willow, balsam fir, maple, birch, and trembling aspen. In the summer, they eat the buds and leaves of plants. In the autumn and winter, they feed on twigs and bark.

Habitat: Moose are found in different habitats depending on the season. In winter, moose need protection from the cold and deep snow and are often found in mature and dense forest with access to wetlands and floodplains where they can find twigs for food. In spring, moose need access to new plant growth to recover from the winter, and females with calves need protection from predators. They are often found in dense forest this time of year. In summer, moose are found near lakes, ponds, and wetlands where they source nutritious food and relief from the heat.

Life History: Moose live up to 20-years-old. Females can start having calves as young as 1 or 2-years-old, but females aged 4 to 12 have the highest reproductive rates. Mating occurs in the fall (Sep–Oct). It begins with the rutting period, where dominant males attract and defend groups of females. Females carry 1 to 2 calves (twins are common when there is lots of food) for ~240 days (~ 8 months) and give birth in the spring (May-June). Calves stay with mom for about 1 year.

3. Threats to Moose Populations

Moose are not listed on any federal or provincial endangered species lists, except in Nova Scotia. However, both western-scientific data and Indigenous knowledge have suggested moose are declining in many areas of North America. Some of the known threats to moose are:

Harvest: Licensed hunters, rights-based hunters, and poachers cause direct mortality by killing animals. They can also change population structure by selectively hunting certain sex and/or age classes. For example, hunting only adult males will eventually reduce the number of adult males in the population. Increased access to moose, caused by more roads and cut lines, can exaggerate the hunting pressures on moose.

Predation: Predation, mostly by wolves and grizzly bears, is a concern for yearlings and calves. Predators can impact the number of young that survive into adulthood.

Parasites and disease: Infestations of winter ticks have become a threat to moose. They can affect moose behaviour, their ability to keep warm, their body condition, survival, and reproductive success. Brainworm and liver fluke, passed to moose from white-tail deer, can also be fatal.

Changes to habitat: Industrial development such as mining, logging, pesticide use, agriculture, urban sprawl, creation of roads and other linear features (e.g., cut lines, pipelines, ditches), fire suppression, and mountain pine beetle infestations are all potential contributors to moose declines. Changes to moose habitat can also reduce the availability of food, like woody shrubs, and can increase access for predators and hunters.

Climate change: Climate change will likely bring many new threats to moose and make pre-existing threats worse. One concern is that, as annual temperatures continue to rise, the risk of heat stress will increase for moose or they will have to change their behaviour to reduce heat exposure. Climate change may also introduce new diseases and parasites by changing the areas that parasites can survive and/or by increasing contact with other species, like deer, that carry parasites that are harmful to moose.

Moose-vehicle collisions: As roads become more common in moose habitat, collisions with cars are becoming a threat to moose. Using salt on highways can increase the likelihood of collisions, since moose are attracted to roadside pools with high concentrations of salt.

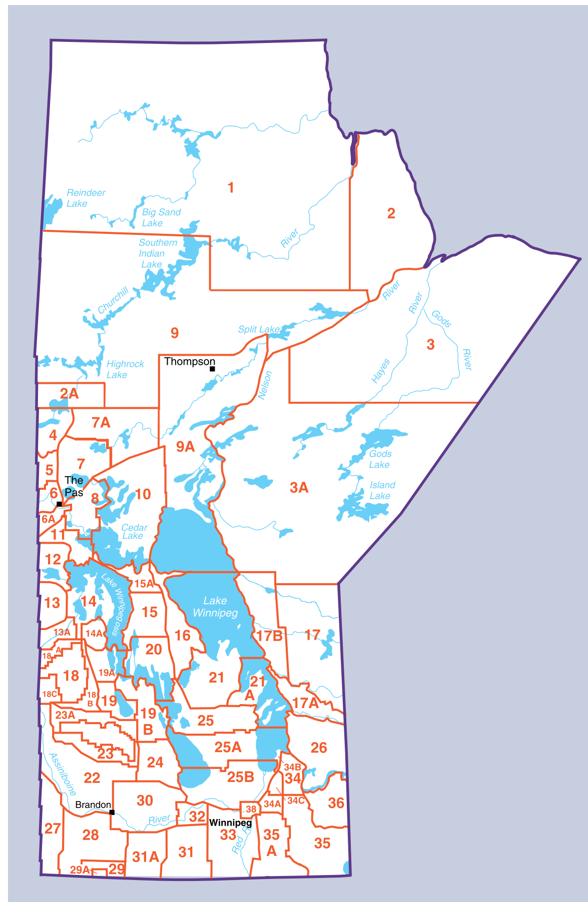
Credit: Juliana Balluffi-Fry

4. Monitoring and Management by the Manitoba Government

Moose are monitored and managed differently across Canada depending on funding, expertise, and priorities of local governments, rights holders, and other stakeholders. The level of Indigenous engagement and inclusion in Crown government-based monitoring, management, and decision-making also varies across the moose range.

In Manitoba, monitoring and management efforts include:

Game Hunting Areas: In Manitoba, moose (and most harvested species) are monitored and managed according to 56 separate Game Hunting Areas (GHAs, see map). Population surveys and harvest regulations are done at the GHA level. It is important to note that GHAs do not correspond easily to territorial boundaries of Indigenous communities. There is a need for data that corresponds better to Indigenous territories. This way, data collected can better speak to the needs of Indigenous communities, assist local decision-making and potentially influence political and economic decisions.



Manitoba Game Hunting Areas.
Map developed by the Province of Manitoba.

Aerial Surveys: Ariel surveys involve flying aircrafts over a survey area and counting moose. Using this method, the provincial government obtains data on the total number of moose in a given area, as well as the breakdown of adult cows, adult bulls, yearlings, and calves, calf survival, cow:calf ratios, and moose distribution. Only a few GHAs are surveyed aerially every year, alternating from year to year. This means there can be large gaps in the data for some areas.

Hunter Questionnaires: The provincial government also offers voluntary hunter questionnaires online, to resident, licensed hunters (www.manitoba.ca/huntsurvey). These questionnaires gather information about hunting location, hunter effort and success, moose and predator sightings, and changes in moose numbers relative to previous years. These surveys are the only way the government collects data on how many animals are harvested in a given year and the locations of successful hunts. However, since they are voluntary, response rates are generally very low, especially for hunters that were not successful – people don't typically report a "zero" on their hunt.

Licensed Harvest Regulations: Any non-Indigenous person who wishes to hunt in Manitoba must possess a license. Resident hunters can apply for and purchase one of four license types. Licenses restricts hunters to certain GHAs and specific seasons that differ in start and end dates. Currently all licenses limit hunters to one bull moose. For all licenses (except a general draw moose license), once a hunter is awarded a license, they can hunt in any GHA that allows that type of license. As a result, while the number of licenses and tags of each type sold each year is known, the location and success of hunts is not, unless the hunter voluntarily reports this information through the online hunter questionnaire. This means there is a lack of information on licensed and rights-based harvest rates, creating a substantial knowledge gap in moose management.

Credit: Eamon Mac Mahon

5. Possible Monitoring Methods

Most of the main moose monitoring methods provide similar data and can be somewhat interchangeable. This means choosing a method to use for a project will depend mostly on available finances, the complexity of the method, the capacity within a community to implement the method, and the specific interests, priorities, and values of each community.

The following methods have been used to monitor large animals by researchers/ scientists, managers, and as part of Indigenous-led monitoring programs. Below you will also find a table comparing different methods with important factors to consider when selecting a method.

Aerial Surveys: Aerial surveys are the most common method used by Crown governments to monitor moose across Canada. A population census is obtained by flying aircrafts over a survey site and having one to two observers count the number of moose. These surveys provide data on how many moose are present, where they are, and 'who' (e.g., males vs. females, young vs. adults) is present. The precision and accuracy of results can vary depending on the:

- expertise of the crews
- visibility impacted by fog, snow, wind, light
- habitats surveyed such as dense vs. open forest
- area surveyed
- analyses conducted on data

This method is useful for surveying large and remote areas. However, the cost of equipment, expertise, and the training required to conduct these surveys mean aerial surveys may be an unlikely tool for community-led monitoring, unless partnered with an external organization.

Radio Telemetry and GPS Collars: This approach is most commonly used in ecological research. It collects location and activity or movement data of collared animals or groups of animals. Most scientific studies that use collars are interested in animal behaviour (tracking movement, activity, and interactions between animals) or precise habitat selection. Collars can be costly, require frequent repairs such as replacing batteries, and often require extra technology/software to download the data. The logistics of this method can be complicated, such as getting permissions and/or support to immobilize and collar wildlife and finding the expertise to do this safely.

Fecal Pellet and Track Counts: Fecal pellet and winter track counts are obtained by walking or snowmobiling set areas and counting/identifying all pellets or tracks observed on the ground. These methods provide an indication of how many animals are present in a given area. Data is usually reported as tracks or pellets per area (such as km2), per time unit (such as day), or an indication of where the animals are located based on the presence or absence of tracks or pellets within different areas.

Conducted by foot or snowmobile, these methods often cover smaller areas. They are good for surveying habitat types that are difficult for aerial surveys, such as dense forests.

The costs of these methods are associated with equipment (e.g., snowmobiles, snowshoes, GPS, notebooks/tablets) and paying for training/labor, which can be costly depending on the desired area and time requirements. The expertise required to conduct track counts (i.e., track identification) is not highly technical and is often common within communities. Environmental conditions, like snow conditions (e.g., the time since last snowfall), vegetation characteristics (e.g., ground cover) and the age of tracks/pellets can affect visibility and how easy they are to identify and count.

Multi-Species Track Counts in the Sahtù Settlement Region, NWT

This wildlife monitoring project was motivated by local Sahtù (Dene) and Métis communities, the NWT territorial government, and industry. Each expressed interest in monitoring the cumulative impacts of oil and gas exploration on wildlife in the Sahtù region. Since 2014, at least three times per winter, ~ 10 transects (along trails and seismic lines within 50 km of the community) were surveyed on snowmobiles by teams of two or three. These teams included at least one youth and one experienced harvester/Elder. Survey routes were traveled at low speed (<10 km/hr) on snowmobiles and fresh tracks of all ungulates (e.g., moose, caribou, deer) and furbearers (e.g., lynx, wolverine, wolf, marten) were recorded when encountered. Surveyors were trained by government biologists at the onset of each season, but harvesters were always asked to confirm track identification and provide interpretations about the tracks that were observed. Mobile data collection applications (with pre-loaded questions and data collection prompts on them) were used on hand-held computers/tablets for paperless data collection. Photos of tracks and surrounding habitat were stored on the app as well. Data was analysed and, in the fall, was shared at local workshops and meetings to review and discuss logistics in order to plan for the next field season.

Trail Cameras: Trail cameras have become a popular tool for wildlife viewing and for ecological research on animal behaviour. They act as an "extra set of eyes" in the forest. Cameras can be set up with motion triggering to take photos whenever an animal passes. Or, they can be set to a schedule throughout the day which can be useful to capture changes in the environment over time. Photos can provide useful information on the animals that are present in an area, how many there are, where they are located, 'who' is present (e.g., male vs. female, young vs. adult), population health, activity patterns, and behaviour.

Trail cameras can be expensive, but they are usually a one-time cost. There is a wide range of cameras available with different features and at different price points. Some maintenance is required (e.g., replacing batteries, clearing vegetation, repositioning if they are moved), but with enough battery power, cameras can stay out for long periods of time and provide observations that are not biased by observers.

Cameras can also provide hundreds or thousands of photos that need to be reviewed and 'scored' to determine which animals are in each photo. This can be time consuming, but also a good opportunity for community and youth involvement in the project.

Land-User Surveys: Land-user surveys use individuals who have land-based expertise, including hunters and trappers, to:

- record wildlife observations such as numbers, location, age, sex, and health of animals.
- report harvest activities, including location of harvest and hunter effort.
- document local or Indigenous knowledge.
- provide biological samples for further analysis (e.g., bones, blood, hair, brain).

Observations can be collected by land-users themselves or by others (e.g. lands staff, Guardians staff) who are engaging with land users on the land or once they return to the community. More basic data collection methods, such as notebooks or datasheets and pencils, can be effective for Elders or individuals who are less comfortable with technology. Technology-based methods, such as smart phones, tablets or mobile applications, can be a way to engage youth in the process. Technology can also increase the types of 'accessory' data that can be collected, like photos, voice notes (for stories or commentary) and automatic GPS location. Technology can also help standardize data collection through pre-made forms and questions. Some of the major benefits of the land-user survey method include:

1. it provides a method to collect harvest data.
2. it can document Indigenous knowledge.
3. it encourages community participation in the program.

Spatial and temporal coverage of data can be quite large if hunters and trappers use different locations spread across the sampling area and if they spend time on the land throughout the entire year.

One limitation is that observations can be biased because of hunter behaviour. For example, hunters often spend more time in habitats where moose observations are likely to be higher than average because their intention while on the land is to find moose.

Semi-Structured Interviews: This method involves collecting and documenting Indigenous knowledge from Elders, land-users and/or other Indigenous community members. Semi-structured interviews are when the interviewer does not strictly follow a formalized list of questions. Instead, the interviewer asks more open-ended questions allowing for discussion and knowledge-sharing rather than a straightforward question-and-answer format. This is one of the more advanced methods of qualitative data collection and requires training and practice to be done well. It is also a method that community members can be trained to do. If youth take part in interviews with Elders, this can promote the sharing of culture from older generations to younger generations within the community. This method has been used to determine monitoring and research priorities, identify important habitats or areas for moose, emphasize cultural value of moose in management plans, and influence harvest quotas.

Biigtigong Nishnaabeg Land-User Surveys with Phone App

Biigtigong Nishnaabeg is an Indigenous community in northwestern Ontario. They developed a moose monitoring program in collaboration with the Anishinabek/Ontario Fisheries Resource Centre (A/OFRC), in response to community concerns of declining moose populations. Data on moose sightings and harvest were collected by hunters and land-users using a mobile application by Trailmark systems. Individuals were also able to record their own observations and Indigenous knowledge in the form of photos, audio, and text, in order to document changes in population trends and behaviour over time. In addition to the land-user surveys, 35 members of the community were interviewed and shared Indigenous knowledge on moose population trends and threats to moose.

Table 1: Summary and comparison of common moose monitoring methods including data acquired, cost and complexity. Costs are ranked from low ($) to high ($$$$). Complexity is also ranked from low (*) to high (****) in terms of training and capacity required, as well as other logistical concerns.

Method	Data Acquired	Cost ($ = low, $$$$ = high)	Complexity/ Considerations (* = low, **** = high)
Aerial Surveys	• Abundance • Distribution • Population composition	**$$$$** Costs include: flight costs, surveyors' time	**** Training and expertise of people executing survey; flight capacity; analytical capacity
Radio Telemetry/ GPS Collars	• Distribution/ Habitat use • Behaviour/Activity	**$$$$** Costs include: collars/refurbishing old collars, immobilization and handling of animals, data analysis	*** Training and expertise required to capture animals and set up collars; analytical capacity
Fecal Pellet and Track Counts	• Abundance • Distribution • Mammal diversity	**$$** Costs include: wages for data collectors (usually a lot of hours required), transportation costs (snowmobile/ATV rentals, snowshoes), safety and field equipment (e.g., GPS, snowshoes)	** Training required to identify tracks (land-users often know this already); training required for data recording and navigation; data recording and navigation; difficult to do in remote areas; if conducted on foot it can take a lot of time/effort to cover necessary distances
Trail Cameras	• Distribution/ Habitat use • Population composition • Mammal diversity • Health	**$$$** Costs include: cameras, batteries, wages for people putting cameras out, transportation costs, safety and field equipment (GPS, snowshoes, if needed)	*** Capacity to use cameras; batteries die easily in the cold; analyses are often time consuming; identifying animals in photos

Method	Data Acquired	Cost ($ = low, $$$$ = high)	Complexity/ Considerations (* = low, **** = high)
Land-User Surveys	• Observations • Harvest • Indigenous knowledge	**$ to $$** Costs include: honoraria for participants, materials for data recording, wages for people accompanying land users, transportation, safety and field equipment.	* Land-users need to be trained in data recording; Indigenous knowledge element can require more expertise (see semi-structured interviews section)
Land-User Surveys with Mobile Applications	• Observations • Harvest • Indigenous knowledge	**$$** Costs include: technology (phones, tablets), licenses for apps, honoraria for participants, wages for people accompanying land users, transportation, safety and field equipment	** Primary user of technology needs to be trained; technology can be unreliable in the cold and rain; Indigenous knowledge element can require more expertise (see semi-structured interviews section)
Semi-Structured Interviews	• Observations • Harvest • Indigenous knowledge • Community priorities and research questions	**$** Costs include: honoraria for participants, wages for interviewers; hiring someone with social scientist expertise to help with study	** Creating interview questions that get desired information; summarizing, analyzing, and interpreting qualitative data needs to be objective; special care needs to be taken to document and interpret Indigenous knowledge

6. Study Design and Data Collection Considerations

Below are some data and study design considerations to think about when developing a monitoring program and/or a research project. These will ensure that appropriate data are collected and that interpretations of the data are as close to ‘reality’ as possible.

Before starting a project, it is important to decide which is being done, monitoring or research. Your choice could change how data are collected, for how long, and how they will be used.

Monitoring vs. Research

Monitoring
Monitoring is the process of gathering information about the state of the environment, such as animal abundance, temperature, forest cover, water chemistry, etc. The goal is to make conclusions about system change over time. Change in the environment is often measured in reference to a baseline level (e.g., the start of the monitoring program) or based on a judgement of the desired state of the system (e.g., what it was generations ago).

Research
Research involves hypothesis-testing. All data collected is geared towards answering a specific question. Research seeks to do something that has not been done before, and to go into a situation with a question and come out with an answer

These questions often deal with the impact of something on something else, such as the impact of wolf population numbers on moose population numbers.

Sample Size: Large sample sizes (i.e., large number of observations) are needed for results to be accurate, reliable, and reflect reality. The smaller your sample size, the more likely an outlier (i.e., an extreme value), or biased data will skew your findings. This is especially important if findings will be used to make conclusions about a larger population or survey area. A larger sample size also increases the likelihood that small patterns can be detected. Consider increasing sample size by:

a. increasing the number of observers collecting data at a given time.
b. increasing the frequency of sampling such as every day, or twice a day, as opposed to once a week.
c. increasing the time window that sampling occurs, if possible. For example, all year, instead of only during the summer.

Standardization of Methods and Repeatability of Results: Standardization helps minimize biases and subjectivity that could be introduced by observers due to their own personal characteristics and the context within which data is collected. Standardization can be achieved through written, step-by-step protocols. This helps ensure that every person collecting data follows the same approach and all data points are comparable. This also helps make results repeatable over time — data is collected in the exact same way every time (i.e., internal consistency) and by every observer (i.e., replication).

Controlling Results for Unit of Effort: Spending more time outside or covering larger areas will lead to a greater number of moose observations. This means data such as moose sightings, track counts, photos from trail cameras should be reported as a function of the effort that went into collecting them (e.g., number of kilometers surveyed, or the number of days sampled). The resulting value will be something like "moose sightings per kilometre driven", or "moose sightings per day", or "tracks per kilometre snowshoed". For spatial analyses, you could also control for spatial variables, like habitat type (e.g., "moose photos per day per habitat type").

Recording Negative Results: Recording zeros or negative results is critical. These are often seen as less important or less exciting to report, but zeros are required to give context to the positive results by having something to compare them to. In the context of moose monitoring, or harvest reporting, a negative result would be an unsuccessful hunt or a day when zero moose were observed.

Ecological Variables Vary Over Time and Space: Processes in the natural world change both over space (from location-to-location, habitat-to-habitat, north-to-south, etc.) and time (day-to-day, month-to-month, year-to-year, etc.). Depending on the trends or patterns of interest, it is necessary to control for one in order to determine the effects of the other. For example, if you are interested in changes in moose abundance over time, then spatial locations of sampling should be held constant. Otherwise, it would be difficult to determine if any changes over time were caused by differences in habitat, or temperature, or sunlight, or snow depth of the locations that were sampled.

Credit: Eamon Mac Mahon

Study Design and Sampling Methods: Often, survey respondents or sampling locations are chosen based on convenience or voluntary responses, and this can lead to a lot of bias in the sampling. Some thought should be put into sampling and study design in order to minimize biases. Below is a description of a few common sampling methods. Those marked with an * tend to be less biased:

- **Convenience sampling:** choosing a sample that is readily available in some non-random way.
  - E.g., surveying every person you see at a mall on a Monday afternoon. This could bias your sample towards people who shop at malls, live in the area, and do not work on Mondays. This would likely not capture variation in the population at large.
- **Voluntary sampling:** putting out a request for members of the public to join the sample, and allow people to decide whether or not to be in the sample. This approach can lead to bias because people who respond tend to have the time and energy to participate and tend to have strong opinions compared to the general population (i.e., very positive or negative opinions).
  - E.g. If a new regulation like no smoking is put into place at a local restaurant and you put up a flyer on the door asking people to call you with their opinions, you are more likely to get phone calls from people who are particularly angry or happy about this new regulation.
- ***Simple random sampling:** every individual/location has an equal chance of being included in the overall sample. Random samples are fairly representative since they don't favour a particular group of person or sampling unit.
  - E.g. #1, pulling names out of a hat for survey respondents.
  - E.g. #2, you split up your study area into a grid of 10km x 10km squares and place one trail camera in every square.
- ***Systematic random sampling:** members of the population or locations within the study area are put in some order, a starting point is selected at random, and then every nth one is selected from the sample.
  - E.g. #1, community members are alphabetized by first name, and starting at a random name, every 25th person is interviewed.
  - E.g. #2, sampling locations are ranked by 'tree density' or by 'proximity to water' and, starting at a random point, every 10th location is sampled.
- ***Stratified random sampling:** the population/sampling area of interest is first split into groups, then the overall sampling population/area is made up of people or locations from each of those groups. This sampling method reduces bias by ensuring that each group is represented in the final sample.
  - E.g. for a survey, you split the population into groups based on age and whether they hunt or not. From these groups, you end up surveying 10 youth non-hunters, 10 youth hunters, 10 adult non-hunters, and 10 adult hunters.

Mixed Methodological Approaches: 'Mixed Methods Research' (MMR) is a research approach that involves researchers collecting and analyzing both quantitative and qualitative data. Then, both data sources are purposefully and carefully analyzed and interpreted at different stages throughout the research project. This approach draws on the potential strengths of both methods, allowing research to explore diverse perspectives and uncover trends that may not come out with one approach alone. MMR could be particularly valuable in the context of research with/by Indigenous communities because it could interweave quantitative data (likely based on western scientific methods), Indigenous knowledge, and other elements of Indigenous culture (e.g., stories, culture, art, music, etc.) into environmental monitoring and research. Qualitative data (e.g., Indigenous knowledge, stories, observations) can be used as a way to build, guide, explain, and interpret quantitative data, and can be kept as a separate entity, reported alongside quantitative data.

The use of both western science and Indigenous knowledge has also been referred to as a **Two-Eyed Seeing approach** (*Etuaptmumk*, in Mi'kmaw), a term coined by Mi'kmaw Elder Albert Marshall. This name refers to "learning to see from one eye with the strengths of Indigenous knowledges and ways of knowing, and from the other eye with the strengths of western knowledges and ways of knowing … and learning to use both these eyes together, for the benefit of all." (from http://www.integrativescience.ca/Principles/TwoEyedSeeing/).

Gitanyow Harvest Monitoring and Management Program (Koch 2016): Between 2001 and 2011, moose declined 68% in the Gitanyow Lax'yip (traditional territory; in BC) due to an over-harvest of cow moose. As a result, the Gitanyow Hereditary Chiefs initiated moose monitoring and an Indigenous harvest permitting program within their traditional territory. As part of the permitting program, a hunting quota was set and enforced. All community members had to ask permission of the Chief to hunt in a given area, and hunting seasons were closed once the pre-determined harvest quota had been reached. In addition, a team of two wildlife monitors (i.e., Guardians) drove accessible roads to conduct patrols of the territory, collecting data on hunting activity, successful harvests, moose and wolf sightings, roadkill observations, and mapping of brush levels along the highway (to determine if roadkills were linked to visibility). Additional harvest information was obtained through in-person discussions or through follow-up phone surveys with harvesters. According to the Gitanyow report (Koch 2016), wildlife monitors had a significant presence in the local communities and across the territory, making it difficult for moose harvests to go unnoticed. The report also stated that the success of the permitting program was a result of: 1) having the Hereditary Chiefs office coordinate the permits, and 2) over time, the concept of obtaining a permit was more accepted and understood by community members.

Privacy, Consent, and Data-Sharing: It is essential to have informed consent from individuals who participate in the research process. To give consent, individuals must sign a consent form that details (in plain and clear language) what the data will be used for, and who it will be shared with. Before results are shared, interpretations of the data should be 'checked' with community members to ensure they reflect the ideas and desires of the community. A good resource for data considerations is the OCAPTM guidelines on data ownership, control, access, and possession (more information at https://fnigc.ca/ocap).

7. Recommendations

Below are eight recommendations to consider when building a community-led monitoring and/or research program. They were derived from a general understanding of what is involved in building research projects, collecting ecological data and considering the challenges and recommendations outlined in reports from other community-led projects. These suggestions are a combination of specific data collection considerations and more big picture recommendations. Communities can take their own context, priorities, capacity, and goals into account when applying these recommendations to their own monitoring program.

1. **A first step of any project could be to determine and document community priorities, project goals, and/or research questions.**

   Indigenous communities may prioritize elements of environmental monitoring/research that go beyond quantitative and qualitative data collection. This may include connecting with the land, generational knowledge transfer, youth involvement and engaging in cultural activities. These priorities should be identified and emphasized when designing a monitoring and/or research program. Here are some things to consider:

   1. Is the goal to set up a long-term monitoring program or to do hypothesis-driven research? Or both? Exploring these questions will determine the study design and data required to meet the goals of the program.
   2. Your goals and research questions could be determined through community meetings or town halls. Consider conducting interviews with community members, and/or also working with external partners.
   3. Writing these goals/questions in a sharable document could facilitate the involvement of community members and external partners. It could also ensure consistency in data collection if the document is available for reference at any point in the project's lifetime.

Credit: Frank A. Wyzwywany

2. **To ensure rigorous and reliable data, prioritize a large sample size and the standardization of data collection.**

   Achieving a large sample size and ensuring standardization of sampling methods are important, regardless of the question being answered. Minimum sample sizes will change as the population or area of interest changes. Statistical power tests can help determine the minimum sample size required to detect a significant effect if one is present.

3. **If focused on monitoring, focus on answering the questions "how many are there?" and "where are they?".**

   The "how many" can be characterized by the relative abundance of moose over time.

   - Control population indices for effort, which includes the area sampled or time spent collecting data (e.g., moose/km or calves/day).
   - Cow:calf ratios or cow:bull ratios are simple yet informative metrics to use as an indicator of recruitment and reproductive potential, which could provide early warning signs of decline.
   - These data can be obtained through all methods: track counts (tracks/km2), fecal counts (fecals/km2), land-user surveys (e.g., observations/day or observations/km), trail cameras (e.g., moose photos/day), and Indigenous knowledge interviews (e.g., trends over time).

The “where” can be characterized by the location of moose within the territory.

- Control numbers for effort and habitat type (e.g., moose/km in open habitat vs. dense forest, or calves/day close to roads vs far from roads).
- Habitat types should be sampled randomly and equally (see simple stratified random sampling study design). If it is possible to identify specific habitat types (i.e., with the help of biologists or local expertise), transects and trail cameras could be placed equally across these habitats (e.g., open, young coniferous, old coniferous, mixed hardwood, wetland, etc.).
- These data can also be obtained through all methods if habitat data are collected alongside count data.

4. Highlight Indigenous knowledge within monitoring and research programs using a Mixed Methods approach.

To gain the highest level of insight into local moose population trends, a mixed methods approach, or a Two-Eyed Seeing approach could be powerful. This would involve engaging knowledge holders of your community. It could have many benefits, including intergenerational knowledge sharing between knowledge holders and youth.

By identifying the important pieces in Recommendation #1, you can then identify how best to design your monitoring and management programs to weave Indigenous knowledge and western science that best meets your community’s needs.

5. If harvest data are a community priority, consider initiating a rights-based harvest reporting program within the community.

A lack of harvest data for both rights-based and licensed harvest is a noticeable knowledge gap in moose management.

Indigenous community members or organizations could create and enforce harvest reporting of rights-based hunting (and licensed hunting) in their own traditional territory. This could be done through land-user surveys (which are potentially already being conducted) or through a separate program where rights-based and licensed harvesters report harvest to a designated person or organization within the community (see *Gitanyow* Harvest Monitoring and Management Program).

6. **Build partnerships beyond the community.**

   Building partnerships with external organizations such as government, academics, industry, and non-governmental organizations is likely to increase the long-term success of community-led monitoring and research programs, particularly by increasing funding opportunities.

   Partnering with experienced wildlife biologists or managers could also facilitate training and capacity building opportunities for community members, help when troubleshooting methods, and streamline data analyses and inclusion of data into provincial and federal decision-making.

   External partnerships might help secure a level of funding necessary to continue long-term sampling and building capacity within the community to collect data independently.

7. **Communicate broadly and communicate often.**

   Effective and consistent communication with each rights holder or stakeholder (e.g. with community, leadership, external decision-makers, partners, industry), is important at all stages of the project. It could build trust within the community, help troubleshoot logistical issues, and could help increase internal and external support for the project, a likely determinant of overall success.

   In other monitoring programs, an important step seemed to be presenting results back to the community. This was paired with regular discussions and re-evaluations of the methods, challenges, and goals of the program. This also allowed for improvements to be made to tricky elements of the program, and community trust to be maintained throughout.

8. **Protect data and intellectual property with data-sharing and authorship agreements.**

   If data is going to be shared with external partners in any form, an Information Sharing Agreement will ensure that all parties involved agree on the use and ownership of intellectual property.

   If data is ever published publicly, an Authorship Agreement can be created, outlining the people/organizations that need to be included as authors on the document and the requirement for communities to be consulted prior to publication or any media attention.

Champagne and Aishihik First Nations Harvest Reporting and Predator Control Program

In response to moose declines between 1998 and 2008, a three to five year Alsek Moose Management Program was developed in 2015. This program was a partnership between the Champagne and Aishihik First Nation (CAFN), the Alsek Renewable Resource Council (ARRC), and Environment Yukon. Their management plan includes moose and wolf aerial surveys (conducted by government), moose recruitment surveys (conducted by government), mandatory harvest reporting (for licensed and Indigenous hunters), and a community-led wolf trapping initiative. The need for more accurate harvest reporting initiated a harvest data-sharing strategy between CAFN and Yukon government to combine information on licensed and Indigenous harvest, and to encourage members of CAFN to consult Indigenous harvesters and communities about appropriate harvest limitation approaches. In addition, a pilot wolf-trapping initiative was designed within the CAFN territory to assist in moose recovery efforts by aiming to reduce predation rates by wolves, but also to promote community members being on the land, increased stewardship, education, and humane trapping skills. Participating CAFN trappers receive a daily honorarium and gas/maintenance stipend, as well as a fur handling incentive if they donate furs to the program, for local craft making and marketing. In the first year, community members engaging with this program trapped a total of 17 wolves from the area.

8. Glossary

Abundance: the number of individual animals (of a single species) in a given area.

Relative Abundance: how common a species is relative to other species in the same area.

Accuracy: the degree to which information actually describes what it was designed to measure (i.e., how well it reflects reality).

Bias: Inclination in favor of or against one thing compared with another, usually considered to be unfair. In research, refers to any systematic error introduced by selecting or encouraging one outcome or answer over others.

Body Condition: a measure of physical health of an animal, usually measured by how fat an individual is,

Distribution: the geographic area where individuals (of a single species) live.

Ecology: the area of science that tries to understand how animals interact with each other and their physical environment.

Habitat: the area where an animal lives, including everything it needs to survive (e.g., food, water, protection from predators).

Herbivore: an animal that feeds on plants.

Indigenous knowledge: refers to the knowledge that Indigenous communities accumulate over generations of living in a particular environment that incorporates all aspects of life (spirituality, culture, language, ceremony, the environment).

Licensed harvester: any non-Indigenous harvester that has purchased a license from the government in order to hunt.

Management: the process or practice of actively protecting animals and their environment, often involving human-intervention or manipulation of either one.

Monitoring: process of collecting observations over time and across locations to gain information about the environment. The purpose is often to understand what the environment looks like now, compared to the past, or to guess what it might look like in the future compared to now.

Population Demographics: the age and sex structure of a group of animals, which can change with births, deaths, and movement of animals to and from other areas.

Population Index: indicates relative size of a population and shows population trends (up, down, stable) but does not provide an actual estimate of the number of animals. Indices are used to summarize what a group of animals looks like in a single number that can be tracked over time or compared to different areas.

Precision: refers to how close different estimates of the same thing are to each other.

Reproductive Success: the number of young an individual produces per breeding event (e.g., year) or their lifetime. It can also include the success of their offspring, themselves, which would indicate how many animals in the population can be associated with a single individual.

Recruitment: the process by which new animals are added to the population, which can occur through births of new young, maturation into adults, and immigration of new animals from other areas.

Repeatability: how consistent something is over time, when it is measured in the same way.

Research: hypothesis- or question-driven knowledge gathering. It is often defined as active creation of new knowledge or concepts or methods by asking a question, collecting information to answer that question, and then summarizing what was found.

Rights-based harvester: refers to Indigenous hunters since it is their constitutionally protected right to harvest wildlife.

Species Diversity: the number of species in a given area.

Stakeholder: in the context of environmental monitoring and/or research, this word is used to refer to individuals or organizations that have an interest in wildlife or the environment. For example, the provincial government, a trappers association, Parks Canada, a naturalist group, are all stakeholders that could be included in conversations or decisions about the environment.

Standardization: to establish something that can be repeated exactly the same way every time, regardless of who does it, when, and where.

Statistical Power: the likelihood that your experiment detects a trend, if the trend exists.

Two-Eyed Seeing: a term coined by Mi'kmaw Elder Albert Marshall, this is an approach to understanding the world that involves seeing from one eye with the strengths of Indigenous ways of knowing, seeing from the other eye with the strengths of western science, and to use both eyes to see the world together.

Western science: a system of knowledge that relies on certain laws that are established through the application of the scientific method. So-called scientists use this term to differentiate what they do from other ways of collecting information about the world, like Indigenous science.

Credit: Phil Walker