



Review of post-2010 Literature on Human Effects on Barren-Ground Caribou: Focus on Traditional Knowledge, Western Science and Caribou Protection Measures

Prepared for the Nunavut Wildlife Management Board
By Trailmark Systems Inc.

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Executive Summary

The Nunavut Wildlife Management Board (NWMB) reviewed current scientific research and Inuit Qaujimajatuqangit and traditional knowledge regarding human disturbance on barren-ground caribou. Results of the review may inform future management decisions regarding the protection of caribou and caribou habitat, as per the NWMB's functions outlined in the *Nunavut Land Claims Agreement*. The review included an evaluation of the effectiveness of current Nunavut Caribou Protection Measures, and a summary of how other jurisdictions are mitigating impacts of human disturbance on caribou. The current review focuses on post-2010 references in order to build upon a similar review carried out by the Government of the Nunavut (EBA Engineering Consultants Ltd. 2011).

The literature review and resulting database contain 72 scientific references, 52 traditional knowledge references and 30 references regarding caribou protection measures. A small number of references (e.g. EBA Engineering Consultants Ltd.) were reviewed for all three components of the literature review. Where possible, guidelines, protocols and procedures for carrying out caribou protection are also included (e.g. AANDC Caribou Protection Measures).

Findings from the literature were organized around three issues: linear features (such as roads, power lines and pipelines); resource development infrastructure (such as buildings or open pit mines); and aircraft and vehicles. Local scale and regional scale effects along with cumulative effects are also considered.

Linear Features

Linear features such as roads can affect caribou by increasing disturbance, creating partial barriers to movement, increasing access for harvesting, and altering migration (Wolfe *et al.* 2000; Wray 2011; EMAB 2012; Tłıchq Government 2013; Sangris 2012; Jacobsen 2013; GSCI 2015). Some studies show that roads cause detouring of migrations, range abandonment and, ultimately, population decline (see e.g. references in EBA Engineering Consultants 2011). However, some researchers and community elders state that the impact may be seasonal: the road may be less a barrier during peak periods of migration than during other parts of the year. Noel *et al.* (2004) reported neutral effects of roads on caribou behavioural response by concluding that “distribution of calves and adult caribou were not strongly influenced by presence of the road”. However, this conclusion was later criticized by Joly *et al.* (2006) and contradicted by NRC (2003). Given these discrepancies, results from the literature review suggest that understanding effects on barren-ground caribou from linear features are complex.

Resource Development Infrastructure

Indigenous community members identify resource exploration, extraction and development (e.g. mining, oil and gas) and their associated infrastructures as a main source of impacts on barren-ground caribou. Noise, light, dust, pollution, physical structures, cumulative effects, among others, are reported to cause disturbances, shifts in migration patterns, habitat destruction, injuries, contamination, and changes in the overall health of barren-ground caribou.

Mining infrastructure includes buildings and pit mines. Caribou may respond to mine disturbance in all seasons (Weir *et al.* 2007), although the impact of mines seems to be most prominent in the pre-calving and calving seasons. Indigenous community members and scientists alike report that such infrastructure attract caribou seeking refuge from the sun, predators, and insects or deflect caribou in terms of both their small-scale movements and large-scale migrations (KHTO and Golder 2011; Johnson and Russell 2014).

Human infrastructure can act as complete or partial barriers influencing or hindering caribou movements and preventing groups of animals from reaching important calving areas or feeding sites (Sivertson 2012).

Boulanger *et al.* (2012) found that caribou occupancy in the central Arctic was negatively influenced by resource development infrastructure and human activities. Smith and Cameron (1983) reported that mining facilities modify caribou movement and affect herd composition, suggesting lower caribou occupancy rates, and herd displacement particularly for cows with calves.

Vehicles and Aircraft

Community elders have expressed concern about the impacts from aircraft and vehicles, particularly with respect to noise, pollution and contaminants and the associated responses in caribou (Whaèhdòè Nàowòè Kò 2001; Thorpe *et al.* 2001; Kendrick *et al.* 2005; Łutsel K'e Dene First Nation 2005; BHP Billiton 2007; Legat *et al.* 2008; Sahtú Land Use Planning Board 2010; BQCMB 2011; KHTO and Golder 2011; Judas 2012; North Slave Métis Alliance 2012; WRRB 2013; ACFN 2013; Barnaby and Simmons 2013; ACCWM 2014; GSCI 2015).

The science literature is in agreement: disturbances such as low level aircraft flights and vehicles (e.g. ATV, snowmachines) can increase caribou energetic costs if those activities interrupt foraging or cause the caribou to move away in response to the disturbance (Weladji and Forbes 2002; BQCMB 2011; KHTO and Golder 2011; North Slave Métis Alliance 2012; WRRB 2013; ACFN 2013; Barnaby and Simmons 2013; ACCWM 2014; GSCI 2015).

The nature and magnitude of vehicular disturbance on caribou movements, behaviour, and overall health may depend on the time of year, habitat and size of the herd. A number of studies suggest that caribou are adaptable and can habituate to a wide variety of disturbance stimuli, including moving objects (EBA Engineering Consultants 2011).

Local Scale Effects

The key question behind disturbance studies is the effect of human disturbance at the population level. Much of the relevant literature focuses on readily observable behavioural responses. However, measuring physiological and demographic responses to disturbance is far more challenging in the field.

According to the traditional knowledge literature, caribou can sometimes adapt and habituate to disturbance: caribou “born into” a fragmented and frenetic landscape know nothing different. While habituation may reduce stress levels, community members assert that this observation should be viewed in the context of the negative impacts (vehicle collisions, contact with contaminants, injury from infrastructure) associated with being in proximity to such developments (KHTO and Golder 2011; Parlee *et al.* 2013).

Individual-based behaviour due to human disturbance is not consistent across populations or individuals. Behavioural responses are context-dependent as they are based on the frequency and type of prior exposure (to a disturbance type) and resulting conditioning (e.g. Beale 2007, cited in EBA Engineering Consultants 2011). Behavioural responses are not always predictable, and responses may be interpreted differently (by researchers studying the animal). Also, habitat quality may influence disturbance response: for example, an individual might have a higher threshold to flee in a high quality forage site versus one with poor or lower quality (e.g. Gill *et al.* 2001).

Community members speak of caribou showing fright-and-flight behaviour such as running quickly (“gallop”) and chaotically or tilting their snout high in the air (Thorpe *et al.* 2001; Wray 2011; EMAB 2012; GSCI 2015) that can result in elevated glucocorticoid levels indicating physiological stress (Dantzer *et al.* 2014). Harvesters explain that the texture and taste of meat from stressed caribou is different. One study of caribou calf mortality documented that three young caribou were trampled during panic and flight from either wolves or aircraft (Miller and Broughton, 1974, as cited in EBA Engineering Consultants 2011).

Regional Scale Effects

At a population or regional level, both scientific understanding and traditional knowledge point to rapid and unprecedented declines in barren-ground caribou. As reviewed in Sivertsen (2012) a large number of scientific studies have reported negative impacts of human infrastructure on *Rangifer*

space use at the regional scale (e.g. Johnson *et al.* 2005, Vistnes and Nellemann 2008, Vors and Boyce 2009, Nellemann *et al.* 2010, Polfus *et al.* 2011).

However, some elders assert in the traditional knowledge literature that caribou are not declining, but rather shifting migration routes or intermixing, challenges that are confounded with the differences in how biologists versus community members classify herds. Elders have expressed the belief that disrespect shown to caribou is responsible for caribou decline and shifts in migration routes.

Although caribou show fidelity to migration routes and calving grounds, caribou shift to other routes when these well-known routes become low in forage quality (Parlee *et al.* 2013). The degree of changes in the location of calving grounds plays an important role in how susceptible barren-ground caribou may be to potential population-level effects (as a result of human disturbance). Developments that affect calving caribou and calving grounds must be avoided. Caribou are particularly sensitive during their calving period and stress only leads to harm for caribou.

Despite dozens of studies carried out over nearly half a century, EBA Engineering Consultants, (2011) concludes that human impacts on caribou are difficult to quantify and that results are often not comparable across studies let alone regions, seasons and herds. Traditional knowledge, however, suggests that profound and overarching effects of environmental change on a local, regional and global scale supercede any other type of human effect on barren-ground caribou (KHTO and Golder 2011).

Cumulative Effects

The traditional knowledge literature reviewed describes cumulative effects as a significant threat to barren-ground caribou (BQCMB 2011; KHTO and Golder 2011; Beaulieu 2012; Sangris 2012; EMAB 2012; Parlee *et al.* 2013; GSCI 2015), and recommends greater coordination of research and monitoring across ranges (EMAB 2012; Parlee *et al.* 2013). Exploration and development activities are cited as the main contributors to cumulative effects.

Gunn *et al.* (2011) note that a cumulative effect assessment is usually undertaken for any major projects subjected to environmental assessment. However, these cumulative effects assessments are proponent rather than issue-driven, and have not made a significant contribution to managing cumulative effects.

The impact of development on caribou is usually not due to single roads, mines, cut-blocks or seismic lines; rather, it is the cumulative effect of many habitat alterations including disturbances over time that affects caribou numbers and distribution

Caribou Protection Measures

Two versions of Caribou Protection Measures are currently in place in Nunavut; these are included as Appendices in the Keewatin and North Baffin Regional Land Use Plans (Nunavut Planning Commission 2000a and 2000b respectively). Some additional degree of protection is offered to caribou in the Keewatin and North Baffin Regions through the land use plans developed by the Nunavut Planning Commission in 2000, as well as through measures put in place for the protection of caribou and their habitat by the Qikiqtani Inuit Association in 2014.

Between 1993 and 1996 the Nunavut Final Agreement was ratified and the *Nunavut Land Claims Agreement* came into force. Existing land use plans were updated by the newly formed Nunavut Planning Commission to ensure compliance with Part 5 Article 11 of the *Nunavut Land Claims Agreement* (Nunavut Planning Commission, 2000a and 2000b). These versions of the Keewatin and North Baffin Land Use Plans were signed off in 2000, and have not been modified since. Nunavut's current Caribou Protection Measures only afford protection to caribou within these areas, and only from those activities that are required to obtain a land use permit. Both land use plans can potentially offer some additional measure of protection to caribou during calving and migration in the form of Conformity Requirements, Terms, and a Code of Good Conduct for Land Users.

In January, 2014 the Qikiqtaani Inuit Association developed Caribou Protection Measures specific to the Mary River Project in cooperation with Baffinland, based on the original measures developed in 1978 and the 2000 North Baffin Regional Land Use Plan, with modifications specific to the proposed Mary River Project (Qikiqtaani Inuit Association 2014). Caribou Protection Areas as defined in the North Baffin Regional Land Use Plan will have to be adopted before mitigation efforts can be developed. There may be a need to update the project-specific Caribou Protection Measures to reflect modifications to the Regional Land Use Plan (Qikiqtani Inuit Association 2014).

Existing CPM in Other Jurisdictions

In other parts of Canada and in Alaska caribou and their habitat are protected from exploration and development activities through a variety of management tools. The majority of these seem to be project-specific and take the form of operational guidelines, permit conditions, stipulations, and requirements attached to land use permits.

The NWT requires that land users develop a project-specific Wildlife and Wildlife Habitat Protection Plan and/or a Wildlife Effects Monitoring Program (Government of Northwest Territories 2014). A caribou protection plan must be submitted to the Department of Sustainable Resource Development before an exploration or construction activity is initiated within an identified area (Government of Northwest Territories 2014). In a number of Inuvialuit communities, Community Conservation Plans

are also in place that include considerations specific to the migratory nature and aggregated calving of barren-ground caribou.

Like the Northwest Territories, the Yukon has no public documents outlining mitigation and management plans for barren-ground caribou.

In Alberta, members of the mining and forestry industry must submit a caribou specific protection plan identifying mitigation measures aimed at minimizing habitat loss (Government of Alberta 2012).

Manitoba employs a similar approach where project-specific mitigation measures are attached as conditions to permits issued to industry (Manitoba Conservation 2011).

British Columbia takes the project-specific approach a step further, by requiring proponents to develop and implement a mitigation plan that can be demonstrated to have either no impact or a net gain to the South Peace Northern caribou within 10 years of project approval (British Columbia Ministry of the Environment 2013a).

As is the case in much of Canada, the State of Alaska does not have a publicly available document outlining caribou mitigation measures required by developers (EBA Engineering Consultants 2011), and does not have a land use plan in place in some of the areas most heavily impacted by oil and gas exploration (Canadian Parks and Wilderness Society 2013).

The need for designating protected areas to preserve critical or sensitive habitat for caribou is well acknowledged across the range of the species (Protected Areas Secretariat 2014; Canadian Parks and Wilderness Society 2013; Cree Nation 2012; Manitoba Conservation 2011; Gunn and Poole 2009; Labrador Woodland Caribou Recovery Team, 2004; Nunavut Planning Commission 2000a and 2000b). However, the designation of land as a national/provincial/territorial park, wilderness area, wildlife reserves, or similar can be lengthy process impeded by conflicting interests between those with non-complementary priorities and the need to consider often complex inter-jurisdictional processes.

In most cases, industrial activities on calving grounds are prohibited or restricted to some degree during calving season.

Recommendations for Caribou Protection

The traditional knowledge literature is consistent in recommending the following to respect and protect barren-ground caribou and caribou habitat:

- Respect caribou according to traditional laws.

- Apply the Precautionary Principle.
- Protect calving grounds.
- Avoid harassment.
- Let the land rest and heal.
- Impose community-based monitoring and stronger regulations.
- Consider scale.

With respect to caribou protection measures, a review of the literature suggests the following:

- Establish designated protection areas: There is little doubt that establishing designated protected areas in critical caribou habitat can only benefit the species in the long term.
- Consider seasonal protection: enact mobile protection measures around calving periods (e.g. May 15 to July 15).
- Consider protecting traditional and annual calving grounds.
- Consider mobile protection measures that move with the herd.
- Protect habitat corridors: develop guidelines relating to remediation of lands to increase the connectivity of suitable caribou habitat and, where this is not possible, to enact policy on the permanent loss of habitat resulting from industrial activity.
- Create temporary seasonal roads located outside of core habitat areas whenever possible
- Monitor caribou in terms of population size, population structure, health and growth rate of the population and distribution and habitat use continue to be critical.

Closing

Neither the scientific nor the traditional knowledge literature can be said to contain a single unified perspective on how human development affects barren-ground caribou. However, the literature(s) identifies a number of key trends, as well as outlier events.

While barren-ground caribou population dynamics are driven by the availability, quality and accessibility of forage (e.g. see references in Schaefer 2013), impacts from cumulative effects and environmental change are likely causing the most significant human disturbance to barren-ground caribou. Disrespect shown to caribou is also said to be a key factor.

While the existence of a zone of influence (ZOI) has been generally accepted, questions remain as to its significance for a herd's demographics, causative mechanisms, and the extent to which it can be mitigated. Generally, the ZOI is likely to be dynamic, depending on the size, location and nature of the development (e.g. open pit versus underground; mines versus roads; etc.), the level of industrial activity or volume of traffic, time of year (e.g. calving, post-calving, rutting), and herd characteristics (population status, demographic structure, etc.).

Due to extremely high mobility, lower range fidelity and large fluctuations in spatial distribution of barren-ground caribou, it has been very difficult to clarify human-caused effects. To this date, scientific studies have not been able to clearly quantify, predict or identify threshold levels for human disturbance, and their effects on population demography and dynamics via e.g. survival and reproduction. It is also very likely that, even if thresholds were identified, these would show a high degree of plasticity depending on local ecological settings (varying across seasons, herds and habitat).

The only conclusion that can be postulated is that it is extremely unlikely that human disturbances will have a positive effect – effects will most likely be either neutral or negative. Even if regional or local effects may be considered “neutral”, it remains unknown whether such “neutral” effects can accumulate and result in negative impacts in the longer term.

1.0 Introduction

Changes in barren-ground caribou are being observed around the circumpolar world, both by community members and wildlife biologists. The rate of change in these populations is unprecedented in living memory and calls for innovative wildlife management tools. The words of northerners best tell the story:

In northern Canada we have ʔekwò [caribou] all over northern parts of the Arctic Ocean, all the way from Alaska, Yukon, NWT, and then Quebec, Innu, Labrador, even as far as Newfoundland. There's ʔekwò all over the place (Sangris 2012: 78).

These, then, were the sights that greeted the first European explorers to the northland: great herds of caribou roaming the Arctic tundra in countless numbers, comparable to the buffalo herds of the prairies, followed by nomadic bands of Indians and Eskimos [sic.] However, the advent of Europeans upset the centuries-old balance between caribou herds and their human predators (Banfield 1961: 57).

At least 14 of the 19 major herds of barren-ground caribou in Russia, Canada, Alaska and Greenland have declined since peaks in the 1990s (Gunn in BQCMB 2011: 16).

I'm going to talk about how we can co-exist and still walk side by side with ekwò. We need to really work on that (Sangris 2012: 75).

I know for I saw it with my own yes and that's what I am talking about. I don't talk with uncertainty (Romie Wetrade in Legat et al. 1995: 12).

Yes, we do rely heavily on the caribou and this is our main substance that we really depend on. . . . There are some people that are really accustomed to live with other type of food such as fish. But most of us here depend on the wildlife, you know, such as caribou (Elder Pierre Tyokka in WRRB 2010: 215-216).

There was a Denesųtiné prophet from Łutselk'e who said, 'One day we're going to walk on the caribou trails with tears in our eyes.' Sometimes you hope he's wrong, but the way that development is happening and the way our hunting practices are going, I just don't think he's wrong. When I use traditional knowledge to predict the future of caribou, it doesn't look good for our grandchildren, our children. The future for the caribou is not good. Only we can help them. I think the big thing is to control development across our land, across Canada and the Northwest Territories. I hope that my son's children and his children's children will see caribou herds migrating through our land (Beaulieu 2012:65).

As such, the Nunavut Wildlife Management Board has taken steps to better understand barren-ground caribou in Nunavut by contracting Trailmark Systems Inc. to conduct a literature review on the effects of disturbance on migratory barren-ground caribou and how they can be most effectively mitigated.

2.0 Project Understanding

The overall purpose of the literature review was to summarize the most current scientific research, Inuit Qaujimajatuqangit and traditional knowledge of human disturbance on barren-ground caribou, with a focus on information post-2010. The review included an evaluation of the effectiveness of current Nunavut Caribou Protection Measures and a summary of how other jurisdictions are mitigating impacts of human disturbance on caribou.

The final report from this project will be used as a tool by the NWMB in future management decisions regarding the protection of caribou and caribou habitat, as per the NWMB's functions outlined in the *Nunavut Land Claims Agreement*. In addition, the report will inform a workshop on barren-ground caribou convened by the NWMB in Iqaluit on November 4-5, 2015.

This report first presents results from a review of the traditional knowledge and Inuit Qaujimajatuqangit literature, followed by findings from the scientific literature, and closes with a discussion of caribou protection measures. Human disturbances and their reported effects on caribou are organized around: linear features such as roads, power lines and pipelines, resource development infrastructure acting as physical barriers such as buildings or open pit mines, and disturbance by aircraft and vehicles.

3.0 Methods

The project was carried out in two phases: literature review (Phase 1000) and reporting (Phase 2000).

Literature Review

The first phase of the work included a review of:

1. Current scientific research on human disturbance on ungulates, with a focus on migratory barren-ground caribou (mainly post-2010 research);
2. Inuit Qaujimajatuqangit and traditional knowledge related to the impacts of human disturbance on ungulates, with a focus on migratory barren-ground caribou;
3. The current Nunavut Caribou Protection Measures including their development, rationale and effectiveness; and

4. What other jurisdictions (e.g. Northwest Territories, Quebec, Yukon, Manitoba, etc.) are doing to mitigate the impacts of human disturbance on caribou and caribou habitat and their effectiveness.

A search through published and readily available literature was carried out and a master list of all records including relevant meta-information was compiled for years post 2010. We included publications prior to 2010 if they were deemed to be relevant and/or seemed to be key publications on human disturbance on caribou. The current effort was to augment and update a similar literature review conducted by Government of Nunavut – Department of Environment in 2011 (EBA Engineering Consultants Ltd. 2011).

A list of online journals and websites reviewed and keywords entered into online research databases was recorded. Keywords used included combinations of “barren-ground caribou” and:

- traditional ecological knowledge; traditional knowledge; Indigenous knowledge; Inuit Qaujimajatuqangit;
- resource development; oil and gas; mining; development
- linear features; roads; pipelines; powerlines
- vehicles; aircraft
- protection measures
- sensory disturbance
- anthropogenic disturbance; human disturbance
- fright and flight behavior; stress
- cumulative effects

These keywords and keyword combinations were entered into an online search engine (Google Scholar) to try to uncover relevant references. As time allowed, the search also considered academic databases (e.g. ASTIS); conference abstracts presentations / transcripts; and key Arctic and/or ungulate journals (e.g. *Rangifer*). Readily available traditional knowledge and Inuit Qaujimajatuqangit reports were reviewed; however, unpublished and/or grey literature was not (e.g. minutes from regional wildlife organization or hunters and trappers organization meetings). Together these steps provided a sound methodological base for the actual writing and summary process (Phase 2000). Appendix A shows the list of websites and search engines reviewed for this research whereas the list of references is presented in Section 8.0.

Specifically, this review centred on readily available online publication databases and resources (e.g. Mackenzie Valley Review Board, Arctic Institute of North America, Government of the Northwest Territories, Government of Nunavut, Canadian Environmental Assessment Agency registry, ArcticNet, Aurora Research Institute, Nunavut Research Institute, Gwich'in Social and Cultural Institute, World Wildlife Fund, Canadian Polar Commission, Agreements, Treaties and Negotiated Settlements Project, and Indigenous Studies Portal), academic holdings (e.g. Canadian Periodicals, Ecology and Society Journal, Environment Journal, Arctic Journal, Canadian Mining Journal) library holdings (e.g.

Inuvialuit Cultural Resource Centre) and academic search engines (*e.g.* JSTOR, Canadian periodicals, Epscohost, Springerlink). Frequently the bibliographies of relevant documents served as key resources to locate additional sources using a version of the 'snowball technique' (Neis and Felt 2000). As such, we consulted additional publications that were mentioned in existing literature reviews (*e.g.* EBA Engineering Consultants Ltd. 2011) but were not located specifically through our database search. We also included agency reports or other publications that were already available in Trailmark's internal literature database. NWMB provided several key references for review from their online library.

As key references were identified, they were entered into a bibliographic database (EndNote® by Thomson Reuters) to enable easy sorting and analysis of references as well as storage of PDF versions of most documents (*e.g.* journal articles, reports). Section 8.0 contains the full list of references reviewed.

Finally, the database was exported and PDF versions were provided to the NWMB via an external hard-drive.

Reporting

Key references were reviewed with a focus on documenting, evaluating, and understanding the effects of human disturbance on barren-ground caribou within the broader context of caribou protection. Dr. Joerg Tews and Rebecca Jeppesen sourced and reviewed scientific references while Natasha Thorpe assembled and considered traditional knowledge and Inuit Qaujimaqatuqangit sources. Both teams then collaboratively authored the report with assistance from Beth Keats.

Caveats

This literature review was carried out within a limited time frame and budget. Accordingly, the following caveats are to be considered:

1. The focus of references was on post-2010 publications and barren-ground caribou in Arctic Canada. Budget did not allow for an extension to other research areas (*e.g.* caribou behaviour), geographical areas (*e.g.* Alaska, Greenland, Scandinavia and Russia). In order to avoid duplicating efforts, the focus of the literature review was post-2010 as the Government of Nunavut recently commissioned an extensive literature review of sources prior to 2010 (EBA Engineering Consultants Ltd. 2011). However, several key documents pre-dating 2010 are included to provide context and/or when they are heavily cited in post-2010 literature. In some cases, relevant references post-2010 weren't available (*e.g.* management plans may not have been updated in the last 10 years).

2. Given that many TEK reports remain unpublished, in part due to confidentiality and intellectual property rights concerns, inquiring phone and email contacts with industry officials and TEK practitioners would have been helpful.
3. It was not possible to review hundreds of pages of consultant reports prepared for environmental impact assessments of proposed mining or oil and gas developments; although it is recognized that there may be some additional information contained in these industry reports that may be relevant. However, a selection of reports that were readily available is included in the present review. The scope of work did not allow for all reports to be reviewed.
4. It is noted that detailed herd specific management plans exist in most jurisdictions and are, in many cases, accompanied by action plans and recovery strategies. A number of these documents have been included in the review; however, this resource base was not prioritized for thorough investigation given the parameters in the scope of work.
5. With respect to Caribou Protection Measures, relevant legislation was not included in this literature review as we understand that the NWMB is currently undertaking a dedicated review of the legal aspects and enforceability of such measures.
6. Out of respect for the nature and quality of traditional knowledge, rather than simply review the literature, much of the original 'voice' of these primary sources was preserved through inclusion of direct quotes.

4.0 Findings

The literature review and resulting database contain 72 scientific references, 52 traditional knowledge references and 30 references regarding caribou protection measures. A small number of references (e.g. EBA Engineering Consultants Ltd.) were reviewed for all three components of the literature review. Where possible, guidelines, protocols and procedures for carrying out caribou protection are also included (e.g. AANDC Caribou Protection Measures).

Several key documents were the foundation from which the current analysis was conducted. Some of these are literature reviews, while others speak to the intersections of traditional knowledge, land use / development and caribou or of scientific research, land-use development and caribou.

The following post-2010 references formed a significant component of the Traditional Knowledge literature review.

The Environmental Monitoring Advisory Board (EMAB 2012) for the Diavik Mine carried out a workshop with their Traditional Knowledge and Inuit Qaujimajatuqangit Panel to explore and make recommendations around monitoring caribou at the Diavik Diamond Mine. The report includes detailed discussions of: People and Caribou in the ?ek'atì (Lac de Gras) Area; Aboriginal "Monitoring": A Way of Life; Recommendations for Action: Monitoring Across Cultures.

In 2013, Parlee and Thorpe carried out a review of traditional knowledge of barren-ground caribou in the Northwest Territories (Parlee *et al.* 2013) that is a relevant contribution to the current review. As a co-author of the report, liberty has been taken to insert key sections on industrial effects in the current review.

The Beverly Qamanirjuaq Caribou Management Board (2011) produced a detailed report of a workshop held with barren-ground specialists in February 2010 in Saskatoon entitled *Commentary from Workshop Participants about Challenges Facing the Beverly and Qamanirjuaq Caribou Herds and Some Possible Solutions*. This report contains many quotes and findings relevant to human effects on barren-ground caribou and is frequently cited throughout this review.

The Gwich'in Social and Cultural Institute published Gwich'in Knowledge of Bluenose West Caribou: A part of the Nin Nihlinehch'i' – Łi' hàh Guk'àndehtr'inahtii (Animals at Risk - animals we are watching closely) Project based on interviews carried out between 2014 and 2015 around the Bluenose and Cape Bathurst herds for the purpose of management planning and for species at risk processes. The report includes traditional knowledge around caribou health, biology, populations, movements and migrations related to human effects. There is a section titled Industry and Development.

The Kugluktuk Angoniatit Association (Kugluktuk Hunters and Trappers Organization) collaborated with Golder Associates in 2010 to look at *Effects of Development on Barren-ground Caribou: Insight from Inuit Qaujimagatuqangit and an Ecological Model* (KHTO and Golder 2011). Interviews carried out as part of the Inuit Qaujimagatuqangit component of the work provide insight into how development has influenced movements and migration, led to changes in habitat, and responded to human disturbances including mining, roads and noise. Insights into the role of predators were also included.

Barnaby and Simmons (2013) facilitated and prepared a report on the *Bathurst Caribou Harvesters' Gathering* held in January, 2013. Full transcripts were not reviewed for this work, but they would likely provide additional relevant information. The workshop included discussions around traditional monitoring and management systems and Aboriginal laws about caribou and developed a series of recommendations related to caribou and caribou habitat.

In April 2015, the Government of the Northwest Territories Species at Risk Committee recently prepared a draft Species Status Report for Barren-Ground Caribou in the Northwest Territories (www.nwtspeciesatrisk.ca). As this draft has not been finalized, it was not possible to include a review of it in the current document. However, once finalized, this will be an informative reference for both community and traditional knowledge and scientific knowledge. It should be noted, however, that community review of the traditional knowledge in this report has not been carried out in full.

Williams (2015) completed an interesting thesis on the proposed Mary River Project environmental impact assessment process, suggesting that the “potential to negatively impact caribou and Inuit harvesting of caribou was not thoroughly assessed, nor was it meaningfully informed by those concerned about the mine (e.g. Inuit organizations and residents of potentially impacted communities)” (Williams 2015: i). Through his analysis, Williams reviewed much of the traditional knowledge and Inuit Qaujimajatuqangit relevant to barren-ground caribou in the Qikiqtani Region that is also relevant to this review.

There are several key traditional knowledge and Inuit Qaujimajatuqangit works conducted prior to 2010 that could be further reviewed, particularly works from the West Kitikmeot Slave Study carried out in the 1990s and 2000s which supported several traditional knowledge initiatives carried out by:

- Łutsel K'e Dene First Nation
- Whaèhdqò Nàowòd Kò [Dogrib Treaty 11, Tłıcho Government]
- Kitikmeot (Qitirmiut) Inuit

Other key projects include:

- Caribou and Roads Project carried out by Rescan Environmental Services Ltd. for BHP Billiton and the Ekati Diamond Mine
- Naonayaotit Traditional Knowledge Project carried out by the Kitikmeot Inuit Association

The World Wildlife Fund has been active in carrying out traditional knowledge interviews related to caribou as part of their initiatives around Arctic shipping (e.g. Polar Code for Arctic Shipping) and developing an Arctic-wide conservation plan for wild reindeer and caribou.

Several boards have been created specifically for barren-ground caribou herds (e.g. Beverly-Qaminirjuaq Caribou Management Board; Porcupine Caribou Management Board; Bathurst Caribou Management Board) while other boards have been established through land claim agreements (e.g. Nunavut Wildlife Management Board, Wek'èezhii Renewable Resources Board) (Kendrick 2013). Each has been active in carrying out focused efforts around barren-ground caribou and provided entries into public records. Where possible, these have been reviewed (e.g. BQCMB 2014), but a more thorough review should be done. The current review was not intended to be comprehensive and therefore much important traditional knowledge remains within the archives.

For the western science literature the following references (post-2010) were identified as most relevant. Some of these sources are review articles, while others are empirical studies:

- Nagy's (2011) thesis on use of space by caribou in Northern Canada.
- Integrated Ecological Research (2015): a draft guidance for monitoring the zone of influence (ZOI) of anthropogenic disturbance on barren-ground caribou

- EBA Engineering Consultants (2011): an extensive review of anthropogenic disturbance on ungulates, guidelines and mitigation of impacts.
- Russell's (2014) technical report on Kiggavik Project Effects and an Energy-Protein and Population Modeling of the Qamanirjuaq Caribou Herd.
- Boulanger *et al.* (2012) paper on estimating the zone of influence of industrial developments on migratory caribou.
- Sivertsen (2012) work on the influence of natural and anthropogenic factors on *Rangifer* movements and habitat use.
- Taillon *et al.* (2012) studied the shifting of migratory caribou calving grounds in the Arctic.
- Herrmann *et al.* (2014) studied the effects of mining on reindeer/caribou populations and indigenous livelihoods in Sweden and Canada.
- Adamczewski *et al.*'s (2013) workshop report on modeling cumulative effects in barren-ground caribou.
- Gunn *et al.* (2014) authored a discussion paper on insights into integrating cumulative effects and collaborative co-management for migratory tundra caribou herds in the Northwest Territories.

The following sources are likely most relevant in informing discussions around Caribou Protection Measures:

- Gunn *et al.* (2007) provide a comprehensive summary of the existing Nunavut caribou protection measures, and evaluate their effectiveness in protecting caribou from industrial land use between 1978 and 2005. Our analyses also suggest that satellite telemetry and contemporary GIS techniques could be easily adapted as a set of consistent rules to form mobile protection measures, that move with the herd;
- In 2009, Gunn and Poole conducted a pilot project to assess the use of mobile protection measures for barren ground caribou in the Northwest Territories. The theory of the approach is that the caribou stay protected regardless of their location, while operations are only affected when caribou are actually in the area. Through surveillance around seven exploration sites and the use of locational data from collared cows they concluded that the mobile protection measures were relatively efficient in late winter.

5.0 Human Disturbance on Barren-ground Caribou

Many sources reviewed cite that there has been a steady decline in the amount of suitable caribou habitat, that most populations of barren-ground caribou are presently in decline and that the overall health of individual caribou is likewise observed to be in decline in the Arctic (Whaèhdqò Nàowòd Kò 2001; Thorpe *et al.* 2001; ACFN 2003; Kendrick *et al.* 2005; Łutsel K'e Dene First Nation 2005;

Dumond 2007; Community of Aklavik *et al.* 2008; Community of Inuvik *et al.* 2008; Community of Paulatuk *et al.* 2008; Community of Tuktoyaktuk *et al.* 2008; Legat *et al.* 2008; Croft and Rabesca 2009; Sahtú Land Use Planning Board 2013; WRRB 2013; North Slave Métis Alliance 2012; Beaulieu 2012; Judas 2012; Barnaby and Simmons 2013; ACCWM 2014; GSCI 2015).

Wildlife biologists as well as leaders, Elders, hunters, and other community members report that barren-ground caribou habitat is degrading and fragmenting owing to wildfire, climate change, access roads, pipelines, mining and mineral exploration projects, hydroelectric developments, disturbances from vehicles and machines, seismic lines, utility corridors and more. The cumulative impact of these activities on caribou habitat has not gone unnoticed by people who share their lands, waters, and world with barren-ground caribou. In 2011, participants from a workshop held by the BQCMB on caribou identified five factors as among the main issues affecting Beverly and Qamanirjuaq caribou:

1. Climate change
2. Loss of habitat due to forest fires on the winter range
3. Disturbance from human land use activities
4. Harvesting
5. Predators (especially on the calving grounds). (BQCMB 2011: 30)

The current review focuses on the third of these main issues, specifically, *disturbance from human land use activities*. A discussion of findings from traditional knowledge sources is presented first (Section 5.1), followed by western scientific sources (Section 5.2).

To provide an appropriate overview, we grouped our literature review into relevant thematic sections. For the first three sections in each of the traditional knowledge and western scientific sections, we summarize and discuss three main types of human disturbance and their reported effects on caribou: linear features such as roads, power lines and pipelines (Sections 5.3.1 and 5.4.1), resource development infrastructure acting as physical barriers such as buildings or open pit mines (Sections 5.3.2 and 5.4.2), and disturbance by aircraft and vehicles (Sections 5.3.3 and 5.4.3). In sections 5.3.4 to 5.3.5 and 5.4.4 and 5.4.5 we will look at how these disturbance types are affecting caribou on different spatial and temporal scales. Local scale, short term effects (Sections 5.3.4 and 5.4.4) can be characterized as an immediate response (e.g. movement) with physiological effects for the individual caribou or groups of caribou. Regional scale effects (Sections 5.3.5 and 5.4.5) occur over longer time periods and may result in population-level consequences (e.g. migration) for caribou. In the last two sections (Sections 5.3.6 to 5.3.7 and 5.4.6 to 5.4.7) we summarize our findings with respect to cumulative effects and identified knowledge gaps.

Finally, caribou protection measures are discussed (Section 6.0) in the context of existing caribou protection measures in Nunavut (Section 6.1) and other jurisdictions (Section 6.2).

5.1 Traditional Knowledge

Traditional knowledge documented with indigenous communities across the Arctic and sub-Arctic contains observations of both direct and indirect impacts to caribou and caribou habitat owing to human disturbances. Aboriginal and Inuit notions of caribou behaviour are assembled from long-term observations and use as well as cultural practices carried out through a relationship of reciprocity.

Indigenous peoples have witnessed relatives “coming to visit” when a caribou comes close to their camp, bulls fighting to mate with cows, “herds” intermixing and shifting migration routes, individual caribou proudly prancing or running in circles to the point of exhaustion to avoid insects, populations falling as human disturbances threaten caribou and their habitat, and increasing when conditions are favourable (Whaèhdqò Nàowoò Kò 2001; Thorpe *et al.* 2001; ACFN 2003; Kendrick *et al.* 2005; Łutsel K’e Dene First Nation 2005; Dumond 2007; Community of Aklavik *et al.* 2008; Legat *et al.* 2008; Croft and Rabesca 2009; Sahtú Land Use Planning Board 2013; KIA 2012; WRRB 2013; North Slave Métis Alliance 2012; Beaulieu 2012; Judas 2012; Barnaby and Simmons 2013; ACCWM 2014). That Inuit are here today is testament to how they persevered through the years when the caribou did not come and thrived in subsistence and material wealth the years when the ground shook with caribou.

In northern aboriginal communities, the study of caribou has always been a part of hunting practices and requires the monitoring of body condition during butchering and food preparation. Caribou have long been the main currency not only for the “Caribou Inuit”, but also for all “caribou-eaters” of the far north. Old-time stories recount a life where barren-ground caribou were “everywhere and anywhere” while, still, nothing was wasted: a single caribou provided fur for clothing, shelter; bones for tools, implements, nutrition; and meat for food, sinew, fat, and more (AREVA Resources 2012; Judas 2012; KIA 2012; Sangris 2012; Wray and Parlee 2013; ACCWM 2014).

For each animal from the hoofs to the antlers, they would use everything. They made tools from it, they ate the meat, and they made clothes from the hides. They made dry meat. They would even make lard from the bone marrow. Ekwò, brain is like ice cream, I cook it and I eat it. They used the whole thing. That’s why they were really lucky with the animals in those times. (Judas 2012: 51)

Today, as in the past, people tell of experiencing great losses in practical, financial, nutritional, material, spiritual, and cultural ways when the “caribou do not come” (Thorpe *et al.* 2001; Whaèhdqò Nàowoò Kò 2001; ACFN 2003; Kendrick 2003; Łutsel K’e Dene First Nation 2005; Wray 2011; Parlee *et al.* 2013; GSCI 2015).

For these reasons combined, it is difficult to imagine a people more expert in the ways of caribou or grounded in an ethic of profound respect for caribou. This review can only provide a brief insight through the multiple sources that have been considered, and should not be assumed to be

comprehensive. Indeed, even if every reference had been reviewed, the rich understandings inherent in traditional knowledge are unavoidably lost both in translation and in written form.

Consider the challenges of recording what is otherwise an oral tradition; the complexities inherent in “being in relationship” with caribou; variations and differences in caribou behaviour, habitat, migrations, movements etc. across the vast territory of Nunavut, and the realities of trying to speak with confidence about observations made within a time of rapid environmental change and the associated realities of living within profound uncertainties and extremes (Krupnik and Jolly 2002; BQCMB 2011; Legat 2012; Parlee and Furgal 2012; Jacobsen 2013). Unprecedented rates of caribou population decline while levels of industrial development increase.

This review includes instances where traditional knowledge of caribou converge or diverge within the sources considered, where possible. Multiple consistencies about barren-ground caribou were shared through research initiatives, workshops, meetings, and the environmental processes for various proposed industrial developments within the ranges of barren-ground caribou. At the same time, these consistencies were sometimes paired with contrary observations.

Inuit associations have long documented local expertise and understandings through meetings, workshops, and other gatherings. It was not possible to access these unpublished sources, but it is recognized that many of these documents could provide important contributions to understanding barren-ground caribou.

Northerners are concerned about the potential impacts of development on caribou (KHTO and Golder 2011; EMAB 2012; Legal 2012; Parlee *et al.* 2013), notably starting with the Berger Inquiry of the proposed Mackenzie Valley Pipeline of the 1970s. These concerns have continued to be shared ever since, with various types of resulting initiatives such as Caribou Protection Measures, discussed in Section 6.0.

Most people really couldn't afford to go hunting with airplanes. There weren't that many jobs. There was no mining, and there were no winter roads. There were very few non-aboriginal hunters. There was no outfitting. So there wasn't much impact on the caribou in the 1970s. The animals returned fairly quickly [after a decline in the mid 1970s] (Beaulieu 2012: 63)

*I am worried that if there is too much mining going on up here in the North, caribou might just change their route and not come around completely (Anonymous C 1998 in Thorpe *et al.* 2001).*

The last few decades in Nunavut and the Northwest Territories have seen both wildlife biologists and community members link population declines in barren-ground caribou with human disturbances. At the same time, sources reviewed stressed that large-scale environmental change and cumulative impacts are fundamentally influencing all other human disturbances. Operating within this larger sphere of influence, it is simply not possible to isolate any one type of human disturbance. Even if this

were a possibility, environmental change is an additional dominant factor impacting caribou and their habitat (Whaèhdòq Nàowoò Kò 2001; Thorpe *et al.* 2001; ACFN 2003; Kendrick *et al.* 2005; Łutsel K'e Dene First Nation 2005; Dumond 2007; Community of Aklavik *et al.* 2008; Community of Inuvik *et al.* 2008; Community of Paulatuk *et al.* 2008; Community of Tuktoyaktuk *et al.* 2008; Legat *et al.* 2008; Croft and Rabesca 2009; Sahtú Land Use Planning Board 2013; KHTO and Golder 2011; WRRB 2013; North Slave Métis Alliance 2012; Legat 2012; Barnaby and Simmons 2013; ACCWM 2014; GSCI 2015).

In 2011, KHTO and Golder (2011) reported that there were an estimated 551 previous and existing developments within the range of the Bathurst herd including operating mines, exploration camps, roads, and more. They collaborated on a study that used both science and Inuit Qaujimajatuqangit to investigate questions relating to the effects of development on caribou using spatial data collected from long-term monitoring of collared animals and directed interviews with local elders and hunters from Kugluktuk. Through these processes, the study aimed to better identify if and how human developments in the Central Arctic are affecting caribou.

According to Inuit Qaujimajatuqangit documented, there were differing opinions as to how sensitive caribou are to mineral developments. While some interviewees thought that mineral development was having a profound impact on migration, others supposed that climate change was having a larger effect. Dust, noise (e.g. blasts) and roads were particular concerns related to mining while at the same time, caribou have been observed using mining developments for refuge from heat, predators and insects. Some interviewees commented that caribou are becoming habituated to mineral exploration and development, taking advantage of refuge opportunities provided by the buildings or using the site as a directional landmark.

Several interviewees explained that caribou just “pass through” mineral development areas rather than “hanging around.” These results suggested that, according to Inuit Qaujimajatuqangit, caribou could habituate to human disturbances and that they could be both deflected or attracted to developments, especially resource development infrastructure (KHTO and Golder 2011).

At the same time, results from the scientific energetics modeling exercise exploring how human activities interact with demographic processes (e.g. parturition rates) was found to be low. The scientific component suggested that the effects of mining operations (alone) are limited and unlikely to be a major contributing factor to the recent declines on the Bathurst herd. In the end, the study likely raised more questions than provided answers.

5.3.1 Linear Features

Ever since people were relocated to semi-permanent and permanent communities in the Arctic they have observed how caribou interact with roads, corridors, pipelines and other linear disturbances (Benn 2001; Thorpe *et al.* 2001; Whaèhdòq Nàowoò Kò 2001; Kendrick 2003; Kendrick *et al.* 2005;

Inuvik Community Corporation *et al.* 2006; BHP Billiton 2007; Legat *et al.* 2008; Katz 2010; Nagy 2011; BQCMB 2011; AREVA 2012; Kavik-Stantec 2012; Łutsel K'e Dene First Nation 2012; Northwest Territory Métis Nation 2012; EMAB 2012; WRRB 2013; BQCMB 2014). Linear features provide easier access to remote areas of caribou ranges, increase hunter access, alter caribou migration patterns, and can lead to a higher number of caribou harvested (Wray 2011). Roads have an impact on caribou as they open up areas that may have been previously difficult to access either by vehicle or skidoo (EMAB 2012; Tłıchǫ Government 2013; Sangris 2012; Jacobsen 2013; GSCI 2015).

There is lots of development and harvesting is now easier with snow machines. The community has grown so harvest over the past 15 years has increased (Jorgen Bolt in BHP Billiton 2007: 5-6).

I'm sure if they're coming to a road and there's lots of activity they're not going to walk right through it (GSCI 2015: 197).

What it does is opens up the country to everybody. You just go down the highway until you see the tracks. . . people don't realize it. It's going to change the way we do things so much, right, from cutting wood to. . . your peace and quiet on the land is not going to be there anymore. Ten years ago, when they put the coal plant between here and Good Hope, they made that winter road all the way down to Thunder River. Everybody was on there that had a 4x4, hauling wood. And many caribou were shot, many (James First in GSCI 2015: 50).

I never see Aboriginal people over hunting. They always take home what they can provide for their families. But access to winter roads is a big problem. It brings in poachers from all over. The wildlife officers in the community go home at 5:00 pm and the poachers are out at 6:00 pm (Sangris 2012: 78).

People shoot off the road or they will take a snowmobile or walk into the bush to find and kill caribou. People will also go by snowmobile to non-highway accessible areas on trails once travelled by dog team and snowshoe. . . . Observations of caribou made while hunting and carrying out other activities on the land are a major source of information about caribou for Fort McPherson hunters (Wray 2011: 51-52).

Other hunters feel that the Bluenose have become more spooky and wild in recent years due to being chased by skidoos (Julie-Ann Andre in GSCI 2015: 25).

In addition to these widely observed impacts, people draw from their lifetime of observing caribou on the barrens to predict and/or infer how caribou will react to indirect impacts from linear features. For example, people report first-hand knowledge of how caribou respond to loud sounds (e.g. caribou “get spooky”) and so predict that caribou will similarly respond to vehicular or aircraft noise (KHTO and Golder 2011; EMAB 2012; GSCI 2015).

Likewise, people know that caribou often prefer the easy walking along an esker or the escape from insects that it offers and so predict that caribou will alter their migrations by traveling along elevated roads or linear landscape features (Thorpe *et al.* 2001; BHP Billiton 2007; Parlee *et al.* 2013). Community members have observed that caribou seek out roads for insect relief and ease of travel (KHTO and Golder 2011; Thorpe *et al.* 2001; GSCI 2015).

Such relationship-based understandings are central to Indigenous ways of knowing. For example, roads lead to more traffic which leads to stressed caribou which leads to changes in overall caribou health which leads to changes in human health and so on:

Using high-speed skidoos to chase caribou when hunting them is “not very good for the caribou or the meat, because it gets stressed,” (Julie-Ann Andre in GSCI 2015: 55).

Finally, linear features fragment caribou habitat and are known to influence caribou migration (Whaèhdòq Nàowoò Kò 2001; Kendrick 2003; Kendrick *et al.* 2005; BQCMB 2011; GSCI 2015). Others have reported that caribou travel along seismic trails or linear disturbances, but some areas are becoming too overgrown for them to use (GSCI 2015).

*The land out there most the time when you can see through the clouds, look like that checkerboard floor -- there ain't a darn place where a little rabbit can live or a chicken can lay their eggs, where can a caribou feed?” (N. Kakfwi in Fort Good Hope Berger Commission Community Transcripts 1975: 1923, lines 3-7 in Parlee *et al.* 2013: 59).*

“The roads bisect the migration routes and disrupt the natural behaviour of the caribou,” (Liza Enzoë of Łutsel K'e in Kendrick *et al.* 2005: 183).

Caribou are known to avoid newly disturbed habitat such as roads and thus alter their migration routes if they come across new construction (KHTO and Golder 2011; GSCI 2015).

I know with disturbances, they tend not to return after they found out it's disturbed. Like, if somebody made a big cat road, well, the next year when they came, they would detour that area, (Julie-Ann Andre in GSCI 2015: 35).

Even if it was a good area, they'd stay away from it. They don't like disturbed areas, (Julie-Ann Andre in GSCI 2015: 35.)

Parlee *et al.* (2013: 56-69) provide a fulsome review of available traditional knowledge relating to linear features and migration, as cited below.

Roads built to mine resources are interpreted as a significant problem for barren-ground caribou. Many elders have described the roads in the Bathurst and Beverly range as contributing to changes in caribou movement and migration. While some elders think there are ways of technically managing the impact (e.g. by limiting the height of roads), other elders perceive a negative effect on caribou as inevitable.

In a few years, the caribou will change their route again. They will go a different way; they will be disturbed by the winter road, planes, and blasting. You will see [these changes] in three to five years from now (Louis Abel of Łutsel K'e in Parlee et al. 2005: 35).

Regarding the winter road, if you make a road, you cannot make it too high. It's too hard for the caribou to get over it. It should be lower. The caribou won't just pass through a little pathway you make, they go all over. The road needs to be fixed (JB Rabesca in Parlee et al. 2005: 35).

No matter what you do, caribou will be affected by these mines and roads. The only way to not affect the caribou is to have no mines and roads. If there is a mine, there will be roads. And if you have a road, there will be trucks on it. If they put it through, you can't stop everything for the caribou but maybe that is what the caribou need (Pierre Catholique of Łutsel K'e in Parlee et al. 2005: 35).

Some elders suggest the impact may be seasonal; during peak periods of migration, the road may be less of a barrier than during other parts of the year.

Although we have all seen ʔekwō in association with the ice road, the ʔekwō do not like to cross roads unless they are in the migration mode. They become very skittish when trying to cross roads, as they can smell the human scent. When they are not in migration mode and simply foraging during the winter, if the ʔekwō sniff our scent, they will turn back (Romie Wetrade of Gameti in Whaèhdqò Nàowòd Kò 2001: 13).

Traditional knowledge speaks to the impacts that roads cause to caribou migration. Community members thus consider how railways may similarly impact caribou:

And the people who lives [sic] in Arctic Bay and Pond Inlet, that would be my concern about their caribou -- caribou habitat... Like, when you were showing the slide [referring to Baffinland's presentation] I noticed there was a caribou trail. Perhaps if you don't cross over the caribou crossing path as perhaps move -- move the railway somewhere else (David Inngaut in NIRB, 2012F, p. 1867 in Williams 2015).

In Alaska and the Northwest Territories, people have experience with oil and gas development. Pipelines are thought to act as a barrier to movement for barren-ground caribou.

The only thing that they really have to worry about is crossing the creeks and the rivers, but my main concern is probably the Natives and people in the Delta, maybe perhaps in the Yukon Territory, that these caribou, they migrate through this route, and it is also their calving ground, and if this pipeline is to be built, and if it is to come through this way, I believe it will have a great effect on the caribou (D. Gordon in Aklavik Berger Commission Reports & Community Transcripts 1975: 99, lines 23-30 in Parlee et al. 2013: 59).

5.3.2 Resource Development Infrastructure

Resource development is presently identified by community members as a key impact to barren-ground caribou. People are concerned about noise, light, dust, pollution, cumulative effects and more. Resource exploration, extraction and development (e.g. mining oil and gas) and the associated infrastructure and activities have caused disturbances, shifts in migration patterns, loss of habitat, injuries, contamination, and altered the overall health of barren-ground caribou. The impacts of the physical constructs mining are thought to both attract and deflect caribou, thus altering their behaviour (elaborated in Sections 5.3.4 and 5.3.5).

I've heard some people say that the caribou are not avoiding the mine, but some are saying they are avoiding the mine. There are two opposing views. There's nothing traditional anymore. The mines have changed that, and we have to start thinking that way. Don't try to brainwash the Aboriginals into thinking the mines are not affecting the caribou herd. Common sense tells me it is affecting the movement and the behaviour of the caribou. You may or not accept that view, but that's my opinion and I think it makes common sense (Ed Jones in EMAB 2012: 18).

Recently an elder from Hall Beach raised concerns about how the Mary River Project infrastructure would impact caribou:

I want you to make sure that these migration routes are kept free and open for caribou, and I think we misunderstood earlier that you're going to make an embankment for caribou to cross just like human beings will be able to cross through, you mentioned that we're going to be able to cross through the embankment ourselves as well as the wildlife, and I don't think the wildlife are going to think like human beings. They don't have boundaries (Solomon Qanatsiaq in NIRB, 2012H, p.1009 cited by Williams 2015: 83).

An overarching concern held by many northern indigenous groups is that mining development will “spoil” or “ruin” the land such that caribou - along with other animals - will never return even long after an area is reclaimed. Calving grounds are particularly sensitive. Reasons suggested for why caribou might not return to a particular migration route or calving ground include landscape changes,

contaminants, and disrespect shown to the land. This understanding is typically associated with the recommendation that action must be taken to avoid such impacts:

In the North where ?ekwò [caribou] are thinning out, we have to take action. We must protect those calving grounds, the home of ekwò. There are people who are exploring for gold at the calving grounds. If we don't put some kind of protection on the calving grounds, those ?ekwò are going to have problems. It's like disturbing a bird nest. If you disturb a bird nest, the birds don't come back. Same thing with ekwò. If you disturb the calving ground, they'll go elsewhere. They may decide to disappear (Sangris 2012: 78).

The elders suspect that ?ekwò have probably gone east because there's been too much exploration or drilling going on in the calving grounds. And at the same time, the calves are not strong. And heavy sports hunting is going on for big game, so for years and years the mature bulls have been taken out. The elders believe the cows might have sensed something is wrong and gone to join other herds (Sangris 2012: 78).

Each and every mine that they [caribou] run into because they have a scent gland right at the bottom of their feet, they collect all these chemicals and everything on the bottom of their feet. They walk on it and it stays with them for a number of miles before it can rub off. In that time, I believe what they have stepped on will actually sieve through that scent gland and into the body. That is why you see lame caribou or something. It's what I looked at when I was living at Pellatt Lake (Bobby Algona in KIA 2012: 39).

Mining infrastructure is reported to have changed migration routes and caused caribou to mix with other herds. Inuit, for example, have long understood the importance of using structures such as *inuksuit* to divert caribou movements while hunting. Knowledge about the influence of these physical structures on the tundra informs observations and predictions of how resource development infrastructure alters movements and migrations.

There's roads and mines and all activities where all the caribou pass, I mean, that block the caribou...elders said that when something like that happens, caribou don't go there again" (Harvester in Parlee and Furgal 2012: 37).

Way back in the 1980s, we had all kinds of caribou come north. There were no mines. We had no complaints about caribou. Since the mines came up, we've had lots of complaints about caribou. I told those guys when I was in a meeting, you should be monitoring the caribou before they hit the mine when they're coming back from the calving grounds, about 10 or 15 miles out from the minesite. Then when they pass the mine and after they pass the mine, monitor them and see how they look. I used to see a lot of crippled caribou around the mine in the 1990s when I was working down there with Anne Gunn. But they never did it. They never listened to my suggestions. (Alfred Lockhart in EMAB 2012: 22).

Not too long ago [approximately 1997] two big herds used to come around Łutsel K'e, and people came from all over to hunt the caribou. In the years following, the herd began coming towards us, but then turned away. Now that there are mines with roads and high snow drifts on the sides, the caribou won't cross and their migration route is disrupted. The old people said if you pile up snow into drifts, the caribou would not cross them. They just move alongside of it. This is what is happening with the winter roads. They don't teach kids about this anymore. The white man does not know this. The way the caribou migrate has been disrupted. The roads bisect the migration routes and disrupt the natural behaviour of the caribou (Liza Enzoe of Łutsel K'e in Kendrick et al. 2005: 183).

And then you go sleep for a while, sleeping period, you wake up, and the caribou are still coming! 24 hours a day, nonstop. And then Lupin came in, it's right on the Bathurst herd major migration route, and the winter road, the whole system, all along that migration route. After they came in, for myself, we started noticing that less and less caribou were coming through over the years. . . . less and less. And now there are hardly any more coming through, right to Bathurst because of all these mines along the way (C110 in KIA 2012: 39).

As reported by GSCI (2015: 49), active development is thought to impact caribou in the following ways:

Caribou have very good smell and sight so any industrial development scares them away (BCMWG).

There used to be quite a bit of seismic work out there [with Colt]. And because of all that noise, they just kept away. You wouldn't see them around there. And it was good for me at that time, because they drove all the caribou to my side (James Firth).

Although not reported as often, some traditional knowledge holders report that the caribou's instinct to migrate drives them through any obstacle:

There's no way you can keep an animal out of its migrating route when it's migrating somewhere. It's either going north or coming back south. There was always a different route they use. No matter if there is a tailings line, they'll go over it. Just like the mountains, they go over that mountain. They'll even cross a strong river (John Ivarluk in EMAB 2012: 22).

Williams (2015: 75) suggests that many community members expressed concerns about Baffinland's assessment of impacts on caribou and harvesting and that they were not adequately addressed, especially in light of current declines in caribou:

For example, an individual from Hall Beach stated:

I went hunting recently but got lost as I couldn't find any caribou. I remember before exploration commenced there was an abundance of caribou. Once Baffinland exploration activities commenced, including aircraft flights, the calving grounds of caribou were affected (NIRB, 2011, p. 31).

A community member from Pond Inlet also raised concerns about caribou:

We've heard that there'll be no significant impact to wildlife et cetera. We have to go far distances to hunt for caribou and yet Baffinland continues to tell us there'll be no significant impacts but that's false (ibid., p. 46).

An individual from Arctic Bay voiced a similar sentiment:

Also caribou calving grounds will be impacted. We presently have to go to Repulse Bay to hunt caribou. Professionals in this room are making money but we value our wildlife,'(ibid., p. 49, cited in Williams 2015: 75).

Mining operations generate dust that people cite as being a threat to caribou. Elders across Nunavut as well as the Northwest Territories have long highlighted concerns that dust from mining activity would negatively affect caribou habitat (EMAB 2002; Legat *et al.* 1998).

As cited in Parlee *et al.* (2013: 64-65):

The areas affected by the two oldest diamond mining projects (Ekati Diamond Mine and Diavik Diamond Mine), originally predicted to be between three-five km in radius around each mine site, have been expanded recently to a radius of between 40 and 70 km around each mine site (Diavik Diamond Mine 2011; EMAB 2001). The main concern leading to this change was the impact of dust on sensitive lichen habitat (EMAB 2001). The development of mines and mining exploration in the Bathurst and Beverly caribou range have, according to Tl̥i Ch̥o and Denésołine elders, contributed to changes in caribou migration.

*The caribou used to migrate to our land. But now there are mines in the way of their major migration route. That's the reason why caribou mind-spirit is weak – it is too weak to come toward our land now. The caribou feel like there is something in their path, so they turn the other way. The smell of fumes and smoke can blow far on the barren ground, and the caribou can sense that (Caroline Beaulieu of Behchoko in Legat *et al.* 2008: 28).*

In addition to direct loss and fragmentation of habitat, the noises, smells and increased activity associated with pipeline development are perceived as being stressful on caribou.

I know myself if caribou are five miles away and there is no wind, dead calm, you can't go near them just on account of the noise. If you happen to step on fresh snow and they are five miles away, laying down on the ground, then they hear you and they are gone. You can't shoot them. And we have got to wait for three days to catch up to them; that is going to happen to the pipeline. Another thing when the pipeline is going to happen, then it's going to be noisy, they can't cross the pipeline because it is too noisy and they will be cut off a lot of feeding. Stop the feeding, you got to feed in certain places in the winter and every year. Some years they feed in some places and other years they feed other places in the wintertime, and then in the summertime another place, and that's the way they grow a crop for the caribou, and what is going to happen to that (D. Itsi in Aklavik Berger Commission Reports & Community Transcripts 1975: pp. 1104, lines 9-25).

By observing the mines I've seen that they are not good for the caribou. In the past, the caribou used to migrate and stop in the Dathi Kué (Walmsley Lake) area. Very few caribou move through that area now. People also do not go up into that area now. You go to the mines to observe the caribou. I've been up to the mines three times and have observed the caribou there. You just see a few caribou here and there. For me the mines have changed the way caribou behave, although I am not all that sure how much they have changed. I know the main caribou migration trails are still there. In the past you could see caribou trails all along the landscape, even in the summer. You could see their tracks everywhere. Now you do not see them that much. Just some of the main migration routes remain. These are the only tracks you see.

In the past you could see where the caribou have played when they've stopped, but now you do not see these signs of caribou playing. You only see the migration trails. After they put the mines up in the barrens the caribou have changed for me. The meat, however, still tastes the same. The way I hunt, I know how far the caribou are from my house. These days the caribou are much farther away than they used to be. In the past it was not like that (Noel Drybones of Łutsel K'e in Kendrick et al. 2005: 185).

As discussed earlier, traditional knowledge confirms that caribou are very sensitive to noise from resource development:

Elders went to Diavik to look at the mine site and there were not many caribou there. We used to see a lot of caribou migrate through that area. We suspect the noise from the mine has made the caribou move away. A lot of the old caribou trails are now covered with moss. There is so much noise from the mine site; the caribou are migrating away from the site instead of going along the shores (Elder in EMAB 2004: 34 in Parlee et al. 2013).

Noise from resource development, snowmachines, blasting and other human disturbances causes stress in caribou, as evidenced by observed changes in caribou behaviour as well as the taste of the meat (Thorpe et al. 2001; Wray 2011; EMAB 2012; GSCI 2015).

I guess you hear it too from the old peoples, not only that we live with it, we eat it so we know when a caribou or a moose is harassed. In our language, you know, we don't eat it, we just feel a little bit because the texture of the meat, it gets in our Slavey language "tantii" affects the texture of the meat so you're not encouraged to eat that. . . (Anonymous in Parlee and Furgal 2010: 37).

Long ago, when elders hunted they used to take their time and they say the meat tasted better. When people chase with skidoos, their heart is just pumping and their blood is just flowing, so it tastes different (P. Colin 2008 in Wray 2011: 117).

5.3.3 Vehicles and Aircraft

In the past, one of the few disturbances to wildlife was the barking of dogs from dog teams. Today, wildlife are bothered by a regular stream of aircraft overhead and snow machines on the ground (BQCMB 2011: 40).

Disturbances from airplanes, skidoos, and vehicles affect caribou movements, behaviour and overall health in various ways and magnitudes depending on the time of year and size of herd. Community members have expressed concern about the impact from aircraft and vehicles, particularly with respect to noise and the associated responses in caribou. Pollution and contaminants from vehicles and aircraft are also seen to cause an effect on caribou (Whaèhdqò Nàowoò Kò 2001; Thorpe *et al.* 2001; ACFN 2003; Kendrick *et al.* 2005; Łutsel K'e Dene First Nation 2005; BHP Billiton 2007; Legat *et al.* 2008; Sahtú Land Use Planning Board 2010; BQCMB 2011; KHTO and Golder 2011; Judas 2012; Legat 2012; North Slave Métis Alliance 2012; WRRB 2013; Barnaby and Simmons 2013; ACCWM 2014; GSCI 2015). People talk about low elevation flying being harmful to caribou, addressed since the advent of Caribou Protection Measures (discussed in Section 6.0). As one respondent states "low-level flying bothers caribou, as does the activity of active development" (Tom Wright in GSCI 2015).

If we look at the same picture, we're going to have different views, for those of you who are not familiar with wildlife, their behaviour and what they're doing. Those of us who are hunters probably know what the herds are doing. The caribou are running in front of the helicopter. When a caribou gets scared or surprised or threatened, that's what they do. They put their nose up and sometimes they jump and then they go on a really fast gallop because they don't know what's going on and they're threatened. If I was to walk over there and the caribou sees us, they are going to go slow and take their time and look at us. They are not threatened because we're not creating noise or surprising them or anything. They know we're there, so they won't act like that. When a caribou is stressed, they're going to run and run, and probably go a long distance moving because they're threatened. They are acting like a bully. When a caribou gets scared and surprised, that's what they do. They get uptight and come together. If that helicopter comes,

we'll both put our horns down and go after it. That's how a caribou looks like when they're threatened or surprised (Fred Sangris in EMAB 2012: 20-21).

In the literature reviewed, caribou are described as naturally calm and curious without vehicles and aircraft and other resource development activities. However, these types of disturbances cause caribou to become stressed and spooked.

Nowadays we're using skidoos and all those fast motors. But sometimes we're not lucky because the machine is loud and ekwò won't go near. When we used to travel with dogs, there was no noise. The dogs were like our radio-collar for finding ekwò. When the dogs would start sniffing, we would know that there was something there, maybe animals like ekwò. That's how we would know where ekwò were. But right now, we've got radio-collars and we know where all ekwò are migrating, so if we want to hunt we can just go in front of them and then wait for them until they get there (Judas 2012: 51).

Caribou are thought to migrate faster and farther and to express more confidence when in larger numbers and without the stress of mining activities such as hauling and explosives:

If we want the caribou to be strong, we have to reduce the hunting. We need to take a look at development, and maybe do some other things to help them along. For example, in 2010 the Bathurst herd, the Northern herd, came down very slowly. They didn't get to the fall hunting area at all that year. They stopped at the north side of the diamond mines. So they were about a hundred kilometres north of where they should have been in the fall. I find that in the last few years when the caribou numbers are low, they move slowly. I think they're not as brave as when they're numbering in the thousands, and they move fast. But the calves are born on the calving ground where it's nice and quiet. When their mother takes them away from the calving ground and just goes a few miles on their migration in the fall, they start hearing these rock trucks and dynamite and other noises. It really slows them down. They stop (Beaulieu 2012: 66).

When caribou are stressed and their health is compromised, community members suggest that they may be found in smaller groups.

In working with community members in the Kivalliq region, BQCMB (2011) further suggests that:

Some of the main human-caused disturbances for Beverly and Qamanirjuaq caribou are increasing mineral exploration and mining (especially uranium exploration), new roads being built, more motor vehicles and snow machines, blasting (and resulting dust on vegetation), utility corridors and aerial surveys. It has led to too much activity on calving grounds, some participants said, with numerous low-flying aircraft over the calving grounds. Disturbing pregnant cows during migration or on calving grounds harms caribou herds the most when population numbers are low. Key habitat – especially the calving grounds – must be protected, with a ban on all exploration and mining activity there (BQCMB 2011:30).

The impact of noise specific to vehicles and aircraft has been discussed in the previous section. Since caribou have a strong sense of smell, it is said that they are particularly bothered by contaminants from vehicles on roads.

5.3.4 Local Scale Effects

Documented traditional knowledge tells us that caribou are extremely smart, have powerful memories, possess a strong sense of smell, and honed internal guiding instincts that together help them migrate along traditional routes (Thorpe *et al.* 2001; Kendrick 2005; Legat *et al.* 2008; EMAB 2012; Parlee *et al.* 2013; GSCA 2015). They are known to be especially sensitive at different times of year, especially during calving, and quick to show signs of stress. This section discusses traditional knowledge of small scale and local effects grounded largely in these broader understandings of caribou.

Joseph used inokhok [inuksuit or stone cairns] when he used to hunt caribou with bow and arrow (in the past). In springtime caribou will go along the inokhok and by them, and follow them. It is really hot in July; then caribou don't care about inokhok. They just walk by when it's really hot. Inuit start using inokhok again in the fall (August). When it is colder the caribou are more skittish, the inokhok may work better in the fall (Joseph Niptanatiak in Caribou and Roads Project in KHTO and Golder 2011:28).

When caribou are healthy and relaxed, they are known to tilt their snouts in the air: “healthy animals walk with their heads up,” (John Jerome in GSCI 2015: 57). They are also known to be playful, jumping in the air to display their good condition:

You could tell looking at a caribou right away if it's a poor one or a fat one... And usually [caribou] try to show off and jump up in the air, let the predators know they were ready for a rumble or something. That must be part of their survival thing. Even the little ones do that (James Firth in GSCI 2015: 29).

Caribou are curious when they are not spooked:

They do play lots you know... play with one another. That is why lot of time you can fool a caribou by rubbing two sticks together, that is because when you rub stick you know they think it's caribou playing over there. Well, they have to go over there and see what it is. They don't walk over there, they just full blast over there... That is why if your caribou run away from you, you hide and rub that stick together, it will come back to you... always come back to you (Gabe Andre in GSCI 2015:30).

In the olden days, when [people would] come on the lake and they'd see caribou on the other side of the lake, they'd sit down and make tea. And the caribou would get curious, and they'd come

over to check what's going on. Even if they smell the smoke, they know it's not a forest fire because it's just a little smoke (GSCI 2015: 25).

While caribou don't seem to be significantly affected by campfire smoke, it is reported in the traditional knowledge literature that caribou are strongly affected by wildfire and the resulting damage to habitat. There are accounts where traditional knowledge suggests that caribou do not always return to migrate through an area that has been heavily disturbed by fire, even when regeneration of lichen has taken place (ACFN 2003). These effects are elaborated elsewhere (ACFN 2003; BHP Billiton 2007; EMAB 2012; GSCI 2015).

When caribou are really stressed they really tilt their nose in the air:

The caribou are running in front of the helicopter. When a caribou gets scared or surprised or threatened, that's what they do. They put their nose up and sometimes they jump and then they go on a really fast gallop because they don't know what's going on and they're threatened. (Fred Sangris in EMAB 2012: 20)



Photo credit: Diane Dul, Diavik Diamond Mines Inc. (From EMAB 2012: 20)

On a local scale, it is widely reported that community members have long understood the importance of leaders in the caribou herds. From cows heading northwards to their calving grounds or bulls heading southwards after the rut, caribou follow the experienced leaders of the group. (Benn 2001; Whaèhdqò Nàowòd Kò 2001; Kendrick *et al.* 2005; WMAC (North Slope) and Aklavik HTC 2009; Padilla and Kofinas 2010; BQCMB 2011; GSCI 2015). Community members have frequently stated that barren-ground caribou use their excellent memories and extraordinary sense of smell—they can smell the old caribou trails on the landscape—when choosing their migration routes (Padilla and Kofinas 2010).

Depending on the scale considered, caribou are known to return to the same calving grounds using the same migration routes year after year (Thorpe et al 2001; Whaèhdqò Nàowòd Kò 2001; Kendrick 2003; Padilla and Kofinas 2010; EMAB 2012; KIA 2012).

Young caribou know where to migrate and use their memories as well as what they have learned from the cows. They follow the leaders and using their sense of smell to guide them to quality forage (Thorpe et al. 2001; Whaèhdqò Nàowòd Kò 2001).

The caribou, or more particularly the leaders, also know where they are supposed to go: “they been going there ever since the world started. Thousands of years” (Joan Nazon in GSCI 2015: 35).

They're going to go where there's the best feed, or where the leaders go. I don't know why the leaders know, but where the leaders go, they go. That's part of their DNA . . . part of their survival (Tom Wright in GSCI 2015: 35).

Caribou have very good smell and sight so any industrial development scares them (James Firth in GSCI 2015: 49).

Cows share their knowledge; they teach their young how and where to migrate:

Bluenose caribou calves learn how to make a living in the world from their mothers. Calves just go only where it go, and follow his mother, that way they know what to do. Calves make a particular sound to call to their mothers, and the mother knows right away, look for young one. That is if the young calf don't know where the mother went...make loud sound, and hear them right away (Gabe Andre in GSCI 2015: 37).

Don't matter if there is 1000 caribou, still calves still know which one is their mother. I see that, if cow is going to cross a lake, or cross a river, the calf can get on the back...sit on their back. They wouldn't swim by themselves...they swim but they wouldn't stay in the water that long, they just jump on top their mother (Gabe Andre in GSCI 2015: 37).

A key theme articulated in the traditional knowledge literature is that caribou can sometimes

adapt and habituate to disturbance. Further, caribou today are “born into” a fragmented and frenetic landscape and know nothing different. While habituation may reduce stress levels, community members assert that this observation should be viewed in the context of the negative impacts (vehicle collisions, contact with contaminants, injury from infrastructure) associated with being in proximity to such developments (KHTO and Golder 2011; Parlee *et al.* 2013).

The young caribou are growing up with the developments versus the older caribou so they are used to it and becoming more accustomed to it (Anonymous in KHTO and Golder 2013: 50).

Bluenose caribou are easily spooked by people approaching them, although some hunters feel they have gotten used to the sounds made by ATVs and skidoos over time. Good hunters know to pay attention to the wind direction and make use of hills and other landforms when trying to get close to caribou (John Jerome in GSCI 2015: 25).

I’ve been with the Bluenose caribou and I worked around the Tuk area lots when all the exploration was going on up there and you would see caribou on those roads and close to the drill sites and whatnot (Harry Carmichael in GSCI 2015: 49).

Wherever there is human activity, the caribou are aware of their surroundings. Some do become skittish, while some become used to human development and it doesn’t bother them (Anonymous in KHTO and Golder 2013: 50).

Traditional knowledge suggests that some caribou can adapt to changes in the environment by migrating along different paths or greater distances (Whaèhdqò Nàowòd Kò 2001; Katz 2010; EMAB 2012; Sangris 2012; Tłìchq Government 2013; Jacobsen 2013; GSCI 2015). Many community members have suggested that shifts in migrations further north is just one way in which caribou are trying to adapt to changes along their range, in their habitat, population and body condition.

Caribou has its own way to survive, they are like human beings. How will they survive? They will probably change what they eat (Dora Nitsiza in Tłìchq Government 2013).

In the same way that caribou are thought to habituate to disturbance, traditional knowledge suggests that caribou will learn to avoid areas with certain types of development and yet be attracted to other areas:

I know with disturbances, they tend not to return after they found out it's disturbed. Like, if somebody made a big cat road, well, the next year when they came, they would detour that area (Morris Blake in GSCI 2015: 50)

Caribou are very intelligent animals. I’ve worked as an outfitter and a guide in the past, and I see that. Thousands of caribou, but they would never come near the camp, never. Not even if the

camp was right on the migration route. They avoid it. But as soon as you put up mine like BHP and Diavik, they just love being around people. They look at the mines as security. They know the people working at the mine are harmless and they know predators like wolves and grizzly bears are sometimes chased away. They never hang around that area, so it's a safe haven for caribou. But at the outfitters camp, no grizzly bear, no wolves, no caribou, no nothing. They know exactly what that camp is and they learn how to avoid it. Think about that (Fred Sangris in EMAB 2012: 22).

These caribou are growing accustomed to mines like a landmark...now they are using them in their travels (Anonymous in KHTO and Golder 2011: 58).

There were caribou around the tank farms. They were hanging around in the shade. They love it! Hiding from the big tanks and building, I was surprised (Colin Adjun in KHTO and Golder 2011: 58).

One time [a bull] was hanging around camp, staying in the wind from a fan... (Colin Adjun in KHTO and Golder 2011: 48).

The caribou know that they cannot be disturbed by the people working there, almost like a game sanctuary. The caribou can get away from predators, (Anonymous in KHTO and Golder 2011: 60).

Try to cool down inside, drop by [the mine] for a while, (Alice Ayalik in KHTO and Golder 2011: 48).

In contrast, much of the traditional knowledge speaks to how caribou avoid areas of disturbance and human development.

With human activity, they sometimes change their migration routes. Lac de Gras, before the diamond rush, caribou used to migrate through there in great big herds...today it is totally different. Only a few in a group, not like hundreds (Anonymous in KHTO and Golder 2011: 56).

Due to noise pollution, their migrations are changing. They don't take their regular trails anymore due to all the mines. Due to all the mines . . . They are going a mile or two away from their trails (Joseph Niptanatiak in KHTO and Golder 2011: 60).

I have seen many changes because of this mining activity, exploration activity, be it a fully grown mine or just one little box. Drilling in the middle of nowhere can actually deter caribou from going to that area and maybe going to another area. That's' what is disrupting the migration route of the caribou (Bobby Algona in KIA 2012: 39).

Some Elders emphasized that the mines are obstacles and intrusions on the caribou's habitat.

Ever since the mine was built, it seems like they are forced and chased away. And the places where they lived are different, it changes with them. They don't seem to stay longer or something seems to chase them away. When your trail is not healthy and you don't feel comfortable with it then you don't stay in one place, but right away you keep moving on, that's how it seems to be with the caribou. Because their traditional path is not good, it's blocked up so the caribou don't stay that long. Because of the mining. When you travel somewhere and your skidoo trail is nice and clear, but as soon as you know that something is bothering you on your trail, like mining, you don't feel comfortable with it and you turn away (Unknown in Tłıchǫ Government 2013: 30).

5.3.5 Regional Scale Effects

Considerations of regional scale and population level effects point more towards complexities in the caribou ecosystem than any inconclusive cause-effect relationships. Given the holistic nature of traditional knowledge, it is not surprising that community members most commonly point to cumulative effects or general trends on a regional scale. A review of traditional knowledge sources shows some of the following key observations on a regional scale:

- Most traditional knowledge sources point to rapid and levels of decline in barren-ground caribou (WRRB 2010; EMAB 2012; Beaulieu 2012; Judas 2012; Legat 2012; Barnaby and Simmons 2013; Jacobsen 2013; BQCMB 2014; GSCI 2015). However, some knowledge holders assert that caribou are not declining but rather shifting in the migration routes. Differences in scale as well as the ways that scientists classify caribou herds (e.g. the debate between Ahiak and Bathurst caribou herds) and indigenous peoples identify caribou further complicates coming to a more fulsome understanding.

I have heard a lot of people talk about names. The Dene people don't have any names for caribou at this time. I think they -- they relate it to the land where the caribou are. But the Dene people have harvested the -- the Bathurst herd for -- ever since I could remember, you know, probably for thousands of years as well (Walter Bayha in WRRB 2010: 220-221).

- Herds of barren-ground caribou are known to mix, especially as their populations decline. For example, island caribou and mainland caribou can reproduce giving birth to what some call a "Heinz 57." In addition to impacts from resource development, typical migration routes and ranges have also changed as populations intermix and decline (GSCI 2015). As a compounding factor, community members have long observed that caribou intermix and don't break them into herds in the same way as biologists (Parlee *et al.* 2013). If "herds" intermix, community members explain that it changes the way that scientists count caribou.

We're just talking about only one caribou. The caribou, ekwò, are all the same, the way I look at the picture. Ekwò are all one, just one animal. I can go back to 1962, and I've observed that since 1990, the population has really been going down (Judas 2012: 49).

Ever since the people start talking about the decline of the Bathurst herd, someone here mentioned that there was no evidence (of what happened to them). Where did they go? Nobody has seen carcasses. I always ask that question. Where did the new herds come from? Where did the Bluenose Herds come from? And then there was the Ahiak Herd. I haven't got an answer yet. To us they are all one herd (Sam Kapolak in Barnaby and Simmons 2013: 14).

Some reports are stating that they -- they don't -- they're not mixing -- the herds are not mixing with each other. We do know that they're mixing with each other (Leon Lafferty in WRRB 2010: 253).

- The profound and overarching effects of environmental change on a global and regional scale supersede any other type of human effect on a local scale. Traditional knowledge suggests that uncertainties and extremes in weather events are unprecedented in people's living memories. This makes it difficult to isolate the effects of mineral development on caribou (Thorpe *et al.* 2001; Krupnik and Jolly 2002; Thorpe *et al.* 2002; Parlee *et al.* 2005; KHTO and Golder 2011; Legat 2012).
- Although caribou show fidelity to migration routes, when these well-known routes become low in forage quality, caribou shift to other routes. Developments along the ranges of barren-ground caribou interfere with this natural cycle (Whaèhdqò Nàowoò Kò 2001; Thorpe *et al.* 2001; ACFN 2003; Kendrick *et al.* 2005; Łutsel K'e Dene First Nation 2005; Legat *et al.* 2008; Croft and Rabesca 2009; Sahtú Land Use Planning Board 2013; WRRB 2013; North Slave Métis Alliance 2012; Beaulieu 2012; Judas 2012; EMAB 2012; Barnaby and Simmons 2013; ACCWM 2014; KIA 2012; GSCI 2015).
- According to traditional knowledge, it can be a very long time before caribou return to an area of disturbance (ACFN 2003; Kendrick *et al.* 2005; Kavik-Stantec 2012; Jacobsen 2013).
- Perhaps the most important factor in determining where caribou migrate and calve is the quality of vegetation or forage within their habitat. Caribou prefer the rich new grasses of the spring and summer to the less palatable lichen of the winter. Caribou learn historical migration routes and use their powerful memories to return to these. At the same time, they use their strong sense of smell to find quality habitat.
- Disrespect shown to caribou is responsible for caribou decline and shifts in migration routes. Today people live in settlements and no longer show the same level of respect to caribou that

their ancestors exhibited, back in the days when caribou and people could speak the same language. When caribou are disrespected, people are known as “pitiful”, lose their caribou “luck” and are not successful in their harvests. Without being able to harvest caribou, people are not “wealthy” in an emotional, spiritual, cultural, materialistic and subsistence way.

In my youth, my father would take me to the barrenlands every year just after I got out of school. He said, “I’m going to teach you, so that you will be knowledgeable. Before you harvest animals, you have to learn to understand them. The way they think, their habitat, the way they live, what they eat. Before you harvest ?ekwò you must understand them first. You must understand the names of ?ekwò and the reason they’re doing what they do, migrating, going to the forest from the arctic barrenlands and back again. And there are traditional laws that come with ekwò. Every Aboriginal child has to understand the laws pertaining to ?ekwò (Fred Sangris 2012: 75).

Long ago, vadzaih [caribou] and men were much closer. Any person, not just a Medicine Man, could talk with vadzaih. When people and vadzaih separated, it was agreed that people could hunt vadzaih; however, a sign of the old relationship remained. Every vadzaih has a bit of ezi, human heart, in him, and every human has a bit of vadzaih heart. People will always know what vadzaih is thinking and feeling, and the vadzaih will have the same knowledge about people. This is why hunting vadzaih is at times very easy, and at other times very difficult (Gwich’in Elders 1997:37).

The caribou will know if a nation took care of them and they will come back, if they were abused they will not come back. If we are going to change the behaviour of the caribou we need to change our behaviour. We need to respect caribou, we can’t butcher and get blood all around. Traditionally woman couldn’t step over caribou blood, the men must ensure that they don’t leave blood on the ground (and make things difficult for women) and we must re-establish our traditions of having a sacred place to put the bones (Chief Charlie Football in Barnaby and Simmons 2013: 10).

- People are not the boss of caribou and so should not speak with authority of their behaviour, ways, knowledge and more. Everybody must follow their cultural rules with respect to caribou to support caribou during this challenging time of increasing effects from human disturbance.

In those times, the elders were really protecting the animals; they really watched everything (Judas 2012: 51).

Caribou are sacred, participants said, and according to custom, people were not even supposed to talk about the animal (BQCMB 2011: 41).

Many elders also speak of a time when people and animals could speak the same language and communicate with each other. These beliefs are not entirely lost to the Gwich'in" (GRRB 2001:24).

Also the rule of not 'talk[ing] smart about animals' reflects the Gwich'in worldview where caribou, and animals in general, are sentient beings who are aware of and respond to the actions and words of humans. The majority of the rules voiced by the elders were also mentioned by the harvesters (Wray 2011; 101-102).

I was introduced to ekwò. I had never seen this animal before. When I first saw them, I asked, 'Grandfather, why are there so many sled dogs on the lake? Big sled dogs. And they're all wandering free!' He said, 'Those are ekwò. They are our traditional food, given to us by the Creator. ?ekwò is there to take care of us until the end of time (Sangris 2012: 75).

These laws apply not only to my people, but to many of the Aboriginal people throughout this whole country who depend on moose, ekwò, muskox and buffalo. We all come from different communities, different languages, but all our minds are the same. Our hearts are with ?ekwò and we have great respect for this sacred animal that we all depend on (Sangris 2012: 76).

- Development that affects calving caribou and calving grounds must be avoided. Caribou are particularly sensitive during their calving period and stress only leads to harm for caribou. Traditional knowledge literature reviewed asserts that calving grounds are unique and should be protected (Wray 2011; Beaulieu 2012; Sangris 2012; EMAB 2012; BQCMB 2011; GSCI 2015; Williams 2015).

My late uncle used to tell me that his dad used to tell him not to make tea around the flat lands as he did not want the ground to be full of soot from the firewood. These areas are the calving grounds for the caribou . . . The area is south of Bay Chimo. My late uncle's dad used to tell him not to make tea around that flat land area but to make tea further away from the area. That was the rule long ago (C13 in KIA 2012: 41)

He is talking about calving grounds. The elders say you should never impact them in one form or another because they are really sacred. They care for these calving grounds, particular spots on the land where it's just like a large swamp, or swampy areas where the ground becomes yellow from the calves. After they calve. And they don't want to dirty that part of the land from all the ashes or any other thing. You can't camp there, or make fires (Bobby Algona in KIA 2012: 41)

Caribou tend to prefer these areas for calving grounds, because of this year's or last year's plants. It's not this year's plants; it is from years before plants. That's why they go there. If they don't find plants they might move to a different area, to a different calving area, it might be past Bathurst. Sometimes they would be on the east side of Bathurst Inlet and sometimes on the west side, all along there, and anywhere, all the way down to James Bay area (KIA 2012: 41).

From what I hear about calving grounds, they use that area for a few years and then there will be no food so they change until the food grows there again. . . they change until the place grows again. They don't just calve in one spot for life. They switch . . . to where there's food for them (C111 in KIA 2012: 42).

Wildlife biologists living in Nunavut and having local knowledge affirm the same:

We can educate hunters and newcomers to correctly select caribou and harvest meat. The community should send good hunters, to reduce waste and make sure good meat is harvested. Having caribou to hunt depends on the numbers of caribou that are produced each year. Pregnant cows should be protected. Usually calving grounds are naturally protected from hunting because of difficulties for access, the hunting season for non-Inuit is closed, skins are of poor quality and not desired, and travel to these areas is difficult. Calving areas should be protected from other activities as well. Activities such as mining and exploration should be better monitored and managed, especially from aircraft traffic (Dumond in BHP Billiton 2007: 5-5).

5.3.6 Cumulative Effects

The very structure of traditional knowledge is much aligned with the web-like concept of cumulative effects. Indigenous peoples typically think in terms of relationships between caribou and their environment that extends to contemplating the complex network of cumulative effects of human disturbances on barren-ground caribou across the North.

It is consistently reported in the traditional knowledge literature review that cumulative effects are perhaps the most relevant threat to barren-ground caribou (BQCMB 2011; KHTO and Golder 2011; Beaulieu 2012; Sangris 2012; EMAB 2012; Parlee *et al.* 2013; GSCI 2015). In particular, effects from exploration and development activities as well as environmental change are considered to be imposing the greatest effects.

Many workshop participants agreed that the caribou herds are decreasing in size, even though actual population numbers are sometimes not known. They also said that this decline is due to multiple factors, not one single factor, and that the cumulative effects of these factors

are of great concern. (Cumulative effects are the combined environmental effects from a series of similar or related activities that accumulate over time and space.) Everyone must work together to reverse this situation, and more consultation by governments and the BQCMB with communities has to be part of this (BQCMB 2011: 29).

The cumulative impact on them is unreal. There are about ten outfitter lodges that concentrate on the range of the Bathurst herd, three diamond mines, and about one thousand kilometres of ice road. I've been on that ice road between late January and mid March and every five minutes a big truck are going by you, where caribou migrate. The mine sites are very noisy (Beaulieu 2012: 64).

There are other herds [besides the Bathurst] that don't experience as much impact because there are no roads cutting across their ranges. . . I think the caribou in the east and the caribou in the west have a better chance than the Bathurst herd. They're very impacted and I know there are going to be more diamond mines going in there. I know our children need to work there, but I think we should really limit how many diamond mines we have running at once. We should talk to the companies that start these diamond mines and ask them to shut down the mine for a few years from 2037 to 2042. Because if they do that, if they put it in the plan and commit to it, then they'll help the caribou (Beaulieu 2012: 67).

So what we're looking at here now is different than anything that we've ever seen in the past. What we're working on here will be used in the future. We have to make sure that it's done right the first time, so that it can be used for the mines that are coming in later on. It's not right now that we're thinking of just one mine, or even the four mines. It's going to be about all the mines that are coming up down the line (Wayne Langenhan in EMAB 2012: 12).

5.3.7 Summary and Conclusions

Traditional knowledge holders have not put forth a homogenous view of how human development affects barren-ground caribou, but rather, have identified key trends and noted outlier events. Even within a community, there is not necessarily one unified voice. As in western science, there are many ways to arrive at a conclusion and there is great richness in this heterogeneity.

Gwich'in Knowledge is a complex of multiple sources of information (including western science) about caribou that harvesters access from a variety of places and make use of in caribou harvesting. I also found that the knowledge of elders and the community harvesters is considered the most important of all information sources in forming understandings about caribou and directing hunting activities (Wray 2011: 1).

Traditional knowledge holders will not speak of that which they have not personally observed. For example, since calving grounds are well regarded as sacred and places to be avoided, many Inuit do not have first-hand knowledge of either their location or stories to tell of what happens on calving grounds. For this reason, there is a strong level of authority assumed in the observations shared throughout the traditional knowledge literature.

The meaningful consideration of Inuit Qaujimajatuqangit in wildlife management is a key concern for Nunavummiut. Indeed, it is standard, accepted and expected practice to incorporate Inuit Qaujimajatuqangit throughout all stages of wildlife management in Nunavut. In the last ten to twenty years, there has been a tremendous increase in the number of local and regional projects carried out in the north that integrate traditional knowledge and western scientific information. As recently as the fall, 2010, a key theme of the 13th North American Caribou Workshop, *Sustaining Caribou and their Landscapes: Knowledge to Action* held in Winnipeg, Manitoba, was the call to integrate more traditional knowledge with western science when considering population decline (Wells 2010; www.nacw2010.ca).

This literature review, in part, responds to this imperative by looking to both Inuit Qaujimajatuqangit and western science to better understand development effects to barren-ground caribou. Traditional knowledge holders and scientists must continue to work together.

Other peoples have come to this country. They want to manage and control the animals and to have authority over them. For example, nowadays biologists are flying out on ?ekwò surveys mostly on their own, with no participation from Aboriginal communities. This leads to conflict. The only way to avoid those conflicts is to have collaboration. If you put Aboriginal knowledge and the scientific knowledge to work together, it will be possible and find a way for ?ekwò to be managed well for the future. One group cannot go and study animals and make decisions by themselves. . . . I've always believed that science is a good thing. But it's still young (Sangris 2012: 76).

I'm confident in traditional knowledge and I love working with scientists. When traditional knowledge holders sit together, we come with different opinion but if we talk about it long enough, we can work it out. It's no different for the biologists when they sit together. But beyond all these arguments, we have to work together to make plans for the future (Beaulieu 2012: 66).

Our harvesting practices are very much community driven. The direction comes from the hunters and the people that go out on the land and observe the wildlife. Hunters go out in different areas and report back what they are seeing. Sometimes we hear that there are a few caribou over there, the east or south. And that is one of the ways we observe wildlife. By working with the wildlife department we are taken very seriously. We have the desire to work with them, based on the understanding that we care and respect wildlife. These are the mechanisms that we use in Nunavut (Phillip Kadlun in Barnaby and Simmons 2013: 15).

My father didn't put me on the barrenlands to punish me. He put me there to learn. I didn't go to an institution to learn, to sit behind the four walls and try to understand ekwò. The best way to understand those species is right there on the land. You have to interact with them. You have to watch them daily. . . what they eat. Watch what they do. Aboriginal people learn by watching the behaviour of ekwò. We don't learn about wildlife behind four walls. We learn by being in the field, by being with ?ekwò all the time (Sangris 2012: 75-76).

The hunters go out on the land and talk about their experiences. This is our raw data. This is our monitoring system of the Dene people (Walter Bayha in WRRB 2010: 223).

Respect for caribou is at the core of a sustainable future for the barren-ground caribou.

When I use traditional knowledge to predict the future of caribou, it doesn't look good for our grandchildren, our children. The future for the caribou is not good. Only we can help them. I think the big thing is to control development across our land, across Canada and the Northwest Territories (Beaulieu 2012: 65).

Most Elders persistently explained that no one can know or understand all the ways of the caribou and that no one can decide or manage for the caribou. The Elders say that the caribou are like persons; they care for themselves just like humans. Each individual caribou and each caribou herd have their own individual will to decide what they want to do, where to go, what to eat and where they want to travel (Tłıchq Government 2013: 18).

Reviewing traditional knowledge, as in this document, is just one way in which we can work together to respect barren-ground caribou and plan for their sustainable future.

5.4 Western Scientific Studies

5.4.1 Linear Features

Linear features acting as a potential disturbance agent for *Rangifer* may include seismic lines, roads, power lines, or above-ground pipelines. Many scientific studies show a negative response of *Rangifer* to linear human features. Roads can affect caribou by increasing disturbance, creating partial barriers to movement and increasing access for harvesting (Wolfe *et al.* 2000). For example, the study of Nellemann *et al.* (2001) showed that in six out of eight sampling years wild reindeer populations in Norway used areas less frequently that were within 2.5 km from power lines: population density was ~80% lower compared with areas farther away.

Although physically possible to cross, roads or power lines can act as barriers for movement if they are perceived as dangerous habitat (Nellemann *et al.* 2001). Contrarily, some authors conclude that

power lines are a minor disturbance (e.g. Flydal *et al.* 2009): in their study the authors made experiments testing the effects of power lines on reindeer behaviour where behaviour inside enclosures with power lines was compared to areas without power lines.

According to a recent boreal woodland caribou study by Johnson *et al.* (2015) the zone of influence (ZOI) (resulting from avoidance response) may vary between 1 to 1.75 km for roads and 0.5 to 2 km for seismic lines. Boreal woodland caribou avoid seismic lines during periods when females and calves are most vulnerable to predators or hunters. They also cross fewer seismic lines and travel faster when they cross them than expected (e.g. Nagy 2011). A ZOI has also been demonstrated for roads in barren-ground caribou range, with avoidance of up to 4-6 km (reviewed by Wolfe *et al.* 2000). Not surprisingly, the degree of avoidance depends on the size of the road and traffic levels; larger roads with higher traffic volumes are avoided more than smaller roads with little traffic (Integrated Ecological Research 2015).

Some studies showed that roads are often suggested to cause detouring of migrations, range abandonment and, ultimately, population decline (see e.g. references in EBA Engineering Consultants 2011). When caribou encounter a gravel road with vehicle traffic their progress across the road may be delayed until traffic subsides (Ballard *et al.* 2000). Roads are also often associated with increased hunting pressure: development of new roads allows access to areas that are otherwise less accessible or frequented. Caribou bearing young avoid roads after giving birth (Dau and Cameron 1986; Cameron *et al.* 1992). On Alaska's North Slope within the Kuparuk Development Area, Cameron *et al.* (1995, 2005) found that linear infrastructures negatively impacted calving caribou: the abundance of calving caribou was less than expected within 4 km of roads and declined exponentially with road density. In the same study (2005) Cameron *et al.* observed that road and pipeline corridors impeded caribou movements: abundance and movements of female were higher in non-impacted areas along the Arctic coast.

Panzacchi *et al.* (2013) found that applying a 1-km radius buffer around roads would reduce the probability of use of traditional movement corridors by nearly 50%. The same study suggested that *Rangifer* tolerance thresholds to human disturbance have to be adjusted to the local ecological settings determining the strength of the motivation of caribou to use a given movement corridor, and to the position of the infrastructure with respect to the core part of the seasonally preferred habitat.

Some studies have reported neutral effects of roads on caribou behavioural response. The study by Noel *et al.* (2004) concluded that distributions of calves and adult caribou was not strongly influenced by the presence of a road, or an above-ground pipeline as in the case of a study by the same author published two years later (Noel *et al.* 2006). However, this conclusion was later criticized by Joly *et al.* (2006) mainly because in the initial study the authors failed to include the effects of expanding infrastructure in their analysis, to incorporate all available surveys, and to discuss data that showed caribou abandonment of the area following further development. Bergerud *et al.* (1984) studied barren-ground caribou populations in context to human disturbance. The study suggested that roads

did not create a barrier to movement, although they did contribute to over-hunting and subsequent herd decline.

Curatolo and Murphy (1986) found that caribou generally crossed over isolated roads away from sites with human activity. Cameron and Whitten (1980) did not detect avoidance of roads outside of development areas and estimated calf percentages in the affected area were similar to regional levels. In the same study, however, it was suggested that cow/calf pairs may avoid areas with building complexes. Curatolo *et al.* (1982) found that caribou encountering gravel roads showed no signs of distress. Interestingly, during fly season, caribou sought gravel roads and spent significantly more time traveling and/or standing on roads, which in fact can be interpreted as a positive effect. As summarized in Russell (2014), there was no difference in activity during winter from caribou adjacent to the Dempster Highway compared to groups at least 10 km from the highway.

Murphy and Curatolo (1987) found that when insects were absent, caribou within 600 m of an elevated pipeline and road with traffic, and within 300 m of a pipeline and road without traffic, and had significantly greater activity budgets than undisturbed caribou further from the source of disturbance (i.e. disturbance effects were significantly greater in the site with traffic). Time spent lying and running and movement rates were the best indicators of disturbance by oil fields, whereas time spent feeding was not affected. The authors conclude that insect harassment, but not oil field development, reduced the time caribou spent foraging.

Ballard *et al.* (2000) state that infrastructure and human activity in the Prudhoe Bay Oil Field have not prohibited or altered caribou movements through the oil fields. They also showed that during times of insect harassment caribou would seek relief in the shade of pipelines. There is consensus that if pipelines are well designed to accommodate caribou, they will habituate to them (Ballard *et al.* 2000). Smith and Cameron (1985) and Curatolo and Murphy (1986) as reviewed in EBA Engineering Consultants (2011) verified that caribou would cross beneath elevated pipelines that were 1.5 m above ground, and that additional clearance did not increase crossing success. However, Klein (1980) suggested reluctance of *Rangifer* to pass under objects.

5.4.2 Resource Development Infrastructure

Mining infrastructure can include buildings and pit mines. Caribou may respond to mine disturbance in all seasons (Weir *et al.* 2007), although the impact of mines seems to be most prominent in the pre-calving and calving seasons. Weir *et al.*'s study (2007) showed that following initiation of the mine construction, caribou abundance increased with distance from the mine site in all seasons, and caribou avoided areas within 4 km of the site in most seasons. Within 6 km of the mine centre, group size and the number of caribou decreased as mine activity progressed in late winter, pre-calving and calving seasons.

Johnson *et al.* (2015) found that depending on the season, the zone of influence (resulting from avoidance response) varied between 2 to 12.5 km for non-linear oil and gas infrastructure. Evidence suggests that there is a strong selection for cows with newborns to space away from human activity in the calving period (Russell 2014).

Using aerial survey data, Boulanger *et al.* (2012) estimated the zone of influence (ZOI) adjacent to the Ekati and Diavik mines at around 11 to 14 km. The same study using GNWT collar data found a weaker ZOI of 11 km, although previous analyses (e.g. Johnson *et al.* 2005) of collar data suggested it might be as much as 30 km or more (Integrated Ecological Research 2015).

In a study using 27 years of location data collected for the Porcupine caribou herd during winter, Johnson & Russell (2014) investigated the zone of influence associated with human settlements, main roads and minor disturbance features including wells, trails, and seismic lines. They found that caribou demonstrated the strongest avoidance response to settlements, followed by main roads and minor disturbance features. As already reviewed in EBA Engineering Consultants (2011), many other behavioural studies have shown that caribou will avoid human corridors and facilities: Cameron *et al.* (2005) and Whitten and Cameron (1985) found that facilities had a negative impact on calving caribou within the Kuparuk Development Area. Dau and Cameron (1986) and Cameron *et al.* (1992) as reviewed in EBA Engineering Consultants (2011) found post-parturient caribou were sensitive to disturbance and avoid gravel pads for up to two to three weeks after birth. Nellemann and Cameron (1998) and Whitten and Cameron (1983) concluded that female caribou were displaced from local calving areas due to the presence of infrastructure. Smith and Cameron (1983) data suggests that mining facilities modified caribou movement and affected herd composition, suggesting lower caribou occupancy rate and herd displacement particularly with cows with calves. As previously reviewed in EBA Engineering Consultants (2011), Griffith *et al.* (2002) concluded that the most consistent behavioural response to development was a demonstrated shift of the calving area. Boulanger *et al.* (2012) found that caribou occupancy in the central Arctic was negatively influenced by resource development infrastructure and human activities. Johnson *et al.* (2005) demonstrated that mines and other major developments, exploration activities, and outfitter camps had negative effects on species occurrence.

Mahoney and Schaefer (2002) stated that development caused a disruption of the timing of migration during construction and longer term diminished use of the range surrounding the project site. Additional studies found similar results in other regions but with a smaller zone of influence (1 to 10 km).

In contrast, Fancy (1983) found no difference between movement rates and activity for caribou near two active drilling sites compared to caribou at controlled sites. Interestingly, many other studies have documented caribou, including cows with calves, utilizing infrastructure facilities, raised gravel berms and pads to reduce the impacts of insect harassment (Hanson 1981). During times of insect harassment caribou are seeking shade adjacent to infrastructure to escape insects, for example, near

buildings and, in some cases, under building and inside some sheds (Ballard *et al.* 2000). As reviewed in EBA Engineering Consultants (2011), during times of increased insect harassment caribou behaviour may change where they exhibit a higher level of tolerance to infrastructure, human presence, and associated activities in exchange for reduced insect harassment (Rescan 1999).

Matthew *et al.* (1998) found that caribou distribution was independent of infrastructure. Caribou utilizing habitat within the infrastructure area, often appeared close to the infrastructure itself, and did not appear to avoid the infrastructure complex. Cronin *et al.* (1998) reported that caribou did not demonstrate any avoidance to facilities during the post-calving period.

5.4.3 Vehicles and Aircraft

Disturbances such as low level aircraft flights and vehicles (e.g. ATV, snowmachines) can increase caribou energetic costs if those activities interrupt caribou foraging or cause the caribou to move away in response to the disturbance (Weladji and Forbes 2002).

Results from studies on caribou behaviour from the Ekati mine in the central Arctic found that people and pick-up trucks were two stressors that caused the greatest displacement to caribou, while blasting, helicopters, haul trucks and sirens caused only minor displacement (Rescan 1999). Horejsi (1981) observed that caribou encountering a moving vehicle exhibited signs of excitement and fright, with females showing greater responses than males (Horejsi 1981). Roby (1978) found the distance maintained by caribou from the Trans-Alaska Pipeline haul road to be negatively correlated with traffic volume suggesting habituation. However, the level of response to vehicles was positively correlated with traffic frequency. He found that cows and calves tended to avoid the entire area. Furthermore, Roby (1978) and Tracy (1977) found cows and calves to react more strongly to passing vehicles than did males (see discussion in EBA Engineering Consultants 2011).

Contrarily, Bergerud (1974) suggests that noise from passing vehicles is not disturbing to grazing caribou. Yet Ballard *et al.* (2000) found that large groups of caribou will utilize gravel pads even when people and vehicles are moving on them. A number of studies suggest that caribou are adaptable and can habituate to a wide variety of disturbance stimuli, including moving objects (see in EBA Engineering Consultants 2011 and references herein). As already discussed in EBA Engineering Consultants (2011) published research on barren-ground caribou responses to snowmachines and ATVs is limited. Not surprisingly, caribou may avoid areas with snow mobile activity, particularly when caribou are directly approached (see EBA Engineering Consultants 2011 and references therein).

Summarizing research results on airplane disturbance on caribou is more challenging due to the complexity of the problem inherent within behavioural response (see EBA Engineering Consultants 2011). Distance of the aircraft from the animal is the most significant factor influencing the level of response from caribou. However, behavioural response also depends on complex interactions of

other factors such as season, group size, previous activity, aircraft type, herd experience, and habitat type (e.g. Shank 1979). Caribou may react differently to aircraft during various seasons of the year. Despite the numerous studies examining this aspect, contradicting results continue to prevail (EBA Engineering Consultants 2011).

In an experimental study, Miller and Gunn (1981) subjected Peary caribou calves to induced helicopter harassment: on 20 occasions 93 bouts of play in calves were observed during harassment. The greatest response of play behaviour was exhibited during the harassment phase. According to the authors calves did not show any evidence of stress and did not exhibit any form of alarm or escape behaviour. The authors hypothesize that the calf-play behaviour was triggered by the harassing stimuli as a result of increased levels of excitation. If such conclusions are valid remains speculative.

Fisher *et al.* (1977), as reviewed in EBA Engineering Consultants (2011), recorded the reactions of caribou to overflights. Distance of the aircraft from the animal was the most important variable affecting response level. Large groups were more reactive than small groups or individuals. Groups with calves were slightly more reactive than groups without calves. Caribou activity at time of the overflight influenced the response with bedded or feeding caribou reacting less than travelling caribou. Finally, larger groups tend to be more sensitive to aircraft in late winter and during the post-calving season. Calef *et al.* (1976), as reviewed in EBA Engineering Consultants (2011), investigated responses of barren-ground caribou to fixed-wing aircraft and to helicopters in northern Yukon and Alaska. Panic reactions or strong escape reactions were observed in a high percentage of all groups when aircraft flew at altitudes of less than 60 m. A general consensus exists that helicopters are more disturbing than fixed-wing aircraft (see EBA Engineering Consultants 2011 and references therein).

5.4.4 Local Scale Effects

For this review we distinguish between local and regional scale human disturbance effects. Population level effects are difficult to study due to the longer time spans involved and overlapping, cumulative effects. Contrarily, the study of local scale effects often focuses on an individual-based response such as fright and flight behaviour triggered by human disturbance. Local scale effects resulting from disturbance can also potentially lead to longer term demographic consequences such as malnutrition and reduced reproduction.

An example of a behavioural response would be an individual animal fleeing from a vehicle. This behaviour can result in a physiological and/or energetic response including changes in blood constituents, body temperature, and heart rates (see discussion in EBA Engineering Consultants 2011). This, in turn can result in reduced fitness and, ultimately, lower fecundity and changes in population demographics. Fright and flight behavioural responses are a result of how much caribou have been exposed to predators (in that area), existing levels of human activity, season, and group

size. In the absence of predators, caribou populations may show a relaxed vigilance behaviour (Reimers *et al.* 2011).

Fright and flight behaviour can result in elevated glucocorticoid levels which are an indicator of physiological stress (Dantzer *et al.* 2014). Although empirical evidence has been scarce so far, some biomedical studies suggest that chronic increases in glucocorticoids can have detrimental effects on survival and reproduction, which could influence the longer term viability of populations (see Dantzer *et al.* 2014 and references therein).

Ultimately, the fundamental question behind disturbance studies is the effect of human disturbance at the population level. Many of the disturbance studies have focused on behavioural responses as they are readily observable. However, measuring physiological and demographic responses to disturbance is far more challenging in the field. A disturbance effect can occur without having an impact to an individual animal. Animals are exposed to disturbances on a regular basis without detrimental consequences as a result of interacting with their environment. Similarly, animals can be exposed to human disturbances without consequence. For example, upon hearing a noise a foraging animal may stop temporarily and lift its head, thus not causing a significant impact.

More intrusive disturbances can occur, such as temporary displacement, without causing physiological duress. However, if the disturbance stimulus is frequent and severe enough, it may lead to lost foraging time, flight behaviour, increased energetic demands and chronic stress (e.g. Beale 2007 and references in EBA Engineering Consultants 2011), effects that would potentially cause negative impacts to an individual animal. The key question is whether or not there is a change in the animal's condition as a result of being exposed to a disturbance and the aggregate impact to the caribou population in question.

Impacts on populations and individuals can be both positive and/or negative, for example, seeking insect relief on man-made berms or deflection as a result of encountering a linear feature such as a pipeline (Ballard *et al.* 2000). The effects of disturbance on wildlife are perhaps some of the least understood and the most difficult to quantify of all the impacts associated with development (Donihee and Gray 1982).

One may hypothesize that individual-based behaviour due to human disturbance is consistent across populations or individuals; however, that is not the case. Behavioural responses are context-dependent as they are based on the frequency and type of prior exposure (to a disturbance type) and resulting conditioning (e.g. Beale 2007 in EBA Engineering Consultants 2011). Behavioural responses are not always predictable and responses may be interpreted differently (by researchers studying the animal). Also, habitat quality may influence disturbance response: for example, an individual might have a higher threshold to flee in a high quality forage site versus one with poor or lower quality (e.g. Gill *et al.* 2001).

Direct disturbance effects may cause an immediate physiological consequence, behavioural modifications, or mortality to wildlife (see EBA Engineering Consultants 2011). Physiological effects can be observed in the form of changes in body condition and productivity, which ultimately can have impacts at the population level. Behavioural modifications can include issues such as disruption from normal activities with energetic consequences, distributional shift in range usage, alterations of movements, such as between foraging habitat and areas of insect relief, and avoidance behaviour. During a severe level of disturbance caribou may exhibit a startled reflex, followed by flight behaviour. During such responses animals may fall or become trampled.

Young ungulates are especially vulnerable to being trampled. One study of caribou calf mortality documented that three young caribou were trampled during panic and flight from either wolves or aircraft (Miller and Broughton, 1974 in EBA Engineering Consultants 2011). Calves can also become separated from their mothers during flight behaviour, leaving them exposed to potential predators. Much of the literature relating to human-wildlife disturbances measures direct impacts such as behavioural responses (e.g. death, energetic costs, altered behaviour, and avoidance of otherwise suitable habitat) (see EBA Engineering Consultants 2011 and references therein).

5.4.5 Regional Scale Effects

Human infrastructure can act as complete or partial barriers influencing or hindering caribou movements and preventing groups of animals from reaching important calving areas or feeding sites. As reviewed in Sivertsen (2012) a large number of scientific studies have reported negative impacts of human infrastructure on *Rangifer* space use at the regional scale (e.g. Johnson *et al.* 2005; Vistnes and Nellemann 2008; Vors and Boyce 2009; Nellemann *et al.* 2010; Polfus *et al.* 2011).

Nellemann *et al.* (2001) showed that densities of wild reindeer in Norway were almost 95% lower in areas within 5 km from power lines associated with roads and ski trails, compared to areas further away. In Alaska a marked decline in calving caribou abundance was observed in areas closer than 4 km from oil field infrastructure (Nellemann and Cameron 1996). In another study Taillon *et al.* (2012) assessed changes in the location of calving grounds used by migratory caribou over 35 years by the Rivière-George (RG) herd and 15 years by the Rivière-aux-Feuilles (RAF) herd, in Northern Québec and Labrador, Canada. Calving grounds moved 300 km northward in the Ungava peninsula for the RAF and shifted over 230 km back and forth to the Labrador coast for the RG. The authors conclude that protection of calving grounds of migratory caribou must consider the dynamic use of space by adult females.

Probably the largest body of work pertaining to human impacts on caribou focuses on the Kuparuk Development Area, west of Prudhoe Bay, Alaska. The Central Arctic caribou herd has been studied for approximately 40 years since oil was first discovered at Prudhoe Bay in 1968 (see EBA Engineering Consultants 2011). Despite dozens of studies, over multiple decades, EBA Engineering Consultants (2011) concludes that the results are difficult to quantify and that results are often not comparable

across studies. Cronin *et al.* (1998) concluded that, at the individual level, caribou may be impacted through disturbance or impedance of movements, but effects at the population level were not apparent and no cause-and-effect relationship has been demonstrated (see also Ballard *et al.* 2000 and references in EBA Engineering Consultants (2011).

The degree of changes in the location of calving grounds plays an important role in how susceptible Barren-ground caribou may be to potential population-level effects (as a result of human disturbance). The same may apply to range fidelity for sedentary woodland caribou. Faille *et al.* (2010) studied the relationship between habitat disturbances and home-range fidelity across three study sites in Québec, Canada, using a broad range of natural and human disturbances. Between 2004 and 2007, the authors tracked 47 adult female caribou using GPS collars. Home-range fidelity varied between seasons, being higher during calving and summer, and lower during winter. Caribou reduced fidelity following natural and human disturbances, the latter having a stronger negative influence. Human disturbances had a strong negative impact on home-range fidelity during annual, summer and winter periods, whereas natural disturbance was the dominant factor during calving. Despite this negative influence on fidelity, caribou tended to demonstrate range fidelity even in study sites most impacted by human activities.

5.4.6 Cumulative Effects

Cumulative effects can be defined as effects which are caused by the combined results of past and current human disturbances (see e.g. Elvin *et al.* 2012) and multiple disturbance agents occurring on multiple spatial and temporal scales. Individual-based and population-level responses from disturbances are complex and can vary among disturbance types, season, and population.

Wolfe *et al.* (2000) conclude that cumulative costs are a function of the intensity and frequency of disturbance effects, the proportion of the population that is exposed to disturbance, the location and temporal extent of disturbance and the suite of disturbances that impinge on individuals across seasonal ranges. Mineral exploration and extraction are increasing in polar regions and the resulting disturbances on *Rangifer* are broad and vary across subspecies, space (winter and summer grazing areas), and time, including seasons (e.g. pre-calving, calving season) or phases of mining activity (Herrman *et al.* 2014).

Increased human presence and linear human infrastructure associated with mining development, such as roads, railway tracks, power lines, can encroach upon migration paths and lead to a direct and indirect loss of habitat (i.e. habitat fragmentation). Some evidence shows that *Rangifer* may avoid industrial sites, buildings, and move away from aircrafts. In Nunavut, mining activities increasingly occur near calving grounds where females are most sensitive to human disturbance. The nutritional or stress cost of responding to human disturbance may have cumulative implications for individual fitness and population productivity. Human-caused disturbances can also modify interspecific interactions, such as predation rates.

In summary, the impact of development on caribou is usually not due to single roads, mines, cut - blocks or seismic lines; rather, it is the cumulative effect of many habitat alterations including disturbances over time that affects caribou numbers and distribution (Adamczewski *et al.* 2013) (see illustration in Figure 1).

Rangifer populations are subject to population cycles with times of very low abundance, even in the absence of any human disturbance. There are associated risks present for such population dynamics: if populations are at low levels and/or experience prolonged low fecundity rates, human disturbances such as mining activity nearby or in calving areas (or other critical habitat) may have proportionally more severe effects.

Gunn et al (2011) note that each of the major projects that are subject to environmental assessments include cumulative effects assessments but they are proponent rather than issue-driven and have not made a significant contribution to managing cumulative effects. Concerns about cumulative effects and limits to development footprints are an on-going concern (see GNWT, 2015 and references therein and Gunn et al. 2014). For example, the recommendations of the Joint Review Panel (2010), which recognized the threat of the Mackenzie Gas Project, included range management plans for the winter ranges of the Cape Bathurst and Bluenose-West herds, which would include linear and area density development thresholds.

5.4.7 Summary and Conclusions

There is a strong ecological distinction between sedentary and migratory caribou (Schaefer 2013). Migratory caribou such as Barren-ground caribou may show 100-fold changes in population abundance (Bergerud 1996; Couturier *et al.* 2010) and dramatic changes in the size of migratory herds are the norm (Gunn et al. 2011). Whereas sedentary caribou (including populations of boreal woodland caribou) are primarily regulated by predators, Barren-ground caribou population dynamics are driven by the availability, quality and accessibility of forage (e.g. see references in Schaefer 2013). Although wolf predation is important for Barren-ground caribou, forage (in concert with climate) tends to be the principal limiting driver, especially at high population densities (Schaefer 2013 and references therein).

While the existence of a zone of influence (ZOI) has been generally accepted, questions remain as to its significance for a herd's demographics, causative mechanisms, and the extent to which it can be mitigated. Generally, the ZOI is likely to be dynamic, depending on the size, location and nature of the development (e.g. open pit versus underground; mines versus roads; etc.), the level of industrial activity or volume of traffic, time of year, and herd characteristics (population status, demographic structure, etc.).

Due to extremely high mobility, lower range fidelity and large fluctuations in spatial distribution of barren-ground caribou, it has been very difficult to clarify human-caused effects. To this date, scientific studies have not been able to clearly quantify, predict or identify threshold levels for human disturbance and their effects on population demography and dynamics via e.g. survival and reproduction. It is also very likely that, even if thresholds were identified, these would show a high degree of plasticity depending on local ecological settings (varying across herds and habitat).

The only conclusion that can be postulated is that it is extremely unlikely that human disturbances will have a positive effect – effects will most likely be either neutral or negative. Even if regional or local effects may be considered “neutral”, it remains unknown whether such “neutral” effects can accumulate and result in negative impacts in the longer term.

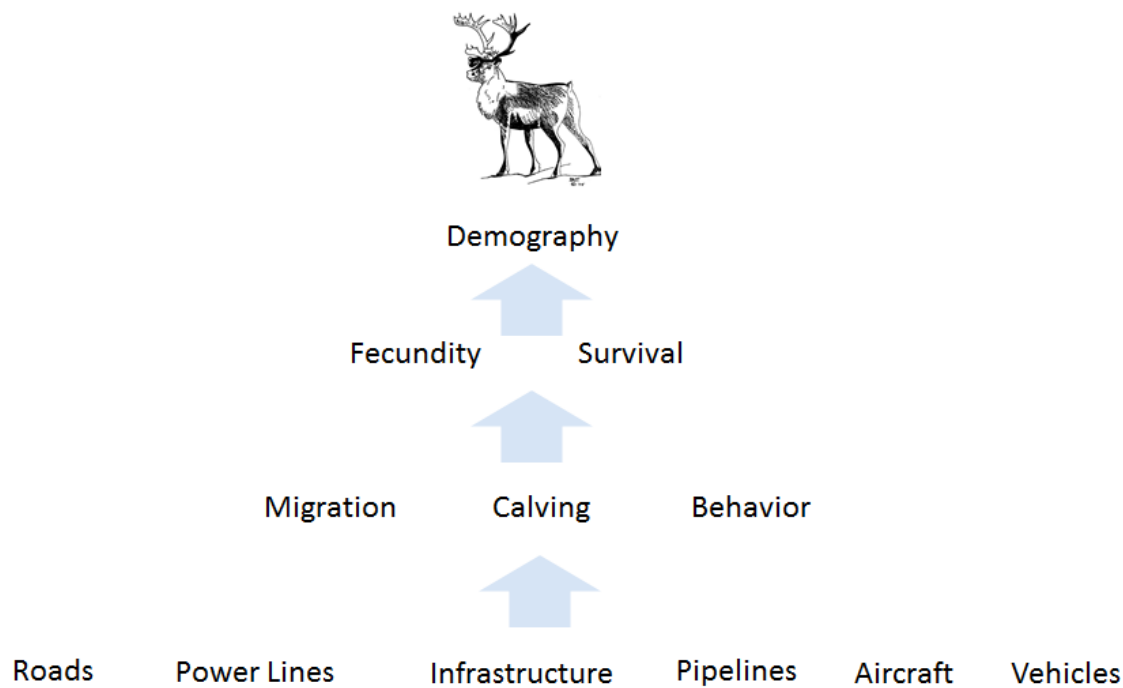


Figure 1: Human disturbance agents and their effects on caribou population demography

6.0 Caribou Protection Measures in Nunavut

The existing Caribou Protection Measures in Nunavut are summarized in section 6.1. Their origins (6.1.1) and rationale (6.1.2) are discussed, followed by a summary of their assessments as found in the literature (6.1.3). Some additional degree of protection is offered to caribou in the Keewatin and North Baffin Regions through the land use plans developed by the Nunavut Planning Commission in

2000. This is discussed in section 6.1.4, while section 6.1.5 outlines the measures put in place for the protection of caribou and their habitat by the Qikiqtaani Inuit Association in 2014.

In Section 6.2 we summarize the measures and guidelines currently employed by other jurisdictions in an attempt to balance the needs of caribou with the economic benefits of resource extraction. We have broken these down into the categories of designated protected areas (6.2.1), calving grounds (6.2.2), migration routes and water crossings (6.2.3), other habitat considerations (6.2.4), and sensory disturbance – including roadways, aircraft, dust, and noise (6.2.5).

Finally, we make use of the same categories to summarize relevant recommendations from the literature in sections 6.3.1 to 6.3.5, with the addition of a section to emphasize the need for ongoing research and monitoring (6.3.6).

6.1 Existing Nunavut Caribou Protection Measures

Two versions of Caribou Protection Measures are currently in place in Nunavut; these are included as Appendices in the Keewatin and North Baffin Regional Land Use Plans (Nunavut Planning Commission 2000a and 2000b respectively). These measures were originally written by Aboriginal Affairs and Northern Development Canada (then the Department of Indian Affairs and Northern Development) to offer protection to the Beverly and Qamanirjuaq herds from development and exploration activities in the vicinity of Baker Lake. They were later included as an example of the types of measures that could be considered in land use planning for the north Baffin region (Nunavut Planning Commission 2000b). The North Baffin Land Use Plan (Nunavut Planning Commission 2000b) recognizes the need to modify the protection measures to the Baffin herd, specifically to designate regional caribou calving areas; however it seems that this exercise was never completed. In any case, the measures as included did have the potential to offer some degree of protection to Baffin caribou. Following from the Keewatin Land Use Plan (Nunavut Planning Commission 2000a) the North Baffin Caribou Protection Measures are intended to apply to all lands, including Inuit Owned Lands and Crown Land. A Land Use Plan for the West Kitikmeot was drafted, which included a modification of the Keewatin Caribou Protection Measures; however, the plan was never formally adopted (Gunn and Poole 2009).

6.1.1 Origins of Existing Nunavut Caribou Protection Measures

Nunavut's Caribou Protection Measures were conceived, developed, and implemented within the first few months of 1978 (Gunn *et al.* 2007 and Nunavut Planning Commission 2000a). A German company, Urangesellschaft Canada Ltd., was giving consideration to mining uranium in the Baker Lake Area during a period of caribou decline (Nunavut Planning Commission 2000a). During the process Interdisciplinary System Ltd. was contracted to undertake an investigation of the potential effects of such a development on wildlife in the region, including an evaluation of the importance of

wildlife harvesting to Inuit (Gunn *et al.* 2007 and references therein). The resulting report suggested that exploration and development activities be separated from caribou, and identified calving grounds and traditional water crossings through interviews with Inuit (Gunn *et al.* 2007 and references therein).

The report raised conflict between Aboriginal Affairs and Northern Development Canada and the community of Baker Lake, which ultimately ended in the courts (Court Order T-1628-78; Gunn *et al.* 2007 and references therein). The community's position was that resource extraction activities posed a threat to local caribou populations, while Aboriginal Affairs and Northern Development argued that the decline was a result of harvesting and wolf predation (Gunn *et al.* 2007 and references therein). In April of 1978, the federal judge stated: "The minerals, if there, will remain; the caribou presently there, may not" (Gunn *et al.* 2007 and references therein). He recommended that aircraft avoid low level flights over the Beverly and Qamanirjuaq herds, and, which ultimately prompted Transport Canada to issue a set of relevant recommendations to pilots. The judge ruled that the findings reported in the report produced by Interdisciplinary Systems would provide the basis for caribou protection (Gunn *et al.* 2007 and references therein). The Caribou Protection Measures, as currently included in Appendix H of the Keewatin Land Use Plan, were introduced by Aboriginal Affairs and Northern Development within a week followed shortly afterwards with the formation of the Beverly-Qamanirjuaq Caribou Management Board (Gunn *et al.* 2007 and references therein). Shortly after the ruling, Transport Canada independently issued a separate set of recommendations against low level flights in the vicinity of the Beverly and Qamanirjuaq herds (EBA Engineering Consultants 2011).

A year later Aboriginal Affairs and Northern Development launched a comprehensive study of land use opportunities in Lancaster Sound (Nunavut Planning Commission 2000b). The need for a guiding document was recognized, and the Lancaster Sound Regional Land Use Planning Commission was formed in 1986 (Nunavut Planning Commission 2000b). The Keewatin and Lancaster Sound Land Use Plans were developed, and from what we can gather, relatively well implemented until the monitoring required to implement the measures was stopped in 1990 as a result of insufficient funding (Gunn *et al.* 2007).

Between 1993 and 1996 the Nunavut Final Agreement was ratified and the *Nunavut Land Claims Agreement* came into force. Along with these changes, came a shift in land use management. Land use permits were to be issued by the Regional Inuit Associations and the existing land use plans were updated by the newly formed Nunavut Planning Commission to ensure compliance with Part 5 Article 11 of the *Nunavut Land Claims Agreement* (Nunavut Planning Commission, 2000a and 2000b). The revised versions were signed off by the Nunavut Planning Commission, Aboriginal Affairs and Northern Development, and the Government of Nunavut (Nunavut Planning Commission 2000a and 2000b). These versions of the Keewatin and North Baffin Land Use Plans were signed off in 2000, and have not been modified since. As such, Nunavut's current Caribou Protection Measures only afford protection to caribou within these areas, and only from those activities that are required to obtain a land use permit.

6.1.2 Rationale of the Existing Nunavut Caribou Protection Measures

It is evident when reading through the existing Nunavut Caribou Protection Measures, that they were primarily intended to provide protection to Beverly and Qamanirjuaq caribou during calving season and at traditional water crossings. As calving was identified to be the most sensitive time for these caribou (EBA Engineering Consultants, 2011 and references therein) Caribou Protection Areas were developed based on the traditional calving grounds of the herds as per data provided by the Canadian Wildlife Service and the Northwest Territories Fish and Wildlife Service, and through the knowledge shared by Baker Lake residents (Gunn *et al.* 2007). Prior to 1990, aerial monitoring efforts were conducted annually to compare the actual location of that year's calving grounds with the Caribou Protection Areas (Gunn *et al.* 2007). Until monitoring was discontinued in 1990, annual reports on the actual locations of calving caribou provided Aboriginal Affairs and Northern Development Canada with the information they required to modify the boundaries of Caribou Protection Areas from year to year as deemed appropriate (Gunn *et al.* 2007 and references therein). The boundaries outlined in the 2000 Land Use Plan reflect the last such modification (Gunn *et al.* 2007).

During their revision of the Keewatin Regional Land Use Plan in 2000 (a), the Nunavut Planning Commission determined that additional protection was warranted in a number of locations. Through cooperation with federal departments, the Thelon Game Sanctuary was established, and National Historic Sites have been developed at the appropriately named Fall Caribou Crossing near Baker Lake, and at Sentry Island outside of Arviat (Nunavut Planning Commission 2000a). For clarification, the 2000 Keewatin Land Use Plan states that:

...existing Conservation Areas, the Thelon Game Sanctuary and the McConnell River, Harry Gibbons and East Bay migratory bird sanctuaries shall retain their current status. Development activities shall continue to be prohibited within the Game Sanctuaries (Conformity Requirement 2.1, Nunavut Planning Commission 2000a).

Inside the Caribou Protected Areas, industrial activity is halted between May 15 and July 15 annually (i.e. calving season; Nunavut Planning Commission 2000a). Under the original plan, a monitoring program was in place that provided decision makers with information on the distribution of caribou (Nunavut Planning Commission 2000a). This afforded some measure of flexibility, as a land use inspector had the authority to lift these restrictions should caribou be outside the vicinity of a particular operation. Similarly, restrictions could be lifted before July 15 if the monitoring data indicated that caribou were unlikely to make use of the area during that time frame. Outside of designated protected areas, land use activities are able to proceed unless caribou are present (Nunavut Planning Commission 2000a). This combination theoretically minimizes the impact to industry while maintaining some degree of protection for calving caribou; however, the practicality of this approach was also lost when monitoring was discontinued.

6.1.3 Assessment of the Existing Nunavut Caribou Protection Measures

The issue of the effectiveness of the Caribou Protection Measures was first quantitatively addressed by Mychasiw in 1984 (Gunn *et al.* 2007 and references therein). The result was based on the number of times a request for a release from the Caribou Protection Measures was denied by Aboriginal Affairs and Northern Development Canada – a method ultimately determined to be of questionable reliability (Gunn *et al.* 2007 and references therein).

Nearly 15 years later, consultants were hired by Aboriginal Affairs and Northern Development Canada to conduct interviews with land use and wildlife management agencies in Nunavut and the Northwest Territories (Gunn *et al.* 2007 and references therein). As summarized by Gunn *et al.* (2007) the report –which was completed in 2001 - laid out the following primary conclusions: i) the discontinuation of the monitoring program makes it impossible to assess either the effectiveness of the Caribou Protection Measure or the rate compliance with them; ii) the lack of annual survey data has resulted in out-dated Caribou Protection Areas meaning the amount of protection afforded caribou by these boundaries is unknown; and iii) the existing Caribou Protection Measures provide protection to caribou themselves but not to their habitat, and pertain to exploration activities more so than to development.

In contrast, the Nunavut Planning Commission determined that “...the existing regulatory structure provides sufficient protection for these areas at this time” (from the Keewatin Regional Land Use Plan; Nunavut Planning Commission 2000a) which they based on the fact that the Beverly and Qamanirjuaq herds had thrived during the 15 years that the Caribou Protection Measures had been in place. The Keewatin Regional Land Use Plan (Nunavut Planning Commission 2000a) acknowledges, however, that the measures should be reviewed as additional information about caribou becomes available.

With respect to the effectiveness of the measures in north Baffin, the Nunavut Planning Commission (2000b) recognized that significant areas of caribou habitat were lacking formal designation, and that their protection would thus depend on cooperative efforts between government agencies and land users.

In 2007, Gunn *et al.* conducted a comprehensive review and assessment of the existing Caribou Protection Measures. Their findings are primarily based on a comparison between the Caribou Protected Areas and the actual locations of calving between 1978 and 2005, and a review of the available data produced through the application of the measures.

To compare actual calving grounds with the Caribou Protection Areas, Gunn *et al.* (2007) used monitoring data for the period of 1978 to 1990, and data from telemetry collars from Qamanirjuaq

cows for 1993 and 2005 (no relevant data were available for 1991 and 1992). They found that on average 68% ($\pm 19.4\%$ standard deviation) of the annual calving grounds were within the Caribou Protection Areas. The collar data were also able to provide the authors with the information they needed to locate the geographic center of the calving grounds. In most years (1993 to 2004) the center was within the Caribou Protection Areas. However, in 2005 following a particularly harsh winter resulting in a delayed migration of the herds, only 27% of the Qamanirjuaq caribou calved within the Caribou Protection Areas. Gunn *et al.* (2007) also found that the timing of caribou calving is variable: they tend to enter the protected areas before May 15 in some years, and later in others. They also suggest that a pattern exists, whereby the caribou tend to arrive early and leave early in one year, and enter and leave later the next. In addition, there was evidence supporting an overall shift in the calving season, with caribou tending to calve later in more recent years (Gunn *et al.* 2007). They suggest that the borders of the Caribou Protection Areas should be updated and combine data obtained from satellite collars and the most recent knowledge about traditional calving grounds.

Using the information on caribou calving timing and locations, Gunn *et al.* (2007) determined that if the Caribou Protection Measures had not been in place, calving caribou could have been exposed to 64 projects covered by land use permits in the Kivalliq Region between 1980 and 1990 (43%). Similarly, between 1993 and 2006 they calculated that in the absence of Caribou Protection Measures Kivalliq herds would have been exposed to an additional 19 operations (16%). If, on the other hand, the Caribou Protection Measures were in place but monitoring was not available (i.e. meaning no operations are released from the provisions) caribou would have been protected from 65 land use permits within the Caribou Protection Areas. Outside of the Protection Areas the absence of monitoring means that there is no basis for suspension of operation whether caribou are in the vicinity or not.

Between 1993 and 2005, Gunn *et al.* (2007) determined that up to 17% of permits issued may have had caribou in the vicinity, which would have prompted a suspension had monitoring been available. Before that period, there were two instances when operations were suspended as a result of caribou being detected in the area through monitoring efforts. In addition, one camp shut down voluntarily when calving caribou were present (Gunn *et al.* 2007). With respect to compliance, Gunn *et al.* (2007) note that no independent data exist and that the rate of inspection is only 47% for open permits. In their concluding remarks, Gunn *et al.* (2007: 32) issued the following statement:

. . . prospecting permits, quarry permits or leases, mineral claims and surface land leases are also potential sources of human activity on calving and post-calving ranges (that currently do not require land-use permits) . . . as of September 2006, (Aboriginal Affairs and Northern Development) had issued 37 prospecting permits, 417 mineral claims and 10 mineral leases for the Beverly and Qamanirjuaq calving grounds. At this stage, it is unknown how those translate into activities on the ground. The only protection for caribou is if any of the activity reaches the stage of application for a Land Use Permit.

6.1.4 Additional Protection Offered through Existing LUPs

The Keewatin and North Baffin Regional Land Use Plans can potentially offer some additional measure of protection to caribou during calving and migration in the form of Conformity Requirements, Terms, and a Code of Good Conduct for Land Users.

The following points are relevant examples from the Keewatin Regional Land Use Plan (Nunavut Planning Commission 2000a):

- Conformity Requirement 2.6 prohibits development activities on both Inuit Owned and public lands and waters in caribou calving areas during calving season, and in caribou water crossings (page 80);
- Conformity Requirement 2.8 lists sites located within caribou calving areas as a priority for clean-up of industrial waste (page 80);
- Code of Good Conduct for Land Users #3 recommends against low altitude flights whenever possible in areas where they will disturb wildlife (page 98);
- Code of Good Conduct for Land Users #4 broadly states that land use activities should be conducted in a way that conserves renewable resources in a given area (page 98); and
- Code of Good Conduct for Land Users #6 cautions that land use activities should be restricted during calving, post-calving and migration (page 98).

Similar statements can be found within the North Baffin Regional Land Use Plan (Nunavut Planning Commission 2000b: 84-87, 109) with the addition of a recommendation that “The (Qikiqtaaluk Wildlife Board) and the communities should carry out research on caribou in the region, particularly with regard to calving grounds and migration patterns. . .” (Nunavut Planning Commission 2000b: 37).

6.1.5 Mary River Project Specific Caribou Protection Measures

In January, 2014 the Qikiqtaani Inuit Association announced that Caribou Protection Measures specific to the Mary River Project had been developed in cooperation with Baffinland. They were based on the original measures developed in 1978 and the 2000 North Baffin Regional Land Use Plan, and incorporated modifications to account for specifics pertaining to the proposed Mary River Project (Qikiqtaani Inuit Association 2014).

The joint statement from the Qikiqtaani Inuit Association and Baffinland notes that Caribou Protection Areas as defined in the North Baffin Regional Land Use Plan have never been adopted (Qikiqtaani Inuit Association 2014). In light of this, both parties recognized that the development of Caribou Protection Areas will be required to identify where certain mitigation efforts may be

required and that there may be a need to update the project-specific Caribou Protection Measures to reflect modifications to the Regional Land Use Plan (Qikiqtaani Inuit Association 2014).

The Mary River Caribou Protection Measures specify that Baffinland will work with a designated Terrestrial Environment Working Group to identify designated water crossings, taking seasonality and ice formation into consideration (Qikiqtaani Inuit Association 2014).

With respect to mitigation of disturbance during the calving season and at designated crossings, monitoring will be required to identify relevant thresholds that will be used to trigger appropriate mitigation strategies (Qikiqtaani Inuit Association 2014). Such thresholds will incorporate caribou presence and herd size, and could potentially trigger a shutdown of local operations. As with previous land use plans in the territory, flexibility is incorporated in that operations may be permitted to take place in season should pre-determined criteria be met (Qikiqtaani Inuit Association 2014). Similarly, traffic may be limited during calving season should cows and calves be observed within 100 m of roads or railways (Qikiqtaani Inuit Association 2014). This threshold, however, may be modified depending on herd size and could trigger a variety of mitigation efforts including: reducing vehicle speed, conveying trucks, and the use of pilot vehicles (Qikiqtaani Inuit Association 2014). In the event that Project Protection Zones are established, roads and rail bed berms may be required to have lower slopes, enhanced snow clearing may be required, and modifications to existing infrastructure may be required in order to maximize the line of sight between drivers and caribou. In addition, trucks may be capped, blasting may have to be avoided when the winds reach a given speed, and dust suppression on hard surface roads may be required to dust fall onto surrounding vegetation that may be used as forage by caribou (Qikiqtaani Inuit Association 2014).

6.2 Existing CPM in other jurisdictions

In other parts of Canada and in Alaska caribou and their habitat are protected from exploration and development activities through a variety of management tools. The majority of these seem to be project-specific and take the form of operational guidelines, permit conditions, stipulations, and requirements attached to land use permits. Following an overview of these procedures in different jurisdictions, Sections 6.1.3 through 6.1.5 summarize the information we were able to locate on protection and mitigation measures in place that are specific to caribou.

Nunavut's Caribou Protection Measures were used as the basis for much of the caribou management framework that exists today in the Northwest Territories (EBA Engineering Consultants 2011). In their 2011 review of guidelines to mitigate the impact of human disturbance on ungulates, EBA stated that there were no public documents outlining mitigation and management plans for barren-ground caribou in the Northwest Territories. The Northwest Territories requires that land users develop a project-specific Wildlife and Wildlife Habitat Protection Plan and/or a Wildlife Effects Monitoring Program (Government of Northwest Territories 2014). Together, these documents will ensure that land users develop wildlife and habitat mitigation, protection, and monitoring programs appropriate

for the nature and scope of their project on both local and landscape scales (Government of Northwest Territories 2014). Neither of these requirements addresses the conservation needs of caribou specifically; however, the territory requires that a caribou protection plan be submitted to the Department of Sustainable Resource Development before an exploration or construction activity is initiated within an identified area (Government of Northwest Territories 2014). Using this approach, regulatory agencies can ensure that measures are in place and applied consistently to control or limit the extent of human disturbance on caribou and their habitat (EBA Engineering Consultants 2011; Government of Northwest Territories 2014). In a number of Inuvialuit communities, Community Conservation Plans are also in place that include considerations specific to the migratory nature and aggregated calving of barren-ground caribou. These plans generally have a broad scope, stressing the importance of habitat protection and identifying areas of special interest rather than specifying details of required mitigation efforts (EBA Engineering Consultants 2011).

Like the Northwest Territories, the Yukon has no public documents outlining mitigation and management plans for barren-ground caribou. In 2009 the territory undertook a decision to implement interim conservation measures for the Porcupine herd in order to fulfill obligations under the land claims agreements (Environment Yukon 2009). This interim approach is still in place as Yukon works towards a set of guidelines and mitigation strategies based on a zone-of-influence approach to caribou protection (EBA Engineering Consultants 2011).

Northern Quebec and Labrador share a number of caribou herds, both migratory barren-ground and sedentary woodland populations. Nunavik identified caribou as a priority species to Nunavimmiut in Plan Nunavik – a document prepared by Kativik Regional Government and Makivik Corporation (2011) in response to the Quebec Government's Plan Nord (2010). Plan Nunavik recognizes the importance of engaging in discussion surrounding the potential implications of human disturbance and the need for herd specific management actions to effectively conserve their caribou populations. Similarly, in 2004 the Labrador Woodland Caribou Recovery Team, identified the evaluation of land use changes on the quality and quantity of available critical and recovery habitat for caribou as a priority in the region, and determined that it was necessary to develop a set of guidelines and recommendations to mitigate impacts in these areas.

In Alberta, members of the mining and forestry industry must submit a caribou specific protection plan identifying mitigation measures aimed at minimizing habitat loss (Government of Alberta 2012). For projects that are not subject to an Enhanced Approval Process, the Department of Environment and Sustainable Development reviews these protection plans and can request modifications and attach conditions to the permit before any exploration or construction activities occur within particular areas (Government of Alberta 2012). The Alberta Woodland Caribou Recovery Team (2005) has criticized this approach of applying project specific operational guidelines for not being applied consistently.

A similar approach is employed by the province of Manitoba, where project-specific mitigation measures are attached as conditions to permits issued to industry (Manitoba Conservation 2011). In relation to caribou, such conditions are most often related to sensitive areas, movement corridors, and critical habitat (Manitoba Conservation 2011).

British Columbia takes the project-specific approach a step further, by requiring proponents to develop and implement a mitigation plan that can be demonstrated to have either no impact or a net gain to the South Peace Northern caribou within 10 years of project approval (British Columbia Ministry of the Environment 2013a). The province has adopted a mitigation hierarchy of avoid, minimize, restore, or off-set and outlines principles and considerations for each level (British Columbia Ministry of the Environment 2013a).

As is the case in much of Canada, the State of Alaska does not have a publicly available document outlining caribou mitigation measures required by developers (EBA Engineering Consultants 2011), and does not have a land use plan in place in some of the areas most heavily impacted by oil and gas exploration (Canadian Parks and Wilderness Society 2013). As summarized by EBA Engineering Consultants (2011), specific recommendations are generally included as stipulations attached to development permits. A primary difference is that recommendations cannot be enforced while conditions carry some degree of regulatory protection under relevant legislation. When it is discovered that a developer is not complying with the regulations, the United States Fish and Wildlife Service will work with industry to develop a strategy for moving forward (EBA Engineering Consultants 2011).

6.2.1 Designated Protected Areas

The need for designating protected areas to preserve critical or sensitive habitat for caribou is well acknowledged across the range of the species (Nunavut Planning Commission 2000a and 2000b; Labrador Woodland Caribou Recovery Team 2004; Gunn and Poole 2009; Manitoba Conservation 2011; Cree Nation 2012; Canadian Parks and Wilderness Society 2013; Protected Areas Secretariat 2014). However, the designation of land as a national/provincial/territorial park, wilderness area, wildlife reserves, or similar can be lengthy process impeded by conflicting interests between those with non-complementary priorities and the need to consider often complex inter-jurisdictional processes. For example, First Nations communities in Alaska are in support of protecting a large tract of land in the Peel River watershed area that would provide protection to woodland caribou in the area; however the Yukon government has expressed interest in opening much of the same tract of land to developers (Canadian Parks and Wilderness Society 2013). Similar experiences have been reported for the development of Thaidene Nene by the Łutsel K'e Dene First Nation (see for example <http://landoftheancestors.ca/>)

Despite these challenges, new designated protected areas do become established. As mentioned previously, the Thelon Game Sanctuary and National Historic Sites were established with the 2000 modification of the Keewatin land Use Plan (Nunavut Planning Commission 2000a). A more recent (September 2015) example is from the Northwest Territories, where surface and subsurface rights were withdrawn in an area of more than 14,000 square kilometers based largely on recommendations by the Edézhíé Working Group (Protected Areas Secretariat 2014). The agreed upon boundary conserves the most important tracts of land for conservation of local wildlife, while excluding some the largest mineral deposits of interest to developers (Protected Areas Secretariat 2014).

In Quebec, the Cree have proposed the designation of lands in the Broadback Watershed as protected areas to conserve habitat for herds of woodland caribou (Cree Nation 2012). Their proposal makes use of two levels of protection in an attempt to balance competing ecological and economic interests in the area. The first level of protection would afford full protection from development, while the second level would be subject to specialized management practices (Cree Nation 2012).

6.2.2 Calving Grounds

In most cases, industrial activities on calving grounds are prohibited or restricted to some degree during calving season. This approach is similar to that described under Nunavut's current Caribou Protection Measures. For example, in Alberta industrial activities (with the exception of reforestation efforts) should not be approved between mid-February and until mid-July (Government of Alberta 2012). Other jurisdictions include considerations for calving season in the conditions and stipulations they attach to land use permits that limit the use of heavy equipment or blasting for example in calving season (EBA Engineering Consultants Ltd. 2011). In Alaska, the number of trips in and out of an industrial site should be minimized between May 20 and August 20 annually when caribou are within 0.5 miles (EBA Engineering Consultants Ltd. 2011). This approach is intended to protect caribou from the sensory disturbance of ongoing operations, but does not afford any solid protection to the habitat itself.

Among the few sources of information that we located that make specific mention of calving grounds, only Quebec seems to have any solid habitat protection in place. In the late 1990s the province designated the calving grounds the Leaf River and George River herds as Wildlife Habitat, affording the area legal protection against any activities that could negatively impact the habitat (Taillon *et al.* 2012 and references therein).

6.2.3 Migration Routes and Water Crossings

Outside of the current Nunavut Caribou Protection Measures, we were unable to find any reference to existing protection or mitigation measures for caribou water crossings or migration routes in Canada.

Stipulations often included in land use permits issued in Alaska prohibit permanent oil and gas facilities in primary caribou travel corridors, and recommend that pipelines be elevated a minimum of 7 feet, or that ramps be installed over those that may otherwise impede caribou movement (EBA Engineering Consultants Ltd. 2011). Similarly, it is recommended that land users monitor the potential for caribou crossings, and that roads be evacuated to allow large herds to cross with minimal disturbance. Interestingly, Alaska also specifically identifies the importance of caribou having unimpeded access to areas of insect relief during the summer months (EBA Engineering Consultants Ltd. 2011).

6.2.4 Other Habitat Considerations

Despite the lack of specific wording relating to calving grounds, water crossings, and caribou migration paths, the Northwest Territories and British Columbia make use of some fairly general language to mitigate disturbance to caribou during these periods. The Government of Northwest Territories simply requires that appropriate measures are in place to prevent or mitigate negative impacts to caribou and their habitat resulting from industrial operations within designated areas (EBA Engineering Consultants Ltd. 2011). In British Columbia, industrial land users must consider the amount and distribution of caribou habitat across all seasons in relation to the zone of influence of a given project when developing their proposed mitigation plan (British Columbia Ministry of the Environment 2013a). Specifically, they are required to identify how and to what extent the impact of their activities could be minimized or avoided by relocating their base of operations and/or adjusting the proposed timing of their operations (British Columbia Ministry of the Environment 2013a). In addition, they must propose offsetting measures to address the issue of residual impacts, and provide documentation to confirm that the proposed approach is a financially feasible option for the company (British Columbia Ministry of the Environment 2013a).

6.2.5 Vehicles and Aircraft

Vehicular traffic and low flying aircraft and their associated noise, and dust can effectively contribute to the fragmentation of a herd's range (Labrador Woodland Caribou Recovery Team 2004). With respect to roadways and travel corridors, Alberta emphasizes the use of temporary roadways whenever possible (Alberta Woodland Caribou Recovery Team 2005) that are to be removed annually before the winter season (Government of Alberta 2012). The theory is that this will limit the amount of traffic and minimize the long-term impacts on caribou habitat, particularly once the site is no longer active. The Alberta Government (2012) also requires that proponents develop strategies to mitigate the creation of travel corridors which could potentially be used by hunters, poachers, and by natural predators. A common stipulation in permit issues to land users in Alaska is that the maximum speed on roadways should be limited to 15 miles per hour when caribou are in the vicinity (EBA Engineering Consultants Ltd. 2011).

Following the issuance of the Caribou Protection Measures by Aboriginal Affairs and Northern Development Canada in 1978, Transport Canada posted guidelines for aircraft flying in the Keewatin Region (EBA Engineering Consultants Ltd. 2011 and references therein). Included in this list were recommendations to maintain a minimum altitude of 2,000 feet above ground level over calving areas, post-calving areas, and water crossings, and an altitude of 1,000 feet above ground level during spring migration and any other time over a group of caribou. The Northwest Territories has developed their own set of recommendations for pilots to follow, which suggests not taking off, flying over, or landing in calving areas of barren-ground caribou at all during the early summer season (EBA Engineering Consultants Ltd. 2011). In addition, the Environmental Impact Screening and Review Board formed under the Inuvialuit Final Agreement frequently advises minimizing the number of flights, promotes the use of small fixed wing aircraft, and cautions against hovering or circling over calving areas in the conditions they attach to land use permits in the region (EBA Engineering Consultants Ltd. 2011). Yukon has also increased the level of protection given to caribou herds in the region by developing a set of guidelines more stringent than those suggested by Transport Canada. These include advising pilots to maintain an altitude of 1,000 feet above ground level year round, and generally avoiding areas frequented by caribou known either through the pilot's personal observations on past flights or through discussion with the regional wildlife biologists, which is encouraged (EBA Engineering Consultants Ltd. 2011).

7.0 Recommendations

7.1 Traditional Knowledge Literature

Several documents from the literature review include a list of recommendations to protect barren-ground caribou and their habitat. For example, participants at the BQCMB Caribou Workshop made the following recommendations as a result of group discussions over two days (BQCMB 2011: 49-50):

- Revisit existing BQCMB reports with recommendations on ways to protect the Beverly and Qamanirjuaq herds and habitat, and send revised papers to governments.
- Compile permit conditions already issued to reduce disturbance.
- Patrol roads.
- Gate roads to control and reduce access.
- Pressure for protection of important habitat, including calving and post-calving areas (BQCMB). This includes a ban on permitting activities in these areas.
- Increase enforcement with more conservation (renewable resources) officers.
- Create more education campaigns (pamphlets/posters) and programs.
- Develop a more effective caribou management plan with action plans (BQCMB).
- Develop strong contemporary protective measures in advance of development.
- Establish an initiation/orientation period for aircraft, tourism, winter road companies.
- Pressure for no disturbance on migration routes.

- Create partnerships between communities and mining companies.
- Report infractions of wildlife legislation to conservation (renewable resources) officers.
- Ensure community representatives are involved in land use planning with governments, regulatory agencies, and resource management boards.
- Have residents monitor disturbance.
- Develop an alternative to collaring in order to monitor caribou.

Other consistent messages found throughout the traditional knowledge literature include:

- Respect caribou according to traditional laws.
- Apply the Precautionary Principle.
- Protect calving grounds.
- Avoid harassment.
- Let the land rest and heal.
- Impose community-based monitoring and stronger regulations.
- Consider scale.
- Work together despite challenges.

Respect Caribou According to Traditional Laws

Because it is what we eat, and that's how much they have respect for caribou. My mother says you can't laugh at bigger animals like caribou, moose. You can't talk smart about them; you have to have respect (E. Kay, 2007 in Wray and Parlee 2011: 73).

Wray and Parlee (2013: 74) discuss Gwich'in rules about caribou that echo rules expressed by others across the North (e.g. Padilla 2010; ACCWM 2011; Wray 2011; EMAB 2012; Legat 2012; Parlee et al. 2013):

- Don't laugh or "talk smart" about animals
- Don't shoot rutting bulls. Know/have knowledge/information about when the bulls are rutting and inedible so they are not shot and wasted.
- Don't leave wounded caribou behind.
- Let caribou cross the highway; the highway is closed when caribou are crossing.
- Take all the gut and parts home and clean up the site. You can use all of the parts, and leaving them on the side of the road is a problem.
- Share meat.
- Don't throw out meat or waste meat. Work with caribou meat immediately upon receiving it.
- Wait for each other when hunting.
- Don't hunt within the 500 m corridor on each side of the Dempster Highway.
- Don't chase caribou with skidoos.

Apply the Precautionary Principle

Often the results of work carried out by proponents of a development or other type of human disturbance do not align with the understandings of those most familiar with the land. In the absence of complete knowledge, a precautionary principle should be applied. As Williams (2015) reports:

During these sessions, Baffinland reiterated the conclusions in the FEIS. In relation to caribou they stated: "After design and mitigation, the Project is expected to cause no significant effects on caribou habitat, movement, mortality, and health (Baffinland, 2012D, slide 76).

This perspective was not shared by other actors attending the Final Hearings. As during previous phases of the EIA, considerable concerns were expressed about the Project, Baffinland's FEIS, and specifically about the potential for adverse effects on caribou. For example, during their presentation the GN stated that it is likely that the Project could have a significant impact on caribou (GN 2012B). They pointed to multiple stressors (e.g. mine site, railway, and roads) within the calving ground of a sensitive caribou population, and indicated that the impacts on caribou due to yearlong use of infrastructure, as well as the effectiveness of mitigation measures remain unknown (*ibid.* Williams 2015: 81)

The BQCMB has long urged governments and regulatory agencies not to issue permits on the calving ground. Yet mineral tenures have been issued, with uranium exploration from UraVan Minerals Incorporated owning more than half of almost 600 active mineral claims held by six companies on the Beverly calving ground in 2009-2010 (BQCMB 2015: 39).

After the Final Hearings concluded, the NIRB determined that the Mary River Project (MRP) should be approved, despite ongoing concerns raised by community members, and recognition from the QIA and GN that the assessment was incomplete and that impacts on caribou were not thoroughly assessed. After getting the final stamp of approval from the Federal Minister at AANDC, the MRP was granted a project certificate on December 28, 2012 (NIRB, 2012D). (Williams 2015: 86)

Protect Calving Grounds

Throughout the literature reviewed, community members have long advocated for the protection of calving grounds otherwise referred to as "nurseries" or likened to "a bird nest" (Thorpe *et al.* 2001; BQCMB 2011; Parlee *et al.* 2013; KIA 2012; GSCI 2015). The following excerpts speak to this point:

Workshop participants said the most sensitive caribou habitat should be given top protection – and that means full protection for calving grounds, with no permits issued in the calving

grounds and no flights allowed over calving grounds during the calving season. Caribou, are all, are a resource shared by different jurisdictions. Protecting a caribou herd's calving ground is more important in efforts to safeguard a herd than anything else (BQCMB 2011:38).

Protecting calving grounds and the Thelon region should be mandatory since uranium and other mineral exploration and activities affect caribou and habitat. Participants from Saskatchewan and Manitoba emphasized that governments, regulatory agencies and industry are not giving Northerners information. When communities write letters to governments, they don't get responses. When governments collect caribou samples, there is rarely feedback on test results. And generally, information gathered is not dealt with right away. Workshop participants said that governments, regulatory agencies and industry must be accountable to stakeholders. They must publicize best practices, informing the public who is working on caribou ranges, when they will be there, where they will be working, what they are doing there, and why they are doing it. Consultation with communities must be meaningful (BQCMB 2011: 39).

Avoid Harassment

Chasing caribou with aircraft, snowmobiles or all-terrain vehicles is harassment, participants stressed, as is bothering pregnant cows when they are migrating to the calving grounds. Hunters should keep a respectful distance from the animals, taking their time before shooting and then moving away as soon as possible. Using traditional hunting methods is a good option, and a number of participants recommended talking to elders when they returned to their communities. When people see hunters not using good hunting practices or breaking wildlife regulations, they should report them to conservation officers or other authorities (BQCMB 2011: 39).

Let the Land Rest and Heal

You know, sometimes your body gets tired. You need to lay down and rest. Without anybody bothering you, just rest. When you wake up you feel good. We need to do this for the Earth, let it rest for a little while (Beaulieu 2012: 67).

Regulation/ Monitoring

Many community members suggested that tougher restrictions for protecting caribou and their important habitats should be imposed when issuing land use permits, and that government officials should do inspections more frequently to make sure companies are following the conditions outlined in their land use permits (BQCMB 2011: EMAB 2011; GSCI 2015).

Consider Scale

Scale can influence whether impacts are considered significant in a mining context. For example, the GN argued that since Baffinland measured impacts on the scale of the entire North Baffin caribou range (rather than at the more relevant scale of the Regional Study Area) may have led to the conclusion of “low magnitude” impact (GN 2012: 16 *in* Williams 2015: 81).

Work Together Despite Challenges

I’m confident in traditional knowledge and I love working with scientists. When traditional knowledge holders sit together, we come with different opinion but if we talk about it long enough, we can work it out. It’s no different for the biologists when they sit together. But beyond all these arguments, we have to work together to make plans for the future (Beaulieu 2012: 66).

The vast expanse and remoteness of Baffin Island provides a number of logistical constraints for wildlife research. Many feel that there should be a greater reliance on Inuit Knowledge in wildlife research because it is very difficult to conduct successful and accurate aerial surveys. As well, some people may have a hard time understanding biologists when Inuit Qaujimajatuqangit is not used or referred to. Participants strongly felt that community-based monitoring, as well as Inuit input into study design must be integral for future scientific population assessments.

Many feel that there should be a greater reliance on Inuit Knowledge in wildlife research because it is very difficult to conduct successful and accurate aerial surveys (Government of Nunavut 2013: 3).

Harvesters reported that most of their knowledge about caribou was attained from other hunters and elders. Such emphasis on peers and elders within the knowledge-practice complex reinforces previous research and literature on the significant role that local knowledge systems play in local behaviour and resource management decision-making. This finding is significant given the breadth of information about caribou being shared through other government and popular sources (Wray 2011: 69).

As Williams discusses:

Scholars have argued that epistemological differences exist between Inuit Qaujimajatuqangit and Western knowledge systems that make their integration challenging. For example, Bates (2007) believes that Inuit may not predict and plan in the same way as Western scientists and policy makers. He states that the Western tendency to “claim knowledge about the future is perceived as rather futile, and even arrogant by many Inuit” because these predictions ignore the inherent complexity and uncertainty of the world (*ibid.*, p. 93). Bates goes on to posit that because of this reluctance to predict the future, Inuit prefer to pursue knowledge that

maintains flexibility and resilience in order to respond effectively to future conditions (*ibid.*). This characteristic of Inuit Qaujimajatuqangit can be expected to interact with EIA processes in at least two ways. Firstly, Inuit may be reluctant to definitively state (especially in formal consultation processes) what they perceive as the future risks or outcomes of a particular project. This could lead Western scientists or policy makers to conclude that IK does not exist or is inconclusive in relation to certain issues, and therefore lead them to proceed with Western knowledge as the only information available. The second is that large-scale projects may tie a community's wellbeing to a single resource or industry and therefore threaten the characteristics of flexibility and resilience on which Inuit place so much importance (*ibid.* Williams 2015: 30-31).

Recommendations from the traditional knowledge literature are supported by many of the recommendations found in the scientific literature, as discussed in the following section.

7.2 Western Science and Caribou Protection Measures

Generally speaking, there has been a fair amount of research conducted into the effects of human disturbance on caribou (as per Section 5.0 of this report), which has led to multiple discussions amongst various community members, stakeholders, wildlife and land managers, industry, and conservationists. The inevitable result is that there are far more recommendations for how to minimize the effects of industrial operations on caribou than have been implemented to date. We recognize that effective wildlife management often relies on the application of multiple strategies, particularly in instances where the population is declining or is otherwise considered at risk. We have sifted through literature and focused here on findings and recommendations from the Western Science literature and studies that pertain specifically to the potential development of Caribou Protection Measures."

7.2.1 Designated Protected Areas

There is little doubt that establishing designated protected areas in critical caribou habitat can only benefit the species in the long term. Francis and Nishi (2015) suggest that the highest quality habitat be provided with formal protection, and Manitoba Conservation (2005) recommends expanding existing protected areas within the current legal framework to secure specific habitat characteristics known to be of importance to the species. It is further recommended that habitat management zones be established within the Owl-Flintstone range, taking the seasonal requirements of calving, nursing, and wintering into consideration (Manitoba Conservation 2011).

The Labrador Woodland Caribou Recovery Team (2004) has identified the need to map existing protected areas in relation to critical and recovery habitat as an urgent priority and necessary step in identifying gaps in habitat protection.

With respect to Nunavut herds, the Bathurst Caribou Management Planning Committee (2004) suggested that the Northwest Territories Protected Areas Strategy be provided with the information they would require to identify areas for protection across the range of the herd. The Government of the Northwest Territories is currently sponsoring a Bathurst Caribou Herd Range Plan that will help to inform decision-making (see update: <http://www.wrrb.ca/news/bathurst-caribou-range-planning-process>). In the Qikiqtaaluk, the Nunavut Planning Commission (2000b) recommended that relevant parties cooperatively determine whether designated protected areas are required for north Baffin caribou. The Advisory Committee for Cooperation on Wildlife Management Bluenose-east, Bluenose-west and Cape Bathurst Caribou Management Plan (2014) is largely comprised of the comments, concerns, and suggestions that arise during community consultations. There was a resounding message that there is little point in protecting the caribou themselves if their habitat is not afforded an adequate level of protection.

7.2.2 Calving Grounds

Stemming from their assessment of the existing Caribou Protection Measures in Nunavut, Gunn *et al.* (2007) found that variation in the location and timing of calving depends largely on winter icing conditions, which have the potential to influence migrations routes. They suggest enacting Mobile Caribou Protection Measures that eliminate industrial activity between May 15 and July 15 provided satellite telemetry and aerial surveillance data indicate that calving caribou are not expected to be in the vicinity. Such an approach was incorporated in the draft West Kitikmeot Land Use Plan, and has been endorsed by the Bathurst Caribou Management Planning Committee (2004).

Taillon *et al.* (2012) had similar findings working with the George River and Leaf River herds in Quebec. They analyzed 15 years of aerial survey data and 20 years of telemetry data cumulatively covering a 37-year period, and found significant variation in the locations of calving grounds over time. The authors concluded that designating particular areas for protection may not provide a high level of long-term protection to calving caribou. However, this should be taken on a case by case basis, as widescale movement of calving grounds are usually accompanied by other factors, including major declines in the population.

Both Taillon *et al.* (2012) and Gunn *et al.* (2007) make reference to the difference between annual calving grounds, which are used by female caribou to calve in a given year, and traditional calving grounds, which encompasses variation in the location of the calving grounds observed over time. Taillon *et al.* (2012) recommend that the larger traditional calving ground be provided with some basic level of protection, while annual calving grounds are subject to restrictions on seasonal use.

7.2.3 Migration Routes and Water Crossings

One of the primary concerns Gunn *et al.* (2007) had when reviewing the Caribou Protection Measures was that the lack of monitoring since 1990 effectively meant that caribou were provided with no protection outside of the Caribou Protection Areas, as there was no basis on which to suspend activities. When analyzing caribou distribution data, they found that upwards of 17% of operations may have been subject to suspension of activity at some point between 1978 and 2005 given that caribou were in the vicinity.

As a follow to the 2007 assessment, Gunn and Poole (2009) conducted a pilot study on the use of Mobile Caribou Protection Measures in the Northwest Territories. When a collared cow was determined to be within a given distance of an active operation, it triggered aerial surveys over the general area. The results of the surveys would in turn be used to determine whether a suspension of activity was possible or imminent. Gunn and Poole (2009) determined that the approach was appropriate for late winter (the time of year the pilot study was conducted) but cautioned that both systems of monitoring were required in order to minimize disturbance to land users while maximizing the mitigation benefit to caribou.

The appeal of Mobile Caribou Protection Measures is that they move with the herd, through calving, during migration, in wintering areas, and over water crossings. This approach is in line with recommendations made by Francis and Nishi (2015) based on their work on migratory herds in the Yukon, who stressed the importance of maintaining migration corridors between summering and wintering areas. With respect to water crossings, Nunavut Tunngavik Inc. (1994) noted that the effect of shipping traffic in areas of dense ice formation should be considered in developing a land use plan for the Western Kitikmeot.

7.2.4 Other Habitat Considerations

Both Labrador and the Northwest Territories have determined that it is necessary to evaluate the effects that current level of impact human activity have had on caribou habitat. The Labrador Woodland Caribou Recovery Team (2004) emphasized the need to assess changes in land use patterns over time and their respective degrees of impact on the quantity and quality of essential caribou habitat. This assessment could then serve as a basis from which to develop a set of recommendations regarding mitigation measures in these areas. As of 2013, the Northwest Territories has been working towards the development of a collaborative protocol for tracking disturbance to wildlife habitat (Canadian Parks and Wilderness Society 2013).

A disturbance management threshold of 65% has been identified for woodland caribou across their range, with a management objective of maintaining self-sustaining populations (Environment Canada

2012). How this may compare to a similar measure for barren-ground caribou is unknown, although calculation may be useful in future land-use planning.

Of equal importance may be the need to consider which factors may be the most influential to ensuring population viability. On investigating this question in relation to the Carcross herd in the Yukon, Francis and Nishi (2015) determined that habitat loss within the herd's wintering range may in fact pose the most significant risk. As such, they recommend prioritizing the conservation of these areas.

A similar study in Quebec examined the connection between disturbance on various parts of the range of local woodland caribou and the viability of the population and found that the best course of action would be to restore habitat that had previously been the site of industrial activities (Rudolph *et al.* 2012). This approach is in line with that suggested by the Bathurst Caribou Management Planning Committee (2004) to develop guidelines relating to remediation of lands to increase the connectivity of suitable caribou habitat and, where this is not possible, to enact policy on the permanent loss of habitat resulting from industrial activity.

The effectiveness of any habitat management approach can be influenced by the spatial scale upon which it is carried out. This may be particularly true for long-range migratory species such as barren-ground caribou. Manitoba Conservation (2005) notes the importance of considering local, regional, and landscape scales. They emphasize the importance not only of identifying critical patches of habitat, but also in maintaining connectivity between them to assure population viability. From their work in the Yukon, Francis *et al.* (2013) recommend that a range assessment approach be applied in caribou management. They describe a range assessment as a methodical approach to assessing risks, defining management objectives, and ultimately identifying relevant management actions. They note, however, that there are few examples of this method in progress and recommended that a pilot project be undertaken with two herds of woodland caribou in the Yukon.

7.2.5 Vehicles and Aircraft

In their 2005 Conservation and Recovery Strategy for Woodland Caribou, Manitoba Conservation recommends assessing the degree of disturbance from all types of vehicles, followed by an investigation into the potential consequences of traffic in the species range. In their 2011 Action Plans, Manitoba recommends establishing guidelines for the creation and management of resource roads, including the recommendation that steps should be taken to reduce access by hunters, and recreationalists. This may address some direct mortality and reduce disturbance to some degree; however, as noted by the Alberta Woodland Caribou Recovery Team (2005) industrial traffic, in many cases, is responsible for the majority of the potential disturbance.

Following from some of the practices currently employed in other areas of Canada, Francis and Nishi (2015) recommend creating temporary seasonal roads located outside of core habitat areas whenever possible.

7.2.6 The Need for Continued Research and Monitoring

A recurrent theme throughout the literature reviewed, was the need for ongoing research and monitoring. The following population parameters have been put forward in various literature resources reviewed:

- Population size (Francis and Nishi 2015; Saskatchewan Ministry of Environment 2013; Manitoba Conservation 2005);
- Population structure (Francis and Nishi 2015; British Columbia Ministry of the Environment, 2013a; Saskatchewan Ministry of Environment 2013; Manitoba Conservation 2005);
- Health and growth rate of the population (Francis and Nishi 2015; British Columbia Ministry of the Environment 2013a; Saskatchewan Ministry of Environment 2013); and
- Distribution and habitat use (Saskatchewan Ministry of Environment 2013; Manitoba Conservation 2011; Bathurst Caribou Management Planning Committee 2004).

In addition to ensuring that managers have up to date information on the status of caribou populations, it is equally important to develop an understanding of whether the protection measures in place are effective, and to what extent (Bathurst Caribou Management Planning Committee 2004; Manitoba Conservation 2005; Gunn *et al.* 2007; Manitoba Conservation 2011; Government of Northwest Territories as per Canadian Parks and Wilderness Society 2013; Alaska Department of Fish and Game 2014). To do so may depend on monitoring the scale and location of human activity in relation to caribou distribution (Francis and Nishi 2015). In some cases it may be possible, and thus advisable, to directly monitor the responsiveness of caribou to land-use activities (Bathurst Caribou Management Planning Committee 2004; Manitoba Conservation 2011; Francis and Nishi 2015).

Finally, the importance of ongoing monitoring and reporting at each project site has been emphasized by Nunavummiut in consultation concerning the Bluenose east Bluenose West and Cape Bathurst Caribou Management Plan (Advisory Committee for Cooperation on Wildlife Management 2014). This sentiment is in line with the vision of the Bathurst Caribou Management Planning Committee (2004) to implement monitoring and mitigation protocols specific to each project site to minimize the effects of land use activities on caribou.

8.o List of References

Traditional Knowledge

Advisory Committee for Cooperation on Wildlife Management [ACCWM] (2014). We Have Been Living with the Caribou All Our Lives: A Report on Information Recorded during Community Meetings for “Taking Care of Caribou - The Cape Bathurst, Bluenose-West, and Bluenose-East Barren-ground Caribou Herds Management Plan”.

AREVA Resources Canada Inc. [AREVA] (2012). Kiggavik Project EIS Public Engagement and Inuit Qaujimagatuqangit. Pickering, Ontario. **Tier 2 Volume 3: 98**

Athabasca Chipewyan First Nation Elders [ACFN], J. Tanner, and A. Rigney. (2003). Footprints on the Land: Tracing the Path of the Athabasca Chipewyan First Nation. Fort Chipewyan, AB.

Banfield, A.W.F. (1961). Migrating Caribou. *Natural History* 20: 56-64

BHP Billiton Diamonds Inc. (2007). Ekati Diamond Mine. Caribou and Roads: Implementing Traditional Knowledge in Wildlife Monitoring at the Ekati Diamond Mine. 2006 Annual Report. Rescan Environmental Services Ltd. Yellowknife, NT.

Barnaby, J. and. D. S. (2013). Bathurst Caribou Harvesters’ Gathering. Wek’èezhìi Renewable Resources Board, Yellowknife, NT, Tłı̨chǫ Government & Wek’èezhìi Renewable Resources Board.

Beaulieu, D. (2012). "Dene Traditional Knowledge about Caribou Cycles in the Northwest Territories." Rangifer **32**(2): 59–67.

Benn, B. (2001). Fall Movements of the Porcupine Caribou Herd Near the Dempster Highway. Inuvik, NT, Gwich’in Renewable Resources Board.

Beverly and Qamanirjuaq Caribou Management Board [BQCMB] (2011). BQCMB Caribou Workshop February 2010- Detailed Report: Commentary from Workshop Participants about Challenges Facing the Beverly and Qamanirjuaq Caribou Herds and Some Possible Solutions. M. Soublière. Stonewall, MB, Beverly and Qamanirjuaq Caribou Management Board.

----- [BQCMB]. (2014). Beverly and Qamanirjuaq Caribou Management Plan 2013-2022 (Detailed). Stonewall, MB.

Community of Aklavik, Wildlife Management Advisory Council, and Joint Secretariat (2008). Aklavik Inuvialuit Community Conservation Plan: Akaqvikmiut Nunamikini Nunutailivikautinich. Inuvik, NT, Joint Secretariat.

Community of Inuvik, Wildlife Management Advisory Council and Joint Secretariat (2008). Inuvik Inuvialuit Community Conservation Plan. Inuvik, NT, Joint Secretariat.

Community of Paulatuk, Wildlife Management Advisory Council, and Joint Secretariat (2008). Paulatuk

Community Conservation Plan: A Plan for the Conservation and Management of Renewable Resources and Lands within the Inuvialuit Settlement Region in the Vicinity of Paulatuk. Inuvik, NT, Joint Secretariat.

Community of Tuktoyaktuk, Wildlife Management Advisory Council, and Joint and Secretariat (2008). Tuktoyaktuk Community Conservation Plan. Inuvik, NT, Joint Secretariat.

Croft, B. and J. P. Rabesca. (2009). Caribou Harvest Reporting Pilot Project Conducted in the Tli Cho Communities in the Winter of 2007/2008 and 2008/2009: Preliminary Results. Yellowknife, NT, Government of the Northwest Territories, Department of Environment and Natural Resources: 14 pp.

Dumond, M. (2007). Western Kitikmeot Caribou Workshop, Final Wildlife Report, No. 19. Kugluktuk, NU, Department of Environment, Government of Nunavut.

EBA Engineering Consultants Ltd. 2011. Anthropogenic disturbance on ungulates, guidelines and mitigation of impacts, Government of Nunavut, Department of Nunavut

Environmental Monitoring Advisory Board [EMAB], Traditional Knowledge and Inuit Qaujimajatuqangit Panel. (2012). A Way of Life: Bridging Science and Aboriginal Knowledge in Caribou Monitoring at Diavik Diamond Mine. S. C. Limited.

Gwich'in Institute Elders (1997). Nành' Kak Geenjit Gwich'in Ginjik: Gwich'in Words About the Land. Inuvik, NT, Gwich'in Renewable Resources Board.

———. 2001. Gwìndòo Nành' Kak Geenjit Gwich'in Ginjik (More Gwich'in words about the land). Inuvik, Northwest Territories: GRRB.

Gwich'in Social and Cultural Institute [GSCI] (2015). Gwich'in Knowledge of Bluenose West Caribou: A part of the Nin Nihlinehch'i' – Łi' hàh Guk'àndehtr'inahtìi (Animals at Risk - animals we are watching closely) Project. K. Benson. Fort McPherson, NT: 61.pp.

Inuvik Community Corporation, Tuktuuyaqtuuq Community Corporation and Akłarvik Community Corporation (2006). Inuvialuit Settlement Region Traditional Knowledge Report. Calgary, AB, Mackenzie Project Environmental Group.

Jacobsen, P. (2013). Tłıchǫ Knowledge of Environmental Changes: Implications for Caribou Hunting. Behchokǫ, NWT, Tłıchǫ Government.

Judas, J. (2012). "Tłıcho Stories for Ekwò Management." Rangifer 32(2): 49–51.

Katz, S. (2010). Traditional Knowledge on Caribou Ecology: Vegetation -> Caribou -> Wolf -> Food Chain. Inuvik, NT, Aurora Research Institute.

Kavik-Stantec (2012). Inuvik to Tuktoyaktuk Highway Traditional Knowledge Workshops: Inuvik and Tuktoyaktuk, February 2012. Final Report. Inuvik, NT & Calgary, AB, Kavik-Stantec: 53.

Kendrick, A. (2003). Caribou Co-Management and Cross-Cultural Knowledge Sharing, University of Manitoba.

Kendrick, A., P.O.B Lyver, and Łutsel K'e Dene First Nation (2005). "Denésoliné (Chipewyan) Knowledge of Barren-ground Caribou (*Rangifer Tarandus Groenlandicus*) Movements - Denésoliné (Chipewyan) Knowledge of Barren-ground Caribou (*Rangifer Tarandus Groenlandicus*) Movements." *Arctic* 58(2): 175-191.

Kitikmeot Inuit Association (2014). Naonaiyaotit Traditional Knowledge Project Hannigayok (Sabina Gold & Silver Corp. Proposed Back River Project). Results from Data Gaps Workshops. Final Report. B. C. Ltd. and S. G. Services. Kugluktuk, NU.

Krupnik and D. Jolly (eds.) 2002. The Earth is Faster Now: Indigenous Observations of Arctic Environmental Change Fairbanks, AK, Arctic Research Consortium of the United States.

Kugluktuk Hunters and Trappers Organization (KHTO) and Golder Associates Ltd. (2011). Effects of Development on Barren-ground Caribou: Insight from Inuit Qaujimagatuqangit and an Ecological Model.

Legat, A., G. Chocolate, and M. Chocolate (2008). Monitoring the Relationship between People and Caribou. Whatì, NT, Tłıchǫ Government: 35.

Legat, A. (2012). Walking the Land, Feeding the Fire: Knowledge and Stewardship Among the Tłıchǫ Dene. Tucson, AZ, University of Arizona.

Łutselk'e Dene First Nation and Wildlife Lands and Environment Department (2005). Ni hat'ni - Watching the Land: Results of 2003-2005 Monitoring Activities in the Traditional Territory of the Łutselk'e Denésoliné.

North Slave Métis Alliance Alliance [NSMA] (2012). North Slave Métis Alliance Traditional Land Use, Occupancy and Knowledge of the Thor Lake Project Area. Yellowknife, NT, North Slave Métis Alliance.

Northwest Territories Métis Nation (2012). Gacho Kue Mine Project Values, Interests, and Issues Identified at NWT Metis Nation Community TK Study Sessions. Fort Smith, NT, Northwest Territories Métis Nation: 7.

Padilla, E. and G. Kofinas. (2010). Documenting Traditional Knowledge of Caribou Leaders for the Porcupine Caribou Herd in Dawson City, Old Crow, & Fort McPherson. Inuvik, NT, Porcupine Caribou Management Board: 48.

Parlee, B., Manseau, M., and Łutsel K'e Dene First Nation (2005). "Watching the Land: Results of 2003-2005 Monitoring Activities in the Traditional Territory of the Łutsel K'e Denesoline." *Arctic* 58(1): 25-37.

Parlee, B., N. Thorpe and T. McNabb (2013). Traditional Knowledge: Barren-ground caribou in the Northwest Territories. Edmonton, Alberta, University of Alberta.

Parlee, B. and C. Furgal. (2012) "Well-being and environmental change in the Arctic: a synthesis of selected research from Canada's International Polar Year program, Climatic Change." Climatic Change.

Sahtu Land Use Planning Board (2013). Final Sahtu Land Use Plan. Fort Good Hope, NT, Sahtú Land Use Planning Board.

Sangris, F. (2012). "Renewing Our Traditional Laws through Joint Ekwo (caribou) Management, The 13th North American Caribou Workshop." *Rangifer* 32(20): 75-80.

Thorpe, N., N. Hakongak, S. Eyegetok and the Kitikmeot Elders (2001a). Thunder on the Tundra: Inuit Qaujimajatuqangit of the Bathurst Caribou. Vancouver, BC, Tuktu and Nogak Project.

Thorpe, N., N. Hakongak, S. Eyegetok, and Qitirmiut Elders (2001b). Tuktu and Nogak Project: A Caribou Chronicle, Final Report to the West Kitikmeot Slave Study Society. Ikaluktuuttiak, NU: 155.

Thorpe, N., S. Eyegetok and N. Hakongak (2002). Nowadays It is Not the Same: Inuit Qaujimajatuqangit, Climate and Caribou in the Kitikmeot Region of Nunavut, Canada. The Earth is Faster Now: Indigenous Observations of Arctic Environmental Change. I. Krupnik and D. Jolly. Fairbanks, AK, Arctic Research Consortium of the United States: 200-239.

Tłìchq Government. (2013). Tłìchq Wenek'e Tłìchq Land Use Plan. Behchokò, NT, Tłìchq Government: 66.

Wek'èezhì Renewable Resources Board [WRRB] (2013). Tłìchq Wildlife Research Workshop, Summary Report. Gamètì, NT, Wek'èezhì Renewable Resources Board.

Whaèhdò Nàowò Kò (2001). Caribou Migration and The State of Their Habitat, Final Report to the West Kitikmeot Slave Study. Yellowknife, NT: 120.

Wildlife Management Advisory Council [North Slope], Aklavik Hunters and Trappers Committee, and Aklavik Hunters and Trappers (2009). Aklavik Local and Traditional Knowledge about Porcupine Caribou. Whitehorse, YT, Wildlife Management Advisory Committee [North Slope]: 111.

Wildlife Management Advisory Council [WMAC], Aklavik Hunters and Trappers Committee and Aklavik Hunters and Trappers (2009). Aklavik Local and Traditional Knowledge about Porcupine Caribou. Whitehorse, YT, Wildlife Management Advisory Council [North Slope]: 111.

Williams, A. (2015). Governmentality and Mining: Analyzing the Environmental Impact Assessment for the Mary River Mine, Nunavut, Canada. Master of Arts, Carlton.

Wray, K. (2011). Ways We Respect Caribou: Hunting in Teet'it It Zheh (Fort McPherson, NWT), University of Alberta.

Wray, K. and B. Parlee. (2013). "Ways We Respect Caribou: Teet'it Gwich'in Rules." Arctic 66(1): 68-78.

Western Science

Adamczewski, J., Nishi J., Gunn A., Antoniuk, T., Johnson, C., Russell, D., Blondin, T., Legat, A., Beaulieu, D., Virgl, J., Chocolate Pasquayak, M. Wooley, B. (2013). Modeling Cumulative Effects in Barren-ground Caribou Range: Proceedings of a Workshop in Yellowknife, February 2008, Manuscript Report No. 233, 82 pp.

Ballard, W.B., M.A. Cronin and H.A. Whitlaw. (2000). Caribou and oil fields, Chapter 5, Pgs: 85-104 *In: The Natural History of an Oil Field, Development and the Biota*. Truett, J.C. and S.R. Johnson (eds.). Academic Press. New York, New York. 422 pp.

Beale, C.M. (2007). The Behavioral Ecology of Disturbance Responses. *International Journal of Comparative Psychology*, 20(2): 111-120.

Bergerud, A.T. (1974). Decline of caribou in North America following settlement. *Journal of Wildlife Management*, 38: 757-770.

Bergerud, A.T., R.D. Jakimchuk & D.R. Carruthers. (1984). The buffalo of the North: Caribou and human developments. *Arctic*, 37 (1): 7-22.

Bergerud, A. T. (1996). Evolving perspectives on caribou population dynamics, have we got it right yet? *Rangifer*, Special Issue 9: 95-116.

Boulanger, J., K. G. Poole, A. Gunn, and J. Wierzchowski. (2012). Estimating the zone of influence of industrial developments on wildlife: a migratory caribou *Rangifer tarandus groenlandicus* and diamond mine case study. *Wildlife Biology* 18:164–179.

Calef, G.W., E.A. DeBock and G.M. Lortie. (1976). The reaction of barren-ground caribou to aircraft. *Arctic*, 29(4): 202-212.

Cameron, R.D. and K.R. Whitten. (1980). Distribution and movements of caribou in relation to the Kuparuk Development area. Second Interim Report. Alaska Department of Fish and Game. Juneau, Alaska. 35 pp.

Cameron, R.D., Reed, D.J., Dau, J.R., and Smith, W.T. (1992). Redistribution of calving caribou in response to oil field development on the Arctic Slope of Alaska. *Arctic* 45(4): 338 – 342.

Cameron, R.D., Lenart, E.A., Reed, D.J., Whitten, K.R., and Smith, W.T. (1995). Abundance and movements of caribou in the oil field complex near Prudhoe Bay, Alaska. *Rangifer* 15:3 – 7.

Cameron, R. D., W. T. Smith, R. G. White, and B. Griffith. (2005). Central Arctic caribou and petroleum development: distributional, nutritional, and reproductive implications. *Arctic*:1–9.

Couturier, S., R. D. Otto, S. D. Côté, G. Luther, and S. P. Mahoney. (2010). Body size variations in caribou ecotypes and relationships with demography. *Journal of Wildlife Management* 74: 395-404.

Cronin, M.A., W.B. Ballard, J.D. Bryan, B.J. Pierson and J.D. McKendrick. (1998). Northern Alaska oil fields and caribou: A commentary. *Biological Conservation*, 83(2) 195-208.

Curatolo, J.A., S.M. Murphy and M.A. Robus. (1982). Caribou responses to the pipeline/road complex in the Kuparuk Oil Field, Alaska, 1981. Alaska Biological Research. Fairbanks,

Alaska. 64 pp.

Curatolo, J.A. and S.M. Murphy. (1986). The effects of pipelines, roads and traffic on the movements of caribou, *Rangifer tarandus*. Canadian Field-Naturalist, 100(2): 218-224.

Dantzer B, Fletcher QEF, Boonstra R, Sheriif MJ. (2014). Measures of physiological stress: a transparent or opaque window into the status, management and conservation of species? Conservation Physiology 2 (1)

Dau, J.R. and R.D. Cameron. (1986). Effects of a road system on caribou distribution during calving. Pages 95-101 In: Proceedings of the Fourth International Reindeer/Caribou Symposium, Whitehorse, Canada, 1985. Special Issue No. 1: 374 pp.

Donihee, J. and P.A. Gray. (1982). A review of road related wildlife problems and the environmental management process in the north. Department of Renewable Resources, N.W.T. Information Report No. 2. 20 pp.

EBA Engineering Consultants Ltd. (2011): Anthropogenic disturbance on ungulates, guidelines and mitigation of impacts, Government of Nunavut, Department of Environment.

Elvin, Sandra S.; Fraser, Gail S. (2012). "Advancing A National Strategic Environmental Assessment For The Canadian Offshore Oil And Gas Industry With Special Emphasis On Cumulative Effects.". Journal Of Environmental Assessment Policy & Management: 37.

Faille, G., C. Dussault, J.-P. Ouellet, D. Fortin, R. Courtois, M.-H. St-Laurent et C. Dussault. (2010). Range fidelity: the missing link between caribou decline and habitat alteration? Biological Conservation, 143: 2840-2850.

Fancy, S.G. (1983). Movements and activity budgets of caribou near oil drilling sites in the Sagavanirktok River floodplain, Alaska. Arctic, 36:193 - 197.

Fisher, C. A., D.C. Thomas, R.L. Wooley and P.S. Thompson. (1977). Ecological studies of caribou on the Boothia Peninsula and the District of Keewatin, NWT, 1976, with observations on the reaction of caribou and muskoxen to aircraft disturbance, 1974-1976. Prepared for Polar Gas project, Renewable Resource Consulting Services Ltd. 239 pp.

Flydal K, L. Korslund, E. Reimers, F. Johansen, and J. Colman. (2009). Effects of Power Lines on Area Use and Behaviour of Semi-Domestic Reindeer in Enclosures. Int. J. Ecol. 1-14.

Gill, J.A., K. Norris and W.J. Sutherland. (2001). Why behavioural responses may not reflect the population consequences of human disturbance. Biological Conservation, 97: 265-268.

Griffith, B., D.C. Douglas, N.E. Walsh, D.D. Young, T.R. McCabe, D.E. Russell, R.G. White, R.D. Cameron, and K.R. Whitten. (2002). The Porcupine caribou herd. Pages 8-37 In: Douglas, D.C., P. E. Reynolds and E. B. Rhode (eds.). Arctic Refuge coastal plain terrestrial wildlife research summaries. U. S. Geological Survey, Biological Resources Division, Biological Science Report USGS/BRD BSR-2002-0001.

Gunn, A., K. Poole, J. Wierzbowski, and M. Campbell. (2007). Assessment of Caribou Protection Measures. Submitted in fulfillment of NCR #830359 Indian and Northern Affairs Canada, Gatineau, Quebec. 45 pp.

Gunn, A., D. Russell and J. Earner. (2011). Northern caribou population trends in Canada 2010. Canadian Biodiversity: Ecosystem Status and Trends 2010, Technical Thematic Report No. 10. Canadian Councils of Resource Ministers, Ottawa.

Gunn, A., C.J. Johnson, J.S. Nishi, C.J. Daniel, M. Carlson, D.E. Russell and J.Z. Adamczewski. (2011). Chapter 8: Addressing cumulative effects in the Canadian Central Arctic -- understanding the impacts of human activities on barren-ground caribou. Pages 113-133 in P.R. Krausman and L.K. Harris (Eds.). Cumulative effects on wildlife management: impact mitigation. CRC Press, Boca Raton, Florida.

Gunn, A., D. Russell, and L. Greig. (2014). Insights into integrating cumulative effects and collaborative co-management for migratory tundra caribou herds in the Northwest Territories, Canada. Ecology and Society 19(4): 4. <http://dx.doi.org/10.5751/ES-06856-190404>

Hanson, W.C. (1981). Caribou (*Rangifer tarandus*) encounters with pipelines in northern Alaska. Canadian Field-Naturalist, 95(1): 57-62.

Herrmann, T. M., Sandström, P., Granqvist, K., D'Astous, N., Vannar, J., Asselin, H., Cuciurean, R. (2014). Effects of mining on reindeer/caribou populations and indigenous livelihoods: community - based monitoring by Sami reindeer herders in Sweden and First Nations in Canada. The Polar Journal , 1 - 24. doi: 10.1080/2154896X.2014.913917

Horejsi, B.L. (1981). Behavioral Response of Barren Ground Caribou to a Moving Vehicle. Arctic, 34(2):180-185.

Integrated Ecological Research. (2015). Caribou Zone of Influence Technical Task Group, Draft guidance for monitoring the zone of influence (ZOI) of anthropogenic disturbance on barren-ground caribou, March 10, 2015, retrieved on Oct 2, 2015 at: http://www.reviewboard.ca/upload/project_document/EA1314-01_ZOI_Draft_Guidance_Document_10Mar15.PDF

Johnson, C.J., and Russell, D.E. (2014). Long-term distribution responses of a migratory caribou herd to human disturbance. Biological Conservation 177:52-63.

Johnson, C. J., M. S. Boyce, R. L. Case, H. D. Cluff, R. J. Gau, A. Gunn, and R. Mulders. (2005). Cumulative effects of human developments on arctic wildlife. Wildlife Monographs:1-36.

Johnson, C.J., Ehlers L.P.W., Dale R.S. (2015). Witnessing extinction – Cumulative impacts across landscapes and the future loss of an evolutionarily significant unit of woodland caribou in Canada. Biological Conservation 186, 176–186.

Joint Review Panel. (2010). Foundation for a Sustainable Northern Future: Report of the Joint Review Panel for the Mackenzie Gas Project. Chapter 10: Wildlife. Published under the authority of the Minister of Environment, Government of Canada. March 2010. 62 pp.

Joly, K., C. Nellemann, and I. Vistnes. (2006). A reevaluation of caribou distribution near an oilfield road on Alaska's North Slope. *Wildlife Society Bulletin* 34, 866-869.

Klein, D.R. (1980). Reaction of caribou and reindeer to obstructions – a reassessment. p.: 519-527. In: Dantzer, E., E. Gaare and S. Skjenneberg (eds.). *Proceedings of the 2nd International Reindeer/Caribou Symposium*, Roros, Norway, 1979. Direktoratet for vilt og ferskvannsfisk, Trondheim. 779 pp.

Mahoney, S.P. & Schaefer, J.A. (2002). Hydroelectric development and the disruption of migration in caribou. *Biological Conservation* 107: 147-153.

Matthew, A.C., S.C. Amstrup, G.M. Durner, L.E. Noel, T.L. McDonald and W.B. Ballard. (1998). Caribou distribution during the post-calving period in relation to infrastructure in the Prudhoe Bay Oil Field, Alaska. *Arctic*, 51(2):85-93.

Miller, F.L. and E. Broughton. (1974). Calf mortality on the calving grounds of Kaminuriak caribou during 1970. *Canadian Wildlife Service Report Series No. 26*, Information Canada, Ottawa.

Miller, F.L. and A. Gunn. (1981). Play by Peary caribou calves before, during and after helicopter harassment. *Canadian Journal of Zoology*, 59: 823-827.

Murphy, S. M. & Curatolo, J. A. (1987). Activity budgets and movement rates of caribou encountering pipelines, roads, and traffic in northern Alaska. *Can. J. Zool.* 65, 2483-2490.

Nagy, J.A.S. (2011). *Use of Space by Caribou in Northern Canada*, University of Alberta, PhD Thesis.

Nellemann, C. and R. D. Cameron. (1996). Effects of petroleum development on terrain preferences of calving caribou. *Arctic*:23-28.

Nellemann, C. and R. Cameron. (1998). Cumulative impacts of an evolving oil-field complex on the distribution of calving caribou. *Canadian Journal of Zoology*, 76:1425-1430.

Nellemann, C., I. Vistnes, P. Jordhøy, and O. Strand. (2001). Winter distribution of wild reindeer in relation to power lines, roads and resorts. *Biological Conservation* 101:351-360.

Nellemann, C., I. Vistnes, P. Jordhøy, O. G. Støen, B. P. Kaltenborn, F. Hanssen, and R. Helgesen. (2010). Effects of recreational cabins, trails and their removal for restoration of reindeer winter ranges. *Restoration Ecology* 18:873-881.

Noel, L.E., Parker, K.R., and Cronin, M.A. (2004). Caribou distribution near an oilfield road on Alaska's North Slope, 1978-2001. *Wildlife Society Bulletin* 31:757 –771.

Noel, L.E., K.R. Parker, and M.A. Cronin. (2006). Response to Jolly *et al.* (2006), A reevaluation of caribou distribution near an oilfield road on Alaska's North Slope. *Wildlife Society Bulletin* 34:870-873.

National Research Council. (2003). Cumulative environmental effects of oil and gas activities on Alaska's North Slope. The National Academies, Washington, D.C., USA.

Panzacchi M., Moorter, Bram Van, Per Jordhøy, Olav Strand. (2013). Learning from the past to predict the future: Using archaeological findings and GPS data to quantify reindeer sensitivity to anthropogenic disturbance in Norway, *Landscape Ecology*, Volume 28, Issue 5, pp 847-859.

Polfus, J., M. Hebblewhite, and K. Heinemeyer. (2011). Identifying indirect habitat loss and avoidance of human infrastructure by northern mountain woodland caribou. *Biological Conservation* 144:2637-2646.

Reimers, E., Lund, S., Ergona, T. (2011) Vigilance and fright behaviour in the insular Svalbard reindeer (*Rangifer tarandus platyrhynchus*), *Canadian Journal of Zoology*, 2011, 89(8): 753-764, 10.1139/z11-040

Rescan. (1999). Wildlife effects monitoring program. Rescan Environmental Services Ltd. Report Prepared for BHP Diamonds Inc.

Roby, D.A. (1978). Behavioural patterns of barren-ground caribou of the Central Arctic Herd adjacent to the Trans-Alaska Oil Pipeline. M.S. Thesis, Univ. of Alaska, Fairbanks. 200 pp.

Russell, D. E. (2014). Kiggavik Project FEIS: Tier 2 Volume 6: Terrestrial Environment; Attachment A: Kiggavik Project Effects, Energy-Protein and Population Modeling of the Qamanirjuaq Caribou Herd, 41 pp.

Schaefer, J.A. (2013). Caribou and the Keeyask Generation Project. Retrieved on October 5, 2015, <http://www.cecmanitoba.ca/resource/hearings/39/CAC-016%20Caribou%20and%20the%20Keeyask%20%28Report%29%20Schaefer%20Nov%204,%202013.pdf>; 26 pp.

Shank, C. C. (1979). Human-related behavioural disturbance to northern large mammals: a bibliography and review. Foothills Pipe Lines (South Yukon) Ltd., Calgary, AB.

Sivertsen, T. R. (2012). The influence of natural and anthropogenic factors on Rangifer movements and habitat use. Department of Animal Nutrition and Management Uppsala, 2012, Swedish University of Agricultural Sciences, 30 pp.

Smith, W.T. and R.D. Cameron. (1983). Responses of caribou to industrial development on Alaska's Arctic Slope. *Acta Zool. Fenn.*, 175: 43-45.

Smith, W. T., and R. D. Cameron. (1985). Reactions of large groups of caribou to a pipeline corridor on the Arctic Coastal Plain of Alaska. In: Cameron, R.D., W.T. Smith and K.R. Whitten. 1985. Distribution and movements of caribou in relation to the Kuparuk

Development area. Progress Report. Alaska Department of Fish and Game. Juneau, Alaska. 35 pp.

Taillon, J., Festa-Bianchet, M., and Côté, S.D. (2012). Shifting targets in the tundra: protection of migratory caribou calving grounds must account for spatial changes over time. *Biol. Conserv.* In press. doi:10.1016/j.biocon.2011.12.027.

Tracy, D.M. (1977). Reactions of wildlife to human activity along Mount McKinley National Park road. Unpublished M.Sc. thesis, University of Alaska, Fairbanks. 260 pp.

Vistnes, I. and C. Nellemann. (2008). The matter of spatial and temporal scales: a review of reindeer and caribou response to human activity. *Polar Biology* 31:399-407.

Vors, L. S. and M. S. Boyce. (2009). Global declines of caribou and reindeer. *Global Change Biology* 15:2626-2633.

Weir, J. N., S. P. Mahoney, B. McLaren, and S. H. Ferguson. (2007). Effects of Mine Development on Woodland Caribou *Rangifer tarandus* Distribution. *Wildlife Biology* 13:66–74.

Weladji RB, Forbes BC. (2002). Disturbance effects of human activities on *Rangifer tarandus* habitat: implications for life history and population dynamics. *Polar Geogr* 26: 171–186.

Whitten, K.R. and R.D. Cameron. (1983). Movements of collared caribou, *Rangifer tarandus*, in relation to petroleum development on the arctic slope of Alaska. *Canadian Field-Naturalist*, 97(2): 143-146.

Whitten, K. R., and R. D. Cameron. 1985. Distribution of caribou calving in relation to the Prudhoe Bay oil field. In: Cameron, R.D., W.T. Smith and K.R. Whitten. 1985. Distribution and movements of caribou in relation to the Kuparuk Development area. *Progress Report. Alaska Department of Fish and Game*. Juneau, Alaska. 35 pp.

Wolfe, S.E., B. Griffith and C. Gray. (2000). Response of reindeer and caribou to human activities. *Polar Research* 19:63-73.

Caribou Protection Measures

Advisory Committee for Cooperation on Wildlife Management. (2014). We have been Living with the Caribou all our Lives: a report on information recorded during community meetings for ‘*Taking Care of Caribou – the Cape Bathurst, Bluenose-West, and Bluenose-East Barren-ground Caribou Herds Management Plan*’. Yellowknife, NT.

Alaska Department of Fish and Game. (2014). Operational Plan for Intensive Management of the Fortymile Caribou Herd in Game Management Units 12, 20B, 20D, 20E, and 25C during Regulatory Years 2014-2019. Prepared by Division of Wildlife Conservation. 26 pp.

Alberta Woodland Caribou Recovery Team. (2005). Alberta Woodland Caribou Recover Plan 2004/05 -2013/14. Alberta Sustainable Resource Development, Fish and Wildlife Division. Alberta Species at Risk Recovery Plan No. 4. 58 pp.

Bathurst Caribou Management Planning Committee. (2004). A Management Plan for the Bathurst Caribou Herd. 51 pp.

British Columbia (B.C.) Ministry of Environment. (2013a). Implementation plan for the ongoing management of South Peace Northern Caribou (*Rangifer tarandus caribou* pop. 15) in British Columbia. Victoria, British Columbia.

British Columbia (B.C.) Ministry of Environment. (2013b). Guidance for the Development of Caribou Mitigation and Monitoring Plans for South Peace Northern Caribou –April 17, 2013. 23 pp.

Canadian Parks and Wilderness Society. (2013). Population Critical: How are Caribou Faring? First Annual Report on Government's Efforts to Conserve Canada's Declining Boreal Caribou Populations. Prepared by Canadian Parks and Wilderness Society and the David Suzuki Foundation. 32 pp.

Cree Nation. (2012). Broadback Watershed Conservation Plan. 5 pp.

EBA Engineering Consultants Ltd. (2011). Anthropogenic disturbance on ungulates, guidelines and mitigation of impacts, Government of Nunavut, Department of Nunavut.

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

Environment Yukon. (2009). Rationale for Implementing Conservation Measures to Protect the Porcupine Caribou Herd. Yukon Government. 43 pp.

Francis, S., and J. Nishi. (2015). Range Assessment as a Cumulative Effects Management Tool: Assessment of the Carcross Caribou Herd Range in Yukon. Prepared for Environment Yukon, Fish and Wildlife Branch Regional Programs. 84 pp.

Francis, S., T. Antoniuk, J. Nishi, and S. Kennett. (2013). Range Assessment as a Cumulative Effects Management Tool: A Recommended Approach for Environment Yukon. MRC-13-01. Prepared for Environment Yukon, Fish and Wildlife Branch Regional Programs. 84 pp.

Government of Alberta. (2012). Caribou Protection Plan Guidelines and Caribou Calving Information. Environment and Sustainable Development. Caribou Protection Plan – Integrated Resource Management Division. 3 pp.

Government of Northwest Territories. (2014). Wildlife and Wildlife Habitat Protection Plan and Wildlife Effects Monitoring Program Guidelines. Department of Natural Resources. Wildlife Division. Draft Report. 54 pp.

Gunn, A., K. Poole, J. Wierzychowski, and M. Campbell. (2007). Assessment of Caribou Protection Measures. Submitted in fulfillment of NCR #830359 Indian and Northern Affairs Canada, Gatineau, Quebec. 45 pp.

Gunn, A. and K. Poole. (2009). A Pilot Project to test the use of Aerial Monitoring to Supplement Satellite Collared Caribou for Caribou Protection Measures. Prepared for Deline Renewable Resources Council. 16 pp.

Kativik Regional Government and Makivik Corporation. (2011). Plan Nunavik. Published by Avataq Cultural Institute. Westmount, Quebec. 469 pp.

Labrador Woodland Caribou Recovery Team. (2004). Recovery Strategy for Three Woodland Caribou Herds (*Rangifer tarandus caribou*; Boreal population) in Labrador. Prepared by Isabelle Schmelzer on behalf of the Labrador Woodland Caribou Recovery Team for the Inland Fish and Wildlife Division, Department of Environment and Conservation, Government of Newfoundland and Labrador. 60 pp.

Manitoba Conservation. (2005). Manitoba's Conservation and Recovery Strategy for Boreal Woodland Caribou (*Rangifer tarandus caribou*). Government of Manitoba. 22 pp.

Manitoba Conservation. (2011). Action Plan for Boreal Woodland Caribou Ranges in Manitoba (*Rangifer tarandus caribou*). Draft Report. Government of Manitoba. 61 pp.

Nunavut Planning Commission. (2000a). Keewatin Regional Land Use Plan. 110 pp.

Nunavut Planning Commission. (2000b). North Baffin Regional Land Use Plan. 130 pp.

Nunavut Tunngavik Inc. (1994). Revised Report on Resource Management Planning in West Kitikmeot. Prepared by the West Kitikmeot Resource Management Planning Working Group. 71 pp.

Protected Areas Secretariat. (2014). Northwest Territories Protected Areas Strategy. Edehzhie Candidate National Wildlife Areas. Public Information Pamphlet. 2 pp.

Qikiqtaaluk Inuit Association. (2014). Joint Statement of QIA and Baffinland to the Nunavut Planning Commission and the Nunavut Impact Review Board regarding Appendix I of the North Baffin Regional Land Use Plan. 5 pp.

Rudolph, T., P. Drapeau, M.H. St-Laurent, and L. Imbeau. (2012). Status of Woodland Caribou (*Rangifer tarandus caribou*) in the James Bay Region of Northern Quebec. Presented to the Ministère des Ressources naturelles et de la Faune du Québec and the Grand Council of the Crees (Eeyou Istchee). Prepared by the Woodland Caribou Recovery Task Force Science Advisory Group Nord-du-Québec. 85pp.

Saskatchewan Ministry of Environment. (2013). Conservation Strategy For Boreal Woodland Caribou (*Rangifer tarandus caribou*) in Saskatchewan. Saskatchewan Ministry of Environment. Fish and Wildlife Technical Report 2014.

Taillon, J., Festa-Bianchet, M., and Côté, S.D. (2012). Shifting targets in the tundra: protection of migratory caribou calving grounds must account for spatial changes over time. Biol. Conserv. In press. doi:10.1016/j.biocon.2011.12.027.

Appendix A: Websites searched and visited

List of Online Publication Databases and Resources Searched (Western Science, Traditional Knowledge & Measures)

Agency / Organization / Government	Website and/or Reference Link
Alaska Native Knowledge Network	www.ankn.uaf.edu
Alaska Resources Library & Information Services	http://www.arlis.org/docs/vol2/point_thomson/1011/1011A_~1.pdf
Arctic Institute of North America	arctic.ucalgary.ca
Arctic Journal	www.ucalgary.ca/arctic-journal
ArcticNet	www.arcticnet.ulaval.ca
Audobon Society	http://www.protectthearctic.com/studies_caribouOil.html
Aurora Research Institute	http://nwtresearch.com/sites/default/files/compendium_2014.pdf
Aurora Research Institute	http://data.nwtresearch.com/
Canadian Arctic Resources Committee	www.carc.org
Canadian Environmental Assessment Agency	www.ceaa-acee.gc.ca
Canadian Polar Commission	www.polarcom.gc.ca
CircumArctic Rangifer Monitoring	www.carma.caff.is
Ecology and Society Journal	www.ecologyandsociety.org
Eeyou Protected Areas and Conservation	http://www.eeyouconservation.com/docs/Broadback_Eng_sm.pdf
Environment Journal	www.placesjournal.org
Government of Alberta - Environment and Parks	http://esrd.alberta.ca/fish-wildlife/wildlife-management/caribou-management/caribou-action-range-planning/caribou-action-range-planning-faqs.aspx
Government of Alberta - Environment and Parks	http://esrd.alberta.ca/fish-wildlife/species-at-risk/default.aspx
Government of Alberta - Environment and Parks	http://esrd.alberta.ca/fish-wildlife/wildlife-management/caribou-management/caribou-action-range-planning/default.aspx
Government of Alberta - Environment and Parks	http://esrd.alberta.ca/fish-wildlife/wildlife-management/caribou-management/caribou-protection-plans/default.aspx
Government of British Columbia - Ministry of Environment	http://www.env.gov.bc.ca/wld/speciesconservation/nc/documents/Final_Wilson%20%202012%20%20PNCP%20management%20model.pdf
Government of British Columbia - Ministry of Environment	http://www.env.gov.bc.ca/wld/speciesconservation/nc/index.html
Government of British Columbia - Ministry of Environment	http://www.env.gov.bc.ca/wld/speciesconservation/nc/documents/Natural%20Resource%20Board%20Direction.pdf
Government of British Columbia - Ministry of Environment	http://www.env.gov.bc.ca/wld/speciesconservation/nc/documents/South%20Peace%20Northern%20Caribou%20Mitigation%20and%20Monitoring%20Plan%20Guidance.pdf
Government of Canada - Justice Laws	http://laws-lois.justice.gc.ca/PDF/SI-2013-125.pdf
Government of Canada - Justice Laws	http://laws-lois.justice.gc.ca/eng/regulations/SI-2013-125/FullText.html
Government of Canada - Justice Laws	http://www.laws-lois.justice.gc.ca/PDF/SI-2013-59.pdf
Government of Canada - Justice Laws	http://www.laws-lois.justice.gc.ca/eng/regulations/SI-2013-59/page-2.html#docCont
Government of Canada - Justice Laws	http://www.laws-lois.justice.gc.ca/eng/regulations/SI-2013-59/page-1.html
Government of Canada - Justice Laws	http://www.laws-lois.justice.gc.ca/eng/regulations/SI-2013-59/index.html
Government of Canada - Species at Risk Public Registry	http://www.registrelep-sararegistry.gc.ca/virtual_sara/files/plans/rs_caribou_boreal_caribou_0912_e1.pdf
Government of Manitoba	http://www.gov.mb.ca/conservation/wildlife/pdf/caribou_action_plan_11_29_2011.pdf
Government of Manitoba - Conservation and Water Stewardship	https://www.gov.mb.ca/conservation/wildlife/sar/pdf/caribou_strategy.pdf
Government of Newfoundland Labrador - Department of Environment and Conservation	http://www.env.gov.nl.ca/env/wildlife/endangeredspecies/Woodland-Caribou-Recovery-Plan.pdf
Government of Northwest Territories - Environment and Natural Resources	http://www.enr.gov.nt.ca/gsearch/draft%20west%20kitikmeot%20land%20plan
Government of Nunavut	http://www.nunavut.ca/files/2014-04-11%20KIA%20Submission%20to%20NPC%20on%20DNLUP.pdf

Government of Nunavut	www.gov.nu.ca
Government of Quebec - Développement durable, Environnement et Lutte contre les changements climatiques	http://www.mddelcc.gouv.qc.ca/communiqués_en/2013/c20130426-caribou.htm
Government of Quebec - Plan Nord	http://plannord.gouv.qc.ca/wp-content/uploads/2015/04/Long_PN_EN.pdf
Government of Quebec - Plan Nord	http://plannord.gouv.qc.ca/wp-content/uploads/2015/04/Synthese_PN_EN.pdf
Government of Quebec - Plan Nord	http://plannord.gouv.qc.ca/en/documents/
Government of the Northwest Territories - Environment and Natural Resources	http://www.enr.gov.nt.ca/programs/barren-ground-caribou/ahiak-beverly-and-qamanirjuaq-herds
Government of Yukon - Environment	http://www.env.gov.yk.ca/publications-maps/documents/chisana-mgmt-plan-2012.pdf
Government of Yukon - Environment	http://www.env.gov.yk.ca/publications-maps/documents/carcross_caribou_assessment_march2015.pdf
Government of Yukon - Environment	http://www.env.gov.yk.ca/publications-maps/documents/pch_scientific_rationale_conservation.pdf
Government of Yukon - Environment	http://www.env.gov.yk.ca/publications-maps/documents/rancheria_habitat_management.pdf
Government of Yukon - Environment	http://www.env.gov.yk.ca/publications-maps/documents/habitat_40milecaribou_dawson2012.pdf
Government of Yukon - Environment	http://www.env.gov.yk.ca/publications-maps/documents/caribou_recovery_programs.pdf
Government of Yukon - Environment	http://www.env.gov.yk.ca/publications-maps/documents/Range_Assessment_Recommendations_MRC-13-01.pdf
Government of Yukon - Environment	http://www.env.gov.yk.ca/publications-maps/plansreports.php#caribou
Government of Yukon - Environment	http://www.env.gov.yk.ca/publications-maps/plansreports.php#wf_mgt
Government of Yukon - Environment	http://www.env.gov.yk.ca/animals-habitat/mammals/caribou.php
Government of Yukon - Regional Land Use Planning	http://www.emr.gov.yk.ca/rlup/dawson-regional-land-use-plan.html
Government of Yukon - Regional Land Use Planning	http://www.emr.gov.yk.ca/rlup/peel-watershed-regional-land-use-planning.html
Gwich'in Social and Cultural Institute	www.gwichin.ca
Indigenous Studies Portal	portal.usask.ca
Inuvialuit Cultural Resource Centre)	www.irc.inuvialuit.com / www.inuvialuitlivinghistory.ca
Mackenzie Valley Review Board	www.reviewboard.ca
Manitoba Wildlands	http://manitobawildlands.org/pdfs/MBConCaribouStrategy2006.pdf
Manitoba Wildlands	http://manitobawildlands.org/bio_species_mb_caribou.htm
Northwest Territories Protected Areas Strategy	http://www.nwtpas.ca/areas/Sitesheet-Edehzhie.pdf
Nunavut Research Institute	www.nri.nu.ca
Parnasmiautik - Nunavik	http://www.parnasmiautik.com/wp-content/uploads/2013/02/Plan_Nunavik_06_20.pdf
Parnasmiautik - Nunavik	http://www.parnasmiautik.com/plan-nunavik-past-present-and-future/
Parnasmiautik - Nunavik	http://www.parnasmiautik.com/
Rangifer Journal	www.septentrio.uit.no
Société Pour La Nature Et Les Parcs Du Canada: Section Quebec	http://snapqc.org/en/index.php/communiqués/canadas-governments-lagging-on-caribou-conservation-cpaws-annual-review
State of Alaska - Department of Fish and Game	http://www.adfg.alaska.gov/index.cfm?adfg=librarypublications.wildlifepublications&sort=all&publicationtype=Species+Management+Report&species=Caribou&submit=Search
State of Alaska - Department of Fish and Game	http://www.adfg.alaska.gov/index.cfm?adfg=caribou.research
State of Alaska - Department of Fish and Game	http://www.adfg.alaska.gov/index.cfm?adfg=caribou.main
State of Alaska - Department of Fish and Game	http://www.adfg.alaska.gov/index.cfm?adfg=animals.main
The Canadian Boreal Forest Agreement	http://cbfa-efbc.ca/wp-content/uploads/2015/09/CBFACaribou_guidelinesIteration2_EN.pdf
University of Saskatchewan - Rangifer Anatomy Project	http://www.ucalgary.ca/caribou/
WKSS Reports	http://www.nwtwildlife.com/wkss/
World Wildlife Fund	www.worldwildlife.org