CARIBOU LEADERSHIP:

A STUDY OF TRADITIONAL KNOWLEDGE, ANIMAL BEHAVIOR, AND POLICY

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A

THESIS

Presented to the Faculty

of the University of Alaska Fairbanks

in Partial Fulfillment of the Requirements

for the Degree of

MASTER OF SCIENCE

By

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Fairbanks, Alaska

August 2010

Abstract

Caribou leaders are a key concept in traditional hunting practice with indigenous caribou hunters of Northwestern Canada. Some hunters perceive that "letting caribou leaders pass" prevents disruption to caribou migration. This concept was adapted to roadside hunting through an enforced hunting closure on the Dempster highway during the fall migration of the Porcupine Caribou Herd. This study sought to define caribou leaders through traditional knowledge, experimentally test for leadership in captive caribou, and identify barriers to applying the traditional concept to policy. Findings indicate that caribou leaders are defined in multiple context-specific ways, and the term can represent all age and sex classes of caribou. Respondents described practical applications of caribou leadership to ensure caribou harvest or ease reindeer herd management. Female caribou emerged as leaders in pairs during the experiment, which indicated that females could become leaders at this scale. The analysis of "letting the leaders pass" policy showed that context specificity, together with social and political change, as well as an institutional mismatch prevented continued use of the traditional concept as enforceable regulation.

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Chapter 1 Introduction: A multi-disciplinary study of caribou leaders

1.1 Caribou leaders: A concept in hunting practice of indigenous hunters

The concept of caribou (*Rangifer tarandus*) leaders is widely evoked throughout indigenous communities of northern Alaska, northern Canada, and Scandinavia. Some caribou are perceived to lead other caribou, affecting their movements, at both the local scale of small foraging groups and the regional scale of migration and selection of wintering sites (Alaska Department of Fish and Game, 2005; Berkes, 2008; Gubser, 1961; Sherry and Vuntut Gwitch'in First Nation, 1999; Smith and Cooley, 2003). Caribou leaders are commonly described through discussions of appropriate hunting practice and ethical behavior of indigenous hunters (Smith and Cooley, 2003). Documentation about indigenous hunting practices specifically describes hunters not shooting caribou leaders (Gubser, 1961; Gunn et al., 1988). Hunters believe that such hunting practice ensures caribou stay in areas close to hunters, thereby maximizing harvest.

The leaders of the Porcupine Caribou Herd have been considered key to traditional hunting practice for indigenous hunters in the Yukon and Northwest Territories (northwestern Canada) (Porcupine Caribou Management Board, 1995; Sherry and Vuntut Gwitch'in First Nation, 1999; Smith and Cooley, 2003). The two following quotes, taken from interviews with caribou hunters used for Chapter 2 of this thesis, illustrate the indigenous belief that: (1) shooting caribou leaders disrupts caribou

movement and migration, (2) protecting leaders is a hunting practice passed down through generations.

> If you shoot the leader, then the herd go different direction, or they get lost, or they get mixed up with other caribou. You know, that's why Native people don't shoot the leader.
>
> (Dawson Elder)

> My mama always tell us don't bother 'em. Let them go through first, there be more caribou coming. And if they have a trail, caribou follow. She said don't bother 'em. So we always respected, we never bother the front caribou.
>
> (Old Crow hunter)

However, caribou leaders are not easily defined as one particular sex or age class, as knowledge of caribou leaders appears to be specific to each hunting context. The lack of common understanding and the interest in using the concept of caribou leader when addressing management problems creates a need to define what indigenous caribou hunters mean when they talk about caribou leaders (Smith and Cooley, 2003).

In my study of caribou leaders, I focused on three Porcupine Caribou user communities (Canadian Yukon and Northwest Territories) including Dawson City (pop 1327), Fort McPherson (Pop 776), and Old Crow (pop 253) (Statistics Canada, 2006) (Fig. 1). Fort McPherson and Old Crow hunters have a long history of depending on Porcupine Caribou meat for survival (Kofinas, 1998), whereas Dawson hunters have a lower harvest rate of Porcupine Caribou, because most people of the region have historically harvested moose and Forty-mile herd caribou (Mishler and Simeone, 2004). Additionally, Old Crow differs from the other communities because it has no road access. Therefore, caribou hunters were expected to offer a broad range of perspectives on

caribou leaders according to differences in location on the winter range and access to the road.

1.2 Scientific investigation of caribou leadership behavior for harvest management

Few scientific studies have observed caribou leadership behavior (Benn, 2001; Miller et al., 1971; Paine, 1988). Conversely, wildlife biologists have studied caribou population ecology extensively for application to herd management (e.g., Griffith et al., 2002). There exists a disciplinary disconnect between the study of animals behavior and management of wildlife populations (Young, 2005). However, there is a growing body of literature on leadership behavior in various species, with direct applications to population management (Bailey et al., 1998; Conradt and Roper, 2005; Couzin et al., 2005; Dumont et al., 2005; McComb et al., 2001; Rands et al., 2003). The scientific focus on leadership behavior has attempted to explain how groups of animals move and whether a consistent leader exists in processes such as migration or feeding.

The identification, use, or elimination of leader animals is central to the practice of reindeer herding to facilitate herd management (Baskin, 1989). Baskin and Hjalten (2001) described the tendency of a group of reindeer to run away following a leader, and herders consequently eliminating the most nervous animals to ease herd management. Additionally, herders used docile animals as decoys to lead otherwise unmanageable groups of domestic reindeer to a new pasture, or a group of wild reindeer into ambush (Ingold, 1986). Domestication of wild reindeer through the practice of reindeer herding includes selective elimination of leaders (Baskin, 1989; Ingold, 1986), suggesting that

caribou leadership may be, in part, genetically determined. Coltman et al. (2003) and Garel et al. (2007) found that selective harvest had population wide effects and evolutionary implications for populations of bighorn sheep (*Ovis canadensis*) and mouflon (*Ovis gmelini musimon*), raising questions about the possible implications of harvesting leaders beyond the issue of distribution and movements of caribou (See discussion in Appendix 1).

As road networks are expanding worldwide, wildlife is interacting with roads in some of the most remote lands of the planet (Forman et al., 2003). Some argue that the expanding human infrastructure has and/ or will potentially have a negative effect on caribou (Griffith et al., 2002; Nelleman et al., 2001). Scientific investigation of caribou leadership has become important to understanding the impact of human infrastructure and related activities on caribou movement (Benn, 2001; Smith and Cooley, 2003).

Although leadership in caribou has not been measured with the scientific method, social characteristics and migratory behavior of caribou are extensively documented for caribou and reindeer (*Rangifer tarandus*). Authors have described these gregarious animals as having well established learned migratory behavior with fidelity to calving grounds or crossing points (Dahle et al., 2008; Kelsall, 1968). Barren ground caribou (*Rangifer tarandus granti*) appear to aggregate and disperse easily, with group aggregation to achieve location of feeding sites, breaking trail, avoiding predators or escaping (Bergerud, 2000). The tendency of a group to follow the first "leader" animal that leaves the herd is well documented for reindeer (Baskin, 1989; Paine, 1988). Caribou

leaders could thus exist for migration purposes, and/ or during ephemeral social interactions.

1.3 Indigenous harvest of Porcupine Caribou on the Dempster Highway

Harvest of the Porcupine Caribou Herd in Canada is regulated through the regional governments of the Yukon and Northwest Territories. The Porcupine Caribou Management Board (PCMB) was created in 1985 as an advisory body to:

- Co-operatively manage the Porcupine Caribou Herd and its habitat in Canada, to ensure continuance of the herd for subsistence use by indigenous users, while recognizing that other users may also share the harvest.
- Maintain communication with the indigenous users of Porcupine Caribou.
- Review technical and scientific information relevant to the management of the Porcupine Caribou Herd and its habitat, and make recommendations on its adequacy.
- Encourage indigenous users and other harvesters of Porcupine Caribou to participate in the management of the herd.
- Maintain a list of eligible indigenous users for each user community, and keep up-to-date information on the sub-allocation of the indigenous user harvest allocation among communities. (Porcupine Caribou Management Agreement (PCMB, 1985))

The board is composed of representatives of indigenous, regional, and federal governments and was created to involve and include indigenous hunters in the management process (Kofinas, 1998). Since its formations, one of the board's main focuses has been to address perceived problems associated with hunting caribou from the Dempster Highway that intersects the winter range of the Porcupine Caribou Herd (Fig.1.1). Issues addressed have included safety, access to caribou using snowmobiles, hunters' management of harvest by-products (gut piles), differences in indigenous and non-indigenous hunting regulations, and disturbance of migration.

The Porcupine Caribou Herd population is currently estimated at 90 000-100 000 animals (PCMB, 2010a). Despite a continuous decline in the population since 1989 (178 000 animals counted by photocensus), the PCMB does not view current indigenous harvest as unsustainable (PCMB, 2005). Nevertheless, in 2006, the PCMB passed a resolution stating that the PCH is in immediate need of conservation due to the ongoing population decline (PCMB, 2006). The impact of concentrated roadside hunting on the caribou remains of concern. Indeed, the low growth rate of the Porcupine Caribou Herd could indicate that it may be particularly sensitive to anthropogenic disturbance (Griffith et al., 2002). Reported harvest of Porcupine Caribou for Alaska and Canada averaged 1774 animals per caribou year (June 1- May 31), harvesting up to 2.4% of the herd in 1997-98, the year for which caribou harvest reports was highest (Dorothy Cooley, Pers comm. 10 October 2008). Due to sparse reporting by some user groups, these totals underestimate actual harvest levels, thought to average about 4000 caribou, with 60% cows harvested (PCMB, 2010b). Dempster Highway harvest averages 70% of total

reported harvest, where kill location is reported, although numbers still exclude a large proportion of non-Dempster harvest (Dorothy Cooley, Pers. Comm. 15 December 2008).

The Porcupine Caribou Management Board recommended action to protect the leaders of the caribou herd and promoted the notion of "letting the leaders pass" (PCMB, 1995). Indigenous Elders and hunters became concerned that caribou were abandoning wintering areas east of the Dempster highway because hunters shoot caribou leaders (Benn, 2001) and as a result deflect migration to other parts of the herd's winter range. Following this concern, The PCMB stated that the traditional knowledge of caribou hunters should be used in conjunction with harvest management due to continuing uncertainties from scientific investigation of hunting impact on the Dempster highway (PCMB, 1995). In 1999, the Yukon government imposed a one-week hunting mandatory closure on the Dempster highway in accord with PCMB recommendations (Government of the Yukon, 2002; PCMB, 2000).

The closure was designed to let a large group of caribou cross the Dempster Highway. Caribou leaders were difficult to define for use in hunting policy and the measure remained controversial with some hunters. In 2007, the Canadian Justice department decided to cease enforcement of proposed regulations (PCMB meeting, 22-24 September 2007, Whitehorse, Yukon). Attempts by the PCMB to resolve issues associated with hunting on the Dempster highway have been time consuming and conflict-driven, and resulted in ongoing co-management challenges such as problems of compliance combined with the continuing decline of the Porcupine Herd (Kofinas, 2005; Kofinas et al., 2006).

The "let the leaders pass" policy was implemented under the assumption that harvesting caribou leaders had a negative effect on the caribou herd. However, this assumption is untested. Instead, this assumption exists as a perception of indigenous hunters and is thus an underlying theme through Chapters 2 and 4 of this thesis. Appendix 1 briefly discusses the potential for such a population level effect.

1.4 Overview of thesis and methods

The objective of this study is to contribute to understanding caribou leadership behavior and how it can be applied to hunting management. I used a mixed methods approach because different methodological perspectives were needed to answer different questions relevant to the research problem (Brannen, 2005; Denzin, 1970). Because social and environmental needs are linked, they should be considered separately when seeking to understand the application of knowledge for resource management (Jentoft, 2006; Kofinas et al., 2000). Combining different forms of knowledge, such as scientific and indigenous perspectives can lead to new scientific insights, build partnerships among users and managers, and result in more effective harvest management and conservation of wildlife (Berkes, 1993; Folke, 2004; Huntington et al., 2004; Moller et al., 2004; Olsson and Folke, 2001).

Because caribou leadership is a concept that (1) arises from perspectives of indigenous hunters, (2) needs further scientific investigation, and (3) is used for harvest management that is controversial, I used a combination of qualitative and quantitative methods to answer my research questions (Fig. 2). I separated the three areas of

investigation into three chapters, further outlined below. I analyzed results separately, according to the methods and assumptions of each chapter. Together the three components of the study provide an interdisciplinary approach to a social-ecological problem and illustrate the complexity of using the concept of caribou leaders for management of indigenous hunting.

In Chapter 2, I assumed that definitions of caribou leaders were dependent on cultural context and personal hunting experience of caribou hunters, and therefore defined caribou leaders through a qualitative analysis of interviews. I conducted semi-structured interviews with Elders and hunters of three indigenous communities in the Porcupine Caribou Herd range. I analyzed interviews through content analysis and coding process, using HyperRESEARCH^{TM} qualitative data management software. I conducted additional interviews with reindeer herders of the Seward Peninsula (Alaska). I obtained approval for this research through the University of Alaska Fairbanks (UAF) Institutional Review Board (IRB) (protocol # 06-39- approval 20060620 and # 07-12- exempt 20070306). I also obtained approval with each representative organization associated with the communities I visited and people I interviewed in accordance with IRB protocol.

In Chapter 3, I predicted that female caribou would emerge as leaders based on a literature review of leadership behavior in models and various species. I tested for leadership in an experimental captive herd when caribou crossed a visual barrier to reach a feeding site. I recorded which of the male or female went through the barrier first. I used captive caribou at the University of Alaska Fairbanks Robert G. White Large

Animal Research Station. The UAF Institutional Animal Care and Use Committee (IACUC) approved this study (protocol # 07-08, final approval # 20070322).

In Chapter 4, I reviewed the recent history of caribou hunting management as a case study with a focus on the "let the leaders pass" hunting regulation implemented on the Dempster Highway of Yukon and Northwest Territories. Through an analysis of problems in policy implementation I identifed barriers of using indigenous people's knowledge as the basis of formal hunting regulations. The sources of evidence for the analysis were archives of the management process, interviews with Elders and caribou hunters, and observations of a co-management board meeting.

This multidisciplinary approach served to define the concept of caribou leaders in traditional indigenous hunting, showed how leadership can be measured in captivity, and illustrated the limitations of using indigenous people's knowledge to design hunting regulation. In Chapter 2 I found that there exists a range of context-dependent definitions for caribou leaders according to interviews conducted with caribou hunters and reindeer herders. In Chapter 3 I showed that female caribou were leaders in an experiment with captive caribou. In Chapter 4 I concluded that barriers to traditional knowledge-based co-management arose due to a mismatch between the enforced "let the leaders pass" policy with context-specific knowledge, social and political changes, as well as a traditional focus on education. The findings emphasized the challenge of integrating caribou leader protection into formal management of indigenous hunting. The mixed methods approach in this thesis provided added understanding to manage for caribou leaders.

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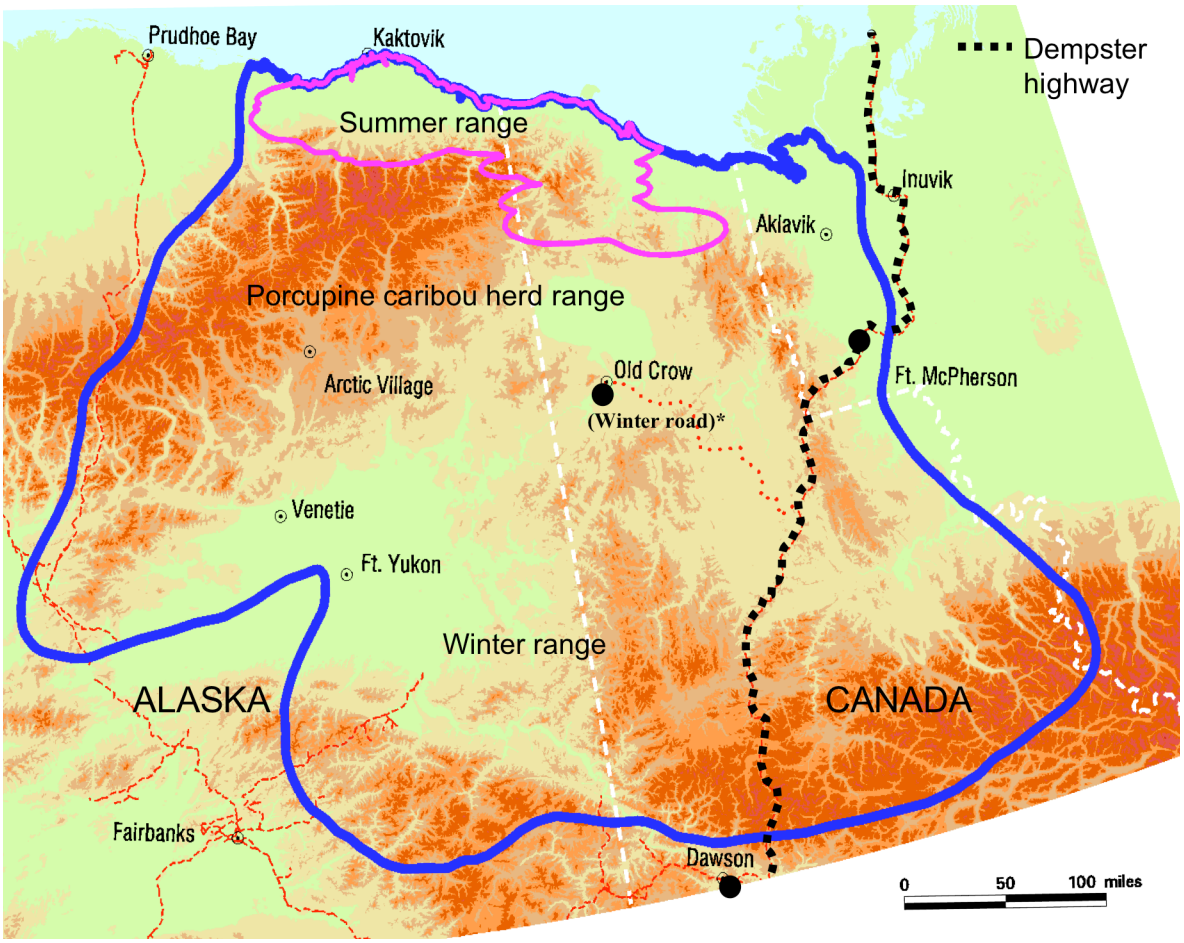


Figure 1.1. Map of the Porcupine Caribou Herd range and Dempster Highway. The communities of focus in the investigation of caribou leaders were Old Crow, Fort McPherson and Dawson. The dotted line to Old Crow represents an occasional winter ice road that is generally not available for hunting access (Map modified from Sustainability of Arctic Communities Project of National Science Foundation, 2004, map created by Stephen Braund and Associates).

* The dotted line from Dempster Highway to Old Crow represents a winter ice road, used in the 1970s during oil and gas exploration, and used again recently to deliver construction materials to the community for a new school. Access has been highly restricted and its use not available for caribou hunting.

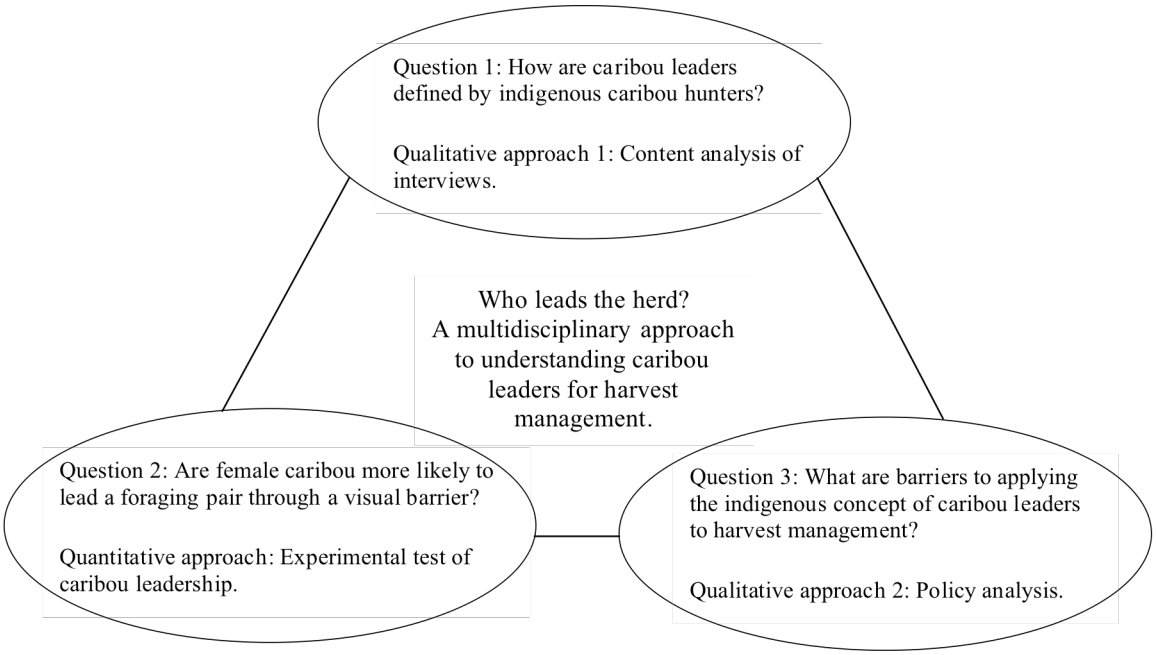


Figure 1.2. Overview of questions and respective methodological approaches for this study of caribou leaders.

Chapter 2 Defining caribou leaders in traditional knowledge of the Porcupine Caribou Herd.[1]

2.1 Abstract

Policy to prevent migration shifts of the Porcupine Caribou Herd was based on ambiguous definitions of caribou leaders. "Caribou leader" is a flexible term defined in ways directly applicable to hunting traditions or herding reindeer, thus highly dependent on social-ecological context. I conducted interviews with indigenous Elders and hunters in three Porcupine Caribou Herd user communities (northwestern Canada) and reindeer herders of the Seward Peninsula (Alaska) to document the traditional ecological knowledge concept of "caribou leaders". I found that different sex and age classes of caribou could be leaders as they take on different behavioral roles in the herd. Whereas most respondents said that cows went ahead of the herd during spring migration, both bulls and cows could be ahead of the fall migration. Leaders were described both at the local caribou group and whole herd scale. A major difference between hunters and reindeer herders was the perception that caribou migration respectively could and could not be deflected by disrupting or shooting caribou leaders. Elders of Porcupine Caribou communities discuss caribou leaders primarily to educate younger generations and promote use of traditional hunting methods.

[1] Padilla, E. 2010. Defining caribou leaders in traditional knowledge of the Porcupine Caribou herd. Prepared in the format for Arctic.

2.2 Introduction

I conducted this study to describe diverse definitions of caribou leaders and help inform management of indigenous caribou hunting, due to a current lack in consensus of what constitutes a caribou leader in traditional knowledge. I described traditional knowledge of caribou leaders based on interviews conducted with Elders and hunters of the Porcupine Caribou Herd. I focused on distinguishing between sex and age of caribou leaders to aid in identifying caribou leaders in practice. Further discussion of the integration of traditional knowledge into management continues in Chapter 4 of this thesis.

Documenting and applying traditional ecological knowledge (TEK) has become a widely acclaimed tool for managing subsistence resource use (Berkes, 2008; Davis and Wagner, 2003; Government of the Northwest Territories, 1993; Moller et al., 2004). Traditional knowledge is viewed as a useful complement to scientific data because it adds temporal continuity and local specificity (Berkes, 1993). Although TEK has been documented extensively with indigenous populations in the Canadian Arctic, its integration into resource management has in some cases fallen short of success (Nadasdy, 2003). Authors point to the nature of traditional knowledge, such as context-dependency or its holistic nature, as a cause for misinterpretation when translated for use in resource management (Antweiler, 1998; Cruikshank, 1998; Houde, 2007; Jentoft, 2006; Nadasdy, 1999).

Traditional knowledge about caribou leaders (i.e. caribou that lead a group or herd of caribou) is sparsely documented for indigenous caribou hunter groups. Gubser (1961)

describes caribou leaders in his early ethnography of Nunamiut Eskimo at Anaktuvuk Pass (Alaska). Similarly Porcupine Caribou hunters traditionally avoided shooting caribou leaders to ensure caribou harvest throughout the hunting season (Sherry and Vuntut Gwitch'in First Nation, 1999; Smith and Cooley, 2003). Traditional hunting strategies of Inuit in the Northwest Territories show concern for deviating caribou movement from common migration routes. For example, Gunn et al. (1988) described that hunters were inconspicuous at water crossings until lead caribou crossed, so that following caribou would continue to swim across when hunters began to shoot. Similarly, Stewart et al. (2004) reported that hunters avoided butchering animals or disposing of bones near migration routes to avoid diverting caribou movement. The practice of letting the leaders pass is still supported in areas across northern caribou subsistence communities and some indigenous Elders have brought the concept of caribou leaders to the forefront of management discussions (Alaska Department of Fish and Game, 2005; PCMB 1995).

There exists a concern among Yukon and Northwest Territories communities, that disturbing or shooting caribou leaders could cause caribou to abandon important wintering areas (Benn, 2001). Following this concern, Smith and Cooley (2003) reported hunters' predictions of caribou reactions to roadside disturbances. Hunters in their study based their answers on their own interactions with caribou. They found that "taking the leaders" was a predictor of how caribou react to human disruption. Participants in the study mentioned caribou leaders when talking about the location of caribou killed in a group. They described different caribou leaders including individuals or groups of

animals with different behavioral roles in the herd (e.g., steering migrating groups, detecting danger). The study recommended further work on defining caribou leaders following this range of opinions.

Monitoring of Porcupine Caribou Herd (PCH) movement along the Dempster Highway during the fall migration is generally limited to harvest reports, documented local observations, and radio telemetry data. Thus the sex and age compositions of caribou approaching the highway, as well as numbers of caribou traveling alone or in groups, are poorly understood. A study of the Gwitch'in Renewable Resource Board on PCH fall movements near the Dempster Highway recorded caribou numbers during the fall migration when leading groups of caribou first approached the Dempster Highway (Benn 2001). Observed numbers ranged from a single female, three caribou, smaller scattered groups of 30 or 50, to larger groups from a few hundred to 2000 animals. Whether caribou were male or female was not consistently recorded, and observations included mixed groups, small groups of bulls, or several cows with calves. This study had limited use for interpretation, although it suggested that a wide range of caribou group size and composition exists during the first two weeks that the Porcupine Caribou approach the Dempster Highway.

The Porcupine Caribou Management Board (PCMB), the Canadian co-management body that advises on herd management decisions, recommended action be taken to protect caribou leaders (PCMB; 1995). However, definitions of caribou leaders for management purposes were unspecific or arbitrary. A hunting closure in Yukon and Northwest Territories was designed to let a large group of caribou cross the Dempster

Highway before hunting would commence. A one-week hunting closure was instituted into the regulatory regime of Yukon Territory with no specific definition of caribou leaders (Government of the Yukon, 2002; PCMB, 2000) (Fig. 2.1). Conversely, the Government of the Northwest Territories proposed a hunting closure for the first 200 caribou to cross the road, including cows, calves and young bulls, assuming they are the leaders of the herd (PCMB, 2000).

The ambiguity in defining “caribou leader” and resulting need for "systematically gathered community-based knowledge" led to an approval by the PCMB in 2006 to conduct this study (Appendix 2). This study was valuable as the relative lack of traditional knowledge documentation regarding caribou leaders contrasts with how widespread this concept is with indigenous caribou hunters. Additionally, traditional knowledge of caribou hunters may explain how sex and age of caribou relates to leadership in the herd. The objective of the study was to inform management on local definitions through the documentation of traditional ecological knowledge, with the goal of protecting both the Porcupine Caribou Herd and ensuring local communities’ on-going access to caribou.

2.3 Methods

2.3.1 Study sites

I conducted this project in three First Nation communities in the Canadian Yukon and Northwest Territories that are primary users of Porcupine Caribou. They included Dawson City (pop 1,327), Fort McPherson (pop 776), and Old Crow (pop 253) (Statistics

Canada 2006). The research was conducted in partnership with the Trondëʼk Hwëchʼin First Nation based in Dawson, Yukon Territory, the Teetliʼt Gwichʼin Renewable Resource Council of Gwichʼin First Nation, based in Fort McPherson, Northwest Territories, and the Vuntut Gwitch'in First Nation, based in Old Crow, Yukon Territory. I selected these communities for the spread in geographic location along the Porcupine Caribou migration and wintering range, the communities' involvement in issues related to Dempster Highway hunting, as well as their differing characteristics (i.e. population, road access). Fort McPherson and Dawson hunters make extensive use of the Dempster Highway for accessing Porcupine Caribou, whereas Old Crow hunters primarily use river and snowmobile access, depending on the season. Fort McPherson hunters take the greatest number of caribou of all communities of Canada and Alaska that hunt Porcupine Caribou, and Old Crow harvests the highest number of caribou per capita of all communities. While Dawson harvests caribou, the community is more dependent on moose (Kofinas, 1998).

I also conducted shorter informal interviews with Seward Peninsula Reindeer herders, western Alaska, USA. This site was included in the study because reindeer herders have a contrasting approach to caribou leaders from PCH hunters. The inclusion of knowledge of reindeer herders' management of leaders was valuable to compare which sex, age, and group size of caribou they identified as leaders with hunters' perceptions of caribou leaders. Unlike caribou hunters, they aim to deflect the migration of the caribou herd to protect their own reindeer from migrating away with caribou. They also have in

depth local knowledge of the way the Western Arctic Caribou herd migrates through their range (Schneider et al., 2005).

2.3.2 Research cooperation with communities and selection of respondents

I initiated this phase of the study by obtaining research approval from participating First Nations and the PCMB, and research permits from government agencies of NWT and Yukon Territory. The following institutions approved interviews: the Trondëʼk Hwëchʼin First Nation, Teetliʼt Gwichʼin Renewable Resource Council, Vuntut Gwitch'in First Nation, the Gwichʼin Social and Cultural Institute, and the Inuvialuit Tribal Council. The Northwest Territories Aurora Research Institute (Scientific Research License No. 14020N), and the Yukon Heritage Resources Unit (Yukon-Canada Scientists and explorers Act License 06-48S&E) granted formal research permits. My research protocol and instrument were reviewed and approved by the University of Alaska Fairbanks (UAF) Institutional Review Board (IRB) (protocol # 06-39- approval 20060620). In addition, the Kawerak Reindeer Herders Association and the UAF IRB (protocol # 07-12- exempt 20070306) approved interviews with Seward Peninsula reindeer herders about caribou leaders of the Western Arctic herd.

I conducted 29 interviews with Porcupine Caribou hunters and Elders during summer 2006, completing nine in Dawson City, eleven in Fort McPherson, and nine in Old Crow. In each community I hired and worked with a local assistant, who worked with the local First Nation, or renewable resource council to select interviewees. I asked to interview a mixed sample of Elders and hunters with a high level of expertise in hunting

Porcupine Caribou and or traditional knowledge pertaining to caribou migration and caribou leaders. All respondents from these communities were members of the local First Nation. Both younger and older hunters were selected to capture changing knowledge (Stevenson, 1996) but also to capture a wider space/ time scale (Ferguson and Messier, 1997). Local organizations advertised this study of caribou leaders for several weeks before my arrival to inform the community in general. Local assistants contacted specific respondents informally to ask for their participation in interviews shortly before they were conducted.

I classified respondents as "Elder" versus "younger hunter". Classification was made through information from local organization staff members and or Gary Kofinas, who had previously worked in these three communities. Additionally, age 65 and above were classified as Elders, adding two interviews to the Elder category, as the interview asked for date of birth. I used this combined method to classify Elders because they are usually older members, although recognition depends on the community's recognition of the Elder (Hart, 1995). I spent 8-10 days in each community conducting interviews, which was not sufficient to provide other substantial evidence for Elder status based solely on community recognition. I interviewed five women and 24 men. Their ages ranged from 42 to 91 years of age, with 16 being Elders. I called the rest of the respondents "younger hunters". All but one of the respondents reported having extensive personal hunting experience. Also, among some Gwitch'in it was not culturally appropriate for women to hunt. Elder vs. younger hunter proportions for each community are shown in Figure 2.2. The larger proportion of Elders in Fort McPherson may have

resulted from Elders being more available for interviews and my receiving help from a very experienced assistant.

I interviewed six reindeer herders from the Seward Peninsula (Alaska). I attended the 2007 annual Reindeer Herding association meeting in Nome and asked all reindeer herders attending for a voluntary interview through a presentation outlining this project. There was no specific selection of respondents as all reindeer herders present at the meeting were invited to interview. As reindeer herders, all respondents had Elder status.

2.3.3 Data Collection

Interviews were semi-structured and most questions were open-ended to allow subjects the freedom to respond with detailed information and anecdotal personal accounts (Huntington, 2000; Perecman and Curran, 2006). Interview questionnaires for Porcupine Caribou hunters and reindeer herders are found in Appendices 3.A and 3.B. The question of whether participants recognized caribou leaders was designed for a closed response to allow quantification of results. I used semi-structured interviews to promote unanticipated responses and connections, as I expected the concept of caribou leaders in traditional knowledge was more complex and different from what I may perceive. Thus, this interview method partially addressed the issue of interviewer and interviewee having different cultural backgrounds. Interviews were constructed around the assumption that traditional knowledge is rooted in local cultural context and arises from long term interaction between people and resources, (Berkes, 2008; Folke, 2004).

I audio-recorded all interviews with Porcupine Caribou hunters and transcribed their script entirely. Interviews took from 15 min to 1 h 11 min in duration, with a recorded interview total of 17 h 50 min. I asked questions during interviews in Dawson with the assistant helping clarify when necessary, whereas assistants in Old Crow and Fort McPherson conducted the interviews in all but two cases. Interviews in Dawson were longer on average (50 min) than Fort McPherson (34 min) and Old Crow (27 min). This difference may have been due to assistants rushing through some questions when they considered them repetitive. All subjects were remunerated 50 Canadian dollars per interview. Interviews with Seward Peninsula herders were informal, lasting 5-15 min and recorded through personal notes without an assistant present.

2.3.4 Data analysis

I used HyperRESEARCH^{TM} coding software for qualitative analysis and a content analysis protocol through open coding. I identified common themes and concepts across interviews in relation to context to describe caribou leader concepts in local/ traditional knowledge (Krippendorff, 2004). Open coding provided the basis for arriving at categories of responses that were captured as quotes within each interview. I started the analysis broadly by looking at all the words in each interview and extracting many key words. Then, I went through interviews a second time and grouped words with similar themes. Finally, I created overarching categories going through all interviews a third time. Using these codes, I analyzed the interviews comparing types and frequency of responses in all categories.

The remainder of the chapter is organized according to these categories. Some of the topics included in the analysis will be addressed in more depth in Chapter 4 of this thesis, including the Elder/ younger generations knowledge gap and the interviews' focus on education. The results presented below focus on the ways in which people identified caribou leaders.

2.4 Results

Overarching themes included associating caribou leaders to migration, perceived existence of caribou leaders, identifying class of leaders (sex/ age/ reproductive status), behavioral (social) roles, numbers of caribou leaders, spring and fall migration leadership. Below I present frequency of mentions and references to interviews for each theme, as well as short descriptions, summarizing responses. Quoted text from interviews includes the home community of respondents in parentheses. I provide a brief comparison of perceptions of caribou leaders as held by Porcupine Caribou hunters and Seward Peninsula reindeer herders. Further elaboration on results and context-specificity is continued in the discussion section of this chapter. I also include a description of hunting traditions relevant to caribou leaders, as these help establish the context for respondents' understanding of leadership. Finally, I compare understanding of Elders and younger hunters, as well as responses from different communities for Porcupine Herd user interviews. Additional themes such as hunting experience, hunting ethics, and political views were identified, but were mostly beyond the scope of this chapter and included in Chapter 4 of this thesis.

2.4.1 Associating caribou leaders with migration

I began interviews with the general question: "How do caribou know where to go when they migrate?" 41% of interviewees mentioned that caribou leaders enable migration. For example, one hunter suggested that the knowledge of individual caribou guides migration.

> It's one caribou just going, eh, they follow that caribou, so they know where to go.
>
> (Fort McPherson)

However, the majority of respondents did not directly associate caribou leaders with how caribou know where to migrate, regardless of the respondent's community. Typical responses explained migration through food availability and variable weather conditions, not an individual caribou's ability to lead. Respondents also explained migration as the result of caribou having been around for a long time and knowing migration routes with visible and olfactory trails guiding them.

> Caribou herd they know where to go. Because they probably know where's their food and they, you know, their foot marks, all that, it never go away.
>
> (Dawson)

Several also noted that knowing why caribou migrate was a difficult question.

> It is hard to answer that question because it's nature, the caribou, it's like it's natural. They are born, once they're born they know too and they migrate through this way and then they migrate back. . . . Don't know, its a hard question, nobody knows.
>
> (Old Crow)

2.4.2 Perceived existence of caribou leaders

Eighty two percent of respondents said that caribou leaders exist and described a leader's identifying characteristics. Only three respondents said that caribou leaders did not exist (all from Dawson) and two other individuals were unsure (one in Dawson, one in Fort McPherson). Respondents in Dawson who said there are no leaders also linked their opinion on leaders to the hunting regulations.

> It's not Rudolf, that's for sure. They just come in a great big herd. You don't see one crossing and say, ok, it's ok you can come now. You know, it's a big herd. And maybe, it's really hard to say. And I do know that they always speak of leaders, I know that. I also know that there is an issue about having to let the leaders pass. I don't understand myself how they determine leaders.
>
> (Dawson)

2.4.3 Class (age/ sex/ reproductive status) and behavioral (social) roles of caribou leaders

No single age/ sex class was uniformly identified as leading. 79% of interviewees mentioned cows as leaders or traveling ahead of the herd, four respondents specifically described them as young (all in Fort McPherson) and two as an older cow without a calf (both in Old Crow). Ten interviewees mentioned the cow and calf leading and four described the cow and calf as the only caribou leader there is (two in Dawson, two in Fort McPherson). 62% interviewees stated that bulls are the leaders, five specifically as large mature bulls (three in Dawson), nine as young/ "dazhoo tsoo" (five in Old Crow). Three interviewees, one from each of the caribou user communities, mentioned the wolf as leader, and one respondent in Dawson mentioned that ravens tell caribou when it is time to migrate.

Interviewees also described leaders as having a wide range of behavioral (social) roles as part of the herd. Several alternative terms other than “leader” were used to describe the roles of these caribou, including “boss”, “trailbreaker”, “scouts”, “teacher”, “guards” and “fool”. Behavioral roles of leaders also included mating, fighting and enabling escape from predators. Descriptions of behavioral roles were an exceptionally rich and diverse aspect of interviews.

> These young caribou, two to four year olds, those they don't mate, and the bulls and young, the young bulls and girls, they go, that's how these dry cow teach them to go, generation after generation, that's the ones. Then behind stays the big cows, those with the bulls, those are the ones that mate. So when you get up Dempster you watch, you see first bunch, they're little, they're small, not so brushy, some bulls are big, eh, big horn, that's the young cow, bulls. Then these young bulls go with them, they protect them. It's just like a guard to them, they're always the guard these young bulls, they watch, one sleep nighttime, one stay up they watch, one or two. Then they fool them and they just take off.
>
> (Fort McPherson)

Based on leader age/ sex/ reproductive status class identification questions, I identified six main classes of leaders beyond the sex class distinction with their accompanying behavioral roles (Table 2.1).

Coding of interviews indicated that multiple classes of caribou co-exist as leaders, as they assume different behavioral roles. Bulls and cows were described as both having leadership roles by 58% of interviewees (four in Dawson, six in Fort McPherson, eight in Old Crow). In addition, five individuals mentioned the older cow, the cow and calf, and the bulls both young and older to all have leadership roles (one in Dawson, four in Old Crow). Overall, respondents in Old Crow suggested that there were multiple types of

caribou leaders more frequently than in other communities, although I identified this theme throughout all communities.

> There's caribou leaders, there's a number of caribou leaders. *Dazhoo tsoo* is one of the leaders, he's a leader but yet he travels behind so *dazhoo tsoo* is a very important part of the caribou herd. *Vadzai njoo'* that's the older women *vadzai njoo'* is one of the main caribou leaders, it's like an old women wants the caribou start and all the caribou start moving. So, those are the two leaders that the Elders talk to me about a long time ago, so *dazhoo tsoo* and *vadzai njoo'* because they understand, they migrate, they go ahead, they go ahead of the herd and they just make trail. They know where to go according to the weather and the rain so those two are really important.
>
> (Old Crow)

2.4.4 Seasonality of caribou leadership and position of leaders ahead of the herd

Too few questions about seasonality were answered to provide a clear comparison between all four seasons, or contrasting migratory periods with non-migratory periods. However, 75% of interviewees specifically described caribou going ahead as leaders during fall and spring migrations. Table 2.2 shows the spread of responses for the two migration seasons. Of people who mentioned spring caribou leaders, 88% said that cows or the single cow and calf led in the spring. Of people who mentioned fall caribou leaders, this percentage was only 47% versus 53% for bulls or mixed sex groups of caribou leading.

Thirty-one percent of respondents also pointed out that leaders might not always be ahead. In particular they may change their position in a group or leading the migration according to their role and necessity of exercising that role (e.g., breaking trail, predator avoidance). The quotes below illustrate how the position of leaders at the front of a group may be changed by snow conditions or predation.

> Leading the herd of caribou the old mother will go on ahead . . . but then they get out of the way and let these young bulls go ahead and break the trail . . . these young caribou go ahead and break the snow trail like that and if they get out of course then another old mother will come and straighten them out again."
>
> (Old Crow)

> In the herd you can pretty well see which ones are the leaders, when you see a bunch of caribou, maybe 20 or more something like that, it don't matter what number it is, but there is always a leader at the front and leader at the back of the herd cause if they ever run into any predator or they get scared for some reason then there is also a leader at the back. (Old Crow)

Overall, respondents generally agreed that cows went ahead of the spring migration, but there was little agreement about which sex of caribou led the fall migration.

2.4.5 Number of leaders and scale of leadership

Fifty-eight percent of respondents addressed the number of leaders associated both with each smaller herd of caribou or caribou ahead of the migration. Leaders were described both at a larger (i.e. whole herd) and a smaller scale (i.e. smaller group of caribou). Table 2.3 shows how often caribou leaders were identified as lone or few animals versus large groups.

In each community, one interviewee (interviews 9, 14, 22) advised that the large group of leaders (several hundred or more) could not be considered "leaders" according to their training and observations. Rather, leaders are one or two caribou that travel ahead.

> A lot of people today they never had the training that I had, so they just figure the first bunch and see some caribou leading. They think they're the leaders but it's not. The caribou already went ahead. It's one or two caribou. They're already way ahead. It's just a bunch that's following them.
>
> (Old Crow)

Additionally, caribou leaders were described as traveling alone way ahead of the migration when referring to the migration scale (one in Dawson, two in Fort McPherson, three in Old Crow). Although only four interviewees specifically said that every group of caribou had leaders, the many descriptions of behavioral roles (i.e. trailbreaker, breeder, teacher, etc…) imply that leadership behavior is perceived to occur at the scale of every smaller group of caribou.

2.4.6 Hunting practices relevant to caribou leaders

I identified two different hunting traditions with relevance to caribou leaders. 27% of interviewees described that each small herd has a leader. When hunting, that caribou leaders should be shot first in order to confuse the rest of the herd and harvest a maximum number of caribou (one in Dawson, four in Fort McPherson, three in Old Crow).

> When you hunt caribou and you want to get lots, you always shoot the leader, and that confuses the rest. And then when another one tries to lead you shoot that one. So you can actually get a big pile of caribou if you just shoot the right way, because they get confused, there's no leader.
>
> (Fort McPherson)

Thirty-one percent of respondents said that they would not shoot caribou leaders according to their traditional hunting practices (three in Dawson, three in Fort McPherson, three in Old Crow)

> People used to take care of them long ago you know, leave the leaders alone for Awhile and then another bunch down here, about 1000, don't bother that one, you know, just leave it . . . and later on they go back to this other one.
>
> (Fort McPherson)

The range of descriptions for these two different hunting traditions suggests that timing and place of the hunt, as well as seasonal migration determine the appropriateness of harvesting caribou leaders. In the context of caribou first arriving to an area during fall migration, it may not be appropriate to harvest leaders. Outside of this context, a small foraging group could be harvested by shooting leaders.

2.4.7 Reindeer herder perspectives on caribou leaders

In Table 2.4 I show reindeer herders' perceptions of caribou leaders as a comparison with the above results for Porcupine Herd hunters. Similarly to PCH hunters, 83% mentioned just a few caribou are leaders, although one person described a very large group of caribou. In their observations of fall migration, 50% said both bulls and cows are leaders. Young bulls were described as walking ahead, which is similar to PCH hunter descriptions of young bulls as scouts or trailbreakers.

Reindeer herders perceived that shooting or disrupting caribou leaders did not impact caribou migration. Unlike caribou hunters, herders actively tried to divert and disrupt caribou ahead of the migration, to protect their reindeer. Only limited success was reached through repeatedly herding caribou away from ranges by snow-machine. This perspective contrasts with PCH caribou hunters' consideration for caribou leaders, due to the assumption that leaders impact group movement or migration.

> Tried to get rid of bulls, but then pods of the caribou herd come in bunches of 150-500, at the end of February and in March there are quite a few caribou around.
>
> (Seward Peninsula, Alaska)

> The old timers said if you kill one caribou, the rest will go look for it, you can't change the route. You can't change anything about caribou. Travel 150 miles per day just to take care of reindeer, put them in safe place, chase caribou, but next day, same thing.
>
> (Seward Peninsula, Alaska)

2.4.8 Comparing responses of Elders and younger hunters

Levels of detail in descriptions of caribou leaders varied between Elders and younger hunters (Fig. 2.3). I used three measures to compare level of detail including coexistence of different caribou leader classes (a), whether interviewees elaborated on caribou behavior beyond leadership (social roles) (b), and whether additional characteristics were used to describe leaders beyond the cow/ bull distinction. I found that Elders gave more detail for all three measures compared with younger hunters. A larger proportion of Elders said multiple types of leaders coexist compared with younger hunters (13/16 vs 7/13). A larger proportion of Elders described social roles of caribou leaders (14/16 vs 6/13). A larger proportion of Elders gave detailed descriptions beyond sex of leaders (10/16 vs 3/13).

2.4.9 Comparing responses across communities

Interviewees from different communities described caribou leaders in similar ways, but with some differences in level of detail (Fig. 2.4). I used two measures to compare responses, including whether people elaborated on caribou behavioral (social)

roles (a) and whether they described leaders beyond the cow/ bull distinction (b). I found the largest difference between Dawson respondents and the other two communities' respondents. Less people attributed social roles to caribou leaders (55% vs 72%, 88%) and none made detailed descriptions of cow caribou leaders.

2.5 Discussion

2.5.1 Descriptions of caribou leaders: Summary of findings

This study found that caribou leadership exists as a complex aspect of caribou behavior, as described through the knowledge of caribou hunters and reindeer herders. Caribou leaders were mentioned as a driver of caribou migration along with other factors, such as forage availability, weather, and visual trails. The large percentage of people in Dawson (44%) who either said caribou leaders did not exist or were unsure, could be explained by the location of the community away from major migration routes, limited hunting of the Porcupine Herd, and their First Nation's political opposition to hunting regulations based on traditional knowledge of caribou leaders that is not locally practiced.

The description of caribou leaders from those interviewed did not match the definition implied by the Yukon fall hunting regulation on the Dempster Highway. The one-week hunting closure allows a very large group of caribou "leaders" to cross the highway in the Yukon Territory; in NWT the policy states that 200 females are to pass before hunting is allowed (PCMB, 2000). However, the majority of respondents referenced leaders in terms of one to a few caribou leaders per caribou group or leaders traveling ahead of the migration, and not only females were leaders in the fall.

Furthermore, interviews indicated that there is no single definition of "caribou leader" and instead suggested that caribou leadership is part of a more complex understanding of caribou social behavior. Multiple sex/ age classes of caribou leaders were recognized in association with different behavioral roles. Different classes of caribou leaders arise under different circumstances of predation, weather, or type of activity (i.e. migrating, feeding). For example, young bulls were described as going ahead of the spring migration only in conditions of heavy snowfall for the purpose of breaking trail. Whereas more people agreed females were ahead of the spring migration, no consensus was found for sex of leaders during fall migration.

When comparing descriptions of caribou leaders for PCH hunters and Seward Peninsula reindeer herders, similarities were found, including descriptions of specific sex/ age classes of caribou leaders (young bulls, older females), and travel alone or in small groups ahead of the fall migration. The comparison suggests that caribou leaders can be described in similar ways for different caribou herds. However the small sample of reindeer herders interviewed, lack of audio recording, and comparatively brief interviews with reindeer herders limits further interpretation. I also noted an important difference in the perceived impact people have on caribou migration when disrupting leaders. Reindeer herders see no significant disturbance to caribou movement despite large efforts to disrupt or eliminate caribou leaders, whereas PCH hunters described a significant impact to caribou movement through hunting practices (i.e. protect or shoot depending on outcome desired). This suggests that this study's respondents' socio-economic background may be a factor in how people perceive their impact on caribou migration.

2.5.2 Variability and context-specificity of traditional knowledge on caribou leaders

The term caribou leader as described by those interviewed encompasses a variety of different caribou in different sex/ age classes, with some caribou holding different behavioral roles in a group of caribou or the herd. This finding is consistent with a range of caribou leaders described in the study on roadside disturbance by Smith and Cooley (2003). Respondents also pointed to coexisting "leaders". Based on interview analysis, different types of caribou leaders arise depending on ecological context, whether caribou are moving, mating, feeding, predated upon, and most importantly, how people perceive caribou while they are hunting them. Ferguson and Messier (1997) argued that traditional knowledge on caribou may appear to conflict among hunters because they use different locations at different times. Cruikshank (1998) also says traditional knowledge further varies with time and place of the individual's observations. Nadasdy (2003) cautions against discrediting the validity of traditional knowledge based on variability in the context of co-management. Variation in location and timing of hunting trips and scale of behavioral observations explains in part the range of different caribou leaders identified.

The variability of responses can be further explained by social and cultural context. Berkes et al. (2000) argue that traditional ecological knowledge arises through social mechanisms such as rules and norms. In my interviews, the concept of caribou leaders was mostly referred to as a hunting tool. Behavioral observations were described as part of hunting trips, lessons from Elders, and part of people's hunting culture. Thus, people recognized caribou leaders through cultural context, suggesting that factors such as Elder status and relationship with own Elders influence perceptions of caribou leaders.

Elder and younger respondents differed in level of detail due to differences in past and recent hunting experience. Elders in Dawson and Fort McPherson tended to have spent more extensive time hunting on the land before the Dempster Highway was constructed. They also tended to give more detail, representing leaders in small groups and associating various behavioral roles to leaders. Younger people in these communities, who have hunted mostly on the highway throughout their adult lives were more general about leaders (cows/ bulls distinction only). Younger hunters may not have acquired the detailed knowledge of caribou leadership because of modern hunting techniques, easy access to caribou on the highway, and shorter average time spent hunting. A few younger hunters said that they had not learned about caribou and caribou leaders from Elders, but relied on personal experience. Understanding caribou behavior in detail may have been more useful in the past as the harvesting of caribou prevented life-threatening starvation and people's access to caribou was more limited.

Differences in level of detail of descriptions for caribou leaders between communities illustrates the variation in locations along the caribou migratory route. Old Crow interviews described caribou social roles and characteristics of caribou leaders with the most detail. Most Old Crow hunters hunt caribou in locations where caribou can be observed during migration. Those interviewed in Dawson reported less detail on caribou leadership than those in Old Crow and Fort McPherson. Dawson is located at the edge of the wintering range, north of which caribou tend to settle after the fall migration to feed and mate. Thus people's behavioral descriptions differ, emphasizing for instance mating bulls, and giving no detailed descriptions of cow leaders. One Dawson hunter remarked

that he knew females gather to migrate north in the spring, but this happened further north of where he traveled, and he was not usually there to hunt/ observe them. Several Dawson First Nation members also explained that their people traditionally favored hunting moose and 40-mile caribou herd. The Porcupine Caribou Herd represented a small portion of those First Nation members' harvest and was mostly accessed through the highway. The intermediate level of detail on caribou leaders described in Fort McPherson compared with the other two communities is consistent with the community's proximity to observe fall and spring migration, yet the extensive use of the highway's easy access for hunting.

Variability of responses among interviewees in this case cannot be used as a basis for rejecting information obtained through traditional knowledge. Instead it exposes the role of context in shaping variation in perception, differences in lifestyles, generational or social change, language barriers, etc, as described by Cruikshank (1998), Fergusson and Messier (1997), and Nadasdy (2003). When people speak of the same caribou herd, themes such as caribou leaders may be used to represent regional conditions, but local variation stems from geographical differences in caribou migration, ease of access to caribou, people's cultural identity with caribou, and necessity of harvesting caribou for survival. Thus, findings from this study caution against generalizing about caribou leadership regionally, even when managing one herd. The challenge of using context-dependent knowledge for management is further discussed in Chapter 4 of this thesis.

2.5.3 Methodological and analytical limitations to results

The findings from this study provide information about the diversity in perceptions of caribou leaders, reflecting knowledge for a subset of hunters (9-11 per community) in three communities. Individual knowledge is further dependent on specific hunting localities. Although a widespread concept of caribou leaders is often expressed by caribou hunters, the analysis of responses reported here prohibits generalizations about the perceptions of caribou leaders as held by indigenous hunters. Nevertheless, insight was gained about people's knowledge of caribou leaders and their understanding of aspects of caribou behavior. Moreover, the findings illustrate context specificity and the holistic nature of local and traditional knowledge.

In my study, I attempted to ask apolitical questions about people's knowledge of caribou leaders, their roles, and hunting practices as related to leaders. Political context is an integral part of knowledge and how it is reported (Agrawal, 1995; Nadasdy, 2003). Unless interviewees volunteered political opinion about the caribou harvesting policy, the political aspects remained hidden and unavailable for my analysis.

The population sample included a mix of Elders and younger respondents, even though some local residents recommended that our study only interview Elders. Elders gave a richer description of caribou leaders than younger hunters. This difference suggests a more complete picture of the traditional concept of caribou leaders could be obtained from selectively interviewing Elders. Indeed, in other studies Elders have been found to hold more detailed traditional knowledge than younger respondents because they generally have more extensive experience following traditional hunting practices

and more teachings from previous Elders (Barnhardt, 2005). This study contributes evidence for understanding the differences in how knowledge is reported between Elder and younger hunter groups.

Parts of the questionnaire did not elicit responses, caused annoyance and in two cases caused a "shut-down" of responses by interviewees. Most people commented on a question perceived as nonsensical, repetitive, or could not be answered based on their knowledge. Questions perceived as uninteresting caused abridged responses (e.g., seasonality). The questionnaire would have benefited from "pre-test interviews" and a shorter, more open-ended interview format, as well as follow-up interviews.

Disparity between indigenous dialects and English language definitions of caribou leaders revealed that caribou leaders are different types of caribou. A few interviewees used Gwitch'in names of caribou leaders and explained their perceived roles inside the caribou herd. The Gwitch'in language dictionary includes 14 words for caribou for the Fort McPherson dialect alone (Gwitch'in Language Center, 2005). Similarly Kofinas (1998) identified 19 different terms for caribou in the dialect of Tughuh. The different terms give specific information about a caribou, including sex, age, season, reproductive condition, and are associated with specific behavior within a herd of caribou. I could have obtained a richer picture of caribou leaders using indigenous dialects and a translator. Although the option of a translator was offered in each community, all of the interviewees wished to be interviewed in English. Ensuring that the hired assistant could speak the indigenous language and preparing a translated consent form may have enhanced the quality of information gathered. Nevertheless, interviews showed that the

English translation of "caribou leaders" is vague and a much more complex understanding of caribou behavior exists.

2.5.4 Worldview-based understanding of caribou leaders

This study illustrates that traditional ecological knowledge of caribou leaders includes not only factual knowledge and observations, but is rooted in cultural values and ethics (Houde 2007). The latter aspects are often ignored when TEK is integrated into management, using a scientific design-oriented approach (Leach et al., 1999). Not only is knowledge of caribou leaders specific to people's experiences, it is also rooted in a holistic approach to hunting that cannot be easily integrated into a bureaucratic, science-based model of management. However, Berkes and Berkes (2009) argue that the traditional holistic approach is particularly well suited to deal with many variables qualitatively rather than few variables quantitatively. Holism in TEK could therefore be recognized as a tool to provide valuable insight in understanding complex problems.

One of the surprising aspects of interviews was some Elder's willingness to defend what should remain unknown. Whereas some stated that they did not know the answer to a question, others specified that questions could never be answered because some aspects of nature are inaccessible to people's understanding. One interviewee explained that some details in the questionnaire were not directly relevant to people's hunting practice, and therefore should remain unknown. This acceptance of the aspects of nature that are not understood illustrates the direct relevance of traditional ecological knowledge to survival, culture, and society. It also stresses the trust people put in nature's

ability to support them, and that nature can function on its own without added understanding, and the humble position people should hold as a part of nature. People's traditional view includes the notion of respect in every aspect of hunting practice. Lack of respect, and not lack of understanding, was mentioned as the main reason for social and ecological issues. Thus, the notion of caribou leaders not only is highly context dependent, but is rooted in respect, a holistic worldview, and social-cultural values. Resulting discrepancy of traditional knowledge with enforced hunting regulations is further discussed in Section 4.51 (Chapter 4).

2.5.5 Ways of learning and sources of knowledge on caribou leaders

People reported knowledge of caribou leaders is based on different ways of learning and sources of knowledge. The majority of behavioral descriptions came from people's own observations. Hunters spent much time observing caribou during hunting trips. A few of the younger hunters acknowledged that they were self-taught due to parents struggling with alcoholism or residential school, and relied more heavily on personal observations. Although most easily appreciated by a non-indigenous audience, this observational source of knowledge is at the greatest risk of being misinterpreted (Cruikshank, 1998; Houde, 2007). In this study, I therefore tried to stay close to what people said, avoiding generalizations and including all descriptions of caribou leaders, not excluding those that could seem "irrelevant" or "implausible" (e.g., wolves as leaders of the caribou herd). Nevertheless, due to my cultural bias, this interpretation may not reflect exactly what interviewees intended to convey about caribou leaders.

Another major source of knowledge, acknowledged at the beginning of most of the interviews, was the teachings of people's own Elders. This is the component that has been most associated with richness and detail of traditional ecological knowledge (Barnhardt, 2005). Indeed, Elders that received the most intensive teachings from their Elders gave more detailed descriptions of caribou leaders and clearly explained the occurrence of multiple leaders. The richer, more complex interviews showed locally specific understanding of caribou leaders. They also helped to reconcile apparently conflicting views on whether bulls or cows were leaders. Indeed, Elders explained behavioral roles associated with a range of perceived caribou leadership, and gave more context-specific descriptions.

Not surprisingly, many interviewees referred to caribou migration in locations beyond their own hunting expertise, especially when talking about migration to the calving ground in the spring. Widespread access to mainstream media and the effort of the Gwich'in Nation in lobbying against oil and gas development of Area 1002 in the Arctic National Wildlife Refuge on the North Slope of Alaska, in part, explains this broader knowledge and interest. Additionally, radio collar spatial data for PCH animals has been made available to PCH hunters to assist in their hunting effort (Kofinas, 2005). Thus, younger hunters tended to refer to radio collars when talking about large-scale movements. Some younger respondents also referred to knowledge of caribou migration they had acquired during formal education. Although these references were minimal compared to people's own observations and teachings from Elders, I chose not to ignore information associated with such sources of knowledge. I based this choice on the idea

that traditional knowledge is constantly evolving, gradually incorporating aspects of other cultures, reformulating and reinterpreting ideas and beliefs (Krupnik and Vakhtin, 1997). Thus traditional knowledge cannot be extracted and separated from a mix of cultural influences; rather this is part of the dynamic process of culture change.

2.5.6 Further work

Based on this study of caribou leaders in traditional knowledge, I recommend the following approaches and areas for future research. (1) Focus on indigenous language traditional terms for caribou during interviews. These terms help define the aspects of caribou "leadership" behavior in context. (2) Involve local youth when conducting interviews. Elders are more enthusiastic about passing on their knowledge to their own youth than to outsiders, and the involvement of youth would have provided a dual benefit of the study. (3) Conduct focus group research. Focus groups have shown to provide useful documentation of traditional knowledge, sometimes superior to that gathered during one to one interviews (Smith and Cooley, 2003). The concepts of caribou leaders are complex and interpretation of differences and context specific details may be facilitated with this method. (4) Conduct similar interviews/ focus groups in caribou subsistence communities across the Arctic to capture the geographical spread and understanding of this caribou leader concept.

2.6 Conclusions

Those who were interviewed used "caribou leaders" as a broadly defined term. The concept was associated with different sex/ age classes of caribou, different behavioral roles and even included wolves. However, the common theme relating caribou leaders to traditional hunting practice was the potential for caribou leaders to modify behavior of caribou groups at smaller or larger spatial scales. Hunters reported that they traditionally protect or shoot certain caribou leaders to maximize their harvest. Recognizing which animals are the leaders, when to protect or shoot them, depends on hunting experience and passing down of knowledge from generation to generation.

Knowledge of caribou leaders is situationally specific and requires that a hunter understand aspects of the ecology and behavior of the caribou herd. This knowledge is often time and space dependent. As was evident in the findings of this study, each person drew on a variety of knowledge sources to formulate their interpretation of caribou leadership. Additionally, his or her interpretation was rooted in social, cultural and political context. The holistic nature of TEK prohibits those who document such knowledge to extract only certain aspects deemed useful for management or generalize across localities. Without context and variability, TEK-based management is no longer relevant to people's traditional hunting practices.

Elders call for greater efforts to educate youth as traditional ecological knowledge is becoming less detailed with a reduction of time spent out hunting on the land and conflicts with other aspects of social-cultural change (Section 4.41, Chapter 4), Elders emphasize respect for the animals and hunting ethics, in an attempt to reconnect younger

hunters with their caribou resource, to protect both the resource and the subsistence lifestyle. Elders may have brought the concept of caribou leaders to public attention as a way to promote social wellbeing and cultural heritage, to increase resilience of the community. The findings in this study can be used to aid in such educational efforts, however, they are not easily incorporated into a harvest management strategy. The barriers to using traditional knowledge through the "let the leaders pass" policy and its enforcement are discussed in Chapter 4 of this thesis.

2.7 Acknowledgements

Many thanks to all the people who offered their time and shared their knowledge with me during interviews. In alphabetical order, thanks to Neil Colin, Art Christiansen, Woodie Elias, Amos Francis, Donald Frost, Percy Henry, Ronald Johnson, Angie Joseph-Rear, Roberta Joseph, Peter Josie, David Harvey Kassi, Danny Kassi, Peter Kay, Peggy Kormendy, Irwin Linklater, Peter Nagano, Robert Rear, William Teya, Wanda Pascal, Abraham Stuart, Abraham Peterson, Michael J. Pascal, Ernest Vittrekwa, Joel Peter, Randall Tetlichi, Peter Tizha, George S Moses, and to others who did not wish to be mentioned in this section.

I thank those who assisted me during interviews, May André, James André, Cheryl Charlie, James McDonald, and Ryan Peterson. Many thanks to Joe Tetlichi and his family for welcoming me into their homes.

I also am grateful to my advisor Gary Kofinas for his extensive help on this project, and to my additional two committee members, Brad Griffith, Greg Finstad, for

their thoughtful review of chapters and guidance in the research process. I also give special thanks to Dorothy Cooley, Deana Lemke, Bill Schneider, Barney Smith, members of the Porcupine Caribou Management Board, and others.

This project was supported by the Porcupine Caribou Management Board, Vuntut Gwichin First Nation, Tetlit Gwich'in First Nation, Tr'ondëk Hwech'in First Nation, Environment Canada (Yukon Government), the IGERT program at the University of Alaska Fairbanks, CARMA, the National Science Foundation, the Heterogeneity and Resilience of Human –Rangifer Systems Project, and the Institute for Global Awareness.

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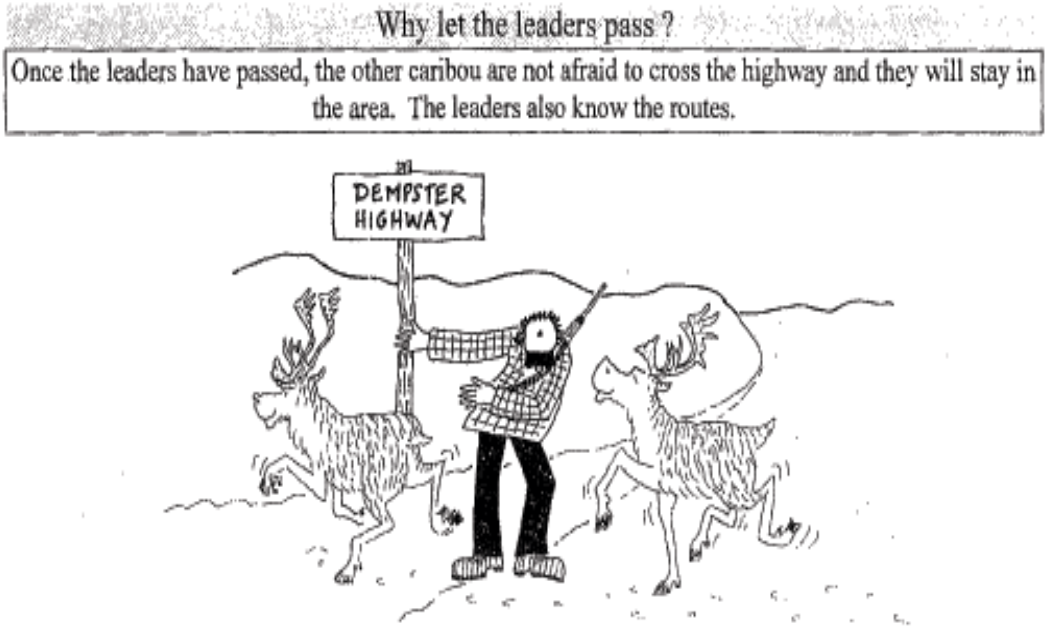


Figure 2.1. “let the leaders pass” cartoon by Doug Urquhart, as printed in PCMB (1995:10)

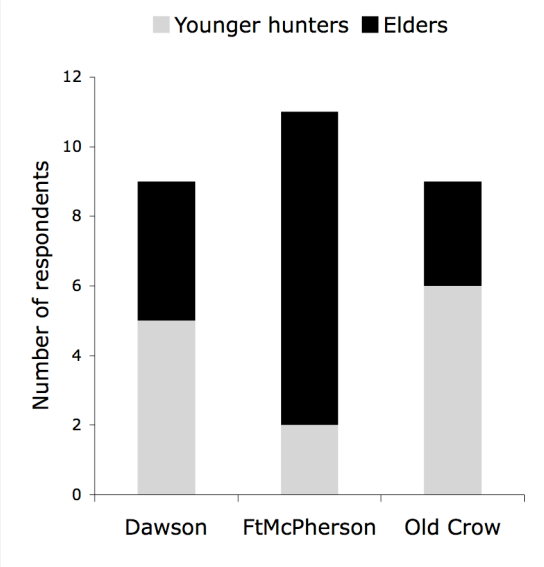
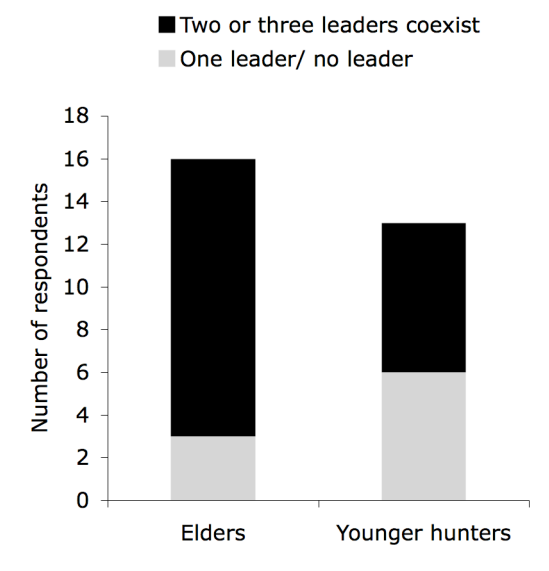
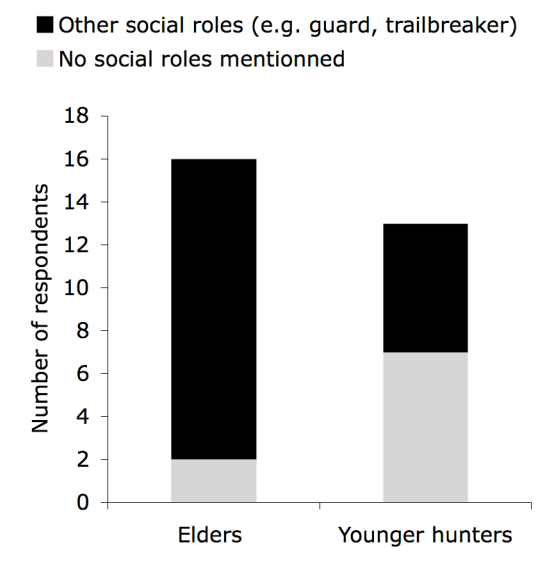


Figure 2.2. Proportion of Elders interviewed in each community.

(a)



(b)



(c)

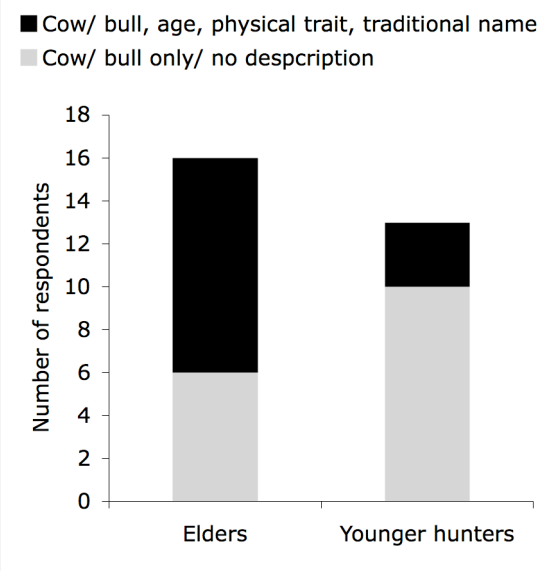


Figure 2.3. Comparing richness of responses between Elders and younger hunters: (a) several types of caribou leaders coexist (b) specific behavioral social roles of caribou leaders (c) description of leaders' age, other physical attributes, a traditional name.

(a) (b)

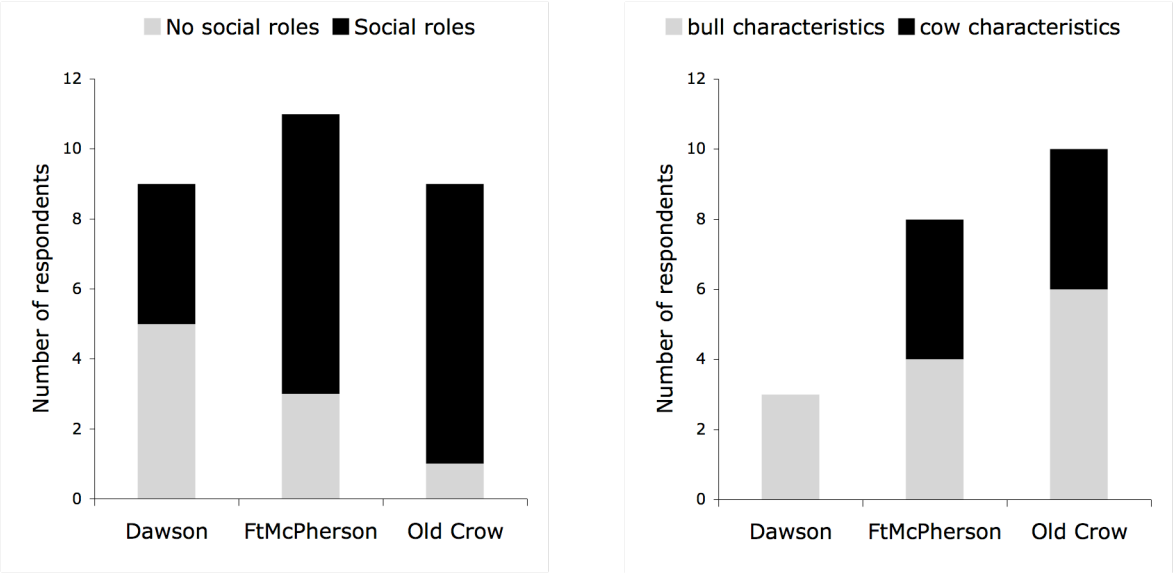


Figure 2.4. Differences of responses between communities: (a) Respondents that mentioned social roles of caribou leaders (b) Respondents that specified characteristics of cow and bull as caribou leaders.

Table 2.1. Sex-age/ role-specific caribou leaders described in Porcupine Caribou communities.

Type of leader	Roles	Mentions (n=29)	Interview references
Young/ small bulls (dazhoo tsoo)	Guards, trailbreakers, fool caribou (trickster).	9 (Elders: 6)	11,12,18,20,21,22, 23,24,27
Older dry cow (vadzai njoo)	Knows the way, teacher.	2 (Elders: 1)	22,23
Single cow and calf pair ahead	Scouts, trailbreaker, knows the way.	10 (Elders: 6)	1,6,8,14,18,22,23, 24,25
Young/ small cows	Maternal urge, trailbreaker, scout.	4 (Elders: 3)	11,12,13,19
Large mature bull	Boss, breeder, teacher, knows the way.	5 (Elders: 4)	1,2,5,15,24
Wolves	Doctor.	3 (Elders: 2)	6,14,29

Table 2.2. Sex class of caribou that travels ahead during spring and fall migration

Fall			Spring		
Sex class	Mentions (n=29)	Interview references	Sex class	Mentions (n=29)	Interview references
Cows	6	1,9,11,13,17,25	Cows	12	1,2,3,5,8,11,13,17,21,25,27,29
Bulls	7	2,15,16,20,21,23,24	Bulls*	2	27,29
1 Cow and calf	3	6,14,18	1 Cow and calf	4	14,18,23,24
Mixed sex	3	8,12,19			

* Interviews 27 and 29 mentioned bulls were only ahead under deep snow conditions to break trail, but females would still show the way. Additionally, interviews 1,2,5 mentioned that bulls were still "leaders" in the spring even though cows traveled ahead.

Table 2.3. Number of caribou leaders and scale of leadership

Number of leaders	Mentions (n=29)	Interview references	Scale of leadership	Mentions (n=29)	Interview references
1-few (<5)	14	1,5,9,10,11,12,14,17,18,20,22,24,25,28	For every group of caribou	4	5,14,17, 25
			Ahead of the fall/ spring migration	6	9,12,18,20,25,29
10-15	1	19	Ahead of the fall migration	1	19
Several hundred*	3	4,8,9	Ahead of the fall migration	3	4,8,9

* Interviews 8,9 reported this large group was what they "heard" were called leaders for the purposes of the hunting regulation on the Dempster Highway, but not expressing their own views or observations. Interviewee 9 then described leaders in the "1-few" category from personal observations.

Table 2.4. Seward Peninsula reindeer herders' descriptions of caribou leaders traveling ahead of the herd during fall migration for the Western Arctic Herd.

Sex/ Age class	Numbers	Distance	Mentions (n = 6)
Young bulls	1-few (<5)*	1-5 days ahead	5
Older cows	1-few (<5)	1-5 days ahead	2
Mixed older (skinny) bulls and cows	30 000	N/A	1

* One respondent mentioned lone bulls traveling ahead could not necessarily be called leaders because they were "just sniffing around" and other caribou were not following them.

Chapter 3 Leadership in captive barren-ground caribou (*Rangifer tarandus granti*): an experimental approach[2]

3.1 Abstract

Indigenous caribou hunters suggest a need to manage and protect leaders in harvested animal groups. I investigated leadership in captive barren-ground caribou (*Rangifer tarandus granti*) in a controlled experiment. The definition of leaders was the first animal in a male-female pair to cross an artificial barrier to reach a new feeding site. I used two multi-layered vertical barrier conformations and found females crossed the entrance of the barrier first more frequently than males (7 versus 1), but not the exit. My finding of female leadership was consistent with studies of sex-specific leadership in various group-living species that have shown females are more likely to lead.

3.2 Introduction

Leadership behavior in groups of moving animals has been defined in multiple ways; for example, (i) the ability to guide other group members to a new location (Beekman, Fathke, and Seeley, 2006), (ii) characteristics of individuals, such as sex and age (Couzin and Krause, 2003), or (iii) simply as the position at the front of a moving group (Gueron, Levin, and Runbenstein, 1996). Despite controversy surrounding definitions and mechanisms of leadership in animal groups, leaders exist at least under

[2] Padilla, E. 2010. Leadership in captive barren-ground caribou (*Rangifer tarandus granti*): an experimental approach. Prepared in the format for Journal of Applied Animal Behaviour Science.

this latter definition. An observational study on grazing heifers (*Bos aurus*), defined leadership as a behavior consistently initiated by certain individuals, rather than just the consequence of animals gradually moving away from a group and being followed (Dumont et al., 2005).

Both behavioral observations and mathematical models have contributed to present understanding of leadership in moving groups of animals. Reports of leadership in gregarious species range from honeybee swarms and fish shoals to elephant herds and primate families (Beekman, Fathke, and Seeley, 2006; Leblond and Reebs, 2006; Leca et al., 2003; McComb et al., 2001). However, only limited generalizations can be made on the existence of leaders or mechanisms of leadership based on available data and analyses. A Study on African buffalo (*Syncerus caffer*) found no leaders, but instead found that adult females were consistently the sex and age class to show "voting" behavior, an expression of the direction in which the herd should go to forage (Prins, 1996). On the contrary, Dumont et al. (2005) suggest grazing heifers have single individuals with strong leadership traits that are independent of characteristics such as sex or age.

Theoretical models by Couzin and Krause (2003) suggest that group self-organization produced a set of leaders dependent on individuals' experience and characteristics (e.g., sex/age) that affect physical attributes (e.g., walking speed). For example, young males who walk fast could be segregated at the front of the group coincidentally, because they walk fast, not because they aggregate to travel together. In contrast, Conradt and Roper (2005) predicted that social interactions would influence the

timing of travel and number of leaders, when several animals of the same sex are in the group. Signaling and social learning may create leadership when the position of group members depends on tendency of individuals to interact with others who possess certain characteristics (e.g., males tend to interact with females) (Lachlan, Crooks, and Laland, 1998; Mosley, 1999). Although these models addressed leadership in large groups of moving animals, groups as small as a foraging pair were shown to have leaders in a model that contrasted feeding and predation tradeoffs (Rands et al., 2003).

Despite different explanations for leadership behavior, most studies indicated that characteristics such as sex, age, and energetic and reproductive status of individuals were associated with the relative position at the front of the group and/or the ability of an animal to be a leader. Age, nutritional status, and boldness of character were identified as leadership characteristics in a modeling study of foraging pairs and observed in shoals of golden shiners (*Notemigonus crysoleucas*) (Rands et al., 2003; Leblond and Reebs, 2006). Interestingly, leadership was not associated with dominance status in herbivores (Bailey, Dumont, and WallisDeVries, 1998; Mosley, 1999; Paine, 1988; Reinhardt, 1983).

Females are most often identified as leaders throughout the scientific literature. Studies of sex-specific leadership in cattle, bighorn sheep, elephants, capuchin monkeys, geese, guppies and brown surgeonfish, showed that females were consistently more likely to lead, although observations were often limited to a single leader for each social/foraging group (Kiflawi and Mazeroll, 2006; Lachlan, Crooks, and Laland, 1998; Lamprecht 1992; Leca et al., 2003; McComb et al., 2001; Réale and Festa-Bianchet,

2003; Reinhardt, 1983; Reinhardt, 2005). In a semi-wild cattle herd, older males were more likely to lead only when they encountered an unfamiliar herd (Reinhardt, 1983).

The scientific literature for *Rangifer tarandus* suggest female leadership is also an important aspect of caribou behavior. Although few scientific studies have investigated caribou leadership, Miller, Jonkel, and Tessier (1971) and Klein (1971) suggested that a few leaders with previous travel experience are needed for migration in *Rangifer*. Similarly, reindeer herds composed of young reindeer are unmanageable unless a leader is introduced to direct herd movement (Baskin, 1989). A single adult female added to a group otherwise lacking leaders would enable herd management (Baskin, 1989). Paine (1988) also described leadership as a central characteristic of *reindeer and caribou* behavior that is distinct from dominance. When the herd is alarmed, he describes that experienced and/ or alert animals break away from the herd and lead other animals to a new location. He also describes that cows aged five to six years old lead herds to new pasture along established trails. Finally, he argues that the follower phenomenon is the most important aspect of leadership behavior. Despite evidence for the existence of leaders in *Rangifer tarandus*, De Vos (1960) noted a lack of specific leader animals in his observations of barren ground caribou.

The Porcupine Caribou Management Board (PCMB, 1995) urged hunters to protect caribou leaders of the Porcupine Caribou Herd in Northwestern Canada hunting, in order to promote herd migration to wintering grounds east of the Dempster highway. Assumed caribou leadership is also partially the basis of road management in western Alaska as associated with the Red Dog Mine. Road closures are designed to minimize the

disturbance on caribou migration (Haley et al., 2009). Identifying caribou leaders may become an important tool in managing for the sustained harvesting of caribou if hunters can select caribou that are not leaders based on sex.

I used a behavioral approach to study sex-specific leadership of caribou *(Rangifer tarandus granti*). The definition of leader was the first animal in a male-female pair to cross a vertical artificial barrier to reach a feeding site. Females were found or expected to lead based on the literature described above. Therefore, I hypothesized that females would cross the barrier first.

3.3 Materials and methods

3.3.1 Study site and animals

I conducted the experiment at the Robert G. White Large Animal Research Station (LARS) University of Alaska Fairbanks, from 15-22 August 2007. Experimental caribou were all born in captivity, but originated from caribou of the Delta and Porcupine Herds in Alaska (respectively 1984 and 1987). Trials took place in two pens, which contained low grassy vegetation. The University of Alaska Fairbanks Institutional Animal Care and Use Committee (IACUC) approved this study (protocol # 07-08, final approval # 20070322).

3.3.2 Preliminary trials and study design

I used two pens, pen A (LARS pen 7) and B (LARS pen 8), to conduct my trials. Four caribou (two cows, one calf, one yearling bull) not used in the experimental part of

the study, were allowed to graze freely in both pens. LARS staff recorded the area where animals spent most of their time grazing and I termed this the "preferred grazing area" (Fig. 3.1).

I conducted preliminary trials to test barriers for animal safety and reaction. A captive herd of 18 adult caribou and 5 calves was exposed to barriers simulating roads (black garden shading material) and vertical obstacles (plastic yard fence). Caribou ate the garden shading material and LARS staff deemed injury to caribou was possible with fencing material placed on the ground. Based on these trials, I chose a plastic yard fence with lattice (1.5 meters high) to create a visual barrier and then used the barrier to divide pens into two separate sections. LARS staff set up barriers in pens A and B that were composed of 2 to 3 rows of fencing (Fig. 3.1). This barrier allowed two animals to pass side by side through openings and corridors (1.8 meters wide).

Additionally, staff mowed grass on the release side and placed a feed bucket within the preferred area to increase incentive (Fig. 3.1). In August 2007, LARS staff segregated caribou used in the experiment from other caribou for one week before trials. Staff placed buckets containing "D-ration" feed (Ruminant D: Alaska Mill & Feed, Anchorage) next to the regular feed stations in the holding pen (LARS pen 1) so caribou would become familiarized to being fed a supplement ration in a recognizable container. During trials, staff released caribou on the non-preferred grazing area and let animals pass through the barrier at will.

I used 15 captive caribou (10 cows, 5 bulls) at LARS that ranged in age from 1 to 13 years (Table 3.1). I randomly assigned each male and female to 10 mixed-sex pairs. I

included all males twice, due to the low number of male caribou available at the facility Calves accompanied cows in 4 different trials where the calf was not yet weaned from its mother. All animals were naïve to the experimental conformations of the barrier but were familiar with the pens. In order to limit learning of male caribou that had previous experience passing through a barrier, I divided trials into two groups and assigned five pairs to pen A and five to pen B. Each male went through pen A first and then pen B with a different female. I used order of passage data for eight pairs as the effect. One cow died during the experiment from unrelated causes and the other pair was dropped from the analysis because of a sick calf that may have caused the mother to modify her behavior while crossing the barrier.

3.3.3 Protocol for observations

All trials began between 10:00 h and 11:00 h to match normal feeding periods. LARS handlers separated each pair from the rest of the herd approximately 15 min before the start of the trial. Handlers lead each male/ female pair of caribou to gate 1 of pen A (trials 1-4) or pen B (trials 5-8) (Fig. 3.1) through an existing fenced-in corridor. I recorded the order in which the male or female went through the entrance and exit of the barrier with a camera (Sony SNC RZ30N) placed and 4.5 m across from gate 1 and elevated 3.6 m off the ground (Fig. 3.1). After both caribou crossed the exit at least once, handlers led both caribou out of the pen through gate 2 (Fig. 3.1).

3.3.4 Data analysis

I used Fischer's exact test (two-tailed probability for 2 x 2 contingency table) to test whether there was a significant difference between frequency of females and males passing the barrier entrance or exit first. I chose this test because of the small sample size (Zar, 1996). I tested the effects of a) using the same individual males twice and b) which pen was used on male leadership through a logistic regression with the following equation:

$$\text{Log odds (male first)} = \beta_0 + \beta_{male} + \beta_{pen}, \quad \text{(eq. 3.1)}$$

where β_0 is the frequency of males going first, β_{male} is the individual male used in each pair, and β_{pen} indicates whether the observations took place in pen A or B. I used a "males first" hypothesis, as the least probable hypothesis. I used SAS for all statistical analyses (SAS online manual, Version 8, 2000). All tests were conducted at an a priori alpha of 0.05.

3.4 Results

Females first crossed the entrance of the barrier more frequently than males (7 versus 1 respectively; $P = 0.01$). There was no difference between how often females and males first crossed the exit of the barrier (5 versus 3 respectively; $P = 0.61$).

I found no effect of repeatedly using caribou males across trials ($\chi^2 = 0.0$, $P = 1.0$).

3.5 Discussion

Leadership by captive female caribou through the entrance of the barrier to reach a new feeding site was consistent with the observations by Miller, Jonkel, and Tessier (1971) that cows directed group movement of wild caribou when groups encountered a barrier. My findings support female biased leadership among various species (Kiflawi and Mazeroll, 2006; Leca et al. 2003; Mosley 1999).

While females led through the entrance, neither sex tended to exit first. Pen A featured a corridor from entrance to exit, where animals exited in the same order they entered. The width of the barrier corridor necessary for two animals to move around each other may have been underestimated. In pen B, the maze design of the barrier likely caused the difference in entrance and exit order. Caribou could go left or right through a barrier opening, with the left turn leading to the exit. In one trial, the female entered ahead of a male, but turned right instead of left, reached the dead-end point, turned around and caused the male to rush ahead to the exit. Animal order at barrier entrance may be a better test of leadership in this study, due to naïve caribou pairs, the chance factor involved with solving the maze, and a corridor that was potentially too narrow. Nonetheless, a maze design may be appropriate in some cases (e.g., using experienced animals). For instance, a multi-arm radial maze has been used successfully to estimate leadership in cattle pairs (Bailey, Howery, and Boss, 2000).

Because there were few captive caribou, I obtained a larger number of observations with naïve caribou through pairing males and females instead of using the whole herd (n=1). By definition, the second caribou followed the leader caribou through

the barrier in all trials. The inclination of the second animal to follow the first was demonstrated by apparent active searching for the other animal. Although little is known about leadership in pairs of captive caribou, Bailey, Howery, and Boss (2000) showed that leader-follower phenomena occurred in pairs of cattle navigating a maze to find a feeding area. Additional evidence in homing pigeons suggests that pairs navigate more efficiently with a leader than individually (Biro et al., 2006). Possible behavioral inferences from leadership in naïve pairs of captive caribou to migration of wild herds are limited. For instance, reindeer herds split due to road disturbance showed decreased movement rates, which suggests that a minimum number of animals, greater than a naïve pair, are required to start migration (Klein, 1971). Thus, female leadership in a captive pair of caribou may not be applicable to a migrating herd. Context specific female leadership may explain why de Vos (1960) did not observe any particular sex or age class leading the herd in his observations of migration, whereas Paine (1988) and Baskin (1989) mentioned females as leaders in specific cases (e.g., under alarm or foraging bouts).

Several studies have indicated that characteristics (e.g., sex, age) determine what individuals are leaders or followers (Couzin et al., 2005, Dumont et al., 2005). Indigenous hunters recognized different types of caribou leaders through sex, age, and reproductive status (Section 2.43). In this study, sex was the only potential leadership characteristic that was tested, although age and individual character of animals may have contributed to my results. Because all animals had similar previous knowledge of the pens and traveling through fenced corridors, but were equally naïve to the particular

barrier setup, greater knowledge of the setup by one animal over the other in a test pair did not explain leadership. Male-female pairs were formed shortly before each trial, so dominance of one animal over the other could only be established through previous interaction while they were in the captive herd.

Females were older than males on average, but I cannot make any inferences about age of males or females leading due to the uneven age distribution and small sample size of the study group (Table 3.1). Of the 4 males that went first through the entrance (1) or exit (3), three were yearlings. Although this suggests that age may influence leadership, sample size and age distribution prohibits this level of inference. Other potential characteristics include boldness or risk taking as associated with leadership (Leblond and Reebs, 2006). Younger males may be more likely to take risks because they lack experience. Interestingly, young bulls are also referred to as "leaders" and "scouts" in traditional knowledge of caribou hunters (Section 2.43). Risk-taking may have been a factor for caribou going first to cross the barrier. Nevertheless, the second caribou followed the first in each trial to the new feeding location and enabled me to call the first caribou a "leader".

Evolutionary pressure to increase reproductive fitness through foraging could explain female sex-specific leadership in caribou (Kiflawi and Mazeroll, 2006). Animals in my study were not under nutritional stress and had equal access to feed. However, nutritional intake of female caribou in early fall (August-September) affects their ability to either breed or produce milk and survive the winter (Chan-McLeod, White, and Russell, 1999). Body weight during this period has been directly related to successful

pregnancy and earlier parturition (Adams and Dale, 1998; Cameron and Ver Hoef, 1993). Additionally, females are recovering from pregnancy and lactation in late summer. In a model by Rands et al. (2003) predicting foraging behavior for "fat" and "lean" players, the "lean" player's foraging behavior is directed by its own reserves, whereas the "fat" player's responds to the state of the "lean" player. This model predicted that leaders and followers would spontaneously arise in a pair due to individual's decisions that maximize their survival. Chan-McLeod, White, and Russell (1999) showed breeding females are leanest amongst reproductive categories in early fall. My study took place in August when male caribou also need to forage in preparation for the rut. Although males and females are both under evolutionary pressure to gain weight, females may still emerge as leaders because they are "leaner" at that time. Nevertheless, female leadership may only be specific to time of year and scale. For instance, Cameron and Whitten (1979) showed that females with calves in the Central Arctic Herd stayed in the northern part of their range longer in August. Thus, females with calves may not lead the fall migration. The observational study by Prins (1996) contradicts the "leaner" animal explanation as he found the animals in the front of a moving group were in higher than average body condition .

Practical management applications for the Porcupine Caribou Herd based on the outcome of this study are limited. In 1995, members of the PCMB received a recommendation from the community of Fort McPherson (Northwest Territories, Canada) that a "let the leaders pass" policy be implemented that would create a seasonal hunting closure on the Dempster Highway (Section 4.44). Noting the absence of

scientific studies on caribou herd leadership and difficulties on completing them, the co-management body recommended a hunting closure based solely on traditional knowledge (PCMB 1995). As I showed in Chapter 2, the traditional knowledge of community members described caribou leaders as specific to context (e.g., timing and location of observation, behavior of leader, hunting technique). All sex and age categories were identified as potentially assuming leadership in some context. In contrast, this study points to specific female leadership in pairs of captive caribou where a barrier is first encountered at a local scale.

Because of my small sample size and the use of captive caribou, I cannot make inferences about migration in large herds of wild caribou. This study, amongst aforementioned studies and Chapter 2 of this thesis, show that females tend to be leaders at different scales, including pairs. However, the emergence of female leadership may be dependent the type of movement or behavioral activity. A "letting the leaders pass" policy may enhance survival of some unknown percentage of all females. Population-level effects of selectively harvesting caribou leaders are discussed in Appendix 1 of this thesis. Despite this study's limitations, managers, co-management boards, and communities may promote further discussion of caribou leaders through hunter education.

3.6 Acknowledgements

The University of Alaska Fairbanks Institute of Arctic Biology 2006 summer research grant funded this study. I thank Bill Hauer, Sandy Garbowski, Perry Barboza,

and others at the Large Animal Research Station who made this study possible. I also thank my graduate advisory committee, Gary Kofinas, Brad Griffith and Greg Finstad for their support and ideas in this project. Members of the spring 2008 BIO 694 scientific writing class helped greatly with reviews of this manuscript.

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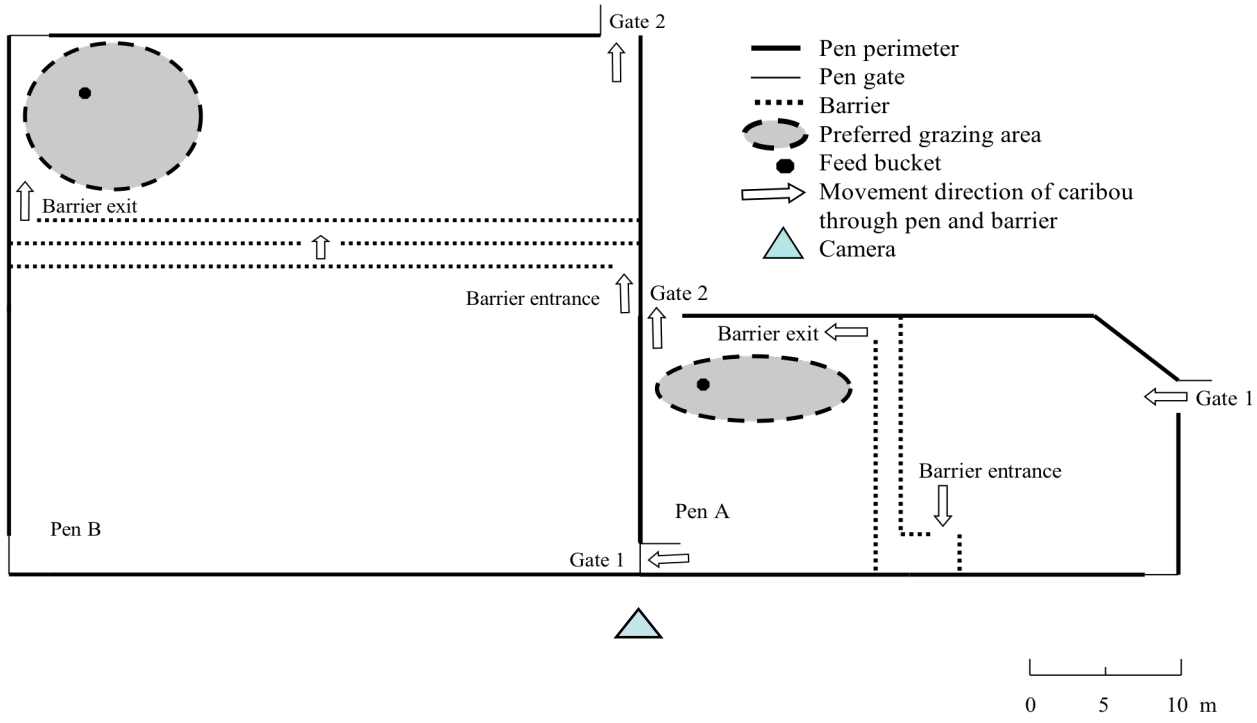


Figure 3.1. Pen A (809m^2) and B (2023m^2) configuration during August 15-22, 2007 at the Large Animal Research Station, University of Alaska Fairbanks, Fairbanks, Alaska.

Table 3.1: Observations of sex specific leadership in caribou crossing artificial barriers took place between 15-22 August 2007 in pens A and B at the Large Animal Research Station (University of Alaska Fairbanks). I withdrew two pairs of caribou from the study following the death of one cow (X) and the weakened condition of a calf in another pair (Y).

	Pair		Age				First through	
Date	Trial	Pen	Male	Female	Calf present	Pair withdrawn	Entrance	Exit
08/15/07	1	A	4	3	Yes	No	F	F
08/15/07	2	A	1	13	Yes	No	M	M
08/16/07	3	A	5	11	No	No	F	F
08/16/07	4	A	7	10	No	No	F	F
08/17/07	5	B	5	1	No	No	F	M
08/17/07	6	B	4	10	Yes	No	F	F
08/21/07	7	B	7	11	No	No	F	F
08/22/07	8	B	1	4	No	No	F	M

Chapter 4 "Letting the Leaders Pass": Barriers to using traditional ecological knowledge in co-management as the basis of formal hunting regulations[3]

4.1 Abstract

I studied the application of traditional ecological knowledge (TEK) as the basis for formal hunting regulations. I conducted a case study of the Porcupine Caribou Herd "let the leaders pass" policy established for the Dempster Highway, and identified conditions creating barriers to the use of traditional ecological knowledge (TEK) in co-management. Stated as propositions, barriers include, but are not limited to: (1) the context-specific nature of traditional ecological knowledge limited its application in conventional resource management (2) changes in traditional authority systems, hunting technology, and the social organization of harvesting caribou affected the applications of TEK approaches (3) indigenous efforts towards self-government and political autonomy limited regional co-management consensus (4) there was a cultural mismatch between using TEK as enforcement and its use for education. The process of identifying and understanding the social dynamics related to these barriers may make apparent solutions for transforming the co-management process.

[3] Padilla, E., Kofinas, G. 2010. "Letting the Leaders Pass": Barriers to using traditional ecological knowledge in co-management as the basis of formal hunting regulations. Prepared in the format for Journal of Human Organization.

4.2 Introduction

This paper explores the conditions creating barriers that limit the successful application of traditional ecological knowledge (TEK) in co-management. Regulating hunting to "let the caribou leaders pass" of the Porcupine Caribou Herd (PCH) along the Dempster Highway (northwestern Canada) provides an informative case study.

I used the term traditional ecological knowledge (TEK) instead of indigenous knowledge or local knowledge, despite ambiguous definitional issues, as it is more specific to indigenous peoples' knowledge of the land (Berkes 1993). I use Fikret Berkes' working definition of TEK: "A cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment." (2008: 7)

The term co-management has also been defined in multiple ways, as reviewed by Carlsson and Berkes (2005). Their review emphasized that co-management has complexities, variations, and a dynamic nature that are not captured by most definitions. I chose to use Sara Singleton's definition as it best reflected the ideals of co-management in this study: "The term given to governance systems that combine state control with local, decentralized decision making and accountability and which, ideally, combine the strengths and mitigate the weaknesses of each." (1998: 7)

Achieving effective co-management is in many respects a collective action problem among stakeholders, including governments. Understanding co-management dynamics of the let the leader pass regulations suggest the need to consider the costs and benefits of

various actors at various scales, from the individual hunter to communities, First Nations, and territorial and federal governments. As noted by several studies, co-management is typically no panacea (Caulfield 1997; Kofinas 1998; Kofinas et al. 2002). Despite the theoretical promise of a co-management arrangement leading to more effective resource management (Osherenko 1988) , political conflicts have in some cases led to problems (e.g., Nadasdy 2003a). The interactions of governments, communities and hunters at different scales were a key consideration during analysis for this study.

Authors argue that incorporating TEK into decision-making can potentially increase resource management effectiveness (Berkes and Turner 2006; Houck 2003; Folke 2004; Kofinas et al. 2000; Stevenson 1996). Berkes (2008) described traditional knowledge and management as "trial and error" and "learning by doing" approaches, and managing for the unknown. These similarities indicated the potential for resource users, managers and scientists to work together in an adaptive co-management system. In Canada, several co-management bodies formed to involve indigenous resource users in the management process, including the use of TEK (Houde 2007).

In 1986, the Canadian Federal Government established the Porcupine Caribou Management Board (PCMB), through the formal Porcupine Caribou Management Agreement (PCMB 1985) signed by the Yukon Territorial Government, Northwest Territories Government, and First Nations of the region

One of the motivations in establishing the co-management arrangement was to address long-standing issues related to hunting Porcupine Caribou along the Dempster Highway. A range of issues was of concern to both government officials and hunters, including safety, the abandonment of traditional hunting practices for highway hunting with trucks, and harassment of the herd. Among the concerns was the worry that highway hunting was causing a deflection of the caribou herd migration from wintering grounds east of the highway and thus, making caribou unavailable to local hunters. Based on a recommendation from local hunters to the PCMB, TEK was used by Yukon Government and Northwest Territorial Government as the basis of hunting closures along the highway to let the "leaders of the caribou herd pass" (PCMB 2000:14). The complete reliance on TEK as the basis for the hunting regulation set the hunting closure apart from the other hunting regulations.

The "let the leaders pass" policy was implemented differently in the Yukon from the Northwest Territories, where it was not formally enforced. My focus in this chapter is on the Yukon implementation of the rule established in 2000, and its eventual rejection by the Canadian Justice after it was challenged in court in 2007. Table 4.1 shows how the PCMB has engaged in an ongoing process of community consultation, media coverage, and workshops to address, reassess, and propose new hunting regulations for the Dempster highway since 1986. I focused on the one-week closure regulation because it

was the regulation most closely based on indigenous knowledge. Through the case study I sought to identify the barriers to the successful application of the TEK-based policy.

I explored the case of the "let the leaders pass closure" through a historical account of managing for indigenous people's caribou hunting on the Dempster highway, dividing the historical events into 4 phases. These include: (1) Traditional hunting (pre-contact-1950s), (2) Pre co-management: Dempster highway and early management (1960s-1985), (3) Early co-management (1985-1995), (4) recent co-management (1995-present) based on TEK. I described the socio-political context of indigenous hunting management around the Dempster highway from the early traditional authority system to the recent PCMB co-management. I used the set of conditions illustrated in this case study to identify the barriers that prevented successful integration of TEK in regulatory management. Barriers included (1) the context-specific nature of traditional ecological knowledge limited its application in conventional resource management (2) changes in traditional authority systems, hunting technology, and the social organization of harvesting caribou affected the applications of TEK approaches (3) indigenous efforts towards self-government and political autonomy limited regional co-management consensus (4) there was a cultural mismatch between using TEK as enforcement and its use for education. I combined TEK and co-management literature in review, together with the set of conditions surrounding the "let the leaders pass" regulation to illustrate how TEK integration of caribou leaders in regulatory resource management fell short of success.

4.3 Methods

4.3.1 Analytical framework

I used a "single case study" approach to analyze the "let the leaders pass" policy (Yin 2009). As defined by Robert Yin, a cases study is: "An empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident" (2009:18). Yin (2009) goes on to describe how case study research can be used as a comprehensive research strategy to evaluate the effectiveness of public programs. As Yin notes, case study research can provide insight into specific complex phenomena where experiential research and controlled variables are not possible. Case study research also has limitations in the extent to which one can generalize (Yin 2009). However, authors have used single case studies to assess the effectiveness of integrating TEK with resource management (Berkes 2008; Nadasdy 2003a).

Elucidating the conditions for successful co-management was used in Pinkerton's (1989) seminal analysis. Barriers to successful co-management have also been used in case studies as a method of analysis (e.g., Gunderson, Holling, and Light 1995). For example Pinkerton (1999) argues that identifying the nature of barriers and ways to overcome them in smaller-scale case studies of co-management implementation is a valuable method of analysis that can contribute to broader understanding of adaptive management systems.

These approaches follow a "grounded theory" tradition common in qualitative social science research (Strauss and Corbin 1990).

4.3.2 Sources of evidence and historical account

I studied the case of indigenous caribou hunting from the Dempster Highway using multiple sources of evidence. Where possible I sought to triangulate findings from multiple sources to confirm factual information (Yin 2009:18). Historical events were reconstructed through archival research, review of co-management board minutes and other documentation, informal interviews with key informants, attendance of a co-management board meeting, and interviews with local caribou hunters. Interview protocol was reviewed and approved the University of Alaska Fairbanks (UAF) Institutional Review Board (IRB); protocol # 06-39- approval 20060620. I attended and observed the key co-management board meeting (PCMB meeting, Whitehorse 22-24 September 2007) where the Yukon minister of environment announced the "let the leaders pass" policy would become a voluntary compliance policy only (22 September 2007). At the meeting, as well as during fieldwork in three user communities, I spoke informally with key informants about what they perceived to be barriers to enforcing this TEK-based policy (n=4). I analyzed interviews with indigenous Porcupine Caribou hunters (n=29) to illustrate diverse resource user opinion about implementation of the "let the leaders pass" policy. Whereas Elders and some younger hunters described caribou leaders in the

context of traditional hunting practice in detail, younger hunters illustrated the shift in hunting practice according to more modern technology use.

Based on this evidence, I presented a historical account of events, using it to describe the complex set of conditions that surrounded policy recommendations for the Dempster highway, led to the "let the leaders pass" regulation, and its discontinuation. These included: who managed for indigenous caribou hunting, what the management strategies were, how they were implemented, when, and for how long. I described the management strategy under which the "let the leaders pass" policy was implemented and why it was no longer enforced. Throughout the account, I described the relevant interactions between different levels of government, communities and hunters. This factual account served to illustrate the context that led to the struggle of interests between government agencies, communities, resource users and their cultural values and management approaches.

4.3.3 Analysis to identify "barriers"

I identified barriers by classifying conditions from the historical account under general themes (e.g., worldview aspects of traditional knowledge, problems of scale, institutional dynamics, social characteristics, etc…) that I based on a review of a wide range of literature, including but not limited to traditional knowledge and co-management. I then grouped these themes and conditions to generate aforementioned four major

"barriers" specific to the case. The barriers reflect the consequences of specific sets of conditions on the implementation of the "let the leaders pass" regulation.

4.4 The Case: Historical events of Dempster highway hunting issues and management

In the sections below I describe the sequence of events relevant to the "let the leaders pass" regulation through 4 historical phases. These include a description of traditional hunting before formal management was imposed, early management by regional government, and co-management in its beginning and later phases.

4.4.1 Traditional hunting

Kofinas (1998) explains in detail the local system of caribou management for Porcupine Caribou user communities, including informal institutional arrangements shaping decision-making. From pre-contact with westerners to the mid 1900s, hunting was commonly conducted in the form of community hunts under the direction of a chief or leader (Slobodin 1962). Hunting caribou successfully was a matter of survival. The community worked together to kill, butcher, and distribute caribou meat. Old stories of “at time before there was time”, as reported by Elders, tell how caribou and people were one, caribou give themselves to hunters as gifts, and the relationship between people and caribou is reciprocal with each partner fulfilling a set of obligations (Kofinas 1998:130-143). From these notions derived norms for respectful behavior towards animals such as proper butchering, obligations of sharing the harvest with others, and sanctions against disrespectful or wasteful behavior. These key components of traditional hunting are still

present today in the worldview of indigenous caribou hunting. Elders speak of this traditional hunting method as a model for good hunting and compare it to the less structured modern hunting.

> Around fifties before that, you, well people used to move you see, and I seen it too, because when you move, there was one guy, chief, always one guy that talked in the morning, you don't just go out there, you can't. So the guy that's in charge, and this is really morning too, as soon as you get up after dark, you got to get up. And he tell you got to go this way today, you go this way and you go there. Sometime when there's lots of people, another bunch go there. If you see caribou you don't just shoot it, have to come back, caribou going to come back. The herd. So the next day, you start planning that night. Next day you go there and everybody hunt, that's way you do it you don't just go hunting. . . . Should be certain time you go up on the highway. There's people with every truck. Should be one boss, and then there wouldn't be a problem. (Fort McPherson)

> We had one boss that we go out hunting, we all gather together and the oldest guys told us what to do, you go there, you go there, you go there so everybody knows who's here who's there. That's the way we used to do it. (…) We used to have, circle around the caribou. Now you just go up and help yourself, and don't have to wait for nobody. (Old Crow)

Beginning in the late 1950s to the 1970s, there was a significant change in the social organization of traditional caribou hunting because of the introduction of new technologies (i.e. snowmobile and automobile) and modernization. A hunter described this change in hunting practice, using trucks for shorter hunts:

> People never used to hunt in town like this, like nowadays; they were gone for couple weeks sometime, a month, they just live out there. Nowadays they hunt with trucks they don't even skin caribou up, they bring them back like that. Nowadays the generation is different from long ago, way different, way way different. More modern than long ago. (Fort McPherson)

Consequently, hunting effort decreased, hunting became a more individualized activity, the community hunt under the leadership of a skilled “boss” became an anomalous means

of harvesting, and the role of the hunting leader in overseeing group hunting mostly disappeared.

4.4.2 Pre-PCMB: Dempster highway and early management

The Dempster Highway, called “The road to resources”, was constructed to connect southern Yukon with anticipated hydrocarbon development activities in the Mackenzie Delta region, with construction initiated in 1959. In 1979 the portion of the highway at the Yukon – Northwest Territories border was completed, linking the Yukon Territory community of Dawson City to the Northwest Territories communities of Fort McPherson, Tsiigehtschik (Formerly Arctic Red River) and Inuvik. Early scientific studies investigated the impact of the highway and traffic on the highway on caribou migration but found little to no evidence of disturbance (The Dempster Highway Working Group 1978). In 1979, the Canadian Federal Government convened a panel of caribou scientists to assess the potential impacts of the highway on Porcupine Caribou. The commission's final report suggested that increased access and hunting from the Dempster highway would reduce Porcupine Caribou Herd size by 30 to 40% (The Alaska Highway Pipeline 1979). Additionally, residents of Old Crow, Yukon, an off-road community that generally accesses the herd via boat and snowmobile, echoed biologists concerns over hunting caribou on the highway. For instance, the commissioner to the Yukon, amongst other government officials, sided with Old Crow community concerns in a memorandum to the Chairman of the Council for Yukon Indians (8 March 1977): “We believe that the general consensus in Old Crow is that all hunting [from the Dempster

highway] be stopped and it is our conviction that these people are most closely tied to the Porcupine Caribou population" (Appendix 4a).

Articles in the local media in the mid to late 70s warned of the Dempster highway impact with headlines such as "Highway could deplete herd" (Fraser, 1976:22) or suggestions such as "Improper management of the area could result in the herd's extinction, according to many experts" (Renaud, 1978: p unknown). The concerns regarding the future of the Porcupine Caribou were also elevated to a national and international level, through the large environmental impact assessment process chaired by Thomas Berger ("The Berger Inquiry"), which studied the effects of a proposed pipeline from the Mackenzie Delta and Alaska to southern markets (Berger 1977). The impact assessment captured the attention of many Canadians and brought a heightened awareness of the Porcupine Herd and the Dempster (Page 1986).

From the formation of the Yukon Territory in 1889 until 1985, regional government became responsible for regulating hunting. At the time, scientific studies were regarded as the primary source of information on which to base wildlife management decisions (McCandless 1985), as was also evident in historical Yukon government memorandums between the director and assistant director of wildlife (18 July 1977: Appendix 4b; 6 July 1978: Appendix 4c). In 1978, a Dempster highway committee was formed by the Yukon Government's Department of Renewable Resources in order to assist in coordination of the Porcupine Caribou herd. The committee included two representatives of the Yukon and Northwest Territories respectively. Their authority only stretched to non-indigenous hunters, unless the species was declared as endangered,

as were barren ground caribou in the Northwest Territories. A particular focus of the Committee was on finding ways to limit indigenous hunting, as these users constituted the majority of caribou harvesters. The absence of recognized rights by indigenous Porcupine Caribou hunters was discussed by top Yukon government officials. The Yukon Government Assistant Director of Wildlife (18 July 1978), questioned whether indigenous people should be given special rights to hunt caribou, and did not recognize a need to hunt for survival in contemporary times.

> Perhaps the question of Native hunting rights could be evaluated. In my opinion, there is no dependence anymore on caribou to survive. If caribou are not shot because they don't come close to a community, meat is being made available through other means. In light of this I question the philosophy that this herd should be managed primarily for Native use and to perpetuate traditional lifestyle (Appendix 4b)

After an abnormal calving year reported in 1977, continued predictions of a declining population sensitive to subtle increases in harvest, and observations of changes in the migration route, biologists urged for a closure of the road to hunting through memorandums (18 January 1978: Appendix 4d; 17 June 1977: Appendix 4e). Their recommendations to government led to establishment of a 16 km no-hunting corridor along the highway (1978). The restrictive corridor had the desired impact as hunting dramatically reduced in subsequent years, partly through compliance of indigenous hunters who perceived that the regulation superseded constitutionally stated aboriginal hunting rights. However, from 1981, the general perception changed to view the corridor hunting restrictions as not applicable to indigenous people, and caribou hunting from the Dempster again increased in the Fort McPherson Area. The hunting corridor was reduced to 2 km and indigenous harvest in the Southern portion of the Dempster Highway also

increased. These multiple changes in no-hunting corridor policy were the first of continuous changes in hunting management strategy from then onwards.

In 1983, a wildlife advisory committee meeting proposed a range-wide management plan and increased cooperation with indigenous hunters to establish harvest quotas. Through my archival research and interviews with indigenous hunters, I found that increasingly publicized issues of unethical hunting and stories of caribou slaughter in media tainted the image of Northwest Territory hunters throughout the 1980s, a perception that residents of some communities still hold. Abandoned carcasses and gut piles by and on the road, as well as harvesting of many animals by few hunters (for later distribution in the community), as observed by passing non-indigenous truckers, contributed to this perception. In contrast, government agencies perceived communities in the Yukon Territory as having little to no impact on the caribou population because of their smaller human population and more traditional style of harvesting (i.e., not road hunting), as seen in memorandum (Appendix 4f). A preferential consideration for opinions voiced in Old Crow, the Canadian community most dependent on Porcupine Caribou, may have set the stage for increased inter-community conflict through new efforts at range-wide management.

4.4.3 Early co-management

The PCMB was established in 1985, through a Canadian formal co-management agreement (the In-Canada Porcupine Caribou Management Agreement (PCMB 1985)), in large part to address the Dempster hunting management issue (PCMA 1985; Kofinas

1998; Kofinas et al. 2000). One of the PCMB's primary goals is to "cooperatively manage to ensure conservation of the PCH with the view to ensure continued subsistence usage" (PCMB 1985). The co-management board established by the agreement was created during a period when the Government of Canada started involving local resource users in decision-making and recognizing indigenous right to the land (Houde 2007). With representatives of First Nations of Yukon and NWT, the Inuvialuit, non-indigenous users, the two territorial governments, and federal government, the co-management board has grappled with problems associated with the Dempster since its inception. Since the Canadian Porcupine Caribou co-management arrangement was established, conflicts between government agencies and communities have reduced. However, inter-community conflicts have increased, following perceptions of unethical hunting, struggle to jointly manage caribou hunting on the Dempster highway, and the signing of land claims agreements by the region's First Nations (Kofinas 2000; Kofinas et al. 2006).

Cumulative impacts on caribou migration of human activities along roads continue to be of concern to scientists (Wolfe, Griffith, and Gray Wolfe. 2000). Although the Porcupine Herd has declined steadily since 1989, it has not suffered the drastic decline foreseen in 1979 despite highway hunting. Since the establishment of the PCMB, the greater concern has been the displacement of caribou from winter grounds due to highway hunting disturbance (PCMB 1985-2007; Smith and Cooley 2003).

Since 1986 the PCMB has addressed Dempster Highway hunting issues with a number of implemented recommendations, including a no-hunting corridor, an off-road

vehicle access policy, and most recently the one-week hunting closure to “let the leaders (of the caribou herd) pass”. An original member of the PCMB, who was also an Elder and the traditional chief of Fort McPherson, took a leading role in addressing Dempster hunting issues at the local level by patrolling the highway, talking with hunters, and cleaning unsightly kill sites. The effectiveness of his efforts in the new context of individual highway hunting was limited. In addition to these initiatives, the PCMB produced and distributed a video on the problems of Dempster hunting to residents of local user communities.

Since the PCMB was created, recommendations for addressing Dempster problems have sought to strike a balance between hunter compliance, representation of traditional knowledge, and protection of the caribou herd, producing several modifications in formal policy. Two major sets of recommendations were implemented by the Yukon Government and enforced on indigenous hunters. In 1990, snow machine access was permitted for indigenous hunters from November 1st, and a 2 km no-hunting corridor was implemented. In 1999, the no hunting corridor was reduced to 1 km (mainly to ensure hunter safety), a one-week hunting closure to "let the caribou leaders pass" was implemented, and snow machine access was allowed only when the ground is covered in snow and frozen. Later, in 2006, the PCMB proposed a third set of recommendations, including mandatory safety orange vests and a modified one-week closure with different

timing on Northern and Southern portions of the highway (Table 4.1). In spite of its on-going efforts to address Dempster issues, the problems persisted.

4.4.4 Emerging conditions of co-management: Traditional knowledge based management under a new political context.

After local deliberations by community hunters and leaders, the Tetlit Gwich'in Renewable Resource Council (i.e., local renewable resource council of Fort McPherson hunters and trappers) sent a representative to the PCMB at its spring meeting in 1994, requesting that the board implement a closure of highway hunting upon the first arrival of caribou each fall. The local council representative explained that the proposed closure would be based on the traditional knowledge of not disturbing lead caribou during migration. As a follow up in 1995, a "Dempster workshop" of Canadian hunters, elders, and resource managers was organized by the PCMB. Participants discussed that scientific impact studies of the Dempster highway on caribou were not feasible and that management decisions should rely on information from traditional knowledge of indigenous Elders instead (PCMB 1995:10). The "let the leaders pass" proposal came forward at a time when the idea of integrating TEK to the co-management was gaining international popularity as a solution for solving complex resource management problems (Berkes 1993, Houde 2007). At a subsequent meeting, the PCMB endorsed the alternative approach and recommended the "let the leaders pass" closure, which resulted in a formal regulation, put into law by the Yukon Government. The PCMB and the

partner management agencies had hoped the "let the leaders pass" regulation would be embraced by hunters because it was conveyed to the Board as a traditional practice (Dorothy Cooley 2010, pers. Comm. May 28). The one-week hunting closure was initially applied to the entire length of the Dempster highway, and later separated into two different closure periods to correspond with different North and South migration timing (PCMB 2006).

The "let the leaders pass" management strategy was based on a practice not traditionally applied to a highway. The policy was formulated as a one-week closure, a time chosen somewhat arbitrarily, to ensure the caribou leaders would have time to pass. In interviews, hunters expressed differing opinions about the idea of a closure, with some recommending longer closure, up to a month long, while others preferred to use individual judgment as to whether leaders had already passed, and not be subjected to a closure.

During the 22-24 September 2007 PCMB meeting, the PCMB Chair noted that that honoring Elders' concern for protecting the caribou leaders was a priority. The following quotes illustrate Elders' general dissatisfaction with current hunting practices of younger indigenous hunters:

> That's the way they used to hunt, they don't like mess and they want people to take everything. Nowadays, they just go and make a mess. (Fort McPherson)
>
> Well one of these days, I don't like to say this but some people they kill too much caribou, I don't know what's wrong with them, they don't need all that caribou. (Fort McPherson)
>
> That's the way you do the caribou, you're not supposed to carry caribou through town, it's not allowed, but today they do. It was strict law those

> days, from Elders. . . . You make some bad luck too, that's why you got to do a good job on the caribou. (Old Crow)

The PCMB emphasized the notion of respectful hunting in media and education outreach, but the regulation was still contested on the grounds that it did not match with some people's perceptions of "traditional hunting practice". In addition, in a 2006 review of Dempster highway regulations initiated by the PCMB, the Yukon minister of environment received mixed support for a proposed second hunting closure from affected Yukon and Inuvialuit communities (PCMB 2007).

Despite general support, one member of one community was able to discontinue the regionally implemented regulation. In September 2007, a stay of proceedings against a Trondek Hwëch'in (Dawson) First Nation's member ended enforcement of the one-week closure to let the leaders pass. This member violated the hunting closure and planned to contest his case in court. During the interview I conducted with him, he explained his dissatisfaction with the regulation that he perceived as an infringement on his indigenous hunting rights. He perceived that consultation done to formulate the regulation did not adequately recognize traditional knowledge for Dawson First Nation members. Out of nine Elders and hunters interviewed in Dawson, three hunters said that the hunting closure did not match their elder's teachings, and another four Elders and hunters were in partial disagreement with "letting the leaders pass". Based on these interviews and the informal discussions with PCMB representatives, there was at least partial support for this Dawson member's case in the community. Before the case could be heard in court, the

Canadian department of justice recommended voluntary compliance rather than enforcement. In September 2007, the Yukon minister of environment announced to the PCMB that the one-week closure and the no hunting corridor would not be implemented until further consultation established consensus between all affected parties.

The PCMB struggled to find long-term solutions to hunting concerns on the Dempster highway (Table 4.1). Some hunters contested the "let the leaders pass" recommendation, as they perceived it to interfere with traditional hunting practices. Although TEK inspired the regulation, the resulting one-week closure recommended by the PCMB and enforced by the government of Yukon still was contested as constituting a mismatch with some Elder's teachings. Inter-community conflict continued as diverging opinions on how to manage for PCH hunting along the highway were exposed through the co-management process.

The political context since the establishment of the PCMB has also changed dramatically since the Yukon and NWT signed land claims agreements in the 1980s and 90s. While Northwest Territory communities fell under the land claims agreements for Gwitch'in (1992) and Inuvialuit (1984) respectively, the Yukon First Nations negotiated and signed the Umbrella final Agreement under the Council for Yukon Indians (1993). Unlike the Northwest Territories, the latter allowed self-government and regulatory organizations under separate First Nation agreements for each community. First Nations signed Individual Land Claims and Self Government agreements from 1995-1998.

During the September 2007 meeting, the PCMB discussed the legal challenges that had undermined the formal "let the leaders pass" regulation in Yukon and endorsed

voluntary compliance. The former secretary of the board suggested that the emergence of greater First Nations political autonomy would result in a role for the co-management organizations, focusing more on facilitation rather than making recommending about specific regulations to government ministers. In subsequent efforts to develop a harvest management strategy, the PCMB put a greater emphasis on achieving full consensus of parties (PCMB 2010).

The "let the leaders pass" approach sharply contrasted the approach used by regional governments before the co-management board was created. It was less restrictive for hunters than a loss of indigenous hunting rights envisioned by some government officials of the pre-PCMB. Yet enforcement of this rule was also discontinued. Despite ongoing efforts by the PCMB to create lasting regulations with indigenous user groups, dissatisfaction among some hunters continued.

4.5 Discussion: Conditions creating barriers in using TEK-based hunting regulations in co-management

The efforts of the PCMB to experiment and learn from its experience with the Dempster demonstrate how co-management is a process of trial and error, and how in the process of integrating knowledge systems in co-management, the application of TEK can encounter significant barriers. Although co-management in some cases brings scientists, locals and managers together for shared decision-making (Osherenko 1988), combining knowledge systems is a challenging practice (Kofinas 2005; Nadasdy 2003b). The following section focuses on the barriers that prevented the lasting implementation of a

traditional knowledge-based regulation. I divided the discussion in four parts that reflected different barriers identified for the "let the leaders pass" case study: (1) the context-specific nature of traditional ecological knowledge limited its application in conventional resource management (2) changes in traditional authority systems, hunting technology, and the social organization of harvesting caribou affected the applications of TEK approaches (3) indigenous efforts towards self-government and political autonomy limited regional co-management consensus (4) there was a cultural mismatch between using TEK as enforcement and its use for education. This list of barriers is not all-inclusive, but identification and discussion of the barriers may help to transform co-management for a more effective management of indigenous hunting.

4.5.1 The context-specific nature of traditional ecological knowledge limited its application in conventional resource management

TEK and traditional hunting practice are not only concerned with facts and observations about the environment, but also with how people relate to each other, and how they should behave in their society and their environment (Collings 1997). For instance, the concept of caribou leaders likely arose to ensure the availability of caribou to harvest and increase chances of human survival. Protecting caribou leaders is a social norm, embedded in the general notion of respect for animals, part of the worldview that all living things are inter-connected (Wilson 1996).

Conventional resource management can fail to recognize the social/ worldview aspects of TEK and selectively focuses on factual data (Nadasdy 1999). The formal one-

week closure regulation may be perceived to match the traditional notion of caribou leaders poorly, as it does not address this context and specific cultural aspects. However, traditional knowledge's different components, such as social norms and spiritual aspects, cannot be separated from what is perceived as "factual" information, as it strips traditional knowledge of its meaning (Cruikshank 1998; Houde 2007; Wilson 1996). Beliefs and practices about caribou leaders have traditionally not been described with respect to highways, or at the regional scale of the herd. Instead, they have been described through individual hunting experiences, in the context of traditional community hunts, and on a local scale (Chapter 2). The literature shows that TEK is locally restricted and in most cases cannot be easily applied outside of that locality (Antweiler 1998; Cruikshank 1998). Moreover, TEK is directly related to resource use practice, and can vary widely between social groups, time and place (Berkes, Colding, and Folke 2000).

As I described in Chapter 2, there was a diversity of hunters' and Elders' descriptions of caribou leaders, all of which were considered as traditional knowledge and vary with time in caribou migration, location, ecological context, political context, and hunting experience, including the status of the person interviewed. With such varying concepts of caribou leaders, it was challenging to create one cohesive regulation across a vast region that is locally endorsed. The following quotes illustrate how people perceive differences in traditional knowledge practice and education between indigenous hunters in the Porcupine region.

> You can't paint every First Nation with the same brush. This First Nation here It'll say it is very good, we've got no one around here that hunts like that. (Dawson)

> People you interview, they will probably interview different form me because we learn from our people, sometime our dad, our grandfather. I go in the mountain with them and they tell story about animals and I do something, I shoot caribou. (Fort McPherson)

For some community members, the regulation may thus appear inconsistent with the stories they heard from their Elders or their personal experience hunting caribou. The cultural/ worldview aspects, variability, context dependence on local Elders and experiences caused a regional, one-size fits all regulation like the one-week closure, to be locally contested. The one-week closure did not address local/ individual variations and social norms aspects of the "let the leaders pass" concept. However, the context specific aspects of TEK alone did not preclude its use for management, rather social context, political issues, and an institutional misfit prevented it, as I explore in following sections.

4.5.2 Changes in traditional authority systems, hunting technology, and the social organization of harvesting caribou affected the applications of TEK approaches

The "let the leaders pass" concept was rooted in a traditional hunting authority system, not in the more modern individualistic hunting practice (Chapter 2). However, the PCMB adapted the concept to fit the modern context of highway hunting. In interviews, several Elders described traditional hunting in which a chief or hunting leader prevented group members from hunting or making decisions about what to hunt individually. Other accounts tell how the collective hunt was well coordinated with individuals having specific roles (Bali and Kofinas 2009). However, hunting practice has become more individualistic and requires less connection with the land (Barnhardt 2005). Today, every First Nation member, whereas chief, Elder, or young hunter, can choose

which caribou to harvest, based on the individual's indigenous right to hunt, unless there is a conservation issue (Government of the Yukon Territory 2002). Also, modern hunters are not always subject to the judgment of their piers or Elders during hunts carried out alone. This modern individual hunting practice may have caused the traditional community-oriented authority system to become eroded (Feldman 1997).

Managing use of caribou within a democratic process while traditional practices are changing is challenging (Donnelly 1984). Some argue that conservation laws have eroded the social power of Elders in a democratic process, and placed Elders in an inferior social position (Phuthengo and Chanda 2004). Although "let the leaders pass" TEK was incorporated into management, it was applied outside of its enforcement context, which was the traditional community-oriented authority system. The formal agency enforceable regulation was not flexible, since the closure was imposed and did not call for hunters' judgment during every hunt as to which caribou were the leaders of the herd. Government agency enforcement effectiveness is limited with First Nation rights through land claims, while Elders' informal enforcement is limited through the modern context. Thus, making a formal regulation, even if based on TEK, is insufficient to ensure compliance with management plans or ethical hunting practice.

The Yukon Government following the recommendation of the PCMB has changed Dempster hunting regulations for many years, fine-tuning them, ultimately trying to identify the set of workable rules that would accommodate all user groups (Table 4.1). Agrawal (1995) argues that traditional knowledge is also ever changing, similarly to science, and thus is not indefinitely conserved. TEK has two faces, one

concerned with ancestral practice and another concerned with adaptation to the present and future (Berkes, Colding, and Folke 2000). It is therefore not bound to the past, but is rooted in ancestral practices while incorporating aspects of modern societies (Stevenson 1996). TEK inspired the "let the leaders pass" policy in the context of adapting to modern hunting. It was not enforced in the context of social hunts, nor was it applied in the context of ensuring people's immediate survival. TEK was used as a fact to create an inflexible rule.

4.5.3 Indigenous efforts towards self-government and political autonomy limited regional co-management consensus

Collings (1997) argues that if political autonomy overrides resource availability concerns, there is lack of consensus among users. A Tr'ondëk Hwëch'in First Nation member legally challenged the no-hunting closure to let the leaders pass on the basis of inconsistency with his individual subsistence rights, based on the Dawson First Nation land claims agreement (PCMB, Sept 22 2007). The Porcupine Caribou Management Agreement, and other co-management agreements, were signed to provide for power sharing between indigenous user groups and government agency (Houde 2007; Pinkerton 1989). However, the PCMB was created before Yukon First Nations signed land claims under the Council for Yukon Indians Umbrella final Agreement (1993). First Nations agreements in the Yukon Territory further empowered individual members to defend their indigenous rights when there were no conservation issues. Such rights include caribou harvest according to "traditional hunting practices". Recent First Nation

agreements in the case of Tr'ondëk Hwëch'in First Nation, signed in 1998, and the low harvest of PCH for this First Nation, compared to other user groups, may help explain their high interest to assert political autonomy and counter the formal closure to let caribou leaders pass.

Adding to the barrier following from political autonomy, is the representation problem in northern co-management, well documented in other co-management studies (Kofinas 1998; Kruse et al. 1998) The representation problems results from board members who do not view themselves as representatives of their communities or First Nations, and thus create a communication disconnect in convening the political position of First Nations during deliberations at board meetings.

The power of individuals to challenge decisions made through the co-management process decreases the potential for durable formal regulations and compliance. Users may perceive the co-management board as less valuable to advancing individual rights (Usher 1993). Through land claims agreements, First Nation members were empowered to become managers, yet formal regulations through co-management still distinguish users from managers. TEK-based information may vary depending on the purpose and interests it serves, it is not neutral, and can be used for political objectives (Agrawal 1995; Wavey 1993). Thus PCMB management based solely on TEK resulted in community-to-community conflict where there was a struggle between political autonomy and restrictive formal regulations viewed by the board as for the common good. In the following quote, a Dawson hunter forecasted this issue of compliance and community conflict.

> Don't attack a person that doesn't go under YTG [Yukon Territory Government] law, because like I said, it's going to lead into Indian wars. Which is beginning now, it's going to come. (Dawson)

In comparing case studies, Ostrom (1990) found that the absence of locally derived rules and enforcement, lack of explicit recognition of land claims agreements, and unwillingness to recognize the legitimacy of diverging interests in a heterogeneous region are institutional weaknesses that can lead to institutional failure and ecological and social degradation. The use of TEK-only based regulation exposed the regional heterogeneity. The latter was exacerbated by the need for explicit recognition of locally specific indigenous rights and government through land claims agreements. Regulations and enforcement became increasingly resisted and contested when limiting indigenous rights (Wavey 1993).

In the past, the PCMA enabled recognition of indigenous people's hunting rights through the PCMB. However, in the new context of land claims agreements, there exists and institutional mismatch of the PCMB and the emerging indigenous self-governments. In the case of the "let the leaders pass" discontinuation, land claims agreements enabled an individual to defend his indigenous hunting rights where a conflict arose with PCMB recommendations. Dawson First Nation perceived Dempster hunting regulations imposed by Yukon Territorial Government to interfere with their recently acquired political and cultural autonomy through self-government.

4.5.4 There was a cultural mismatch between using TEK as enforcement and its use for education.

One of the major issues with researchers' documentation of TEK is obtaining traditional knowledge that is associated with the Elders (Barnhardt 2005; Davis and Wagner 2003). While some argue that traditional knowledge is not compromised and still fully practiced with younger Gwitch'in generations (Sherry and Myers 2002), others argue that older Elders are the only members of the society left with the "original" traditional knowledge (Davis and Wagner 2003). Researchers prefer capturing the knowledge of Elders because the knowledge of younger generations is regarded as eroded (Barnhardt 2005).

The PCMB likewise relied on Elder's knowledge of caribou leaders to derive a widely applicable regulation. However, knowledge passed down by Elders varies locally (Chapter 2). Younger Dawson First Nation members saw the one-week closure as mismatched with their own Elder's teachings, and therefore did not recognize it as legitimate, although interviews with Elders in Dawson showed that some, but not all, recognized caribou as having leaders. The focus on enforcing this regulation regionally may have overshadowed the educational potential of "letting the leaders pass".

Moller et al. (2004) emphasized the use of traditional knowledge as an educational tool to promote sustainable harvest, and not produce prohibiting laws. Likewise, some authors caution against regulating based on TEK, and focus on gathering information and educating (Fernandez-Gimenez et al. 2008, Wavey 1993). During the PCMB Dempster Highway Workshop (1996), Elders urged for revival of traditional

hunting practice. Elders interviewed in the caribou leaders study warned that traditional knowledge and practice are no longer properly followed by younger generations. Elders thus pushed for the “let the leaders pass” concept to ensure continued availability of caribou, but also to bring youth back to traditional ways, addressing both conservation and social goals. This strategy emphasized the social role of Elders as educators.

Elders are considered the best educators for hunting because they have the most knowledge acquired throughout their lifetime (Hart 1995). It is suggested that elders favor educating over formalizing hunting rules (Fernandez-Gimenez et al. 2008). Educating youth about TEK or traditional hunting practices does not necessarily match modern practices but emphasizes values that were continually important to people’s survival in the past (Barnhardt 2005). The hunter interviewed below describes the confusing aspect of managing resource use through government-initiated co-management rather than Elders' education.

> Natives use common sense, common knowledge, if they think and speak from they're heart, they'll never have a problem. If you start speaking from your head in these boards and committees out there, governments, and pretty soon you're all mixed up and you don't even know what the decision is anymore. But if they think about it, go back to their Elders, and these kids are smart now, in both worlds, I think they can take anybody on. (Dawson)

Elders started all interviews by talking about respectful hunting according to traditional values and their own Elders’ teachings. These interviewees blamed the lack of good hunting practice on the lack of traditional education, not the lack of regulation enforcement.

> Well what I think is sad, nobody teaching anybody, that's why they go up there and just shoot. Just one but you can't handle. There is no teaching going on. Well all these things is ours, not for you, not for the government, it's our people doing that, it's up to us, see you can't fix it. . . . But you have to teach them skin caribou and stuff like that, and we're not doing that, it's our fault. Can't blame the younger people with it, it's our fault; we're not doing it. Elders supposed to tell chief what to do, not him. (Fort McPherson)

Although the one-week closure was primarily based on a broad definition of caribou leaders derived from Elder's knowledge, it did not actively engage Elders in implementing the “let the leaders pass” rule locally. Thus, Elders blamed poor hunting practices along the Dempster highway on the lack of traditional education, while management focused on enforcement of the "let the leaders pass" regulation.

4.6 Conclusions

The case of regulating for “letting the leaders pass” illustrated how the use of TEK, like science-based management, interfered with traditional subsistence hunting, causing inter-community conflict, lack of compliance, and no long-term solutions to a specific resource management concern. This study identified four barriers to the application of the TEK-based regulation: (1) The one-week closure did not address local/ individual variations and social norms aspects of the “let the leaders pass” concept. (2) "Letting the leaders pass" was not enforced in the context of social hunts, nor was it applied in the context of ensuring people’s survival. (3) Dawson First Nation perceived Dempster hunting regulations imposed by Yukon Territorial Government to interfere with their recently acquired political and cultural autonomy through self-government. (4) Elders blamed poor hunting practices along the Dempster highway on the lack of

traditional education, while management focus was on enforcement of the "let the leaders pass" regulation.

Based on the findings of this case study, I make the following suggestions for future co-management activities related to indigenous caribou hunting on the Dempster highway. Firstly, co-managers should be attentive to the differences in informal customary hunting traditions and formal rules that carry the force of law. Then, co-managers need to ensure that recommendations generated by the board have the full support of indigenous groups that share authority in resource governance. Where there is limited consensus, more consultation may be needed. Moreover, co-managers should find ways of supporting the role of elders in education and oversight of hunting activities. Finally, all parties should hold open discussions about the similarities and differences in perspectives on caribou and caribou hunting (e.g., what is a leader?) to avoid conceptual ambiguity.

Hunters and managers perceived a dual benefit of the "let the leaders pass" policy: (1) ensuring access to caribou by hunters, and (2) minimizing disturbance to herd migration, as well as promoting maximum use of the winter range by caribou. Ironically, an unintended consequence of "letting leaders pass" may be an increase in total harvest levels. Although deflecting caribou could lower harvest, other issues such as population effects of selectively eliminating leaders could be problematic (see Appendix 1).

What appears to be a failure to find a workable solution to Dempster hunting issues throughout the PCMB's history may be the result of social change and an effort to adapt to that change through the co-management board forum of discussion. Indeed,

management approach needs to be flexible, allowing for changes in management strategy to reflect the ever-changing/ adapting qualities of TEK. The PCMB has encountered a number of barriers to the management strategies proposed and implemented over the years. Nevertheless, the organization has succeeded in experimenting with new recommendations, learning from unsuccessful management, and moving on to new strategies, including rethinking their core functions as a co-management board. The barriers to "letting the leaders pass" can be seen as a door to innovative and more effective future management of indigenous hunting on the Dempster highway.

4.7 Acknowledgements

I thank current and former members of the PCMB for informing our discussion of Dempster caribou hunting management. I thank committee members, Gregory Finstad and Brad Griffith, for their suggestions on improving this paper. Finally, I am again grateful for the time and information people shared with me during interviews of the caribou leader project (2006).

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Table 4.1. History of Porcupine Caribou Management Board (PCMB) consultation process and actions with Dempster highway hunting regulations (Source: PCMB Annual Reports 1986-2007).*

Annual report	Board activities directly related to Dempster highway hunting	Recommendations/ Regulations
1986-87	Dempster highway committee formed to obtain background information and each member to consult with user communities and draft recommendations for minister.	No mentions
1987-88	No mentions	Preparations of recommendations: Current 1 km corridor should be maintained, and enforcement increased to address harassment of wildlife, reduce meat wastage, and maximize safety.
1988-89	Detailed review of Dempster management options Dempster committee tours user communities to get input on management options. Production of two newspaper articles to prepare communities to in depth discussion of recommendations. Production of interactive video used in public meetings in each community to explain Dempster issues and encourage public input.	No new mentions
1989-90	No new mentions	Board adopts Dempster recommendations (see above)
1990-91	Technical report on PCH management published	**New regulations: voluntary compliance/ enforced**

Table 4.1 (Cont.)

Annual report	Board activities directly related to Dempster highway hunting	Recommendations/ Regulations
1989-90 (Cont.)		Snow machine use through the corridor is allowed for Native hunters from Nov 1 (and non-native hunters through emergency closure).
1990-91		No hunting corridor of 2 km (1 km on each side) enforced on non-native hunters, and voluntary compliance by native hunters until land claims are settled. Exemption for native elders hunting on their own. Remove gut piles from road Employ a variety of communication to inform hunters of regulations and good hunting practices. Yukon department of natural resources should conduct a study of effects of highway disturbance. To incorporate agreements into Yukon Government Dempster highway management plan.
1991-92	No new mentions	Restated recommendation for signs for hunters along highway
1992-93	Urge for re-analysis of hunting regulations	No new mentions
1993-94	Sensitive habitats of the PCH report published.	Dempster hunting signs erected by Yukon government in accordance with 1990 recommendations.
1994-95	Hosted a Dempster workshop in Fort McPherson to review	No new mentions

Table 4.1 (Cont.)

Annual report	Board activities directly related to Dempster highway hunting	Recommendations/ Regulations
1994-95 (Cont.)	effectiveness of 1990 recommendations. Found that some solutions were not effective. Also decide that a scientific study of the effects of the highway on caribou was not feasible and thus should use traditional knowledge to recommend regulations.	
1995-96	Approved consultation protocol for revisions to Dempster highway recommendations	No new mentions
1996-97	Distributed pamphlet to all households in user communities, outlining concerns and proposed solutions. Described Dawson meeting as "a very good start on an old problem"	No new mentions
1997-98	Meeting of user community leaders and representatives in Dawson. First time that all communities openly discussed concerns. Identified concerns and drafted proposed solutions for review by communities.	Sent recommendations from Dawson meeting to governments.
1998-99	PCMB chair traveled to communities to explain the regulations and their importance.	Yukon government accepted recommendations and set a 60 day review period for regulations
1999-00	Representatives of Yukon renewable resources and PCMB members visited communities for consultation on how to improve implementation of regulations.	**New regulations: enforced** 500 meter corridor on either side of the highway One week hunting closure to let

Table 4.1 (Cont.)

Annual report	Board activities directly related to Dempster highway hunting	Recommendations/ Regulations
1999-00 (Cont.)		the leaders pass: Enforcement of the 1-week closure to let leaders pass: Oct 20-27.No use of snow machines until ground is frozen and covered with snow Cow season extended to Jan. 31 to correspond to bull season.
2000-01	Renewable resources/ YTG study of highway activity impact on caribou using focus groups.	Not mentioned.
2001-02	Mandatory review process.	NWT closure to let the leaders pass: voluntary compliance.
2002-03	Mandatory review process meeting. Dempster highway subcommittee meeting, including representatives from all user groups. No consensus could be reached on changes to regulations. Suggestion for revised closure to the let leaders pass to close highway twice (once north, once south) when they cross at different times, to better reflect the migration pattern divide First Nation summit, also unable to reach consensus.	Recommendation: Amend regulation to allow for second one-week closure. Enforcement of the 1-week closure to let leaders pass twice: Sept 13-20 (North) and Nov 1-8 (South). Recommendation: shorter cow hunting season (3 months).
2003-04	Caribou hunter survey, questionnaires returned mostly from non-native hunters. Satisfied with regulations, but encouraged complete cow hunting ban/ increased restrictions.	Enforcement of the 1-week closure to let leaders pass Nov. 5-12.

Table 4.1 (Cont.)

Annual report	Board activities directly related to Dempster highway hunting	Recommendations/ Regulations
2004-05	PCMB Chair made a trip to the highway during the spring hunt to speak to hunters and noted awareness of safe and ethical hunting, and improving gut pile awareness.	Enforcement of the 1-week closure to let leaders pass Oct 17-24. Recommendation: Blaze orange safety vests.
2005-06	Proposed 6 regulations to user communities and public to collect feedback (shorter hunting season, removing 500 meter corridor from some sections, orange safety vests, educational programs, harassment of caribou by snow machines, hunting ban of mature bulls in fall).	Enforcement of the 1-week closure to let leaders pass Oct 7-14
2006-07	Received feedback for proposed regulations.	**New recommendations to the minister**: ** Mandatory orange safety vests. Education sub-committee to address harassment and bull hunting ban. Revised 1-week closure to let leaders pass (separate timing on North and South portions of highway) (minister said it accepts this regulation but will first consult with First Nations).

* The summary includes only activities for the board that were mentioned in the annual report and directly related to Dempster highway hunting issues. This summary may not be all inclusive of activities undertaken. Additionally, the PCMB held several community meetings during each year and received public comment. Various forms of media were also used to communicate PCMB recommendations to users (newspaper, radio, etc…).

Activities were often restated from one report to the next. This summary attempted to reduce the repetition when no new action was taken.

** Note **changes to regulations**: fall 2007 no enforcement of safety corridor or hunting closure to let the leaders pass to stay charges against a Tr'ondëk First Nation citizen)

Chapter 5 Conclusion

In this study, I explored indigenous perceptions of caribou leadership, how caribou leadership can be tested using the scientific method, and how caribou leadership was incorporated into co-management of indigenous hunting. I used a multi-disciplinary, mixed methods approach to gather sources of evidence and conduct my analyses. I conducted interviews with Canadian indigenous Elders and hunters of Porcupine Caribou as well as reindeer herders of the Seward Peninsula (Alaska) to document concept of caribou leadership as expressed in traditional knowledge (Chapter 2). I designed and carried out an experiment to test for female leadership in captive caribou (Chapter 3). Finally, I identified conditions creating barriers to the traditional knowledge based "let the leaders pass policy", which was implemented by the Porcupine Caribou Management Board as a management strategy for addressing hunting disturbance of caribou migration on the Dempster Highway in Yukon and NWT (Chapter 4). Below, I summarize the findings of Chapters 2, 3, and 4.

In Chapter 2, documenting traditional knowledge of caribou hunters and reindeer herders revealed a complex and context dependent indigenous understanding of caribou behavior. "Caribou leaders" was a widely recognized and broadly defined term, inclusive of all sex and age classes of caribou and different behavioral roles. The resulting definitions of caribou leaders was ambiguous. Elders gave more detailed descriptions, notably the co-existence of multiple types of caribou leaders to fulfill context specific behavioral roles. Both caribou hunters and reindeer herders used caribou leaders to

manipulate caribou movements at smaller and larger spatial scales. However, only caribou hunters perceived that disruption to caribou leaders had an effect on the direction of migration. Both female and male caribou were described as leaders in the fall migration, when the hunting closure occurred on the Dempster Highway.

In Chapter 3 I found that female caribou were more likely to be the first animal in a male-female pair to cross an artificial barrier to reach a new feeding site. The follower phenomena supported identifying the first caribou as a "leader". Findings were consistent with female leadership found in studies on various species. My experimental test was used as a tool to measure frequency of male and female caribou leaders in a very specific situation with captive caribou. The use of naïve caribou pairs was effective to maximize sample size of a small number of experimental animals. Age, risk taking, and differences in energetic states, may have been additional factors in predicting female leadership, but superior knowledge by one animal was not a factor in this study. The uneven spread in ages amongst the experimental population prevented the use of age as a variable. For future experiments using this tool, I do not recommend a maze conformation for the barrier, unless the aim is to test for leadership between experienced versus inexperienced animals. The study's experimental aspects and small sample size prohibited generalization to wild populations of caribou.

Combined, the findings in Chapters 2 and 3 suggest that caribou leadership is an important aspect of caribou behavior and ecology, and may become increasingly important to management of wild caribou populations, in particular where indigenous people participate in the management process. Nonetheless, insights from both TEK and

scientific sources of knowledge revealed that caribou leaders were not easily identifiable for use in hunting management policy. On one hand, traditional knowledge offered a picture too complex to create a rule-based hunting management strategy with an ambiguous definition of caribou leaders. On the other hand, the experimental test of leadership was too simplified to generalize to behavior of wild populations of caribou.

In Chapter 4, my policy analysis of the "let the caribou leaders pass" rule indicated that a combination of social and political conditions created barriers to incorporating the traditional knowledge concept of caribou leaders into enforceable hunting regulation. These barriers included a mismatch of the "let the leaders pass" regulation with 1) local/ individual variations and social norms aspects of the “let the caribou leaders pass” concept, 2) the context of social hunts and traditional authority system, 3) institutional changes, particularly Dawson First Nation's recently acquired political and cultural autonomy through self-government. 4) Elders focus on education rather than enforcement. The implications of these barriers to the co-management process suggest a need for greater consultations and public discussion to avoid conceptual ambiguities and political conflicts. Co-managers should recognize the links between TEK based rules, the informal authority system and education by Elders that served as the basis for their past success. Most notably, this study of the "let the leaders pass" policy illustrated co-management as a trial and error process, with the continuous need to adapt to a changing social, cultural, and political context.

Identifying caribou leaders is complex and there are significant barriers to using caribou leadership in wildlife management. Nevertheless, understanding caribou

leadership its context, and the scale at which it occurs are likely to become increasingly important to managing wild populations of *Rangifer*. Uncertainties about the impact of roadside hunting on population of the Porcupine Caribou Herd suggest the need for further investigation of caribou leadership behavior. Advances in scientific understanding of leadership behavior may help identify mechanisms of leadership in migratory caribou. This would in turn help assess the impact of roadside hunting on caribou migration when caribou first arrive near the Dempster highway in the fall. This study contributed to understanding various characteristics of caribou leadership behavior. Such characteristics are important to identify and link to potential population effects. A brief discussion is included in Appendix 1. Future work in this area should provide a scientific basis on how to incorporate caribou leadership to harvest management.

Due to limitations (i.e. costs) in conducting scientific studies at the scale of caribou herds and the complexity of caribou behavior, extensive documentation of traditional knowledge on caribou leaders across several caribou ranges may be helpful in advancing understanding of this concept. Such a study would be invaluable to gain insight on how hunters' knowledge and use of leadership behavior impacts caribou movement at local scales. Similarities in customary protection of caribou leaders across locations and cultures would provide strong support for the need to protect caribou leaders where concentrated human disturbance occurs. Moreover, sparking discussions of caribou leaders in the context of the indigenous tradition of Elders educating youth about hunting practices ensures that caribou leaders will remain a topic of discussion amongst hunters and managers.

Appendix 1
Selective harvest of caribou leaders

This thesis focused on the traditional hunting practice of letting caribou leaders pass, and implications for herd movement and migration. This section briefly discusses the link between caribou leaders and population dynamics. This aspect is key to understanding how caribou leadership behavior should be incorporated into management of wild caribou herds.

The process of domestication through selective removal of leaders in reindeer (Baskin, 1989) raises concern that selective harvest of caribou leaders could have evolutionary consequences on wild caribou herds. Studies of trophy hunting in bighorn sheep (*Ovis canadensis*) and mouflon (*Ovis gmelini musimon*), suggest that selective harvest of large rams has evolutionary consequences on the population, due to the loss of traits associated with high reproductive fitness (Coltman et al., 2003; Garel et al., 2007). Certain characteristics of caribou leadership behavior and caribou harvest provide a starting point for understanding the link between harvesting caribou leaders and a population-level effect. Characteristics of caribou leadership in table 1.A-1 are based on evidence from the literature and findings from this thesis.

It is important to note, that caribou leaders are generally not associated with dominance (Paine, 1988; Section 2.43, Section 3.2); thus leaders may not have heritable physical traits that confer greater reproductive value, such as greater antler size or body mass. Since reproductive value is a main driver of population dynamics (Grey and Law 1987; Hauser et al., 2006; MacArthur, 1960), the effect of selectively harvesting caribou

leaders is unclear. Nonetheless, caribou leaders may have heritable characteristics for behavior that increase the reproductive fitness and survival rates of leaders and/ or other animals in the herd (characteristics 2, 3, 4). In the case of selectively harvesting caribou leaders, population dynamics may be affected because a beneficial behavior is eliminated from the gene pool, rather than certain physical traits. A negative effect on the Porcupine Caribou Herd is an untested assumption of the "let the leaders pass" policy.

If characteristics 1 and 5 in table 1.A-1 were true, caribou population demographics could be affected following the long-term selective removal of caribou leaders from the population. However, Section 2.4 of this thesis indicated that either cows, or bulls, or both could be at the front of fall migration, depending on the year. Since the concern of shooting caribou leaders is for fall migration, this variability in composition may mitigate the magnitude of a demographic effect. Under an "extreme" scenario, characteristic 1, 2 and 5 (table 1.A-1) suggest that the ability of caribou to migrate at all might be compromised if the total number of animals in the population fell below some unknown threshold, or if increased road and pipeline construction caused the caribou herd to split, as seen with the case of wild reindeer in Scandinavia (Klein 1971).

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Table 1.A-1. Characteristics of caribou leaders that may cause a population-level effect when caribou leaders are selectively harvested by hunters.

	Characteristic	Evidence
1	Caribou leadership may be associated with certain genetic, phenotypic, and learnt characteristics (including sex/ age, "alertness", or experience)	The domestication process of reindeer herding by eliminating leaders suggests that leadership might be genetically determined (Baskin, 1989). A model by Couzin and Krause (2003) showed that leadership is based on individual characteristics such as sex, age, or experience. Paine (1988) found that experienced or alert caribou are more likely to break away from a group and emerge as leaders. Chapter 3 indicated that female caribou are more likely to emerge as leaders in pairs. In Chapter 2, respondents used sex and age as the main variables to describe caribou leaders.
2	Caribou leaders may enable migration, and not all caribou have leadership potential for migration	Reindeer herders selectively eliminate leaders to create sedentary herds (Baskin, 1989). Leadership at the scale of pairs (Rands et al., 2003; Chapter 3) may not be sufficient to enable herd migration (Klein, 1971). Indeed, Dumont et al. (2005) argue the higher the cost of the move (i.e. longer distance, faster travel) the fewer animals emerge as leaders. In Chapter 2 Elders indicated that caribou leaders that "know the way" similarly emerge in small numbers during migration.
3	Caribou leaders may enable escape from predators	In Section 2.46 of this thesis, I describe how hunters are able to stop a group of caribou from escaping by targeting leaders.
4	Caribou leaders may enable habitat selection	Paine (1988) observed cows 5-6 years old to lead groups to new pastures along established trails. Additionally, a study by Bailey et al. (1998) manipulated movement of domestic cattle herds by targeting individual leader animals to improve utilization of grazing areas.
5	A disproportionately high number of caribou leaders may be shot when hunters don't "let the caribou leaders pass" on the highway.	In Chapter 1, I describe the indigenous concern for shooting caribou leaders on the highway. Highway hunting also constitutes the largest proportion of the estimated annual harvest for this herd (Section 1.3).

Appendix 2
Porcupine Caribou Management Board study approval

Porcupine Caribou Management Board
Box 31723, Whitehorse, Yukon Y1A 6L3
Phone: (867) 633-4720 • Fax: (867) 293-2904 • Email: pcmb@inetg.ca

May 29, 2006

To whom it may concern:

Re: Caribou "leaders" research project

The traditional ecological knowledge on caribou is of great interest to the Porcupine Caribou Management Board (PCMB) and its local user communities. The study project proposed by Gary Kofinas and Elisabeth Robins of the University of Alaska Fairbanks addresses the traditional knowledge on caribou "leaders" and speaks directly to questions we regularly face regarding the current rules and practice for Dempster Highway hunting. This project should provide important information about the ecological dynamics of the Porcupine Caribou Herd and complement science-based research.

Research of this nature is of particular interest to us, in that it would provide systematically gathered community-based knowledge that would supplement the information we regularly receive. Because we use traditional and scientific information to guide our management decisions, we expect this project will be a great resource to us.

The PCMB has worked with Gary Kofinas for twelve years in a variety of successful projects. The PCMB fully supports the proposed project and recommends that you assist Gary and Elisabeth in their efforts in this project.

If you have any questions about the PCMB's support of this project, please contact me.

Sincerely,

per: Joe Tetlichi
Chair

Appendix 3
Interview questions

3.A. Questionnaire used for Porcupine Caribou hunter interviews

(1) When caribou move on the land, how do they know where to go?

(2) In the fall, how do caribou know where to go to spend the winter?

(3) What is a caribou leader?

(4) Are they always leading?

(5) Some people talk about "leaders of the herd" and others about "the vanguard of the caribou herd." Is there a difference?

(6) Which caribou usually lead the herd in the fall migration?

(7) Which caribou usually lead the herd in the spring migration?

(8) Are there caribou leaders during other times of the year?

(9) How do caribou behave when they have to cross a river or a road?

(10) How do caribou behave when they come to a river or a road?

(11) How does that affect the herd's migration patterns?

(12) What is the role of the leader when the caribou have to cross a river or a road?

(13) Does this knowledge help you when you hunt? If so, how?

3.B: Questionnaire used for reindeer herder interviews

(1) When does the Western Arctic Caribou Herd arrive on the Seward Peninsula? Which caribou from this herd usually come first?

(2) Have you seen or heard of caribou leaders? (yes/ no)

(3) What do you mean when you speak of caribou leaders? Could you define what a caribou leader is for us?

* If the following questions have not already been addressed, questions 4-7 will be asked accordingly:

(4) Which caribou are usually leaders? (Females/ males/ calves/ old/ young/ pregnant/ other:_____)

(5) Do leaders travel in the main herd, with a smaller group of mixed caribou, in a group of (just) caribou leaders, or alone? (If appropriate: Where are the leaders compared to the main herd? How many leaders usually travel together?)

(These differences are useful to clarify, as there has been much discussion about how many caribou are leaders and where they are located compared to the main herd (e.g., cases of road closures))

(6) Do the caribou have leaders only for the migration, or do they have leaders all the time? Also when they are foraging?

(7) Are the leaders the same in the spring and in the fall?

(8) What have you seen caribou leaders do? Are caribou leaders important to the herd? Why?

(Different situations could include: barriers/ driving reindeer away/ feeding/ migrating/ reproduction/ predators/ calves/ deep snow/ dominance status, etc.)

(9) Is the word « leader » the best word to describe these caribou or are there other better words? (Scouts, vanguard, boss, etc.)

(10) How does reindeer herding relate to caribou leaders?

Appendix 4

Memo references

Dempster Highway collection of archives, in possession by Gary P. Kofinas,

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