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Representing Traditional Knowledge: Resource Management and Inuit Knowledge of Barren-Ground Caribou

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Comanagement regimes in Canada's North rarely include indigenous systems for understanding the environment. Mapped representations and accompanying narratives illustrating the collective knowledge of indigenous hunters can make unique management contributions. Both the multigenerational knowledge of indigenous communities and opportunities allowing a discussion of diverse ways of interpreting environmental observations are crucial to involving indigenous learning systems within current regional wildlife management. It is not just the factual "data" of indigenous hunters that are relevant to resource management. It is the opportunities for social learning or for resource managers to understand how indigenous hunters learn about the environment that are directly relevant to resource management decision making.

Keywords barren-ground caribou, cross-cultural learning, indigenous, Inuit Qaujimajitugangit, knowledge systems, traditional knowledge

> *Inuit Qaujimajituganqit*, or IQ as it is increasingly called, certainly incorporates within it the kinds of facts about the environment that many non-Inuit take to be the meat of TEK [traditional ecological knowledge]. However, to the best of my understanding this knowledge is only a part of IQ, which is itself an epistemological system about how to learn, be, and behave with respect to the surrounding world. (Wenzel, 2004, 78)

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In northern Canada, most wildlife management organizations attempt to include "local" and/or "traditional" knowledge in collaborative decision-making (Sherry and Myers 2002; Peters 2003). However, in the majority of cases, the knowledge of indigenous resource users is incorporated into decisions only when it fits within current resource management models of thinking (Nadasdy 2003). Without the participation of indigenous resource users in the design and interpretation of traditional knowledge studies, the results of such studies run the risk of paring down rich, multidimensional knowledge systems into weak data sets that have little application to regional resource management issues (Huntington 2000; Davidson-Hunt 2006; Huntington et al. 2006). We define knowledge as information or experience interpreted through a cultural lens that provides meaning (Worsley 1997).

Over the course of the last two decades, northern resource management institutions have made commitments to predicate their decisions on the use of traditional knowledge. In some cases these institutions are mandated to consider traditional knowledge on at least an equal footing with scientific information (Diduck et al. 2005). However, a number of barriers persist, including the differences between scientific and traditional knowledge systems, political differences that make some resource managers skeptical of the value of traditional knowledge, and confusion about the kind of knowledge that traditional knowledge represents (Peters 2003). Moreover, there are currently few venues available for the consistent and regular exchanges between scientists and traditional knowledge-holders required to apply traditional knowledge to resource management issues and to allow the creation of "co-produced" or hybrid knowledge (Kofinas 1998; Huntington et al. 2002). This article examines how indigenous hunters' observations and knowledge of caribou can increase the depth and breadth of the information used in managing barren-ground caribou ranges. We also discuss the opportunities and challenges for social learning between indigenous hunters, resource managers, and scientists by discussing the efforts of a barren-ground caribou management board.

Barren-ground caribou management issues are ecologically complex and can involve multiple neighboring herds with overlapping winter distributions (Gunn et al. 2001). These herds move across vast landscapes and are harvested by numerous indigenous communities and subject to the management decisions of a variety of regional governments. Not only are the worldviews of the management participants diverse, but the translation of social and ecological concepts between the cultures present at the management table can be extremely challenging. The caribou herds discussed in this article not only are an important economic resource to the Dene, Inuit, and Métis hunters who harvest them, but figure prominently in the spiritual lives and cosmologies of these northern cultures. The social learning required to attain a common framework of understanding requires in-depth cross-cultural learning: How do the indigenous communities situated on the caribou ranges express and understand caribou population dynamics and the connections between people and caribou? Social learning is described as "learning that occurs when people engage one another, sharing diverse perspectives and experiences to develop a common framework of understanding and basis for joint action" (Schluser et al. 2003, 311). It is only through collective social learning that bridges can be made between the diverse parties engaged in solving management dilemmas (Diduck et al. 2005).

A number of research initiatives have begun the process of documenting aboriginal caribou hunting communities' traditional knowledge of barren-ground caribou populations (Thorpe and Kadlun 2000; Łutsël K'é Dene First Nation 2001;

Legat et al. 2001; Lyver and Łutsël K'é Dene First Nation 2005; Kendrick et al. 2005; Parlee et al. 2005). In addition, advances in spatial analysis and associated software programs have recently developed to represent the complexity of animal movements and distribution (e.g. O'Brien et al. 2006). In recent years, geographic information systems (GIS) has been explored as a means of representing knowledge in a holistic rather than a reductionist fashion and is described as a tool that complements many indigenous worldviews (Fox 2002).

It is very difficult and expensive to collect information about the habitat and population dynamics of barren-ground caribou herds. Harvest numbers are difficult to collect intensively over the long term, and aerial census surveys are expensive to perform; they are usually done once every 6–7 years. Satellite collars can provide valuable information, but only a segment of the population (in this case select adult females) is usually collared. Aboriginal caribou hunters, through the extent of their travel on the range and observations and handling of animals, have different information and means of making management decisions and are never completely comfortable making decisions strictly based on aerial survey results. Hunters from communities located directly on the caribou ranges are equipped to assist with the interpretation of changes in vegetation, snow, weather, and fire and the current and future effects of these changes on caribou. It is key to remember that it is these same hunters who will have to accept not only the benefits, but the costs of management decisions.

Case Study and Methods

Our case study focuses on the knowledge of two Inuit communities that hunt primarily on the ranges of the Beverly and Qamanirjuaq caribou herds, as well as a number of smaller neighboring herds. The ranges of these herds lie between Great Slave Lake in the Northwest Territories and the western shores of Hudson Bay, extending more than 1,000 km from north to south and more than 500 km from east to west (Figure 1). The last census surveys of these herds were completed in 1994, revealing population numbers of 276,000 for the Beverly herd and 496,000 for the Qamanirjuaq herd (BQCMB 2005).

The Beverly and Qamanirjuaq Caribou Management Board (BQCMB) is a comanagement body made up of representatives from 21 Dene, Inuit, and Métis communities, all located on the ranges of the herds. The BQCMB is also comprised of Canadian government members from two provinces, two territories, and the federal department of Indian and Northern Affairs. In the late 1970s, government managers determined that the barren-ground caribou herds were declining, possibly due to overharvesting by aboriginal communities. Aboriginal communities questioned the evidence managers were using to come to such conclusions. After several years of heated negotiations, an agreement was signed in 1982 to form the BQCMB in order to facilitate discussions aimed at ending the impasse. The BQCMB's primary management objective is to recommend management actions that will maintain the herds and their harvest by the aboriginal communities that have traditionally hunted them (BQCMB 2005). The BQCMB has faced a number of complex management issues over the years, including accelerated mining and exploration activities, road development, and an increased intensity and frequency of forest fires (Kendrick 2000).

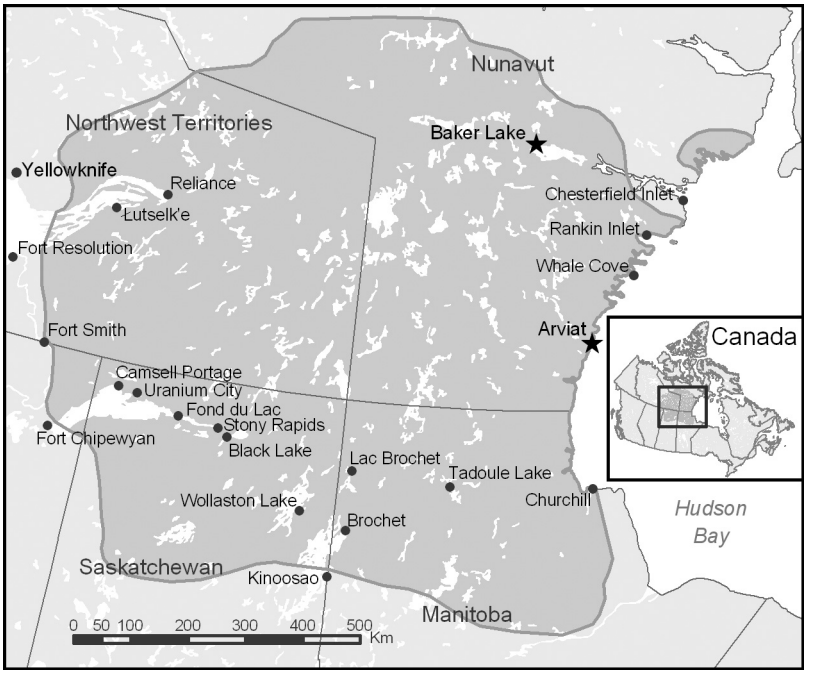

Figure 1. The Beverly and Qamanirjuaq caribou ranges.

In order to bring local and traditional knowledge into its management recommendations in a more in-depth and regularized manner, the BQCMB sponsored 2-year projects (2001–2002) in the Nunavut communities of Arviat and Baker Lake that documented the local observations of barren-ground caribou hunters (Figure 1). These projects were modeled on the experiences of the Arctic Borderlands Ecological Knowledge Co-op Society in the Yukon (Kofinas et al. 2002), and aimed at designing community-based ecological monitoring projects that allow the collection and interpretation of aboriginal caribou hunters' observations by community hunters and elders.

Baker Lake is home to roughly 1,500 people and 320 km inland from the west coast of Hudson Bay, in the Canadian Inuit territory of Nunavut. Baker Lake is the community closest to the calving grounds of the Beverly and Qamanirjuaq caribou herds. Arviat is a community of more than 2,000 people located on the Hudson Bay coastline, north of the Manitoba–Nunavut border on the spring and fall migration routes of the Qamanirjuaq caribou herd (Figure 1).

Interviews with 20 active hunters in each of the communities of Baker Lake and Arviat were carried out in the autumn of 2001 and 2002 by local researchers hired by the BQCMB (a total of 80 interviews: 40 each year). In the spring of 2003, interviews with elders were conducted by local researchers in both Arviat and Baker Lake to document changes observed by elders through their lifetimes on the caribou ranges (a total of 16 interviews). Workshops with hunters and elders in Arviat and Baker Lake were carried out in the spring of 2004 to discuss the interview results and to determine key signs of change on the caribou ranges that may be used to focus future long-term community-based monitoring projects in the two communities.

The insights from these workshops also inform this article. All transcripts and available video footage of these workshops/interviews are archived with the BQCMB and/or the Baker Lake and Arviat Hunters and Trappers Organizations.

With the aid of local interviewers, hunters and elders mapped their observations on individual base maps. These observations were then digitized and saved as shape files in a geographic information system (ArcView 3.2, ESRI, Inc.). A Microsoft Access (2002 version) database was created to hold the qualitative data associated with the mapped observations. ARGOS satellite collar data (Service ARGOS, Inc.) collected from a number of adult females of the Qamanirjuaq, Lorillard, and Wager Bay herds were also included in the analysis (courtesy of the Government of Nunavut's Department of Environment). Satellite collar data from the Beverly herd were not available for this analysis. Collars were placed on 20 females thought to be from the Beverly herd in March 2006, but due to herd mixing with two and possibly three other herds, it was later found that the majority of the collars were placed on animals that were not from the Beverly herd (BQCMB 2006).

Hunters and elders in both communities mapped the extent of their lifetime familiarity with the caribou ranges. Active hunters also mapped their harvesting activities for the following 6-month periods: March–October 2001, March–October 2002, and November 2001–March 2002. We calculated the distance that hunters traveled from settlements to find caribou and the similarities and differences between hunters' observations of spring and fall caribou migration movements (observations of mixed groups) and the locations revealed by satellite collar data (recording the movements of a small number of breeding females). Qualitative analysis included content analysis of information obtained from the semidirected interviews and group workshops. Narratives were sorted into themes and coded.

Results

The maps created from the interviews noted earlier in this article illustrate collective community harvesting activities and observations set in a temporal and spatial context. We found that narratives were key to understanding the context of the experiences and ways of thinking that informed geo-referenced community knowledge. Our results therefore combine both maps and narratives to give a more comprehensive understanding of the knowledge shared by elders and hunters during individual interviews and group workshops. We first outline the extent of the collective experiences of elders and hunters on the caribou ranges, and then examine hunters' observations of the seasonal distribution and movements of the animals and their interpretation of location data collected from satellite collars (only excerpts of the results are presented; for more detailed information see Kendrick 2005). Quotations are presented here in translation from the original Inuktitut. Quotations from 2003 interviews demarcate individuals through the use of initials rather than full names because the terms of consent for these interviews assured the confidentiality of participants.

Experience on the Land—Elders and Younger Hunters

The collective experience that hunters and elders have of the caribou ranges is impressive; the ranges cover an area larger than Ireland, and include most (but not all) of the tundra portion of the Beverly and Qamanirjuaq caribou ranges

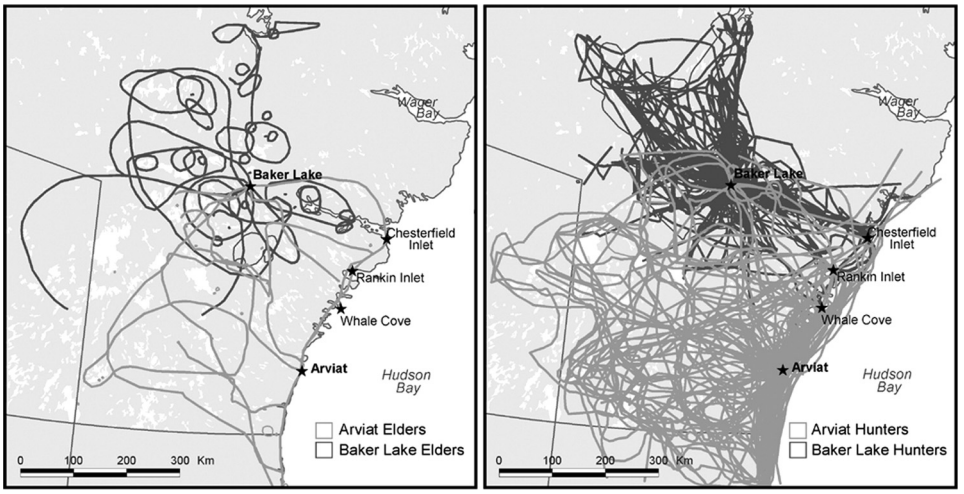

Figure 2. Collective lifetime harvesting areas of Baker Lake and Arviat elders and hunters (elders harvesting areas appear on the left; Baker Lake: $n = 8$, Arviat: $n = 8$; active hunters harvesting areas appear on the right; Baker Lake: $n = 40$, Arviat: $n = 40$).

(Figure 2). The ranges of each of the latter two herds stretch between 500 and 600 km east–west, and individual caribou in these herds can travel between 1000 and 2000 km annually (Wakelyn 1999a; 1999b). While the lifetime travel areas marked by elders are smaller than those mapped by younger hunters, elders are remembering the areas they used for harvesting purposes before they settled year-round in Arviat and Baker Lake in the late 1950s when hunters traveled on foot and by dog team. In contrast, in the last 30 years, most hunters have replaced dog teams with snow-machines, including in their maps of lifetime travels the routes they used to travel from current town sites back to traditional seasonal harvesting areas. These experiences on the land provide critical information on range characteristics, seasonal environmental conditions, and the distribution and condition of the animals. With a range of accumulated knowledge, experience, and interpretive skills stretching through a longer depth of time, elders are better able to recognize changes than younger hunters:

> The water and the ground have really changed. Usually the weather blows from the west, now it is blowing from the north so when the weather changes, it usually changes the hair [of the caribou]. When there is cold/hot weather the hair changes all the time. The hair on the caribou depends on the weather. In the fall, it is very fine hair. In the spring they are shedding. But when the weather changes, the hair changes with it. Every animal with fur, the temperature affects caribou. When there is a lot of snow, there is a lot of water in the lakes and rivers. If there is little snow, I have noticed the rivers and lakes drying up. It is changing from the past when there was lots of water. The caribou mainly feed on the ground and get fatter because they are feeding well. When it is too dry, they get skinny, they are not chewing on ground plants since it is too dry. When it is too dry in the summer, it is too hard to swallow. (PS, Arviat 2003)

Also central to this experience is how elders and younger hunters still share knowledge prior to and upon returning from harvesting activities in order to ensure safe travel and a successful harvest. When elders (now 60 years of age and older) were young, people would travel on the land for months at a time and gather periodically at fall and winter camps where information about wildlife behavior, movements, and distribution was shared. In recent years, younger hunters often travel without their families, but the entire community is aware of their harvesting activities, sharing news over VHF (very high frequency) and CB (citizens' band) radios, and greatly anticipating the return of hunting parties. Hunters' observations are usually shared, and elders often provide advice to younger hunters on how to remain safe and hunt successfully while out on the land and/or interpret the observations of younger hunters within their wider lifetime experiences:

> Today, it is different because some caribou are now coming from the northwest down towards Arviat and unlike in the past they were coming from the southeast... Now the caribou are moving in circles. There are now wolves just west of South Henik Lake with the caribou. (MM, Arviat 2003)

At a larger scale, communities are as interested in understanding the knowledge and hunting needs of other communities as they are in ensuring that their own community's knowledge is documented and utilized appropriately. For instance, hunters in Arviat are in contact with hunters in communities further up the Hudson Bay coastline (Whale Cove, Rankin Inlet) in the coldest winter months:

> January is a cold month. The caribou are further inland. The caribou that are close to Arviat [at other times of year] are further up north by Whale Cove. Caribou with calves are mostly inland. (NM, Arviat 2003)

Experienced hunters and elders have a rich level of understanding of fluctuating body condition within individual caribou. Hunters commented that in order to understand the quality and extent of change, observations need to be understood in context, i.e., in September, if there is fat on the chest and stomach areas of a male caribou, this means that an animal is in good health. Hunters emphasized that there are different terms and qualities to describe an animal's body condition. For example, hunters commented that the fat color differs depending on the sex of the animal, the time of year, and the animal's diet.

Seasonal Differences in Hunting Pattern—Spring to Early Fall Harvesting

Among currently active hunters, Arviat hunters collectively mapped spring to early fall harvesting areas covering two to three times as much land as Baker Lake hunters (1500 vs. 550 km^2) (Figure 3). A large number of Arviat hunters stayed within a 4- to 20-km radius of the town site with a few hunters traveling distances as far as 500 km from town. Some Arviat hunters move over a larger area in order to regain access to inland areas that are relatively far removed from the community's present location on the coast of Hudson Bay. These "super-hunters" (Kofinas 1998; Kendrick et al. 2005) are described as hunters that journey much farther, visiting parts of

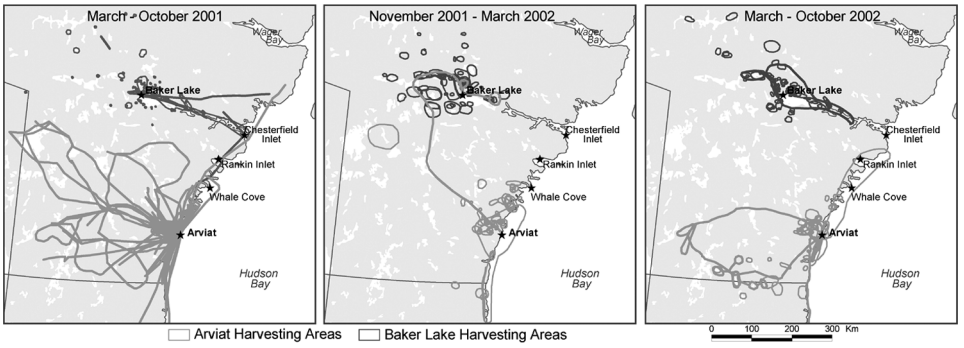

Figure 3. Seasonal harvesting areas of Baker Lake and Arviat hunters (Baker Lake: $n = 40$, Arviat: $n = 40$).

the caribou range not visited by other hunters. They may effectively serve as "scouts" for the community, scoping out the migration routes in use by caribou.

From Baker Lake, most harvesting activities occurred approximately 10 km north of the town site. Some hunters traveled as far as 300 km from town to hunt. The differences observed in the extent of the harvesting areas covered by hunters in the two communities can be explained by the geographical location of these two communities in relation to the ranges currently occupied by the herds. Baker Lake is more than 300 km inland from the Hudson Bay coast and situated on the overlapping ranges of up to five caribou herds including the Beverly, Qamanirjuaq, Wager Bay, Lorillard, and Ahiak herds. In comparison, Arviat is located on the spring and fall migration routes of only one herd, the Qamanirjuaq herd. Baker Lake harvesting activities therefore encompass a smaller area, and their knowledge pertains to different animals, distinct groups of caribou likely presenting different behaviors, thriving on a different range and exposed to different environmental conditions.

Seasonal Differences in Hunting Pattern—Late Fall/Winter Harvesting Activities (2002)

Winter harvesting activities were mapped in 2002 only. In the Arviat area the highest concentration of harvesting activity occurred 80 and 130 km north of the town site along the Hudson Bay coast (south of the community of Whale Cove) (Figure 3). No hunting activity was documented beyond a 200-km distance from town. Arviat hunters commented that there are currently better winter feeding areas by Whale Cove and Rankin Inlet. Figure 3 (November 2001–March 2002 hunting) certainly shows the highest concentration of hunting activity in areas just south of Whale Cove. These overlapping harvesting activities may reveal the location of stable wintering areas and help to pinpoint areas of the range where hunters have more detailed knowledge of vegetation and snow conditions. In the winter of 2002, Baker Lake hunters showed a high concentration of effort in areas some distance (roughly 50 km) north of the town site. The highest degree of overlapping harvesting activity occurred 30–40 km southwest of the town site and 30–40 km north of the town site. There were also overlapping harvesting activities approximately 100 km east of Baker Lake. A couple of "super-hunters" traveled up to 300 km northwest of town.

Hunters' narratives suggest that weather and snow conditions play a greater role in defining caribou distribution than other factors. It is the elders who comment on the range of conditions that characterize prime wintering areas, illustrating the significance of knowledge informed by the cumulative knowledge of the elders and their ancestors about variations in caribou habitat. Older hunters expressed their knowledge of seasonal feeding grounds and the connection to seasonal variation in the distribution and individual body condition of caribou:

> When the feeding [ground] is all dried up, [the caribou] move further to find ground that is not too dry. The caribou coming from inland are skinnier since they are moving all the time. The coastal caribou are always feeding well on kelp and they are much fatter than the ones inland; they taste different ... In the fall, at freeze-up or in the winter the meat tastes the same in the winter and the fall. They feed more in the winter. When it starts to freeze up it is moister inland so they taste the same at the coast and inland. (LK, Arviat 2003)

Hunters' Observations of Caribou Movements and Distribution and Satellite Collar Data

Collars are placed on adult females by the Government of Nunavut and are used to depict specific herds' distributions and seasonal movement patterns (Figure 4). The data revealed that in the spring of 2001, Arviat hunters concentrated their hunting efforts in the area most heavily used by the collared Qamanirjuaq caribou. Again in parallel to the collar data, the spring 2002 harvesting efforts of Arviat hunters are far more thinly distributed and reach much further inland. In contrast, Baker Lake hunters concentrated their spring 2001 harvesting activities relatively close to town, while collared animals from the Wager Bay and Lorillard herds are well north of these harvesting areas. Two possibilities exist to explain this difference: Baker Lake hunters may have been hunting Beverly caribou (there were no collars on Beverly animals in 2001/2002) or they may have been hunting bulls and juveniles rather than cows (only mature cows are collared). In the Arviat area, the autumn months of both 2001 and 2002 reveal widely scattered distributions of collar data. However, Arviat hunters concentrated their hunting relatively close to town, having no need to travel too far inland in order to find animals. According to the autumn collar data for the Baker Lake area, hunters are possibly harvesting from the Lorillard and Wager Bay herds rather than the Qamanirjuaq herd. One hunter comments on the differences between the knowledge older hunters have about caribou distribution and the information revealed by collar data and his use of both sources of knowledge as a younger hunter:

> The other thing about the collared caribou is that I didn't grow up with some of these older guys, going out hunting and not relying on the collared caribou, for hunting and stuff like that. I usually check before I go hunting, I check the collared caribou [maps displaying collar data]... Sometimes we go out ... and all we see is a herd of maybe 10 caribou with a collar and there's no caribou around for another 40 miles... And then the bigger herds, the hunters find and they don't have a collar at all... There's a difference in the knowledge of the hunters and the collared caribou that the biologists rely on. (JC, Arviat 2004)

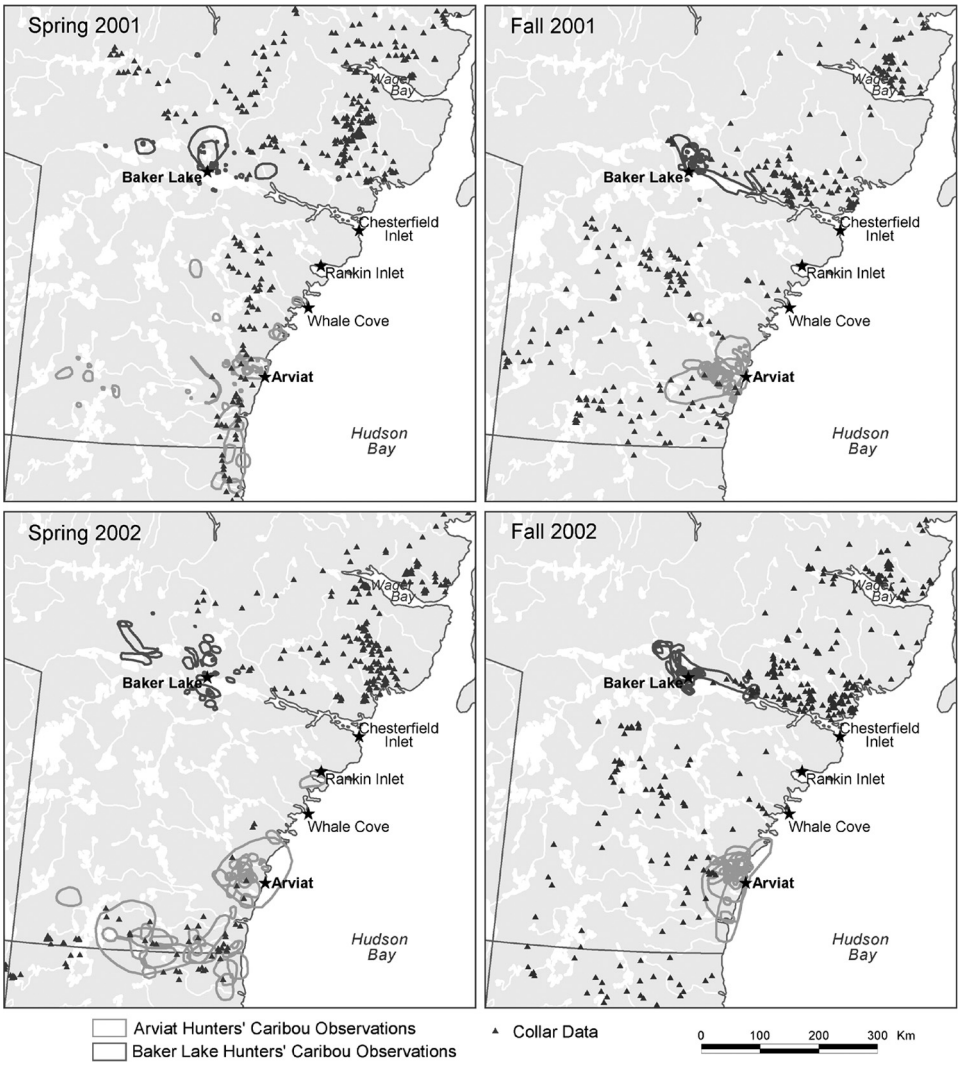

Figure 4. Spring and fall caribou observations of Baker Lake and Arviat hunters and corresponding collar data for the Qamanirjuaq, Wager Bay, and Lorillard herds (spring = Julian dates: 64–145, fall = Julian dates: 201–293).

Analyses of collar data from caribou herds in northern Québec reveal significantly frequent overlaps between the rutting ranges of migratory herds and that a significant number of females switch calving sites at least once in their lifetimes, while some migratory animals migrate into the ranges of sedentary herds (Boulet et al. 2007). If this is also the case in the Kivalliq region, there are major implications for herd-based management decisions. The collar data for the herds in the Kivalliq region show that throughout the year Baker Lake hunters have consistent access to a number of smaller herds, unlike Arviat hunters, who have reasonably secure access to caribou only during the spring and fall migrations of the Qamanirjuaq herd.

At certain times of year it is very difficult to tell whether animals are being harvested from one population or another. The winter distributions of the Beverly and Qamanirjuaq herds can overlap with neighboring herds (Gunn et al. 2001). As a result it is hard to make decisions on hunting allocations and quotas. Not much is known about the dynamics between different populations and the characteristics of larger and smaller herds over both short and long time periods. If hunters are observing herd mixing behavior in certain areas, their observations could make a valuable contribution to understanding the complexity of overlapping herd distributions and refine the use of the results of harvest studies to create hunting quotas. Hunters and elders often make distinctions between caribou populations in relation to the direction animals have traveled from in relation to other populations; i.e., Baker Lake elders speak of the *Arviamiut* caribou or "caribou moving from Arviat" (Qamanirjuaq caribou) that move into the Baker Lake area at certain times of year.

Discussion

The narratives and focus-group discussions informing the maps produced from hunters' direct observations on the caribou ranges, as well as hunters' and elders' commentaries on the maps produced from collar data, are key to applying spatial data to management issues. However, there are numerous challenges associated with using such information in collaborative resource management settings. If resource management efforts limit the inclusion of traditional knowledge to the collection of the year-to-year observations of resource users, the cumulative experience of indigenous communities and alternative ways of understanding and experiencing the environment are lost. During focus-group discussions and semidirected interviews, elders commented extensively on changes in the behavior, movements, distribution, and individual body condition of caribou, namely, their concern that caribou no longer avoid areas of human activity and that their health is detrimentally affected as a result. Arviat and Baker Lake elders also discussed how closely the traditional calendar of the inland Inuit followed the migratory movements and behavior of barren-ground caribou populations and how the timing of this calendar is now changing.

Many communities are located in areas where caribou ranges overlap, and this has direct implications for "herd-based" management decisions when the allocation of domestic needs and commercial quotas from specific herds is under discussion. One important factor that the BQCMB projects revealed is that communities are often located on parts of the range where there is significant overlap between the ranges and often only one or some of the herds is considered. Other community-based caribou research projects also revealed community insights into herd overlaps (see Kofinas et al. 2002; Lyver and Łutsël K'é Dene First Nation 2005; Kendrick et al. 2005). The current BQCMB management plan does not currently refer to such overlaps, though there are other barren-ground caribou management plans that acknowledge significant overlaps with smaller neighboring herds (for example, the Bathurst Caribou Herd Management Plan 2004).

In the case discussed in this article, hunters and elders mapped their general harvesting areas rather than pinpointing specific kill sites. Narratives and focus-group discussions revealed a depth of supplemental observations about vegetation, snow conditions, changes in the use of main migration routes, water crossings, and observations about the condition and behavior of both harvested and nonharvested

animals. These supplemental observations and elders and hunters interpretations of spatial data provided important context to both the mapped observations produced from the hunters and the collar data. Although the information revealed by the collar data is indeed expansive, collar data cannot reveal the supplemental knowledge and accumulated experience of the range held by indigenous hunters and elders. While Figure 4 shows that hunters did not map the fall and spring migrations of animals recorded by collar data, narratives revealed that while hunters may have met their harvest needs close to town, they were aware that animals migrated through areas further from town (and recorded by collar data). Without these narratives, it might be concluded that the knowledge that indigenous hunters hold of the caribou ranges is limited to their day-to-day observations of the ranges. The risk of creating maps that become separated from the interpretive power of narratives is the risk that hunters' observations are used in inappropriate ways as a result.

Efforts to map the traditional knowledge of indigenous resource users can facilitate collective deliberation about the use of indigenous knowledge in resource management settings; however, maps cannot replace these deliberations. The risks that indigenous knowledge can be co-opted or misinterpreted as a direct result of the relative ease of its access are explored in the traditional knowledge literature (Duerden and Keller 1992; Davidson-Hunt 2006; Caine et al. 2007). The documentation of the collective knowledge of traditional resource users is a relatively recent occurrence (Freeman 1976). It is necessary to review the messages that are conveyed with the maps and to reflect on the risks taken in portraying information through maps directly with the communities involved (Fox 2002; Chuenpagdee et al. 2004).

Most northern resource management institutions continue to struggle to document and incorporate traditional knowledge in management decisions. This is true despite the fact that there is significant traditional knowledge held by indigenous resource users in the north and there are strong policy and legal imperatives to use traditional knowledge in management decisions by indigenous and co-management institutions (Caine et al. 2007). Indigenous resource users have significant representation at northern management tables, though some would argue that these resource management institutions are still inherently colonial in structure and therefore prone to dismiss and/or co-opt traditional knowledge systems (Nadasdy 2003; Caine et al. 2007).

Our case study shows that there are also significant challenges that lie in securing the time and resources necessary to develop methodologies to properly record and interpret the knowledge of indigenous resource users. Traditional knowledge studies require innovative participatory methodologies. Techniques for communicating and interpreting results face challenges on a number of fronts: Methodologies must include culturally appropriate peer review processes, contextualize the means of data collection, establish sampling efforts with community-based organizations, take into account diverse linguistic and cultural concepts, and account for the scale of the knowledge imparted. We must also understand how to apply local-scale observations of familiar issues to larger scale and often unprecedented management issues, e.g., the impact of road construction, mining development, and hunting quotas for activities occurring in a remote part of the range.

Regular workshops allowing for the exchange of knowledge between indigenous resource users, scientists, and managers about possible changes in the environment and subsequent management issues are important, but only one of many forms of communication that must occur in order for the traditional knowledge of indigenous

resource users to be properly interpreted and applied to management issues (Huntington et al. 2006). Without active community research participation and ownership in management processes and traditional knowledge studies, the ability to interpret local knowledge is fundamentally compromised (Huntington et al. 2006). With increasing work to develop methodologies to document and learn from local and traditional knowledge systems, the overall knowledge used in management decisions will ultimately be better accepted when crucial management issues are faced.

Conclusion

The mapped representations of local communities' observations of the environment reveal only a small part of the learning that indigenous communities have to bring to resource management decisions. The narratives and cumulative experience of elders provide a wealth of knowledge and interpretive skills to understand the visual pictures illustrated through mapping exercises. The ability to understand changes in the environment with any great temporal or geographical breadth is exceptionally challenging. It is increasingly difficult to understand the differences between signs of adaptive change and signs of ecological crisis. Incomplete knowledge will always be a pervasive feature of vast landscapes and generalization from one area to another is often not appropriate. The challenge is even greater in the highly remote areas of the North. Northern land use planning agencies attempts to maintain landscape connectivity in the face of climate change and industrial development is highly scale dependent. The mapping and discussion of community-based observations are key to efforts to understand how best to prevent the negative impact of anthropogenic activities or how to best plan for sustainable land use activities on these vast landscapes (Kofinas et al. 2002; Huntington et al. 2002).

Community focus groups revealed that hunters and elders were as interested in understanding the knowledge and hunting needs of other communities as they were in ensuring that their own community's knowledge was documented properly. There is a tension involved in recording community observations and traditional knowledge that allow easily compared results that may generalize variability, lose community values, and mask anomalies. Narratives may be more difficult to analyze and represent, but reflect a range of local variability in observations and reflect the range of natural history observations and environmental history of the ranges.

Throughout the course of the research described in this article, hunters and elders discussed the context of their environmental knowledge: The land is as much a living embodiment of their personal and ancestral history as it is a record of wildlife harvesting activity. It is vital to keep in mind that behind one-dimensional mapping exercises lies the learning that provides meaning and interpretation to the documentation of indigenous knowledge of the environment.

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