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An integrated assessment of Porcupine caribou seasonal distribution, movements, and habitat preferences for regional land use planning in northern Yukon Territory, Canada

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Abstract: This study was undertaken to improve understanding of Porcupine caribou herd distribution, movements, and habitat preferences to assist with developing a regional land use plan for the North Yukon Planning Region, Yukon Territory. Three different methods were used to identify current and historical patterns of caribou distribution and habitat preferences within the region to prioritize conservation areas. Two of the approaches focused on incorporating information on caribou distribution and migrations from scientific and local knowledge, while the third focused on identifying and mapping habitats suitable for supporting caribou. Local knowledge dating back to the 1930s and two decades of satellite telemetry data confirmed that most of the planning region is used by the Porcupine caribou herd and highlighted areas of concentrated use. Maps of suitable winter habitat derived from expert opinion ratings of habitat use did not agree with the other information sources. The local knowledge and satellite telemetry analyses were used to identify spatially explicit priority areas for caribou conservation and the results were applied to develop conservation recommendations for a draft regional land use plan. The plan will be submitted to government approval bodies for review in the spring of 2007. The success in implementing conservation strategies for the Porcupine caribou herd will be reviewed and evaluated following adoption of a final approved plan.

Key words: concentrated use areas, conservation, cumulative effects, cumulative impacts, habitat suitability, home range, local knowledge, *Rangifer*, thresholds, traditional ecological knowledge, utilization density.

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Introduction

To fulfill its land use planning mandate under the terms of the Vuntut Gwitchin First Nation (VGFN) Final Agreement (Department of Indian Affairs and Northern Development, 1993), the North Yukon Planning Commission (NYPC) must develop and recommend a draft regional land use plan for the North Yukon Planning Region by the spring of 2007. The planning region is located in Canada's Yukon Territory, encompasses the traditional territory of the VGFN, and is approximately 55 500 km^2 in size (Fig. 1).

The NYPC is an independent body comprised of six publicly appointed members. Representation is equally split between VGFN and Yukon Government. Members are charged with developing regional land use goals, objectives, and management recommendations for submission to VGFN and Yukon Government for consideration and approval. Under Chapter 11 of the VGFN final agreement, "regional land use plans shall include recommendations for the use of land, water and other renewable and non-renewable resources in the planning region in a manner determined by the Regional Land Use Planning Commission" (Department of Indian Affairs and Northern Development, 1993).

Under the terms of the VGFN Final Agreement (Department of Indian Affairs and Northern Development, 1993) and the NYPC precise terms of reference (North Yukon Planning Commission, 2004), there

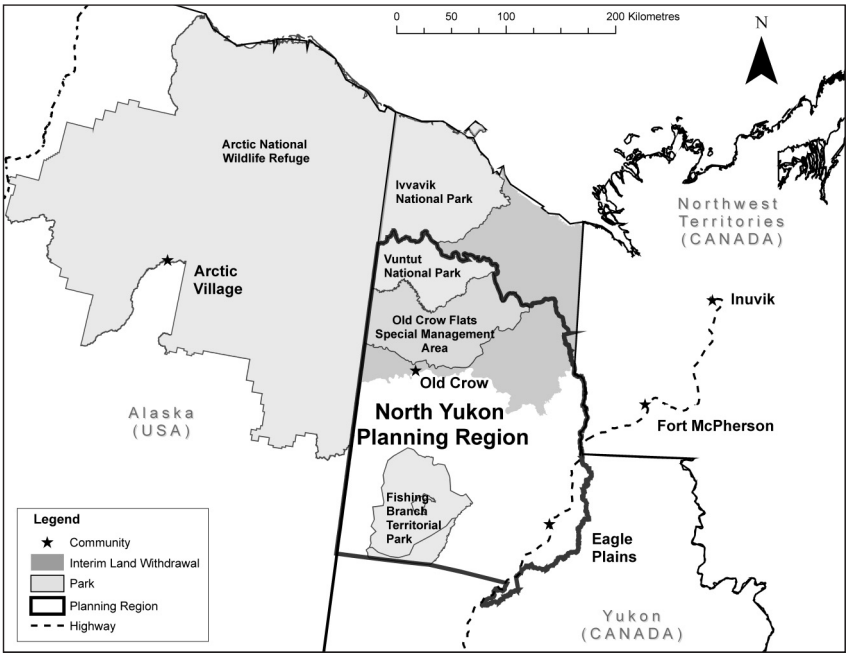

Fig. 1. Location of the North Yukon Planning Region (thick black outline) in northern Yukon Territory, Canada. Protected areas within the region include Vuntut National Park and Fishing Branch Territorial Park. A protected land designation for the Old Crow Flats Special Management Area (SMA) is in progress (March 2007). An additional protected area under interim land withdrawal is also shown.

are five general guiding principles that the Commission must follow during plan production: 1) recognize and promote the cultural values of Yukon Indian people, 2) promote and ensure sustainable development, 3) integrate decision-making, 4) recommend measures to minimize land-use conflicts, and 5) consider scientific and traditional (local) knowledge of resources equally. An additional important consideration for the Commission is to recommend tools and approaches to mitigate potential cumulative effects/impacts of multiple land use activities on resources.

VGFN settlement lands account for 7762 km^2 or 14% of the planning region (areas not shown). Most of the remaining non-settlement lands are managed by the Yukon Government. The only permanent community in the region is Old Crow with a population of approximately 270 residents (Yukon Department of Health and Social Services & Yukon Bureau of Statistics, 2005). There is also a small year-round service facility located at Eagle Plains along the Dempster Highway.

Much of the land in the region has existing protected area status or is under a land withdrawal order that prohibits exploration and development activities. The land withdrawal area is considered a protected area at present, but the order is for an unspecified time period and could be lifted in the future. The protected areas include Vuntut National Park, Fishing Branch (Ni'iilii'njik) Territorial Park, Old Crow Flats Special Management Area (OCF-SMA), and the land withdrawal area extending south and east of the OCF-SMA. The area delineated at the southern limit of Fishing Branch Territorial Park is designated as a Habitat Protection Area (HPA). This area is to be managed as a conservation unit to maintain ecological integrity, but it is not a protected area. The protected areas and HPA represent approximately 46% of the region's area. Outside these areas, the remaining settlement and non-settlement lands have undetermined management objectives. These are the areas of focus for NYPC activities.

A recurring issue of concern expressed at community consultations is the conservation of the Porcupine caribou herd across the region, given the potential for oil and gas exploration/development activities and the uncertain effects of climate change on caribou. Consequently, the NYPC, VGFN, Yukon Department of Environment, and other plan partners identified caribou as a resource of primary interest for further study in the context of producing a land use plan.

The Porcupine caribou are a tundra herd of Grant's caribou (*Rangifer tarandus granti*) that range from Northeastern Alaska to the Yukon/Northwest Territories border. The most recent population survey estimated the herd size at 123 000 animals, down from a 30 year high of 178 000 animals in 1989

(McNeil *et al*., 2005). This herd has special cultural and ecological significance to First Nations and has been a high profile population internationally with ongoing proposals for hydrocarbon exploration and extraction on their calving grounds in Alaska (Griffith *et al*., 2002).

Within the planning region, the community of Old Crow is one of the primary users of the herd and subsistence harvest remains strong (Berman *et al*., 2004). Porcupine caribou are harvested during the fall, winter and spring periods along the Dempster Highway corridor by other communities and non-first nation hunters in the Yukon and Northwest Territories (Kofinas & Braund, 1998). Caribou primarily occupy the planning region during the fall migration, rut, winter, and spring migration seasons. The range of dates for these seasons has been reported elsewhere (Porcupine Caribou Technical Committee, 1993; McNeil *et al*., 2005). The Porcupine Caribou Technical Committee (1993) assessed the relative importance of habitats to caribou during these seasons, according to six criteria, and concluded that these seasonal habitats were less important than the calving, post-calving, and early summer habitats. A detailed description and characteristics of the range are reported in Russell *et al*. (1993).

The identification and conservation of significant areas of use for the Porcupine caribou herd were considered regional priorities. To address the information needs of this requirement, the NYPC collected, analyzed, and interpreted spatially explicit scientific and local knowledge of caribou use of the region from 2004-2006. The need for and benefits of sharing and integrating scientific and local knowledge to improve resource decision-making have been well documented (Russell *et al*., 2000; Huntington *et al*., 2002; Danby *et al*., 2003; Kelsey, 2003; Berman & Kofinas, 2004; Moller *et al*., 2004; Ellis, 2005). This study was undertaken to achieve three objectives: 1) to integrate and compare various sources of data on caribou distribution to identify spatial patterns in seasonal habitat use, and presence/arrangement of suitable habitat, 2) to identify areas of conservation priority for caribou, and 3) to apply the information to develop and recommend conservation strategies in a draft regional land use plan, with emphasis on mitigation and management of potential cumulative impacts to caribou.

Material and methods

Three different methods were employed to identify current and historical caribou use areas. Two of the approaches focused on incorporating population-level information on caribou distribution and migration patterns in the four seasons when caribou primarily occur within the planning region: fall migration, rut, winter and spring migration. The population distribution information was obtained from local knowledge of significant caribou use areas and analyses of satellite telemetry data. The third approach focused on collaboratively developing expert opinion ratings of habitats suitable for supporting caribou during the winter season and applying the ratings to a habitat map of the region. Each method is described below.

Table 1. Seasonal definitions used for the Porcupine caribou herd.

Season	*Date*
Winter	December 1 to March 31
Spring Migration	April 1 to May 31
Calving	June 1 to June 10
Post-calving	June 11 to June 30
Early summer	July 1 to July 15
Mid to late summer	July 16 to August 7
Fall migration	August 8 to October 7
Rut	October 8 to November 30

Satellite telemetry analyses

In June 2005, the Canadian Wildlife Service and the NYPC analyzed a long-term (1985-2004) satellite telemetry dataset of collared Porcupine caribou cows to quantify seasonal habitat use and migrations of the herd, and to examine landscape level patterns of distribution. A detailed description of the satellite collar project can be found on the Taiga Net website (Taiga Net, 2006). The analysis identified general use areas, concentrated use areas and mean directional vectors for animal migrations between seasons.

The annual cycle was divided into eight seasons based upon caribou activities (Table 1; Porcupine Caribou Technical Committee, 1993). The dataset included an average of 11 collared animals per year with 68 different animals over the time period. Caribou locations for each season were limited to a maximum of 10 random samples per animal to ensure that no animal was over-represented (McNeil *et al*., 2005). Of the 18 979 locations, 4306 were randomly sampled for this study with 450 to 650 locations per season. Utilization density grids were created for each season using fixed-kernel analysis procedures (Seaman *et al*., 1998). General use areas, representing habitats where most of the satellite collared animals were found at low density, were derived from the 99% isopleth for each seasonal kernel analysis (Griffith *et al*., 2002). Concentrated use areas, representing habitats occupied at a higher density of animals than other areas within

the herd's range, were derived from the 60% isopleth. While the 50% isopleth has been used to denote concentrated use areas for the Porcupine caribou herd (Griffith *et al*., 2002), the 60% isopleth was initially chosen to provide a conservative estimate. The 60% isopleth has recently been used to identify concentrated use areas for other caribou populations, as a result of exponential fit modelling (Schindler, 2005; Schindler, *pers. comm.*).

Migration patterns were considered supplementary information to the identification of concentrated use areas. General migration pathways between seasons were derived for fall migration through to spring migration. For each animal, point to point linear migration vectors were created between the last location in one season's concentrated use area and the first location in the following season's concentrated use area. Animals had to be present in both concentrated use areas, across seasons, to be included for analysis. Individual migration vectors were then subjectively assigned to a general migration path, based on travel direction and geographic locations of departure and arrival. For example, if two animals generally traveled in a south to north direction between Old Crow and Old Crow Flats, across seasons, they would both be assigned to this migration path. Based on this subjective assignment, a mean directional vector was computed for each general migration path.

Local knowledge workshop

In November 2004, the NYPC hosted two interactive community workshops in Old Crow, YT, with Vuntut Gwitchin elders and other community residents to document local sources of information on wildlife use of the region. Both workshops were public sessions, and residents collectively shared their historical and current knowledge of caribou distribution. A total of 18 workshop participants (13 male/5 female) and 11 support staff participated in the workshops. All participants were current or former hunters of varying ages. Approximately two-thirds of the participants were young or middle-aged adults, and the rest were elders. Local knowledge of general caribou distribution spanned from at least the 1930s to present. Many stories told at the workshop reflected a historical knowledge base much older than this period. Information on caribou distribution across various portions of the region and for various life functions (general range, breeding area, migration corridor, and mineral lick) was obtained. Participants provided locational information for the months of August through to May, corresponding to the fall migration, rut, winter, and spring migration periods. Temporal trends in caribou distribution were not obtained. Support staff delineated important caribou areas and migration routes on 1:250 000 scale paper maps. This information was subsequently digitized and attributed in ArcGIS v. 9.1 (ESRI Inc., Redlands, California, USA), a geographical information system.

Habitat suitability workshops

At the November 2004 workshop, participants expressed an interest in assessing the winter habitat use of Porcupine caribou. Residents were familiar with and comfortable in rating caribou use of winter habitats only. As a result, two habitat suitability workshops were held in January 2005 with biologists and community residents to collaboratively rate various habitats for their winter value to caribou. This expert opinion based approach, referred to as a Delphi process, aims to develop consensus between experts over several rounds of deliberation on the assumption that combining the expertise of several individuals will provide more reliable results than consulting one or two individuals (MacMillan & Marshall, 2006).

At the outset of the workshops, participants developed a common definition and understanding of the winter season. Definitions of seasons were discussed and decided upon by Old Crow residents and biologists. For caribou, the winter period was defined as November 1st to March 31st, differing from the Porcupine Caribou Technical Committee definition of December 1st to March 31st (Porcupine Caribou Technical Committee, 1993).

In early January 2005, the Yukon Department of Environment held a habitat suitability mapping workshop in Whitehorse, YT. Three biologists with expert knowledge of the habitat use and requirements of Porcupine caribou rated the relative value of various winter habitat types within the region. Reference photos of 28 unique habitat types (summer images) depicting various vegetation communities, elevation gradients, and physical characteristics were shown to participants who then collectively rated the habitats for their relative winter importance to caribou. The habitat types represented the range of habitat features found throughout the region. Participants were asked to classify the value of habitats into one of four categories (0=lowest; 1=low; 2=moderate; 3=high).

A subsequent habitat suitability workshop was held in late January 2005 with Old Crow residents. The workshop was a public session and most attendees were also present at the wildlife workshops in November 2004. Workshop participants were shown the same representative photographs of various habitat types. Participants were likewise asked to rate the habitat types for their relative value to caribou. A total of 17 Old Crow residents and 5 support staff participated.

Habitat suitability ratings from both workshops were combined to produce one composite rating for

each habitat type. Habitat ratings were compiled in a database and the values were linked to a biophysical habitat map (v. May 2006) of the planning region. The biophysical map showed the same 28 habitat types with their ratings and the spatial arrangement and location of each habitat in the region. The ratings and coverage were spatially comprehensive within the region, and there were no missing values.

The biophysical map was derived through a predictive ecosystem modeling process. Three primary layers of mapped information were used to create the biophysical map of the region: 1) vegetation cover data (25m resolution) from Earth Observation for Sustainable Development Landsat interpretation (Natural Resources Canada, 2000), 2) a 90m digital elevation model (DEM) of the Yukon Territory, and 3) a 1:250 000 scale vector map showing regional terrain features. A relative soil moisture model was derived from the DEM, providing a reasonable approximation of ecosite conditions stratified by elevation and terrain features. Regional terrain mapping refers to a method of delineating and describing regional terrain conditions that are ecologically relevant (i.e. influence the distribution, structure and productivity of vegetation communities). Regional terrain features are similar to surficial geology and included pediment slopes, major stream valleys, glaciolacustrine basins, bedrock, plateaus, and mountains in the region. A description of the biophysical mapping methodology is available at the NYPC website (North Yukon Planning Commission, 2006). The biophysical map was reviewed for adequacy and accuracy in its representation of habitat types, and was found to be adequate for the purpose of regional habitat characterization (Cryo Geographic & Makonis Consulting, 2006).

A preliminary habitat map with the ratings was shown to participants in April 2005 for review, refinement, and further discussion. The ratings for specific habitats were adjusted where required, based on a consensus decision by the participants. A final map of winter habitat suitability for Porcupine caribou was then produced.

Maps showing caribou concentrated use areas, migration patterns, important areas from local knowledge sources, and winter habitat suitability were overlaid and visually compared in ArcGIS v.9.1 to identify priority areas for caribou conservation. Conservation priorities were subjectively determined by Commission members through collective interpretation of this information. A rigorous statistical analyses and comparison of the spatial trends in the data was not considered appropriate given the varying quality, resolution, and scale of the data.

Results

The satellite telemetry data confirmed that the Porcupine caribou herd uses the North Yukon Planning Region extensively. General use areas (99% isopleths) during all seasons covered 96% of the planning region (Fig. 2). Within the region, the concentrated use areas occupied a total area of 19 224 km^2, representing approximately 35% of the total planning region area. Approximately 55% of the total concentrated use area in the planning region is present in the existing Parks, Old Crow Flats SMA, Fishing Branch HPA, and the region under land withdrawal. The concentrated use area within the planning region represents 33% of the total range-wide fall migration/rut season concentrated use area of the herd, 36% of the winter season, and 13% of the spring migration season, respectively.

General migration patterns of the herd show that animals converged on the North Slope of the Yukon Territory and Alaska during the spring migration period, en route to the calving grounds. During the fall migration to rut period, the herd displayed large variability in directional migrations between habitat patches (not shown). In general, fall migration occurs as a southward movement of animals into the Richardson and Ogilvie mountain ranges. Between the rut and winter periods, caribou move more locally across habitat patches within these same mountain ranges.

The local knowledge map also confirmed that Porcupine caribou currently are, and have historically been, distributed across the region (Fig. 3). Several north-south migration corridors were identified through the Richardson Mountains, the perimeter of Old Crow Flats, and the central portion of the planning region. Numerous localized important caribou range areas were identified, particularly around the Old Crow Flats, and several regional mountain ranges south of Old Crow (i.e. Sharp Mountain, western Richardson Mountains). All polygons represent individual or collective knowledge of caribou distributions from workshop participants. Some of the polygons overlap where the same areas were identified by multiple participants. Most of the caribou distribution data from the community wildlife workshops were recorded for areas near Old Crow, during the winter season when caribou are present and harvested near the community.

The winter habitat suitability map (Fig. 4) reveals a predominance of high quality winter habitat in the southern portions of the planning region, particularly in the southeast. The northern portion of the range was classified as low to lowest quality winter habitat, while the Richardson Mountains along the eastern edge of the planning region were identified as moderate winter habitat. Approximately

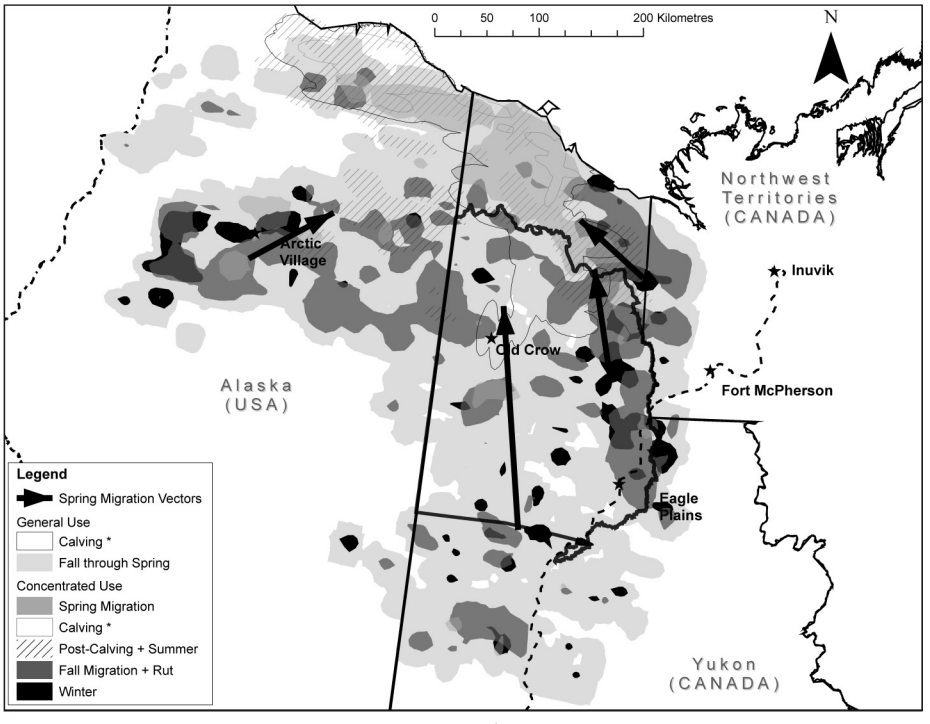

Fig. 2. General (99% isopleths) and concentrated use areas (60% isopleths) of the Porcupine caribou herd by season. Mean directional vectors (black arrows) show migration pathways between winter and spring migration seasons. * Calving areas shown as per Griffith *et al.* (2002).

47% of the planning region area was rated as moderate to high quality winter habitat (35% and 12% for each class, respectively). Within the winter concentrated use areas in the planning region, approximately 54% of the occupied habitat was rated as moderate to high quality (41% and 13% for each class, respectively).

Discussion

Two decades of satellite telemetry data and local knowledge dating back to the 1930s confirmed that most of the planning region is used by the Porcupine caribou herd at some time during their annual cycle, but primarily during fall migration, rut, winter, and spring migration seasons. Caribou are also found in the extreme northern portion of the region during the calving and mid/late summer seasons.

Several areas of the planning region had overlapping concentrated use areas across these seasons, suggesting a higher intensity of use. The analysis of caribou migration and distribution showed that the Richardson Mountain range is a consistently important area for the herd during fall, winter and spring. The northern portion of the Richardson range has been a consistent concentrated use area during summer. In contrast, the Eagle Plains basin has received less use by the herd, consistent with findings dating back to the 1970s (Russell *et al.*, 1992). Probable factors and explanations for these observed patterns have been reported (Russell *et al.*, 1993; Russell, 2000).

Concentrated calving areas within the region have been documented, but calving in the region is infrequent. Most calving occurs on the North Slope of Alaska in the Arctic National Wildlife Refuge (ANWR) (Griffith *et al.*, 2002). Concentrated use areas during the calving and mid/late summer seasons are contained within the existing protected areas, Old Crow Flats SMA, and the region under land withdrawal. Limited use of the planning region was observed during the post-calving and early summer seasons. During these seasons, satellite collared animals have been found concentrated along the North Slope of Alaska in the Arctic National Wildlife Refuge (ANWR) (Griffith *et al.*, 2002; McNeil *et al.*, 2005).

In general, good agreement between the important areas identified from local knowledge sources and the concentrated use areas derived from satellite telemetry analyses was revealed, with the exception of the Richardson Mountain range. This finding was not surprising as VGFN residents have not extensively occupied the Richardson Mountain range in recent times (post 1930). The community knowledge of distribution is best for the winter season when animals are harvested

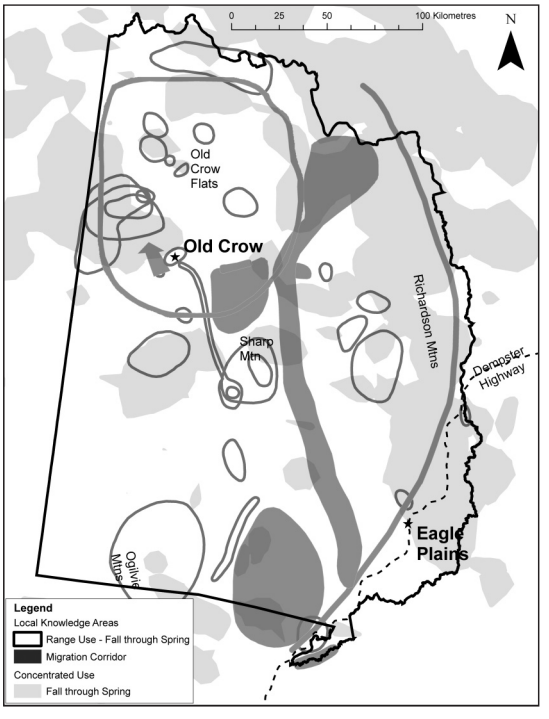

Fig. 3. Overlay of local knowledge and concentrated use areas for fall, winter and spring migration seasons. Important caribou range areas within the North Yukon Planning Region from August to May, as indicated by Old Crow residents, are shown as polygons (dark grey outline). Migration corridors (dark grey shading) and concentrated use areas (light grey shading) are also shown.

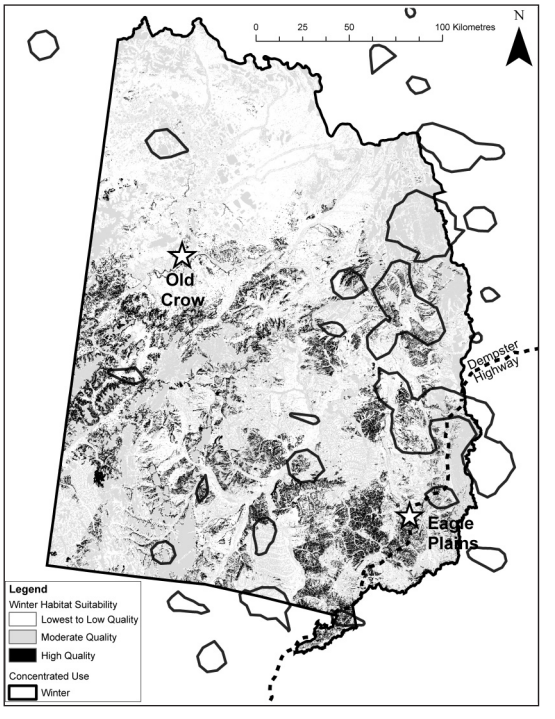

Fig. 4. Overlay of concentrated use areas and habitat suitability map for the winter season. Concentrated use areas (thick black outline), high quality habitat (black shading), moderate quality habitat (light grey shading), and lowest to low quality habitat (no shading) are shown.

near the community. There are local knowledge gaps for many areas that are no longer visited, have not been visited in recent times, or are only visited on a seasonal basis. The local and scientific information sources validated each other for areas that local residents are familiar with, and displayed complementary patterns of animal use of the landscape. Satellite telemetry analyses highlighted priority areas (e.g. Richardson Mountains), while local knowledge was useful to link patches of concentrated use areas via identified traditional migration corridors.

Based on our assessment, we recommend that local knowledge be used as a primary source of information for planning purposes around the vicinity of Old Crow. Local knowledge of caribou hunting areas from past research (Berman & Kofinas, 2004) has also been used to confirm the identification of important areas for Old Crow residents. The satellite telemetry analyses can be used to fill gaps in knowledge for areas that are not frequently visited by local residents.

Habitat suitability mapping derived from expert opinion did not agree with the other information sources. A poor agreement between the winter habitat suitability map and actual distribution of animals was observed, likely owing to several factors that were not considered. Workshop participants noted that caribou occupation of suitable habitats is dependent upon many factors not considered here, including, but not limited to: snow depth/resistance, predation risk, competition for resources, weather, wind, insect harassment, timing of seasonal cycles (i.e. spring green-up), presence of mineral licks, fire history, recent burn intensity, individual/group behaviours, and anthropogenic disturbance.

An additional consideration is that the habitat suitability ratings reported here are based on expert opinion and subjective interpretations of habitat use from summer reference images. It is possible there was some misinterpretation of the reference images in the context of producing the winter suitability map. Owing to these factors and possible issues with the workshop methodology, the map of suitable habitat was not used for identifying caribou conservation priorities.

A particularly important factor that should be considered in future iterations of a habitat suitability map is snow characteristics. We speculate that in deep snow years, snow characteristics (i.e. depth, density, and resistance) are the most important variables likely to predict winter caribou distribution, whereas the presence of suitable vegetation underneath the snow would determine winter habitat suitability in shallow snow years. Caribou may be limited by availability of forage that is inaccessible because of snow cover (Cronin *et al.*, 1998). The southeastern portion of the Porcupine caribou range was identified as having very high quality habitat but it is also an area where deep snow is prevalent (Russell *et al.*, 1993). Johnson *et al.* (2001) found that woodland caribou shifted foraging areas when snow depth, density, and hardness limited access to terrestrial lichens. There is a need for good quality snow mapping, ideally via cost-effective remote sensing to assess patterns of snow conditions throughout the range.

An important consideration for caribou in a land use planning context is the maintenance of migration routes as connections between concentrated use areas and across seasons, particularly for long-distance migrants such as barren-ground caribou. A recent study indicated that long-distance migrants have poor long-term prospects due to anthropogenic impacts and that migration corridors should be conserved (Berger, 2004).

In general, the results reported here are consistent with published findings on the herd's distribution (Russell *et al.*, 1992, 1993). While we identify distribution patterns collectively over the past half-century, there may be habitats used by caribou over longer time scales that are not reflected in these analyses. For instance, areas that were subjected to forest fires within the past 50 years may become more important as lichens recover. Our analysis may have been influenced by short-term changes such as fire history, snowfall and decadal climate patterns. Hinkes *et al.* (2005) reported erratic migrations, range shifts, and changes in migratory behaviours of a barren-ground caribou herd in Alaska and concluded that 20-25 years of monitoring individual caribou herds is too short a time to fully understand the role of movement in caribou ecology. This conclusion was corroborated by several elders at the Old Crow workshop, who commented that changes in caribou use of the landscape required long-term studies on the order of 100 years. Such findings highlight the importance of long-term monitoring to identify changing patterns in caribou distribution.

To address the objectives for this study, we restricted our interpretations and conclusions to the local knowledge and satellite telemetry analyses to recommend regional caribou conservation priorities. The application of the findings toward the development of management direction and recommendations in a draft regional land use plan is discussed below.

Implications for land use planning

Within the planning region, the factors most likely to impact the herd in the near future (5-20 year time horizon) are oil and gas exploration and development and the effects of climate change. The cumulative effects of these factors may be greater than each factor in isolation, particularly when new areas are accessed for development, providing opportunities for additional harvest and anthropogenic disturbance. In Alaska, tundra caribou have shown a particular sensitivity to disturbances associated with hydrocarbon development activities (Nellemann & Cameron, 1998; Cameron *et al.*, 2005). The potential positive and negative effects of climate change on the Porcupine herd have been reported (Kruse *et al.*, 2004; McNeil *et al.*, 2005). Seasonal distribution may deviate from historical and current observed patterns if climate change, development, and harvest pressures concurrently alter the landscape.

Given these potential uncertainties, and the fact that approximately half of the planning region already has protected area, SMA, or conservation land withdrawal status, the NYPC is proposing to use cumulative impact thresholds (limits of acceptable change) as a tool to manage the remaining landscape. This approach is typically referred to as a "flexibly prescriptive" approach to land use planning, in that it provides guidelines, objectives, and stated desirable outcomes for specific land management units without differentiating "acceptable" and "unacceptable" land uses in specific areas. Such an approach would be in addition to the general guidelines and required operating procedures (i.e. seasonal timing windows to mitigate disturbance to caribou concentrated use areas and migration corridors) that form much of the content of existing land-use plans from other jurisdictions. Threshold-based approaches to conserve caribou have recently been proposed or approved for two adjacent land use planning regions in the Northwest Territories and Alaska, consistent with a flexibly-prescriptive planning model (Northeast Alaska Petroleum Reserve, Alaska, and DehCho, NWT) (U.S. Department of the Interior, Bureau of Land Management, 2005; DehCho Land Use Planning Committee, 2006).

A recommended approach by the NYPC is to set limits of acceptable change for two terrestrial indicators: allowable cumulative impact (area of direct surface disturbance) and linear feature density (km/

km^2). A considerable body of research has indicated that these two selected indicators are: 1) easily measured, 2) have demonstrated ecological significance (relevant to caribou conservation), 3) are cost effective to measure and track, 4) are easily understood, 5) are common to most land use activities, and 6) can be actively managed (e.g. Duinker, 2000; Dyer *et al.*, 2001; Environment Directorate, Northern Affairs Program, 2002; Cameron *et al.*, 2005). An additional consideration is that the tracking of the indicators is a politically feasible recommendation that can be relatively easily implemented through existing development review processes. The allowable thresholds for these indicators would be applied to specific land management units. At present, the Commission is proposing two land use designations to apply to the land management units in the region: (a) Protected Area and (b) Integrated Management Area (IMA).

As described above, exploration and development activities are prohibited in protected areas and these were not considered for thresholds. The thresholds would apply to the IMA, which currently have four recommended levels (zones) of desired conservation focus and associated thresholds: I) highest conservation focus, II) high conservation focus, III) moderate conservation focus, and IV) low conservation focus. The levels of conservation within the IMA were determined subjectively by NYPC through overlays of various wildlife/fish and cultural/heritage data, with emphasis on identified caribou and wetland values. For caribou, the conservation priority emphasis was on areas with overlapping concentrated use areas across seasons, overlapping local knowledge areas, and major migration corridors necessary to maintain connectivity between significant areas and seasons. A description of identified ecological and cultural resources that were considered during this process is available (North Yukon Planning Commission, 2006).

For each zone from I-IV, threshold tolerance limits would increase. For example, an IMA categorized as zone I would have the lowest threshold. All exploration, development, and tourism activities would be considered equal opportunities within the IMA, subject to usual permitting processes, general operating procedures and guidelines, and the condition that a threshold is not to be exceeded in a given zone if the activity is approved. For the current status of an IMA to be effectively monitored, the indicators must be tracked, reported and periodically updated/revised as new data become available.

Based primarily on the assessment of the caribou data reported here, and various other wildlife/fish, wetlands, and cultural/heritage data, the NYPC's proposed land management units and designations for the region are shown in Fig. 5. A consensus-based

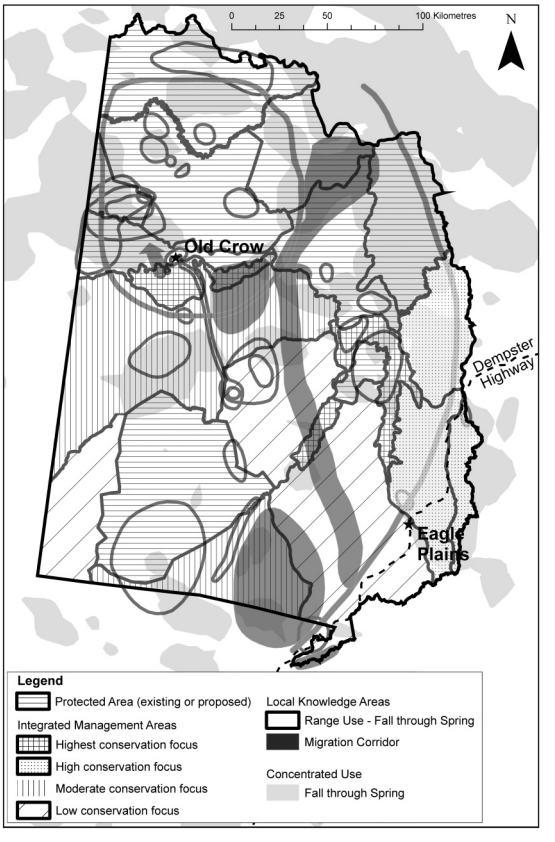

Fig. 5. Proposed land designations and zones overlayed with local knowledge and concentrated use areas for fall, winter and spring migration seasons. Existing and proposed protected areas are shown (horizontal hatch). Integrated Management Areas show proposed highest conservation focus (square hatch), high conservation focus (stippled), moderate conservation focus (vertical hatch), and low conservation focus (diagonal hatch).

decision making process with Commission members and other stakeholders on appropriate zoning and level of conservation focus was used in the proposal. Thirteen distinct units are delineated and the level of conservation focus for each is shown. The areas shown as highest conservation focus contain the region's identified significant wetland complexes (Yukon Department of Environment, unpublished data). These are sensitive permafrost terrain areas that support a variety of wetland-dependent organisms, and are culturally important to VGFN residents. One additional protected area is proposed for the Whitefish wetlands complex, a culturally and ecologically significant and sensitive area, on land owned by VGFN (located in the centre of the highest conservation focus IMA west of the Richardson Mountains). The areas shown as high conservation focus

had overlapping seasonal caribou concentrated use, in addition to other ecological and cultural values (Richardson Mountains).

The highest and high conservation focus zones (zones I and II) and the new protected area proposal captured 61% of the remaining caribou concentrated use areas outside the existing protected areas, Old Crow Flats SMA, Fishing Branch HPA, and the region under land withdrawal. If the concentrated use areas contained within existing and proposed protected areas and zones I and II are included, 82% of the herd's concentrated use areas would have protected area or conservation management designations under this proposal. All observed calving areas, both concentrated and general use, would also be captured under this scenario.

Flexibly-prescriptive planning models appear to hold the best promise to meet stakeholder needs in our planning region, but to be effective must contain quantitative statements about desired future states. Under the guiding principles that the Commission must follow, thresholds are appropriate tools to balance regional economic/development opportunities with the desire to ensure that current and potentially future important areas for Porcupine caribou, other wildlife/fish, and cultural/heritage resources have adequate conservation measures. Such an approach would involve monitoring, tracking, reporting, and evaluating the terrestrial disturbance indicators noted above. Where thresholds are being reached, additional monitoring of other ecological indicators would be required to determine if undesirable impacts to fish and wildlife populations or habitats ensue.

While the precise details of specific land designation units and acceptable thresholds have yet to be agreed upon or approved, and recognizing that threshold limits may be based on subjective determinations, the analysis and integration of scientific and local knowledge of Porcupine caribou herd distribution will play a crucial role in determining land use management recommendations and in NYPC's development and recommendation of a draft land use plan in the spring of 2007.

The success in implementing a thresholds approach to land management decision-making, and the usefulness and acceptance of the threshold metrics themselves, will be evaluated periodically following adoption of a final land use plan. Threshold implementation also provides quantitative criteria to assist assessment boards and regulatory authorities to establish potential project-level contributions to significant cumulative environmental and socio-economic impacts, thereby providing increased certainty and transparency in the assessment process. As better information on disturbance thresholds and potential impacts to caribou becomes available through additional research, the acceptable limits would be adjusted at the next planning cycle, using an adaptive management style approach to refine the values.

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